TECHNICAL UNIVERSITY OF CRETE

MASTER IN TECHNOLOGY & INNOVATION MANAGEMENT

Technology Transfer Practices at the Technical University of Crete

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October 2019,

Chania, Greece

Disclaimer

All data and information reported herein has been obtained directly from the responders of the questionnaires and during interviews. I'd be grateful if any incorrect or misleading representations are brought to my attention for due correction. In any case, I cannot accept responsibility for any such omissions or errors of representation.

I declare that this work is wholly mine and no conflict of interests exists with respect to any reported data or information.

Acknowledgements

I herewith express my appreciation and gratitude to my supervisor Dr. Vekinis George for his support and guidance to whom I credit my interest and enthusiasm on the field of Technology Transfer.

Furthermore I'd like to express my thankfulness to Dr. Zopounidis Constantin for his guidance as well as to all the professors, students and personnel of the Technical University of Crete that held a substantial role in finalizing my Thesis.

Lastly I'd like to also thank my family and friends for their support and patience.

Abstract

The Technical University of Crete (TUC) over the years has developed a large number of Technologies in its laboratories but the extent of their transfer to and commercialization by society and industry in Greece or overseas is unknown. Furthermore, the factors that aid or impede Technology Transfer (TT) from TUC laboratories to society and industry have never been studied in sufficient detail to enable reliable conclusions to be made.

The objectives of the proposed study are therefore to obtain information on the various technologies developed in TUC laboratories

- their protection status,
- their Technology Readiness Level (TRL) and
- any activities and experiences towards commercialization,

using questionnaires and interviews of TUC research staff, and using such Information to estimate the general level of inventiveness and innovativeness of TUC laboratories in conjunction with their capabilities and funding.

The results of the study will contribute towards the further development of an integrated Innovation Management policy at TUC, centered on the existing Innovation House of the University including a “One-Stop Innovation Service” for TUC staff.

Contents

Chapter 1

1. Introduction

Societal growth and development can be empowered through investments in University's Research and Innovation. Surely, just an exceptional idea is not adequate. The road to successful commercialization is long. Nevertheless, triumph is not an unattainable ambition if one is following the right path towards commercialization and right guidelines.

Obstacles and failure factors may arise but these can always be identified and resolved. Thus, it is of vital importance to follow and ensure that the right Technology Transfer (TT) practice is followed. There is no doubt that many technologies remain un-exploited since there is lack of awareness on the best route towards the market entry.

An idea might be abstract; either born with a specific purpose as a result of intensive thought or could be a result of curiosity. Not all of the ideas are translated into successful innovations whereas consistency and Innovation Management is essential in carrying out the right steps and so as to follow the right path towards commercialization.

European Union is widely promoting innovation and industrial competitiveness through Framework Programs by the European Commission. Several of University Programs result either in Radical or Incremental Innovations which may support the local economy as well as R&D within the Universities.

It's an undisputable fact that due to lack of proper guidance might result in innovations that remain unexploited. Thus, Technology Transfer plays a significant role in promoting the results of R&D into successful commercialization. Thereby, its entry to the market results into a growing economy as the end of Innovation is the end of Growth.

This study aims to clarify how TT infrastructure and mechanisms can improve local economy as well as strengthen R&D in the long run. TT offers insights and step by step guidelines to help maximize the best results.

[1]The Technical University of Crete comprises five Engineering Schools, all of which offer undergraduate and postgraduate study programs. The Schools are as follows by year of establishment:

- School of Production Engineering and Management (PEM)
- School of Mineral Resources Engineering (MRED)
- School of Electrical and Computer Engineering (ECE)
- School of Environmental Engineering (ENVENG)
- School of Architecture (ARCH)

1 https://www.tuc.gr/index.php?id=departments-en

Technology Transfer is critical in ensuring maximum utilization of innovative research results by transferring them to the industry and society thereby strengthening the local economy.

The overall objective of this work was to search for and identify technologies that have been developed at the Technical University of Crete over the past years that can be potentially transferred to industry or even the market and thereby commercialization. Simultaneously, the best practices utilized by members of the University will be clarified and discussed for the overall benefit of the TUC.

1.2 How do Inventions get translated into Innovations?[2]

As a researcher an invention is your starting point whereas an Innovation is where you want to go. In addition to this many ideas do not flourish into Innovations. The transformation process depends on the utility of the Invention which is in reference to societal, techno-economic and environmental factors which are in correlation to the demands of the current market trends. Failure towards the transformation process is not a dead-end. Lessons-learnt throughout this process may result into successful future actions.

As aforementioned the market demands might be the key to success. An idea might be born whilst the market demands are not in rise. Despite that its value might increase if the researcher has the vision of how future trends will evolve. Hence, timing is another key factor of successful transformation process of an Invention into an Innovation.

The Value of any technology or know-how can be distinguished into two different categories. Its' intrinsic value which depends on the technology itself of external non-technical factors and its extrinsic value which is determined by the interaction of the technology with external factors such as the market and society.

The intrinsic value of a technology is correlated on the quality of the Science behind the technology as well as the expertise of the Inventors and prospects for future developments. Therefore, its intrinsic value depends on the level of its development or prospects of developments into an industrial product.

The extrinsic value of the technology know-how depends greatly on the interaction with the market and society. The Inventor should take into consideration the market pull and technology push of the technology as well as the prior existence of any enabling technologies. A cost benefit analysis has to be carried out as well as throughout analysis of the societal needs and market trends.

To conclude with an Invention is not an Innovation since it does not have the intrinsic value until the transformation process is carried out. It's worth mentioning that

[2] MTIM Course Inventions in a Scientific Environment and Intellectual Property, Dr. George Vekinis

this process might be carried out either by its Researcher or a professional Manager could be hired if essential.

Keeping up with the market trends, the technological push and pull is of vital importance as well as the Vision and focus of the Inventor towards those.

The technology transformation is a process by which technologies, know-how, expertise or knowledge are transformed into a valuable innovation and adopted by industry or society with the aim of industrial use, societal or environmental benefit or commercial exploitation.

The transformation process plays a significant role into successful commercialization of innovations. This process is complex and demanding towards the right actions taken. It’s crucial to examine extensively the regulatory landscape. The legislation affect this process in actions such as International Transactions, Intellectual Properties, setting up and operating the company as well as Research (e.g. REACH Regulation)[3]. Furthermore, it’s of vital importance to identify the Market Needs and Society need as well as the demands in association with existing technologies. Through research and development stage, the position of the technology vis-à-vis the market and society in order to maximize its relative value shall be continuous evaluated as well as considering the fact that it might occur that development stage takes too long so as the technology’s value might diminish. Lastly, aside from societal or industrial factors there are other key factors that affect the transformation process, keeping your vision and mission in addition to continual effort and persistency is as valuable as excellent knowledge of market and societal needs.

3https://echa.europa.eu/regulations/reach/understanding-reach

1.3 The Technology Transfer Process [4]

Successful researchers identify that having a brilliant ideas is just the beginning. The transformation of an idea into an innovation must be carried out with specific actions and tasks accomplished to determine its usefulness and turned into a commercialized product.

a/a	Stage	Focus of activities	TRL and Critical Milestone	Comments
1	Birth of idea	Originality, non-ambiguity, formulation, potential utility, precursors	TRL 1	Start of the process, sometimes not clear or obvious
2	Proof of concept	H2020/ERC/Ideas proposal, clarity of formulation, precision, reformulation, previous work	TRL 2-3 CM1	Preliminary proof of concept for generic application
3	Research and development	H2020/RD proposal, rigorous research, potential applications, confidentiality		Systematic and rigorous RD, reformulation and re-alignment if necessary
4	IPR protection	Patent or keep secret, first open announcement	TRL 4	Crucial decision on protection before first open announcements
5	Technical feasibility validation	Potential applications followed by focused tests on technical feasibility, preliminary decision on start- up or joint venture	TRL 5 CM2	Decision on which specific application to focus on, seeking support for industrial tests
6	Scale up	H2020/SME Instrument proposal, pilot tests, pilot plant processing, industrial advice, final decision on start- up or joint venture		First exposure to real world, decisions on appropriate scaling up
7	Industrial prototyping	Design and building industrial prototype, probably in collaboration with industry	TRL 6	Based on pilot tests build and test an industrial prototype for application
8	Industrial viability testing	Economic viability of the industrial prototype	TRL 7 CM3	Cost-benefit analysis to prove economic viability
9	Industrialization	Innovation is ready. Actual installation in industry or actual production of a product	TRL 8	Lessons learnt finally applied in industry
10	Commercialization	Valorization of the Innovation and industrial production or marketing and sales	TRL 9	Final Innovation in industrial production and sales

Table 1. The ten stages of the transformation process from the idea to the realization of the innovation.

4 Technology Transfer in Practice: From Invention to Innovation, Dr. George Vekinis, 2014

Of the many steps and activities involved in getting a promising idea valorized to become an innovation, there are ten stages that you need to go through to reach commercialization success. Within these ten stages there are three *Critical Milestones* at which you must stand back and consider your technology very critically (and comparatively) and make some hard decisions in order to answer a "go/no-go" question. These Milestones are the critical points in your transformation route by which time you should have enough information to be able to decide whether or not it is worthwhile to continue with the technology.

