www.universeh.eu

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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Deliverable n°16/D2.2 – Specification and execution of the UNIVERSEH data collection via strategic intelligence, interviews, and workshops

Due date of deliverable: M13 (10/2022)
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Version: final

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Document History

Version	Date	Author	Partner	Summary of main changes
1	02/08/22	René Laufer	LTU	Initial setup
1.1	04/10/22	George Nikolakopoulos	LTU	1st deliverable
1.2	08/10/22	Akshit Saradagi	LTU	Additions and comments
1.3	14/10/22	René Laufer	LTU	1st draft version
1.4	24/10/22	George Nikolakopoulos	LTU	Final version released
1.5	28/10/22	Margot Clauss, Bernd Weiss	LTU	Input from D2.1 data base analysis and H2020 keywords
2	9/11/22	Margot Clauss, René Laufer, Bernd Weiss	LTU	Finalising D2.2 deliverable

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1 – Work Package Objectives

The main objective of WP2 is to host all the related activities for generating a complete 2035 Roadmap and 2050 Vision for the development of the research dimension of the European Space University for Earth and Humanity (UNIVERSEH) and propose a set of specific actions for their future implementation within a corresponding timeline. The roadmap must be understandable for a wide non-technical audience, as it will likely be read and reviewed by policymakers and other potentially non-technical stakeholders. To this end, WP2 includes the following objectives:

- Identification of the societal needs including current and future global challenges, that space related research and innovative technologies can solve in a sustainable way.

- Bringing together and establishing an effective dialogue, cooperation and integration among the various constituencies that are currently active in the field of space technologies, as well as with a critical mass of industrial and academic representatives to create an ecosystem that will shape and drive the future innovation and developments in the space sector.

- Evaluation of the enablers to sustain and maximize the implementation of the technologies promoted in the roadmap.

- Elaboration of a UNIVERSEH research roadmap for 2035, that is adoptable, interdisciplinary, collaborative, innovative, enabling to scale excellence by joining forces at a European level.

- Elaboration of a UNIVERSEH Vision for 2050 that will have the EU being a cornerstone of the related developments.

2 – Deliverable Description

In alignment with the Task 2.1 description the Deliverable D2.1 will report on the workshops and questionnaire survey performed for capturing the research trends in the space community. Creation of workshop, websites, production of workshop video sessions with recording, video interviews and short films. The results from the workshops and survey will be systematized in the online database with open access for the UNIVERSEH partner universities.

Such data will provide additional information for the UNIVERSEH Task 2.4 with Deliverable D2.4 and combined with the data from Task 2.3 with Deliverable 2.3 leading to the 2035 Road Map and 2050 Vision documents.

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Task 2.2 – Specification and execution of the UNIVERSEH data collection via strategic intelligence, interviews and workshops

This task will focus on providing the necessary specifications and activity planning for effective realization of the objectives of Beyond UNIVERSEH related data for the compelling road mapping and strategic vision activities. The specifications will focus on the tools for carrying the survey-mapping activities related to the current trends and future trends in space science and technology. This task will also include the allocation of interviews of UNIVERSEH partners and members of their respective academic networks to ensure an overall coverage of the space sectors, secure a wide geographic coverage and aiming in capturing the main research and technological trends in space science communities and industry. Specifications for the dedicated interview questionnaires will be elaborated, as well as an anonymization process and a data fact-checking process will be ensured. Within Task 2.2, i.e. mapping activities, Beyond UNIVERSEH will cover the majority of the European space sector, including industry, small and medium- sized enterprises (SMEs) and other relevant space technology providers. Task 2.2 will also focus on planning and performing the Beyond UNIVERSEH workshops for capturing the current state of research, innovation and development actions in space-related sectors. The task will focus on academic and industrial players, including relevant SMEs, as well as governmental entities. The workshops will be multi- thematic. Each beneficiary will be responsible for organizing a series of workshops related to their specialization thematic sector e.g. climate challenge, space situational awareness, disaster mitigation, security from space, space exploration, space robotics, energy management, air, food and water management, IA, manufacturing in space, space mining etc. One of the main outputs of this task is to define a strong research identity in the academic / space sector.

Due to the effects of the pandemic situation the decision was made by the WP2 team at the UNIVERSEH meeting in Krakow (June 2022) to complete the strategic intelligence collection and perform the in-person interviews (including the suggested survey in this deliverable) and workshops in parallel to upcoming tasks.

