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European Space University for Earth and Humanity

UNIVERSEH is an alliance of five European universities established to develop a new way of collaboration in the field of Space, within the "European Universities" initiative.

The alliance aims to create new higher education interactive experiences for the university community, teachers and students, and for the benefit of society as a whole. Such initiatives will enable broadminded, informed and conscientious European citizens to capture and create new knowledge and become smart actors of European innovation, valorisation and societal dissemination within the Space sector, from science, engineering, liberal arts to culture.

In Beyond UNIVERSEH, the alliance will develop the research and innovation dimension. By creating a research policy roadmap for 2035 and a vision for 2050 within the space sector, the alliance expects to notably transform the future Space and New Space research landscape, as well to enhance the links between education and research.

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2	24/08/2022	Joanna Wieczerzyńska-van Baarle (AGH)	Tadeusz Uhl (AGH) Victor Dos Santos Paulino (UT), Peter Torlind (LTU), Laura Ferschinger (UDUS), Christian Fish (UNI.LU)	Feedback partners incorporated
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AGH

UNIVERSITÉ DU LUXEMBOURG

LULEÅ UNIVERSITY OF TECHNOLOGY

hhu Heinrich Heine Universität Düsseldorf

1. Executive summary

The Beyond UNIVERSEH WP4 focuses on technology transfer and innovation strategy in the space sector. One of its tasks is to develop strategies to induce or upscale cooperation between academia and the private sector. This report targets at providing an overview of how the collaboration between those two has been developing and what is the current situation. Also, one of the key conclusions for the BU project, would be to elaborate on the economic possibilities to valorise the research in the space sector and intensify collaboration to achieve commercial success.

In order to gather information necessary to make the conclusions, a selection of performed and ongoing space-related projects at the partner universities has been made. Some of the information deemed crucial for considerations is unavailable. This particularly pertains to management related aspects.

However, some assumptions important for the Beyond UNIVERSEH Project could have been made. This report elaborates on these findings and presents chances seen from the perspective of the partner organisations: AGH University of Science and Technology, the Heinrich Heine University Duesseldorf, the Luleå University of Technology, the Université Fédérale Toulouse Midi-Pyrénées, and the Université du Luxembourg. Although this setting gives quite a varied geographical diversity, this report is not supposed to be representative of the whole of Europe. Total number of projects taken into consideration is 98 and it gave some insights about the activities performed at the BU partner organisations. The main hinder is that historical data regarding projects performed is hardly or not available, mainly because of:

- limited or no contact with the PI, little eagerness to share the information
- requested data has never been collected
- data needs to be sought in exhaustive reports
- confidentiality agreements.

Based on data that was possible to collect, the conclusions are as follows:

- projects are funded mainly by space agencies
- collaboration with commercial partners is not quite developed yet
- achieved TRL level is relatively low (up to 5, with one project reaching 7-8)
- majority of projects is performed by 1-2 partners
- there have been more and more projects awarded and performed, with a visible drop in 2020
- most of the projects has been scheduled to last 24-48 months

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- science activities are the most frequently performed undertaking, and out of them the missions are the most common ones
- besides missions, communications is a frequent topic of collaborations
- there is little geographical diversity – vast majority of the projects has been realised on national level only
- 31 projects have indicated to somehow collaborate with other projects
- there are patents and licences resulting from the projects, but its number is unknown

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2. List of abbreviations

- **AGH**- AGH University of Science and Technology
- **ANR-** Agence Nationale de la Recherche
- **BU**- Beyond UNIVERSEH
-
- **CNES-** Centre National d'Études Spatiales
- **DLR-** Deutsches Zentrum für Luft- und Raumfahrt
- **EC**- European Commission
- **ESA**- European Space Agency
- **FFC-** Flygtekniskt Forskningscentra
- **GDPR**- General Data Protection Regulation
- **KAW-** Knut and Alice Wallenberg Foundation
- **Kempe-** Kempe Foundations
- **LTU**- Lulea Tekniska Universitet
- **MEiN-** Ministerstwo Edukacji i Nauki
- **NCBR-** Narodowe Centrum Badań i Rozwoju
- **NCN-** Narodowe Centrum Nauki
- **NFFP-** Nationella flygtekniska forskningsprogrammet
- **NRFP-** Nationella rymdtekniska forskningsprogrammet
- **NGO-** non-governmental organisation
- **PECS-** Plan for European Cooperating States
- **PI**- Principal Investigator
- **SNSB-** Swedish national space board
- **SME-** small and medium enterprises
- **SSF**- Swedish Foundation for Strategic Research
- **TBS**- Toulouse Business School (member of UT)
- **TRL**-Technology Readiness Level
- **UDUS**- Heinrich Heine University Duesseldorf
- **UNI.LU**- Université du Luxembourg
- **UT**- Université Fédérale de Toulouse-Midi Pyrénées
- **UT3**- Université Paul Sabatier Toulouse III (member of UT)
- **VR-** Vetenskapsrådet
- **WP**- Work Package

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3. Definitions

- **Commercial projects**: are the projects which are ordered from industry to academia.
- **External funding project**: project financed by sources from outside the organisation. However, source of funding of 18 of the projects reported in this overview is unknown.
- **Project**: series of actions aimed at reaching particular goal, within determined timeframe and budget.
- **Valorisation**: is the process of transferring knowledge from the organization that holds it to another organization, in an attempt to transform inventions into new products and services that benefit society.

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4. Data collection

This report bases on qualitative multiple case study approach. The BU partners have been asked to provide information regarding the space-related projects performed and ongoing at their universities. The requested information was:

- title and acronym of the project
- budget, starting date and duration of the project
- number and kind of partners engaged, geographical diversity of the consortium
- TRL achieved, whether any patents or licenses resulted from the project
- domain of the research conducted
- main obstacles in realisation of the project
- any collaborations with related projects, follow up or foregoing projects

Since the BU are 5 various universities, some freedom was given to add data relevant for particular organisation. For UT it was valuable to add input about measurable impact, while LTU provided names of the PIs. Moreover, for the analysis and interpretation of the data it is important to note that there were several (more than 5) persons engaged in data collection.