Critical Milestone 1 (CM1): The Stage 1 is whereas the idea is born and preliminary research and studies are carried out which correspond to Technological Readiness Level (TRL) 1. Following during Stage 2, the basic concepts of the technology are conceptualized and the basic principles are identified (TRL 2), where in the meantime the Proof of Concept (PoC) is validated and the functionality of the technology is confirmed (TRL3). Since the Proof of Concept had been tested successfully funding will be easier to get. During CM3 the mains risks that have to be mitigated are the technical ones, the fundamentals of the ideas must be examined and make sure that it abides by basic principles such as in Physics. Furthermore, it has to be assured that no technical problems might arise during the development phase. For TRL 3 development, funding given from the European Commission programs such as the Horizon 2020 which includes ERC. ERC Starting Grants[5] are awarded to researchers of any nationality with two to seven years of experience since completion of the PhD.

Critical Milestone 2 (CM2): In continuance to CM1 the next Stage, Stage 3, is where systematic Research and Development (R&D) is carried out in order to determine at initial stage the feasibility and applicability of this new technology in reference to TRL4 and run towards its optimisation. Protecting and patenting the invention is of major importance. Now we can apply online, at the European Patent Office (EPO)[6] that includes IPR protection in all member countries of the EU. *The invention ownership rights belong to the researcher* . Licensing the know-how of the patent is essential in order to commercialize the technology. To reach the status of an invention and be patentable, a concept should pass demonstrably the three criteria of originality, non-obviousness and potential utility.

5 https://erc.europa.eu/funding/starting-grants
6 https://www.epo.org/index.html

The patent should include the following main parts:

1) Title and Abstract (Summary – Utility of the invention)
2) The Specifications:
   - Title of the invention
   - Technical field
   - Background art
   - Disclosure
   - Drawings – Description
   - Mean for carrying out the invention
   - Industrial applicability

At Stage 5 is where extensive R&D is carried out in terms of technical feasibility by building up prototype at the laboratory reaching TRL 5 and achieving the CM2, indicating that the technology is validated and ready for the next crucial Stages towards commercialization. TRL5 is only an indication of the technology's potential usefulness. Industrial collaborators might be a necessity towards building up the prototype. At his stage the researcher can apply for a H2020 SME funding [7] and/or decide on a Joint Venture, a Contract Research Organization (CRO) or going alone. Viability testing is essential in this stage, much more than pilot testing and building the prototype. Thus, the feasibility of the project will be predetermined. Moreover is essential to take into account the risks that one might encounter.

<u>Critical Milestone 3 (CM3):</u> The most important decision point, thereby a detailed action plan is required. Running towards Stage 6 a scale up prototype is build and testes in a relevant operational environment in reference to all the applications of the technology (TRL6). Following up at TRL7 where based on the scale up prototype, a full prototype in final design is build up and is demonstrated at operational system level. Therefore, all the relevant engineering and manufacturing risks are identified so as all actions mitigating risks are applied. In order to determine TRL7, at Stage 8, techno economic viability tests are implemented. Concluding to the CM3 only when the industrial validation has successfully been completed (TRL8).

Continual review of the technology up to CM3 is important so as to identify arising risks or failures. In addition to this, failure at a certain Stage does not mean that the project is aimless, at any time one can go back to the previous Stage in order to take all the essential corrective actions towards the next Critical Milestone. If the researcher proves technical feasibility but not economical, he/she can go back into repeating the industrial and viability tests.

Since CM3 is achieved, technical feasibility and economic viability tests are validated and successfully completion of a scale up prototype the road to industrialization is closer. The performance and the effectiveness of the technology, the existing enabling technology along with its economic competitiveness and acceptability by the end user are key factors towards moving into commercialization. During Stage 7 and Stage 8 is where

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7 https://ec.europa.eu/programmes/horizon2020/en/h2020-section/sme-instrument

the most crucial assessments are being held and a business plan is requires in addition to examining the Return on Investment (ROI). At TRL9 the industrial development is complete whereas we are moving into proving the new technology into a fully operational environment. Lastly, achieving Stage 9 indicating a fully functioning and operating technology is demonstrated (TRL10) where the technology is ready to be commercialized. Despite that, continual efforts, research, study of the market and the Regulatory Landscape is fundamental.

1.4. Background on the need for TT at the TUCs[8]

The Technical University of Crete (TUC) is a small, young and dynamic University that comprises of five Engineering Schools of which main goals in addition to laboratories or research units are listed in the following sections:[9]

1.4.1 School of Production Engineering and Management (PEM)

The School places emphasis on modern technologies, production systems, management and decision making, finance, operational research as well as ergonomic design, control systems, materials, mechatronics and robotics. The curriculum provides a solid foundation in mathematics, physics, mechanics and informatics. It also provides a comprehensive engineering education while allowing students to focus on specific areas in Production Engineering and Management.

School of Production Engineering and Management (PEM)
Computer Aided Design (CAD) Laboratory
Computer-Aided Manufacturing (CAM) Laboratory
Industrial, Energy and Environmental Systems Laboratory
Intelligent Systems and Robotics Laboratory
Micromachining and Manufacturing Modeling (m3) Laboratory
TUC Eco Racing Team
Computational Mechanics and Optimization Laboratory
Decision Support Systems Laboratory
Dynamic Systems and Simulation Laboratory (DSSL)
Cognitive Ergonomics & Industrial Safety (CEIS) Laboratory
Data Analysis and Forecasting Laboratory

[8] Angeliki Skaraki, Nafsika Nyktari, Vassileios Vazakas, Pantelis Sotirelis, MTIM Technology Management & Entrepreneurship Paperwork, Innovation House of TUC - Building Up an Accelerator, Chania Crete 2017

[9] Technical University of Crete; at a Glance, A short portrait of the Technical University of Crete, Public & International Relations Department

Financial Engineering Laboratory
Management Systems Laboratory
Applied Mathematics and Computer Laboratory
Machine Tools Laboratory
Materials Structure and Laser Physics Laboratory

Table 2. Laboratories of the School of Production Engineering and Management

1.4.2 School of Mineral Resources Engineering (MRED)

The primary goal of the School is to educate engineering students on a broad range of scientific and technical issues related to the extraction and processing of minerals. The coursework focuses, in particular, on industrial minerals and energy resources. The changing demand for minerals has influenced the development and application of modern methods for exploration and exploitation. Dynamic changes in market conditions and the technology currently available have generated the need to train engineering students to be able to successfully face new challenges. Hence, the courses offered in the School aim to deliver a balanced mixture of fundamental skills and knowledge in specialized fields to ensure that graduates have the expertise and flexibility required for success in a competitive global market.

School of Mineral Resources Engineering (MRED)
Inorganic and Organic Geochemistry and Organic Petrography
Applied Geophysics
Petrology and Economic Geology
Geodesy and Geomatics
Geostatics Research Unit
Economic Geology of Industrial Minerals Research Unit
Research Group of Spatial Informatics (SenseLab)
Laboratory of Applied Geology
Laboratory of Rock Mechanics
Laboratory of PVT and Core Analysis
Laboratory of Mine Design
Geology (Stratigraphy – Techtonics – Environmental Geology) Research Unit
Quality Control – Health and Safety in the Mineral Industry Research Unit
Drilling Engineering and Fluid Mechanics Research Unit
Hydrocarbons Chemistry and Technology Research Unit
Laboratory of Applied Mineralogy
Laboratory of Ceramics and Glass Technology
Laboratory of Solid Fuels Beneficiation and Technology
Laboratory of Ore Processing

Microscopy Methods for Minerals and Industrial Products Research Unit
Management of Mining / Metallurgical Wastes and Rehabilitation of Contaminated Soils Research Unit

Table 3. Laboratories of the School of Mineral Resources Engineering

1.4.3 School of Electrical and Computer Engineering (ECE)

The curriculum of the ECE School aims at a high quality theoretical education and hands-on training of engineers in modern technology subjects such as electronics, control systems, computer science and telecommunications. The goal is for students to develop the theoretical background that will allow them to understand the fundamentals of the above technologies in depth so that they will be able to effectively cope with the demands of these rapidly changing fields.

School of Electrical and Computer Engineering (ECE)
Distributed Multimedia Information Systems and Applications Laboratory TUC/MUSIC
Intelligent Systems Laboratory (InteLLigence)
Software Technology and Network Applications Laboratory (SoftNet)
Electronics Laboratory
Circuits, Sensors and Renewable Energy Sources Laboratory
Microprocessor and Hardware Laboratory
Automation Laboratory
Information and Networks Laboratory
Telecommunications Laboratory TUC/TELECOM
Digital Signa & Image Processing Laboratory (DISPLAY lab)

Table 4. Laboratories of the School of Electrical and Computer Engineering

1.4.4 School of Environmental Engineering (ENVENG)

The objectives of the Environmental Engineering School are to provide advanced education of a high standard in environmental science and engineering and to prepare qualified engineers capable of contributing to the measurement, monitoring, assessment, and treatment of problems caused by human intervention in the environment. The mission of the School is to offer courses at undergraduate and graduate levels, advance multi- disciplinary research on environmental issues, and provide environmental services to society and to the scientific community.

