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Zbornik 23. mednarodne multikonference

INFORMACIJSKA DRUŽBA

Zvezek E

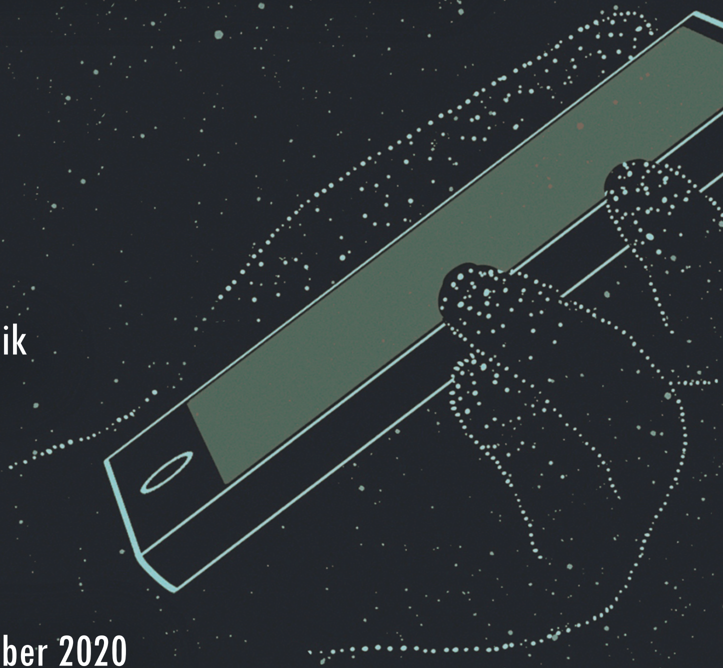
Proceedings of the 23rd International Multiconference

INFORMATION SOCIETY

Volume E

13. Mednarodna konferenca o prenosu tehnologij • 13. ITTC

13th International Technology Transfer Conference • 13 ITTC



Uredili / Edited by

Špela Stres, Robert Blatnik

8. oktober 2020 / 8 October 2020

Ljubljana, Slovenia

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PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2020

Triindvajseta multikonferenca Informacijska družba (http://is.ijs.si) je doživela polovično zmanjšanje zaradi korone. Zahvala za preživetje gre tistim predsednikom konferenc, ki so se kljub prvi pandemiji modernega sveta pogumno odločili, da bodo izpeljali konferenco na svojem področju.

Korona pa skoraj v ničemer ni omejila neverjetne rasti IKTja, informacijske družbe, umetne inteligence in znanosti nasploh, ampak nasprotno – kar naenkrat je bilo večino aktivnosti potrebno opraviti elektronsko in IKT so dokazale, da je elektronsko marsikdaj celo bolje kot fizično. Po drugi strani pa se je pospešil razpad družbenih vrednot, zaupanje v znanost in razvoj. Celo Flynnov učinek – merjenje IQ na svetovni populaciji – kaže, da ljudje ne postajajo čedalje bolj pametni. Nasprotno - čedalje več ljudi verjame, da je Zemlja ploščata, da bo cepivo za korono škodljivo, ali da je korona škodljiva kot navadna gripa (v resnici je desetkrat bolj). Razkorak med rastočim znanjem in vraževerjem se povečuje.

Letos smo v multikonferenco povezali osem odličnih neodvisnih konferenc. Zajema okoli 160 večinoma spletnih predstavitev, povzetkov in referatov v okviru samostojnih konferenc in delavnic in 300 obiskovalcev. Prireditev bodo spremljale okrogle mize in razprave ter posebni dogodki, kot je svečana podelitev nagrad – seveda večinoma preko spleta. Izbrani prispevki bodo izšli tudi v posebni številki revije Informatica (http://www.informatica.si/), ki se ponaša s 44-letno tradicijo odlične znanstvene revije.

Multikonferenco Informacijska družba 2020 sestavljajo naslednje samostojne konference:

- Etika in stroka
- Interakcija človek računalnik v informacijski družbi
- Izkopavanje znanja in podatkovna skladišča
- Kognitivna znanost
- Ljudje in okolje
- Mednarodna konferenca o prenosu tehnologij
- Slovenska konferenca o umetni inteligenci
- Vzgoja in izobraževanje v informacijski družbi

Soorganizatorji in podporniki konference so različne raziskovalne institucije in združenja, med njimi tudi ACM Slovenija, SLAIS, DKZ in druga slovenska nacionalna akademija, Inženirska akademija Slovenije (IAS). V imenu organizatorjev konference se zahvaljujemo združenjem in institucijam, še posebej pa udeležencem za njihove dragocene prispevke in priložnost, da z nami delijo svoje izkušnje o informacijski družbi. Zahvaljujemo se tudi recenzentom za njihovo pomoč pri recenziranju.

V 2020 bomo petnajstič podelili nagrado za življenjske dosežke v čast Donalda Michieja in Alana Turinga. Nagrado Michie-Turing za izjemen življenjski prispevek k razvoju in promociji informacijske družbe je prejela prof. dr. Lidija Zadnik Stirn. Priznanje za dosežek leta pripada Programskemu svetu tekmovanja ACM Bober. Podeljujemo tudi nagradi »informacijska limona« in »informacijska jagoda« za najbolj (ne)uspešne poteze v zvezi z informacijsko družbo. Limono je prejela »Neodzivnost pri razvoju elektronskega zdravstvenega kartona«, jagodo pa Laboratorij za bioinformatiko, Fakulteta za računalništvo in informatiko, Univerza v Ljubljani. Čestitke nagrajencem!

Mojca Ciglarič, predsednik programskega odbora
Matjaž Gams, predsednik organizacijskega odbora

FOREWORD
INFORMATION SOCIETY 2020

The 23rd Information Society Multiconference (http://is.ijs.si) was halved due to COVID-19. The multiconference survived due to the conference presidents that bravely decided to continue with their conference despite the first pandemics in the modern era.

The COVID-19 pandemics did not decrease the growth of ICT, information society, artificial intelligence and science overall, quite on the contrary – suddenly most of the activities had to be performed by ICT and often it was more efficient than in the old physical way. But COVID-19 did increase downfall of societal norms, trust in science and progress. Even the Flynn effect – measuring IQ all over the world – indicates that an average Earthling is becoming less smart and knowledgeable. Contrary to general belief of scientists, the number of people believing that the Earth is flat is growing. Large number of people are weary of the COVID-19 vaccine and consider the COVID-19 consequences to be similar to that of a common flu dispute empirically observed to be ten times worst.

The Multiconference is running parallel sessions with around 160 presentations of scientific papers at twelve conferences, many round tables, workshops and award ceremonies, and 300 attendees. Selected papers will be published in the Informatica journal with its 44-years tradition of excellent research publishing.

The Information Society 2020 Multiconference consists of the following conferences:

- Cognitive Science
- Data Mining and Data Warehouses
- Education in Information Society
- Human-Computer Interaction in Information Society
- International Technology Transfer Conference
- People and Environment
- Professional Ethics
- Slovenian Conference on Artificial Intelligence

The Multiconference is co-organized and supported by several major research institutions and societies, among them ACM Slovenia, i.e. the Slovenian chapter of the ACM, SLAIS, DKZ and the second national engineering academy, the Slovenian Engineering Academy. In the name of the conference organizers, we thank all the societies and institutions, and particularly all the participants for their valuable contribution and their interest in this event, and the reviewers for their thorough reviews.

For the fifteenth year, the award for life-long outstanding contributions will be presented in memory of Donald Michie and Alan Turing. The Michie-Turing award was given to Prof. Dr. Lidija Zadnik Stirn for her life-long outstanding contribution to the development and promotion of information society in our country. In addition, a recognition for current achievements was awarded to the Program Council of the competition ACM Bober. The information lemon goes to the "Unresponsiveness in the development of the electronic health record", and the information strawberry to the Bioinformatics Laboratory, Faculty of Computer and Information Science, University of Ljubljana. Congratulations!

Mojca Ciglarič, Programme Committee Chair
Matjaž Gams, Organizing Committee Chair

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KAZALO / TABLE OF CONTENTS

Zbornik 23. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2020

Zvezek E

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Ljubljana, Slovenia

PREDGOVOR

Spoštovana ministrica, spoštovani direktor, dragi kolegi, prijatelji, sodelavci pri prenosu znanja in tehnologije!
Prisrčna dobrodošlica tudi iz Centra za prenos tehnologij in inovacij na Institutu »Jožef Stefan«.

To je četrti dogodek Konzorcija za prenos tehnologij v Sloveniji, ki ga sestavlja 8 pisarn za prenos tehnologij. Sodelujemo že skoraj 3 leta. Hvaležni smo Ministrstvu za izobraževanje, znanost in šport, da je priznalo poklic za prenos tehnologije in zagotovilo petletni projekt za podporo našim dejavnostim. To sodelovanje praznujemo.

Rada bi se zahvalila vsem 8 partnerjem v konzorciju, ki so prispevali po svojih zmožnostih. Lepa hvala tudi ostalim konferenčnim partnerjem, ki so skušali prispevati po najboljših močeh.

Prav tako bi se rada zahvalila našemu direktorju za njegovo stalno podporo v vseh letih. Čeprav smo bili pogosto prepuščeni svojim zmožnostim, smo jih smeli uporabljati v korist inštituta in tehnološkega prenosa na inštitutu. Tudi ta konferenca je rezultat tega popustljivega okolja, ki je podprlo razvoj vseh področij.

To je 13. Mednarodna konferenca o prenosu tehnologij po vrsti. Od nekdaj se je prilagajala duhu časa, saj je vključevala ugledne mednarodne govornike, predstavitve industrijskih tehnologij in nagrade za najboljše inovacije raziskovalnih organizacij. Te nagrade so bila skozi leta podeljena več različnim slovenskim raziskovalnim institucijam, od katerih so mnoge sedanji partnerji našega konzorcija TTO.

Skozi vsa leta je konferenca vključevala tudi B2R srečanja, na katerih so raziskovalci in podjetja lahko razpravljali o konkretnih vprašanjih. Vključevala je okrogle mize za soočanje različnih mnenj in raziskovalne predstavitve, ki so prikazale vrhunske slovenske znanstvene rezultate. Konferenca je tako raznolika in prav je tako, saj poskuša vključiti vse segmente, ki so ključni za izvedbo znanja in prenos tehnologije.

Vendar se še vedno najdejo novi izzivi, s katerimi se lahko spoprimemo. Danes bo Svetovni urad za intelektualno lastnino na tem dogodku podelil dve mednarodni nagradi - IP Enterprise Trophy in medaljo WIPO za izumitelje. Zahvaljujemo se WIPO za prijazno podporo in soorganizacijo dogodka ter se zahvaljujemo slovenskemu uradu za intelektualno lastnino, ki je to sodelovanje omogočil.

Druga novost konference je rubrika z znanstvenimi prispevki o prenosu tehnologij. Pomembna je, saj si prizadevamo izboljšati učinkovitost prenosa tehnologije. Pri teh prizadevanjih je potreben objektiven pristop, ki se ponuja z znanstvenim načinom razmišljanja - spodbuja analizo, razprave na podlagi podatkov in se podaja v neznano, kjer še vedno veliko vprašanj ostaja neodgovorjenih.

Na primer, predlagani novi slovenski zakon o raziskavah, razvoju in inovacijah uvaja nove spodbude za sodelovanje z industrijo in sodelovanje v projektih EU. Toda zakaj bi bolj spodbujali sodelovanje v projektih EU kot sodelovanje v industrijskih projektih? Kaj natančno šteje za sodelovanje z industrijo? Kakšna naj bi bila odslej vloga spodbud, ki temeljijo na komercializaciji, ki so bile na voljo do zdaj? To so pomembna vprašanja, na katera je treba odgovoriti pred izvajanjem nove zakonodaje.

Prav tako je v novi zakonodaji mogoče zaznati dejavnosti prenosa tehnologije, kar je zelo pozitivno sporočilo. Ampak, ali zakon dejansko opisuje TTO z vrsto strokovnjakov? Ali pa je treba financiranje med raziskovalci na tanko razporediti, da bi se sami ukvarjali s svojimi odnosi med industrijo in akademskim svetom? Kot je povedala gospa ministrica, je ministrstvo pripravljeno podpreti izvajanje instrumenta TTO tudi v naslednjem finančnem obdobju in to pozdravljamo. Ministrstvo pozivamo, naj v predlagani novi zakonodaji jasno formalizira TTO in naj pravočasno predstavi svoje konkretne načrte za poklic prenosa tehnologije v Sloveniji, da bodo TTO neprekinjeno delovale.

Naj na koncu poudarim še, da sta znanost in prenos tehnologije dolgoročni dejavnosti. Naši današnji rezultati v glavnem niso v našo korist takoj, ampak v korist družbi, v kateri želimo, da živijo naši otroci. Zato moramo visoko ceniti duh skupnosti, si prizadevati za svojo popolnost, hkrati pa pomagati tudi drugim, da jo dosežejo .

Hvala vam.

Dr. Špela Stres, MBA, LLM, Vodja Centra za prenos tehnologij in inovacij, Institut Jožef Stefan, vodja organizacijskega odbora konference 13. ITTC

FOREWORD

Dear Minister, dear Director, dear colleagues, friends, co-workers of transfer of knowledge and technology!
A kind welcome also from the Center of technology transfer and innovation at the Jožef Stefan Institute.

This is the 4th event of the Consortium of Knowledge and Tech-transfer in Slovenia, comprising 8 Tech-Transfer Offices, which have been collaborating now for almost 3 years. We are grateful to the Ministry of Education, Science and Sports to have acknowledged the tech-transfer profession and secured a 5-year project to support our activities. We celebrate this collaboration.

I would like to thank all 8 partners in the consortium, each has contributed according to their capacity. Warm thanks also to the other conference partners who tried to contribute in any way possible for them.

I would also like to thank our director for his continouing support throughout the years. Although we were mainly left to our own devices, we were allowed to use them for the benefit of the institute and the tech-transfer at the institute. Also this conference is a result of this permissive environment, who supported development of all fields.

This is the 13th International Technology Transfer Conference in a row. It has always adjusted to the spirit of the time, by including distinguished international speakers, Pitch Presentations of Industry ready Technologies, and the Awards for best innovation from research organizations. These awards have been through the years awarded to several different slovenian research institutions, many of them current partners of our TTO consortium.

Throughout the years the Conference also included the B2R Meetings where researchers and businesses could discuss concrete issues. It included Round Tables to confront different opinions and Research Presentations to show off with the superb Slovenian scientific results. The Conference is so diverse, and it is so, because it tries to incorporate all segments, crucial for the execution of the knowledge and tech-transfer.

However, there are still new territories to venture to. Today, the World Intellectual Property Office will bestow two international Awards at this event – IP Enterprise Trophy and WIPO Medal for Inventors. We thank WIPO for their kind support and co-organization of the event, and we extend our gratitude to the Slovenian IP Office, who made this collaboration possible.

Another novelty of the conference is the Section with scientific contributions on tech-transfer. The section is important, as we strive to improve efficiency in tech-transfer. In that effort an objective approach is needed, and it is offered through the scientific way of thinking – it encourages analysis, data based discussions, and venturing into the unknown, where still many questions lay unanswered.

For example. The proposed new Slovenian Law on research, development and innovation introduces new incentives for cooperation with the industry and for collaboration in the EU projects. But why a higher impetus for EU than for industry project collaboration incentives? What exactly counts as a cooperation with the industry? What should from now on be the role of the commercialization based incentives that were in place so far? These are important questions to be answered before the implementation of the new legislation.

Also, one can sense the tech-transfer activities in the new legislation, which is a very positive message. But, is the law actually outlining a TTO with a set of experts? Or is the financing to be thinly spread among the researchers to deal themselves alone with their industry-academia relations? As the Lady Minister said, the Ministry is willing to support the implementation of he TTO instrument also in the next financing period and this is a very positive message. We urge the Ministry to clearly formalize the TTOs in the proposed new legislation, and to lay out their concrete plans for the tech-transfer profession in Slovenia in time for the TTOs to operate continously.

To conclude, science and tech-transfer are long term activities. The results we produce today are mainly not for our own immediate benefit, but for the society we want our children to live in. Thus we need to value highly the spirit of the community, strive for our own perfection, but also assist others in reaching it.

Thank you.

Dr. Špela Stres, MBA, LLM, Head of the Center for Technology Transfer and Innovation, Jožef Stefan Institute, Head of Organizing Committee of the 13 ITTC

ORGANIZACIJSKI ODBOR, PRIDRUŽENI PARTNERJI IN SPONZORJI / ORGANIZING COMMITTEE, ASSOCIATED PARTNERS AND FINANCERS

The main organizer of the 13th ITTC Conference is Jožef Stefan Institute.

Jožef Stefan Institute Ljubljana, Slovenia

center for technology transfer and innovation at the Jožef Stefan Institute

The organizing committee:

Dr. Špela Stres, MBA, LLM, Jožef Stefan Institute

Doc. dr. Urška Fric, Faculty of Information Studies in Novo Mesto

Robert Blatnik, M. Sc., Jožef Stefan Institute

Marjeta Trobec, M. Sc., Jožef Stefan Institute

The 13th ITTC Conference is organized in collaboration with the International multiconference Information Society (IS2020).

IS Information Society

The 13th ITTC Co-organization partners are:

Slovenian Intellectual Property Office (SIPO)

URAD REPUBLIKE SLOVENIJE ZA intelektualno LASTNINO
Slovenian Intellectual Property Office

World Intellectual Property Organization (WIPO)

WIPO WORLD INTELLECTUAL PROPERTY ORGANIZATION

Chamber of Craft and Small Business of Slovenia

SPIRIT Slovenia - Public Agency for Entrepreneurship, Internationalization, Foreign Investments and Technology

Faculty of Information Studies Novo mesto

Agricultural Institute of Slovenia

Slovenian association of technology transfer professionals (SI-TT)

The 13th ITTC Associated partners are:

National Institute of Chemistry

National Institute of Biology

University of Primorska

University of Maribor

University of Ljubljana

Scientific research centre Bistra

RDA Koroška - Regional Development Agency for Koroška

Regional Development Agency Posavje

Development Centre Novo mesto

University of Malta

Center for Technology Transfer, University of Belgrade

SIS EGIZ

Centre of Excellence for Integrated Approaches in Chemistry and Biology of Proteins

IP Management Poland

GIS – Transfer Center Foundation

Slovenian Innovation Hub - European Economic Interest Grouping, SIH EEIG

The Research-to-business meetings at the 13th ITTC Conference were co-organized in collaboration with the Enterprise Europe Network partners:

Chamber of Craft and Small Business of Slovenia

SPIRIT Slovenia - Public Agency for Entrepreneurship, Internationalization, Fore-ign Investments and Technology

University of Primorska

University of Maribor

Chamber of Commerce and Industry of Slovenia

Area Science Park

Austrian Research Promotion Agency

Innovation Center of the Faculty of Mechanical Engineering in Belgrade

Ss. Cyril and Methodius University in Skopje

Fundación para el conocimiento madri+d

AECIM - Empresas del Metal de Madrid

Fundació Universitat-Empresa de les Illes Balears (FUEIB)

Tera Tehnopolis

Not Enterprise Europe Network partners:

ITC – Innovation Technology Cluster

DIH Agrifood – Digital Innovation Hub for Agriculture and Food production

The Conference is co-financed by:

Consortium for Technology Transfer

Investment is co-financed by the Republic of Slovenia and the European Union under the European Regional Development Fund.

Enterprise Europe Network

Co-financing Enterprise Europe Network's part of R2B international brokerage event of Sector groups BioChemTech and ICT Industry&Services that are formed and co-financed entirely by the Enterprise Europe Network.

A decade of Knowledge Transfer in Slovenia

Desetletje prenosa znanja v Sloveniji

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ABSTRACT

In this paper, we describe the last decade of the Knowledge Transfer development in Slovenia. Knowledge transfer is based on the development of legislative tools, governmental financial tools and performance of the Public Research Organizations in Slovenia. The overview shows and evaluates in numbers what has been achieved. It also presents the fields in which knowledge transfer experts will have to act further in collaboration with Government, Professional Associations and Public Research Organization (PRO) leaderships. Conclusions are drawn to suggest further steps on the path of KT development in Slovenia.

Keywords

spin-off, spin-out, R&D contracts, Intellectual Property Rights (IPR) sales, legislation changes, public research organizations, boundaries, conditions, technology transfer, eco-system

POVZETEK

V prispevku opisujemo zadnje desetletje razvoja prenosa znanja v Sloveniji. Prenos znanja temelji na razvoju zakonodajnih orodij, vladnih finančnih orodij in raziskovalni uspešnosti javnih raziskovalnih organizacij v Sloveniji. Pregled v številkah prikazuje in ocenjuje, kaj je bilo doseženega. Nudi tudi vpogled v področja, kjer bodo v prihodnje strokovnjaki za prenos znanja v sodelovanju z vladnimi, strokovnimi združenji in vodstvi javnih raziskovalnih organizacij (JRO) morali nadgraditi dosedanja prizadevanja. Sklepne ugotovitve predlagajo nadaljnje korake na poti razvoja KT v Sloveniji.

Ključne besede

spin-off, spin-out, pogodbe za raziskave in razvoj, prodaja pravic intelektualne lastnine, spremembe zakonodaje, javne raziskovalne organizacije, meje, pogoji, prenos tehnologije, ekosistem

1. INTRODUCTION

Slovenia is a small country with 2 million inhabitants in Central Europe and 6980 registered researchers [1], the 19th in thus measured research strength out of 127 evaluated countries.

The efficiency of the Intellectual Property Rights (IPR) management system in a country can be evaluated through the successful commercialization of patents and secret know-how originating from Public Research Organizations. The commercialization is taking place through new company creation, IPR licensing and sales and direct R&D collaboration with companies.

The efficiency of the IP management system in Slovenia can be sought from a comparison of the results of three separate time-periods in which the Slovenian governments attempted to manage IPR collectively, using different mechanisms, through Technology Transfer Offices (TTOs). These were the periods of 2009-12, 2013-2014 and 207-2019 (the instrument is active until June 2022, not yet completed).

Since the independence of Slovenia in 1991, a particular legislative system with respect to public research generated IPR has been established. The legislative system, in the case of Slovenia affects the strength and the quality of a national IP management regime.

2. THE LEGISLATIVE CONTEXT

2.1 Slovenian legislative context

The Republic of Slovenia has established universities and public research institutes (PRIs) with *Institutes Act* (1991) [2] and *The Higher Education Act* (1993) [3]. Financing of research work on universities and PRIs (jointly named Public Research Organizations, (PROs)) is implemented with the assistance of the *Slovenian Research Agency* in accordance with various regulations [4].

The researchers compete for the financing of their research plans. They do so in regular time intervals (every year for projects, every four to six years for programmes). Evaluation of the proposals is done on the basis of certain criteria. Thus, it is possible to claim that the financing of research from the public budget is project and programme organised. To a certain degree, such a frequent selection and unavailability of stable long-term financing should support positive selection in the research sphere and enable researchers to work creatively in a relatively secure environment.[1]

With the Act on inventions arising from employment (1995) [5], the Republic of Slovenia has introduced an arrangement similar to the Bayh-Dole Act of the USA. The inventions arise from PROs. All the inventions resulting from the state budget financing, are owned and managed by the PROs. Certain conditions regulate the management of the mentioned inventions. These conditions need to be met, for the PROs to become the owner of the actual invention. These conditions are described in Article 21 and 22 of the Act on inventions arising from employment and are related to the Industrial Property Act.

All EU member states (except Italy and Sweden) – manage their inventions in the way the Republic of Slovenia does, with respect to the responsible PROs. The state renounces the right of ownership of the inventions in favour of the PROs. Consequently, these PROs, as legal entities, are also responsible for commercialization of inventions. Researchers are not personally responsible for the commercialization of inventions,

[1] The status of researchers as civil servants and the absolute impact of the ARRS selection system are not discussed here.

but may capitalize financially (in Slovenia minimum is in the amount of 20 % of the gross related PRO income) in case of successful commercialization takes place. The researchers are thus incentivized to participate, and practically all PROs in Slovenia nowadays have internal PRO Acts distributing the benefits defined by the law.

With the *Supportive Environment for Entrepreneurship Act* (2007) [6] and the accompanying *Record on Keeping Rules on the Innovative Environment* [7]) a legal base for a supportive environment for innovation was created in Slovenia. Entrepreneurship incubators, university incubators and technology parks were explicitly mentioned in Article 2 of the *Record on Keeping Rules on the Innovative Environment*. Each of those supportive organizations was supposed to, in a manner described in the Record, support development and cooperation of the start-up and young enterprises. Technology transfer offices were mentioned by the *Record on Keeping Rules on the Innovative Environment* but were not financed through being part of the listed entities by the same Record.

Last but not least, based on the *Industrial Property Act* (2001) [8] the Slovenian Intellectual Property Office (Article 5 of the Industrial Property Act) was founded, with the main function to accept patent and other intellectual property right applications, manage the related procedure, related registers of rights, provide information services and represent the Republic of Slovenia at WIPO, EPO and other international organizations.

3. TECHNOLOGY TRANSFER OFFICES

In a substantial proportion, the Slovenian science and research activity is financed from public funds - in part from the national public budget, partly from the EU budget (European projects). A considerable proportion of the funding also comes directly from the Slovenian enterprises, which are the generator of public budget.

Therefore, the public research organizations (PROs) are well aware of the fact that the increase in competitiveness of the Slovenian economy also depends on the quality of the cooperation between science and industry.

However, looking at the commercialization side of Intellectual Property Right (IPR), in the end of the first decade of the 21st century, it was obvious that the knowledge and technology transfer potentials were not being fully exploited. The reasons could be sought in the less developed parts of the innovation support system – the intermediaries, which would assist in the commercialization of IPR – the Technology Transfer Offices (TTOs).

3.1 The governmental level

The legal framework for active management of the IPR generated by the PRO, has been set during the period of 1991-1995. The transfer of knowledge and inventions to the market should have been, by law, since 1995, supported by the PROs themselves. In particular the PROs should have been managing the IPR, generated/owned by the PROs. In practice the management and transfer activities should have been actively carried out by the entities, defined by legislation through the *Act on inventions arising from employment*. These entities are called the technology transfer offices (TTO) of the PROs. In addition, the Offices of technology transfer were in explicitly mentioned in the *Record on Keeping Rules on the Innovative Environment*.

Unfortunately, such offices have not been given further legitimacy until 2011, when the Resolution on Research and Innovation Strategy 2011-2021 [9] Slovenia has been adopted. Therefore, IPR in PROs was typically generated on a day-to-day basis without proper assessments of it being made, without commercialization procedures having been considered.

The question of IPR for the market has been raised several times through the years, but since there was little interest in looking at this problem from an integrative point of view, integral solutions were not implemented for almost another decade.

3.2 The institutional level

PROs in Slovenia were very agile in collaboration with the industry during the 1970's and 1980's. This resulted in some very early adoptions of internal Acts on acquiring and management of the IPR by the PRO, which enabled at least incentivizing the researchers with rewards on IPR production (if not management of IPR). The quickest to act was Institute of Chemistry (KI) in 1979, followed by Jožef Stefan Institute (JSI) in 1998, University of Ljubljana (UL) in 2006, National Institute of Biology (NIB) in 2007, University of Maribor (UM) in 2009, University of Primorska (UP) in 2010 [10]. All such Institutional Acts underwent several changes through the years.

Unfortunately, the PROs were not quick to pick up the pace with IPR management, to enable systematic, sustainable and consistent management of IPR generated, and to prevent any issues, as defined in relevant competition, integrity and corruption legislation.

The PROs were creating TTOs at different times and with different efficiencies. The first TTO in Slovenia was founded at JSI in 1996, followed by UM in 2005, University of Ljubljana in 2007, KI in 2010 (first jointly with JSI, then separated in 2012), UP in 2010, NIB in 2010, Agricultural institute of Slovenia (KIS) in 2015, Faculty of Information Studies Novo mesto (FIŠ) in 2017 [11], [12].

Several of the TTOs changed their organizational structure to become more agile and to be able to sustain themselves. Some several times, formal incorporations ranging from an outside company 100% owned by the University, through a separate and financially independent Unit of an Institute to an office or a section within some other entity (the Rectorate of the University, a Faculty or an incorporated Institute of the University).

3.3 The EU context

The *Framework for Research, Development and Innovation* suggests that the field of establishing new enterprises, arising from the knowledge, developed at the research organizations, should be regulated. According to this Framework, commercialisation via spin-offing is allowed (and desirable), if the profits from commercialisation activities are provided as funds for further research activities.

On the other hand, European and domestic competition law prohibit anti-competitive agreements. Thus, any anti-competitive provisions in commercial agreements are void and unenforceable which could lead to the entire agreement being unenforceable. However, the European Commission has produced a number of so-called block exemptions which make certain 'safe harbours' available to companies.

The Technology Transfer Block Exemption (TTBER [13]) covers technology licensing agreements in relation to most intellectual property rights (IPRs), providing a safe harbour to companies active in this business area and in business relations with Public Research Organizations (PROs), too. If an agreement falls within the terms of this block exemption, the companies concerned can be confident that it will not be subject to scrutiny.

Furthermore, "Commission Recommendation on the management of intellectual property and knowledge transfer activities and Code of Practice for universities and other public research organizations", requests the establishment of control over the performance of technology transfer activities to the industry, which since 2013 EC countries, including Slovenia, are recommended to follow.

4. THE FINANCING OF THE TTOs

4.1 The lack of dedicated financing

Even though changes have been observed during the first decade of the 21st century, in European and national legislation, the problem of operationalization of TTOs through dedicated financing in fact remained open. A situation at the end of the first decade of the 21st century was still a gross neglect of the TTOs and their activities by the government.

On the one hand this forced most TTOs to have only 1 or two employees, mainly dealing with other issues of the institution (e.g. PR, research project administration). The two exceptions in size and activities, JSI with 6-15 employees and later TehnoCenter UM with 4-8 employees at the time, however, had little institutional financial support, and had to provide financing for their work from projects (EU projects, work for industry).

Thus, the long-lasting effort for financial support to the TTOs from the side of the government began already in 2008.

4.2 The three phases of the projects

The first partial solutions to the TTO financing started to be generated by the government with the support of the Association of Technology Transfer Professionals of Slovenia (Association SI-TT) already in 2009. Those were the KTT projects and they can be divided into three groups.

4.2.1 INO projects: 2008-2011

Firstly, the INO projects of 2008, 2009, 2011 were financed by the (former) Technology and Innovation Agency (TIA) with the support of the Ministry of Science. These projects involved partners as Slovenian Business and Regional Development Agencies, but also some of the Public Research Organizations. The glass ceiling has been broken, but the projects still focused mainly on promotion and organization of events. These projects explicitly focused on counting the number of leaflets produced and workshops organized. Less focus was devoted to actual Key Performance Indicators (KPIs) that would influence the industrial progress of the country, as number of contracts and their size, patents filed etc.

4.2.2 KTT project: 2013-2014

Secondly, the initial project KTT, lasting from 2013 through 2014, was the first project within which in particular technology transfer in Slovenia was *systematically* (albeit not sustainably) funded. During this first period national funds from the Ministry of Economy were made available for such financing. There were 6 partners involved in the project, but (due to late evaluation and late start) the project only lasted for 16.5 months.

4.2.3 KTT-2 project: 2017-2022

A long three-year period followed with no financing. During that time the Association of Technology Transfer Professionals of Slovenia (Association SI-TT) tirelessly tried to intervene with the Ministry of Science, the Ministry of Economy and the Government Office for Development and European Cohesion Policy, for the KTT project to be renewed and the TTOs to be financed again. This difficult period was intermittent only by harsh and belligerent negotiations among the existing TTOs. The negotiations were initiated by the JSI, but were difficult to lead due to different and partially articulated points of view.

There was a period of genuine despair due to government’s focus on the NUTS3 division of the funds, and the unwillingness to introduce an umbrella accounting, which would affect KTT as operating throughout the country (instead of in a particular NUTS3 region). During this period, with no clear framework and leadership from the side of the government, the idea of the exclusionary operation of a possible new consortium grew among some TTOs. The idea was that some TTOs would be members, others would be left out. Consequently, the willingness of partners to rationally check their capacity, capabilities and achievements with the aim of cooperation remained low, the uncertainty caused the tensions and the competition among the partners to grew. The actions of the leaderships of the PROs, which held separate meetings for Universities and for Institutes, did not add a positive note into the confusion and distrust. Actually, the only joint meeting of the PRO leaderships was organized by JSI on June 12th 2014 in order to evaluate possible further steps, already before the KTT project (phase 2) ended.