Various fields of specialisation of the BU partners clarify quite a wide range of numbers of projects reported per partner; from few at UDUS and UNI.LU, to several dozen selected out of around 500 identified at UT. For this reason, and particularly for the UT, the list of projects taken into consideration is not an exhaustive list but rather a selection of ideal type projects illustrating the diversity of projects.

It turned out that for all BU partners details on budget, starting date and duration was accessible to be found, while facts regarding obstacles in realisation of the projects or TRL were actually impossible to be found, particularly for older projects. However, even if the financial data was somehow kept in university's record, all partners deemed it time consuming to access it.

It seems that even though universities use financial or administrative systems to keep the projects running, no one keeps any general registers on facts that are not so easy to measure or classify. In order to get them, direct contact with the PI is needed and, in such case, following challenges were faced frequently:

- PI not employed anymore at the partner university- need to seek outside the organisation
- PI not eager to share the information
- reasons why particular information is sought not clear enough- need on transparent explanation
- information, even if available, needs to be sought in exhaustive reports
- GDPR regulations, confidentiality agreements.

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5. Selection of space related projects at partner universities

no	BU organisation	Title and/or acronym
1	all	The European space University for Earth and humanity, UNIVERSEH
2	LTU	RIT 2021-Space for innovation and growth, RIT2021
3	LTU	RIT2021-Radical innovation within space applications – with additive manufacturing as an example
4	LTU	RIT2021-SeSSA: L-PBF Stainless Steels for Space Applications
5	LTU	RIT2021-ICEQREME: Interference Control and Estimation with a high-Quality Radio Environment Map of Esrange
6	LTU	RIT2021-Autonomous navigation around small space object (asteroid or space debris)
7	LTU	RIT 2021-Design Factors in Additive Design for Space Applications
8	LTU	RIT 2021-Innovation capabilities in the space industry
9	LTU	RIT2021-The Green Corridor to Space – An Optimal Test Facility for Modern Rocketry
10	LTU	Radical Innovation and Qualification for Additive Manufacturing, RIQAM
11	LTU	Design and Surfaces effect in Qualification of Additive Manufacturing, DYKAM
12	LTU	Mars Lab
13	LTU	In-Situ IWC
14	LTU	Wallenberg - Nanosatellite research
15	LTU	Kempe - Nanosatellite research
16	LTU	Wallenberg - Exoplanetary research
17	LTU	Kempe - Exoplanetary research

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18	LTU	Wallenberg - Nanosatellite research
19	LTU	SWASDAG
20	LTU	SARC Flygtekniskt Forskningscentra
21	LTU	NoICE
22	LTU	Kvarken SAT, KVARKENSAT
23	LTU	CLImaint
24	LTU	Nanosatellite lab
25	LTU	Additive Manufacturing of Ti-6Al-4V: Relationship between Microstructure, Defects and Mechanical Properties
26	LTU	Interference in Global Positioning Systems Signals and its Effect on Positioning and Remote Sensing
27	LTU	Kinetic Modeling of the Solar Wind Plasma Interaction with the Moon
28	LTU	Remote sensing of ice clouds: synergistic measurements and radiative transfer simulations
29	LTU	Studies of auroral processes using optical methods
30	LTU	Microstructure and Mechanical Properties of Ti-6Al-2Sn-4Zr-2Mo and Ti-6Al-4V: Influence of H,O and B
31	LTU	Inelastic behaviour of polymer composites
32	LTU	Representation and Diurnal Variation of Upper Tropospheric Humidity in Observations and Models
33	LTU	O+ Heating, Outflow and Escape in the High Altitude Cusp and Mantle
34	LTU	Mesoscale processes in the polar atmosphere : radar remote sensing,balloon-borne in situ measurements and modeling
35	LTU	Ice Clouds in Satellite Observations and Climate Models
36	LTU	Solar wind ions inside the induced magnetosphere of Mars

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37	LTU	On dynamic array processing for GNSS software receivers
38	LTU	Ti3SiC2 synthesis from TiC and Si powders
39	UT	Space Institute for Research on Innovative Uses of Satellites, SIRIUS
40	UT	Training, REsearch and Applications network to Support the Ultimate Real time high accuracy EGNSS solution, TREASURE
41	UT	To define and develop an operational service offer at competitive costs for the detection and characterization of water stress in grapevines using earth observation data (multispectral images acquired by various sensors, including satellite and drone) and field measurements. EAUSCAN
42	UT	Perturbations Radio dans l'Ionosphère en réponse aux StimuliMagnétosphériques et Solaires (in English: Radio disturbances in the Ionosphere in response to Magnetospheric and Solar Stimuli), PRISMS
43	UT	Fusions de trous noirs massifs: lumière et ondes gravitationnelles (in English: Massive black hole megrgers: light and gravitational waves), MBH-Waves
44	UT	La différenciation des planètes: approche expérimentale et théorique du fractionnement isotopique du Germanium (in English:The differentiation of planets: experimental and theoretical approach to isotopic fractionation of Germanium), PlanetGEM
45	UT	Solar EneRgetic ParticlE aNalysis plaTform for the INner hEliosphere/ Shining a light on solar energetic particle events, SERPENTINE
46	UT	Preparatory Phase for the European Solar Telescope, PRE-EST
47	UT	Linking best-in-class facilities for upper atmosphere and near-Earth space physics, PITHIA-NRF
48	UT	AstroChemical Origins; Peering at the dawn of our solar system, ACO
49	UT	The Extensive and Ubiquitous Role of Polycyclic Aromatic Hydrocarbons (PAHs) in Space, EUROPATH
50	UT	Sentinels Synergy for Agriculture, SENSAGRI

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51	UT	Bringing Earth Observation Services for Monitoring Dynamic Forest Disturbances to the Users, EOMonDis
52	UT	Automation of causality analysis in technical documentation for the detection of "weak signals" in monitoring and operational safety
53	UT	High Productivity Machining "New cutting tools for titanium", UHP-NoToCo
54	UT	Contribution of Natural Language Processing to the resolution of technical problems in the intelligent production and exploitation phases of launch systems
55	UT	Contribution to the study of the understanding of corrosion inhibition mechanisms of light alloys used in aeronautics and space - Development of a robust and discriminating industrial test method, SURFINNOV
56	UT	Fuel cell platform, PAC-AERO
57	UT	High temperature oxidation and corrosion of nickel-based superalloys from additive manufacturing
58	UT	Ionic thrusters PPS-5000, E-POWERDRIVE
59	UT	Compact small scale convection loop for the ISS Experiment Container as part of Thermal Platform, COSMO
60	UT	Understanding of the post aging fatigue damage of Ti21S and modeling
61	UT	Oxidation of Titanium alloys
62	UT	TANKYOU
63	UT	DANKE
64	UT	NANOSTAR
65	UT	AIM
66	UT	Electro magnetic GNC
67	UT	EVHAPS
68	UT	Flying Squirrels