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3 – Data Collection: Starting Points

Initial research conducted in Task 2.1 identified more than 150 possible WP2 stakeholders and other relevant sources of information being able to provide valuable input to the road mapping and vision strategies and with potential benefits in being involved in the Beyond UNIVERSEH WP2 intelligence and information collection. It is suggested to consider clusters of industry and institutional organizations as well as lead companies and entities in identified industry trends and topics of increasing importance.

This data base included European and other international space organizations, space industry representing start-ups and SME, academia and research, associations and interest groups, hubs and business communities.

Trends and Topics of Increasing Importance	Additive Manufacturing, Big Data, Circular Economy, Cybersecurity, Energy Transition, Green Space, Industry 4.0, Machine Learning and Artificial Intelligence, New Space and Space Commercialization (Upstream/Downstream), Quantum and Edge Computing, Reusability, Robotics and Automation/Autonomy	Trends and topics of increasing importance indicate evolving or transformative directions of industries or innovation in general closely related to space

The data base compiled in Task 2.1 as part of Deliverable 2.1 provided the starting points for further data collection regarding strategies and topics of importance (as seen in table above).

3.1 – Data Collection: Introduction

The main aim of the Work Package 2 (WP2) is to host all the related activities for generating a complete 2035 Roadmap and 2050 Vision for the development of the research dimension of the European Space University for Earth and Humanity (UNIVERSEH) and propose a set of specific actions for their future implementation within a corresponding timeline. This roadmap should be understandable for a wide non-technical audience, as it will likely be read and reviewed by policymakers and other potentially non-technical stakeholders.

More specifically, the overall objectives for WP2 can be listed as it follows:

O.1. Identification of the societal needs including current and future global challenges, that space related research and innovative technologies can solve in a sustainable way.

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O.2. Bringing together and establishing an effective dialogue, cooperation and integration among the various constituencies that are currently active in the field of space technologies, as well as with a critical mass of industrial and academic representatives to create an ecosystem that will shape and drive the future innovation and developments in the space sector.

O.3. Evaluation of the enablers to sustain and maximize the implementation of the technologies promoted in the roadmap.

O.4. Elaboration of a UNIVERSEH research roadmap for 2035, that is adoptable, interdisciplinary, collaborative, innovative, enabling to scale excellence by joining forces at a European level.

O.5. Elaboration of a UNIVERSEH Vision for 2050 that will have the EU being a cornerstone of the related developments.

While this deliverable will be focusing in the O.4 and O.5.

Towards this aim, the D2.2 has created a questionnaire in order to voluntarily collect impact on the future of space operations and with an emphasis on space autonomy, while it also elaborated the already existing roadmaps of key space organizations e.g. NASA and ESA.

3.2 – Data Collection: Approach and Structure of the D2.2

In this document, we present deliverable D2.2 which concerns the strategic data-collection and the development of questionnaires to carry out the activities related to mapping of the state-of-the-art in space sciences and engineering. This deliverable lays the groundwork to accomplish objectives **O.4** and **O.5** that are related to the creation of UNIVERSEH research roadmap for 2035 and UNIVERSEH Vision for 2050, which constitute Deliverables D2.5 and D2.6 respectively. Leading up to this deliverable, we have performed the Task T2.2, which is about specification and execution of the UNIVERSEH data collection via strategic intelligence, interviews, and workshops.

In order for the Questionnaire to reveal information that does not already exist in public documents, it was crucial that we first surveyed the current activities and the near and long-term vision documents from the major Space agencies. We present our survey in Section 3, where we capture the important current activities of the major space agencies. In Section 5, we survey the near and long-term future visions of the space agencies. The Questionnaire presented in this deliverable in Section 4 has been designed specifically to gather information about areas that are not covered and in public documents released by space agencies. We specifically focused on questions that would lead the experts in academia and industry to

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comment on how space activities and space missions of the future would cater to societal needs and help in achieving global sustainability goals.