School of Environmental Engineering (ENVENG)
Design of Environmental Processes Laboratory
Energy Management in the Built Environment Laboratory (EMBER)
Environmental Catalysis Laboratory
Environmental Law and Environmental Governance Laboratory
Renewable and Sustainable Energy Systems Laboratory (ReSEL)
Stochastic models of tumor growth Laboratory
Toxic and Hazardous Waste Management Laboratory
Aquatic Chemistry Laboratory
Atmospheric Aerosols Laboratory
Biochemical Engineering & Environmental Biotechnology Laboratory
Ecology and Biodiversity Laboratory
Environmental Engineering and Management Laboratory
Environmental Microbiology Research Unit
Environmental Organic Chemistry and Micro-pollution Research Unit
Physical Chemistry and Chemical Processes Laboratory
Computational Dynamics & Energy Laboratory (CODEN)
Environmental Engineering Laboratory (TUCeeL)
Geodesy and Geographical Information Systems Research Unit
Geoenvironmental Engineering Laboratory
Hydrogeochemical Engineering and Soil Remediation Laboratory
Natural Hazards, Tsunami and Coastal Engineering Research Unit
Water Resources Management and Coastal Engineering Laboratory

Table 5. Laboratories of the School of Environmental Engineering

1.4.5 School of Architecture (ARCH)

The School aims to educate and highly train students across a wide spectrum of knowledge covering subjects in art, technology and science, and connecting theory and design. Its mission is the cultivation and promotion of knowledge through teaching and research in the scientific fields of architecture, urban design and planning, architectural technology, preservation and monument restoration, as well as the environmental-ecological dimension of architectural design. The curriculum covers the above subject areas with courses in Architectural Design, Urban design and Planning, Digital Technologies in Architectural Design, History and Theory of Architecture and Art, Landscape Architecture, History of City and Urban Design, Architectural Technology, Visual Arts, Restoration of Buildings. It is also supplemented with courses in natural and social sciences.

School of Architecture (ARCH)
Applied Mechanics Laboratory (AMELab)
Digital Media Laboratory
Transformable Intelligent Environments Laboratory (TIE Lab)
Materials for Cultural Heritage and Modern Building (MaCHMoB)

Table 6. Laboratories of the School of Architecture

The University's mission is to expand knowledge, to benefit society through research that is integrated with education and to pursue excellence in education and research.

The University is particularly active in conducting basic and applied research and it focuses on promoting research in modern scientific and engineering disciplines. This policy aims to develop research capabilities in areas of advanced technology, leading to international collaborations, addressing practical problems of the industry and generating an impact on other sectors of the Greek economy, and in particular on the economy of the island of Crete.

Undoubtedly, research is one of the strengths of the Technical University of Crete, since in a research conducted by the European Research Ranking for 2014, the Polytechnic of Crete was among the top 10 educational institutions in Greece in the field of research, while for the year 2013 (last analytical results) it was among the top 5 positions in the research funding indicators.

The above proves the very good position of the University of Crete in the field of research among Greek higher education institutions. At the same time, however, the distinctions of the members of the teaching and research staff and the students of the Technical University of Crete in the international arena are the best guarantees for the impact of the research carried out in the institutes' laboratories and research units abroad.

It's an undisputable fact that the Technical University of Crete (TUC) provides a wide-range of tools that facilitate students in conducting basic and applied research in many fields of engineering. The main goal is to oversee how to exploit TUC'S resources in favor of scientific growth and innovation.

Development of an Innovation House (IH) at TUC: The aim of the TUC Innovation House is to promote entrepreneurship within the Technical University of Crete and in general the greater area of Crete. To conclude, TUC has been very strong in technological research and education, however, has been behind in the area of technology transfer and entrepreneurship.

1.5 Objectives and aims of this Dissertation

The central objective of this dissertation is to search for, identify and collate as many technologies under development in TUC as possible and elucidate and catalogue their selected methods used for transferring them to industry and any obstacles encountered.

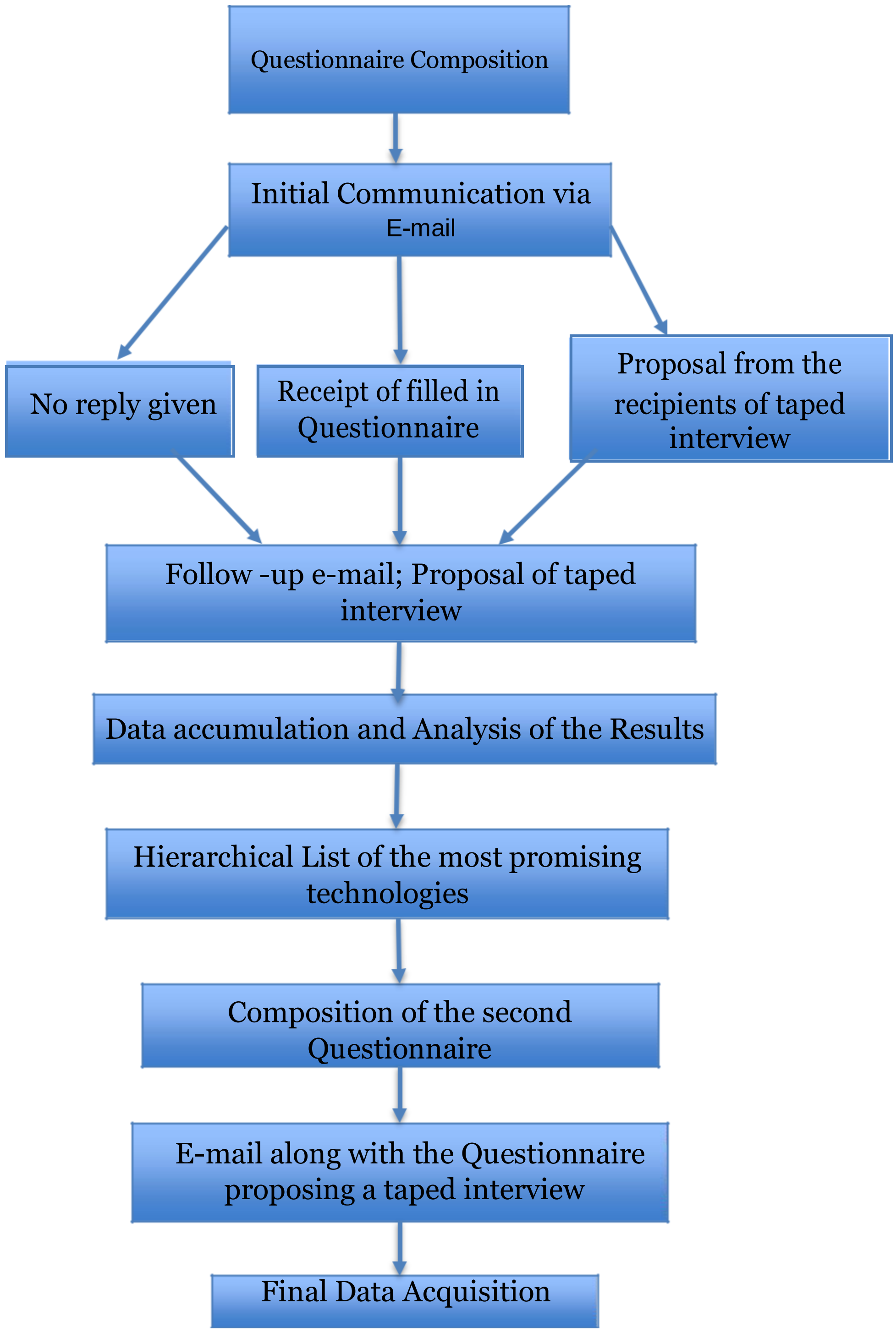
The work was carried out in two stages: first, collecting and collating as much information as possible using questionnaires and face-to-face interviews and secondly, analyzing and cataloguing the methods used for TT and problems and methods encountered during the process.

Based on the results from the questionnaires, a small number of technologies were selected for deeper analysis based on a 2nd questionnaire and an interview. These were then used to develop case studies. Based on the questionnaire results and the case studies, lessons learned and suggestions for overcoming obstacles and optimizing TT are offered.

Chapter 2

2. METHODOLOGY OF DATA ACQUISITION AND ANALYSIS

The data acquisition was based on a two-stage questionnaire sent to a large number of members of staff as well as young researchers followed by face-to-face interviews whenever necessary. Finally, a small number of technologies were selected for further study and are presented as “case studies”.