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69	UT	RODIN
70	UT	SDTplus
71	UT	TASTE Multicore
72	UT	THRUST
73	UT	AGILE 4.0
74	UT	MAIA
75	UT	NEO MAPP
76	UT	PERASPERA-OG1-ESROCOS
77	UT	PIONEERS
78	UDUS	Tackling Mold in Aviation and Spaceflight
79	UDUS	Behaviour of nerve and glial cells in microgravity
80	UDUS	Biology and Mars-Experiment, BIOMEX
81	UDUS	Microcirculation in microgravity
82	UNI.LU	SES Chair in Chair in Satellite Communications and Media Law
83	UNI.LU	Interdisciplinary Space Master
84	AGH	Opracowanie modelu automatycznej wiertnicy rdzeniowej do pracy w ekstremalnych warunkach, w szczególności w środowisku kosmicznym (in English: Development of a model of an automatic core drilling rig for operation in extreme conditions, especially in the space environment), PBS 1/ Wiertnica (in English: PBS 1/ Drilling Rig)
85	AGH	Dystrybucja wzorcowych sygnałów czasu i częstotliwości w optycznych sieciach telekomunikacji (in English: Distribution of reference time and frequency signals in optical telecommunication networks), PBS 1
86	AGH	Inżynieria kosmiczna w służbie nauki - podsystemy badawcze w projektach KN AGH Space Systems. Studenckie koła naukowe tworzą innowacje (in English: Space engineering in the service of science - research subsystems projects in KN AGH Space Systems Team. Student research clubs create innovations)

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87	AGH	Rozwój systemów napędowych w konstrukcjach AGH Space Systems. Studenckie koła naukowe tworzą innowacje II edycja (In English: Development of propulsion systems in AGH Space Systems constructions. Student research clubs create innovations, second edition)
88	AGH	Rozwój systemów rakietowych, łazika marsjańskiego, lądownika planetarnego oraz balonu stratosferycznego w AGH Space Systems (in English: Development of missile systems, a Mars rover, a planetary lander and a stratospheric balloon at AGH Space Systems)
89	AGH	Wydobycie regolitu na powierzchni Księżyca w warunkach obniżonej grawitacji (in English: Mining of regolith under reduced gravity on the lunar surface)
90	AGH	Tomografia gruntu Marsa przy zastosowaniu rozwiązań odwrotnych do fal ELF generowanych przez burze piaskowe w falowodzie grunt - jonosfera (Tomography of the Martian ground using inverse solutions for ELF waves generated by dust storms in the ground-ionosphere waveguide)
91	AGH	European Student Moon Orbiter, ESMO
92	AGH	Pattern recognition-based decomposition method for quad-polarimetric SAR data
93	AGH	MOLE penetrator optimization using the numerical model and operational tests, PECS-KRET
94	AGH	Ultralight drilling rig for planetary exploration
95	AGH	Development of In-situ Regolith sampling Gear for Generous Excavation of Regolith (DIGGER), Digger
96	AGH	Geologic energy storage – a change for Polish energy transition and lunar colonization, GeoStorage
97	AGH	MEthane goes MObile - MEasurements and Modelling, MEMO2
98	AGH	Lądowanie Na Phobosie, Opracowanie Modelu Numerycznego Kontaktu Stopy Lądownika Z Powierzchnią Phobosa (in English: Landing on Phobos, Development of Numerical Model of contact for Lander Foot with Phobos Surface), LOOP

Table 1 Selection of projects

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6. Data analysis

Not all requested data was available for all projects. For this reason the total number of projects taken into account is different for each chart.

1. Number of projects per partner

The BU partners are various universities, and this results in various numbers of projects selected and reported for this overview per BU partner.

For the UT, it is important to mention that there are two groups of organizations at the University of Toulouse:

1) Organizations which had few projects (2-3 projects) because space activities are not the central focus for them (e.g., UT/TBS Education, AGH).
2) Organizations which had many projects during the period considered (for example, UT/UT3 had 469 projects only for the 5 main space related labs since 2015).

For the LTU, the list of reported projects reflects the activities performed at the whole university.

The projects reported by AGH concern the whole university and not the Space Technology Centre.

Activities reported by UDUS were performed by their researchers in cooperation with national and/or European space agencies.

UNI.LU, like UDUS, do not specialise in technical sciences. This seems to be a reason to report few projects, compared to other BU partners.

Chart 1 presents number of space- related projects reported by BU partners.

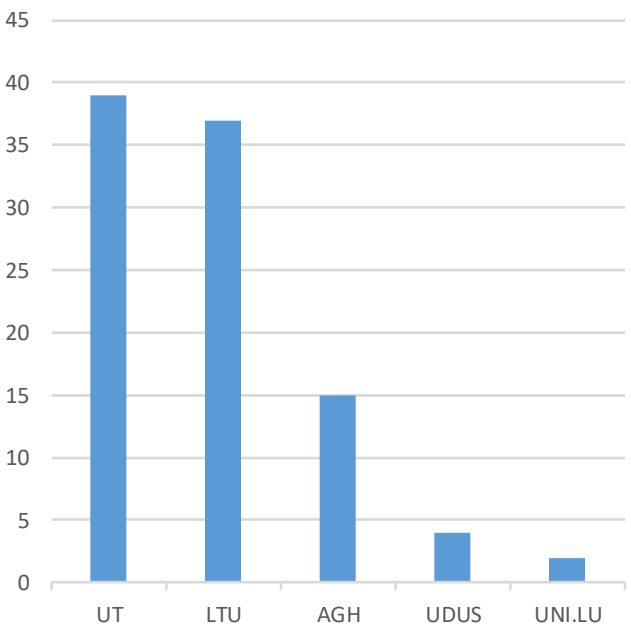

Chart 1 Number of reported projects per BU partner.