3.3 – Data Collection: Mapping of the Current Activities of the Major Space Agencies

In this Section we present a survey of the current activities of the major space agencies of the world. The survey aids in realizing objectives **O.4** and **O.5** and helps in the design of the Questionnaire presented in Section 4. The major space agencies of the world are releasing annual reports detailing their activities in the past calendar year and provide a peek into their ambitions for the next year. As such, these reports are made available for the public on the agencies' webpages, and this is the fundamental based of the D2.2 in order to be fully synced with these activities and roadmaps. By utilizing these reports, we aim to capture current trends, common need-driven and curiosity driven goals and ambitions, use of recent technologies, etc.

3.3.1 – Data Collection: Annual Reports from Space Agencies

Regarding the methodology in creating the D2.2., the previously mentioned annual reports that have been released between 2019-2021, from the following seven major space agencies, will be utilized to gain a perspective on the current scenario in the space industry.

- NASA – the National Aeronautics and Space Administration
  JPL:
  https://www.jpl.nasa.gov/who-we-are/jpl-annual-reports

  Marshall Space Flight Center:
  https://ntrs.nasa.gov/citations/20210011071

- ESA – European Space Agency
  https://www.esa.int/About_Us/ESA_s_Annual_Report

- ISRO – Indian Space Research Organization
  https://www.isro.gov.in/AnnualReports.html

- AIA Aerospace Industries Association

  https://www.aia-aerospace.org/publications/whats-next-for-aerospace-and-defense-a-vision-for-2050/

- CNSA – China National Space Administration
  https://www.uscc.gov/research/chinas-space-and-counterspace-activities

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- SSI – Space Studies Institute of California
  https://ssi.org/programs/research-report/

- JAXA – Japan Aerospace Exploration Agency
  https://www.isas.jaxa.jp/en/about/annual_report/

These annual reports, as well as the future vision ones could also be found in the following one-drive folder and in this link. Beyond_Universeh_Project

For clarity of the presentation, so far, we have considered the annual reports of the first four agencies mentioned in the list above, while key takeaways from the reports can be found in the next subsection. In the future, we plan to consider annual reports of the last three agencies and the activities of the private industries in the space sector.

3.3.2 – Data Collection: Current Trends in Space Sciences and Engineering

The key takeaways from the annual report are presented in the sequel.

Jet Propulsions Laboratory (JPL)

- Mars Exploration (Perseverance Rover and Ingenuity Mars Helicopter).
- Low earth flights (Sea Level Measurements, weather forecasting) supporting oceans and atmospheric sciences.
- Planetary and Satellite studies including exoplanets
- Missions to set up Deep-space networks and Deep Space telescopes

NASA Marshal Space Flight Center

- Artemis Program aiming to land the woman on Moon, with the future aim of landing humans on Mars.
- Development of a sustainable in-space architecture for human space exploration that is aimed to guide missions to moon, mars and beyond
- Focus areas:
    - Flight computing and Avionics
    - Propulsion systems
    - Aerospace power and energy storage
    - Communications, navigation, orbital Debri tracking/characterization systems
    - Human Health, habitation, and life support systems
    - Exploration Destination Systems

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- Sensors and Instruments
- Autonomous Systems
- Materials, structures, and manufacturing research
- Therman Management Systems
- Guidance Navigation and Control

European Space Agency

Goals for 2025

- Boosting EU-ESA relations
- Boosting green and digital commercialization
- Developing space for safety and security

Major Focus Areas

- Human Space Flight and Robotic Exploration
- Mission catering to Earth Observation and Meteorological Studies
- Space safety, security, and cyber resilience
- Space for 5G communication
- Space transportation and operations in space
- Science in Space environments

ISRO (Indian Space Research Organization)

Major Focus Areas:

- Earth Observation, Meteorological Satellite Systems and Applications
- Communication Satellite Systems and Applications
- Navigation Systems
- Space science and Planetary research systems
- Space Transportation Systems
- Human Space Flight
- Space situational awareness and management

AIA Aerospace Industries Association:

Vision 2050 from AIA Aerospace Industries Association

https://www.aia-aerospace.org/publications/whats-next-for-aerospace-and-defense-a-vision-for-2050/

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The report is based on the observations and insights from 70 experts in the Aerospace industry. The report identifies four core areas spanning use of aerospace technology to enhance people's life on earth and space research and explorations. The four core areas are:

- Moving people and goods
- Creating, sensing, and connecting
- Securing and defending our national interests
- Research and exploration

The responses gathered from 70 experts on four carefully designed questions were studied and analyzed. The four questions are the following

1. What are the key disruptive trends that will affect the A&D (Aerospace and Defense) industry?
2. How will these trends alter industry dynamics, profit pools and required capabilities?
3. Which missions, use cases and platforms will emerge?
4. How can industry shape its future?