After 3 years of turmoil, finally, in June 2017 the government decided to finance TTOs of Slovenia with a 5-year project. The current KTT project's mission is twofold: the strengthening of links and increasing the cooperation of PROs and industry and the strengthening the competences of TTOs, researchers and enterprises. Most (80%+) of the finances go to human resource financing.

As of now, all TTOs in Slovenia are jointly collaborating in this project. This *collaborative all-inclusive TTO setup* is considered by most of the utmost importance for coherent further development of the TTOs in Slovenia, but was not an initiative of the government. The government anticipated a competitive call where some of the TTOs would outbid the others, practically eliminating some or preventing others from developing skills at their institution. Such a development would have had disastrous effects on the development of the Technology Transfer scene in Slovenia. Moreover, the rules of the project prohibited active assistance from one PRO to the other, so no PRO can or could take on a case from the other PRO. Some PROs would thus in the exclusive model remain completely unsupported, as far as knowledge and technology transfer is concerned. Both of these features (long gaps between financing and the possible exclusion of some TTOs) need urgently to be rethought for further development – and prevented.

Against the spirit of the 2017 governmental call, the JSI as the consortium leader managed to join forces with all existing TTOs, small and big, some already in existence for a while and kicking-off and some just created. This was not an easy enterprise: some of the larger PROs in Slovenia were at the time interested in forming an exclusive consortium, leaving the other TTOs out of the loop, preventing their further development. Their idea was that not all the TTOs in Slovenia, but only a selected few should have access to the financial support. Against all odds, thanks to the efforts of the JSI and the timely support of the Ministry of Science in 2017, this did not happen. In 2017 all of the institutions that could join the consortium, were invited to do so, and the coordinator made their accession possible, although with several difficulties regarding the quality of the official documentation initially provided.

The current KTT project, 2017-2022, comprises 8 partners, all public research organizations (PROs), represented by their respective technology transfer offices (TTOs), namely, 4 leading institutes and 4 renowned universities.

This helped to forge a network of TTOs in Slovenia, striving for development – competing, but under the leadership of JSI with a logic of the utmost inclusivity.

Every operational TTO in the country has its place in this current TTO project and it should remain so.

On the other hand, inclusivity also has its negative issues. In a huge project with many partners not necessarily everything is running smoothly. Sometimes also tensions tend to interrupt the day-to-day business. The issue of research competition, which appears to be rather smoothly managed by the researchers and the PRO leaderships, is often exhibited as a ruthless and futile brawl on the level of the TTOs. Such tensions are enabled and propelled by the fact that besides by the exhaustive expert work of the TTO, results can currently still also be defined and achieved in a political manner as they are not concrete and precise enough.

The situation resembles the Performance Enhancement System (PES) crisis of the Enterprise Europe Network (EEN) from the period 2014-2016, when the European Commission worked tirelessly to improve the standards of the PES results to a solid and concrete set of PES, which can be easily comparable through the EEN partners. The analytics is done by the EASME and is of utmost importance in EEN development and partner improvement. An improvement is sought from the side of the Ministry to enable such monitoring and analysis of the results in a contextual content manner, in addition to the (albeit very complicated) financial monitoring.

Based on this experience and example, the scientific approach to defining the technology and knowledge transfer KPIs is of the utmost importance in Slovenia. In particular it is necessary to enable fair comparison among the KTT partners, based on monitored, unalterable and unique parameters. It is important to ease out the tensions of the unproductive competition in the world where the Technology transfer industry itself needs still to be professionalized. The objective numbers, comparable among the partners, would enable a better standing and a community, focused purely on development instead of power games.

Lastly, a capacity of all partners to accept the creation of a community of equals who do the best they can in their own fields and on their own institutions, without making a special effort to prevent others' excellence, could also be further improved.

There are as of today no confirmed information on prolongation of this financing, thus the same issue as in 2014 will resurface in two years, in June 2022. What comes next? The system has been set up, people have been brought together to create new and larger, operational TTOs, and educated. The government should be urged to officially lay out their plans to enable planning of the TTOs' future activities.

4.3 The Center for technology transfer and innovation of JSI

The Center for Technology Transfer and Innovation at the Jožef Stefan Institute is currently the coordinator of the project KTT (2017-2022), the coordinator of Enterprise Europe Network Slovenia, and is a financially independent unit of Jožef Stefan Institute, Slovenia, involved in many different international projects.

CTT has been the coordinator of the INO projects in 2008, 2009 and 2011, with different partners (e.g. NIB, KI, UM); the coordinator of the KTT project 2013-2014 under the supervision of Ministry for economics and development; and is also the coordinator of the KTT-2 project 2017-2022 under the supervision of the Ministry of Science, Education and Sports. It should be noted, however, that the coordination of the current project KTT-2 was offered by the JSI to all other partners. In particular it was offered to the UL as the largest university in Slovenia, with similar innovation output as JSI. The offer was not accepted, not in 2017 and not in 2020, when it was repeated.

CTT prepared the project documentation and the proposed financing was split according to the size (in research FTE) of the PRO. The UM was awarded extra financing, following its proposal to coordinate the activities of the consortium in the Eastern NUTS3 region of Slovenia, and due to a claim of a significantly higher output than the corresponding one, relative to the research FTE. JSI made this increase possible by reallocating a share of their own budget to the UM. In addition, a share of the proposed KTT 2017-2022 budget was split equally among all 8 partners, disregarding their size in research capacity, to acknowledge that events and public relations activities require the same effort regardless the size of the institution and the level of results offered by the particular PRO.

The employees of CTT helped lobby for such the KTT-2 consortium project in their roles within the Association SI-TT. They worked coherently and tirelessly for more than 15 years towards a common goal: a creation of a network of Slovenian Technology Transfer Offices. This network is now partially operational. These activities resulted in an active consortium of 8 TTOs and JSI and CTT is currently responsible for executing this project financing scheme.

We urge the government to decide about further support of the TTOs in Slovenia as soon as possible to allow for planning of any transition necessary. Apart from the problem that the financing is running out in June 2022 and that the newly employed and trained personnel will need to plan their further existence, there are also two other issues to be covered.

Firstly, even though well informed from the relevant professional body, the Association SI-TT, the Ministry for Science, Education and Sports decided not to include any mention of the need for, existence or possible financing of the Technology Transfer Offices in the proposal for the new Legislative Act on Research, Development and Innovation in 2019. Several corrections have been made to the proposed Act since then, none of them explicitly denoting the role of Technology Transfer Offices in the system.

And secondly, to allow for the creation of spinoff companies with possible financial investments from the side of the Public Research Organizations, high-level parts of legislation would need to be altered, for example the Act on Public Finances. This can only be done with strong political support and understanding of all involved stakeholders, who, to a great extent have limited understanding of the spinout/spinoff situation. The new Act on Research, Development and Innovation, proposes to overcome this obstacle by overriding the legislative background, but remains yet to be approved.

Thus, to this day, in the absence of legislative changes, there is only one option for successful and fair creation of new enterprises from the institutions of knowledge. This option is the creation of spinout companies with the ultimate requirement for the transparent accounting for the public expenditure.

5. PURPOSE OF THE TTO FINANCING

5.1 Industry relations

The goal of all of the KTT projects was and is to support the industry in Slovenia, rather than an outflow of knowledge abroad or great profit for PROs. Collaboration between PROs and SMEs in Slovenia should be strengthened.

The general process of collaboration [14] is based on several parallel processes. First the internal processes of research institutions need to provide the context and the content of possible collaboration, and with assessments of technology and market the principle decisions are taken. Then the IP rights management can commence. This phase usually lasts for more than two years in which enough time is provided to carry out the processes of finding a domestic or foreign partner for licensing, continuing R&D collaboration or to build up a team for spin-off creation.

Slovenian companies prefer contract and collaborative cooperation to buying licenses and patent rights. Also, a relatively low added value per employee and a low profit margin are not stimulating the research-industry collaboration. On the other hand, Slovenian knowledge, as high profile as it turns out to be in terms of highly cited publications per capita, is small in volume due to Slovenia's small number of inhabitants. As a consequence, the trademark of Slovenian science, IPR or R&D services is not well known abroad.

Primarily domestic, but also international R&D connections should be improved to allow for maximum development of the trademark of Slovenian science for industrial use.

5.2 Creation of new companies from PROs

Companies from PROs can be created either as spinouts (a separate legal entity, which is licensing the IPR from the PRO, but the entity is owned by the inventors) or as spinoffs (an entity owned partially by the PRO, at least in the share of the invested IPR).

The process of building a team for creation of new companies from PROs, involves team building, and education in entrepreneurship. If provided and guided, it can result in spin-off creation, VC involvement and market activities.

Issues, limiting the entrepreneurship activities, are connected to the pull-push principles of technology transfer and the conditions in the state economy. Firstly, the legislation does not allow for the Public Research Organization (with a limited option for the Universities to do so) to co-own and co-manage the newly created business. This severely limits the Organization's interest in the activity. Secondly, even if the creation of spinoffs were allowed, there is a limited capacity of business-oriented experts within the Public Research Organizations, who would be capable of monitoring and steering the spinoff company from the side of a PRO. Too rigid monitoring from the side of a PRO can ruin the spinoff's prospects for growth. Secondly, the same limitation applies for the consultancy available to the Organization, which is in addition to being inexperienced and partly professional, also costly.

The non-moderated situation with unclear options of the entrepreneurial researchers yields unregistered spinout companies of the Public research organizations. This situation is easily moderated via internal policy acts, structuring the process of company creation according to the current legislative limits. Such processes are in place at least at the JSI and UL, possibly also at other PROs in Slovenia, but not all researchers resort to take such routes.

The legislation should be adopted to allow not only for creation, but primarily for successful management of IPR as an investment in spinout companies.

5.3 Investing into IPR

Intellectual, and for the purpose of this article in particular industrial property, is of high importance for development of particular peoples, companies, countries. Indeed, the use of legally protected intellectual property for development of the country is a strategic decision that cannot be done overnight.

Patent system has many positive and less positive aspects, therefore many experts from various universities call for a reform of this system in order to realise its prime objective – "to support and encourage innovativeness".

Despite the above stated, it is important to invest in patents and other forms of intellectual property (IP). Investments in intellectual property increases licensing opportunities and the IP position of the Slovenian knowledge worldwide.

Currently IP costs can be supported within some national instruments (e.g. RRI, Eureka, some start-up funding initiatives), but mainly for companies. KTT is so far the only instrument enabling financial support for investments into IPR at the side of PROs.

Instruments that support investment - and not merely paying for intellectual property rights - should be further developed in Slovenia.

5.4 Strengthening the TTOs competences

The goal of the KTT project is to establish technology transfer centers in Slovenia as integral parts of PROs, which shall, first and foremost, strive to serve the interests of the researcher and the PRO. The TTOs shall assist the researcher throughout the entire procedure of the industry-research cooperation, by raising competences and educating, taking care of legal and administrative issues, and promote research achievements among the industry. Lastly, TTOs shall support the cooperation already established by research groups.

To achieve that goal, a further stable financing should be provided, divided into two parts: a smaller part to be devoted to further promotion activities (events, brochures etc). The majority of the financing should be devoted to actual market activities leading to capitalization of the created IPR.

It is true that a significant part of knowledge, created by the PROs, is transferred via other paths: teaching, publications, conference, STEM activities. The TTO should be involved in all of those as an information provider, when needed and appropriate.

However, the first and most important task of the TTO should be commercialization of IPR and secret knowledge, as there is no better equipped place or better educated people to do that for the benefit of the PRO and the (domestic) economy.

TTOs competences should be further developed and TTOs themselves further financially supported.

6. THE KT ACTIVITIES RESULTS: STATISTICS AND METHOD

In the following we present the results of the KT activities in Slovenia in the past decade. Metrics for collection of this data was not comparable in different periods due to different responsible bodies collecting the data and different understanding of what is actually important.

6.1 Incomparable metrics

Results on KT activities, collected during the periods of 2009-2012, 2013-14 and 2017-2019 are very diversified. One of the reasons of the diversification is the way in which the data were collected and the purpose of its collection.

For example, in the category of patents filed, data was not collected in period 2009-2012, in the period 2013-14 the number of patents filed wherever in the world was collected and in the period 2017-2019 the full report patents were sought for.

Only in the period 2009-2012 patents granted were collected and were divided between those granted in Slovenia (without full report) and elsewhere (also possible without full report, but more likely with one).

IP license and sales were collected in all three periods and R&D sales in period 2009-2012 and 2017-2019.

Number of created spinouts were collected in period 2009-2012 and 2013/2014 and not in the last period, as the Ministry for Science (somehow) concluded this was not a result of the work of the Technology Transfer Office.

Table 1: Overview results reported by the TTOs in the periods 2009-12 [15], 2013-14 [11] and 2017-2019* [16]

	Survey: 2009-2012 (36 months)	KTT: 2013/2014) (16.5 months)	KTT: 2017-2019 (24 months)
Patents filed to IPO with full report	/	/	24
Patents filed wherever	/	67	/
Patents granted in Slovenia	87	/	/
Patents granted with report (different patents in the same family count as many)	21	/	/
IP License & Sales	826.417,00 €	86.500,00 €	726.172,00 €
R&D Sales	21.296.785,00 €	/	2.723.412,00 €
Spinouts	14	6	/
Number of employed in SO companies younger than 5 years	18,4	/	/
New companies in collaboration with PROs thought TTOs	/	/	32

Number of employees in the spinouts created in the last 5 years were only collected in the period 2009-2012.

Number of new companies to be put into collaboration with the Public Research Organization was only collected in the period 2017-2019.

Numbers can be found in Table 1.

The overall results can be seen from Table 2, normalized to the length of 1 year.

Table 2: Overview results reported in the periods 2009-2012 [15], 2013-2014 [11] and 2017-2019* [16], normalized per duration of one year.

	Survey: 2009-2012	KTT: 2013/2014)	KTT: 2017-2019
Patents filed to IPO with full report	/	/	12
Patents filed wherever	/	49	/
Patents granted in Slovenia	29	/	/
Patents granted with report (different patents in the same family count as many)	7	/	/
IP License & Sales	275.472,33 €	62.909,09 €	363.086,00 €
R&D Sales	7.098.928,33 €	/	1.361.706,00 €
Spinouts	5	4	/
Number of employed in SO companies younger than 5 years	6	/	/
New companies in collaboration with PROs thought TTOs	/	/	16

6.2 The period 2009-2012

The 2009-2012 numbers were a result of a SI-TT survey [15]. Based on the collected data of the three largest Slovenian public research organizations - institutes and three universities, an analysis of the results of work in the field of technology transfer in the period 2009-2012 has been prepared.

The logic at the time was that the granted patents are of importance, not the filings. The reason for this was an active pursue of the researchers at the time to file as many patent applications at the national Patent Office, as the filing itself sufficed to gain significant extra points according to the national evaluation at the Agency for Research and Development of Slovenia.

The Association SI-TT as an association of Knowledge transfer professionals was at the time also aware of the importance of other KT categories: R&D, licensing and IPR sales contracts, spinout creation. In their survey it went into as much detail as collecting data on actual employees in these companies.

On the other hand, the numbers in this survey were not monitored or cross-checked in any way. They were self-reported by the TTOs to the SI-TT questionnaire and no proof of actual achievement of the numbers was sought for or delivered, thus their accuracy might be limited. Also, the reported data are considered to be the data about the PRO activity as a whole, not about the share of activity in which the TTO was involved.

6.3 Project results 2013-2014

The 2013-2014 numbers are a result of a reporting, done to the Ministry of Economy and Development in autumn of 2014, within the first KTT project, financed by the Ministry.

The Ministry of Economy was financing the project KTT 2013-14 with national financing. It focused on the Licensing and Sales of IPR and on spinout creation. R&D contracts were at the time considered to be less indicative for a TTO activity (and new company creation was considered to be part of the TTO activity) [11].

Some monitoring was done by the Ministry of Economy to seek proof for delivered results, so the results can be considered as partially relevant as for measuring the activity of the TTO (not the PRO as a whole).

6.4 Project results 2017-2019

The 2017-2019 numbers are a result of a reporting, done every 6 months to the Ministry of Science, Education and Sports. The results were also presented at the 12^{th} International Technology Transfer Conference [16].

The Ministry of Science sought to finance the KTT 2 project with money from the Structural fund, meaning that a local component with direct benefit for the companies of Slovenia had to be proven during the project.

The overall project goals for 5 years (until July 2022) include 40 patent applications at patent offices that perform full examination; 300,000.00 EUR of income from license agreements; 8,000,000.00 EUR income from contract and collaborative research agreements, and 40 new Slovenian companies served according to the public call [17a].

The consortium has already delivered the required results for the new companies served and the license agreements key performance indicators, and there are reasonably optimistic results achieved in the first two out of five years in terms of number of patent applications and contract and collaborative research relations (50% and 40% of the final mark achieved, respectively) [16].

The data is mainly accurate as an indication of the part of the PRO activity in which the TTO is involved (not the activity of the PRO as a whole). Also, the ministry of Science established a precise set of data and documented proofs to be submitted before confirming the results, thus they can be considered as mainly relevant.

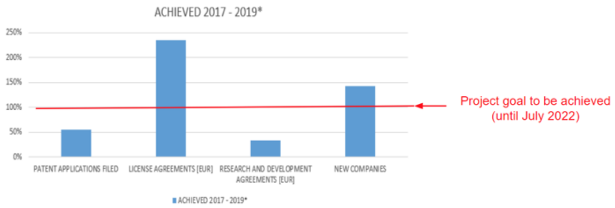

Figure 1: A comparison of 5-year goals and the 2-year performance of the KTT project.

The Ministry of Science in 2017-2019 focused on R&D contracts primarily with national legal subjects, on the new companies brought into collaboration and the national licensing deals. Spinout creation deemed to be out of the scope of the governmental support.

Nevertheless, it is possible that the majority of the reported (as requested) licensing deals are actually being done with unregistered spinout companies of the Public research organizations.

Also, since the Ministry is only monitoring the contracts and not their realization, it is not clear, how much of the reported amounts can actually be considered a PRO income (for incentive distribution).

A huge drop in R&D collaboration can be seen from the data. The KPI of both projects were predefined by the two Ministries. The difference in KPI definitions can be seen from Table 1.

To obtain comparable results in order to estimate the development of the TT profession in Slovenia, it is pertinent to use a similar metrics in every one of the time periods. However, some estimates can also be done when taking a look at the more granular level of data - how the results are distributed over the PROs in a particular year and in which particular fields.

6.5 Scientific output comparison

In an attempt to resolve the reason for the anomalies and drops in performance, an analysis of publicly available data on Research intensity and outputs was performed already in 2015, incorporating financing available to a PRO, its research staff in FTE, number of granted and valid patents (Domestic and internationally) and WoS PRO specific results.

The data was collected from yearly reports of the largest Research organizations in Slovenia: JSI, UL, UM, UP, KIS, KI, NIB and UNG, Thomson Reuters Database as of 1.10.2015, URSIL database as of 1.10.2015, ARRS webpage with financial data as of 1.10.2015, SciVal as of 1.9.2015 Web of Science as of 1.9.2015. The 8 institutions covered 79.07% of the ARRS budget at the time, meaning that 20.93% of the research institutions, financed by the ARRS were not covered by this survey. Number of students at the Universities was not considered as a relevant indicator, as the IPR generated by the students is not owned by the Universities. In addition, number of employees was also not considered, as the employments can range from a full FTE to just a few percent of work obligation, which cannot be treated equally. Also, in the category patents granted at least one university included patents granted to employees (and not the institution itself).

Results of the survey are shown in Table 3 below.

The results show a discrepancy between the amount of financing received for R&D activities from the Slovenian Agency, the number of FTE employed to perform the R&D work (teaching staff FTEs are not included) and the output in terms of number of valid and granted Slovenian patents, number of valid and granted foreign patents and number of publications. In this comparison, data on R&D contracts could not be obtained from public sources.

Table 3: 2015 Quality assessment of 8 Slovenian Research organizations made on the basis of the publicly available data.

ORGANIZATION (RO)	ARRS financing	**SHARE OF FINANCING of projects / lines from ARRS funds from 8 Ros**	number of employees of research FTE in JRO - group H as at 31.12.2013 *	**SHARE – FTE**	number of valid SLO patents as of September 1, 2015	number of granted SLO patents in the last 20 years	**SHARE FROM QUALITY - SLO patents**	number of valid foreign patents as of September 1, 2015	number of granted foreign patents in the last 20 years	**QUALITY SHARE - FOREIGN patents**	WoS publications - articles (2014, KI, UP 2013, NIB average of two quarters * 2) -no necessarily comparable source	**SHARE from QUALITY - articles**
UM	€9,796,995.78	**8.9%**	183	**8.32%**	27	65	**15.86%**	3	4	**16.67%**	550	**16.92%**
IJS	€32,035,245.37	**29.1%**	723	**32.88%**	44	122	**28.62%**	4	9	**30.95%**	808	**24.85%**
UL	€45,702,306.53	**41.5%**	830	**37.75%**	50	132	**31.38%**	3	8	**26.19%**	1230	**37.83%**
NIB	€3,950,023.57	**3.6%**	87	**3.96%**	1	5	**1.03%**	1	1	**4.76%**	118	**3.63%**
KI	€10,228,268.95	**9.3%**	192	**8.73%**	32	92	**21.38%**	3	5	**19.05%**	281	**8.64%**
KIS	€2,368,780.14	**2.2%**	50	**2.27%**	3	3	**1.03%**	0	1	**2.38%**	38	**1.17%**
UP	€4,061,256.28	**3.7%**	119	**5.41%**	0	0	**0.00%**	0	0	**0.00%**	196	**6.03%**
UNG	€1,866,639.01	**1.7%**	15	**0.67%**	1	3	**0.69%**	0	0	**0.00%**	30	**0.92%**
TOTAL	€110,009,515.63	**100.00%**	2199	**100.00%**	158	422		14	28		3251	

As the data covers 79,07% of all national research financing from the ARRS, it is indicative and helps us understand the distribution of knowledge transfer activities throughout the majority of the STEM oriented PROs in Slovenia. The discrepancies could assist us in understanding the year to year difference in performance as shown in Table 1 and Table 2. Further research should be done in this domain.

7. FURTHER DEVELOPMENT

At the general level, primarily domestic, but also international R&D connections should be improved to allow for maximum development of the trademark of Slovenian science for industrial use.

The legislation should be adopted to allow not only for creation, but primarily for successful management of IPR as an investment in spinout companies.

Instruments that support investment and not merely paying for intellectual property rights should be further developed in Slovenia.

TTOs competences should be further developed and TTOs themselves further supported.

Projects funded from the ERDF funds, such as KTT 2017-2022, often have relatively complicated reporting, which represents an administrative work load for TT managers and results in a diminished amount of financing spent from the ERDF in the project as a whole. The Ministry of Science needs to establish a coherent financing over the years, which is not project based.

In the Slovenian case, the Proof of concept fund is not established, which prevents research entrepreneurs to develop their inventions further towards the market. Continuing support of the Ministry and their collaboration with the SID bank could lead to a breakthrough in this domain. The SID bank should continue with a steep pace the creation of the fund to be established by the end of the 2021.

There is a lack of support for spinouts. Start-ups can enter easily a technology park and perform a day-to-day business; in contrast, a spinout has to carry out many internal procedures within the PRO from which it originates in order to start operations. On the other hand, the scale-up phase is well supported (for example, by the national project SIO). Spinout support should become part of the Technology and Knowledge Transfer policy in Slovenia.

The Slovenian legislature (ZIDR) provides incentives for inventors, when the invention is licensed or sold (min. 20% of gross royalty, in practice around 33% of net royalty). There is a lack of recognition for Technology Transfer (TT) managers (compared to inventors). The Ministry of Science should make sure that the incentives for TT officers should become part of the legislation governing the incentives for researchers.

Professionalization is also sought for. For example, the Council for science and technology (SZT) should follow the lead of the European Commission and involve not only researchers and industrialists, but also technology transfer professionals into their developments of the policy inputs. As such, the current SZT lacks a very important component, and that is the knowledge and experience of the man or the woman in between the worlds. The European Commission has already rectified this in the past years, where the TT experts participate very successfully in several high-level Advisory Boards and Expert groups. The Slovenian government should follow that lead.

Last but not least, technology transfer needs stable funding, as a TTO is generally not able to finance itself – apart from the rare cases where industry buys high licenses (a large license can support a TTO for up to 10 years), and this is not applicable to Slovenia with its IP reluctant SMEs with lower than average EU27 technology absorption capacity.

In case when the TTO is supported by the government, it is important that there is good cooperation between the TTO and the government (not just administrative supervision but also content guidelines for future work, content analysis, KPI definition fine tuning, including the development of a toolbox for successful technology transfer as a collection of contracts, good practices and business models.

In essence, a TTO is an important part of the innovation chain and has to be recognized as such.

8. CONCLUSIONS

This paper was written to give an overview of the history/genesis of the current Slovenian technology and knowledge transfer system, unfolding several issues that will need to be addressed in the future to make the knowledge transfer and innovation system of Slovenia to become fully operational. The mistakes made during the short, but significant history od knowkledge and technology transfer in Slovenia, mustn't be lost or else the same mistakes will be repeated. The paper thus describes the effects of having project-based funding of TT with varying scopes and focuses:

i. The lack of continuity makes it hard to keep staff and develop competences over long time;

ii. Changing focus leads to changes in direction (what you measure is what you get) and the mixture of results of the TTOs in Slovenia in the past decade nicely shows the effect of the changing policy;

iii. It becomes hard to keep track of the overall development of TT in Slovenia, which needs to be improved in order to enable quality control.

iv. Exact and exactly measurable KPI should be determined to prevent the reporting manipulation of the support system and the PROs.

v. Constructive, systematic, sustainable, inter-connected and consistent solutions should be sought for, without excluding TTOs. They are players in the field of public research organizations support.

In other countries, the political systems have tended to fund the start-up phases of TT, but they have also had an expectation that PRO's would take over responsibility with time. This has not always happened. Even if the basic funding of the TTO office is secured by the government or PRO, the missing PoC link funding often has to continue on national/regional level for many years for TT to mature. Also, Seed funding for spin-outs is also a long-term need that may require political support.

The recommendations of the paper require further thoughts on the need of priorities for government intervention. These priorities will hopefully be set by the governmental/political structures in Slovenia through the new law on scientific research and innovation activity. The law is at the moment being coordinated interdepartmentally within the Slovenian government. However, the principles and the recommendations and the priorities should then also be followed by the PROs.

Last but not least, Technology transfer is a young discipline. There should be a sensible amount of healthy competition also in Technology transfer. However, this competition should remain cordial and motivational, and avoid any destructive steps, especially if for the purpose of self-promotion.

Having created a Scientific Section to address the issues of Technology and Knowledge transfer within the 13th International Technology Transfer Conference, clearly shows the opportunity for further joint research (nationally and worldwide, and beyond mere best-practice examples) on technology and knowledge transfer from a scientific point of view, influencing the entrepreneurship potentials and setbacks of the researchers and businesses.

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Patents on plasma treatments in agriculture

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ABSTRACT

Patents in the field of plasma agriculture are analyzed in this paper. The first patent application in this technological niche appeared in 1995 and disclosed a method for seed treatment using non-equilibrium gaseous plasma. Since then, over 60 patents were filled in different countries, representing about 7% of published scientific papers in journals indexed by the Web of Science. About half of the patent applications were submitted to the Russian office, followed by Chinese, US, and Korean offices. Five or six patent applications have been submitted annually in the past few years. No Slovenian application has been registered so far.

Keywords

Plasma, agriculture, patent, search

1. INTRODUCTION

Plasma agriculture is among the most promising fields of scientific research and industrial developments. It is an interdisciplinary niche where non-equilibrium thermodynamics meets farming and food industry. There are hundreds of research groups currently involved in developing plasma techniques to treat seeds, plants, crops, storage and packaging devices, food, and feedstock. Many are academic, and they are concentrated on chemical and biological modifications caused by plasma treatment. Some groups have studied the influence of plasma treatment on germination and growth of plants. Few groups have also performed field experiments and studied the role of plasma parameters on the amount and quality of crops. Indirect treatments are popular, too. In such cases, either water for spraying or watering plants is treated by gaseous plasma or soil is treated. The influence of plasma processing on the water-soaking capacity or microbiological picture is studied.

2. PLASMA SEED PROJECT

The project is focused on the development of methods for seed treatment and lasts about 3 years. The following partners are involved in developing a device suitable for treating seeds in the continuous mode: Interkorn Ltd. (Beltinci), Department of Surface Engineering, Jožef Stefan Institute (Ljubljana), Trac Ltd. (Šentjernej), Žipo Lenart, National Laboratory of Health, Environment and Food (Maribor), and Institute of Agriculture and Forestry (Maribor). The project coordinator, Interkorn Ltd., is the largest provider of seed coatings in Slovenia. It provides processing of seeds from separation to cleaning and deposition of various coatings. Processed seeds are further distributed among farms. Quality control and ecological production are among the company's priorities. The company produces and treats seeds of corn, wheat, barley, other cereals, and soybeans. The treatment of seeds is performed on an automated line, which allows for a high quality of processing and traceability of seed batches. It has almost 100 regular customers who provide feedback about harvesting and storage. The company has specialized in treating seeds to protect them against fungi (molds), worms, and birds to enable optimal harvesting. The unique coatings are adopted for use in the west Pannonia region, which has specific climate and soil conditions and ecosystem. The company also provides services for seeds' treatment before storage to minimize the proliferation of molds, which may produce toxins that are harmful to humans and animals. The scientific coordinator is Dr. Nina Recek, a researcher of the Department of Surface Engineering at Jozef Stefan Institute. Other project partners are involved in research on plasma-seed interaction and development of different components for a prototype of the line, which will be used to treat various seeds in the continuous mode. The goal of plasma treatment is to disinfect seeds and improve water uptake and, thus, faster germination as compared to untreated seeds.

3. LITERATURE SURVEY

3.1 Scientific papers

Over 900 scientific papers have been published in journals ranked in the Web of Science. At the time of writing this document, 23 papers are highly cited in the field – received enough citations as of March/April 2020 to place them in the top 1% of their academic fields based on a highly cited threshold for the field and publication year. One paper is labeled as "hot paper" – such papers were published in the past two years and received enough citations in March/April 2020 to place them in the top 0.1% of papers in its academic fields. The majority of these papers deal with scientific aspects, but some also report experiments in the fields. The number of papers rewarded with "highly cited in the field" for the past decade is presented in Figure 1.

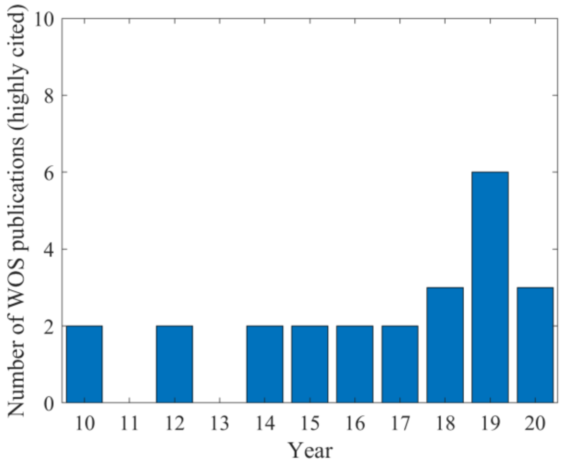

Figure 1: Number of highly cited papers in the field published in the last decade.

The number of scientific papers published in journals indexed by the Web of Science for the past decade is plotted in Figure 2. One can observe a graduate increase in the published papers. The number of papers published per year has tripled in the last decade, which indicates the scientific importance of the interdisciplinary field of plasma agriculture.

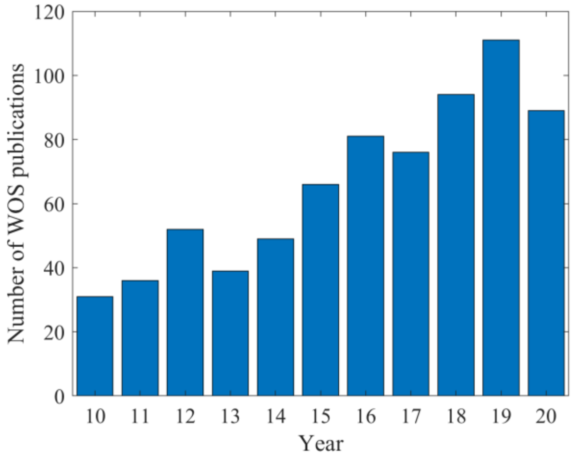

Figure 2: Number of scientific papers published in the past ten years in plasma agriculture.