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2. Consortium budget

Budget available in particular project gives an indication of extent of the project. Usually, low budget projects do not fund any expensive equipment and funding covers personnel costs and consumables only.

Chart 2 presents number of projects in fixed budget category. Important to note is that the total number of projects taken into consideration is 30 and it includes only some of UT and AGH projects, since figures of other projects are not available. The following Chart 3 provides a detailed overview of the fundings of those two universities. It is clear that UT performs projects supported by higher budgets, and this suggests higher advancement of collaborations.

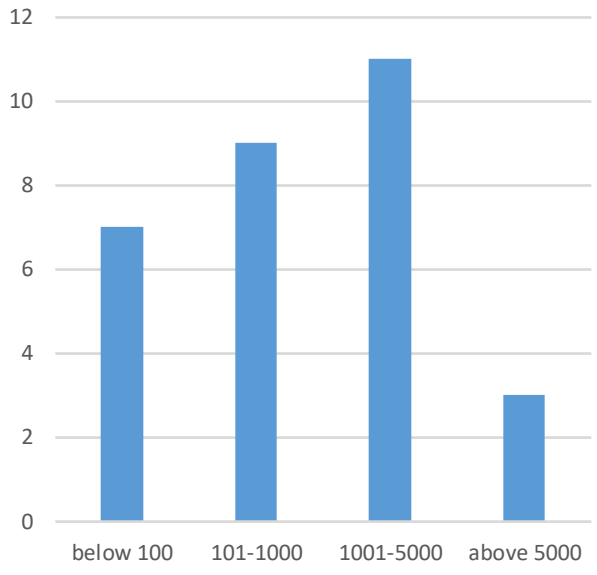

Chart 2 Consortium budget of reported projects, KEur.

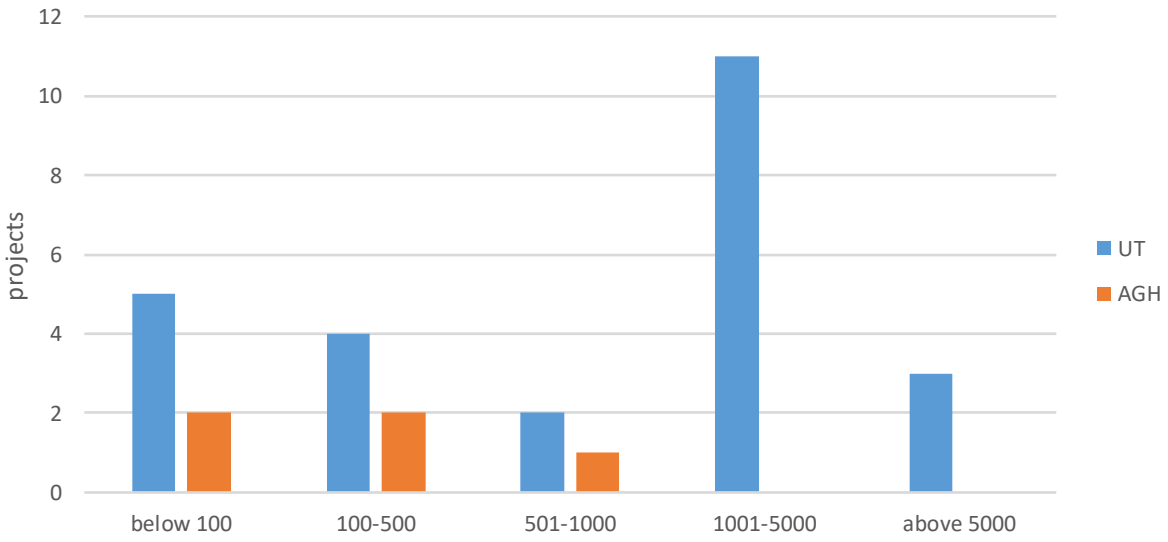

Chart 3 Breakdown UT and AGH consortium budgets, in KEur.

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3. Funding agency

According to Dos Santos Paulino[1] and Sagath[2] the space sector is heavily institutionalised. This finds its reflection among the BU partners as well. It looks like most of the projects have been funded by institutions like space agencies, both at national level as well as ESA operating at European level, or EU.

Considering commercial participants in the collaborations it is remarkable that only few of the reported collaborations did include commercial contribution in their budgets (2 French projects and 1 from Luxembourg) and only 4 of the reported projects were fully financed by commercial entities, with declared budget not exceeding 150 KEur.

Chart 4 presents data of 98 projects and *commercial contribution* is additional to non-commercial funding sources considered.

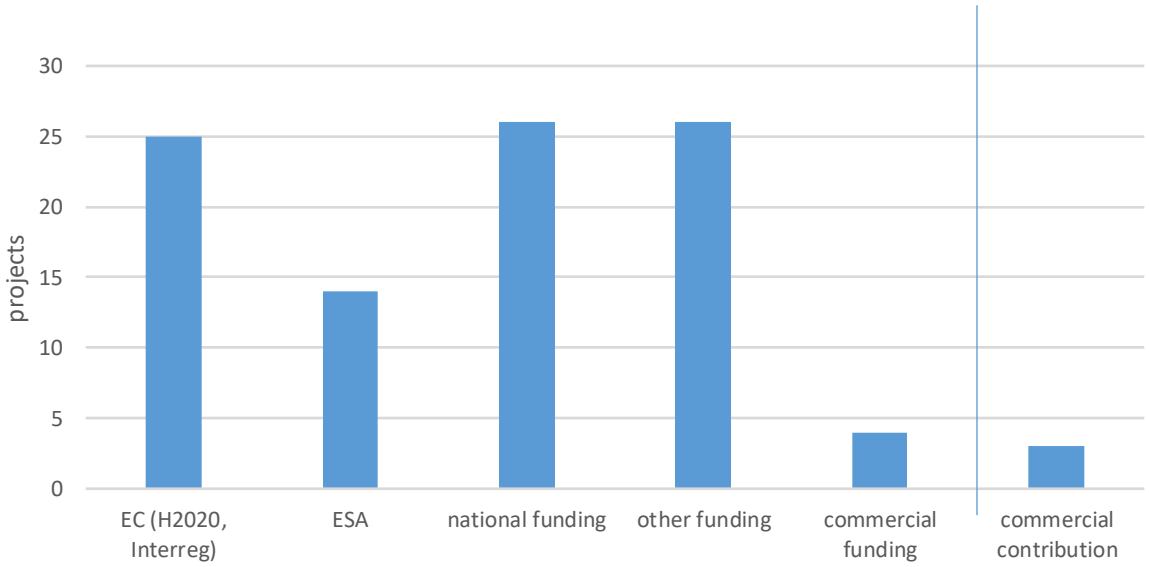

Chart 4 Funding agency/source of funding of reported projects

[1] Dos Santos Paulino, V. (2020). Innovation Trends in the Space Industry. Wiley-ISTE.