Six Categories were identified in which considerable progress needs to be made to enable improvements in the four core areas mentioned above.

1. Autonomy and insights
2. Materials, technologies, and designs
3. Connectivity infrastructure
4. Physical infrastructure
5. Manufacturing processes
6. Industry and government mindset and culture

3.3.3 – Data Collection: Common Current Trends and Future Vision

Based on the information from the previous section, we also make a list of the common trends in all the activities and identify common goals and larger interests pursued by the agencies.

The annual reports of the space agencies revealed that missions being formulated and executed cater both to societal needs and towards furthering scientific knowledge. Space situational awareness, deep-space and planetary exploration, atmospheric studies and earth sciences, and missions geared towards improving connectivity and communication on earth seem to be common trends. Emphasis is being laid not only on formulating mission scenarios catering to these trends but also on establishing infrastructures, support systems and worldwide collaborations that help realize these missions.

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Some of the major activities of the space agencies are towards improving current technologies and developing innovative technologies that support ambitious and long-term missions, such as Human Space Flight (towards Space tourism), robotic planetary and deep-space exploration etc. Due to the rapid rise in activities in space, the topic of sustainable use of outer space, as a resource, is in the spotlight. As a result, the research community is moving towards more sustainable missions like spacecraft refueling, on-orbit servicing, in-space manufacturing and assembly, and space debris capture and removal missions. An additional remark is that all agencies are directing a part of their efforts towards developing technologies that lead to sustainable use of outer space. Assessing climate change on earth and missions geared towards monitoring, forecasting, and averting natural and man-made disasters have received a lot of attention and will continue to do so in the future.

3.3.4 – Data Collection: Broadening the Mapping of Current Research

In the future, we plan to take the activities of more space agencies into account, such as

- **CNSA – China National Space Administration**
  https://www.uscc.gov/research/chinas-space-and-counterspace-activities
- **SSI – Space Studies Institute of California**
  https://ssi.org/programs/research-report/
- **JAXA – Japan Aerospace Exploration Agency**
  https://www.isas.jaxa.jp/en/about/annual_report/

Another direction we plan to pursue is to consider the activities of private industries, such as SpaceX, Blue Origin, Virgin Galactic, Orion Span, Boeing etc.

The survey presented in this Section helped in capturing the current and future trends in space sciences and engineering. The annual reports, although informative and educational, are aimed at the short-term and are by no means comprehensive. For the purposes of compiling a roadmap for 2035 (**O.4**) and a vision for 2050 (**O.5**), strategic data collection through questionnaires, interviews and workshops would be needed. Our initial efforts in this direction have been in the design and setting up of a questionnaire, through which the members of UNIVERSEH, the European Space University for Earth and Humanity, wish to gather information that reveals a more comprehensive view of the research and technological trends in space science communities and industry. Using the information gathered, the UNIVERSEH alliance wishes to compile a roadmap for 2035 and set a vision for 2050 for UNIVERSEH. The set of questions has been designed to cover a broad range of topics and ensure an overall coverage of all the major domains in the space sector.

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3.3.5 – Data Collection: Mapping Tasks and Topics

Following the initial stakeholder analysis from WP 2.1, an in-depth investigation on tasks and current and future topics of interest has been made. In total, 180 stakeholder organizations, private companies, and agency's alike, were examined, and their main themes mapped into 58 topic categories. For each stakeholder, four main themes were selected based on information available on the homepage or in strategic reports. For each main theme mentioned, a topic category received 1 point. The mapping of the main themes was sorted based on their number of mentions, which resulted in the following list:

- Satellite bus / instruments (42 mentions)
- Earth observation (39 mentions)
- Sustainability on Earth (37 mentions)
- Space exploration (25 mentions)
- Humans in space (22 mentions)
- Satellite constellations (21 mentions) and New/Reusable launchers (21 mentions)
- Education and research (18 mentions)
- Space sustainability (15 mentions)
- AI (11 mentions)
- Business development (10 mentions)
- SSA (9 mentions) and Materials (9 mentions)

