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Full Report

Space Education in Europe

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1 About Space and Education

The space sector, including its development, competitiveness, entrepreneurial mindset, and capacity to innovate, strongly relies on its workforce. Academia plays a crucial role in training specialised profiles. The transformation of the space sector, as a result of new technology, business and policy trends, creates new challenges for the European education system, which must adapt to new sector needs. The development of new space technologies, nested in emerging fields such as artificial intelligence, machine learning, additive manufacturing, blockchain or quantum technologies, also creates new needs for a more interdisciplinary education. Beyond these practical considerations, space has also a crucial role to play for education at large as a source of inspiration for new generations.

The development of the space sector has given rise to an increasingly diverse educational landscape with various space-related curricula offered in different fields, from science and engineering to policy and law. In this context, public actors have launched multiple initiatives to promote space education which continues to be an important topic of European policy agendas and public programmes:

- The role of education for the future of the space sector is highlighted in ESA Agenda 2025. The Agency seeks "to offer European talent attractive opportunities within Europe and to adapt higher education curricula to the skills required for the future".[1] The agenda also calls for a stronger inspirational outreach from ESA, in cooperation with other organisations, to increase the share of European students in STEM fields by 20%.
- At national level, countries such as Austria, Germany and the United Kingdom stress the role of education in their space strategies, which lay down action plans to promote space education. Austria's new Space Strategy 2030+ highlights space education as a top national objective to shape the next-generation workforce.[2] The UK Space Strategy seeks to promote space education in different contexts, while the German Strategy (2010) mainly addresses it in the context of Earth Observation.[3]

Concretely, European institutions and space agencies have implemented educational programmes and offer funding opportunities. For example, the SpaceEU project, which is led by Leiden University, aims to foster a young, creative, and inclusive European space community through the implementation of a space outreach and education programme.[4] In the framework of the DLR_Campus Programme, DLR offers several educational opportunities, including laboratories, summer schools, challenges and competitions.[5] Finally, as part of ESA Agenda 2025 strategic priorities, the Space for Education 2030 programme proposal, the ESA Education Programme aims to "support society in providing a long-term response to the emerging global socio-economic challenges and to support emerging economic sectors and megatrends (digital, green, and more), by means of education".[6]

Considering that education is an integral component of public policy and action, ESPI examined the state of play of the European space education landscape and gathered insights into available curricula in Europe and into views and expectations of European students involved in space-related programmes. This report aims to provide a useful source of information on the current space education landscape for the various actors involved including policymakers, agencies, universities, institutions as well as students and young professionals.

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[1] ESA Agenda 2025. *European Space Agency*. 2021.
[2] Austrian Space Strategy. *Austria in Space*. 2021.
[3] National Space Strategy. *HM Government*. 2021. In addition, The space strategy of the German Federal Government. *BMWI*. 2010.
[4] SpaceEU. *European Commission.*
[5] DLR_School_Lab. *DLR*. 2021.
[6] ESA at the forefront of space education. *European Space Agency.* 2021

2 Overview of the European Space Education Landscape

For the purpose of this study, ESPI compiled a comprehensive database of space-related education programmes in Europe. The database aims to cover all fully space-related Higher Education (HE) programmes for the academic year 2021/22 in EU and ESA Member States as well as European Associated Member States. This includes education programmes offered by universities and higher education institutes as well as space agencies, governments, international organisations, and other educational institutions. The database also includes professional trainings and other education programmes.[7] ESPI organised programmes into four categories:

- Bachelor,
- Master (including master, double master, LLM, 5Y degree, double degree, second level master, integrated master programme, etc.),
- PhD,
- Other (including seasonal schools, short courses, online courses, etc.).

For each educational programme compiled in the database, all available information was catalogued including course level; host city; host country; language of instruction; duration of the programme; host university, institute, and department/faculty; macro-area; and programme requirements (i.e., thesis, research project, internship). The number of students attending each programme was not collected. Although a wide range of educational backgrounds can lead to a career in the space sector, the database focuses on space-specialised curricula exclusively. These curricula are organised into five macro-areas to allow for systematic grouping and analysis:

- Aerospace Engineering,
- Space Sciences,
- Juridical, Economic, Social Sciences and Space,
- Space Applications,
- Multidisciplinary Programmes.

2.1 European representation of space-related education

Overall, Europe offers a wide range of space-related higher education programmes that are distributed throughout the continent. ESPI identified and mapped a total of 866 programmes offered by 325 high-institutions and distributed across 30 European countries.

Scope of ESPI Space Education Landscape Analysis	Total
Countries (EU & ESA Member and European Associated States) considered	30
Universities and higher education institutions considered	325
Space-related higher education programmes considered	866

Table 1: Total number of countries, institutions and programmes in ESPI Space Education Database

[7] For further information on the database and methodology, see the Annex.