[2] Sagath, D. (2019). Entrepreneurship in the Dutch space sector: the role of institutional logics, legitimacy and business incubation. Vrije Universiteit Amsterdam.

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4. Consortium composition

Analyse of consortia composition of the funded projects shows that up to two partners is a dominating form of collaboration. Table 2 shows the frequency of given number of partners in a consortium. In the case of a single project participant the project was conducted by one university only, for 2 collaborators the second partner quite often used to be a large scale company. Details on 2- partners collaborations is presented in Chart 5, where *other* category means mainly national space agencies or research institutes. Data concerns 98 projects, from all BU countries.

Number of:			
Partners	projects	partners	projects
1	40	16	
2	34	17	
3	1	18	
4	5	19	1
5	7	20	
6	1	21	
7	1	22	
8		23	1
9	2	24	1
10	1	25	
11		26	
12	1	27	
13		28	
14	1	29	
15		30	1

Table 2 Quantitative consortia composition

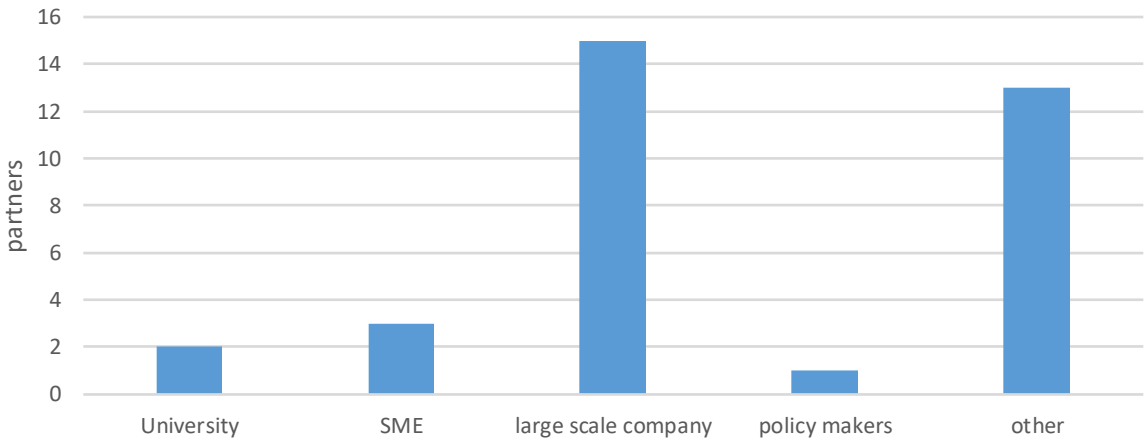

Chart 5 Second partner in 2 partners collaborations

A closer look at collaborations with large scale companies shows that these are LTU and UT collaborating with big enterprises. While most frequent structure engages one big commercial player, there has been a project engaging even 9 large scale companies. This can be seen on Chart 6.

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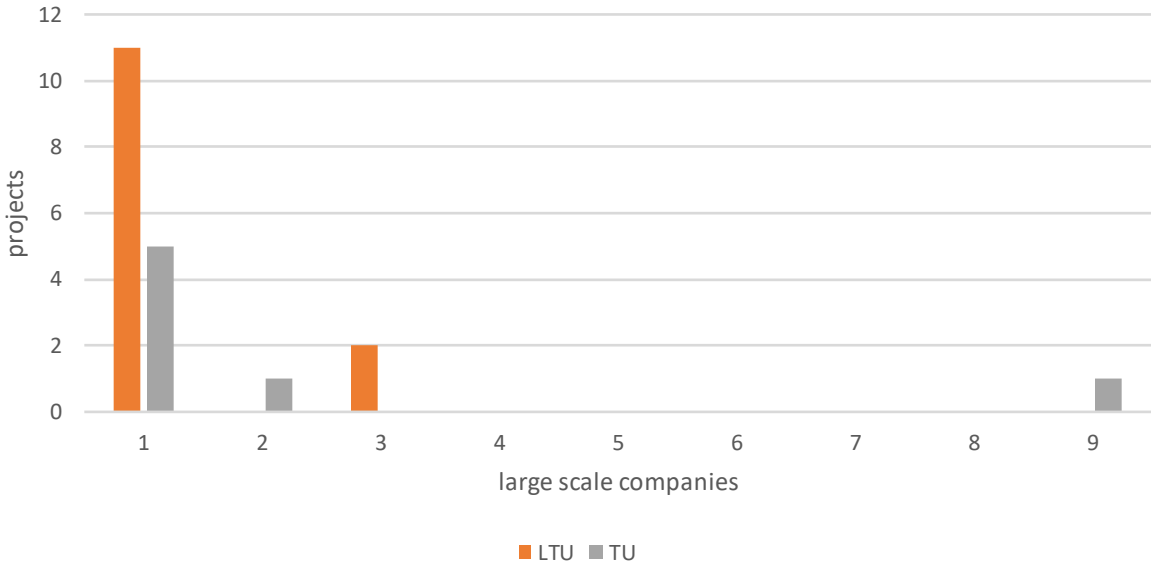

Chart 6 Large scale commercial players in LTU and UT projects

Since the matter of consideration is valorisation of research, it is important to consider the source of funding of the partnerships between universities and commercial entities. Out of totally 20 collaborations with large scale companies only 6 of them have been financed (4) or co-financed (2) by such a company.

Furthermore, engagement of SMEs seems not to be advanced either. There have been 8 projects reported with participating SMEs, mainly funded by non-commercial organisations, with 3 of them reported commercial co-finding. Details on this can be found in Table 3 below.