The first step was to identify as many recipients of the 1st Questionnaire as possible. This was carried out by internet research either based on publications or already known to me Researchers. Moreover an analytical list in reference to their Last Name, e-mail address and field of research was created. All this information were accumulated from the University's Website. In addition, some data were collected from a publication of Innovation and Entrepreneurship Unit by the Technical University of Crete that was published on November 14. A list of all the recipients is included in Appendix 1. Not all of the e-mail addresses are listed as of which were not published and collected through referrals.

The results of the 1st Questionnaire were analyzed and the most-promising technologies were selected based on various to which were then sent a 2nd Questionnaire to obtain more and in-depth information.

The main criteria of selection were specified by the owners and were:

- the current TRL level,
- market entry level,
- state of development towards transfer, and
- which were the most promising towards commercialization.

In total (204) e-mails were send out of which sixteen (16) replied with the filled in questionnaire or asking for a recorded interview which later was carried out. Others replied that would gladly assist to this project but their field of interest and research was either non technological or commercial. Based on the results obtained, further interviews were held and 3 case studies were developed and presented.

The analysis and information obtained enabled the drawing up of certain conclusions and recommendations regarding the technology transfer processes and procedures at TUC. An in depth analysis will follow on Section 3 along with proposals in reference to their Commercialization Readiness Level.

2.1. Preparation and rationale of the Questionnaires

The initial communication with the Professors, Researchers and TUC's Students was made via e-mail. This method was chosen so as to accumulate as many replies as possible. As well as in that way each recipient had the chance to work and reply on each own time. The only drawback through this procedure was the lack of interaction with the recipient as questions could be raised in reference to specific specialized subcategories of the Questionnaire. Therefore, there were interviews that were conducted so as to acquire evident and clear replies.

2.1.1 First Questionnaire

As aforementioned the interviewees were contacted via e-mail, followed with the 1st Questionnaire. The e-mail as well as the attached Questionnaire was written as the following:

E-mail Subject: Questionnaire within the framework of Masters in Technology and Innovation Management, TUC

> Dear Mr. /Mrs.,
> Within the framework of my diploma thesis titled "Technology Transfer Practices at the Technical University of Crete" for the Master's Degree Program "Master in Technology and Innovation Management" of the Technical University of Crete (https://www.mtim.tuc.gr/en/ home/, MSc Director: Prof. N. Matsatsinis), I would be grateful to support me by completing (in summary, it will not take you more than 20 minutes) the attached questionnaire on some of the technologies you are developing or you have developed in the past that could be transferred to the industry with a view to commercialization. Please answer the questionnaire by so that I have the time to synthesize the data. Thank you very much in advance and I confirm that your answers and any information you quote will remain confidential.
>
> Yours sincerely,
> Angeliki Skaraki, BEng
> MTIM Candidate, TUC

Table 1. <u>1st Questionnaire:</u>

Technical University of Crete
School of Production Engineering and Management &
School of Electrical and Computer Engineering
University Campus, Akrotiri
73100 Chania, GREECE
Tel. 28210-37302 , Fax: 282100-6900

MASTER IN TECHNOLOGY & INNOVATION MANAGEMENT

TECHNOLOGY TRANSFER QUESTIONAIRE
(Where applicable, please rate from 1 to 5 or DK (don't know) or NA (not applicable)

TITLE AND BRIEF DESCRIPTION OF THE TECHNOLOGY:

NAME OF RESPONDER AND ROLE IN THE TECHNOLOGY'S DEVELOPMENT:

DATE OF FILLING IN THE QUESTIONNAIRE:

GENERAL QUESTIONS	**ANSWERS/ COMMENTS**
OBJECTIVES OF THE TECHNOLOGY (WHY IS IT BEING DEVELOPED?):	
AIMS OF THE TECHNOLOGY (WHAT ARE THE TARGETED CHARACTERISTICS?):	
MAIN FUNDING SOURCES OF THE TECHNOLOGY:	
MAIN MARKETS/SECTORS TARGETED:	
ARE THERE OTHER OWNERS OF THE TECHNOLOGY'S I.P.:	
Is/was the technology part of a TUC project? Which one?	
If there is a project being executed at present, when is it expected to finish?	
CURRENT TECHNOLOGY READINESS LEVEL (TRL, *see: https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016_2017/annexes/h2020-wp1617-annex-g-trl_en.pdf*	
TARGET TRL OF CURRENT PROJECT:	

QUESTIONS ON TECHNOLOGY DEVELOPMENT AND TECHNOLOGY TRANSFER CHALLENGES AND PROSPECTS	**RATING**	**ANSWERS/COMMENTS**
TECHNOLOGICAL ISSUES		
Considering all similar technologies, how innovative is this technology in each of its potential markets or sectors?		
Are there any serious delays in the technological development or project execution?		
Is there a need to change any of the tasks to achieve the objectives?		
Is a funded follow-up project necessary to achieve the objectives and aims?		

Are there any technical obstacles in achieving the objectives and aims?		
Are there any non-technical obstacles in achieving the objectives and aims?		
Are there any specific obstacles connected with TUC (e.g. academic or administrative)?		
Who else is working on this technology? Judging from their publications and announcements, what is their current TRL?		
Are technological competitors being monitored?		
What are the competing projects?		
Considering new developments in the field, are there any reasons that the project cannot reach its objectives and aims?		
Have you carried out a SWOT analysis of your technology vis-à-vis competing technologies?		
If yes, have you identified routes to address all weaknesses and threats?		
Does TUC have adequate resources for further R&D, if necessary, if you cannot obtain follow-up funding?		
What type of support is available for your project at TUC?		
Are there sufficient funds to complete the RD and reach TRL6? If not, what is still needed and where will the funds be sourced from?		
Are there any additional team members needed to provide their expertise to achieve the objectives and aims?		
Any other Technological issues not mentioned above that may affect the technology's development?		
LEGAL AND CONFIDENTIALITY ISSUES		
How are the results going to be protected?		
In which countries should you protect the results?		
Do you foresee any problems in getting a patent in Greece or Europe?		
Are there sufficient confidentiality safeguards?		
Have you identified the key aspects of your technology that make it unique and innovative?		
Can these key aspects be obvious or reverse-engineered by a skilled person?		
Has a patent application been filed at OBI or EP?		
Has a search been carried out for any publications or patents or announcements on similar technologies?		
Has a patent search been carried out to check for any potential conflicts with other valid patents?		
Is there external dissemination regarding the project?		
Are there any key technical aspects of the Research that have been published or presented publicly?		
Are there any fall-back positions if IP conflicts are identified?		
Does the technology need to conform to any regulations or standards?		
What are the standards needed for this market? Who are the prescribers of these standards?		
Are counterfeits and counterfeiters easy to detect?		
How powerful are the potential counterfeiters?		
Do you use Non-Disclosure (or Confidentiality) Agreements when talking about the key aspects of your technology to third parties?		
Are you aware of any TUC policy for implementing TT of technologies developed within TUC?		
Any other Legal or Confidentiality issues?		
TECHNOLOGY TRANSFER ISSUES		
How long until commercialization of the technology (i.e. to reach TRL9, estimate)?		
What is the current Commercialization Readiness level? (See G. Vekinis "The Researcher Entrepreneur", page 121)		

Have you ever considered how you'll go about transferring your technology to industry or the market?		
Have you carried out a Risk Analysis regarding your technology and its market potential?		
If yes, have you identified mitigation actions for each major Risks identified?		
Is there a need for a commercialization partner?		
Do you or any other team member have experience with Technology Transfer or commercialization of any technology?		
Have you identified potential TT routes?		
Have you carried out a SWOT analysis for each possible TT route?		
Who would be financially interested in exploiting the results?		
How much further investment is required for commercialization?		
How are these funds going to be raised?		
Have you identified specific funding sources for TT?		
Are you or any other team member interested in taking an active role in TT or commercialization?		
Would you take months or even years off your research work to commercialize the technology?		
Would you be interested in TUC support to help you with TT or commercialization?		
Are there any incentives to companies necessary to entice the development of TUC technologies into commercial products?		
Are you aware of the Innovation House of the TUC and its capabilities for TT?		
Any other Technology Transfer issues?		
MARKET ISSUES		
Have you identified all potential industries or markets that your technology may target?		
Is there any need for outside assistance to identify potential market(s) for your technology?		
Which specific companies could be interested in the results?		
Which companies should be contacted first?		
What advantages do the results offer a potential user in each identified market?		
What market needs/demands do the results satisfy?		
Will the results be competitive? In which market or sector?		
Who are the main competitors in each identified market?		
What are the competing technologies, products or services in each market or sector?		
Whom are the new results going to disturb?		
Is there a main player (monopoly) in this market for the results?		
What are the competing technologies' drawbacks in each market?		
What are the competing technologies' advantages in each market?		
What is the target market size? The maximum possible market size?		
What is the national/European cost in this market?		
Will the results be cost and price competitive in each market?		
What will be an acceptable market price for the results, in each market?		
What is the most expensive component?		
What is the price of the main competing products/services?		
How must the results be promoted and marketed in each targeted market?		
Any other Market issues?		
PARTNERSHIP ISSUES (in case of more than one entity owing the technology)		
What is the core business of each partner?		
What is the main market of each partner?		
What is the main geographical market area of each partner?		