Table 1: Mapping Priorities of Tasks and Topics based on Task 2.1 and Deliverable 2.1 Data Base

Main Theme	Priority 1	Priority 2	Priority 3	Priority 4	Total
Satellite Bus / Instrument	30	7	3	2	42
Earth Observation	12	16	8	3	39
Sustainability on Earth	12	14	9	2	37
Space Exploration	2	16	5	2	25
Human in Space	9	4	7	2	22
New and Reusable Launcher	15	4	1	1	21
Satellite Constellation	8	9	3	1	21

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Main Theme	Priority 1	Priority 2	Priority 3	Priority 4	Total
Education / Research	18	0	0	0	18
Space Sustainability	4	5	5	1	15
AI	4	5	2	0	11
Business Development	5	3	2	0	10
Materials	7	2	0	0	9
SSA	4	2	3	0	9
Data	1	3	2	0	6
Life Extension	1	1	2	2	6
Clean Aviation	0	2	3	0	5
Democratizing Space	1	2	0	2	5
Network Building	0	4	1	0	5
Small Satellite	0	4	1	0	5
Software Development	2	2	0	1	5
Space Traffic Management (STM)	0	1	3	1	5
Electric Aircraft	2	2	0	0	4
In-Space Manufacturing	1	2	0	1	4
Maritime Traffic Management	0	4	0	0	4
Military	1	1	1	1	4
New Space Station	2	0	1	1	4
Resources in Space	0	1	3	0	4
Active Debris Removal (ADR)	0	3	0	0	3
Electric Propulsion	3	0	0	0	3

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Main Theme	Priority 1	Priority 2	Priority 3	Priority 4	Total
Space Commercialization	1	0	1	1	3
Additive Manufacturing	1	1	0	0	2
Air Traffic Management	1	0	1	0	2
Aircraft Structure/ Component	2	0	0	0	2
Finance	1	0	0	1	2
Insurance	2	0	0	0	2
Apps	0	0	1	0	1
Art	0	0	0	1	1
Big Data	1	0	0	0	1
Collision Avoidance	0	1	0	0	1
Communication	1	0	0	0	1
Data Analytics	0	1	0	0	1
Data Link Systems	0	1	0	0	1
Deep Learning	0	1	0	0	1
Digital	0	1	0	0	1
Digital Twin	1	0	0	0	1
Drone	1	0	0	0	1
Health	0	1	0	0	1
Innovation	1	0	0	0	1
Medicine	0	0	1	0	1
Microwave	1	0	0	0	1
Oil & Gas	0	0	1	0	1
Project Management	0	0	1	0	1

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Main Theme	Priority 1	Priority 2	Priority 3	Priority 4	Total
Reusability	1	0	0	0	1
Satellite Mass Production	0	0	0	1	1
Satellite service	1	0	0	0	1
Social Media	0	1	0	0	1
Supply Chain Management	0	1	0	0	1
Transport	0	1	0	0	1

Additionally, HORIZON 2020 grant award information regarding classification keywords of funded proposals were analyzed as part of a study for potential LTU-lead funding opportunities in the field of space linked to activities like in example RIT (Space for Innovation and Growth) follow-up. A total of 133 space related keyword combinations were identified and sorted based on the amount of mentioning. Keywords were then combined and clustered related to space segments, upstream (2065 mentions), downstream (2720 mentions), and space-related (539 mentions).

The top 5 sub-segments are:

- Space operations for terrestrial use (downstream)
- Research (general) (upstream)
- Space manufacturing (upstream)
- Product and services form spin-offs and technology transfer (space-relarted)
- Data to function (downstream)

Table 2 lists the result in detail.