Engagement of various partners offers various point of view and credible potential to make the results usable. Chances to disseminate and exploit the results are higher, as project a whole has access to varied markets and public. It can be assumed, that there is still little exchange between academia and non-academia, particularly NGOs and policy makers and, keeping in mind the topic of research, still too little with commercial entities. Perhaps low TRL level that the projects reach is still not interesting enough to attract entrepreneurs.

It can be then concluded that even though commercial entities do participate in the projects, they do not finance it and as such, they are not the ones to solely decide about the project.

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no	Total number of partners engaged:	*Of which SMEs:*	*Of which large scale companies*	Funding agency and programme
1	2		1	EU Interreg
2	2		1	EU Interreg
3	2		1	EU Interreg
4	2		1	EU Interreg
5	2		1	EU Interreg
6	2		1	EU Interreg
7	2		1	NRFP
8	2		1	NFFP
9	2		1	
10	2		1	NFFP
11	2		1	
12	3		1	Funding ANR (Agence Nationale de la Recherche) - National funding Co-funding AID/DGA
13	2		1	1 large scale company
14	2		1	1 large scale company
15	2		1	1 large scale company
16	2		1	1 large scale company
17	5		2	CNES, Airbus Dence and Space, Thales Alenia Space
18	9	1	3	EU Interreg
19	5		3	NRFP
20	10		9	IRT Saint-Exupéry
21	2	1		EU Interreg
22	4	1		CNES, PPAQSE project
23	4	1		CNES + Meetsys
24	2	1		Partnership between University of Luxembourg and SES S.A.
25	2	1		ESA
26	4	3		Occitania Region, Aérosat
27	30	4		HORIZON 2020

Table 3 Participation of commercial entities and its source of funding.

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5. Geographical diversity

Although data for this overview has been collected from various European countries, most of the projects (80) have been performed on national level only and there was no collaboration on intercontinental level reported. Some of them did operate on European level. Like diversity of the partners engaged, geographical diversity is beneficial for the projects and people engaged in them and it seems that this can be improved. Also, considering that space itself it something beyond national boundaries, it may be quite surprising that there are no worldwide cooperations reported by the BU universities operating in Europe. Details on geographical diversity can be found on Chart 7.

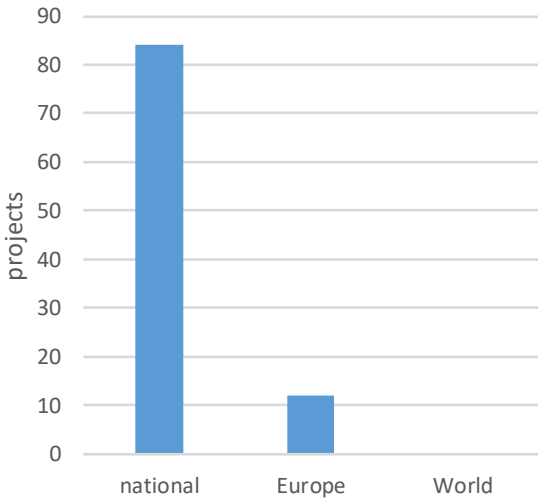

Chart 7 Geographical diversity of the reported projects.

6. Connections with other projects

31 of reported projects have been collaborating with other projects, meaning:

- Followed by new action
- Self being a continuation of a previous one
- Parallel cooperation with other projects working on the same challenge

For one of the projects declared extension was the establishment of a scientific Platform (MoUV) and setting up an enterprise for the promotion of the Scientifical industrialization of Machining and a new research.

Set side by side with low geographical diversity and up to two partners engaged in realisation, this relatively high number (31) may be quite surprising and indicates that long-term and wide collaborations are sought and appreciated.

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7. Development over last years, duration

Out of the 60 projects reported by UT, AGH, UNI.LU and UDUS many of them have started in last 6 years, with the highest number in 2019, so just before the pandemic. The increasing trend seems to collapse in 2020, which may have been caused by the pandemic realities. The overview includes 2022 as well and it may not include the projects still to begin in 2022. Chart 8 presents number of projects run at LTU in 2010 and 2020 and Chart 9 presents starting years of the reported projects at UT, AGH, UNI.LU and UDUS. Data for LTU is analysed separately, since this organisation was able to provide data as originally planned, per 2010 and 2020. It is not certain, though highly probable, that for this university, the number of projects performed is growing as well.