All European countries have at least one educational programme with a space-related focus.

Building on the information identified in the desktop research and database consolidation, ESPI selected six countries to assess the national space education landscapes (France, Germany, Italy, Spain, the Netherlands and the UK).

Space education is mainly offered as a specialisation area, with second and third cycle degrees (master and PhD) representing the vast majority of space-related educational programmes in Europe. This situation varies slightly by macro-area. In the aerospace engineering and multidisciplinary fields, bachelor programmes outnumber PhD programmes.

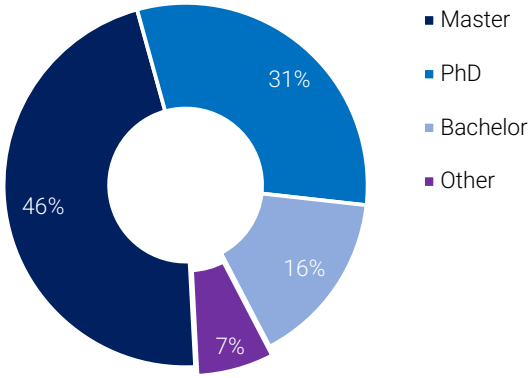

Figure 1: Course level distribution

In order to provide a more representative picture of the European space education landscape Bachelors/Masters and PhDs/Others are addressed in two separate sections.[8]

2.1.1 Space-related bachelor and master programmes in Europe

The majority of European countries have a limited space education landscape with less than five institutions offering bachelor and master level programmes. France and the UK are the countries with the highest number of higher education institutions offering space-related programmes, followed by Spain and Germany. Italy and Poland host between 11 and 20 institutions offering space-related programmes.

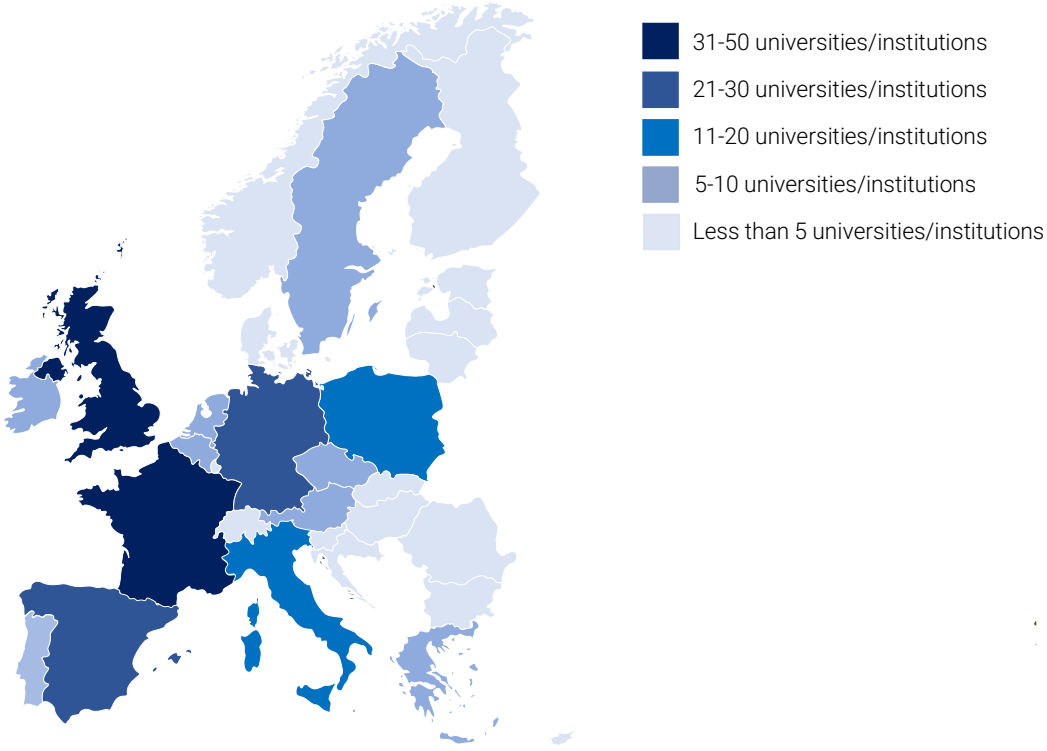

Figure 2: Distribution of universities/institutions offering space curricula by country

[8] While Bachelor/Master programmes usually involve tens to hundreds of students, PhDs usually involve education projects with a handful of selected candidates. Additionally, the selection process and the structure of PhDs vary considerably depending on the country's education system and the higher educational institutions offering them. To account for these differences and avoid a misrepresentation of the place of PhDs in the space education system, doctoral programmes are addressed separately.