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Table 2: Total Amount Keyword Mentions per Segment

C1	Upstream	
C2	Research	1098
C3	Space Manufacturing	842
C4	Ground Systems	125
C5	Downstream	143
C6	Space Operations for terrestrial use	2051
C7	Products and Services relying on satellite technology	166
C8	Signal	42
C9	Data-to-function	318
C10	Space-related	
C11	Space Applications using satellite technology but don't depend on it	198
C12	Products and services from spin-offs or technology transfer from the space sector which use satellite technology but don't depend on it	341

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Organisation	Type of Organisation, Source Material, Country	Tasks and Topics in the Field of Space
Luleå University of Technology (LTU)	Academic Institution/Government, Vision 2030 & Strategic Plan 2020-2025, Sweden	collaboration, digitalization, innovative education, internationalization, sustainability
Rymdstyrelsen - Swedish National Space Agency (SNSA)	Space Agency/Government, Strategy, Sweden	availability of safe and reliable infrastructure, climate change and environmental monitoring, commercial space operations, education, gender equality, innovation and entrepreneurship, international collaboration, participation in exploration and human spaceflight, sustainability,
CNES	Space Agency/Government, France	Education/ Research; Space exploration; SSA; Earth observation
EUSPA	Space Agency/Government, EU	Earth Observation, Data, SAA
DLR	Space Agency/Government, Germany	Education/ Research, Space exploration, Human in space, Earth observation
ESA	Space Agency/Government, EU	Education/ Research, Space exploration , Human in space, Earth observation
IRF	Research centre, Sweden	Education/ Research, Satellite bus/ instrument, Space exploration
JAXA	Space Agency/Government, Japan	Education/ Research, Space exploration, Human in space
NASA	Space Agency/Government, The US	Education/ Research, Human in space, Space exploration, In space manufacturing
Airbus	Company, France	Next Space, Space sustainability, Earth Observation, In Space manufacturing, Satellite mass production
OHB	Company, Germany	Satellite bus/ instrument, Space exploration, Human in space, New/ Reusable launcher
SSC	Company, Sweden	New/ Reusable launcher, Satellite constellation, Earth observation

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Boeing	Company, The US	Space exploration, Human in space, New/ Reusable launcher, Satellite constellation
iSpace	Company, Japan	Human in space, Space exploration, Resource in space
Axiom Space	Company, The US	New space station, Human in space, In Space manufacturing
Aerospace Valley	European competitiveness cluster in aerospace, France	Business development, Network building Sustainability on Earth
Swedish Aerospace Research Center	A Strategic collaboration of Swedish universities and research organizations, Sweden	Education/ research, Network building, Business development

Table 3: Examples of Mapping of Tasks and Topics using organizations' strategic documents.

3.4 – Specification/Execution of data collection via strategic intelligence, interviews, workshops

The work towards the Task T2.2 has been carried out by collecting information from available future vision documents from space agencies, by gathering information through questionnaires and by organizing interviews and workshops. This information will be used to generate a complete 2035 Roadmap and 2050 Vision for the development of the research dimension of the European Space University for Earth and Humanity (UNIVERSEH).

In 'The future of space: 30 voices on 2030', a document released by KPMG[1], there has been a collection of interviews with 30 leading researchers in the Space sector. This report served as a valuable reference on the process of gathering information through strategic interviews and questionnaires and as a source of good practices to be followed in the process.

Furthermore, in the questionnaire presented in the next Subsection, we have selected a set of questions that try to bring out valuable information and perspectives from the UNIVERSEH Alliance members and their network. The target communities and strategy for distributing the Questionnaire among experts from Academia and Industry are presented in Section 4.1.4

[1] https://home.kpmg/au/en/home/insights/2020/05/30-voices-on-2030-future-of-space.html

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3.4.1 – Questionnaire for Mapping the State-of-the-Art in Space Sciences & Engineering

We used the Google Forms platform to create the Questionnaire. In the Questionnaire, we included a brief description of the Beyond UNIVERSEH Project, elaborated on the purpose of the Questionnaire and provided some general instructions to the responders.

Please click on the link [2] to access the Questionnaire. The structure of the Questionnaire (subsections 4.1.1 - 4.1.3) is presented below.

3.4.1.1 – General Information about the Questionnaire and Instructions for responding

Through this questionnaire, the members of UNIVERSEH, the European Space University for Earth and Humanity, wished to gather information to capture the main research and technological trends in space science communities and industry.

3.4.1.2 – Purpose of this Questionnaire

The responses gathered through this questionnaire have been used by the UNIVERSEH alliance members to survey and map activities related to the current trends and future trends in space science and technology, while the main focus was to capture the main research and technological trends in space science communities and industry and compile a roadmap for 2030 and set a vision for 2050.