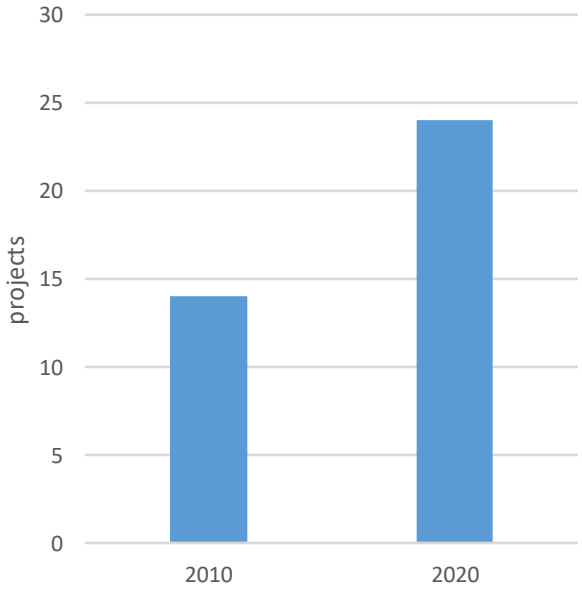

Chart 8 Number of projects at LTU in 2010 and 2020

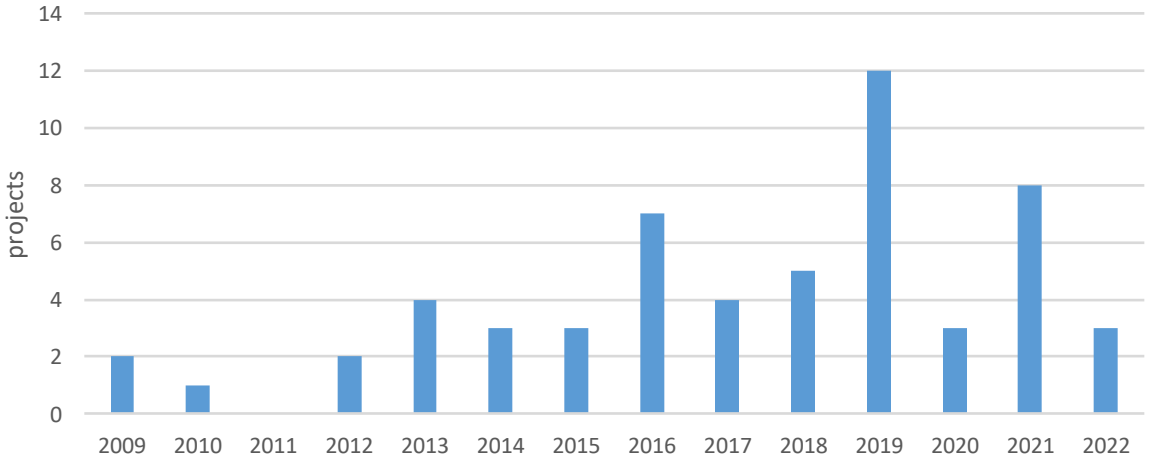

Chart 9 Starting year of the projects (UT, AGH, UNI.LU and UDUS)

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Analyse of projects duration shows that most of the projects have been scheduled for more than 2 years. Longer projects seem to be favourable for development and settlement of long term collaborations. As it can be seen on the Chart 10 the scheduled duration of most of the projects varies from 24 to 48 month. It points that in the space sector rather long projects are preferred.

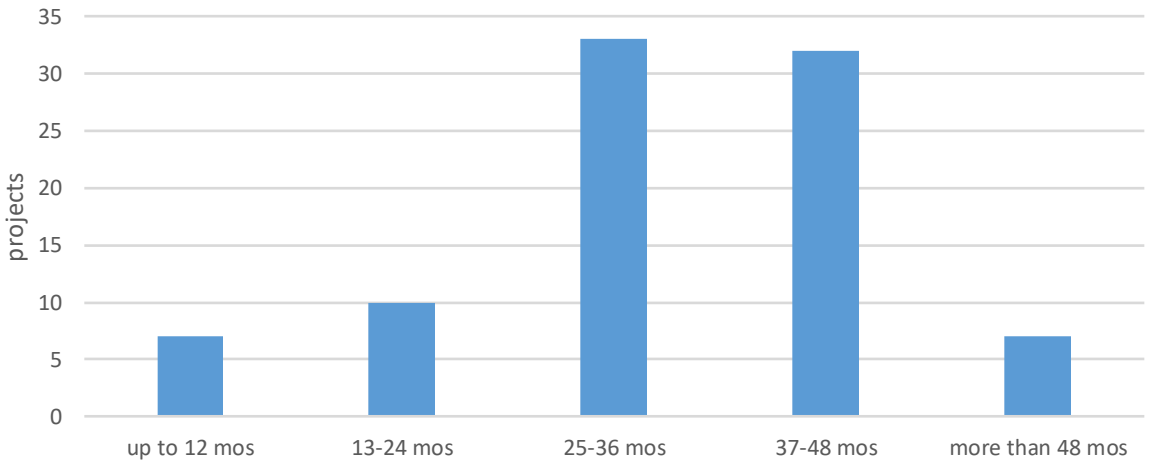

Chart 10 Duration of the projects

8. Research domain

Space sector operates in a multidisciplinary environment linking various research domains, from engineering, through business and entrepreneurship to medicine and psychology. This causes some specification of the projects, that is shown on the Chart 11. As *science activities* category seems to come up most, it has been presented in Chart 12 what exactly they are. It is worth noting that more than 1 category per project was allowed.

Fact that science activities are the most common topic goes along with budget source. Vast majority of the reported projects declares to obtain funding from public funding. This is also how it indeed works. Public funding in space target first science activities, since funding space activities with a commercial potential (e.g., communication, Earth observation) is more complicated because you can distort the competition between commercial organizations.[3]

[3] Ruttan, V. W. (2006). Is war necessary for economic growth ? Military procurement and technology development. Oxford University Press.

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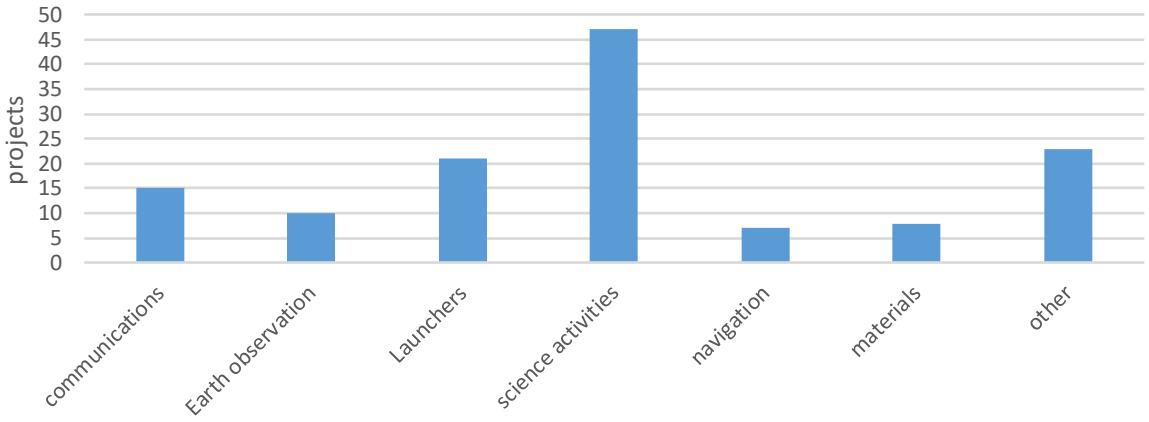
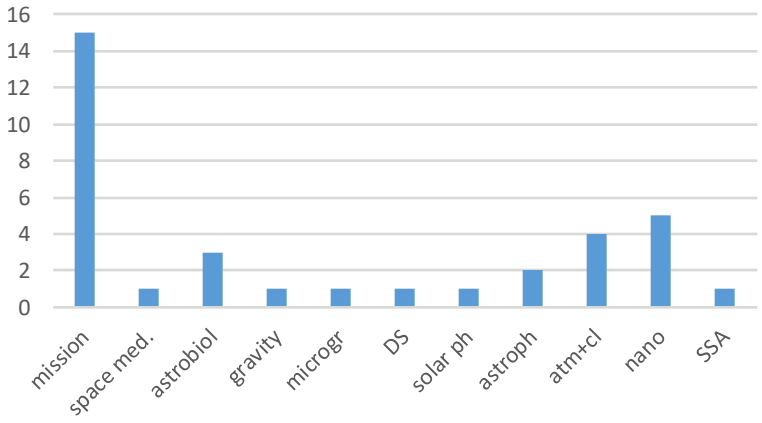


Chart 11 Research domain.