3.2 Patent applications

While the number of scientific papers indicates the scientific importance of the subject, technological importance is revealed from the patents applied at various patent offices worldwide. The first patent in the field of plasma agriculture indexed in the ecpacenet database has the priority date 1995-07-05 [1]. The patent by Filippov, Bitjutskij, and Fedorov discloses a method for pre-sowing seed treatment. The method provides plasma treatment of seeds with low discharge intensity and pressure of inorganic gas, resulting in increased nutritive value of products and reduced power consumption. Since this pioneering work, numerous patents have appeared. Figure 3 represents the number of patents filed per year. The number is slowly increasing. By the time of writing this paper, as many as 67 patent applications appeared in the database. One of the last applications was also Russian [2]. Disclosed is a method for grain disinfection, which involves exposure of the treated grain to a stream of cold plasma at atmospheric pressure. Cold plasma flow is generated due to negative corona discharge between anode and cathode with pulsed voltage in air. Grains with the moisture content of 7-14% are placed on the anode surface and treated for 10 minutes. According to the authors [2], the invention provides a stable disinfecting effect when processing grain (for food and sowing) intended for storage.

Russian inventors are particularly active in filing patent applications in the field of plasma agriculture. Figure 4 reveals the number of patent applications submitted to patent offices in different countries. The Russian office received as many as 33 applications. Next on the graph is the Chinese office with 20 applications, followed by the US office (6 applications) and the Korean patent office (3 applications). Other patent offices received only one application each.

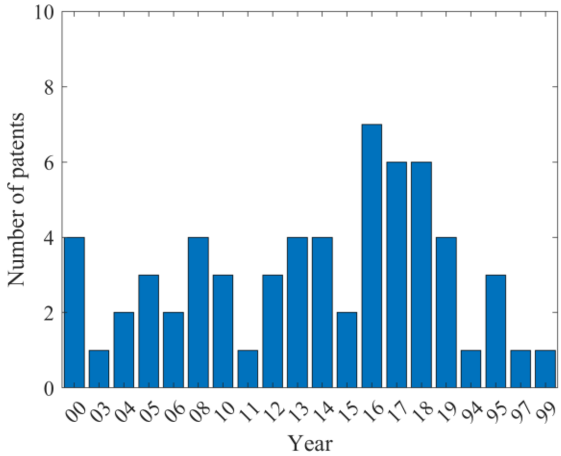

Figure 3: Number of patent applications registered in the Espacenet database.

Of particular importance are patents on the indirect treatment of seeds, usually treating a liquid by gaseous plasma and then soaking seeds in plasma-treated liquid. For example, RU2702594 (C1) [3] discloses a method of activating water or aqueous solutions. The method involves exposing a particular volume of treated water or aqueous solutions to plasma. Contactless activation is carried out. Water or aqueous solutions are exposed to a continuous electrodeless plasma flame created by a UHF-plasmatron, which generates a low-temperature plasma jet in a vapor-gas medium at atmospheric pressure. Device for contactless plasma activation of water or aqueous solutions contains a flame UHF-plasmatron with a capacitive coupling, which includes a magnetron and rectangular as well as coaxial waveguides. The coaxial waveguide is hermetically isolated from the rectangular waveguide by a radio-transparent quartz tube-insulator. The central conductor of the coaxial waveguide is a copper tube configured to supply plasma-forming gas and ends with a nozzle with a hole to form a directed jet of plasma-forming gas. The working part of flame UHF-plasmatron is placed through the seal into a sealed chamber containing a vessel with treated water or water solution fixed on a rod-elevator. The invention provides contactless plasma activation of water or aqueous solutions, enables the exclusion ingress of electrode material into the activated liquid, and provides a high degree of purity of treatment and safety.

A similar device useful not only for water treatment is disclosed by Hummel et al. in the patent application submitted to the US Patent Office [4]. Here, methods and systems for generating a plasma-activated liquid or gas and applying the plasma-activated liquid for agricultural use are disclosed. A system embodiment includes a hand-held device that can be pointed and directed at different target areas of a plant. A method embodiment includes generating a plasma discharge in a gas environment or a liquid environment and applying the gas or liquid to a plant.

Another method for plasma treatment of water is disclosed by Rothschild [5]. The invention generally concerns a machine that creates and infuses charged air products into a flowing water system. A plasma discharge is not in direct contact with the flowing water but is separated from the plasma by a void volume space. The resulting activated water may be used as an industrial wash, antibacterial wash, a medicinal drink, or can be used in agriculture, e.g., for irrigation of crops, plants, or seed treatment.

Nevertheless, another method for the treatment of liquids by gaseous plasma is disclosed by Chieh [6]. An agriculture plasma liquid apparatus includes an inlet pipe, an outlet pipe, an air inlet port, and a plasma liquid generating device. The diameter of the inlet and outlet pipes is rather large. The plasma liquid generating device is connected to the air inlet port to suck air from the air inlet port, communicates with the inlet pipe and the outlet pipe to import liquid flow from the inlet pipe and generate plasma particles into the liquid flow outputting through the output pipe. This solution is useful since many bubbles are formed within the innovative device, so the contact area between gaseous plasma and liquid is large compared to standard solutions.

A more powerful device for the treatment of water with gaseous plasma is disclosed by Lu et al. [7]. The utility model discloses a high-temperature thermal conductance water plasma generation system. Its structure includes high-temperature thermal conductance water plasma generator group, waterway system, and thermal energy system. The central part of the high-temperature thermal conductance water plasma generator is a high-temperature heat pipe, including an inner tube and urceolus. The high-temperature heat transfer medium is mounted between the inner tube and the urceolus at the bottom. The waterway system constitutes a water tank, filter, high-pressure unfamiliar water pump, solenoid valve, and hot water tank. The thermal energy system includes an oil tank, a high-pressure oil pump, an oil flow control valve, a fuel nozzle, and an electronic ignition wire that gradually connects. The high-temperature thermal conductance water plasma generation system causes water decomposition, so the water is transformed into a gaseous plasma rich in hydrogen and oxygen. The device is very efficient. According to inventors, more than 90% of water passing the device is converted. This device can extensively be used for engines, industry and civil boilers, agriculture, chemical industry, and even medicine, as claimed by the authors.

Rocke and Wandell disclose a simultaneous on-site production of hydrogen peroxide and nitrogen oxides from air and water in a low power flowing liquid film plasma discharge for use in agriculture [8]. A reactor system that includes a single reactor or a plurality of parallel reactors is disclosed. A method that includes: injecting a mixture including liquid water and gas into at least one electrically-conductive inlet capillary tube of a continuously flowing plasma reactor to generate a flowing liquid film region on one or more internal walls of the continuously flowing plasma reactor with a gas stream flowing through the flowing liquid film region, propagating a plasma discharge along the flowing liquid film region from at least one electrically conductive inlet capillary to an electrically conductive outlet capillary tube at an opposite end of the continuously flowing plasma reactor, dissociating the liquid water in the plasma discharge to form a plurality of dissociation products, producing hydrogen peroxide and nitrogen oxides from the plurality of dissociation products. Both nitrogen oxides and hydrogen peroxide are useful for the sterilization of agricultural products in an ecologically benign manner.

Go and Lim [9] presented an invention related to a plasma generator for agriculture and stockbreeding. The plasma generator comprises a pair of main bodies, disposed of in an upper portion and a lower portion with a predetermined gap between, a plurality of electrode rods, installed in a direction perpendicular to the pair of main bodies and evenly spaced, an electrode plate installed in a direction perpendicular to the pair of main bodies installed behind the plurality of electrode rods with a predetermined gap between, an electrode sheet disposed on the electrode plate spaced apart from the plurality of electrode rods with a predetermined gap between, configured to generate plasma due to a reaction between a plurality of electrode rods and current, and an insulating plate interposed between the electrode sheet and an electrode terminal provided on the electrode plate to prevent moisture from being introduced into the electrode terminal. The plasma generator produces reactive gaseous species and radiation in the ultraviolet and vacuum ultraviolet range of wavelengths, which was found beneficial for sterilization or at least disinfection of different products.

Lee [10] invented a technique for sterilization of water using gaseous plasma technology. The invention relates to a water sterilization device for agriculture and fishery having a variable plasma device that reduces the costs of production by simplifying an existing plasma generating device. It also raises the productivity of agriculture and fishery and enables the use of seawater and freshwater for agriculture and fishery by properly sterilizing harmful bacteria existing in the seawater and freshwater by controlling the quantity of plasma through frequency variability. The water sterilization device for agriculture and fishery having a variable plasma device according to the present invention comprises a power supply device for supplying power necessary for the device, a water pump for receiving power from the power supply device and introducing water, a variable plasma generating device for sterilizing water being introduced from the water pump by generating plasma and controlling the strength of generated plasma by controlling the frequency of power supplied, a first connection pipe having one side intercommunicating with the water pump and the other side intercommunicating with the variable plasma generating device, a sterilized water storage tank for storing water sterilized and discharged by the variable plasma generating device, a second connection pipe having one side intercommunicating with the variable plasma generating device and the other side intercommunicating with the sterilized water storage tank, a pollutant and foam discharge device installed on the top of the sterilized water storage tank to discharge foam and ozone, and a sterilized water discharge hole installed on the bottom of the sterilized water storage tank to discharge sterilized water in the sterilized water storage tank.

Liu et al. disclosed a method for improving the germination of Stevia rebaudiana seeds. The method relates to a crop seed treatment technique in the technical field of agriculture. The method comprises the following steps: selecting and sterilizing seeds, preparing 6 to 8% aqueous solution of polyethylene glycol, soaking seeds into the prepared solution at the temperature between 20 and 30 °C for 24 to 48 hours, then filtering seeds, cleaning seeds by using clear water, and airing seeds for later sowing. It is generally recognized that molecules of the polyethylene glycol can change biological membrane structures of various cells in cell engineering, in a way that lipid molecules on a plasma membrane at a contact point of two cells are dispersed and recombined. These molecules can also change the osmotic regulation capability of plants, influence on plant physiology and are favorable for absorbing nutrition and inducing the activity of stimulation cells. The method can remarkably improve the capability of resisting adverse situations when the Stevia rebaudiana seeds are germinated so that these seeds still maintain a higher germination rate and germination energy in adverse situations.

As early as in 2007, Russian inventors disclosed a technique for treating fruit [12]. The processing and storage of fresh-cut vegetables, berries, fruits in agriculture, food-processing, and related branches of industry is disclosed. The method involves washing fruit and vegetable products with water preliminarily activated in one or two electrode chambers of one or more diaphragm-type electrolysis units. Further removing water remained on the surface of products after the washing process by blowing with the use of gaseous plasma flow until complete removal of water is achieved. Plasma is produced in a medium of inorganic gas or a mixture of inorganic gases at a frequency of electromagnetic field of 4-40 MHz and at specific electromagnetic power of plasma discharge. Apparatus has at least one washing chamber, one drying chamber, one or more transportation mechanisms, one or more diaphragm-type electrolysis units with power sources, a plasma source with two electrodes, a plasma guide, a high-frequency generator, one or more reservoirs for inorganic gas, and vacuum oil-free pump. The effect of this method is prolonged shelf life of fruit and vegetable products.

The search for patents, as presented in this document, indicates that both direct and indirect plasma treatment result in a good finish of agricultural products. The indirect plasma treatment has a definitive advantage that treated material is preserved since the products are exposed to radicals only (not to powerful gaseous discharges). On the other hand, direct plasma treatment is faster since the concentration of reactive species within the plasma is, by definition, more substantial than in any medium treated by plasma. The users can choose between these two extremes or use a combination of direct and indirect treatment. In such a case, the liquid can be treated with a powerful discharge, while products are exposed to mild plasma conditions.

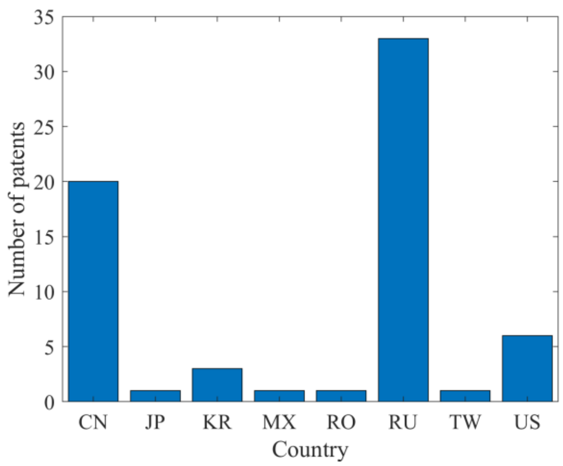

Figure 4: Number of patent applications registered in different countries.

4. CONCLUSIONS

Several innovative techniques have been protected with patent applications in the interdisciplinary field of plasma agriculture. The most innovative countries are China and Russia. The patent applications span from direct treatment of seeds, plants, or crops to indirect treatments using gaseous plasma to modify the chemical properties of liquids. Several techniques are applicable on a large scale, but the beneficial results in terms of improved germination, growth, or better quality or quantity of crops are rarely reported. Plasma agriculture, therefore, remains a technological challenge. Although the scientific literature reports better germination of seeds treated by gaseous plasma either directly or indirectly, the descriptions of patented solutions lack of quantitative reports. In most cases, patent literature does not mention any field experiments, so it is not easy to judge direct applicability. Another deficiency of patent literature is the lack of details about the exact treatment parameters. The patents disclose types of discharges used for plasma generation but hardly mention the useful range of discharge parameters.

5. ACKNOWLEDGMENTS

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Rare earth-based permanent magnets: A proposed way to the circular economy

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ABSTRACT

Critical raw materials, especially the rare earth metals like Dy, Nd, Sm, and recently also the transition metal Co are becoming more and more important to Europe's future energy independence, and offer the ability to be competitive in smart mobility and renewable energy innovation. The primary goal of the efforts from the Department for nanostructured materials from Jožef Stefan is to implement the state-of-the-art laboratory-developed & economically efficient technologies for the recycling and reprocessing of critical metals from end-of-life products. The aim is to integrate them into industrially relevant processes in order to reduce Slovenia and Europe's dependence on economically and strategically sensitive supplies and to increase their competitiveness on international markets.

This article depicts a strategic issue of the European Union in the field of technology transfer, which should benefit the research community and the economy. However, this issue is not being addressed at the proper level: the scientists and industry are working to solve the technical problems, but are not supported sufficiently on the political level.

Keywords

Critical raw materials, rare earth elements, permanent magnets, Nd-Fe-B, Sm-Co

POVZETEK

Kritične surovine, zlasti redke zemeljske kovine, kot so Dy Nd, Sm in v zadnjem času tudi prehodna kovina Co, postajajo vse pomembnejše za prihodnjo evropsko energetsko neodvisnost in ponujajo sposobnost konkurenčnosti na področju pametne mobilnosti in inovacij iz obnovljivih virov energije.

Primarni cilj prizadevanj Oddelka za nanostrukturne materiale Jožefa Stefana je uvajanje najsodobnejših laboratorijsko razvitih in ekonomsko učinkovitih tehnologij za recikliranje in predelavo kritičnih kovin iz izrabljenih izdelkov. Cilj je vključiti jih v industrijsko pomembne procese, da bi zmanjšali odvisnost Slovenije in Evrope od ekonomsko in strateško občutljivih zalog ter povečali njihovo konkurenčnost na mednarodnih trgih.

Članek prikazuje strateško vprašanje Evropske unije na področju prenosa tehnologije, ki bi moralo biti v korist raziskovalni skupnosti in gospodarstvu. Vendar se to vprašanje ne obravnava na ustrezni ravni: znanstveniki si skupaj z industrijo prizadevajo rešiti tehnične težave, vendar na politični ravni še niso dovolj podprti.

Ključne besede

Kritične surovine, redkozemeljski elementi, trajni magneti, Nd-Fe-B, Sm-Co

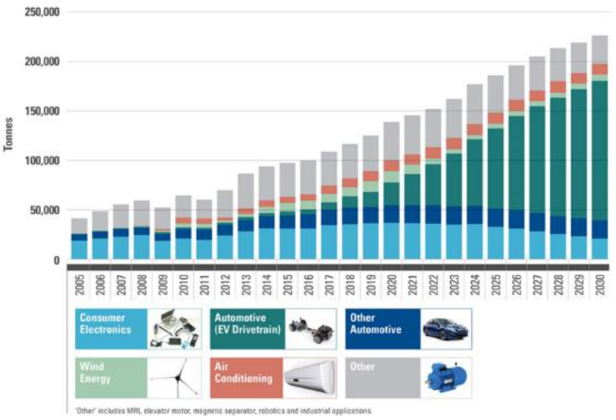
1. INTRODUCTION

EU plans for the transition to a low-carbon society and energy efficiency by 2050 (the so-called European Green Deal) [1] will require radical solutions, especially with the aim of reducing greenhouse gas emissions, which are projected to reduce by as much as 80%. The segments that will contribute the most are the development of green energy and electric mobility. The latter will require highly efficient electric motors to achieve this goal. The efficiencies of electric motors (mass versus efficiencies) based on permanent metal magnets of rare earth elements (such as $Nd_2Fe_{14}B$ and $SmCo_5$, Sm_2Co_{17}) both sintered and bonded are known to be higher than induction motors, which contributes mainly in terms of miniaturization of devices with preserved or even improved efficiencies. From this point of view, permanent magnets are a hot subject to further research with the aim of improving their state-of-the-art properties. However, rare earth metals based on rare earth metals are on the list of the most Critical Raw Materials (CRM) important for the EU, which will require their comprehensive treatment in the form of their complete use without and waste and their efficient recycling of both systems using novel recycling processes that are being developed on the department.

2. CRITICAL RAW MATERIALS

2.1 EUs dependency on critical raw materials and their applications in permanent magnets

One of the major problems EU has been facing since 2011 is ensuring a sustainable access to Critical Raw Materials [2], in particular elements of the lanthanide group, i.e. rare earths. The group understands 15 + 2 elements, the most characteristic and useful of which are permanent magnets: Neodymium, Samarium, Dysprosium and Terbium with lately also Co, that is a transition metal. A key factor influencing that is their natural abundance and related production in only a few countries, such as China, Brazil, Russia, Australia and the Democratic Republic of Congo. Limited access and the political manipulations concerning the CRM issues are attributed to the way some of these countries use trade and tax policies to reserve their natural resources exclusively for their own use. China for the moment controls as much as 84% of the world's rare earth mineral production. Although the trade restrictions that have peaked in 2011 have declined at the moment, fear of a new material crisis still persists.



A Figure 1: Current consumptions of Nd-Fe-B PMs by application and future predictions [3]

A key component of the Europe Green Deal is to accelerate the "transition to sustainable and smart mobility", as transport accounts for a quarter of CO_2 emissions. That is why the electrification of the transport system is receiving large investments and research at the global level. Company Tesla, as the first mass producer of electric vehicles alone, is increasing production to 500,000 vehicles by the end of 2020 and with the expansion of its production plant in Shanghai and the opening of a new one in Berlin in the coming years reached as many as one million new e-vehicles on the market. Also, other major car manufacturers such as Toyota, Honda, Kia, Renault e.g. invest significantly in development and e-production. Volkswagen alone is expected to produce as many as 1.5 million e-vehicles by 2025. In 2011, the EU gave priority to rare earths as the most critical CRMs, but in the years since, it has focused mainly on permanent magnets made out of them based on two alloy systems, namely neodymium-iron-boron (Nd-Fe-B) and samarium-cobalt (Sm-Co). The latter systems are given the highest priority, as they are crucial in e-vehicles in their drive motors, servo controllers, starting motors and regenerative brake generators. The projected consumption and use of permanent magnets based on Nd-Fe-B and Sm-Co is shown in Figure 1. Today, the industry consumes 50,000 tons of these magnets for powertrains in e-vehicles, and consumption is expected to grow to 150,000 tons in the next 10 years. Here, the EU is in a difficult position, as it has no active rare earth mines, so it has to import up to 90% of rare earth-based permanent magnets, while European producers of permanent magnets can be counted on the fingers of one hand. Here, Slovenia is strongly represented by two manufacturers of permanent magnets, namely Magneti Ljubljana d.d. and Kolektor Group d.d., which have managed to maintain a competitive advantage to this day, that gives Slovenia and enormous potential and advantage.

2.2 Novel solutions in Rare earths-based permanent magnets circular economy

2.2.1 The state of the art of the technology

From SICIRS it is evident that, diverse methodologies for recycling Nd-Fe-B magnets have been summarized in detail by many authors [4,5,6]. The recycling approaches can be broadly classified into physical/mechanical processing, pyrometallurgical and hydrometallurgical separation & recovery. Physical/mechanical processing, including resintering [7,8], hydrogenation disproportionation desorption and recombination [9-11], of sintered Nd-Fe-B magnet scrap will typically have a smaller environmental footprint compared to recycling routes, which rely on stripping of the REEs. The pyrometallurgical routes can be used to remelt the REE alloys and extract the different REE in the form of oxide, halide, fluoride or other metallic compound which can then be reduced to metallic form [12-17]. However, these pyrometallurgical processes operate at a temperature of around 750–950 °C and are thus energy intensive. Hydrometallurgical recycling processes designed for Nd-Fe-B magnets are promising due to the mild operating temperature, relatively simple equipment and the continuous separation ability [18, 19]. In hydrometallurgical processes, however, Nd-Fe-B magnets are completely dissolved with an acid. The roasting pretreatment at 900 °C is generally required. Iron, which is the major component of Nd-Fe-B magnets (60–70%) consumes large amount of acid, alkali and other precipitation agents that cannot be recycled in the whole process [5, 19]. REEs are concentrated by solvent extraction and then are precipitated with either oxalic or carbonic acid. The precipitate is further calcined at 950 °C to form REOs, which can then be returned to the initial manufacturing process for Nd-Fe-B magnets [20]. We also reviewed the patent documents using the queries below, from Patbase document system. Results were the following: The most populated field is the one including (($Nd_2Fe_{14}B$ or NdFeB or Nd-Fe-B) as earth particulate material)) in the title or abstract AND FT=(grain boundary*) anywhere in the text. This yielded 97 patent families. On the other hand, using earth particulate material)). Yielded some less, 74 families. On the other hand the search showed that ((Nd2Fe14B or NdFeB or Nd-Fe-B) and single crystal anodic etching is a rather unpopulated field with 0 patent families present at the moment and that our technology is not only operational, but worth exploring in the sense of novelty.

In the proposed method the $Nd_2Fe_{14}B$ grains are recovered by electrochemical etching of the bulk sintered Nd-Fe-B magnets or magnet scraps using an anodic oxidation process presented in Fig. 2 [21,22]. In this process the metallic Nd-rich phase in the grain boundaries is oxidized to Nd^{3+} as ions on the anode. The liquid electrolyte used in this process is formed of a non-aqueous solvent in order to prevent the $Nd_2Fe_{14}B$ grains from oxidation. This allows direct reuse of the collected $Nd_2Fe_{14}B$ grains for new magnet making.

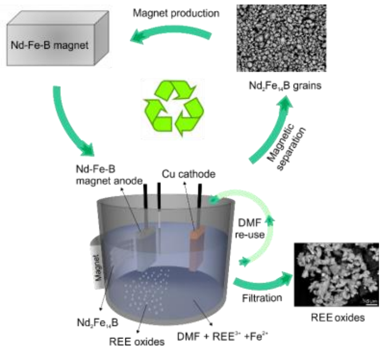


Figure 2: Selective electrochemical etching for recycling of Nd-Fe-B permanent magnets

2.2.2 The economics of the recycling

One of the purposes of the paper is show that although the magnets are needed in Europe, the fact that the rare-earth elements come mostly come from outside Europe presents an intriguing moment in the development of the technology transfer processes in Europe, in line with the recycling recommendations.

The economics of the process of recycling in the field of the rare earth magnet shows that investing into some local technology that would enable extraction from recycled components would benefit the environment and the countries of the EU that do not poses rare earth material sources. However, also such advanced recycling would still carry costs that result in ‘virgin materials’ being cheaper. Thus, considering the economics of the processes and the recommendations of the EU, we must conclude that the changes into a sustainable economy will remain impossible without legislative changes within the EU that are crucially needed to encourage this activity and contribute to the circular economy.

Thus, as a result of our research, we would like to propose some concrete measures to improve the position of the recycling processes of the rare earth metal components in the EU.

A novel recycling route for end of life (EoL) Nd–Fe–B magnets is thus proposed based on the electrochemical etching. Electrolyte can be recovered by distillation and re-used in a closed-loop thus minimizing safety risks and environmental impacts. Upon that the overall REEs mass balance from the initial magnet is 100% preserved that forms a circular economy. The total energy consumption of the magnet-manufacturing process using the proposed electrochemical recycling route is estimated to be ~2.99 kWh kg–1, which is much lower than hydrometalurgy (30.0-33.4 kWh/kg) and directly comparable to direct reuse (3.0 kWh/kg) [8], if we consider the conventional additive of the Nd–Pr hydride (4 wt.%), inclining to as feasible possible production, albeit very green and sustainable. We have shown that recycling process costs are actually a barrier in enlarging the usage of such processes industrially in the EU. Thus we propose a more targeted intervention that would tip the balance towards the recycling processes not only in regard to the rare earth materials, but all that are not applicable in significant enough amounts to be economically viable. The situation could greatly be improved if the EU could import the relevant waste from other regions of the world, which would enable cost reductions of the processes, based on the quantity. On the other hand, the EU could even – maybe – become self-sufficient in the supply of the rare earth materials. This is also a policy that would provide a significant and a wide-ranging impact in other European recycling technologies, dealing with economically negligible amounts of waste that do not prove economically sustainable for recycling.

2.2.3 The solutions to be used for sustainability

Persistent measures to achieve greater sustainability and independence from external suppliers, thus include, among other things, the recycling of industrial wastes and end-of-life products. Permanent magnets based on Nd-Fe-B and Sm-Co systems (as Co, as it is similar to rare earths subjected to major political and economic manipulations) due to the high content of these metals represent the most valuable secondary source of these raw materials. Currently, less than 1% of all rare earths used are recycled, mainly because they are dispersed in many applications, and are difficult to extract. A lot of labor force is therefore needed and the economic calculation does simply not add up.

Currently, the only way to recycle rare earth-based permanent magnets from waste streams of electrical and electronic equipment is by crushing and recycling using physical, chemical or pyrometallurgical pathways, which are costly, energy consuming and environmentally unfriendly. Upon that the developed novel feasible and green solutions for recycling REEs-based permanent magnets are of tremendous impact. The proposed technology for selective PMs leaching [22] and a related technology (EP 019 197 716.4) for complete electrochemical PMs leaching and REE recovery are in the patent procedure at EU Patent office. Efforts are also being made towards permanent magnets circular economy also on the national (ARRS L2-9213, L2-1829) with Magneti Ljubljana Ltd and Kolektor Group Ltd and international level via several European projects that encompasses the mentioned industrial partners in Slovenia and all over EU (ETN-DEMETER, H2020 SUSMAGPRO, ERA MIN II MAXYCLE, EIT RAW MATERIALS INSPIRES). Within H2020 proposal SUSMAGPRO TRLs of 7-9 are aimed via three pilot plants for recycling of EoL permanent magnets that are planned in Europe. Recently we got awarded the EIT RAW MATERIALS proposal on recycling REEs-based permanent magnets from white goods, where we collaborate also and also with Slovenian companies Domel Ltd, Gorenje Ltd, Surovina Ltd and Zeos Ltd.

3. CONCLUSIONS

Despite success stories, the challenge still persists when transferring the technologies form lab scale to functioning production lines, as the requests from the industry are strictly connected with the economic feasibility.

However, the proof of concept of the novel technology is shown on the lab scale reaching TRLs 3-4 and represents only an initiation that a technology could be feasible. Upon that much more investments would have to be made for “technology transfer” projects, to bridge the exact TRL gap between 5-7 like SUSAGPRO. In order for EU to become CO_2 zero efficient in to compete with the far East when it comes to be CRMs independent, the investments in the whole value chain on recycling of PMs have to be made. Slovenia for example has an extreme potential to act as a role model or as a feasible permanent magnet circular economy closed loop example, as it holds a geographical, professional and economical potential as to serve as a central location for the collection of waste magnets and their remanufacturing based on rare earths from the central and eastern parts of the European Union. The later has been recently successfully recognized by the EIT RAW materials scheme via funded INSPIRES project. The use of local suppliers would significantly reduce carbon emissions and it is expected that in a few years Slovenia could produce 10 to 40 tons of Nd-Fe-B alloy magnets per year on the basis of recycling within the European SUSMAGPRO project. And the successful model could be later applied in different EU countries, using the recourse from EoL wind mills for example (like Scandinavian countries). However, this is not going to be possible without legislative changes within the EU that are crucially needed to encourage this activity and contribute to the circular economy, not to forget the most important thing the stimulations from the local governments and European Investment Bank.

This would strongly encourage local productions of rare earth secondary minerals and permanent magnets. Otherwise, the European rare earth industries i.e. permanent magnets will remain exposed to fluctuations in open market prices, making them very vulnerable and consequently uncompetitive.

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Real-time fluorescence lifetime acquisition system

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ABSTRACT
We have developed a novel method for measuring the fluorescence lifetime instead of or in addition to its intensity. We demonstrated an acquisition system that is extremely fast, compact and significantly less expensive than current approaches. We are seeking for partners among optical instrumentation manufacturers for licensing and technical cooperation agreements.

This article covers the analysis of technology transfer processes in correlation with expectations of newly developing biotech market. It concludes that technologies scaling project synergies and outreach are of crucial importance for the development of the technology for market purposes.

Keywords
Fluorescence lifetime; silicon photomultiplier; waveform sampling; knowledge transfer; innovation; patent search; role of market analysis, technology commercialization.

1. INTRODUCTION
This paper describes the application of high-energy physics technology for real-life applications. This is an area, which has always been considered to have a large potential, but too little has been realized. In particular in the detector area estimates show that there could be numerous unused technologies.

Based on the mature technology developed for high-energy physics, we developed a technology that targets primarily at medical, biomedical, biotechnology and pharmaceutical fields, all of which experience significant market growth in the current time period, in particular in the past ten years. The application areas include a detection of the presence of certain organic compounds, measurements of the properties of samples or tissue through the concentration of certain organic compounds, non-invasive determination of the chemical environment in the sample and non-invasive medical diagnostics and guided surgery.

In this article we will first touch upon the promising market capitalization. We will describe the technology at hand into more details, including the benefits, arising from it, the state-of-the-art and the technology scaling. Secondly, we will touch upon the patent databases searches which assisted us in estimating the technology potential, commercialization and IP protection strategy. Lastly, we will touch upon further technology development and market development plans.

1.1 Market evaluation
In the last several years, global market of fluorescence lifetime imaging microscopy developed smoothly, with an average growth rate of 4%. In 2016, global revenue of fluorescence lifetime (FL) imaging microscopy was nearly 155 MUSD; the actual production was about 545 units.

The major players in global Fluorescence Lifetime Imaging Microscopy market include Leica, Olympus, Zeiss, Becker & Hickl, HORIBA, PicoQuant, Bruker, Nikon, Lambert and Jenlab.

We expect this technology to enter the biotech market, which alone (but not limited to the FL imaging microscopy) is expected to hit 727b USD in 2025 [5], providing tangible benefits for society. Many emerging applications require sensors with a wide field of view, good spatial resolution and very fast acquisition times - a parameter envelope not yet reached by present research.

Our goals are to develop a device that uses a wide field illuminator (diffused laser) and a wide field detector, using a single laser pulse, capable of continuous sub millisecond frame rates. Global Fluorescence-Lifetime Imaging Microscopy market is projected to reach $ 1.8 Billion by 2020, with a GAGR of 4% from 2016, and Asia will have a big dynamic momentum on the market growth.

2. TECHNOLOGY DESCRIPTION
2.1 Background
Fluorescence is the emission of light by certain substances (fluorophores) after they are illuminated with light of specific excitation wavelengths. Measurements of the fluorescent light emitted by various samples are used in a very wide range of applications, such as imaging of cell structures, tracking of antibodies and DNA sequencing in biology, detection of cancer cells in medicine and quality control in pharmacy. Besides intensity, the fluorescence lifetime (FL) can also be measured, as pioneered in application of fluorescence lifetime imaging microscopy (FLIM). This has many advantages over the base method, such as independence from fluorophore concentration, reduced damage to the sample (photobleaching) and ability to measure properties of the microenvironment in which the fluorophore is located (pH, oxygenation…).

Currently, FL measurements require sophisticated and expensive instrumentation. Typically, the fluorescence lifetime is determined with time correlated single photon counting (TCSPC) method, which is intrinsically slow. Mature technological developments in the field of high energy physics (HEP) enable direct waveform sampling technology as important and a very cost-effective tool for fast FL applications. By measuring the photodetector signal resulting from complete fluorescence response, FL can be estimated even from a single excitation pulse.