The questions have been designed to cover a broad range of topics, to ensure an overall coverage of all the major domains in the space sector. The responses used internally and securely. We would also ensure anonymity of the responses. A cursory data fact-checking process will be performed, just so we are sure on the numbers and statistics involved. The structure of the questionnaire is depicted in Section 4.1.3.

3.4.1.3 – Questions

1. What according to you are the biggest challenges facing humanity today and do you see space-based technologies offering solutions to these challenges in the near future?

[2] https://forms.gle/sSQEmVJVC38obH3Q7

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2. What are the major goals for your group or organization in the space sector, that you aim to achieve or foresee being accomplished by 2035 and 2050?
3. What percentage of the current space missions would you say are need-driven and are looking to solve societal challenges? By need-driven, we mean earth-oriented applications, intended to provide solutions to problems on earth or improve/enhance life on earth.
4. What according to you are the key technological developments that will be needed to sustainably drive the space industry into the future (over a horizon of 25-30 years)?
5. Which emerging technologies have the potential to be disruptive in the space arena, especially for drastically changing the way things are done or driving the industry away from traditional ways of doing things?
6. What are perhaps unlikely and ambitious goals and missions, but ones you are still hopeful of seeing being achieved by the space community by 2035 and 2050?
7. What role do you see for Autonomy and Robotics-based solutions in Space missions of the future?
8. Currently a lot of the expenditure of space organizations comes from national budgets. Do you see that reducing in the future? What role do you foresee the governments playing in the space sector in 2035?
9. In the future, what do you think space business will look like? For instance, will there be more private entities or government agencies leading future projects and missions?
10. Do you see venture capital investing more and more into the space sector and encouraging start-ups? Should they realistically expect short-term returns or bet on long-term success?
11. How do you foresee collaboration between academia and industry evolving in the future? We see more and more universities across the world involved in the development of micro and nanosatellites and experimental rovers for planetary exploration. Will there be more intense and deeper collaboration between academia and industry in the future?

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12. What is your opinion on the current nature of industry-academia collaborations and what future steps could academia and industry respectively take to improve the industry-academia partnership?
13. Is the rise of SpaceX and Blue Origin an indicator of the possibility that the space race will not be between nations, but between private companies in the future?
14. Which space-based technologies, under development as we speak, have the potential to be big parts of our daily lives by 2035 and 2050?
15. Do you foresee space tourism being a reality by 2035? Will it be affordable enough to be attractive to people from all levels of society?
16. What according to you are the challenges being faced in getting humans into space and in keeping them in space for prolonged durations of time?
17. We are likely to see increased frequency of extreme weather events due to Global Warming. How will space-based missions and technologies help in combating Global Warming and in mitigating the effects of climate change?
18. In the future, ensuring food security while managing our land use sustainably will be crucial. How will space technologies be important for enabling planning and enhancing decision making capabilities related to agriculture?
19. What are your comments on the satellite launch frequency in the last two years? With the growing popularity of small/micro satellites and the respective micro-launch vehicles, do you foresee a rapid rise in the launch frequency in the near future? What problems would this induce?
20. How do you think we could ensure sustainable use of space around earth to prevent accumulation of Space Debris? What changes do you see by 2035 and 2050 over the current state of affairs?
21. Should there be specific laws related to debris-management and would this encourage businesses providing debris-mitigation services? How do you foresee or imagine debris-removal technology evolving by 2035 and 2050?
22. Do you think there will be a system of law and justice for governing activities in space (for example: military operations, security, accountability, ownership of extra-terrestrial

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resources etc.)? When do you see everyone involved in the space industry agreeing on this matter? What space laws do you see being put into place by 2035 and 2050?

23. What technologies under development show most promise in bringing down the cost of satellite launches? Will new types of fuels play a big role in bringing down the cost of launching?
24. Do you see data collected by space agencies through various missions being made open source? This could encourage development of novel analysis and processing methods by researchers from various backgrounds. By allowing direct involvement, would you say there be more awareness and participation in space-related activities?
25. We see that competitions like the DARPA challenges, which envision and set grand targets for areas such as autonomous driving, subterranean exploration and mapping etc. are very popular and see participation from across the globe. Will space technology-based targets in such competitions help increase the pace of progress in some areas? Which space application would you like to see being set as a challenge for future competitions?
26. If you are aware of publications or openly accessible articles that could help us with information relevant to this questionnaire, please provide links to them below.
27. If you wish to comment on areas that were not covered in this questionnaire, you are welcome to add your responses here.