Legend:

mission: planetary missions or planet exploration, mainly Moon and Mars
space med: space medicine
astrobiol: astrobiology
gravity: gravity
micrograv: microgravity
DS: Data Science
solar ph: solar physics
astroph: astrophysics
atm+cl: atmosphere and climate
nano: nanosatelites
SSA: Space Situational Awareness

Chart 12 Science activities details

Other declared activities touch on mining and space resources, but also education and law. Earth observation actions concern both agriculture and climate. Based on data above, it can be then concluded, that communications and missions are fields where most of the projects are realised.

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9. Applicability of the results in the space sector

Results of the space-related research reported by the BU representatives can be exploited both by space sector, as well as beyond it. Potentially they can be applied by entrepreneurial companies and public organisations.

Besides knowledge that used to be shared through publications, conferences, talks and incorporated in the most recent study programmes, there are PhD thesis frequently coming out of the research.

The results of the projects can be applied in:

- aerospace medicine, like effects of microgravity on the cardiovascular system
- microbial safety
- aviation
- modelling of technical problems in a system
- machining
- space law
- dedicated databases building, like biosignature database for Mars missions. Survivability and resilience of organisms in space and under conditions found on mars as an indicator for live in space

10. Projects TRL level and demonstrators

Although it is not clear on what TRL the projects have been operating on average, there are some indications given by the LTU providing some insights.

Also, UT reports one project that reached TRL 7/8 and was followed by establishment of a scientifical Platform (MoUV) and setting up an enterprise for the promotion of the Scientifical industrialization of Machining and a new research project.

At the LTU there have been 4 demonstrators build following the reported projects.

Projects realised by the BU achieve low TRL level. However this is understandable since most

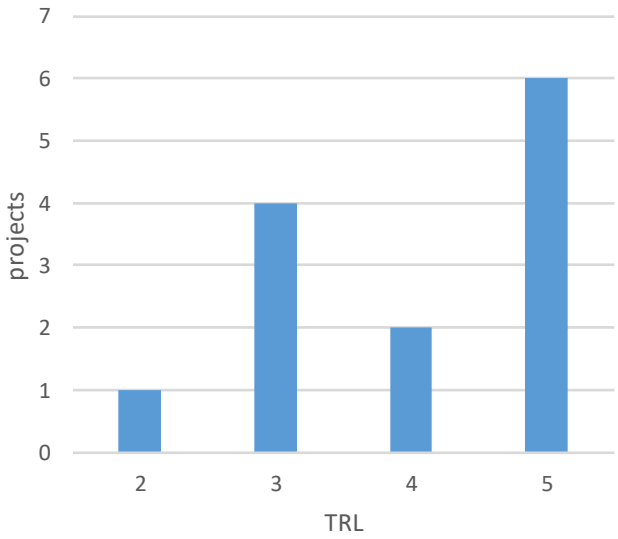

Chart 13 TRL achieved at the projects

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projects are realised by only university teams only, without engagement of industrial partners, see Chart 13.

11. Patents and licenses

Although the BU partners do report there are patents and licences resulting from the projects performed at their universities, it is not clear how many of them can be reported.

12. Main obstacles in realisation of the projects

Information about what were the biggest hinders during the realisation was difficult to obtain. Out of the few reported there were:

- Availability of experts
- Connection between management science and engineering sciences
- Transfer know-how to industrialization and method offices

One of the ESA projects run at AGH has been terminated due to costs exceeding the planned budget.

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7. Conclusions

Based on the figures provided by the BU partners it can be assumed, that the situation at these universities corresponds with the global current condition. Product maturity seems to be not high yet and this is linked to the fact, that there are relatively few entrepreneurial entities engaged in the execution of the collaborations. The main founder of the projects are public organisations, being indirectly the governments responding to political, economic and social trends. Low geographical diversity, limited number and diversity of participants and low TRL achieved can indicate that the market is not well developed yet. However, quite a high number of collaborations with other projects and relatively long projects duration may prove that high quality collaborations are appreciated.

Most common field of research remain scientific activities, with missions as leading topic, followed by communications. This trend seems to be in line with the fact, that most of the funding is provided by governmental organisations.

The number of projects executes seem to have been increasing over last years. The drop in 2020 has been probably caused by the COVID pandemic.

Multidisciplinary utility of the projects results is very promising in the context of economic possibilities to valorise the research results. However, the limited information about patents and licences coming out of the projects does not really allow any estimations on how the BU universities benefit from this.

Amond the BU partners, it is clear that UT and LTU have more advanced collaborations. AGH, specialising in science and technology, reports more projects than UNI.LU and UDUS, but this number is much lower than ones of UT and LTU.

Forming one alliance and aiming at becoming one European University, the BU partners should consider joint undertakings in order to create a well performing, sustainable European University. Sharing experience and best practices seems to be crucial to make future actions of UNIVERSEH successful.

This goal can be definitely achieved by encouraging collaborations between academia and non-academia, for example through EU project funded with a Public Private Partnership approach.

Also, meeting the need for links between commercial and academic spheres though a learning by doing approach is proven to be beneficial and should be implemented as early as possible in teaching process.

Perhaps a good start would be to merge ones networks in the field to support future collaborations. It could get a form of brief database of space projects performed, with topic of the research and contact

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details of the PI as key data. This could help the researchers to get in touch with each other to start collaborations and together form a joint university.

Last but not least, means of active information exchange (workshops, presentations, networking meetings, best practice exchange sessions, management trainings etc.) cannot be missed both when teaching future scientists, as well as when upgrading skills of experienced staff active in non-academia organisations.

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8. List of charts

9. List of tables

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