Real-time Fluorescence Lifetime Acquisition System (RfLAS) was assembled from low cost, commercially available components in order to demonstrate the feasibility of such approach. Calibrated FL standards with lifetimes in the range of 2 ns – 9 ns were used to test RfLAS accuracy and performance for different levels of available fluorescence light intensity and photodetector configurations. Using our prototype, we show that FL of all three fluorescence standards could be measured with an accuracy better than 10% from only a single pulse of excitation light, which improves below 1% level by averaging over only a few tens of pulses. Therefore, RfLAS demonstrates that FL can be acquired practically in real-time for a much lower price point than current state of the art.

The three critical components – the photodetector, waveform sampler and data processing algorithms – lend themselves perfectly for implementation in a single chip. These are also areas of expertise of the authors, and the institutes they are affiliated with. The envisioned integrated detector would push the performance and robustness beyond the present state, and more importantly, using CMOS technology at scale, would collapse the price per unit, opening possibilities to use FL obtained information in much wider areas as currently available.

2.2 State of the art

In TCSPC method, FL is determined from a histogram of measured time delays between excitation pulses and individual fluorescence photons, resulting from said excitations. If more than one photon is detected per pulse, the accuracy is degraded (pile-up effect), so the fluorescence signal has to be at a single photon level. The excitation pulse has to be repeated many times in order to obtain sufficient time delay histogram statistics, leading to long acquisition times and possible photo bleaching of the sample.

The acquisition times are even longer if imaging is required. In this case, laser excitation is scanned over the sample, and sufficient TCSPC statistics have to be accumulated for each scan position (image pixel). Alternative imaging approach is possible with single photon avalanche diode (SPAD) arrays, recently developed specifically for FL application with time-to-digital converters (TDC) implemented on a single chip. These devices have an intrinsic limiting factor, the sensitive area is somewhere between 1% and 20 % [1] as most of the space is used for electronics, and prototypes have a relatively small pixel count.

FL is also measured using frequency-domain technique, where it is derived from phase shift between modulated excitation illumination and resulting modulation in fluorescence signal, and gated detection, where FL is estimated from ratios of fluorescence signal at specific time gates.

Currently, FL measurements require sophisticated and expensive setups, and certain time to reconstruct the FL. In case of imaging, a few frames per second can be achieved at best for sufficient image resolutions [2].

2.3 Technology scaling

In our development plan, we will first build from the selected off the shelf components, a highly integrated multi-channel version of the device. It will be fully decoupled from laboratory equipment; therefore, it can be lent or sold to early adopters. These are crucial for us, we need early feedback, dissemination, and to validate and demonstrate the device in a real operational environment. An extremely important aspect is also presence on the market. Having a community of users, and a device that can be demonstrated in real operating environments will create the foundation for the third step.

Secondly, having built up the necessary experience, and deep understanding of the system, we will make an integrated scalable sensor, the real breakthrough in FL high speed imaging. The sensor will integrate efficiency optimized SiPMs, bump bonded to the electronics wafer, which could be produced in different technologies, with different performances, for different applications.

Taking in consideration mass production, these sensors can be made at a very competitive price. CMOS technology is also very affordable at scale, has a known roadmap and is very well supported. These factors provide a secure path to aggregate scalable solutions.

2.4 Project synergies and outreach

During the initial phases of the technology development, we were searching for cooperation with potential users and partners, focused on fast FL acquisition. We will be able to quickly form a consortium capable of advancing RfLAS. Laying the foundation in the dissemination program, we should build quickly a community of users to provide application test cases and feedback, and most importantly increment to TRL 5-7.

For additional dissemination, we intend to leverage one of the strong points of our technology, its simplicity. We will take an abundant amount of knowledge gained and develop an open source, open hardware, single channel FL acquisition toolkit, composed of hardware solutions based on off the shelf components, data acquisition software and library of end-user experience. The feedback and exposure will directly benefit the project, and increase the speed of development.

2.5 Technology application and demonstration cases

Measurement of FL is a still growing field of research with many applications not realized. A technique, improved in acquisition speed, and even more importantly, lower entry cost, has the potential to advance many fields of science and open new industrial applications. We have discussed concrete applications with potential users, including a pharmaceutical production company, high tech company developing monitoring and metrology technology for food industry and national health institute.

With just this batch of early adopters, RfLAS would improve development and monitoring of biopharmaceutical production. This includes an increase of the quality of food available to consumer and reduction of wasted food by measuring the ripeness of fruits and detecting presence of bacteria on food products; advance the accuracy and speed of diagnostics of histological samples; and contribute to a wide range of material science research.

3. ANALYSIS OF MARKET OPTIONS

3.1 Technology assessment

Supported by a group of specialists we performed a state of the art examination for the mentioned technology.

We found that technology has a significant advantage over the current state of the art. Some technologies touch on similar measurement methods and use language and definitions in patent claims to cover a very wide range of almost all measurement options, but do not cover the details of photodetector implementation. This is one of the significant improvements of our technology: we use silicon photomultipliers (for photodetectors), in connection with the digitization of the signal from the photodetector using a chip and the principle of fast waveform detection.

There are also related patent applications and patents, which describe significantly slower, more complex devices or use alternative technology (TCSPC), which requires higher laser energy input to operate. The higher laser energy also results in photobleaching, which is in our technology avoided due to single photon regime of acquisition. The most related patent application, which also uses a silicon photomultiplier in conjunction with the use of a digitization chip and direct waveform sampling, does not describe a significant improvement in technology. These are namely the simultaneous capture of several sensors simultaneously, capturing the spectrum, which is an important analytical contribution in the submitted patent application of the presented device in the analysis and processing of fluorescent times.

3.2 Benefits and market placement

A silicon photomultiplier is a very fast photodetector, whose response to a single photon is faster than the fluorescence lifetime. Therefore, the shape of the electronic signal, i.e., the waveform, output by the silicon photomultiplier will follow the exponential decay of the fluorescence light resulting from a single pulse of excitation. If the resulting waveform is sampled with sufficient accuracy, the need for long accumulation of single-photon arrival times and large excitation light intensities can thus be avoided. Excitation light with low intensities reduces the risk of photo bleaching. Silicon photomultiplier photodetectors and waveform sampling chips developed for the needs of high-energy physics experiments have become low-cost, off-the-shelf components. Thus, the method allows a cost-effective way to measure the fluorescence lifetime and, at the same time, avoids lengthy data acquisition and photo bleaching of the sample.

The main advantages of the method proposed over TCCSP are cost-effective compared to common TCCSP technology, long accumulation of single-photon arrival times and large excitation light intensities of TCCSP are improved and excitation light with low intensities reduces the risk of photo bleaching.

The technology is in late early stage of development and is fully available for demonstration. It has been developed with the core funding of Slovenian Research Agency and also supported in part by ATTRACT Phase I. Due to the situation in the technology and market field, it was determined, that it is high relevance that its IPR status is arranged.

3.3 Database searches

We have prepared an overview of the state of the art with the help of the commercial patent database Derwent Innovation. In the review, we considered patent applications and patents filed anywhere in the world, and searched using the following key phrases: fluorescence lifetime, silicon photomultiplier, waveform sampling, and a specific content keyword that the authors of this contribution consider as a part of their secret knowhow and is not going to be revealed.

We tested different combinations of words and compared the obtained results with each other. We reviewed the results of the following search strings in more detail:

1.Fluorescence AND lifetime AND silicon AND photomultiplier AND waveform AND sampling AND specific content keyword (No records)

2.Fluorescence AND lifetime AND photomultiplier AND waveform AND sampling (6 records)

3.Fluorescence AND waveform AND photodetector (51 records)

4.Fluorescence AND waveform AND sampling AND photomultiplier (14 records)

The results obtained with the second, third and fourth search sets contain 71 results. Upon examination, 6 of the 51 hits turned out to be highly relevant and 2 relevant. Of the other 14, 4 were highly relevant and two relevant, and of the last six, 3 were highly relevant and 2 relevant. It turned out that the most relevant search was under point 4, where the largest share of relevant hits was. However, the search under point 3 is also important for finding market orientation.

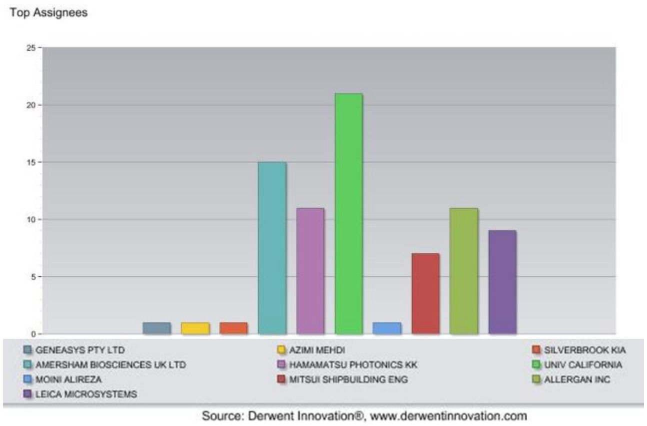

Figure 1: Top Assignees in the World in the field of fluorescence lifetime measurements

Even though we kept in mind that a proper Freedom-To-Operate analysis (FTO) can only be performed when the product is defined, the patent analysis also has given the authors insight into which companies have shown an interest in this type of technology. Top Assignees in the World can be found in Figure 1. Derwent Innovation overview of the field shows a current prevalence of US Universities and Japanese companies in the closest technology searches.

Due to the results of the review of the state of the art, we decided to prepare documentation for the disclosure of the official invention. it makes sense that intellectual property is properly registered with the JSI (it can also be used as a technical improvement / hidden knowledge) - also in terms of the possibility of rewarding inventors for inventions created during working hours.

3.4 Market assessment

The size of the market for measuring fluorescence time, according to data from companies engaged in market research, is currently estimated at over 250 mil. EUR at an estimated average annual growth, since 2016, somewhere around 4%. The advantage over the existing offer is mainly in the relatively favorable design / price of the technology (silicon photomultiplier), speed of data capture and processing, prevention of photobleaching and especially in the possibility of simultaneous capture of multiple wavelengths of light, obtaining important additional information for further processing.

Of course, the market analysis would be more significant and in particular more reliable, if we could identify the first specific application(s) to be addressed by the technology, and then count the potential end users and multiply by the assumed price of the equipment to arrive at an accessible first market. This is an ongoing process which we hope to continue in the next steps.

We have already established contacts with companies, but without adequate protection of intellectual property, contacts cannot grow into more serious forms of conversations and exchange of technical information.

Following proper registration of intellectual property with the JSI, the marketing plan is expected to include: (i) the preparation and publication of a technology offering in commercial databases; (ii) contacting the main players from the list we created as part of internal market research; (iii) depending on the response from the main players, active marketing to other potential partners (through direct contact of potential partners, participation in international partnership events and active marketing within sectoral groups, a project of the European Commission).

3.5 Continuation of intellectual property protection

Given the high technological potential (according to the state of the art) and the high market potential, it makes sense to apply to the Office for the Protection of Intellectual Property, which conducts a full test, UK-IPO, which we also propose to find out within 6 months the invention is new and on an inventive level. Namely, we will receive an international opinion on the patentability of the technology (ISR - International Search Report) from a certified ISA (International Search Authority), on the basis of which we will be convinced of the novelty and inventive step of the proposed technology.

The selection of an office that performs a full test is also a precondition for co-financing the work of patent attorneys within the Technology Transfer project financed by Slovenian Ministry of Science and Sports.

Technology and market assessments proved the relevance and the need for patent application protection.

3.6 Technology commercialization

We are in the process of obtaining IP protection for the core aspects of our development, with patent applications currently filed in UK and European offices. We are in talks with two companies interested in technology, with one we are in the process of signing NDA. Other private entities expressed interest for the development of front ends and data display software. The multichannel instrument will support our commitment to advance as quickly as possible to step three of our development program, to enable the community and users to have on disposal a price competitive and robust instrument for their application.

4. FURTHER TECHNOLOGY, IP AND MARKET DEVELOPMENT PLANS

4.1 Envisioned risks

Our main target is the development program of highly integrated sensors, potentially having some degree of data processing on chip. Modelling, design, production, assembly and testing of such devices are, in a vast majority, also areas of expertise of the authors [6, 7], and the institutes they are affiliated with. We intend to prepare a simulation of such a device, to predict its performance and share the performance envelope with early adopters to shape its final form.

The physical aspect requires multiple R&D cycles which is slow and costly. To mitigate the failure in this task, we will start by assembling some of the ideas we already have on low cost CMOS fabs and unveil potential issues toward high integration. At each iteration, interested users shall be able to test our devices in their respective environments.

4.2 Liaison with student teams and socio-economic study

Our group are open for collaborations, and look forward to establish reliable partnership with users, partners and stakeholders. Our plan envisages their presence from the very beginning and will provide support in their future endeavors, by providing them with better and more advanced instruments. Of special interest are Master students, the next generation of STEM engineers, which will, one hopes, adopt our technology. It is very rewarding having the possibility to empower the younger generation, and give them tools to cover the fear of missing out new opportunities in such an early stage, searching for other possible applications of the developed chip, that may include PET, encrypted LIDAR, and other machine vision applications

5. CONCLUSIONS

The researchers come from a Slovenian public research organization. Their research involves experimental particle physics on large particle accelerators and development of complex detectors. They have analyzed their options with transferring the technology in question, performed market and technology assessment and decided upon an IP and market strategy. Future steps involve in particular wider interaction with potential customers and further development towards a product for the market.

Even though the process of the transfer is described in a historically relevant manner, the authors also acknowledge, that there have been many setbacks within the process itself. It is not that every step has been performed flawlessly, without mistake, setback, delay or disappointment. For example, it took a long time to arrange the internal take up of the technology at the public research organization, even longer to arrange for the dual ownership between the two primary owners, both public research organizations. We need to point out these facts, although we are, for non-disclosure issues not entitled to discuss the details here.

The partners are sought among optical instrumentation manufacturers. As a public research organization, the researchers are available for different sorts of collaboration: Potential partners are offered a license to the granted patent under licensing agreement. Technical cooperation for the development of a complete instrumentation device for measuring the fluorescence lifetime by this method is also considered a viable option.

The timing of technology development is suitable for inclusion in technological processes in the market. With the analysis of the market and patent saturation, we gained an overview of the state of the art and the possibilities for further market orientation. In our opinion, with the timely protection of intellectual property, we have achieved an optimal position for further marketing activities.

6. ACKNOWLEDGMENTS

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Technology marketing support has been obtained through CTT, JSI.

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Regulated toxicity-testing: Spinning out a company in a rapidly changing market

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ABSTRACT

Today, various chemicals and materials are introduced into our daily life. To guarantee their safety, number of tests have to be applied, ranging from simple testing on cell cultures (*in vitro*) to costly animal tests (*in vivo*). In case chemicals are planned to be delivered to a human body, many clinical tests are also required to be performed on humans. Logically, earlier stages of testing are used in selection, for example, of drug candidates or vaccines, or in early decision, for example, to remove dangerous materials from R&D pipelines as soon as possible. Unfortunately, the very expensive intermediate step – *in vivo* animal-based testing often provides wrong answers. Alternatives are being searched for and entire market is about to change with political decisions overtaking scientific and technological developments.

This article covers a relatively new field of how to deal with a situation arising from the fact that an associated novel IP is generated in public research institutions. It depicts how it becomes challenging for the institution and steps to be taken to spin the technology out into a company to a particular turbulent sector.

The article also touches upon the main dilemma on how to keep the novel technology solutions hidden if they need to be adopted by the regulators first. Related to this is also the question, how can one convince the committees at the research institutions as well as the investors that the technology in question actually do hold (enormous) business potential.

Keywords

Biotechnology, spin out, IP transfer, disease prediction, animal alternatives.

POVZETEK

Danes se v naše vsakdanje življenje uvaja različne kemikalije in materiale. Da bi zagotovili njihovo varnost, je treba uporabiti številne teste, od preprostih preskusov na celičnih kulturah (*in vitro*) do dragih testov na živalih (*in vivo*). Če je predvideno, da se kemikalije vnašajo v človeško telo, je treba na ljudeh opraviti tudi veliko kliničnih testov. Logično je, da se prejšnje faze testiranja uporabljajo pri izbiri, na primer pri ožanju nabora kandidatov za zdravila ali cepiv, ali pri zgodnji odločitvi, na primer za čimprejšnjo odstranitev potencialno nevarnih snovi iz razvojnih aktivnosti. Žal zelo drag vmesni korak - testiranje na živalih in vivo pogosto daje napačne odgovore. Zato se iščejo alternative, ki bodo spremenile celotni trg, kar sicer nakazujejo že politične odločitve, ki prehitevajo znanstveni in tehnološki razvoj.

Ta članek zajema sorazmerno novo področje, kako se spoprijeti s situacijo, ki izhaja iz dejstva, da se v javnih raziskovalnih ustanovah ustvari povezan novi IP. Prikazuje, kako postaja omenjeni IP izziv za institucijo, in korake, ki jih je treba sprejeti, da se tehnologija pretvori v podjetje v nek turbulenten sektor.

Članek se loti tudi glavne dileme, kako naj nove tehnološke rešitve ostanejo skrite, če jih morajo regulatorji najprej sprejeti. S tem je povezano tudi vprašanje, kako lahko prepričamo odbore na raziskovalnih institucijah in tudi vlagatelje, da zadevna tehnologija dejansko ima (ogromen) poslovni potencial.

Ključne besede

Biotehnologija, spinout podjetje, prenos intelektualne lastnine, napovedovanje bolezni, nadomestki za živalska testiranja.

1. INTRODUCTION

1.1 The prior art of the technology

Currently, drug, vaccine and material development workflows heavily rely on expensive animal testing, used to reduce selection of possible candidates later on entering the preclinical and clinical testing phases that need to prove these candidates do not harm human health. Unfortunately, molecular driven disease mechanisms are very much different between test animals and humans [1], leading to almost catastrophic 95% probability of failure of, for example, drug candidates at the end of drug developments cycle [2].

This makes the later extremely cost inefficient with costs of 300 - 2000 MIO $ per drug development [3]. Other sectors, such as material safety testing, somewhat ignore this fact and stoically wait for the solution that more exposed and rich pharma sector can bring out.

To boost the launch of numerous new material and chemicals in a safe, hazard-free way, the material-related health adverse effects should be more reliably predicted [4,5]. Currently, the most promising alternatives involve test assays [6] and QSAR [7,8] models, but neither *in vitro* nor *in silico* tools can reliably predict *in vivo* adverse outcomes [9,10]. Particularly, the models unsuccessfully predict the systemic and chronic adverse effects [11].

The need of urgent development of more reliable prediction have been expressed by all the important policy- and decision-makers around the world (OECD, US EPA, NIH, EC, ECHA, etc.), which have highlighted the necessity of exploring the molecular mechanisms behind and identification of the key events in toxicity pathways associated.

During the last 5 years, 12 partners, joined within the SmartNanoTox European project, have worked pushed the mechanistic-prediction of toxicity-related diseases beyond the scientific frontiers. Within this consortium, our group of biophysicists at Jožef Stefan Institute in Ljubljana has led one of the most distinguished breakthroughs in the field in the last decade – the first mechanistic explanation of the transition from acute to chronic inflammation. This discovery enabled us to predict a spectrum of inflammatory outcomes without animal tests for the first time [12].

1.2 The story behind the market and the opportunity

The only way to solve the lack of predictive testing that doesn't rely on animal tests is to develop living organ models (for testing purposes) that develop physiologically relevant responses to various drugs and other toxicants [13,6]. Several research groups and companies (Figure 1) are struggling to make such animal replacement models in a form of miniature and reliable organ copies.

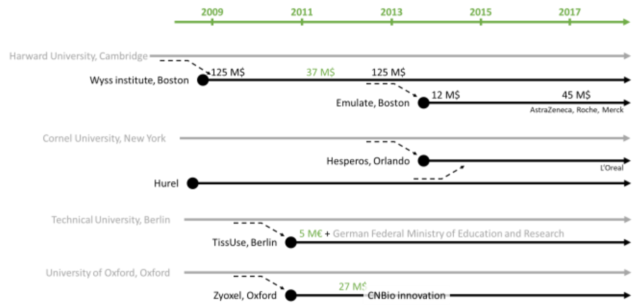

Figure 1: Small R&D institutes (black arrows), spun out from large universities (grey arrows), led the fields of *in vitro* model development. Some initial investments are shown with respect to the source – private (black) and public (green).

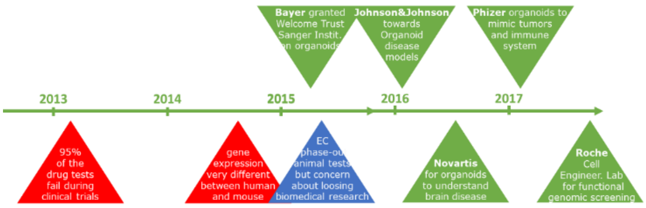

Figure 2: The important moments and decisions that boosted transition from animal-based testing into *in vitro* - or organoid – based testing and forced big pharmaceutical companies to get more involved into the *in vitro* model development

But, as expected this become a tedious, far from straightforward task full of trial-and-error steps. This makes the current developments look like being stuck and represent big challenge for regulatory bodies, which actually don't have clear plans on how to implement political decisions [14] (Figure 2) and public pressure (to eliminate animals from testing).

In terms of market size, toxicology testing market (Figure 3) currently values at around 20.000 MIO EUR per year [15]. Around of 10% of this market is driven by REACH EU legislation [16], which implies testing procedures for about thousands of substances that are produced annually with amounts greater than 1 ton per year. 2% of this REACH-associated segment includes acute & short-term repetitive dose exposure testing with 10,000 animal tests required per year. Value of this market is around 400 MIO EUR per year. Taking into account that most of the market need to be changed, this clearly represent a big opportunity for biotech companies that can bring new alternative solutions to the testing market. Currently, the testing market exhibit 12% annual growth. But is soon to reach its limits in terms of testing capacity, that originate in limited number of animal tests that can be performed in the EU and other players around the world.

On the other hand, there is new material development sector with a fast growth of 20% per year that also requires extensive toxicology testing [17]. With 10.000 patents filed every year to protect various nanomaterials and their applications in addition to around 50,000 publications on the same subject, this sector will soon require much larger testing capacities. The only possible boost can thus come from new technologies and new players to guarantee material safety throughout new smart prediction approaches [12].

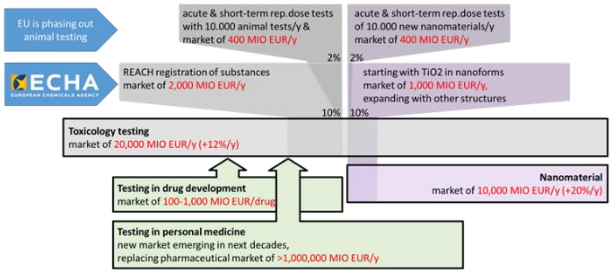

Figure 3: Target markets of acute & short-term repetitive dose toxicology testing in safety assessment of various substances and nanomaterials presented in the context of regulatory framework and political decisions.

To resume, the market is driving into a dramatic change:

- animal tests are considered as golden standard, but are phasing out;
- alternatives are lacking, imposing huge pressure on the regulatory bodies.

This opens new exciting opportunity for new knowledge-based companies, but at the same time impose great risk due to unpredictable development of regulatory framework.

The main contributions of the new companies in this field would cover exactly the market's greatest pains: the animal-free testing of drugs for human use and the prediction of the drug effects on the molecular level.

Not surprisingly, based on our new technology, which is registered as a secret know-how of the Jožef Stefan Institute, we decided to address this market need and participate in the product development and service provision in the new animal-free drug testing as explained above.

2. INITIAL STEPS TOWARD THE SPINOUT COMPANY

The initial steps we took were connected to shaping the idea into a market plan and creating a team to enable the creation of the market plan, sorting out the IP issues with possible other institutions and settling the IP relations within the research organization.

Interestingly, in the need for a business plan, expressed by any of our first investing contacts, we faced a lack of the expertise to create this business plan. Writing a business plan thus lead to complementing the existing team members. In our case, we have identified the need for getting involved someone with more economic background. This was a strenuous task for a group of scientists that have rarely think about nonscientific issues. But, when solved, another perspective enlightened the problem of value creation leading us to much better vision of what the company can do and where it can be after 10 years. Recursively, the business plan have become much more solid while increasing the core team and focusing to its strengths.

While constructing financial projections for our business plan, we have “accidentally” discovered where the business models of the current service providers fail and where our scientific discoveries can really make a difference on a market (and in our budget). As said before, the toxicity testing, as we know today, requires many *in vitro* and *in vivo* tests. Even without clinical tests, all these tests cost lot of resources, making the business very resource-limited and, if you want to pay experts with a reasonably good salary, struggling with either low added value or being uncompetitive on the market. The problem is that it is required to run them all, but the results are not really being used in a smart ways or assembled in bigger picture. They are just there to be reported.

As discussed earlier, in the mean time, our scientific discoveries brought us several steps further, identifying how to use simple but well defined *in vitro* tests to predict disease development, that was till now possible only with much more expensive animal tests. This in turn release the business model from its limitations to human resources and make it more knowledge dependent (with higher added value). This will be beneficial for our company and the market, because the company business will be more competitive and the market prices will decrease at the same time.

Conceptualizing a new company in our case was a challenging task, yet alone in a field that is about to change dramatically and where the constraints are blurring rapidly with time.

The way that a company can be prepared to deal with such a challenge is stricktly by assembling together one big brain with out-of-the-box thinking ability. Inspired by many extraordinary business cases from the human history, we learnt the following lessons, while trying to set up our own company, Infinite-biotech:

- The core team need to dream about it, feel it by heart, and be ready to invest more than it can predict in the worst thought scenarios;
- Although there is always one that lead them all, the brainstorming is the real weapon of the team; the main leader needs others to challenge each other while searching for solutions that really makes the core idea;
- The core team members must complement each other in terms of expertise and at the same time be ready to listen to each other and adjust their ideas; nevertheless, they build entire story from scratch; so they must function as one big organism;
- Finding market opportunity is hard, but even harder is creating business out of it; the team have to search for their strengths enabling them to create high added value and be recognizable by the market;

To conclude, although everyone expects that you have the core team ready and you have already clarified all the business points ahead of writing the business plan itself, its actual the act of assembling the business plan that enables you to clarify of the details. It helps you to search for the missing expertise and complement the team members as well as to clarify many in particular business/finance related points of the very same business plan.

3. SPINNING OUT AND THE IP TRANSFER

Generally, a complex knowledge, required to elucidate basic mechanisms and further develop mechanisms-based testing or even disease prediction, as alternative toxicity testing concepts, logically arise from large publically financed projects that mostly run in well-equipped research laboratories in public research institutions.

The IP created has passed a well-defined procedure that, in our case at Jožef Stefan Institute, involves IP recognition by an expert panel followed by IP transfer to newly registered spin out company. IP must remain confidential during the processes and at the same time ambitious enough. This becomes challenging due to several reasons:

- procedures usually involve many different experts and some of them might have competing interests, but are involved in accordance with their elected position in the panels;
- protection of IP in a form of patents might be problematic because the patent application is disclosed to public sooner than the company might start making revenue to defend its IP, making it more vulnerable; The strategy of filing a patent and then preventing the disclosure by withdrawing the patent it in 18 months (and filing it again, in the same or in a modified form) has been disregarded. Patents might later on be filed, at this point in time the invention is protected as a secret know how;
- hiding IP in a form of secret knowhow might leave the impression that the inventions are not novel enough; many experts evaluating the proposal for IP recognition and company-associated business plans might therefore doubt about the potential of the idea;
- the use of university-internal panels to evaluate invention disclosures and IP can be considered of limited usefulness and it remains to be proven that the panel adds value in the eyes of the VC’s.

The role of IP-transfer-dedicated department is thus even more important. In our case, both the Center for Technology Transfer and Innovation at the Jožef Stefan Institute and the Scientific Council of the Jožef Stefan Institute, were flexible and ambitious enough to recognize the dilemma above and support us in all possible (right) ways: the IP has been registered by the institute in a timely manner, the Scientific council confirmed the creation of the spinout company and the Center for technology transfer and innovation made way and glued together all the necessary pieces for the procedures to come together and obtain the general official support.

Last but not least, as mentioned before, the IP is often created within larger publically financed projects, likely to involve several partners. This inevitably exposed entire process of setting up a spin out company to a problem of shared IP, which can delay entire process substantially. While some universities almost hysterically claim their shares even when it is hard for them to prove their participation yet alone their contribution, this fortunately did not happen in our case.

Partners of the H2020 project SmartNanoTox easily realized that the core idea has originated from the work of our laboratory. However, in relation to multi-partner research projects and shared IP, it is important to distinguish between inventorship and the commercial rights. Inventorship is well-defined and one can contain inventorship even in larger projects. On the other hand the commercial rights can be shared, but the consortium agreement should clearly state, that the partners will not block commercialization. However, in our particular case no partner claimed his share – despite the fact that the general trends were clearly defined already in the afore-mentioned H2020 project.

4. SEARCHING FOR THE FIRST INVESTMENT

As expected, the fact that our idea and technology is disruptive to the established market, adds to the complexity that we have experienced in their search for investors.

While transferring the IP might be enough to start making service-based revenue, it is actually far from sufficient to make revenue from products that allow a company to run into more stable and less human-work-dependent business model. Keep in mind that the research labs often focus on the basic mechanisms thus developing solutions up to a relatively low technological readiness level (TRL). Rarely, the TRL exceeds that of a proof-of-concept or a demonstrator yet alone that of validation of technology in a lab or real environment. Up to a prototype, which is really the one of the most important milestones of the company to enter the market, there is long way to go.

To speed up the required development cycle, a spin out company urgently needs an investment, which usually exceeds several MIO EUR. And despite the numerous venture capital funds (VC) and national agencies that all create an impression of straightforward access to financial sources, the investment into a business, whose potential is yet to be truly developed, is very difficult to find.

On a first sight, incubators might look the best option for spin out company. Nevertheless, they are expected to support startup at regional or national level. However, it turned out they are completely inappropriate choice for spin out companies arising from public-funded basic research due to extremely limited financial support that fails to meet the need for large investment after IP transfer. As stated previously, the TRL of the knowledge in a given situation rarely exceed the proof-of-concept making it far less attractive for direct financial investments.

During establishing our spin out company, we have learnt the two very important factors that influence the decision of an investor to invest into such story are:

- a proof that the entire business endeavor does not belong to a “green field” category;
- a proof that a company can start making revenue associated with the core technologies.

In business, a “green field” means an idea that can be written on a piece of paper with a dubious value that might hide lots of possible pitfalls and obstacles, far from being developed to a TRL high enough to start running even a small revenue. Despite its more or less clear message, we have noticed a very important difference in feedback of the scouts and VCs related to the IP origin. At the beginning, we approached them as a team with potentially powerful idea of the business and they rejects us almost instantaneously. Later on, when we approached them already as a legal entity with IP transfer in progress, their response has changed. Although they were aware of the origin of the IP – in both cases it originates from a large/renowned research institution, their attitude change simply because of the fact that there was an expert panel, which has already identified value of this IP before them. Passing this milestone has clearly brought us closer to reach the final investment.

Not surprisingly, ability of the company to start making revenue with its core knowhow is very important signal to investors. We noticed that this is particularly important for large VC funds. In addition, any effort of entering the market as soon as possible pays off with better business plan. In particular, it helps a company to identify the group of services and products that have higher added value and larger market potential. Further developments of spin out core technologies might thus be heavily influenced with the experiences gained through the first sales activities.

After exploring different possibilities, the best investor turned out to be a person (“angel”) that is aware of the lack of solution and that can see the market niche your new company is trying to address. In many cases, he/she is the CEO of already another company. He/She is able to clearly see the potential of your knowledge and is willing to invest his/her resources (and/or attract others as well) and wait the minimum amount of time needed for the company to develop its core technologies for the future.