What are the strengths and weaknesses of each partner?		
What are the aims of each partner in this project?		
Are there any partners in competition vis-à-vis the results?		
What is each partner's standing in the results' sector?		
What is each partner's financial state?		
How developed is each partner's R&D?		
How much is each partner's investment in the project?		
Is there any precautions taken by TUC when it comes in signing Agreements with entities/partners?		
Are there Collaboration agreements?		
Does a consortium agreement exist?		
Is there a Foreground IP Rights distribution agreement?		
Is there an Exploitation Rights agreement?		
Is there a Background IP rights agreement?		
What licenses on background knowledge must be acquired?		
Any other Partnership issues?		

Any other Issues or Comments regarding the above Technology?

Any comments or suggestions regarding this Questionnaire?

Thank you very much for your help!

Ms Angeliki SKARAKI, MTIM Candidate

As a reply of the initial communication was either the filled in Questionnaires or a request on a face to face interviews as the recipient's time could be limited. Therefore, it was a pleasure to meet and greet a number of distinguished Professors of TUC and conduct an Interview according to the Questionnaire.

Prior to this, the e-mail that was send was the one below:

<u>Second E-mail:</u>

> Dear Mrs. / Mrs.,
>
> I understand that your time is limited and that you are very busy. I wrote you a few weeks ago about completing a questionnaire within my Diploma. As it is very important for me to get successful results, I thought if you would facilitate a brief meeting at the TUC. I remain always at your disposal.
> Yours sincerely,
>
> Angeliki Skaraki, BEng
> MTIM Candidate, TUC

2.1.2. 2nd Questionnaire and case studies

As a result the most promising ones were identified; method and criteria used described on Section 2.2. In continuance to the initial communication a Follow – up e-mail was sent to those that were distinguished. The Follow – up e-mail and Questionnaire are listed below. The basic differentiation from the initial communication that was made prior is the fact the Researchers were asked to participate on recorded interview asking out questions that are listed in the Questionnaire below.

Follow-up e-mail:

> Dear Mr./Mrs.,
>
> I would like to thank you for the time you spent on completing the questionnaire, as part of my diploma thesis titled "Technology Transfer Practices at the Technical University of Crete". To complete my work, I would like to ask you some more questions based on the attached Follow-Up Questionnaire during a taped interview whenever you have time.
> Be rest assured that all information will remain confidential. Thank you very much in advance.
>
> Yours sincerely,
> Angeliki Skaraki, BEng
> MTIM Candidate, TUC

2nd Questionnaire

Technical University of Crete
School of Production Engineering and Management &
School of Electrical and Computer Engineering
University Campus, Akrotiri
73100 Chania, GREECE
Tel. 28210-37302 , Fax: 282100-6900

MASTER IN TECHNOLOGY & INNOVATION MANAGEMENT

TECHNOLOGY TRANSFER QUESTIONAIRE – FOLLOW-UP

Date:

TITLE OF THE TECHNOLOGY:

NAME OF RESPONDER AND CURRENT ROLE IN THE TECHNOLOGY'S DEVELOPMENT:

Please provide responses to the following questions as they concern your specific technology. Your responses will assist us in developing a technology transfer case study including a SWOT analysis, and suggestions and recommendations for your particular technology

#	Question	Response
	TRL AND MARKETS	
1	What is the current overall stage of development of your technology? (describe briefly and estimate TRL) Is there sufficient protection and confidentiality safeguards?	
2	What are the most competitive or unique functions or characteristics?	
3	What are the most promising applications areas?	
4	Which are the most promising markets/sectors?	
5	What are the main competing technologies in these markets and for these applications?	
6	Which are the main players in these markets and for these applications?	
7	Are there any unsatisfied niches in these markets for your technology?	
8	Do any of these players need your technology (to expand their catalogue or enter a new market)?	
9	Have you carried out a technological SWOT analysis (including Risk analysis) for your technology in each identified market and for each identified application?	
	ORGANISATIONAL	
10	Is there a good technical team which can ensure reliable and effective technological development?	
11	Is there a strong, professional management team (including a professional manager and legal support)?	
12	Have you considered all relevant outsourcing/insourcing needs?	

13	Have you carried out an organizational SWOT analysis (including Risk analysis)?	
14	What are the core critical actions and tasks that need to be carried out immediately?	
15	Is there any need to ensure compliance with the REACH or other regulations (chemical, safety, environment etc.)?	
	FUNDING AND COMMERCIALISATION	
16	Have you decided on the most promising route for commercialization?	
17	Is there a funding plan for this route?	
18	If the route involves a start-up have you decided on the shareholder shares and similar ownership aspects?	
19	What is your estimate of your Commercialization Readiness Level (page 121 of Ref)?	
20	What, in your opinion, are the biggest challenges and risks to successful commercialization and how can they be addressed? Page 125 of Ref.	
21	Have you identified a professional Technology Broker to help you in identifying promising market partners and in the ensuing negotiations?	
22	Have you drawn up a detailed Action Plan towards Commercialization including a Timeline and Road Map?	
23	Can the technology be produced and marketed viably to compete with existing technologies?	
24	Is there a viable business plan towards commercialization?	

REFERENCE: G. Vekinis, "The Researcher Entrepreneur: Best Practices for successful technological Entrepreneurship", ATCS, Athens, 2016

Any other Issues or Comments regarding the above Technology?

Any comments or suggestions regarding this Questionnaire?

Thank you very much for your help!

Ms Angeliki SKARAKI, MTIM Candidate

2.2. Elucidation and Cataloguing method

As a result of the first Questionnaire all the data accumulated were sorted out on the following parameters:

- Name of the Recipient
- Working Position
- Project Title
- Sector/ Field of Interest of the Recipient
- Owner of the technology
- Role of the Recipient in the given project
- Type of Technology (e.g. Engineering, Sensors, IT)
- Level of current Development
- Prospects
- Promising markets
- Companies of Interest / Marketing
- TUC Support through (either R&D or Administrative)
- Obstacles
- Funding Expenditures
- Competitive Landscape / Competitors
- EC or Greek Project

Based on this parameter a comparative analysis was carried out so as to identify the most promising technologies and/or projects. Therefore an abstract efficacy rating on the ratio 1 (lower) up to 12 (higher) was created. As a result the most promising were identified; following up to the second Questionnaire. A second e-mail communication was made along with the attached second Questionnaire; only this time an interview was carried out.

As listed above we categorized all the Questionnaires as follows.

- The name of recipient,
- Working Position,
- Department,
- Title of the Project,
- Sector,
- who is/are the owner(s) of the Technology,
- the role of the Recipient at the Project or Technology developed, which companies might be interested in this particular technology, the TUC support such as infrastructure, financial aid, laboratories and tools offered.

Moreover, we took into consideration the obstacles that were mentioned as well as the funding that might be needed to reach commercialization and the competitor's landscape. Lastly, if the Project or Technology developed is supported by the European Union or Greek projects. As a result, we delivered an efficacy rating for each one and amongst these we selected the 5 first projects for the follow-up second Questionnaire.

Decision criteria for 2nd round

The efficacy rating was calculated in respect to various factors. Mainly, if there are already existing funding schemes that EU offers so as to develop further the current technologies described. Additionally, TRL level played a key role in making this decision. A project in low TRL level might be too early to think on Technology Transfer Routes. Furthermore, the novelty of the invention could be low or existing inventions around the same technology could exist in the market already. Lastly, there might be not commercialization efficacy.

TRL	Title	Description
1	Basic principles are observed	This is the starting point and the lowest level of technology readiness. The idea has been born and early-stage scientific research is carried out, including documentary research and exploratory studies.
2	Technology concept is formulated	Once the basic principles have been clarified, the concept is formulated. Research includes analytical studies and experimentation, perhaps with a specific application in mind.
3	Proof of concept is confirmed	Systematic research and development validates the predicted functionality of the technology.
4	Technology is validated in the lab	Design, development and lab testing of technological components are performed. This is a relatively "low fidelity" prototype compared to the eventual system. Potential applications have been identified and protection sought.
5	Technology is validated in a relevant environment	The technology is tested in a lab environment simulated to correspond to the real application. This is a "high fidelity" lab prototype and is used to check *technical feasibility* for a specific application.
6	Technology is demonstrated in a relevant environment	A scaled-up prototype is built, developed beyond Stage 5, and tested in a relevant operational environment corresponding to the eventual application.
7	Prototype system is demonstrated in operational environment	Based on the scaled-up prototype, a full prototype at the final design level is demonstrated at operational system level. Engineering and manufacturing risk is identified and minimized and the *economic cost- benefit* of a full industrial prototype is satisfactory.
8	System complete and qualified	Technology is shown to work in its final form under the expected conditions for the specific application. Industrial development is complete.
9	Actual system proven in operational environment	The system has been used in full operational environment satisfactorily and is ready to be commercialized.