3.4.1.4 – Target Communities for Distribution of the Questionnaire

In addition to existing and established space actors (from both academia and industry), this questionnaire has been distributed among professionals from diverse backgrounds that are/will be contributing to the upcoming space initiatives. In the wake of miniaturization and reducing launch costs, many terrestrial robotics solutions (like machine learning approaches, swarming, resilient autonomy solutions, etc.) are being experimented with in space applications. Thus, we invited the Robotics and Automatic Control community for this data-collection phase and of course the members of the Universeh project. In recent times, the space sector has witnessed a steep rise in the number of private initiatives, not only big companies but new small and medium-sized enterprises and new start-ups. To take their opinions into account, we distributed the questionnaire among them as well.

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At present, this Questionnaire has been circulated among the UNIVERSEH Alliance Members and their collaborators and partners, members of the EU-robotics community[2], and Automatic Control community through IEEE State Space Forum[3]. We are awaiting the responses to this questionnaire. Once a considerable number and diverse set of responses are collected, we plan to consolidate the responses and begin the creation of a Roadmap for 2035 and a vision for 2050 for the UNIVERSEH Alliance. This would be part of Tasks T.4 and T.5 and would constitute deliverables D2.4 and D2.5.

3.5 – Future Vision Documents from Space Agencies

Along with the Questionnaire above, we propose to use the future vision documents released by space agencies and surveys provided by organizations like the Aerospace Industries Association (AIA), for creating the UNIVERSEH Roadmap for 2035 and vision for 2050. These would not just be sources of information but would serve as guiding templates for structuring our roadmap and vision documents. After making a critical analysis of both the information structuring and stylistic elements, we propose to borrow some best practices from the documents and adopt them in structuring our roadmap and vision document. We plan to draw inspiration and gather good practices from the following future vision documents.

- Vision 2050 from AIA Aerospace Industries Association https://www.aia-aerospace.org/publications/whats-next-for-aerospace-and-defense-a-vision-for-2050/

- Vision 2050 from Japanese society for aeronautical and space sciences JSASS Space Vision 2050 : 2021 Edition—Overview— (jst.go.jp)

- Strategic Vision Document 2025 from the Italian Space Agency Institutional Documents | A.S.I. - Agenzia Spaziale Italiana (almaviva.it)

- The future of space: 30 voices on 2030, a document released by KPMG https://home.kpmg/au/en/home/insights/2020/05/30-voices-on-2030-future-of-space.html

- The future of Space Exploration https://en.wikipedia.org/wiki/Future_of_space_exploration

[2] https://eu-robotics.net/
[3] https://state-space.ieeecss.org/

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We intend to bring the information from the above-mentioned list of vision documents and information gathered through the questionnaire together for designing the future directions for the UNIVERSEH alliance.

4 – Conclusions

4.1 – Summary of the Activities so far

We have taken the first steps in realizing Objectives **O.4** and **O.5** by surveying the current activities and future vision documents from major space agencies. We have also presented a Questionnaire in this deliverable that aims to gather information from academic and industry experts on how space-based technologies could make an impact in catering to societal needs and in achieving global sustainability goals. The Questionnaire covered a diverse set of subjects like climate change, communication and connectivity needs, agriculture, disaster management etc. As part of Task T.2, we initiated the strategic data collection phase. We are yet to gather and consolidate the data collected. We await expert responses to the questionnaire, following which we plan to proceed to the elaboration of objectives **O.4** and **O.5**.

4.2 – Future Work

On receiving a considerable number of diverse responses to the Questionnaire, we will proceed with the analysis of the responses and identify areas which have been highlighted by the experts. We plan to organize focused workshops on specific areas such as autonomy in space, sustainable operations in space etc. Such workshops would bring the experts from industry and academic together and we believe that the resulting dialogues and interactions would generate more valuable information for the strategic data collection task T2.2. All members of the UNIVERSEH alliance would take part in hosting such workshops. The data collected from all the activities of task T2.2 would be brought together, following which we will be able to target the major objectives of WP2, which are **O.4** (Roadmap for 2035) and **O.5** (Vision for 2050). Details and results related to Tasks **O.4** and **O.5** will be part of the upcoming Deliverables D2.5 and D2.6, respectively.

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