The main hubs for space education are Paris, Toulouse, Madrid, London, Barcelona and Rome.

Cities	Paris	Toulouse	Madrid	London	Barcelona	Rome
Space programmes	26	23	22	19	11	11

Table 2: Top cities in Europe by number of space-related programmes

Most countries host less than 20 space-related programmes. Comparably to the ranking by number of higher education institutions, the UK and France host the highest number of space educational programmes, followed by Germany, Italy and Spain.

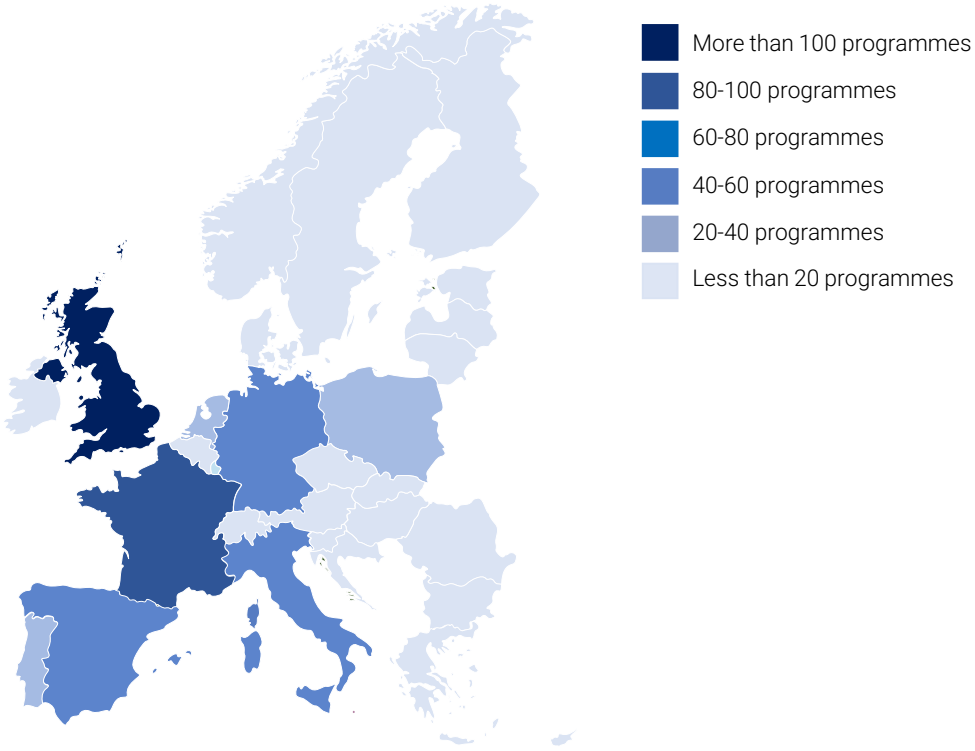

Figure 3: Distribution of space-related educational programmes by country

A comparison of the distribution of higher education institutions and curricula per country shows that:

- **France and the UK host a comparable number of institutions. However, the landscape of the two countries' educational offerings differs significantly**. The UK high-institutions offer approximately 20 more bachelor and master programmes than those in France. The UK indeed houses more than 100 programmes distributed across approximately 40 higher education institutions. France has a little more than 40 institutions offering approx. 90 programmes.
- **The national distribution of programmes between bachelor and master contributes to explain these differences**. France and UK's master programmes represent respectively 19% and 17% of the European space-related educational offer at master level. Nevertheless, there is a huge gap between France's bachelor programmes and UK's. France's space-related bachelor programmes constitute only 8% of the total European offer at bachelor level, while UK's bachelor curricula account for 26%.
- **Some countries host a high number of programmes offered by a limited number of educational institutions**. Examples include the UK, Italy, the Netherlands, Spain and Switzerland. Italy, for instance, houses approximately 50 programmes, but less than 20 institutions. Spain offers more than 50 programmes distributed across approx. 30 high-institutions. Conversely, some countries have an educational offer that is more distributed among the universities, including Ireland, Greece, Denmark, and Croatia.