5. CASE SPECIFIC DATA AND THE IMPORTANT MILESTONES

The following details of our case timeline wants to illustrate the above and put all the discussion into a proper perspective:

- Market niche identification: 2017
- First idea of the company: July 2018
- Decision to protect IP as secret knowhow: September 2018
- First round to potential investors / contact type / contact location: December 2018 / scout, mentor / Switzerland
- 1st version of the business plan: February 2019
- First Financial plan and complementing the team: March 2019
- Second round to potential investors / contact type / contact location: June 2019 / intermediary / Germany
- Third round to potential investors / contact type / contact location: June 2019 / venture capital (VC) fund / Slovenia
- Final decision to make the company a spin out of Jožef Stefan Institute: October 2019
- 2nd version of the business plan: October 2019
- Start / End of the process of IP recognition (as secret knowhow): October 2019 / December 2019
- Approval of the scientific council of Jožef Stefan Institute: January 2020
- Fourth round to potential investors / contact type / contact location: November 2019 / angel related to venture capital (VC) fund / Austria
- Major breakthrough done on scientific side relevant for company business: September 2019 – January 2020
- Negotiation for IP transfer conditions and formal cooperation with date of signing the contracts: February 2020 – July 2020
- Fifth round to potential investors / contact(s) type / contact(s) location: March 2020 – June 2020 / venture capital (VC) funds & angels / Austria, Switzerland, Germany
- First demonstrator of the technology planned to use in a product: April 2020
- Sixth round to potential investors / contact type / contact location: April 2020 / angel, CEO, mentor / Slovenia
- First round to offer services: June 2020
- Complete marketing/sales plan for the company’s services: September 2020

As can be noticed, from the market niche identification to a complete marketing/sales plan three years have passed. The main issues we encountered were twofold:

- In the field of registering the technology at the Public research organizations (PRO) the deadlines constantly moved because we were not sure if the registration is necessary and for what reason; as it turns out, the registration itself is needed to enable the PRO to officially participate in the creation of the company in Slovenia; these clarifications took about a year to settle in with the team and the responsible at the research department;

- In the same field the time lag was also a consequence of a rigid PRO structure in the sense of the time urgency in which a typical spinout company finds itself; however, the procedures were carried out in the end in a timely manner; these procedures were ultimately carried out in less than two months;
- In the field of clarifying internationally on how to create a suitable team and how to attract with confidence a suitable amount of financing necessary to pursue with further technology development; these procedures took about two years; the main issue being that a researcher at a PRO is not in a position to devote a significant amount of time into the development of the market relations;
- With this in mind it needs to be said that an additional issue might be seen in the state of the mind of the researchers who believe that themselves are the only people who can properly present the technology and attract financial support.

In any case, the marketing and sales plan has been completed in September 2020. We plan to continue with the technology development and plan to deliver the services to the market in early 2021.

6. CONCLUSION

Scientific studies have clearly identified the need for a major change in the toxicity testing framework and the politics decides to realize this as fast as possible. This has created an exciting opportunity for business that can be started directly from basic research discoveries.

Because of the huge pressure to bring the future into reality faster than the new tech evolves, several milestones have to be met almost instantaneously: discoveries of the basic concepts, acceptance of the regulatory frameworks and establishment of the alternative testing market (and the trust in the same) that can replace the classical animal testing. Investors became reserved, simply because it is such a big step to the future. Despite the fact that the future is already here and a revolution of the testing market is inevitable.

In June 2019, I have been involved in an interesting discussion on tissue-on-chip technologies and the associated startup companies. The key dilemma associated with these small companies was: why they still get big investments if they can't and don't make big revenues. Yet. The answer given by the CEO of one of the first companies of this kind was marvelous: investors invest into teams that will be capable of reacting to the new market as soon as it will become approved (by the regulators).

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Status quo of computer-implemented inventions in Slovenia and EU

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ABSTRACT
In Slovenia there is no legal basis for computer-implemented inventions, and in the EU such inventions are not yet clearly defined. Over the last twenty years there have been many heated debates in the European arena concerning a single legal instrument, but a final solution remains elusive. In Slovenia and the EU, legal protection of computer-implemented inventions thus remains on thin ice: there are certain non-obvious combinations for obtaining a patent, but ultimately the decisive factor may as well be how the patent application is written. This status quo therefore necessitates an examination of this field: to arrive at a legal basis that would regulate the patenting of computer-implemented inventions it is necessary to identify and address the most critical points. This is the issue that this article deals with. It starts by presenting examples of computer-implemented inventions, followed by an overview of the state of play – the status quo concerning legal protection in Slovenia and the EU.

Keywords
Computer-implemented inventions, patent, copyright, status quo, Slovenia, EU.

1. INTRODUCTION
After Slovenia joined the European Union (EU), adopted the euro, and entered the Organisation for Economic Cooperation and Development (OECD), its integration into the European arena drastically improved, as did its international competitiveness. At present, information technology and digitalisation are highly developed, the country's rankings in a variety of international indices prove that Slovenia is an advanced and digitalised country. Other EU members are likewise considered advanced and digitalised, as the cutting-edge digital technologies they use make it possible to upend existing business models and create new ones, facilitate the development of new products and services, improve the efficiency and competitiveness of the economy, and contribute to socio-economic development in general [1]. The digitalisation of the entire society and economy underpinned by intensive use of information and communication technologies has significant growth potential and as such provides the groundwork for the long-term development and competitiveness of Slovenia, the EU, and Europe in general [1]. We live in an era where information technology may be considered one of the most important industries; consequently, management of industrial property and copyright, which are in the domain of intellectual property rights and are the subject of this article, are extraordinarily important.

Whereas the legal protection of intellectual property rights, as defined by the Convention Establishing the World Intellectual Property Organization (WIPO), is clearly and precisely defined in Slovenian and EU legal instruments, this does not apply to computer-implemented inventions [2]. A computer-implemented invention means any invention the performance of which involves the use of a computer, computer network, or other programmable apparatus, the invention having one or more features that are realised wholly or partly by means of a computer program or computer programs[1] [3]. Due to the recent shift in innovation towards things of a digital nature, computer-implemented inventions account for a large proportion of present-day inventions and creations, and as such represent an important segment of intellectual property [5]. Patents and all other intellectual property rights are the pillars of any innovation system and provide instrumental support in the development of technology and in the growth of national economies [6]. And although efforts to put in place appropriate legal instruments started over two decades ago, they ground to a halt in 2005, when, after a series of heated debates, the European Parliament voted down a proposal for a directive of the European Parliament and of the Council on the patentability of computer-implemented inventions, which the European Commission (EC) had issued in 2002 [7]. At least part of the reason why there is still no appropriate legal instrument is that such inventions are highly specific and demonstrating their technical contribution[2] and industrial applicability[3] may pose a significant challenge. But to a large extent, the reasons lie elsewhere – perhaps in the poor understanding of certain exemptions that apply in granting patent protection to computer-implemented inventions.

This status quo necessitates an analysis of this field and requires that the most critical points be identified and addressed in trying to create a legal basis for the patenting of computer-implemented inventions in Slovenia and the EU. This article presents computer-implemented inventions, the history thereof, and examples past and present. The focus is on the status quo in this field, in Slovenia and the EU, whereby we explore the possible ways of securing legal protection for computer-implemented inventions with the current legal instruments, in particular when such inventions can be patented and when they

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[1] A computer program is an algorithm written in a programming language (e.g. C++, JavaScript, PHP, Python, etc.) that can run on a computer [4].

[2] Technical contribution means a contribution to the state of the art in a field of technology that is new and not obvious to a person skilled in the art. It is assessed by consideration of the difference between the state of the art and the scope of the patent claim considered as a whole, which must comprise technical features, irrespective of whether or not these are accompanied by non-technical features [3].

[3] Industrial applicability assumes that an invention is applicable in industry if the subject of the invention can be produced or used in any economic activity, agriculture included [8].

can be copyrighted. Finally, we highlight the open issues that should inform future work, in particular in the context of how and where technology transfer offices (TTO) can help accelerate the adoption of such legal instruments and improve their clarity.

2. COMPUTER-IMPLEMENTED INVENTIONS

2.1 Theory and Practice

Computer-implemented inventions are defined as inventions the performance of which involves the use of a computer, computer network or other programmable apparatus, the invention having one or more features that are realised wholly or partly by means of a computer program or computer programs [3]. A computer-implemented invention can cover topics related directly to information and communications technology (ICT), e.g. compiling back-ups or data compression, or it can be indirectly related to ICT and only used to control other appliances or devices [9]. Although programs for computers are as such explicitly excluded from patentability (at least at the European Patent Office (EPO)), a product or a method that is of a technical nature, i.e. it produces a further (technical) effect beyond the normal functional interaction of a program and computer, may be patentable, even if the claimed subject matter defines or at least involves a computer program [9].

The first patent application for a computer-implemented invention in Europe was submitted in Great Britain in 1962. The application was made by British Petroleum CO. Ltd., and P. V. Slee and P. M. J. Harris. The patent for the invention *A computer arranged for the automatic solution of linear programming problems* was granted in 1966 [10]. The computer-implemented invention is described as a computer comprising quick-access storage, slow-access storage, and an arithmetic unit, arranged to automatically solve a linear programming problem by means of an iterative algorithm [10].

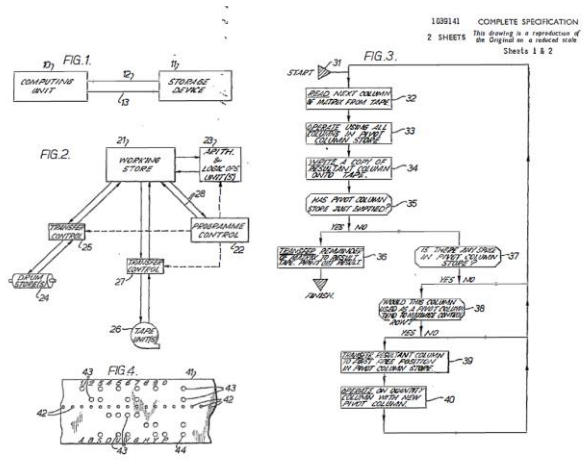

Figure 1: Drawing of patent application GB1039141A for the invention *A computer arranged for the automatic solution of linear programming problems*

One example of a computer-implemented invention that is widely used every day and was granted patent protection in Europe is the electronic anti-lock braking system (ABS). In 1969 ITT Teves (Continental) unveiled an electronically supported ABS system as a premium add-on feature of the Mercedes Bens S-class, and in 2004 electronically supported ABS systems became standard on all new cars in Europe [11]. Another example of a computer-implemented invention that will probably change our everyday in the near future are autonomous vehicles. However, in order for autonomous vehicles to be recognised as computer-implemented invention, numerous experts will need to identify intellectual property issues related to autonomous vehicle technology, and to navigate the complex intellectual property landscape within this rapidly developing sector [12].

2.2 Status quo of Legal Framework: Slovenia

The Slovenian Industrial Property Act (ZIL-1-UPB3), which determines the types of industrial property rights and the procedures for granting and registering these rights, the legal protection of rights, and the representation of parties, stipulates in Article 10, which determines the subject matter of patent protection, that "*patents shall be granted for any inventions, in all fields of technology, which are new, involve an inventive step and are susceptible of industrial application*" [8]. Article 11, which determines exceptions to patent protection, stipulates that (1) "*Discoveries, scientific theories, mathematical methods, and other rules, schemes, methods and processes for performing mental acts as such shall not be considered inventions within the meaning of Article 10,* and that *(2) A patent shall not be granted for: (a) inventions, the exploitation of which would be contrary to public order or morality; (b) inventions of surgical or diagnostic methods or methods of treatment practised directly on the living human or animal body, with the exception of inventions relating to products, in particular substances or compositions for use in any of these methods.* [8]. This means the Slovenian Industrial Property Act does not deal with computer-implemented inventions.

Software[4] that does not provide a technical contribution can therefore be protected only by copyright, whereby ideas cannot be copyrighted. The appearance of a command line interface[5] or a graphical user interface[6], on the other hand, can be protected as a registered design. At the Slovenian Intellectual Property Office (URSIL) it is possible to get a patent for computer or mobile applications, but only under the condition that a technical contribution is demonstrated. One such example is a patent granted in 2012 for the invention *A mobile application and procedure for the processing of environmental information*, which solves technical problems in preventing the generation of waste, reducing the amount of generated waste, channelling waste into reuse, appropriate disposal of individual types of waste, reducing environmental pollution and reducing the demand for the production of new raw materials that subsequently pollute the environment as waste [13]. This was the first such patent granted in Slovenia. Another such example, also granted patent protection in 2012, is the invention *A system for automatic detection and monitoring of harmful insects*, which solves the problem of the time-consuming inspection of insect traps [14]. With the help of cameras in traps it detects and monitors harmful insects [14]. The third such example is the invention *A system and method for printing and delivering of publications such as newspapers on-demand*, which was granted patent protection in 2019 and is classified as a special purpose printing device and device combining printing and other functions [15]. The printing and delivery system consists of at least two internet connected units and a mobile application

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[4] Software is a group of computer programmes that constitute a whole in combination with hardware in a computer.

[5] A command line interface is an interface in the form of lines of text that shows a prompt on the screen into which a user enters a command and executes it with the enter button. If the command is valid, it is executed.

[6] A graphical user interface displays elements such as icons and other tools. It is an interface between the user and the software.

that transmits location data to the printing and delivery device, includes account management functionalities, and sends instructions for printing and billing [15].

2.3 Status quo of Legal Framework: EU

In 2002 the EC issued a proposal for a *Directive of the European Parliament and of the Council on the patentability of computer-implemented inventions.* After a series of heated debates among MEPs, the European Parliament rejected it in 2005 [3]. The adoption of this directive would have created a single set of rules for the patent protection of computer-implemented inventions in the member states. The European Patent Convention Stipulates in Article 52(2) (c) that programs for computers are not regarded as inventions [2]. Recognizing that the European Patent Convention (EPC)[7] established a European Patent Organisation (EPO), which is responsible to grant European patents. This is carried out by the EPO (supervised by the Administrative Council), which is not an agency or an organ of EU. It is an organ of the EPO, which has legal entity and it is an independent inter-governmental organisation[8] [16]. The status quo thus remains the same as in Slovenia. Software that does not demonstrate a technical contribution can only be protected by copyright, which does not protect ideas. The appearance of a command line or graphical interface can be protected as a registered design, whereas a patent for computer or mobile applications can be granted if a technical contribution is demonstrated. Under EPO rules, in the event of such, the software must be connected with the hardware.

3. COPYRIGHT AND COMPUTER PROGRAMS IN SLOVENIA AND EU

3.1 Copyright

Computer programs are defined both in Directive 2009/24/EC of the European Parliament and of the Council of 23 April 2009 on the legal protection of computer programs (the Directive) [17] and the Slovenian Copyright and Related Rights Act (the ZASP) [18]. EU member states protect computer programs by copyright the same way literary works are protected under the Bern Convention for the Protection of Literary and Artistic Works [19]. While a computer program is defined by these legal instruments as a program in any form of expression and is considered a written work, software does not enjoy copyright protection. Due to the requirement that copyright protection applies to the expression of a computer program in any form, algorithms and programming languages that involve ideas and principles do not enjoy copyright protection. Preparatory design work leading to the development of a computer program is considered a computer program provided that the nature of the preparatory work is such that a computer program can result from it at a later stage.

When a computer program can be patent protected or when it can enjoy copyright protection depends on what kind of problem it resolves. If a computer program resolves a business problem, it is protected by copyright. In the event it resolves a technical problem (and meets all other criteria for patent protection) it can be protected with a patent.

[7] The EPC is a multinational convention of which 38 member states participate in, including all 28 member states of the EU and other non EU member states [16].

[8] For the last 50 years, the EU's ambition to create a single, central court for the enforcement of European patents has been frustrated by the EPO's existence as an autonomous, international organisation outside the EU [16].

3.2 Employment and works made for hire

The ZASP stipulates that the employer or person ordering the work is entitled to all economic rights to a computer program if it is created by an employee in the execution of his duties or by an author under a contract for a work made for hire. Economic rights and other rights of the author to such a program are assigned to the employer or person ordering the work, exclusively and without limitations. In accordance with the applicable regulations, the employer or person ordering the work and the employee (author) may agree otherwise, which has also been confirmed by the Supreme Court of the Republic of Slovenia in judgement II Ips 552/2003 [20]. In practice, however, at least regarding computer programs created in the course of an employment relationship, the worker and employer tend not to agree otherwise in the employment contract. The Directive treats the transfer of economic rights to a created computer program the same way as the ZASP, but it deals only with computer programs created in the framework of an employment relationship, it does not regulate computer programs created under a contract for a work made for hire. There are significant differences between instances when a "classic" copyrighted work is created in an employment relationship, and when a computer program is created in an employment relationship.

The ZASP also accounts for instances when an employee creates a copyright work that is not a computer program, in the event of which it stipulates that economic and other rights of the author to this work are exclusively assigned to the employer for a period of ten years from the completion of the work (unless the parties agree otherwise in a contract). Upon the expiration of the term, the rights revert to the employee. However, the employer can claim a new exclusive assignment of these rights, for adequate remuneration. A worker who creates a computer program in the framework of an employment relationship is therefore in a disadvantaged position compared to workers who create other copyright work in the course of their employment.

Despite the copyright protection in place for computer programs, the Directive and the ZASP do not regulate the subject matter exclusively; they allow legal protection under other branches of law [21]. For computer programs, other branches include regulations on patent protection, trademarks, protection of competition, trade secrecy, etc. Due to this non-exclusivity, and the grey area between copyright and computer-implemented inventions, computer programs are therefore often protected as trade secrets and as know-how.

4. CONCLUSION

The status quo in the field of computer-implemented inventions, which are neither legally defined nor legally undefined in Slovenia and the EU, raises many open issues and provides opportunities for future work. In Slovenia it would make sense to examine at which stage TTOs can methodologically and substantively contribute to the examination and presentation of computer-implemented inventions at the level of the national patent office and to the examination of non-obvious combinations that constitute computer-implemented inventions under the ZIL-1-UPB3. At the level of the EU and Europe as a whole, it is necessary to examine how we may contribute to the creation of a legal basis that would ensure uniform patenting of computer-implemented inventions.

TTOs are tightly integrated into the work of organisations that produce inventions. First and foremost, we use our know-how to help researchers who create computer programs by verifying what kind of problem their program addresses and how a quality decision can consequently be made as to the protection of intellectual property (a copyright or patent).

All things considered, we believe that TTOs should at a minimum participate in public debates and present practical examples of researchers who develop computer programs at public organisations, thereby contributing to a constructive decision-making process on the future of the protection of computer programs. However, firstly TTOs have to recognise steps and phases where can TTOs provide methodological and practical support in processing and presentation of computer-implemented inventions at national and EU level.

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Strategic intellectual property management system for universities and scientific organizations for efficient technology transfer

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ABSTRACT

The technology transfer development is a strategic priority in the economies of many countries. For a successful and efficient technology transfer, a high-quality exchange process between science and industry must be established. In this publication author review the specifics of Intellectual Property management systems in higher education institutions. Universities and scientific organizations should strive not only to create patents with public funds and publish in top-rated journals, but also work efficiently with industrial partners to increase the commercialization level of their developments. For that purpose, it is necessary to create a specialized structure in the university – a technology transfer center – that could manage Strategic Intellectual Property by using specific documents that form unique ecosystem.

Keywords

Technology transfer, strategic intellectual property management, universities and scientific organizations.

1. INTRODUCTION

In modern world and Russian practice, the main developers of innovative technologies and suppliers of developments with the potential for commercialization are large universities, research centres and laboratories. Universities and research organizations are increasingly responding to the needs of the real sector of the economy for innovative developments by making changes to R&D plans. Developing towards a larger-scale participation of universities / research institutes in economic processes, offices and technology transfer centres contribute to building communications with other participants in research activities and subjects of the real sector of the economy, contribute to improving the quality of fundamental and applied research, and intensify the cooperation and integration interaction development. Based on fundamental scientific research, the results of the development of these institutions, having an applied focus, allow the companies acquiring them to form new strategic competitive advantages based on significant technological superiority [1]. Today, there is an aim on global and regional agenda to create the environment as well as the ways to make researches' results commercial, to make it possible having an income from the intellectual property. The universities should become the reliable providers of the specific intellectual products to meet the federal and industrial demand. In many strategies of scientific and technological development of countries, this aspect is qualitatively reflected – Russia [2], China [3], Germany [4], South Korea [5], USA [6]. It should also be considered the scientists' interest for publishing their researches' results and being fairly treated. The question of making the balance between scientists, universities and federal parties is not only to appear within one organization. Universities and educational organizations are actively engaged in creating new products, but there is often no systematic work on commercialization - there are questions about attracting industrial partners, setting up accounting for the result of intellectual activity and the amount of royalties pay out.

2. STRATEGIC INTELLECTUAL PROPERTY MANAGEMENT SYSTEM

These problems of technology transfer can be solved by Strategic Intellectual Property Management System (SIPMS), which helps to build the commercialization stage step by step. Speaking about the strategic priorities of such a system it should be working for the researches, university administration and industrial partners to make the mutually beneficial cooperation. This approach guarantees all the parties' interests to be considered and minimizes the risks to lose one's intellectual property. It can also help to build the researches' reputation, attract new employees, and, finally, meet the federal demand for using the knowledge for the national economy benefit.

There is a vital experience of such a system in Russia: National Association of Technology Transfer has a Project Group that organizes an intellectual property management system in higher education institutions [7]. The activities of this group are related both to the holding of events to popularize and involve in the work of the vice-rectors of universities responsible for innovations, as well as a wide range of experts in the field of technology transfer and all interested market participants, and to the implementation of a package of standard documents for the IP management in universities and research centres.

In preparing a set of National Association of Technology Transfer model documents, the Intellectual Property Policy for Universities and Research Organizations, adapted by WIPO and the Ministry of Education and Science of Russia, was used. Pilot implementation of the IP management system to the Lomonosov Moscow State University experience showed that IP management rules in the local regulations should be first consolidated. These regulations can be the Strategy and/or the Policy in the field of IP management. MSU version of such a document is the Provision on IP management, which latest revision was approved in 2018 [8].

Speaking of key strategic principles of the efficient functioning of the strategic system, implemented to the Lomonosov Moscow State University, legal certainty, fair income distribution, and stability could be mentioned. These principles are consolidated in the local regulations. The legal certainty principle implies the right holder to have all the results of intellectual activity certificated, all the rights transactions to be confirmed by entering into a contract and fulfilling its conditions.

According to the fair income distribution principle, the university pays costs to get and renew the patent, including the international ones. The income of the commercial using the intellectual property is shared as following: The authors receive 25%, the faculty – 40%, the university – 35% of the reward. The amount of payments to the authors can be extended by the head of faculty, using the funds which the faculty got in the specified order [8].

An important aspect of successful technology transfer on the part of the authors is associated with the motivational part. [1] For example, Higher School of Economics — National Research University pays 30% of net contractual income [9], Saint Petersburg State University pays 50% of net contractual income for using intellectual property [10], Ural Federal University [11] named after the First President of Russia B. N. Yeltsin pays up to 50% of the royalty income.

The stability principle means that authors should remain confidential and report the university about the intellectual activity result before there will be any information published. The university recourse usage makes intellectual activity result as the university's property. Commission on university IP approves the key deal's conditions, as well as the patenting geography. Earlier, the IP management process in MSU was decentralized and implied several departments' parallel participation. Faculties were responsible for many matters in the field of IP management (including special legal, patent, accounting matters). However, not all the faculties could afford employees from the field needed. That is why there came an idea to reconstruct the IP management system. Moreover, it was necessary to do the rights inventory, analyse the demand for current intellectual activity result and prospective for the ones at the application stage [8].

The new IP management system is working in MSU since 2014 when the decision was taken on the pilot system implementation. Russian Federal Service for Intellectual Property (Rospatent) expertly supported the pilot implementation. The system is constantly developing, considering changing legislation, application practice, and special ministries and departments' recommendations. For example, the Ministry of Economic Development of Russian Federation developed in 2014 [12] and finalized the Recommendations on results of intellectual activity (RIA) management [13]. In 2018, WIPO and the Ministry of Science and Higher Education approved the Policy in the field of intellectual property for universities and research centres [14].

The main chain of a system implemented in MSU is Centre of Technology Transfer. The main goals of technology transfer centres are to promote the development of cooperation chains between science and business, attract investment for the innovative projects implementation and the creation of consortia, commercialize the results of scientific and technical activities, meet transfer innovative developments to industry and the market [16]. Centre of Technology Transfer of Lomonosov Moscow State University is a "one-step" facility for both internal university work and processing external suggestions and external demand. It is staffed with employees in the field of intellectual property management (patenting, licensing, business development and legal issues) with various competencies that allow assistance in the promotion, development and practical application of the Moscow University developments in industry.

Strategic IP management system implementation helped MSU get significant results in two important rankings:

- National University Ranking (Innovations unit). There were 849 scores (8th place) in 2017, 805 scores (5th place) in 2018, and 774 scores (4th place) in 2019 [15].

- Invention Activity University Ranking (scores are summed). There were 57,9 scores (1st place) in 2017, 58,9 scores (1st place) in 2018, and 63,6 scores (1st place) in 2019 [17].

There are about 900 items in the overall MSU IP portfolio. There are also more than 30 valid license contracts made by MSU. At the same time, the income from RIA rights disposal multiply.increased. As a result of successful SIPMS implementation, the following information can be given:

11 licenses were issued with fixed payments for the current period and royalties for future periods;

legal support of transactions with industrial partners were undertaken;

119 notifications on disclosure of intellectual activity results were processed;

42 applications for inventions/utility models were submitted to Rospatent, 2 of them for international protection;

2 applications for industrial designs were submitted;

3 applications for University trademarks were submitted;

30 computer programs and databases submitted for registration;

received 55 patents for inventions/utility models;

received 37 certificates for computer programs and databases;

received 2 trademark certificates;

received 2 patents for breeding achievements [18].

There are also IP commission and Intangible Assets commission in the IP management architecture. The main chain of the system, NATT, is participating at all the stages of life cycle. At the first stage of the research, the Association approves the work conditions, announces the RIA creation, forms a document on its legal protection, and participates in making a request and applying for a patent. As all the actions mentioned above are made by one department, the amount of patent applications has raised up to 100 a year. That is 80% more that it was in 2014. After the grant of the patent, there is still commercial work to do. Be that we mean making additional research, communicating with appraisers, internal and external experts. As well as looking for partners, approving terms of the deals on RIA rights disposal, and controlling over university and developers treatment [8].

In conclusion, it can be noted that MSU has successfully implemented SIPMS, as evidenced by the results. It should be noted that such a system is effective for establishing systemic interaction between main participants in technology transfer, helps to set up a system work on commercialization and consolidate innovative offers for industrial partners. The presence of such system in technology transfer centres helps to work systematically even in the face of external challenges. The main SIPMS value is to reduce uncertainty, regulate liability and establish a standard business process. The presence of the same template for the industrial partner technological request makes it possible to create an innovative development catalog more effectively. Taking into account the professional competence of each university and its structural organization, SIPMS is easy to adapt and change. NATT specialists are currently implementing SIPMS at Sechenov University and D.Mendeleev University of Chemical Technology of Russia [8]. Using this experience, we can talk in the future about the possibility of scaling it in order to form the maturity of universities to introduce their developments into national and global industry.

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Strategic research and innovation partnerships as enablers of technology transfer

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ABSTRACT

Paper address the question of knowledge -transfer activities in the case of two (business and research-led) SRIP. SRIP- Strategic research and innovation partnerships is the form of collaboration between business sector, public research organizations (PROs) and other stakeholders introduced by Slovenian Smart Specialization Strategy. In the paper, we try to find similarities and differences in their positions, perceptions and approaches toward technology transfer, as well as challenges of this process on the level of SRIP as an instrument and on the level of Slovenian innovation system.

Keywords

Technology transfer, Smart Specialization Strategy of Slovenia, SRIP Strateško razvojna inovacijska partnerstva- Strategic development innovation partnership.

1. INTRODUCTION

With adoption of Smart Specialization Strategy of Slovenia (S4) in the end of 2015 (GODC, 2015a), a new form of collaboration between business sector, public research organizations (PROs) and other stakeholders was introduced. So-called Strategic research and innovation partnerships (known as SRIPs, GODC, 2015b) were established in all nine priority areas of S4, following a public call, issued by the Ministry of Economic Development and Technology in December 2016 (MEDT, 2016).

The 3 priority pillars of the Smart Specialisation (a) Digital, b) Circular and c. (S)Industry 4.0 have nine areas of application:

(i.) Smart cities and communities;
(ii.) Smart buildings and homes, including wood chain;
(iii.) Networks for transition into circular economy;
(iv.) Sustainable food production;
(v.) Sustainable tourism;
(vi.) Factories of the future;
(vii.) Health-medicine;
(viii.) Mobility;
(ix.) Development of materials as products.

The idea of the policy makers was to support the formation of a platform, similar to clusters, in each of the priority areas, based as a long-term public –private partnership. The members of SRIPs are to identify value chains within selected priorities (deepen the relatively general priorities) through providing fora for continuous entrepreneurial discovery process (EDP). SRIPs should provide an environment for cooperation in joint R&D projects of various type and enable innovation activity eventually leading to market penetration in S4 priority areas. The objective is to focus and coordinate both private and public investment in R&D and innovation, share capacities, both human and material, with the objective to raise competitiveness and value added in selected sector.

One of the tasks of SRIPs, as specified in documentation explaining the S4, is exchange of knowledge and experience as well as knowledge transfer (SVRK, 2015b). SRIPs should enable flow of knowledge among the members, from the PROs to business sector as well as among the business partners themselves (for example, from large to small and medium size enterprises). They should also enable the transfer of knowledge among the same stakeholders.

The implementation of this expectation of the policy makers, which was spelled out in the public call for the establishment of SRIPs, is the subject matter of our short paper. SRIPs were established in the fall of 2017 and their first mid- term evaluation/ monitoring was performed in 2019 (FDV, 2019).

The monitoring looked at the issues, specified in the public call:

- Implementation of the objectives in Action plans
- Progress in promotion of joint development and services, especially in cooperation and development of joint RRI initiatives to develop and market higher value-added integrated products and services;
- Introduction of horizontal enabling technologies within vertical value-added chains
- Implemented market manifestations, resulting from joint activities.

Mid-term monitoring of the SRIPs resulted in the report to the funders, where the successes as well as some of the problems in functioning of the SRIPs were identified. The main conclusion of the monitoring phase was that the SRIPs are a good instrument to support RIS3 implementation and that most of them have achieved an impressive level of cooperation among their members from different spheres (large and small companies, public research institutions and in some cases, also communities/ municipalities).

Since transfer of knowledge was not considered the primary task in the initial phase of working of SRIPs, the mid-term monitoring had not focused on this issue. Still, we believe it is important to examine how they approach this topic, if at all. To learn more about the position of SRIPs with regard to technology transfer, we designed a small questionnaire for two very different SRIPs: one is primarily business- dominated and the other with more pronounced impact of the public research organizations. Their views on the role of SRIPs as agents for technology transfer are presented in the next segment.

2. INDUSTRY-LED SRIP AND TECHNOLOGY TRANSFER

First, we wished to learn if the SRIP coordination office deals with the questions, relating to technology transfer, especially in view of relatively limited human resources. The answer revealed that the technology issues are mostly addressed at the level of Council of Experts, where new developments in their priority field are discussed, especially in the areas of interest to their members. The office itself has no capability to assist in the actual technology transfer deals; they do however monitor technology developments at global level and pass relevant information to the members. They see their role mostly in establishment of initial contacts between different members, where the office identifies potential for cooperation. Beyond this phase, they currently do not act.

The issue of transfer of technology is in the opinion of the office an important one for their members, but the SRIP can only help in raising the awareness and the promotion of the protection of intellectual property rights, sharing information on cases of successful transfer of knowledge to the market, but not with the actual process of transfer.

Explicitly, the members have not requested services or assistance with transfer of knowledge. They do take part in the events, organized by the Office, where experience and knowledge on the topic of various members is presented. The Office has also organized a set of workshops with one of the leading Slovenian expert on intellectual property rights protection. The workshops had sufficient attendance, but not exceptional, suggesting that the topic is not the most problematic in their industry.

The Office of SRIP sees itself primarily as an intermediary: their role is to monitor the trends in global industry, be well informed of the development plans and needs of their members and act as a matchmaker for the exchange of ideas and formation of joint R&D projects. Up to now, they have not identified specific barriers to transfer of knowledge or technology. They do, however, observe inactivity among PROs, especially research institutes in searching the contacts with industry. Here, researchers from the universities, especially younger ones, are more eager to cooperate with business. On the other hand, the research institutes wait to be approached by the industry and, often reluctantly, respond.

3. RESEARCH-LED SRIP AND TECHNOLOGY TRANSFER

The same set of questions as for industry- led SRIP, were directed to research-led SRIP. Regarding the question, related to technology transfer, we received an answer that coordinating office of SRIP is not dealing with knowledge transfer activities. They don’t have sufficient human and financial resources for this sort of services. However, PRO hosting the research-led SRIP has its own Technology transfer office (TTO), providing the services connected with knowledge transfer for their researchers. Yet, these services are available only for the PRO researchers and their customers.