Table 1. . The nine Technology Readiness Levels[10]

[10] Technology Transfer in Practice: From Invention to Innovation, Dr. George Vekinis, 2014

Chapter 3 Results and Discussion

3.1 Responses from 1st Questionnaire

In continuance to the results from the first Questionnaire we can distinguish some commons in between them. As a reference the table below enable us to compare these results according in correlation to various aspects. The names of the recipients and/or the names of the projects are included in the confidential appendix B which cannot be published. A numerical indication for each technology and/or projects is created as well as the type of technology described. All the data below are gathered with reference to the replies of the interviewees.

a/a	Sector / Type of technology	Current TRL	Owner	EU Project
1	IT	TRL7-8	TUC	H2020 EU Project
2	Learning Environment	TRL9	Project's Team	EC
3	Engineering	TRL5	TUC Project	
4	GIS	TRL8	Project's Team	
5	Microelectronics	NA	TUC	
6	Engineering / Sensors		Professor	NA
7	New Media Arts	TRL8	TUC Project	
8	Drones	TRL7	Project's Team	

9	Process	TRL7	TUC Project / Two private companies	Co-funded by the European Regional Development Fund (ERDF) and managed by the Greek General Secretariat for Research and Technology.
10	Automotive	TRL7	TUC Project	
11	Traffic Management & Control System	TRL4-5	EU & Other Owners	
12	Chemical Process	TRL5	Project's Partners and EU	Yes
13	Engineering /Robotics	TRL7	TUC Project	NA
14	Energy	TRL8	Project's Partners and EU	
15	Chemical Process	TRL3	Professor and Partners	
16	R.E.S.	TRL5	TUC Project	

a/a	TUC support	Funding expenditure	Results
1		The cost of covering the salaries of three engineers until first customer/contract achieved	The tool is open source and with a very permissive license (MIT), the main framework can be part of research work by student, postgrads and researchers. the framework open and free to achieve adoption. Certain parts that are not free are kept strictly proprietary and are not distributed.
2	Software and Hardware	More funding is required, DK the amount	
3	Students	Cannot estimate the amount of further funding required	Published results, the aim was not commercial
4	No. Only personnel, no funding	Research proposals, Funds 80000 Euros	Novel product no competitive technology. 3D GIS is something new in education
5	CAD Tools	Lab facilities improvement	Results stored in hard drives / Some key aspects have been published
6		100k needed	Some minor aspects have been published on their website http://blase.tuc.gr/index.php/en/
7	Laboratories	Personnel (200k funding needed)	Open source software - Licensing Revenue
8	No support from the School, ethical support from the University - self-funded	Need of Project proposals	It was innovative 3 years when the project initiated but now there are competitors
9	Rating: 4 (no further details)		
10	Financial – basic support (Labs-internet-etc)		The results will not be protected – will be published
11	Administrative	The project aim was never to go for TRL 6; if it was, follow-up project would have been planned	Results are protected via publication in scientific journals, have been published in international journals and conferences
12	Administrative	Can be raised through EU Project	The results will mainly be protected within European Countries. There is a Consortium Agreement
13		Would assist	There's a chance that the results will be published.
14	Administrative management of the project	Depends on the application	The rights are protected by EU. The technology is now courtesy of the EU. The dissemination of the results and stimulation of Hospitals administrators to exploit the developed technologies is done by the EU.

15		> 1 mil euro funding needed	Competitive exploitation routes for high-moisture biomasses
16	No, it's independent, part of a contest		

a/a	Prospects	Markets	Obstacles
1	No other tool/framework available with the same capabilities/functionality	IT, IoT	None at the moment. Project completed. Planned expansions may have unforeseen obstacles though.
2	Children's furniture, toy, learning equipment, and educational tool	Education	
3	Recycling Industry – especially for the future needs on PV panels recycling	Recycling Industry	Need for a commercialization partner: weak point of the project. Partners failed to achieve that.
4	To provide a tangible means for earth geomorphological understanding and decision making	Military, Education, Spatial Analysis, GIS services	Need of additional team members
5	Widely applicable to advanced technology nodes	Telecommunication/ Circuits	Annual License fees of CAD , lack of computing power
6	No battery needed.	Automation, Agricultural	Legal Framework
7	Creative learning experience, transformative learning, digital storytelling, Project based learning	Education	3 additional team member needed (UX Developer, Visual Artist), Funding
8	Better communication, smaller size, smarter decision making, cheaper, expandable, useful.	e-health, Search and Rescue, Mobile phones Industry	Funding needed, Legislation on drones that changed since 2015 when the project started

9		Concrete production, Construction sector	Technical:2, Non technical: 3 TUC:3
10	Low consumption, zero-emissions automotive		Race track to be used as experimentation area, Low budget, Administrative: limited experimentation-laboratorial space
11	Individual vehicle speed control/assistance at the approach of traffic signals integrated with control of traffic signals for traffic flow efficiency improvement; distributed, easy and cheap field installation; flexible design; automated calibration and maintenance	Traffic Management	
12	Highly innovative process, higher efficiency than competitive technologies	Energy Sector	
13	Along with a commercial partner and alternations could be redesigned into a commercial product	Military, Airports as guard robot	
14	Implementation in existing and new Hospitals	Hospitals	No
15	Production of porous carbonaceous materials with advantageous characteristics for various environmental applications	Bio-fertilizer market	
16	Solution to energy storage problems	Energy production companies	Collaboration with other engineers, at early stage, study of the Law and R&D required

3.2.1. Case study 1: Technology on IT

This technology is mainly a simulation framework for the Design of Systems of Systems. It is used so as to design and evaluate Cyber-Physical systems with main aim to provide with high accuracy computer simulation of CPS in order to be able to evaluate the hardware, software and network of the system without having to actually implement it, thus saving time and minimizing expenses. Main applications areas initially included CPS/ IoT, after the completion of the tool it became evident that Parallel Systems and HPC systems can be the main targets.

The project is a part of TUC Project and EU funded by Horizon 2020 framework. There are other owners of this technology as there is a Consortium Agreement in place. The project was complete in March 2018. According to the interviewee its' current TRL level is at TLR7-8. Additionally, a spin of company has already been established.

This framework is based on open source technologies and it is quite innovative as the actual interconnection of the different tools into one coherent framework offers higher functionality than the sum of its component. Thus, it's quite competitive as there is no such framework currently in the market with such capabilities and high functionality.

No obstacles till the current point were encountered. Despite that as the operations expand unforeseen ones need to be encountered. The TUC cannot offer further resources or support for Research and Development Work if needed follow up funding will be necessary. Luckily, since the tool is open source and with very permissive license (MIT) the main framework could be part of research work by students or researchers from with TUC. Funding is covered privately as well additional team members are needed, development work is described as the most expensive component.

In regards to IP protections the framework is open and free to achieve adoption. Certain parts of the results are not free and are strictly proprietary and not distributed; no patent protection.

3.2.2 Case study 2: Learning environment – Multifunctional object

This innovative multifunctional object offers a variety of uses for educational purposes. It has many purposes such as children's furniture, toy, learning equipment or educational tool. It offers many uses and spatial arrangements with reference to the "learning through action" approach. The aims of this object is to aid the developmental psychology of children and improve spatial comprehension skills.

The project is part of the TUC, the group aim is to enhance the learning ability of children therefore the project as a design and research framework tool was initiated so as to enhance the educational process. Until now there is nothing similar into the Market. The product according to the interviewee is at TRL9, and it is already ready for commercialization. Educational structures, schools and furniture makers could be interested in financially exploiting the results. No obstacles either technological, technical or non-technical are encounter to this moment. The TUC offered its support by providing the necessary tools, Software and Hardware towards the completion of the project. In order to enter the Market, financial aid is required; by attracting investors. The competitive advantage of this product within the Educational Sector is given to the fact that the product offers more uses and improves in many ways the children's skills as it is multifunctional object and other are mono – functional as others that already exist.

3.2.3 Case study 3: Technology on Engineering; PV Panels Recycling

The aim of this Research project was to develop technology for PV panels recycling. The future needs on PV panels recycling will augment. Process optimization and new technology integration is the main aim of this technology and targeted characteristics. This TUC Project is a part also of a project by the General Secretariat for Research and Technology (GSRT) but currently is not executed further. The current TRL of the project is TRL5 and prototypes do exist but for certain types. Obstacles were risen as funding was required as well more team members for its completion. The TUC offers the expertise and students supported the project. No protection towards the results; as a Research the results were published and held no commercial aim. As it was a part of GRST the project followed regulations by the EU on WEEE. So as the project to reach commercialization five years of continual development is needed, partners and further funding.

3.2.4 Case study 4: Technology on GIS Systems

The objective of this technology is to provide tangible means for earth geomorphological understanding and decision making. The main aims and characteristics of which is the 3D geomorphological modelling and visualization and progress visual and Spatial Intelligence and can be marketed either B2B or B2C. The main markets that this system could enter is Military, Education, Spatial Analysis and GIS services. Further investment is needed that can be raised through Research Proposals. The sensors within the system is the most expensive component.

It holds high TRL level; TRL8, and few months needed to be completed Competitors objectives is just data visualization and do not hold as many application areas. The technology can enter as well disturb various markets such as the Educational, Decision Support Systems (DSS); civil protection entities. In that case of the Educational Sector the standards that need to followed are in regards to safety for children.

3.2.5 Case study 5: Technology on Microelectronics Circuits

The objectives of this technology is the design and development of integrated radio frequency microelectronics circuits for telecommunications applications. The aim is high reliability that outperform published counterparts in parameters such as gain, noise and bandwidth. By implementing innovative techniques the result is the development of faster and smarter systems than the already existing ones. Main Market of interest are the Telecommunications industry. All of the results are stored in local hard drives, and some of the key aspects of this technology have been published. According to the interviewee the most difficult of the research is the expenses, such as the annual licensing fees of CAD Tools and the need of high computing power that is needed for faster circuit simulations. The main support from the TUC is the use of CAD Tools used for the Research. Thus, if funds were to be raised could be spend on improving TUC's facilities and the road to commercialization is paved as long one. The interviewee states that the results will be promoted though publication in scientific papers and conferences. Financial interest might be shown mainly from modern integrated circuit companies.

3.2.6 Case study 6: Technology on Sensors

This sensor based wireless architectures enable connectivity among a large number of sensors while requiring at least one order of magnitude less energy or monetary cost, compared to existing conventional radio approaches. The idea is based on backscatter communication by means of signal reflection rather than active signal transmission. With backscatter communication and appropriate design the RF front-end of each sensor can be simplified to a single transistor reducing complexity and cost by at least one-order-of magnitude compared to conventional radios. Backscatter communication is utilized in RFID systems which target short-range, large bit-rate applications. Some parts of the system could be reversed engineered by an expert but not the sensors. Main markets of interest include the Agricultural and Automation Sector.

The current TRL level is TRL5-6 as well no patent is available but if so the patent will be filled in USA as the professor has the expertise of the US patent system. The project started in 2012 and still there is continual effort until the road to commercialization. In order to be achieved further funding is needed; already from ERC and NSRF grants as well as months of tasks in order to achieve its objectives and aims. The TUC resources are not adequate to execute these tasks. Additional team members are needed, one Business Manager and one Hardware Engineer and a commercialization partner.

3.2.7 Case study 7: Technology on New Media Arts

This Technology offers an upgraded version of the traditional Shadow Theater through a creative digital platform with the aim of offering a tool for creative expression and learning. It employs digital art, computer graphics and animation, virtual and interactive arts. The framework enables participants from remote to engage within learning activities and create their own digital Shadow Theater. The project started as a Thesis paper within TUC and is currently at TRL8. The main target Market is the Educational Institutes but also Public Museums and Cultural entities. So as the project to reach commercialization funding is required and three additional team members such as UX Develop and UNITY Programmers.

The results are not going to be protected, it is an open source framework. The TUC offered its support through its Public Relations Office. Furthermore there are adequate recourses for further Research and Development but funding is of basic necessity so as the operations to expand towards successful commercialization.

3.2.8 Case study 8: Technology on Drones

A UAV integrated with a mobile phone that provides solution to emergencies such as providing information with your location, medical air or reports to local authorities. The objectives building up this technology was to provide a robust, novel and small scale smart drone with the aim of better communication, low expense, high utility and aid in decision making. The project is part of the Laboratory. Main Markets targeted would be Search and Rescue (SAR), mobile phones and drones. Current TRL7 with further actions stalled due to lack of funding. The technology was developed three years ago and was quite innovative at that period of time, since them new technologies and thus competitors have emerged. Additionally, the regulatory landscape need to be studied as it changed since 2015 that the project started.

Key aspects of this technology can be reversed engineered by experts of this field. The results and IPR would be protected in Europe, USA and China. The need of a commercialization partner and funding that can be raised through Project Proposals would aid towards Market entry and actions would take up to one year until reaching CM3. SAR companies, smartphone, drones, e-health and engineering companies could be interested in these results. The main competitive aspects is the fact that mobile phone drones is a novel product; nothing similar to the Market until now. Towards SAR industry the deliverables of this project offer bigger functionality and with mapping and programming capabilities. It addresses to a vast target market of either smartphone users or even hikers.

3.2.9 Case Study 9: Chemical Process

More and more technologies and processed emerge towards diminishing the environmental impact due to large volumes of waste that are produced daily. This process aims towards to the reduction of the carbon footprint due to disposal of large volumes of quarry dust and construction and demolition waste. The project is co-funded by the European Regional Development Fund (ERDF) and managed from the GSRT. The IP are also owned by two private companies. System prototype demonstration is being held to an operational environment and it's currently at TRL7. Concrete and aggregate production and construction companies could be interested in the results.

3.2.10 Case study 10: Eco Friendly Automotive

The aim of this TUC's project is to design and manufacture low-consumption and zero-emission electric vehicles that use hydrogen as fuel. It mainly funded from the University and Sponsorships. Prototypes have been build and it's currently on TRL7. Though, there are technical obstacles such as low budget, lack of laboratorial and experimentation space. Basic support such as laboratories is available from the TUC. The results are not going to be protected but will be published.

3.2.11 Case study 11: Technology on Traffic Management and Control System

This specific technology is a distributed, flexible software or middleware solution for traffic management sector able to operate and optimize at a local level with minimum central knowledge. Its objective is to aid authorities, administrators and operators to improve their management of traffic operations in a cost efficient and effective manner. Main aims are vehicle speed control assistance at the approach of traffic signals integrated with control of traffic signals for traffic low efficiency improvement that is distributed, easy and cheap installation with flexible design and automated calibration and maintenance. Main funding source is an EU Program and it is also part of TUC project.

All the objectives and aims of this projects were achieved and at that time of development no other cooperative systems operational, as well as the team was the first to address this problem as such. The project aim was to reach TRL 4-5 and not TRL6, if so follow up project planning would be required. Support from the TUC was administrative, and all the objectives and aims were accomplished with the involved team members. Knowledge dissemination is supported by the interviewee/ Researcher, as such results are protected through publications in scientific journals. Commercialization was not in pursue from the team. Since the research is published there is the likelihood of it to be copied by other, despite that the original publication defines the creator and the counterfeiter.

3.2.12 Case study 12: Chemical Process

The objectives of this process is to promote sustainable energy production, reducing the carbon footprint by avoiding conventional routes of low energy efficiency and high environmental footprint. It's part of European project and are other partners according to consortium agreement. The project is expected to be finished by 2021. Funding is required for scaling up activities that could be raised through EU Projects. Administrative support is available for the project from the TUC. As aforementioned there is a Consortium Agreement that extensively described how the results protected. Interest will be raised from the Energy Market sector, with conventional energy production technologies as main competitors. The advantage of this new chemical process is that if offers high efficiency in contrast to conventional ones that result in high environmental footprint. Surely the competitors hold the advantage of a well-established structure and therefore market presence.

3.2.12 Case study 13: Engineering Technology / Robotics

Robotics Software that can be implemented as guard robot within Military, Airports. A commercial partner is needed for scaling up actions. With alternations the technology can be redesigned to a commercial product.

3.2.14 Case study 14: Technology on Energy Saving Sector

Energy saving sector technology in public building with main target energy saving at 15% from total consumption. The project has finished during 2016 at TRL8 offering innovative technologies and applications and low cost performance. The TUC supported the projected with its administrative support. Funding was adequate to reach the desired outcome and all the obstacles were achieved. Owners of the IP are all the partners of the project as well the EU that protects the rights of this technology.

3.2.15 Case study 15: Chemical Process

The chemical process is developed with the objective of providing a sustainable exploitation of agricultural waste with high moisture content, and the production of materials with beneficial characteristics for numerous environmental application. The project is not a part of TUC, and funds are raised from local and international private entities. Partners around Greece and Turkey are characterized to a healthy economic state and their area of expertise is Product Development and Biomass Processing and offer well developed Research and Development. The results are going to be protected within Europe and third countries via filing a Patent. The team members are adequate so as the project to be executed and just only fine tuning of certain parts is needed as corrective actions. The Researcher uses Non-Disclosure Agreements when talking about key aspects of the technology, despite that some key aspects have been published or ether presented publicly. The technology offers a sustainable solution to the bio-fertilizer market in contrast to competitors that their technology applies the use of fossil fuels and thus environmental pollutants emission.

3.2.16 Case study 16: Technology on Energy Sector and R.E.S.

Sustainable solution to the energy storage problems. This technology addresses to Energy Production companies and aims the issues of the need of innovative R.E.S. within a fully autonomous space. Key aspects have been published and the technology is at low TRL level as the idea is conceptualized but no further actions took place. Exiting company has worked on similar technology but not in a product at that scale and thus energy production. If further actions were to take place funding would be essential as well as a team of skilled engineers. There is no protections towards the IP rights but according to the interview these would be protected by filing a patent Worldwide. Key aspects can be reversed engineered by a skilled person. The most expensive component is the brake system; rotor, of the technology.