From the side of research-led SRIP members, technology transfer is currently not recognized as a very important topic. Currently main cooperation form between SRIP business members and research organization are joint R&D projects, where intellectual property rights (foreground, background and side-ground) are agreed in advance and they are part of cooperation agreement signed before the project starts. In these projects, in most cases, industrial property rights become property of business partners. This is often the standard condition for cooperation between PRO and business entities in such projects, explained by the fact that the business partners contribute most of the co-financing. So far, research-led SRIP had no case of direct technology transfer, where the coordinating office would be directly involved.

As technology transfer is not recognized as a crucial topic/activity of the SRIP, SRIP coordination office does not detect special needs or requests from the side of SRIP members. Therefore, activities of SRIP coordination office are oriented mainly toward awareness raising and trainings of members through special events and thematic workshops. Research-led SRIP coordination office sees the opportunity for a more active role of SRIP in the technology transfer only if the main stakeholders would request such service, as SRIP itself at the moment has no planned resources for technology transfer.

Research-led SRIP coordination office also detects some obstacles, which prevent transfer of knowledge and technology. In the first place, they point to a relatively complicated and long lasting procedures for knowledge transfer, which demand specific and high professional knowledge in different areas. Secondly, as procedures are mainly focused on financial part of transfer (i.e. licenses or patents costs), this is not found as highly stimulating, especially for Spin-out companies. Third: legally very complicated procedures for knowledge transfer in most PRO, especially universities, requiring a long list of approvals, discourages the process. The SRIP sees solution in changing the current, very restrictive legislation. In order to simplify and standardize these procedures, SRIP suggests preparing Toolbox for SME members in order to help and support them in such procedures.

4. DISCUSSION AND CONCLUSION

With both types of SRIPs, we can find some similarities and common issues: to the first question on the engagement of the SRIP coordination offices in transfer of technology, both pointed out the lack of human resources with specific knowledge and competencies in the field of technology transfer. This is the main reason why they cannot play the role of technology broker. However, this issue does not seem to represent significant problem as this role is also not expected from their members. From the side of SRIP members, the role of SRIP office is not seen in the field of TTO.

Secondly, policy maker, at the time of establishing SRIPs, listed a long range of tasks for the SRIP offices, obviously with the expectations that the SRIP member will be prepared to finance all these tasks. Common rule of 50% public co-financing of the SRIP office activities does not allow them to strengthen the technology transfer activities. On the other side, there is no specific need expressed by the members for SRIP offices to enter the field of technology transfer, which requires a very specific and high professional knowledge. Often, this knowledge and resources already exists at the PRO and universities in the form of existing Technology transfer offices. Most business enterprises, with experience in joint R&D projects, have their in-house capabilities to address the issues of intellectual property rights. The question arises as to what is the situation in SMEs and whether in the case of their more active involvement in joint projects they would benefit from the assistance of the coordination office of SRIP. Here, we see the opportunity for strengthening technology transfer service from the side of SRIP members, coming from the public research community. They should invest more energy into informing SRIP business partners regarding their own R&D work and potentials, of course if they are motivated to more actively transfer their knowledge and technologies. Also, the services in the area of technology transfer, which were developed with public money within PROs, could be offered to SMEs as well.

As we see, the issues identified in the previous studies (Bučar and Rojec, 2019) on knowledge/ technology transfer have not been addressed by SRIPs either. These issues are actually long-term challenge for Slovenian innovation system, which cannot be solved by one, single, time-limited action. The issue requires several systemic changes in different areas, from bridging the gap in understanding the objectives of R&D for PRO and those of business entities. One of the solutions is a permanent long-term, sufficient and clear support of the government to the instruments like SRIP and TTO's.

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The awareness on environmental protection issues as reflected through the inventions

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ABSTRACT

The present study aimed to get the insight into specific environmental issues associated with key enabling technologies and to identify the environmental protection related niche areas of the highest potential for growth to which the future technology transfer activities should focus on. Analyses of environmental related inventions in terms of absolute numbers and their shares within the technology fields of electronics, materials, biotechnology and power sources were based on the annual data for the last decade. The shares of environmentally oriented inventions at the fields of electronics, materials, biotechnology and fusion power over the last decade remained as low as 1%, 5%, 9% and 2%, respectively, indicating low market demand for environmental applications. On the contrary the shares of inventions related to green power sources increased from 54% to 60% over the last decade, most probably due to intragovernmental actions on reduction of carbon dioxide emissions that took place over the last decades. Similar actions should be implemented promptly in order to support the innovativeness and technology transfer related to management of electronic and material waste in the following decades.

Keywords

Technology transfer, environmental protection, key enabling technologies, electronic waste, recycling, recovery, metals, rare earths, batteries, fossil fuel, fusion, nuclear, green power generation.

1. INTRODUCTION

Key Enabling Technologies (KETs) – a group of six technologies: micro and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics, and advanced manufacturing technologies – increase industrial innovation to address societal challenges and creating advanced and sustainable economies [1]. In addition to having the highest potential for growth at the global markets the KETs have several applications related to the environmental protection, but there are also certain environmental issues associated with KETs at various fields.

Information technology is important for the growth of any country, but with the sudden development of new TV sets, smartphones, computers and their relatively short lifespan, the accumulation of waste electronics is increasing. Waste electrical and electronic equipment contains toxic substances that may leach into the ground and emissions that may escape into the air when disposed. Direct environmental impacts are the release of acids, toxic substances and heavy metals and carcinogenic chemicals [2].

In developed countries, formal sectors for e-waste management are being established, which take care of manual disassembly followed by semi-automated separation of various materials from which further attempts are made to recover metals using "state of the art" methods in smelters and refineries. In underdeveloped countries, equipment disassembly and separation of materials is manual, and the recovery of metals is made by heating, burning, and acid leaching of e-waste scrap in small workshops causing additional damage to environment [2].

Many batteries still contain heavy metals such as mercury, lead, cadmium, and nickel, which can contaminate the environment and pose a potential threat to human health. Batteries represent a complete waste of a potential and cheap raw material, when improperly disposed. In addition, battery recycling is not feasible from economic point of view. However, nanotechnologies could provide more economical battery recycling in the future [3].

Nanotechnologies are also used in radioactive waste clean-up in water, direct seawater desalination and disinfection by using nanochannels and nanopores, oil and water separation, detection of pollutants, carbon dioxide fixation, artificial photosynthesis, photocatalytic degradation of organic pollutants in waste waters, superhydrophobic and intelligent construction materials etc. [3].

In biotechnology, biological treatment plants are well known for removal of organic impurities in solid, liquid and gaseous form and removal of heavy metals from waste materials. An important application of environmental biotechnology are also biosensors enabling biomonitoring, including monitoring of biodegradability, toxicity, mutagenicity, concentration of hazardous substances, and monitoring of concentration and pathogenicity of microorganisms in wastes and in the environment [4].

Photonics have enormous potential of reducing the greenhouse and non-greenhouse gas emissions by reducing the electricity consumption from traditional energy sources [5]. Photonics have already significantly contributed to climate protection by applications such as energy saving light bulbs and LED lighting, photovoltaics and communication via fibre optic networks. Other environment protection related applications of photonics are at the moment in the beginning of their growth trajectory and include early detection of forest fires, laser-supported metal recycling and optical communication in 5G mobile networks [5].

In best case scenario, the introduction of automation will have a positive impact on the environment: greenhouse and non-greenhouse gas emissions will be reduced as well as the use of natural resources. However, automation will lead to increased electricity consumption, so the impact of increased automation on the environment depends primarily on how society will cope with the replacement of "dirty" energy sources. In worst case scenario, automation at the expense of increased electricity consumption would lead to increased greenhouse and toxic gas emissions and increased consumption of natural resources, increased consumption of rare materials for building electronic equipment and increased electronic waste [6].

In addition to the growing need for recycling, recovery and regeneration due to lack of natural resources there is also a growing need associated with the electric power generation [7]. In particular, the source of electricity will determine the extent of damage that power generation will cause to the environment. Primary energy sources such as crude oils, coal and natural gas exhibit the highest amounts of greenhouse and toxic gases and should be reduced on behalf of the increased use of nuclear [8] and presumably fusion [9], hydro power and especially green power sources such as geothermal, wind, solar and bio energy [7].

Environmental protection related inventions will benefit the society and benefiting the society should be the main and only morally acceptable focus of public as well as private entities.

In this study, we examined the emergence of patent documents related to environmental protection at the fields of electronics, materials, biotechnology and power sources. We hypothesized: (i) that environmental applications should account for about half of all innovations now days; (ii) that the share environmental applications had grown sharply over the past decade.

The aim of this study was to search for the guidelines for future technology transfer based on the occurrence of environmental related inventions at the mentioned main fields of technologies and identifying the environmental protection related niche areas of the highest potential for growth to which the future technology transfer activities should focus on.

2. METHODOLOGY

The results of this study are based on comparison of the occurrence of patent documents between the general key enabling technology (KET) areas and its sub-areas related to environmental protection applications (e.g. area of "electronics" compared to its subarea "electronic waste") within the priority period from 2008 until 2018. Since the content of patent applications is normally confidential for the first 18 months after the priority date, the priority period 2008-2018 is quite well reflecting the known prior art of the last decade (June/July 2010 to June/July 2020). This paper was written in August 2020.

Keywords denoting different areas and subareas within KETs were selected based on the known literature considering the widest possible coverage of technology fields: The keyword (*electronic*) was selected to cover electronics, micro- and nano-electronics; the keyword (*material*) was selected to cover materials and advanced materials as well as micro- and nano- materials and consequently a certain range of nanotechnologies; the keyword (*bio*) was used to cover biotechnology.

Various combinations of keywords referring to metals, rare earths and batteries were selected rather than those referring to advanced production and photonics. According to the literature the natural resources such as metals and rare earth elements and magnets are often a limiting factor of advanced production, electronics and photonics sectors. For the purpose of this study batteries were classified among the materials although in reality the field of batteries is rather interdisciplinary representing the intersection between electronics, materials, chemistry, advanced production, photonics and energy conservation.

Fusion as the potential new power source and traditional power sources such as nuclear and fossil fuel were compared to green power sources such as hydro, wind, solar, geothermal and bioenergy.

The analyses was performed using PatBase [10] in August 2020. The exact keywords and combinations with basic Boolean operators and symbols are listed under the PatBase queries in Table 1. The PatBase search was set to search within titles, abstracts and claims (TAC) which are usually available in English language after publication by majority of national patent offices. Priority date (PRD) field was set to search within a certain year. In Table 1 the PRD was set to year 2018 for all the queries and the results were further analysed by PatBase analyticsv2 providing the numbers of filed, granted and published patent families, top five assignees and top five jurisdictions. Ten separate searches for data on the number of patent families without further analysis with PatBase Analytics v2 were performed for each of the priority years from 2008 to 2018 and graphically presented on Figure 1 and Figure 2. The calculations in Table 2 are based on the same dataset as Figures 1 and 2. Tables and Figures were prepared by Microsoft Excell software. Whenever average values were calculated the corresponding standard deviations are presented next to the average values (e.g. average value ± standard deviation).

There were 651.578 patent families for the query "TAC=(*material* and PRD=2018:2018)". PatBase analyticsv2 is capable of analysing up to 250.000 patent families at once. In order to maintain the comparability of results and for the reasons described in the previous paragraphs of this section, only the areas of metals, rare earths and batteries and their corresponding environmental protection related subareas were included into the analysis.

3. RESULTS

The patent families (Table 1 and 2, Figures 1 and 2) having priority filing dates in 2018 were published in summer 2020 and therefore represent the latest known prior art in the time this paper was written. Approximately half of the patent families filed in 2018 were granted by at least one jurisdiction and each of them was published by approximately five different jurisdictions. The term "invention(s)" will be used in the following text referring to the filed, granted and published patent families at the fields of Electronics, Materials / Chemistry, Biotechnology and Power Sources.

Table 1: Number of filed, granted and published inventions (patent families) and top five assignees and jurisdictions based on the specific PatBase queries denoting wide areas (white background) and environment protection related sub-areas (shadowed background) within the technology fields.*

Technology Fields	Areas and Sub-Areas	PatBase query	Patent families filed	Patent families granted	Patent families published	Top five assignees	Top five jurisdiction
Electronics	Electronics	TAC=(*electronic*) and PRD=2018:2018	174.737	88.457	577.376	Samsung Electronics Co. Ltd GuangDong Oppo Mobile Lenovo Group Ltd Qualcomm Inc Apple Inc.	China P. Rep. USPTO WIPO Japan EPO
	Electronic waste	TAC=(*electronic* AND *waste*) and PRD=2018:2018	2.332	1.170	12.229	Ford global technologies Alibaba Group holding Ltd. Beijing Qihoo Tech Co. Ltd Netease Hangzhou Networl Co. Ltd Univ. Shanghai 2ND Polytechnic	China P. Rep. WIPO USPTO EPO Japan
Materials	Metal	TAC=(*metal*) and PRD=2018:2018	218.502	108.249	757.025	Taiwan Semiconductor MFG Co. Ltd Samsung Electronics Co. Ltd Intel Corp; LG Chemical Ltd. BOE Technology Group Co. Ltd	China P. Rep. USPTO WIPO Japan EPO
	Metal recycling	TAC=(*metal* AND (recover* OR recycl*)) and PRD=2018:2018	9.587	4.285	54.242	Exxon Mobil Corp. Univ. Kunming Science and Tech Univ. Central South UOP LLC BASF SE	China P. Rep. WIPO USPTO EPO Japan
	Battery	TAC=(batter*) and PRD=2018:2018	145.739	82.062	331.599	LG Chemical Ningde Contem… Sonoef Hefei Tech Hefei Guoxuan Bosch Gmbh	China P. Rep. USPTO WIPO Japan South Korea
	Battery recycling	TAC=(batter* and (recycl* or regenerat*)) and PRD=2018:2018	2.484	1.087	9.221	Toshiba KK Bosch Gmbh Toyota Jidosha KK Honda Motor Co. Ltd Toyota Motor Corp.	China P. Rep., USPTO WIPO Japan EPO
	Rare Earths	TAC=(rare AND earth* AND (magnet* OR element*)) and PRD=2018:2018	2.971	985	13.769	TDK Corp. Nichia Corp Hitachi Metals China Petroleum Univ Jiangxi Scientific	China P. Rep. USPTO WIPO Japan EPO
	Rare Earths recovery	TAC=(rare AND earth* AND (magnet* OR element*) AND recover*) and PRD=2018:2018	164	60	1.223	Sabic Global Technologies BV Exxon Mobil Corp. Univ Jiangxi SCI and Technology Inner Mongolia Jarud Banner Luan Commissariat A Lenergie Atomique	China P. Rep. WIPO USPTO EPO Canada
Biotechnology	Biotechnology	TAC=(bio*) and PRD=2018:2018	99.862	37.244	497.744	IBM Samsung Electronics Co. Ltd Univ. California Univ. Jiangnan Univ. South China Tech.	China P. Rep. WIPO USPTO EPO Japan
	Bio waste treatment	TAC=(biotreat* OR Biodegrad* OR bioaugment* OR biosens* OR biomonitor*) and PRD=2018:2018	7.208	2.566	42.793	Univ. Jinan Univ. Tianjin Univ. California Univ. South China Tech. Univ. Zhejiang	China P. Rep. WIPO USPTO EPO South Korea
Power sources	Fossil Fuel	TAC=(power AND (crude* OR coal OR gas OR fossil)) and PRD=2018:2018	27.824	15.535	110.970	Tokyo Electron Ltd. Applied Materials Inc. Toyota Jidosha KK United Technologes Ltd. Huaneng Clean Energy RES Inst.	China P. Rep. USPTO WIPO EPO Japan
	Nuclear	TAC=(nuclear AND power) and PRD=2018:2018	3.214	1.739	11.245	China General Nuclear Power China General Nuclear Power ENG Cnnc Nuclear Power MAN Co. Ltd. Jiangsu Nuclear Power Corp. China Nuclear Power Design Co. Ltd.	China P. Rep. WIPO USPTO South Korea Japan
	Fusion	TAC=(fusion AND power) and PRD=2018:2018	1.512	708	17.226	State Grid Corp. China Hewlett Packard Development Co. Siemens AG Saint Gobain SA Corning Inc.	China P. Rep. WIPO USPTO EPO Japan
	Green	TAC=(power AND (hydro* OR wind OR solar OR geothermal OR bio*)) and PRD=2018:2018	48.465	27.245	167.115	State Grid Corp. China Beijing Hanergy Photovoltaic Invest Beijing Boyang Dingrong PV Tech Beijing Goldwind Science and Hanergy Mobile Energy Holding	China P. Rep. WIPO USPTO EPO Japan

** PatBase queries were based on the keywords to be searched in titles, abstracts and claims (TAC) across the patents and patent applications having priority date in 2018 (PRD=2018:2018). Analyses were performed using PatBase in August 2020. Priority patent applications are published after 18 months from the priority date. The represented data therefore reflects the present known state of the art.*

There is a correlation between number of filed, granted and published patent families within the categories of Table 1. Average ratio of number of granted and filed patent families was 0,46 ± 0,08 and the average ratio of number of published and filed patent families was 5 ± 2. The results in the following Table 2 and Figures 1 and 2 are based on the filed patent family data.

The queries referring to technology field of Materials have jointly contributed the highest number of inventions filed in 2018 followed by the fields of Electronics, Biotechnology and

Power. The situation is different when comparing environmental protection subareas within the general technology fields. The highest number of environmental related inventions is the subarea Green followed by Metal recycling, Bio waste treatment, Battery recycling, Electronic Waste and Rare Earths recovery subareas representing the descending order of Power, Materials, Biotechnology and Electronics fields in terms of the number of inventions (Table 1). A similar order in the number of inventions by field has been observed over the past decade (Figures 1 and 2) with the exception in the field of Batteries and Biotechnology. In 2008 fewer Battery related priority patent applications were filed as compared to Biotechnology, but from 2015 onwards the field of Batteries exceeded the field of Biotechnology by the number of inventions due to presumed exponential growth (R2 = 0,98) of Battery related inventions (Figure 1). However, in general the number of inventions within all areas has been growing over the priority years 2008 – 2018 (Figures 1 and 2, Table 2). Moreover, the number of inventions in general areas of technology as well as the number environmental related inventions were growing proportionally resulting in similar proportions of environmental related inventions within the general areas in 2008 and 2018 (Table 2).

The proportion of environmental related inventions within the general fields of Electronics, Materials and Biotechnology was low, ranging from 1% up to 10%, throughout the whole priority filing period 2008-2018. The said proportions have slightly increased over time except the proportions of Bio waste treatment related inventions, which dropped from 10% to 7% from 2008 to 2018, respectively. On the contrary, the proportion of Green Power within the field of different Power sources was higher than 50% in 2008 and increased to 60% in 2018 (Table 2, Figure 2).

Top five assignees are presented for each of the areas listed in Table 1. Some of them are active in more than one area at the same time: Samsung Electronics in areas of Electronics, Metals and Biotechnology; LG Chemical in areas of Metals and Rare Earths; Exxon Mobil Corp. and Univ. Jiangxi Scientific in area of Rare Earths and Rare Earth recovery; Toyota Jidosha KK in area of Battery recycling and Fossil fuels; University of California in Biotechnology and Bio waste treatment and State Grid Corp. China in areas of Fusion and Green Power Sources. The top assignees listed under the general areas usually differ from the ones listed under the environmental protection related subareas (Table 1).

In general, based on the number of published inventions the top five jurisdictions were China, America, Europe and Japan appearing in descending order. South Korea is classified among top five jurisdictions in the areas of Batteries and Bio waste treatment and Nuclear Power sources displacing European, Japan and European jurisdictions from the top five jurisdictions at the said areas, respectively. Canada displaced Japan among the top five jurisdictions at the field of Rare Earths recovery.

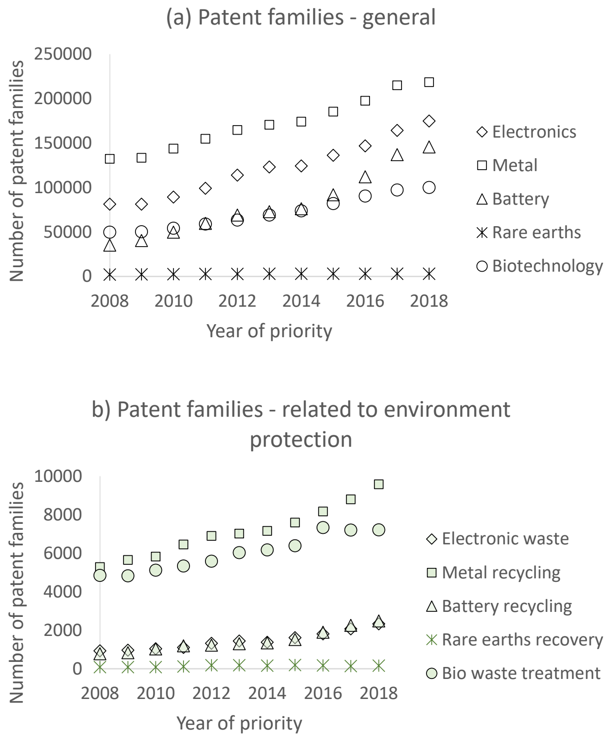

Figure 1: Number of inventions (patent families) with priority dates ranging from 2008 to 2018 referring to: (a) general areas of Electronics, Materials - including metal, rare earths and batteries - and Biotechnology; (b) environment protection related sub-areas of electronic waste, recycling or regeneration of materials - metal, rare earths and batteries - and bio waste treatment.*

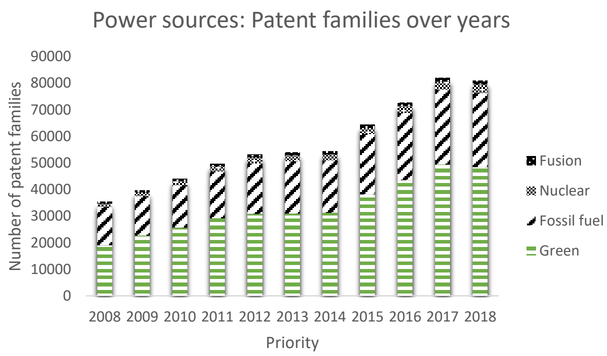

Figure 2: Number of inventions (patent families) with priority dates ranging from 2008 to 2018 referring to different power sources: fusion; nuclear; fossil fuel including crude oil, coal and gas; and green including hydro, wind, solar, geothermal and bioenergy sources.

**Analyses were performed in August 2020 using PatBase [10] and PatBase queries listed in Table 1.*

Table 2: Absolute numbers of general and environmental related inventions (patent families) filed in 2008, 2018 [Nr.] and the proportions [%] of environmental related inventions (patent families) filed in 2008 and 2018 and the 10-year average (Avrg) proportion with corresponding standard deviation (stdev).*

Environmental related subareas		General areas		Number and percentage of environmental related patent families in priority years: 2008 [Nr.]				2008 [%]	2018 [Nr.]				2018 [%]	2008-2018 Avrg		Stdev
Eletronic waste	:	Electronics	=	928	:	81266	=	1,1%	2332	:	174737	=	1,3%	1,2%	±	0,1%
Metal recycling	:	Metal	=	5284	:	132352	=	4,0%	9587	:	218502	=	4,4%	4,1%	±	0,1%
Battery recycling	:	Battery	=	776	:	35109	=	2,2%	2484	:	145739	=	1,7%	1,8%	±	0,2%
Rare Earths recovery	:	Rare Earths	=	88	:	2123	=	4,1%	164	:	2971	=	5,5%	5,0%	±	1,0%
Bio waste treatment	:	Biotechnology	=	4850	:	49774	=	9,7%	7208	:	99862	=	7,2%	8,6%	±	0,9%
Green Power	:	Power	=	19023	:	35513	=	54%	48465	:	81015	=	60%	58%	±	2%

*data on the number of patent families for individual filing years 2008-2018 are represented at the Figures 1 and 2. The PatBase queries referring to the keywords shown in Table 1 were combined with the priority dates (PRDs) ranging from 2008 to 2018 reflecting the known prior art from 2010 to 2020.

4. DISCUSSION

The results indicate that the shares of environmental applications account for less than 10% of all innovations in the fields of electronics, materials and biotechnology now days and there was no sharp growth of the shares of environmental applications observed over the past decade in these fields (Table 2 and Figure 1), which is not consistent with any of our introductory hypotheses. On the other hand, in the field of power sources the environmental applications account for more than half of all inventions, while their share grew from 54% to 60% over the past decade, which is consistent with the hypotheses.

A possible explanation for extremely low share (approximately 1%) of inventions in the field of "electronic waste" within the wider field of "electronics" could be due to inappropriate methodological approach - choosing too secular keyword for the analysis (as explained latter this was not the case). Electronic waste is indeed a mix of different materials and its recycling is therefore closely linked to the recycling of various materials including metals, rare earths and batteries [2]. Interestingly, Samsung Electronics did not only appear among the top five assignees in the field of its core business (electronics), but also in the field of metals, which is not surprising, since Samsung is investing in the development of metals (e.g. semiconductors), which are an integral part of electronic devices they are producing [11].

However, the proportions of inventions related to recycling, recovery and regeneration of metals, rare earths and batteries were low as well, amounting approximately 4%, 5% and 2%, respectively. And the top five assignees in the general areas of electronics, metals, rare earths and batteries were mostly different to those associated to the subareas related to recycling, regeneration and recovery of these products.

With electrification of transport and growing demand for natural resources, the need for batteries and battery recycling is growing sharply, which explains the presumed exponential growth in terms of the number of inventions in this area. It is not surprising that representatives of automotive industry and/or auto parts suppliers Toyota, Honda and Bosch are among the top five assignees in the subarea of battery recycling. It seems that national programs need to become involved to support the recycling of products, otherwise these activities would not be economically feasible for large corporations. For example, Toshiba, Panasonic and Sharp funded an Electronic Manufacturers Recycling Management Company (MRM) in 2007 and Toshiba as the top assignee in the field of batteries is also a partner of the Rechargeable Battery Recycling Corporation (RBRC) under the national U.S. Call2RecycleTM program dedicated to recycling of batteries [12].

Surprisingly, two large IT corporations Samsung and IBM appeared in the general area of Biotechnology, most probably due to their activities in healthcare and life sciences, such as computational biology [13] and pharmaceuticals [14]. However, the Bio waste treatment subarea was dominated by universities. Universities of California and South China appeared among top five assignees in both, general Biotechnology area and Bio waste treatment subarea as well. In addition to the absence of large corporations at the subarea of “Bio waste treatment”, the average proportion of “Bio waste treatment” related inventions has decreased from 10% to 7% over the last decade.

Technology transfer in the field of environmental solutions is often unsuccessful because, as evidenced by the low proportions of environmental inventions in this study, market interest in environmental technologies is low. As a result, a negative feedback loop arises: (i) Environmental solutions are not a priority to companies, since they present financial loss rather than profit to them. For example, the introduction of recycling of products in parallel with the production would drastically affect the price of products and consequently the competitiveness; (ii) Public research organizations, which are supposed to be a driver of innovation and the well-being of society are trying desperately with the commercialization, but they sooner or later stop with patenting of environmental solutions due to the low probability that these technologies will be licensed out to companies. Therefore, it would be illusory to expect that the corporations mentioned in this study - in other words the largest producers of waste and pollution - will begin to change their attitude towards the environment on their own [15].

As mentioned in the introduction, photovoltaics and other photonic applications will contribute to reduced electricity consumption and consequently lower greenhouse gas emission [5]. On the other hand, advanced production will increase the consumption of electricity and presumably increase the greenhouse gas emission [6]. Switch to green power sources is therefore extremely important [7]. However, it is necessary to understand that the power generation from green sources is less reliable due to low capacity potential and dependency of momentary environmental parameters. Therefore, complete transition to green sources is most probably not possible and the need for reliable power sources, such as fossil fuels and nuclear power will remain [8].

Fusion power will be able to replace environmentally harmful energy production with fossil fuels in the future, if successful [9], but decades will pass by then. This is also evident from the number of inventions related to fossil and nuclear power sources, wherein a number of inventions related to less environmentally friendly fossil fuel was approximately nine times higher as compared to cleaner nuclear and fusion power sources. However, the major concept of the vast majority of fossil fuel inventions was related to carbon dioxide according to PatBase Analyticsv2 [10], indicating that research and development in this area is mainly concerned with optimizing fuel use towards lower carbon dioxide emissions, which is admirable.

Even more favorable trends were observed in the field of green power at which the share of inventions was high and has grown from about 54% to 60% in the last decade. These data are encouraging in terms of reducing the global warming, environmental pollution and health hazard originating from "dirty" power sources, which gives optimistic forecast for the future.

A kind of "push" obviously exists at the energetics sector that forces states, governments and consequently all kinds of private and public entities including the players of innovation ecosystem to deal with environmental issues. This might be not only due to a lack of natural resources, but also due to clear rules at international and intergovernmental level, which oblige countries to respect the environment globally. The 1997 Kyoto Protocol, which has been in force since 2005 and replaced by the Paris Agreement in 2015 [16] seems to play a key role encouraging innovation towards the use of green energy sources by reducing the carbon dioxide emission [7].

Despite the fact that some countries do not respect the Kyoto Protocol and later Paris Agreement, it still is a good practice as it has - by insisting on solving climate problems at the international and intergovernmental level - created markets for green power sources around the world. Even China for example, which has often been declared a non-Kyoto country, is active producer of the equipment related to exploitation of green power sources – most probably due to the existence of global market as well as due to its own awareness on the environmental issues in the last decades [17]. Environmental issues associated with the "dirty" power sources are decades old and have been consequently addressed more in detail by the relevant authorities as compared to newer environmental threats (e.g. electronic waste, batteries, rare earths, metals etc.).

The establishment of the UN E-Waste Coalition and the introduction of the Platform for Accelerating the Circular Economy (PACE) [18] will hopefully lead to at least as effective international protocols in the field of electronics and waste material recycling as were established in the field of power sources. Measures that would encourage companies to protect the environment should therefore apply to all companies and all countries in order to maintain healthy competition between them. Once such a global pressure will be established, new markets will appear committing the private and public entities to become innovative also at the field of environment protection.

Technology transfer within the innovation ecosystem is a part of the solution, but unfortunately it works well in case of clear demand for breakthrough technologies at the market. In the field of alternative energy sources, intergovernmental agreements have emerged over the decades, creating such a demand for technologies enabling the exploitation of alternative power sources. This can be observed by the high number and shares of inventions in the field of green power sources.

However, the need in the market has yet to be created for technologies dealing with recycling of waste electronics and waste materials. And it is illusory to expect that this demand will arise on its own without adequate political support to put pressure on manufacturers globally. The task of the innovation ecosystem stakeholders is therefore to properly present these problems to the interested public, through which the pressure to the policy makers will be exerted. In fact, it would be great, if the solution in the field of electronic waste and waste materials management would be even more efficient and implemented faster than in few decades.

5. CONCLUSIONS

Although the number of inventions has generally increased over the past decade, the share of environmentally oriented inventions has not changed at the fields of electronics, materials and biotechnology, and has remained on average as low as 1%, 5% and 9%, respectively.

Large corporations leading at the areas of electronics, materials and biotechnology are not as innovative and active at the subareas related to the recycling of their own products, therefore they should refocus and invest into the environmental protection. In order to do so, legal basis, programs and incentives for non-profit recycling at national, international and global levels are beneficial.

On the contrary, the situation is more optimistic in the field of electric power generation, wherein the share of inventions related to green power sources grew from 54% to 60% in the last decade suggesting that technology transfer works well in case of clear demand at the market. In the field of alternative energy sources, intergovernmental agreements have emerged over the decades, creating such a demand for technologies related to exploitation of green power sources.

The players of innovation ecosystem should therefore convince and support the interested public to exert the pressure to the policy makers in order to create a market demand for the technologies dealing with recycling of wastes, especially electronic and material waste through establishment of intergovernmental agreements on the global scale.

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Transfer of knowledge and skills in STEM: Exploring and promoting digital analysis skills - Testing optimal conditions of X-ray irradiation

Prenos znanja in veščin na področju STEM: Raziskovanje in promocija digitalnih veščin: Testiranje optimalnih pogojev rentgenskega obsevanja

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ABSTRACT
In this paper, we describe the transfer of knowledge and skills between the High school and University system in establishing of a digital environment for analytics in physics experiments. ICT skills are essential in establishing the potential for automated or digital analysis in the observation of physics experiments. We have proven that this claim is valid in the case of X-ray detection on a imaging phantom. We photographed an irradiated imaging phantom under different initial conditions and tried to compare results with each other in terms of different output parameters as optimal voltage used and signal to noise ratio. With the help of independently created automated Python software for the RGB analysis of the images and using analytical tools as Root and Logger Pro programmes, we showed that collaboration between the two educational systems is crucial for the transfer of knowledge and skills.