3.3 Advanced technologies for 2nd stage case studies

An efficacy rating was given to all the technologies with reference to the current TRL, Prospects and obstacles that need to be addressed. Out of these the ones with the highest rating (scale 1:lower – 12: higher) and the most promising ones, a second communication with the recipients was made so as to conduct a taped interview and accumulate the utmost information needed.

3.3.1 Case Study 1: Technology on IT

Novel simulation framework with key advantages characteristics. A spin off company has already been established and Collaboration Agreements. It's a part of H2020 TUC Project that is executed fully and the framework is based on open source technologies. Research and Development is already complete but the main framework can be part of research work by TUC's students, postgraduates and researchers.

Risk Analysis:

The first risk is funding; the expense of covering the salaries of the engineers. Furthermore there is a community that is working on tools with a specific method. The risk is that the framework might not manage to enter existing communities or the solution that is being offered won't become market acceptable. Another critical aspect is the fact of how to promote a specific component of the framework in other entities. In the research community it is open source but its' license isn't the same with other components. As a result the permissive license are more preferred whereas this framework is collections of various components. Each component has its own individual license that mostly are according with MIT license which is a permissive one. In commercial environments a commercial license might be needed. The tools being used within the framework is a complex one, in case that need to be replaced with a more permissive one there might be obstacles within the adaptation procedures of the overall framework.

SWOT Analysis:

STRENGHTS	WEAKNESSES
Accuracy Novelty High reliability and performance Scaling potential Fast execution time Open Source Interconnection of the different tools Real time communication between components Developed R&D	Not established Market presence
OPPORTUNITIES	**THREATS**
Ease of further funding (e.g. SME instrument) Market requirements and potential Adaptation	Complex License

Action Plan:

The framework on technological level is ready. A client will might need to make some modifications. It's an open-source framework, aside from some components which in case someone wants to utilize them will need to address to the research partners since some components were developed from them. The framework is based on a series of open source packages that until now the user had to simulate separately and find ways to connect and make use of the results from each tool in order to move up to the next processing part and get the results. Until now there wasn't any evident method to combine them all together. Moreover, basic components couldn't connect with other tools that are widely used for Verification, PoC, or system architecture. Specifically, there are tools were you can develop a code but they simulate natural processes e.g. temperature (sensors). Within this novel framework all the components are a uniform - a connected package. Furthermore, due the fact that several of basic protocols have been used, for interface you can connect with specific methods, components that until now were independently functioning such as Ptolemy and Simulink by MatLAB.

Since the tools being used within the framework are complex it is suggested that test phases could be implemented so as to check the feasibility of it adapting to a permissive one. Thus, the usability might increase in commercial environments. Additionally, it is of crucial importance to establish its' market presence and market readiness either with B2B meeting with potential customers or being part of seminars within Educational Institutes. A professional in Technology Transfer would aid in actions toward identifying the potential customers and Negotiations.

The projects' team can apply for SME Instrument - The Business Acceleration Services [11] . The support can take the form of coaching, training, links to investors, partnering and networking; as it will aid to accessing new markets or potential customer. Coaching covers various activities such as business development, organizational development, cooperation, and financing.

3.3.2 Case study 2: Learning environment – Multifunctional object

"Learning through action" approach is widely promoted within the Educational Sector, purpose being well served through this multifunctional object. A wide selection of such products already exist in the Market. The key competitive advantage of this multifunctional object is the fact that it serves many purposes whereas others that already exist to the Market are mono-functional for financial reasons resulting to higher expense for the customer. In basic equipment there is a wide range of products. Meanwhile, there are few that satisfy that gap. There is a huge demand without the corresponding supply. The product is ready for commercialization, but it is of high importance to ensure proper guidance by professional and attracting investors; either private companies or Angel Investors. With their guidance and expertise the product could enter the Market. Along with some modifications could led into mass production, an outcome that is desired by the Team of the project.

11 https://ec.europa.eu/programmes/horizon2020/en/h2020-section/sme-instrument

SWOT Analysis:

STRENGHTS	WEAKNESSES
Design Multifunctional Unique Skilled team	Need of Management team Marketing deficiency Lack of funding
OPPORTUNITIES	**THREATS**
Similar products to the market not multi-purposed	Competitors with established presence

Action Plan:

Erasmus+ program is an opportunity to promote the product. The professor can make a call via Erasmus+ to teachers of Primary School from all around EU Countries to visit the TUC so as to experience the beneficiary outcomes of the product. The international teachers along with the Team of the project will visit Primary Schools of Chania. As such, there are two beneficiary outcomes. First of all exchange of ideas among the Teachers of the Schools and most importantly the engagement of the multifunctional object by the students that will be attended from both. Aside from these action, it is of vital importance to attract investors and the aid from a Technology Broker. Through a Joint Venture is recommended with a company with strong presence, healthy financial position, established in the Market and strong Management team.

3.3.3 Case study 4: Technology on GIS Systems

Application areas within Educational sector, Military, Public Safety and Decision Support Systems. The main competitive advantages of the project are that is custom for educational purposes, can be connected with VR and provides real time target matching. In Spatial Information sector there is not a competing technology. 3D GIS is something new in education. The technology as a completed system is innovative, there is no competition since there's not as such technology in this market, would best be described more complementary than competing. For individual applications of the system such as VR/projectors there are competing technologies (e.g. interactive boards).

SWOT Analysis:

STRENGHTS	WEAKNESSES
Various application areas Novel technology Spatial Intelligence No competing technology	Insecure funding Ineffective marketing strategy Lack of networking,
OPPORTUNITIES	**THREATS**
Education Sector market size	Commercial system Marketing system structure

Action Plan:

Outsourcing of key parts of the product need to be identified of frame manufacturing, sensors and projectors. A spin-off establishment, since the technology is well developed, within the TUC and seeking a commercial partner with the capabilities of mass productions to manufacture and industrially development of the product. It is crucial that the professor ensure patent protection and Collaboration Agreements will take place.

CHAPTER 4 CONCLUSIONS and RECOMMENDATIONS

Research and Development is well anticipated and perceived within the TUC. Professors and Student are keen on advancing existing technologies or thinking ahead of our time resulting to innovative technologies.

4.1 Conclusions

Many projects are part of the TUC and most of them funded by the EU funding schemes. The Researchers are well informed on the European programs that aid towards Development of their technologies. The laboratory facilities could be upgraded, e.g. lack of space or computer power. The main concern from all interviewees is the expense and how to be covered that is why so many apply for research proposals so as to attract the necessary funding. It is certain that through a commercial partner or investors these gap would be covered. But there are not many actions and outreach held from TUC such as Open Innovation Day at TUC, Exhibitions, and Seminars or Press that could attract investments and raise the interest.

The TUC offers resources such as Hardware, Software but there is no funding available. Most of the recipients received administrative support from the TUC. Out of these case studies that reached or are to reach high Commercialization Readiness Level are to take the route of establishing a spin-off company or already have. Most of the technology are keen on towards diminishing the negative environmental impact and offer a sustainable solution.

Lastly, an issue well displayed is the fact that there is no evident guideline and legal framework for DEP Members. Events are held by the Innovation House so as to promote Entrepreneurship but to my knowledge do not offer connections to seed investments or educational components so as to accelerate growth.

4.2. Conclusions from the Second Questionnaire and Case Studies

The biggest weakness of the Projects are mainly the lack of marketing and/or how to establish market presence. In addition to this a management team and support is needed. The technologies offer high competitive advantage and novelty and could led to mass production if the right partner were to be found.

4.3 Recommendations

It's an undisputable fact that the Technical University of Crete (TUC) provides a wide-range of tools that facilitate students, researchers and professors in conducting basic and advanced research in many fields of engineering. But how these recourses in favor of scientific growth and innovation? Establishing an accelerator focused on transforming promising spin-offs into scalable businesses seems auspicious.

Accelerators, also known as seed accelerators, are fixed-term, cohort-based programs, that include mentorship and educational components and culminate in a public pitch event or demo day. Accelerators require little to no equity, they focus on biotech, financial technology, clean tech or product-centric companies and they can either be privately or publicly funded and focus on a wide range of industries.[12]

The TUC is able to provide advanced level knowledge, tools, administrative and legal aid so as to launch and accelerator. TUC has been very strong in technological research and education, however, has been behind in the area of technology transfer and entrepreneurship.

TUC Professors, Researcher and Students need access to mentoring and structural resources in order to prosper. Through seminars and Training programs will benefit from seminars and courses of Management, Marketing, and Finance. The TUC is suggested to include within the accelerator a Legal Aid department which could aid in legislative procedures. The accelerator will be part of the Innovation House as the aim of the Innovation House is to promote entrepreneurship within the Technical University of Crete and in general the greater area of Crete.

12 http://incubator.al/the-accelerator/

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APPENDIX

Appendix 1: e-mail address of the recipients accumulated from the TUC online websites

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Appendix 2: e-mail addresses collected through Innovation and Entrepreneurship Unit's Publication

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