Keywords
Digital technologies, digital skills, data analysis, STEM, X-ray detection, imaging, observation

POVZETEK
V tem prispevku opisujemo prenos znanja in veščin med gimnazijo in univerzitetnim sistemom pri vzpostavitvi digitalnega okolja za analitiko v fizikalnih eksperimentih. IKT spretnosti so bistvenega pomena pri ugotavljanju možnosti avtomatizirane ali digitalne analize pri opazovanju fizikalnih eksperimentov. Dokazali smo, da ta trditev velja v primeru rentgenskega zaznavanja na slikovnem fantomu. Fotografirali smo obsevan fantom za slikanje v različnih začetnih pogojih in poskušali med seboj primerjati rezultate glede na različne izhodne parametre kot sta optimalna uporabljena napetost in razmerje signal / šum. S pomočjo neodvisno ustvarjene avtomatizirane programske opreme Pyton za RGB analizo slik in z uporabo analitičnih orodij kot sta programa Root in Logger Pro smo pokazali ključno soodvisnost med obema sistemoma izobraževanja za namen prenosa znanja in spretnosti.

Ključne besede
Digitalna technologija, digitalne veščine, analiza podatkov, STEM, rentgensko zaznavanje, slikanje, opazovanje

1. INTRODUCTION
In today's world, knowing digital approaches is increasingly crucial. On the other hand, the relationship between the various branches of science - chemistry, physics, computer science - even in the education system itself is still in its infancy. Interdisciplinarity and cross-curricular integration depend on individual initiatives. Particularly noteworthy is the link between information technology and science education to motivate young people to STEM content. In this context, digital skills are crucial for establishing closer links between science and education. We presented one of the options in our paper.

In this paper, we describe an experiment done in collaboration between the International Baccalaureate at the Gimnazija Bežigrad and the Faculty of Physics and Mathematics of the University of Ljubljana. The aim of this experiment was twofold: firstly, to explore how changing the voltage affects different image quality properties in X-ray Imaging phantom detection; secondly, to explore how and to explore digital tools necessary to execute the experiment as a regular study and collaboration tool. The experiment and its data analysis allows for an exploration of digital tools in STEM experiments and can represent a good basis for further collaboration between the institutions.

The crucial element of this work was to establish a collaboration that would enable the realization of the goal. The goal of this research was to prove the correlation between the voltage applied to the X-ray apparatus and the image quality of the recorded picture. We were also exploring the impact of the distance between the fluorescent screen and the phantom irradiated by the x-ray apparatus on the intensity of the light measured.

The experiment conducted is based on the theory of X-rays. The rays are produced by an apparatus, where a certain voltage is applied to a X-ray tube that accelerates the electrons towards the molybdenum's anode. The x-ray beams are the result of the interaction of electrons with matter. They are shielded by a collimator so that can only exit the sources at a certain spatial angle.

The detection of X-rays was achieved by taking a picture of a fluorescent screen [1], which emitted fluorescent green light when hit by x-rays, with a camera. The acquisitions had to be taken in complete darkness with a long exposure time to enable enough light to accumulate on the sensor.

After the data was converted to numerical form, a double error function was fitted on the 2D response image. The parameters, which I received as an output, were then used in the analysis.

2. METHODS
The experiment was performed at the University of Ljubljana, Faculty of Mathematics and Physics. I used the experimental equipment for the X-ray exercise of the subject Laboratory experiments V [2].

The detection of the x-ray particles was double-phased. The apparatus used to produce x-rays was "Didaktiksysteme 554811" [3]. The first part of the experiment was acquiring data in the form of captured photos, whereas the processes and techniques employed further on my research are analytical and systematical.

However, there is a second segment of activities embedded in this paper. It presents a proposal for technology transfer between different parts/sectors of the educational system. In particular, the paper proposes to enhance the capabilities of high schools by giving them access to digital tools that can only be found on the university level, but which could potentially be utilized by high school students.

2.1 Transfer of knowledge from one to the other educational environment

It has soon become clear that without digital tools the observation of the processes taking place in the imaging phantom and the setup as a whole would be impossible on the level of accuracy requested to draw reliable conclusions.

Thus the second aim of the study was to use existing and to develop missing digital tools to enable RGB analysis of the images taken.

These tools were developed with the assistance of the experts from the University of Ljubljana, Faculty of Mathematics and Physics and Jožef Stefan Institute.

The main purpose of the collaboration was to enable quick, accurate and reliable analysis.

On the other hand, the process at hand demanded that a knowledge transfer in terms of technologies used and skills that enable analysis, to be transferred from one educational environment to the other, to enable analysis of the data themselves.

2.1.1 Transfer of knowledge and skills in STEM

During the measurements it soon became obvious that the scope of analysis is too broad and too extensive to allow for a usual approach of analysing single data sets with simple analytics tools as Excel or Logger Pro analysis, which are usually used in the high school environment.

Thus in a constructive dialogue with my IB Physics teacher it was decided to seek for further assistance with the experts at the Faculty of Matematics and Physics and Jožef Stefan Institute.

They proposed to collaborate on creating suitable analytics tools that would be useful for the concrete analysis, but would also be further used in the IB process, if necessary. The digital skills in question included in particular:

- Python script-image color processing,
- Root script-intensity analysis and
- image splitting.

The relevant digital skills to be transferred from a University to a High School environment proved to be crucial for the execution of the research at hand.

To understand how the process of knowledge transfer happens from a University to a High School environment, we need to start with more background information on how collaboration between high school and faculty commenced and where in the process the knowledge transfer occurred.

2.1.2 Process of transfer

Since 2017 in Slovenia there is a systematic approach, the project SKOZ [4], trying to connect students from high schools to mentors at the Public research organizations. Although this particular connection has been established via personal means, it is significant, that the researchers involved take part in the initiative SKOZ.

The project itself will end at the end of 2020, during which time, together with schools from the Western Cohesion Region, research partners and business partners, established a solid and functioning network of organizations that encourage the most talented students with projects. Jožef Stefan Institute took part in the initiative, supporting more than 40 students so far.

The purpose of SKOZ was to connect students with mentors and experts for the transfer of knowledge, in order to allow specific subjects from a supportive environment to deal with the field of work in specific research of the students.

Gimnazija Bežigrad was not the recipients of the funds of the tender announced in August 2017 by the Ministry of Education, Science and Sport. Even though it was not actively involved, it still aimed at supporting and encouraging collaboration of the experts with talented students.

In line with the idea of the project, in which the experts of the Jožef Stefan Institute actively collaborated and understood its purpose, also other more personal initiatives as this one were absorbed.

Thus on the point where digital skills transfer of knowledge was established as a break through element, which will enable this study to be carried out, although via personal contacts, the collaboration has been established between the IB Gimnazija Bežigrad student and the experts from Jožef Stefan Institute and Faculty of Mathematics and Physics.

The transfer of knowledge resulted in the setup of the processes required for the data analysis, as described below.

2.2 Analysis of data

2.2.1 Python script- image color processing

The photos taken by the camera were then transferred to a computer, where further analysis was carried out. The captures were analyzed using a Python script that determines a specific RGB light composure of a certain pixel on a straight line, whose direction and extremes are provided by the user. The result of the image color processing is a graph of light intensity in the correlation with coordinate of the pixel explored. The base code was found on the internet [5] and was then changed so that it suited my experiment's needs.

2.2.2 Root script- intensity analysis and image splitting

ROOT [6] was in this experiment used in two parts of analysis. Firstly, the picture of the phantom had to be split up in several smaller pictures, which were only showing one hole in the phantom at a time. This step was required to enable easier management with the original data. Other processes in the analysis were then run on large amount of very similarly structured photos, which enabled the code to be less complicated.

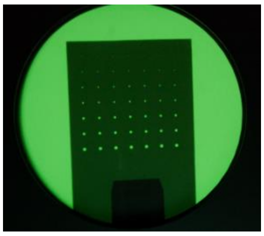


Figure 1. Irradiated phantom

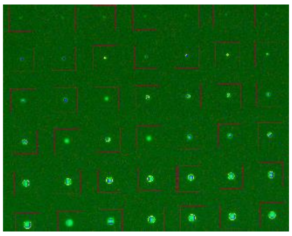


Figure 2. Image splitting

Secondly, the color analysis done in ROOT analysis framework is similar to the one in Python. However, in this case the options for the analysis are much wider. A light composition analysis investigation can be done over the x-, y- axis and over the whole picture. To achieve the highest accuracy of the outputting values the analysis over the whole picture was done. The program tried to fit an error function [7] on the 2D response. Borders of such a signal is usually treated as a Gaussian function [8], so when a number of signals are treated together as one signal, convolution of the point response with the image shape makes the borders take form of an error function. The fitting of an error function was in my case used all around the given circular 2D signal (Fig.6).

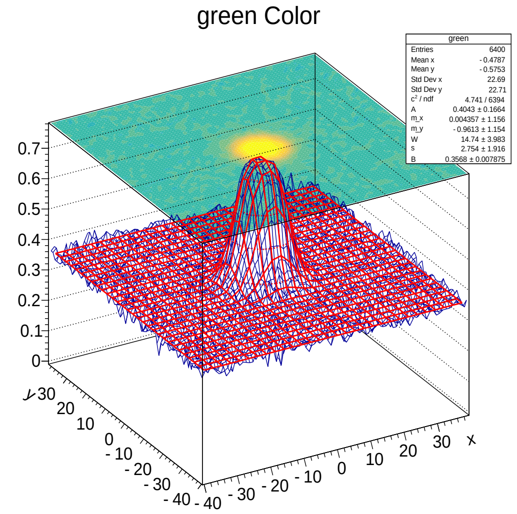


Figure 3. 2D histogram of a captured photo

The outputs that determined the double error function were:

-A, the height of the signal,
-W, the width of the signal,
-B, the height of the background,
-∂, the width on the half of the height of the graph od derivative of the error function

2.2.3 LoggerPro analysis

The data acquired from the analysis by the code in Python and ROOT can be transferred to LoggerPro by importing the data as a text file with different columns. After the data is appropriately represented, we can identify the average height of the signal and the average width of the border by using cursor coordinates displayed by LoggerPro. The data gathered was then presented in the table to show the correlation. Graphs were drawn to explore different dependences.

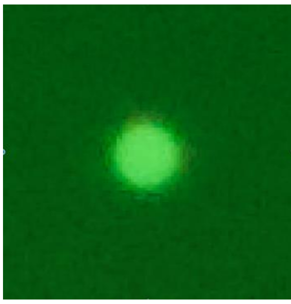
3. RESULTS

The images captured using the phantom with holes and the above described setup (Fig.3), were analyzed using the described digital tools.

Our goal was to determine the sharpness of the holes' images. The results acquired from the exploration were firstly in the form of pictures (see example in Fig.7). After the analysis using the developed Python programming tools the results had a numerical form, since they represented an average width of the signal and the average height. Both obtained values are an important test of the sharpness of the picture border and the quality of the photo.

After the ROOT script was run on a set of little pictures, as presented above, the code tried to find the best fit for the mentioned double error function. The parameters that root used to find the best correlation, were then exported to a .txt file, where they could be used for further analysis.

On the pictures captured with the lower input voltage the smallest holes of the size of 0.5mm were really hard to see and the analysis of light intensity on those was not returning consistent results. That is why I decided to perform the research only on the remaining 6 different sizes of gaps (0.8mm, 1mm, 1.4mm, 1.6mm and 2mm).



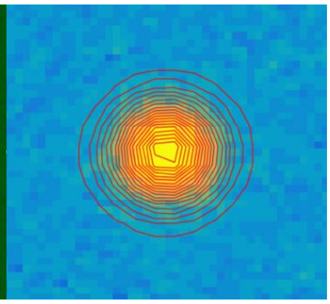


Figure 4. Example of analyzed material (left)

Figure 5. Python color intensity test (right)

The voltages used in this experiment are displayed in the table below:

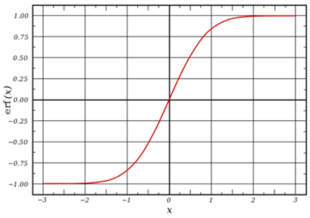
Table 1. Accelerating voltages used on the X-ray apparatus

Trial no.	1	2	3	4	5	6
Voltage [kV]	35	32	29	26	23	20

The aim of this experiment was to explore how changing the voltage affects different image quality properties.

3.1 Resolution dependence on the voltage

σ is a parameter of the error function that essentially tells us how steep the border between the peak of the signal and background of the measurement is. It represents the width of a derivative function of the error function. The width of the derivative is a statistical value that tells us how well the border of the picture was captured, the quality of the image can be described.



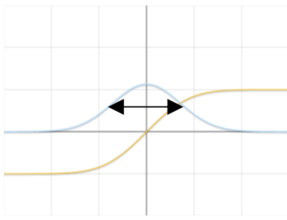


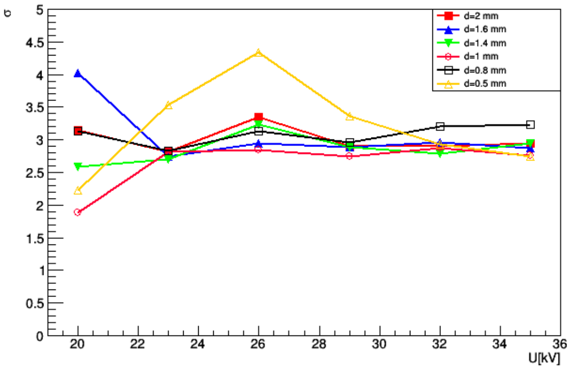
Figure 6. Error function (left)

Figure 7. Average width of the derivative function of the error function (right)

The data that was processed with the mentioned codes resulted in the graph, where the *sigma*-value does not increase or decrease with the variation of voltage. There was no found correlation since the changes in the values with different voltages are probably a result of a statistical error. The data gathered and averaged is collected in the table and the graph below.

Table 2. σ's average values for different gap diameters and voltages

Diameter of the hole [mm] / Voltage [kV]	2	1.6	1.4	1	0.8	0.5
35	3.07	3.43	3.47	3.38	3.63	3.72
32	3.03	3.45	3.46	3.46	3.60	6.04
29	3.00	3.44	3.47	3.41	3.11	3.54
26	3.21	3.66	3.70	3.49	3.68	2.97
23	2.92	3.33	3.48	3.17	3.28	3.55
20	3.93	4.39	4.46	8.93	10.17	4.01



Graph 1. σ 's correlation with voltage

We can clearly see that the differences between the values are not the consequence of the variation of voltage.

4. DISCUSSION

4.1 Usefulness of the Transfer of knowledge

As the baseline, I need to reconfirm the thesis that none of this work would be possible without the collaboration between Gimnazija Bežigrad and Jožef Stefan Institute alongside with the Faculty of Mathematics and Physics. The knowledge transferred in the field of digital skills and analysis were of the utmost importance for the design and execution of the experiment.

The role of the project SKOZ was previously explained and can here be reconfirmed that it has created, at least for this particular setup of people, technologies and skills needed, an awareness of a need for collaboration and transfer of knowledge between the different educational systems.

The creation of digital skills in a different environment and a transfer of knowledge and promotion of digital analytics has been subject to personal experience and efforts, which I am thankful for. This, however, also sheds a ray of light onto the future possible transfer of knowledge and skills between the two educational systems.

4.2 Accuracy of the established digital tools

The ROOT and Python analysis scripts I ran on captured photos often did not give very accurate output, because the starting parameters were not set correctly. Even though I worked on improving the code to the point, where the efficiency and reliability was relatively high, there were still some cases where the code using the described models did not converge with the initial parameters provided. Especially the part of the experiment, where the Root script was finding optimum double error function to fit on the given data, was problematic, since a small difference in the way function was structured had major impact on the output parameters.

To conclude, the experiment could of course be performed more efficiently, professionally, accurately, the errors could be minimized. However, I believe that with given time, resources and my non-existing previous experience with such machinery, the experiment was performed optimally, and the results are quite relevant as they show how and to what degree digital skills are important in analysis of data obtained in physics experiments.

Moreover, not only is the transfer of knowledge important between the industry and public research organizations. It is pertinent that the transfer of knowledge is supported between the educational systems to allow for an optimal human resources development for the future industrial needs.

5. CONCLUSION

Ultimately, the results could not have been obtained without using digital skills. STEM collaboration between high school and experts with highly developed digital skills is of utmost importance in order to firstly promote digital skills at a relatively early age of students, and secondly, to enable the students to learn them and use them in real-experimental setups, measurements and analysis.

The conclusion is, that transfer of knowledge is very important in the STEM field and that young people can obtain many options and opportunities with such transfer of knowledge, which would otherwise not be achievable for them – and is not time financially or consuming for the university system at all. Only through transfer of knowledge and skills between the two educational systems optimal solutions can be found.

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DODATEK / APPENDIX

INTRODUCTION AND AIM OF THE CONFERENCE

Conference topic: How to maximize the impact of technology transfer funnel at TTOs?

Subtopics:

Assisting enterprises in order to better use the RTD results from public research organizations

How to approach enterprises? The perspectives of TTOs, researchers and enterprises. The value proposition of early stage technologies for enterprises.

Creation of an efficient national Proof-of-Concept (PoC) funding system.

Helping spin-offs to succeed.

Improving the knowledge base of technology transfer experts.

Objectives of the Conference

The main aim of the Conference is to promote knowledge exchange between academia and industry, in order to strengthen the cooperation and transfer of innovations from research labs into industrial exploitation. The Conference goal is also further strengthening the knowledge base and experiences of technology transfer professionals at public research organisations.

In the past events, we hosted more than 2500 participants, including investors, inventors, researchers, students, technology commercialization and intellectual property experts, start-up funders, industrial development experts etc. We have successfully organized eleven competitions to award the team with their technology and business proposition with the biggest commercial potential, which led to successful start-ups and licensing contracts. Biannually we organise Research2Business (R2B) pre-scheduled meetings in order to give the participants additional opportunity to meet and discuss possible cooperation. Researchers presenting their work being financed by Slovenian Research Agency (ARRS) is another channel for enterprises to get familiar with recent discoveries and development opportunities.

Conference prize for the best innovations in 2020

The main objective of the special prize for innovation is to encourage commercialization of inventive/innovative technologies developed at public research organizations and to promote cooperation between research organizations and industry. One of the main objectives is also promoting the entrepreneurship possibilities and good practices in the public research organizations. Researchers are preparing business models for their technologies and present them to an international panel of experts in a pitch competition. They need support in many aspects of their path from research to industrial application. The researchers and their team need assistance, knowledge and tools to develop business models, find appropriate partners, form a team, and secure financial resources to bridge the gap from publicly funded research to the market, either in their own start-up (spin-out) company or by licensing out their technology. How shall they do it and how can we help them?

The Conference pitch competitions in the last eleven years resulted in spin-out company creation or licensing case development in at least one case per competition each year. In many cases, young researchers that participated in pitch competition in the past years, have been involved for the first time in an organized and structured process of development business model around their technology and preparation of the targeted (pitch) presentation about their planned venture to investors and technology commercialization experts.

WIPO IP Enterprise Trophy

The aim of the WIPO IP Enterprise Trophy is to stimulate Slovenian enterprises to intensify their cooperation with public research organisations. We wish to expose as a good practice those enterprises that are constantly and methodologically using the IP system in their business activities.

WIPO Medal for Inventors

The goal of the WIPO Medal for Inventors is to award inventive and innovative activity of Slovenian public researchers and to recognize their contribution to national wealth and development.

Research2Business meetings

In the course of the conference, pre-scheduled Research2Business (R2B) meetings will take place, allowing the representatives of companies and research institutions to discuss possible development solutions, inventions and commercially interesting technologies. Such meetings present an excellent basis for possible future research cooperation and business synergies.

Opportunities arising from publicly funded research projects / presentations of successful scientific projects

Researchers will be presenting their work that is being financed by Slovenian Research Agency.

Key stakeholders

The conference involves different key stakeholders in the process, public research organizations as knowledge providers, technology parks as infrastructure providers, business accelerators, intellectual property offices, IP attorneys, agencies, consultants, capital (venture capital companies, agencies, business angels), SMEs, international enterprises, private innovators, and others.

Target audience and benefits

Target audience of the conference are researchers, students and post-graduate students with entrepreneurial ambitions, representatives of industry, established and future entrepreneurs, innovators and also representatives from governmental institutions and policy-making organizations.

Introduction to the International Technology Transfer Conference

The International Technology Transfer Conference (ITTC) is organized by the **Jožef Stefan Institute** (Center for Technology Transfer and Innovation) for the 13th year in a row. The first ITTC was organized in 2008. The ITTC has, through the years, been presented in different formats and it is currently organized as part of the International multiconference Information Society (IS2020), organized by the Jožef Stefan Institute.

The Center for Technology Transfer and Innovation at the Jožef Stefan Institute is the coordinator of the project KTT (2017-2022), coordinator of Enterprise Europe Network Slovenia, and is a financially independent unit. The CTT is presently involved in 4 projects, having recently been involved in three additional ones. The Conference has been organized with the support of partners from the KTT project (2017-2022).

The previous project KTT, from 2013 through 2014, was the first project within which technology transfer in Slovenia was systematically funded from national funds. There were 6 partners involved, but the project only lasted for 17 months.

The current KTT project, 2017-2022, comprises 8 partners, all public research organizations (PROs), represented by their respective technology transfer offices (TTOs), namely, 4 leading institutes and 4 renowned universities.

The project's mission is twofold: the strengthening of links and increasing the cooperation of PROs and industry and the strengthening the competences of TTOs, researchers and enterprises. Most (80%+) of the finances go to human resource financing.

Support of Slovenian Industry

The goal of the KTT project is to support the industry in Slovenia, rather than an outflow of knowledge abroad or great profit for PROs. Collaboration between PROs and SMEs in Slovenia should be strengthened. However, Slovenian companies prefer contract and collaborative cooperation to buying licenses and patent rights. Also, a relatively low added value per employee and a low profit margin are not stimulating the research-industry collaboration.

Investing into Intellectual Property Rights

Despite the above stated it is important to invest in patents and other forms of intellectual property (IP). Investments in intellectual property increase licensing opportunities and the IP position of the Slovenian knowledge worldwide.

Research2Business meetings

One-to-one research-to-business pre-scheduled (virtual) meetings allow the representatives of companies and research institutions to discuss possible development solutions, inventions and commercially interesting technologies. Such meetings present an excellent basis for possible future research cooperation and business synergies. The meetings focus on applications, solutions and expertise in natural sciences like electronics, IT, robotics, new materials, environment, physics, chemistry and biochemistry. Companies and researchers book meetings also with technology transfer experts from the Center of technology transfer and innovation. The meetings are held virtually through b2match platform.

The Research-to-business meetings at the Conference were co-organized in collaboration with the Enterprise Europe Network partners.

Strengthening the Competences of TTOs

The goal of the KTT project is to establish technology transfer centers in Slovenia as integral parts of PROs, which shall, first and foremost, strive to serve the interests of the researcher and the PRO. The TTOs shall assist the researcher throughout the entire procedure of the industry-research cooperation, by raising competences and educating, taking care of legal and administrative issues, and promote research achievements among the industry. Lastly, TTOs shall support the cooperation already established by research groups.

#
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for their evaluation of written technology commercialization proposals and selection of winning teams, authors of inventive technologies with the best potential for commercialization of the technologies, developed at Public Research Organizations.

We are particularly grateful to the members of the **EVALUATION COMMISSION**:

Jeff Skinner, London School of Business,

Jon Wulff Petersen, TTO Ltd., Denmark,

Alojz Barlič, Slovenian Intellectual Property Office (SIPO),

for their evaluation and selection of the awardees of the WIPO IP ENTERPRISE TROPHY and WIPO MEDAL FOR INVENTORS.

Day 1

OVERVIEW OF THE PROGRAMME

8 October 2020 (virtual teleconference)

08.30 – 09.00	**Registration**
09.00 – 09.15	**Welcome address** Dr. Simona Kustec, Minister, Ministry of Education, Science and Sport Prof. Dr. Jadran Lenarčič, Director, Jožef Stefan Institute Dr. Špela Stres, MBA, LLM, Head of the Center for Technology Transfer and Innovation, Jožef Stefan Institute
09.15 – 10.00	**Keynote speech: Does the relation between the technology transfer and business education system influence the transfer efficiency?** Dr. Jeff Skinner, Executive Director, Institute of Innovation and Entrepreneurship, London Business School, UK **Keynote speech: How to maximize the impact of technology transfer funnel at TTOs?** Dr. Jon Wulff Petersen, Director, Technology Transfer, Plougmann Vingtoft, Denmark
10.00 – 12.00	**Best innovation with commercial potential: Pitch competition**
12.00 – 13.00	Lunch break
13.00 – 13.20	**Award announcement: Best innovation with commercial potential** **Award announcement: WIPO IP Enterprise Trophy**
13.20 – 15.20	**Paper presentations: scientific papers on technology transfer and intellectual property** **Round table on IPR management in industry:** Mag. Mladen Vukmir, Vukmir and Associates, Zagreb, expert in IPR management, patent attorney Mr. Gverino Ratoša, innovation in automotive industry, Hidria d. o. o. Mr. Drago Lemut, Director, company Le-Tehnika d. o. o. Prof. Dr. Alexsandre Marin, Director TTO, University POLITEHNICA of Bucharest; EEN member, EU IPR Helpdesk Ambassador
15:20 – 16.50	**Opportunities arising from publicly funded research projects / presentations of successful scientific projects** **Award announcement**: **WIPO Medal for Inventors**
16.50-	Closing
Parallel session: 9:00 – 13:00	**Besearch2Business meetings (B2R meetings)**

WELCOME ADDRESSES

From 9:00 to 09:15

Honorable Speakers:

Dr. Simona Kustec, Minister
Ministry of Education, Science and Sport

Prof. Dr. Jadran Lenarčič, Director
Jožef Stefan Institute

Dr. Špela Stres, MBA, LMM, Head of the Center for Technology Transfer and Innovation,
Jožef Stefan Institute

KEYNOTE SPEECHES

From 09:15 to 10:00

Honorable Speakers:

Dr. Jeff Skinner, Executive Director,

Institute of Innovation and Entrepreneurship, London Business School, UK

Does the relation between the technology transfer and business education system influence the transfer efficiency?

Dr. Jon Wulff Petersen, Director,

Technology Transfer, Plougmann Vingtoft, Denmark

How to maximize the impact of technology transfer funnel at TTOs?

Does the relation between the technology transfer and business education system influence the transfer efficiency?

Keynote speech by Dr Jeff Skinner, Executive Director, Institute of Innovation and Entrepreneurship, London Business School, UK

The summary written by: Tomaž Justin, Miha Pitako, Robert Blatnik, Center for technology transfer and innovation, Jožef Stefan Institute

Dr Jeff Skinner shared the business and research practice of how multiple relations between the technology transfer and business education system can influence the transfer efficiency. The question of "Can the relationship between the technical universities improve and benefit technology transfer from connecting with business schools and how?" arose as a focal point of where and how technology and business meet and evolve together seeing that technology transfer should be complemented with a great business strategy. People from science, technology, engineering and mathematics (STEM) usually have useful tech knowledge and ideas but those ideas lack support by people who could and would want to commercialize the idea.

The efficiency of technology transfer can be improved if we help researchers to learn how to sell their knowledge and how to combine their talents with the entrepreneurs' ones both exploiting existing business education systems and opportunities. Researchers have to go on a business and commercial journey from their laboratories to the world. They have to be empowered to effectively and efficiently search for the right application, with the right team and business model around the technology they invented.

This is where business schools can complement the journey of the invention or innovation to the market as they can provide people with knowledge and skills of entrepreneurial methodology, offer existing business courses accessible to researchers, provide access to MBA students who love to work on cool stuff and have already established "entrepreneurial clubs" for networking and exchange of ideas.

How can we combine these talents effectively? Researchers should mix and form teams with those who have business know-how and entrepreneurial spirit. In trying to combine these talents effectively we tried different approaches in order to form teams out of mixing people with different technical talents and people with business know-how. Researchers may join existing MBA courses to understand how business "think" and enable them to form teams with MBA students that may last beyond the course. As it turns out the sooner an idea can generate a critical mass of people supporting it the more likely it is to have market success. With bringing new venture ideas to the MBAs, they may be able to test different business models for technology commercialisation regardless, none of them is tailored to technology transfer exclusively. Business people should understand the business aspect of the technology transfer.

By bringing people together into a single space to share ideas we are trying to establish a "cohort feel" to enable ideas support with people helping each other in different areas of expertise in order to enable freedom over scheduling and duration of the project as technology transfer projects may take months if not years to come to fruition.

The other option is to inject technology transfer projects into MBA courses that may bring useful ideas on how to commercialize the innovations or inventions. Technology Transfer

Offices (TTOs) select promising projects that are elaborated almost as a consultancy project. We can argue if we do like that technology transfer opportunities are written up as teaching cases.

We may want to venture out of the classroom with enabling co-curricular activities organized by the school's staff. It is even better that students form semi-structured opportunities to mingle. At London Business School we are organizing hackathons, launchpads, team-forming workshops, competitions and challenges in order to achieve inter-sectoral mingling. By doing so we established several effective semi-structured educational opportunities for researchers to become better sellers.

On one hand, after joining some forms of business education, some of the researchers may be even more curious about the efficient process of commercialization. On the other hand, Business Schools have assets that TTOs can use. For example, entrepreneurship courses to learn and team-build or MBA students who crave tech opportunities with some social capital in the business world that can enable the technology project to reach the market.

But business education for researchers to become better sellers will always be a bit ad hoc and focused on the individual rather than project development. As it turns out the technology transfer projects are often about personal skills training. This is making it much more difficult to demonstrate the impact of the business education system on the transfer efficiency in short term.

There is no steady state for technology transfer offices. This is why one should not overthink things but just do something, act on them. TTOs have to constantly think of new ways of engaging.

To conclude: TTOs at STEM and business schools should enable and support mingling and networking within formal or informal mixing of different student's 'clubs. Be it medical clubs, media clubs, management clubs and others that can provide an environment in order to enable team formation of differently skilled people to gather around an idea as quickly as possible.

The quicker an idea gathers a team the more likely it is to succeed.

How to maximize the impact of technology transfer funnel at TTOs?

Keynote speech by Dr Jon Wulff Petersen, Director, Technology Transfer, Plougmann Vingtoft, Denmark

The summary written by: Tomaž Justin, Miha Pitako, Robert Blatnik, Center for technology transfer and innovation, Jožef Stefan Institute

Dr Jon Wulff Petersen, pointed out that technology transfer is a contact sport demanding a team effort with work that has to be organized systematically by clear concepts and rules whilst working with academia. This leads to the need of combining individual and team approaches.

Technology transfer offices (TTOs) connect academic, scientific and research institutions with the industry and interact with various groups of people with different competences and roles, ranging from researchers, patent specialists, external project pilots, external mentors, seed investors and so on. The key is to form a team very early on, even around immature ideas.

Since technology transfer is not an individual challenge, technology transfer requires a system thinking where organizational knowledge build-up is a key. Acknowledging the fact that we will always be short on resources, early funding such as proof of concept and seed capital has to be spent wisely. It is very important for technology transfer offices, apart from the skilled individuals, to have systems, processes and tools in the TTOs to overcome eventual lack of resources. This lack of resources is a challenge that requires clever systems and embedded processes such as the “Triangle method”, project and decision-making questionnaires, templates and other tools. The technology transfer system with a technology transfer office has to be robust enough to tackle good staff members leaving the successful TTO and joining the industry. On the other hand, when a TTO is on the rise one has to think of how to plug new people into TTOs as the TTO gets successful.

The “Triangle method” is an important vehicle system that follows the case of technology evaluation for technology transfer all the way through the process. It is a way of organizing questions for which you want answers to when you have new technology. Some questions are more important than others and some are showstoppers. The TTO triangle method links six segments where specific value is added to them for the technology evaluation. The segments we observe in the TTO Triangle are: Application, Market, Competition, Human resources, Development time and cost and Intellectual property rights and regulatory.

The TTO Triangle method is also an effective communication tool towards the team, to be used in explaining to the team, researchers and other colleagues or the outside world about the new technology. It can be used as well as a portfolio management system and as a tool for introducing new staff members into the system.

An additional tool is the NABC - Needs, Approach, Benefits, Competition - which was developed at Stanford University and is broadly used in Scandinavia along grading and comparing inventions. The NABC is preferably using a simple system, like 10-point scale, which can also be used to provide new insights. It helps us understand what are we missing or what do we have to improve.

The TTO Triangle method and NABC can be useful communication tools for creating team spirit and energy in the process. Communication assures progress, creates transparency, commitment and back up for the technology transfer system and the TTO.

A lot of work in technology transfer offices runs in circles – from analysing ideas to business development where we can be successful or the idea goes bad. Transparency in communication with participants within the process of technology transfer is imperative for when or if the invention is given back to the researchers at a certain stage of the evaluation or transfer process. The "giving-back" should be a positive learning process for the whole team, in particular for the researchers who should know the criteria and the decision-making foundation in advance.

It is helpful for the TTO staff to be outgoing, to understand technology and have great social skills. The TTOs staff should be mindful not to get too far ahead of the research team they are trying to help. The feeling of ownership should remain with the R&D team. The R&D team should be encouraged and not frontrunner by the TTO stuff.

To maximize the impact of technology transfer funnel at TTOs, stakeholders have to build a local technology transfer ecosystem that will work with local, near-by resources. Early stage technology transfer does not work well on long distances. Inventors have to connect with management professionals and do bottom-up market analysis rather than top-down one.

BEST INNOVATION WITH COMMERCIAL POTENTIAL: PITCH COMPETITION

From 10:00 to 12:00

Moderator:

Robert Blatnik, Senior Technology Manager | Spinnovator, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

Evaluation commission:

Andreja Satran, Managing Director, ABC Accelerator

Dr. Jeff Skinner, Executive Director, Institute of Innovation and Entrepreneurship, London Business School

Dr. Jon Wulff Petersen, Director, Technology Transfer, Plougmann Vingtoft

Robert Al, Head of Business development, TU/e Innovation lab, Eindhoven University of Technology (proxy member: Mark Cox, Knowledge Valorisation Officer, TU/e Innovation lab, Eindhoven University of Technology)

Presentation of six (6) selected business model proposals from public research labs to the technology transfer experts.

Course of the competition

Robert Blatnik, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

The 12th annual competition for the best innovation in 2020 at public research organizations (PROs) aims at stimulating the researchers from public research organizations to develop business models for commercialization of their inventions. The competition was initiated with a public call, which was open to authors of inventive technologies with a proposed business model for commercialization. Eligible applicants for the call are individuals, employed at PROs, which are developing innovative scientific-research ideas into a viable business model. Possible business models are either licensing the technology to industrial partners or commercialization in a spinout company. The teams have prepared their application and pitch presentation following the guidelines, which were introduced by the Organizer of the Conference at the dedicated preparatory webinar which was organized for the teams. The webinar consisted of three one-hour parts. The researchers learned the guidelines on how to prepare their pitch presentation. In a series of three webinars we went through the process of preparing a pitch of their invention and business model to a potential investor or a partner in a future venture; either licensing the technology to an industrial partner or via commercializing of the technology in their own spin-out company. We have discussed which are the stronger points in the specific business model of participants and how to prepare an effective and appealing presentation for the intended audience of their pitch. The guidelines for preparing a pitch included the following elements: Cover / Introduction slide (name & compelling tagline); Deal (what you are selling, to whom, for what price); Market & segmentation (target customer, market size, trends); Customer value proposition and why now; Product (the solution); Financials; Impact; Competitive advantage; Team & founder's/inventor's dream; Summary / three key points to remember. The written description of the proposed invention/innovation included the following chapters: Title of the idea with a brief commercial tagline; Summary; The Science; The Opportunity (problem and solution); The Plan (Development stage and Business model); The Team; Impact.

The teams and their applications with the proposed business models were evaluated by an international panel of experts which constituted the evaluation commission. The members of the evaluation commission are the following experts: Andreja Satran, Managing Director, ABC Accelerator, Dr. Jeff Skinner, Executive Director, Institute of Innovation and Entrepreneurship, London Business School, Dr. Jon Wulff Petersen, Director, Technology Transfer, Plougmann Vingtoft, and Robert Al, Head of Business development, TU/e Innovation lab, Eindhoven University of Technology and his proxy member: Mark Cox, Knowledge Valorisation Officer, TU/e Innovation lab, Eindhoven University of Technology.

The experts evaluated the proposals in two phases. The 1st phase was the evaluation of written descriptions and the 2nd phase was the evaluation of the five-minute pitch at the Conference. The evaluation experts used the predetermined evaluation criteria which were already defined in the public call. The Criteria for evaluation are divided into six lots, which together account for total of 19 criteria. The criteria are presented in the table 1; each of the 19 criteria brings at the most 10 points. After the pitch the experts exchanged their views and opinions and selected the winner(s). The Criteria is presented in the Table 1.

The traditional pitch competition, which this year had its 12th anniversary, stimulated six innovative and entrepreneurial research teams to prepare their pitch and apply for competition. Members of the teams have participated in three preparatory workshops to develop their pitch and receive comments for improvements of their presentations. The workshop was organized by Center for Technology Transfer and Innovation as part of the KTT project, financed by Slovenian Ministry of education, science and sport. The teams are entirely or partly employed at the Slovenian PROs, Jožef Stefan Institute, National Institute of Chemistry, National Institute of Biology and University of Ljubljana.

Criteria lots	**Criteria**
1. Overall	Degree to which project aligns with market need
	Project's IPR situation
2. Product/application advantage	Unique benefits
	Meets customer needs better
	Value for money
3. Market attractiveness	Market size
	Market growth
	Favourable trends
4. Competitive situation	Degree of entry barriers
	Level of competitiveness
	Manufacturing / processing synergies
5. Technology maturity	Technical gap
	Complexity
	Technical uncertainty
6. Risk versus return	Expected profitability (e.g. NPV)
	Return (e.g. IRR)
	Payback period
	Certainty of return / profit estimates
	Low cost & fast to do

Table 1: Criteria for evaluating the applications (source: Jon Wulff Petersen, TTO A/S, Denmark)

Abstracts of the Competing Teams and their Technologies

Contact-based, leaching-free antimicrobial textile

Authors/inventors: Marija Vukomanović, Srečo Škapin, Danilo Suvorov

PRO: Jožef Stefan Institute, Ljubljana, Slovenia

Abstract:

Antimicrobial textile market is currently valued at around 10.48 billion USD with predicted growth rate close to 9.8% for the period from 2020 to 2026. The development of new fabrics is promoting the market growth. Further up-scaling of the production is particularly expected to support the healthcare industry's requirement for masks and other medical textiles amid the spread of the COVID-19 pandemic.

Besides being efficient against microbes, antimicrobial component inside textile has to meet important additional criteria regarding: (i) toxicity, (ii) allergenicity, (iii) irritation and (iii) sensitization. These are the most challenging criteria in selecting adequate antimicrobial component. Silver is frequently used antimicrobial present in many products (i.e. AlphaSan®, Silpure®, Silvadur™, SmartSilver®, Silvérion 2400). Integrated inside textile in form of ions or (nano)particles it is leached to provide antimicrobial activity. Lately there have been a lot of concerns about safety of this technology. Sweden's national agency for chemical inspection has ruled silver as health risk (for human genetic material, reproduction, and embryonic development). Regulations in USA and Australia limit application of antimicrobial silver, particular in healing procedures. Still there is a high demand for discovery and implementation of the novel strategies able to replace existing, potentially toxic antimicrobial technologies. The last opens wide highways for innovation and progress in this area.

Our team is designing innovative antimicrobial technologies for more than 10 years. We are holding EU patent on contact-based, non-leaching gold-based technology with proven efficacy in replacing antimicrobial silver (illustrated in Fig.1). Our next challenge is to formulate product prototype that will place our technology closer to the market.

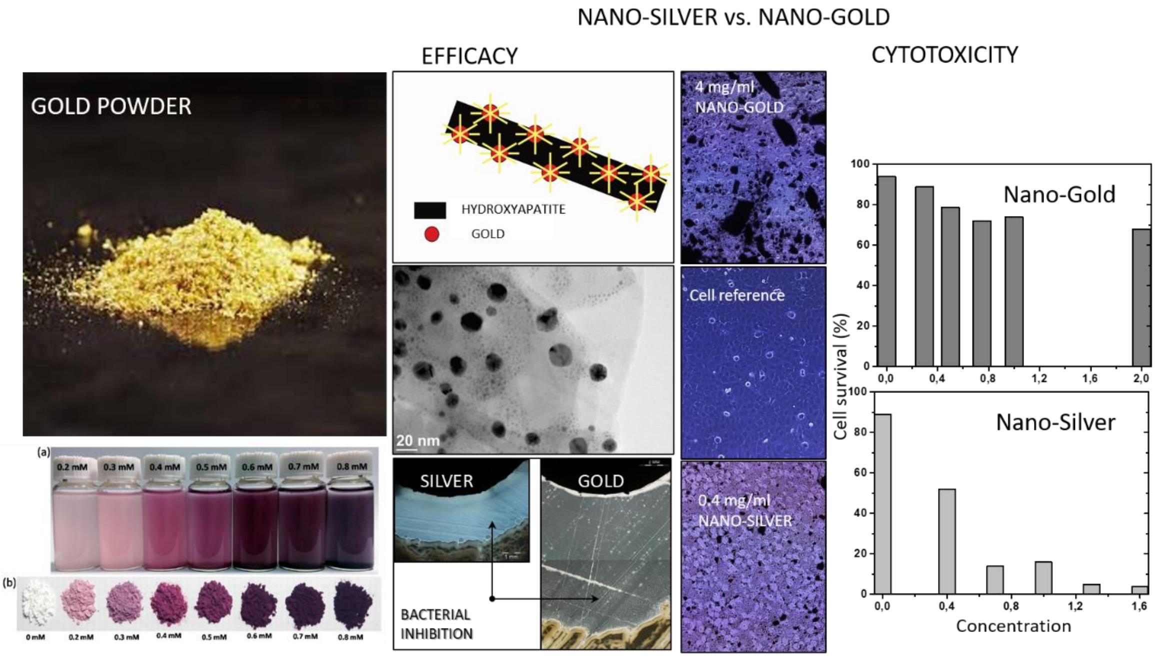

Figure 1: Current state of the invention: gold powder its efficacy and cytotoxicity in direct comparison to nano-silver. Doctoral dissertation, M. Vukomanovic, 2012.

DiTeR: Dynamic thermal line rating software

Authors/inventors: Gregor Kosec, Jure Slak

PRO: Jožef Stefan Institute, Ljubljana, Slovenia

Abstract:

One of the important aspects of transmission lines is overheating and thus the transmission capacity of the transmission network is often limited by the maximum allowed temperature of the conductor. Traditionally, the static capacity of the line is conservatively set for unfavourable weather conditions, i.e. hot sunny windless days. A more sophisticated approach is to dynamically determine the capacity considering the weather conditions or the weather forecast, which results in a considerable increase of the transmission capacity of the line. Based on experiences from theoretical studies and technology transfers, we developed a software package DiTeR that enables forecasting of thermal rating of power lines. The implemented software package has achieved high reliability and industrial level of use (TRL 9), thus representing a product that can be marketed on an international level. With DiTeR, any transmission system operator can much better utilize its power transmission network. Additionally, DiTeR increases the reliability of the transmission network and offers support for decision making in forecasts of extreme events. Currently, it is in operational use by the Slovenian transmission operator ELES that monitors 27 transmission lines with it.

Figure 1: The image shows an overhead powerline that collapsed due to extreme icing. This event triggered the creation of software for thermal management which evolved into DiTeR. Eles d.o.o., February 2014.

Single step production of Bio-based methacrylic acid for plastic and coating industries

Authors/inventors: Ashish Bohre, Miha Grilc, Blaž Likozar, Peter Venturini, Martin Ocepek and Miha Steinbücher.

PRO: National Institute of Chemistry, Ljubljana, Slovenia

Industrial partner: Helios Tblus d. o. o., Slovenia

Abstract:

Methacrylic acid (MAA) is an industrially important monomer, widely used to produce organic glass (poly-methyl methacrylate), acrylic fibres, plastics, and paints. Currently, the majority of MAA in the industries are produced through acetone-cyanohydrin process. This unsustainable method relies on expensive and extremely toxic feedstocks and corrosive concentrated acids. Besides the use of harmful substrates, low atom economy, poor product selectivity and the net emission of greenhouse gases are other drawbacks, associated with the industrial process, while the production is based exclusively on a non-renewable fossil-based resource. We have invented an efficient and sustainable catalytic route for the production of MAA. MAA is sourced from inexpensive and abundant lignocellulosic biomass derived feedstocks thus addressing one of the major issues associated with the utilization of depleting fossil fuel based feedstocks. Our technology provides industrially-relevant yield and selectivity, with more than 90 % of purity of MAA in a single step process. The archived MAA yield is higher compared to the previously reported method that utilized noble metal catalyst and alkaline base as a co-catalyst. Our catalytic process enables to replace the current multiple-step and energy-intensive industrial process of the MAA production in a single step from petroleum-based chemicals with the bio-based feedstock under relatively mild operating conditions.

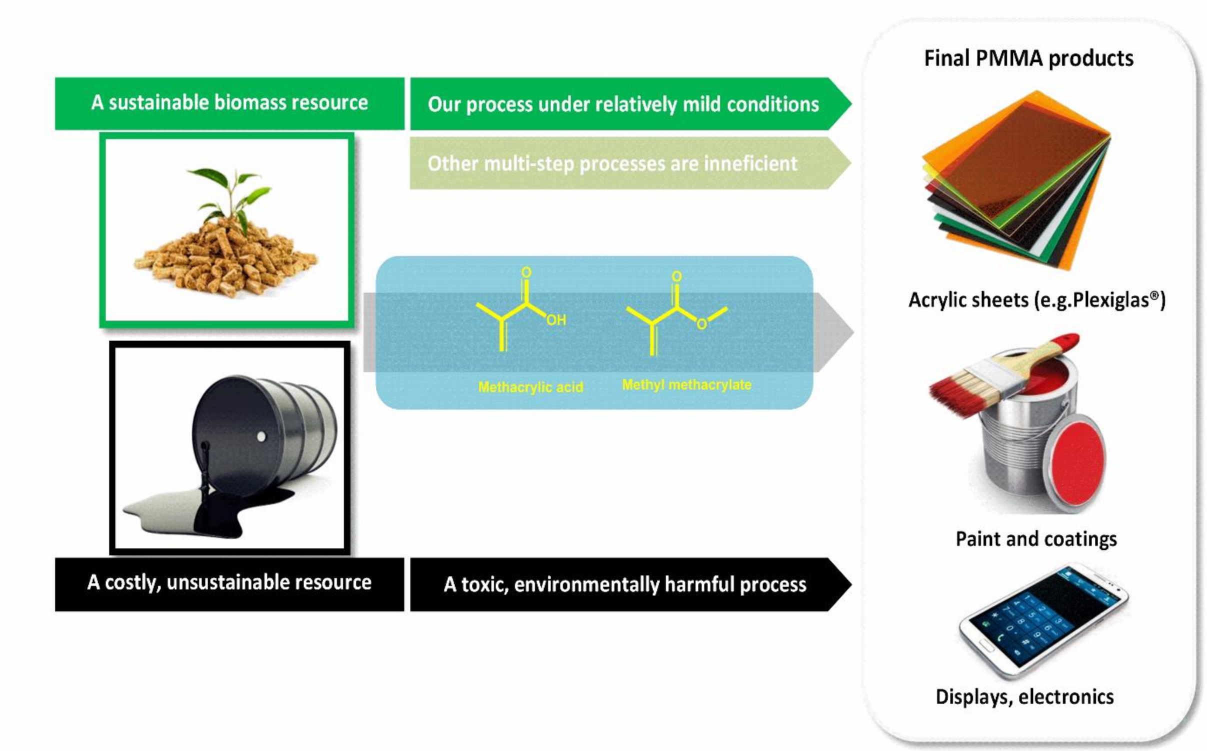

Figure 1: Single step production of Bio-based methacrylic acid for plastic and coating industries. Ashish Bohre, Miha Grilc, Blaž Likozar, Peter Venturini, Martin Ocepek and Miha Steinbücher, 2020.

A scalable method for eco-benign destruction of waterborne microorganisms

Authors/inventors: Gregor Primc, Arijana Filipić, Rok Zaplotnik, David Dobnik, Ion Gutierrez Aguirre, Matevž Dular, Martin Petkovšek, Miran Mozetič

PRO: Jožef Stefan Institute, Ljubljana, Slovenia; National Institute of Biology, Ljubljana, Slovenia; University of Ljubljana, Slovenia, Faculty of Mechanical Engineering, Ljubljana, Slovenia

Abstract:

Water scarcity is one of the biggest problems we are facing today so there is a global need for a stable supply of safe, pathogen-free water. Contaminated waters come from various sources including hospitals, farms and irrigation systems. These waters are guided through water-treatment systems; however, they usually do not inactivate viruses. Currently, chlorination, or similar chemical methods, are used for water disinfection, what represents potential environmental hazard. Chlorinated water released to the environment can cause adverse changes to many useful, but chlorine susceptible microbes. Treatment by ultraviolet radiation or ozone is only feasible for the disinfection of small quantities of contaminated water and efficient decontamination is limited by water turbidity. Our innovative technology presents an eco-friendly way for inactivation of waterborne microorganisms, particularly viruses, with low operation costs. The first phase is penetrating the market of small irrigation systems, such as hydroponics, second phase is a device for cleaning the heavily virus-contaminated water from clinics and the third phase, if successful with previous two phases, are large users, such as wastewater treatment plants and urban water systems with a large purification device. Globally, there are roughly one million potential small users and several thousand large users. Our technology exploits synergistic effects of two technologies (plasma and cavitation). The efficiency of its decontamination potential has been proved in laboratories, and the patent application to EPO has been submitted in October 2020.

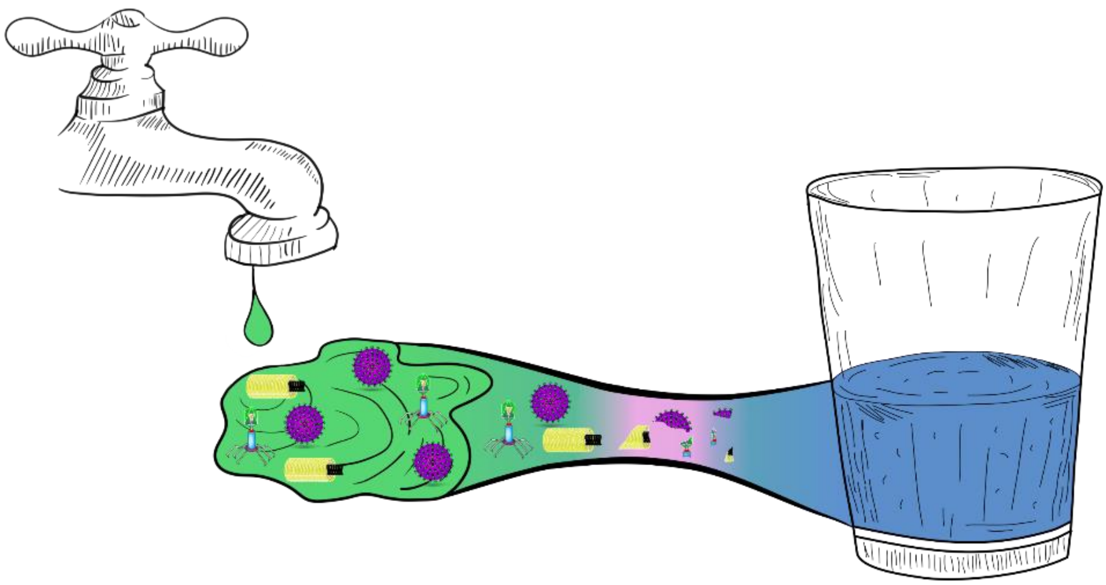

Figure 1: Abstract illustration on cleaning virus-contaminated water with synergistic effect of plasma and cavitation. Author: Gregor Primc (2020).

Enhanced cross-differential dynamic microscopy. A DLS-like particle characterization technique for cost-effective and accurate analysis of complex systems

Authors/inventors: Andrej Petelin, Natan Osterman, Luka Cmok

PROs: Jožef Stefan Institute, Ljubljana, Slovenia; University of Ljubljana, Slovenia

Abstract:

Enhanced cross-differential dynamic microscopy (C-DDM) is a cost-effective tool for the analysis of the soft matter dynamics in biosciences and biopharmaceuticals, paints, inks and coatings, nanomaterials, foods and drinks, pharmaceuticals and drug delivery, and academic research. The sensitivity of the method promises to be comparable to current commercial tools, like Dynamic Light Scattering (DLS), with added benefits of the multi-angle characterization for the analysis of complex systems, so it covers a broader range of use compared to DLS. The market size for DLS devices in European academic research is estimated to 15000 potential customers and 100 devices sold per year. C-DDM will be marketed as a complementary tool for studying the more complex system, or replacing more standard DLS applications. So, all current customers of DLS are potential buyers of C-DDM. Globally, in the long term, adding industrial customers into play, an estimated 1M revenue is viable, which is enough for a small-size sustainable business. We are a team of three, capable of completing the first phase of the development plan, that is, bringing the first device to the market in a year or two, and raising funds for further development. Team members have a good track record in applied research and have plans to improve the device in the future and to apply the technology for liquid crystal characterization and particle characterization tools for industrial research. For this, we will have to be successful in drafting the research projects and obtaining human resources (students). After finishing the research and development stage within three to five years, the team will assess the market and technology state and decide on future directives (licensing, spin-off).

A New Paradigm on Plastic Waste »PLASTICS - the Problem or the Solution«

Authors/inventors: Andrej Trkov, Luka Snoj, Stane Merše, Blaž Likozar, Johannes T. van Elteren

PRO: Jožef Stefan Institute, Ljubljana, Slovenia; National Institute of Chemistry, Ljubljana, Slovenia

Abstract:

Plastic waste is a big problem for the environment. Significant reduction of plastic use by replacement with more sustainable materials, circular economy and change of our behaviour is the key priority. However, plastics are hard to replace for some specific purposes, but eventually all plastic products become waste.

The objective is planet-friendly production of essential Eco-plastics and final disposal of unrecyclable plastic by burial as a form of long-term carbon storage.

Current practice of dealing with waste plastic is recycling (not all plastic is recyclable), disposal by incineration (CO2 emissions, hazardous combustion by-products), chemical reforming (e.g. synthetic fuels, etc.) and bio-degradation (possible micro-plastic residuals).

A new paradigm is proposed, promoting the synthesis of Eco-plastics from CO2 from the air and hydrogen from water by electrolysis (or otherwise), polymerization into plastic resins for industrial use, collecting and compacting plastic products when they become waste, and disposing them as a way of long-term carbon storage, thus returning some of the carbon from fossil sources back into the ground.

The key point is the availability of cheap electricity. Renewable sources of energy like the sun or the wind are strongly fluctuating. They result in surplus energy at peak hours and must have backup at production minima, which can be provided by the nuclear without a CO2 burden on the environment. Plastic production from electricity production peaks would make good use of this energy and help to stabilise the energy grids.

Based on the experience of the team, our role in the scheme is to develop and optimize the system for the synthesis of plastic resins on a small scale. The know-how would be offered to external partners for application on industrial scale. Likewise, we would seek partners for the back-end of the process on super-compacting, canning and disposal of waste plastic.

Award announcement: Best innovation with commercial potential

From 13:00 to 13:10

Moderator:

Robert Blatnik, Senior Technology Manager | Spinnovator, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

Evaluation commission:

Andreja Satran, Managing Director, ABC Accelerator

Dr. Jeff Skinner, Executive Director, Institute of Innovation and Entrepreneurship, London Business School

Dr. Jon Wulff Petersen, Director, Technology Transfer, Plougmann Vingtoft

Robert Al, Head of Business development, TU/e Innovation lab, Eindhoven University of Technology (proxy member: Mark Cox, Knowledge Valorisation Officer, TU/e Innovation lab, Eindhoven University of Technology)

ANNOUNCEMENT OF THE WINNER

The evaluation commission weighed all the criteria in the evaluation process and selected the winning teams.

The second award of 500 Euro goes to the team members:

Marija Vukomanovič, Srečo Škapin and Danilo Suvorov, coming from the Jožef Stefan Institute, for their technology:

Contact-based, leaching-free antimicrobial textile »Silver-free, wearable germ protection«.

The first award of 2000 Euro goes to the team members:

Gregor Primc, Arijana Filipić, Rok Zaplotnik, Miran Mozetič, Ion Gutierrez-Aguirre, David Dobnik, Matevž Dular and Martin Petkovšek coming from Jožef Stefan Institute, National Institute of Biology and University of Ljubljana.

In the opinion of the experts, the presented technologies of both teams bring value to society, have great potential to be brought to first customers and to be industrially scaled up. The qualified and passionate teams have key skills and knowledge for successful further development of the application which will bring value to the customers.

Congratulations!

Award announcement: WIPO IP Enterprise Trophy

From 13:10 to 13:20

Moderator:

Marjeta Trobec, Spinout and Promotion Specialist, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

Evaluation commission members:

Jeff Skinner, London School of Business

Jon Wulff Petersen, TTO Ltd., Denmark

Alojz Barlič, Slovenian intellectual property office (SIPO)

ANNOUNCEMENT OF THE WINNER WIPO IP Enterprise Trophy

By celebrating the achievements of inventors, creators and innovative companies around the world, the World Intellectual Property Organisation Awards aim to help foster a culture in which innovation and creativity are encouraged and appreciated at every level of society.

The WIPO IP Enterprise Trophy is awarding enterprises for their good practice to constantly and methodologically using the IP system in their business activities. Among the applications, the jury has decided to award Razvojni center eNeM Novi Materiali d. o. o. .

Justification: Razvojni center eNeM Novi Materiali is actively cooperating with several public-research organisations. In the last ten years they have been developing new products based on public-research transfer. Those products also have suitable IP protection. The applicant has persuaded with the outstanding use of the IP system and activities to build public respect for IP via different public campaigns, mostly environment oriented and based on the newly developed products. And finally, they constantly and methodologically encourage the creativity and innovativeness among their staff.

Congratulations!

Award announcement: WIPO Medal for Inventors

From 15:20 to 15:30

Moderator:

Marjeta Trobec, Spinout and Promotion Specialist, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

Evaluation commission members:
Jeff Skinner, London School of Business

Jon Wulff Petersen, TTO Ltd., Denmark

Alojz Barlič, Slovenian intellectual property office (SIPO)

ANNOUNCEMENT OF THE WINNER WIPO IP Enterprise Trophy

The WIPO Medal for Inventors is awarding Slovenian public researchers for their contribution to national wealth and development.

The "WIPO Medal for Inventors" goes to Prof. Dr. Alenka Vesel.

In the last decade she has gained several international patents, she is a cofounder of company Plasmadis and her IP has resulted in different products and services being brought to the market.

Congratulations!

Research2Business meetings (R2B meetings)

Parallel session from 9:00 – 13:00

Robert Premk, Center for Technology Transfer and Innovation, Jožef Stefan Institute

About

Traditional biannual Research2Business (R2B) meetings promote and encourage cooperation among researchers and/or representatives from research institutions and companies on the international level. Main focus is transfer of developed or in development technologies and techniques from research institutions in business processes of the companies, while searching for opportunities to develop new solutions for challenges the companies are facing in the business-as-usual activities, or to look for partners for different topics and calls.

Course of event

Distinguishing feature of Research2Business meetings in the frame of 13th International Technology Transfer Conference was the completely virtual form of the meetings through the b2match platform. In the registration period between May and October 2020, 134 participants from universities, R&D institutions, companies, start-ups, associations submitted their interest to participate at the meetings. They were from 14 different countries: Austria, Bulgaria, Croatia, Ireland, Italy, Lithuania, North Macedonia, Morocco, Romania, Serbia, Slovenia, Spain, Turkey and United Kingdom.

Two sessions of meetings were organized between 9 AM and 1 PM (CEST), where scheduled duration of each meetings was 20 minutes. In total 51 meetings were held, where registered participants could attend the meetings from their office with their computer, laptop or other devices with camera, microphone and connection to the internet.

In both sessions more than 13 hours of conversations were held, with average length of each meeting at around 15 minutes. The meeting with the longest duration lasted for 23 minutes and 39 seconds.

Although the format of this year edition of meetings was virtual instead of physical one, the participation exceeded expectations and attendance from previous years, while statistics and feedback already confirms that this type of meetings can provide excellent opportunity for individualized and thorough conversation between representatives of research and/or business community.

Day 2

CONFERENCE CEREMONY

Overview of the Conference Ceremony

9 October 2020

Jožef Stefan Institute, Ljubljana, Slovenia

Location: Main Lecture room at the Jožef Stefan Institute (A-building)

11:30 – 11:35	Musical performance
11:35 – 11:40	**Welcome speech** Prof. Dr. Jadran Lenarčič Director of Jožef Stefan Institute
11:40 – 11:50	**Opening speech** Dr. Jure Gašparič, State Secretary of Ministry of Education, Science and Sport
11:50 – 11:55	**Greetings** Prof. Dr. Mojca Ciglarič Chair of the Programme Committee of IS2020 Dean of Faculty of Computer and Information Science
11:55 – 12:10	**Awards of IS2020** Prof. Dr. Mojca Ciglarič, IS Programme Chair Prof. Dr. Matjaž Gams, IS Organization Chair Prof. Dr. Stane Pejovnik, Slovenia Academy of Engineering Prof. Dr. Nikolaj Zimic, AMC Slovenia President Prof. Dr. Sašo Džeroski, SLAIS President Dr. Mark Pleško , President of Slovenian Academy of Engineering Niko Schlamberger, President of Slovenian Society Informatika Robert Blatnik, M. Sc., Member of 13. ITTC Organizing Committee: - Award for the best innovation with commercial potential in 2020 - WIPO IP Enterprise Trophy - WIPO Medal for Inventors
12:10 – 12:15	Musical performance

13. ITTC Award Speech

Robert Blatnik, Center for Technology Transfer and Innovation, Jožef Stefan Institute
Marjeta Trobec, Center for Technology Transfer and Innovation, Jožef Stefan Institute

The award for “The best Innovation with commercial potential from a public research organisation in 2020 with the award fund of 2.500 Euro goes to two teams:

500 Euro award goes to the team members:

Marija Vukomanovič, Srečo Škapin and Danilo Suvorov, coming from the Jožef Stefan Institute, for their technology:

Contact-based, leaching-free antimicrobial textile »Silver-free, wearable germ protection«.

2000 Euro award goes to the team members:

Gregor Primc, Arijana Filipić, Rok Zaplotnik, Miran Mozetič, Ion Gutierrez-Aguirre, David Dobnik, Matevž Dular and Martin Petkovšek coming from Jožef Stefan Institute, National Institute of Biology and University of Ljubljana.

The presented technologies of both teams bring value to society, have a great potential to be brought to first customers and to be industrially scaled up. The qualified and passionate teams have key skills and knowledge for successful further development of the application which will bring value to the customers. We congratulate the awarded team and invite the team representatives to accept the award.

By celebrating the achievements of inventors, creators and innovative companies around the world, the WIPO Awards aim to help foster a culture in which innovation and creativity are encouraged and appreciated at every level of society.

The evaluation committee for the WIPO Awards consisted of Dr. Jeff Skinner, Dr. Jon Wulff Petersen and Mr. Alojz Barlič from the Slovenian Intellectual Property Office.

The WIPO Medal for Inventors is awarding Slovenian public researchers for their contribution to national wealth and development.

The "WIPO Medal for Inventors" goes to Prof. Dr. Alenka Vesel.

In the last decade she has gained several international patents, she is a cofounder of company Plasmadis and her IP has resulted in different products and services being brought to the market.

The WIPO IP Enterprise Trophy is awarding enterprises for their good practice to constantly and methodologically using the IP system in their business activities. Among the applications, **the jury has decided to award Razvojni center eNeM Novi Materiali d. o. o. .**

Razvojni center eNeM Novi Materiali is actively cooperating with more than 5 public-research organisations. In the last ten years they have developed several new products that have IP protection and are based on public-research transfer. They have persuaded also with the outstanding use of the IP system and activities to build public respect for IP.

Congratulations to all of the awardees!

Indeks avtorjev / Author index

Indeks avtorjev nerecenziranih prispevkov v dodatku / Index of authors of unreviewed contributions in the appendix

IS 2020

13. Mednarodna konferenca o prenosu tehnologij • 13. ITTC

13th International Technology Transfer Conference • 13 ITTC

Špela Stres, Robert Blatnik