Europe offers a wide variety of space-related studies

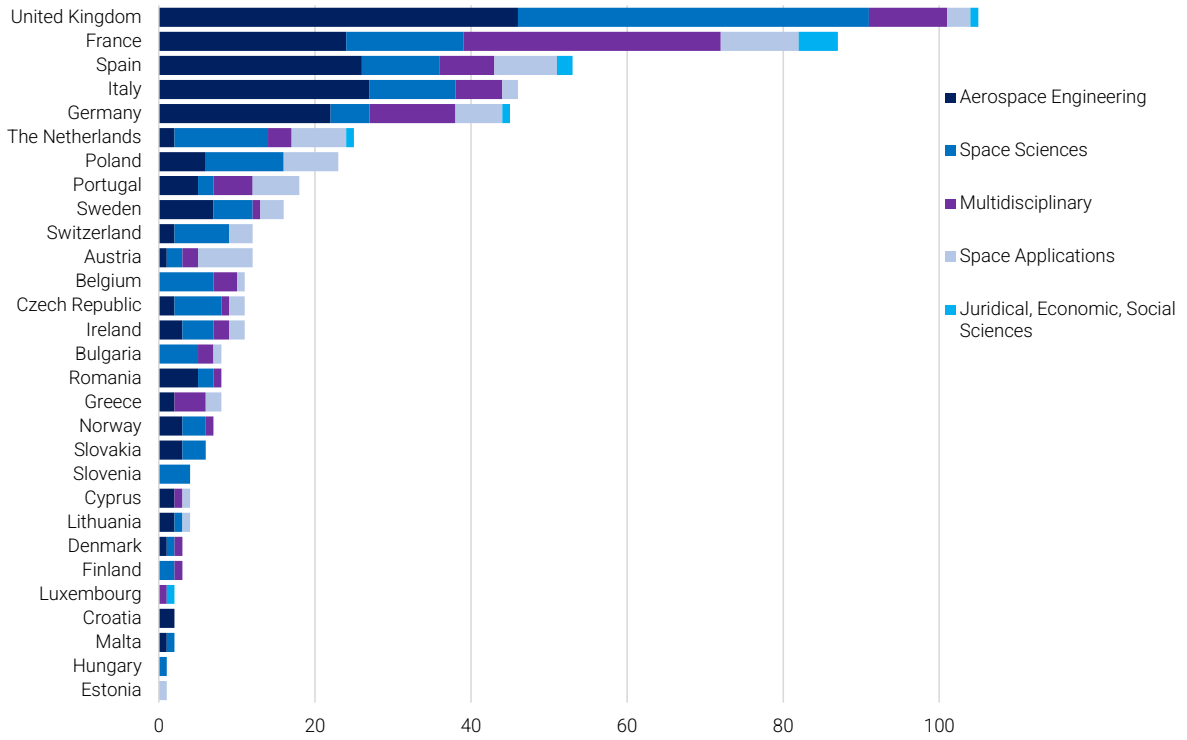

Figure 4: Bachelor and Master distribution by macro-area and country

General trends among bachelor and master level programmes can be identified when programmes are grouped according to the macro-areas:

- **Aerospace engineering and space sciences represent a vast majority of space educational programmes, respectively 36% and 30% of the total bachelor and master offer, and 65% of the countries house at least one programme in both fields**. Despite the traditional ones, the aerospace engineering macro-area includes programmes in satellite telecommunications and navigation engineering, space systems engineering, and space propulsion engineering, among others.
- The space sciences educational offer is more distributed across the countries compared to aerospace engineering. 83% of the countries offer at least one programme in the field of space sciences and 76% in the field of aerospace engineering. **Nevertheless, the UK is home to approximately 27% of Europe's bachelor and master programmes in space sciences, and France holds the second highest share (9%)**.
- After aerospace engineering and space sciences, programmes in the multidisciplinary macro-area represent the third largest share in Europe. **Multidisciplinary programmes account for 18% of the total offer at bachelor and master level in Europe**. Multidisciplinary curricula comprise interdisciplinary educational degrees, cross-cutting and macro-areas related educational programmes. Selected examples are the Astronomy and Business Studies MSc of Leiden University which combines research-oriented studies in astronomy with training in management and entrepreneurships; and the Bachelor and Master in Aerospace Informatics of the Julius-Maximilians University of Würzburg, which teach students to develop complex technical hardware and software system for space-related uses.[9] While the number of multidisciplinary programmes varies significantly by country, these programmes are also distributed across 69% of the countries.

[9] Astronomy and Business Studies (MSc). *Leiden University*. 2021. Additionally, Aerospace Informatics. *Julius-Maximilians University of Würzburg.* 2021. Also, Aerospace Informatics, Master. *Julius-Maximilians University of Würzburg.* 2021.

- **Curricula related to space applications represent 13% of all bachelor and master programmes in Europe and are offered by 65% of the countries**. This macro-area encompasses all curricula concerning the space applications and services domains, and particularly educational programmes both targeting them directly and addressing their use in other fields. For instance, the 2-year Master in Aerospace Systems - Navigation and Telecommunications organised by the High Institute of Aeronautics and Space (ISAE) and the National School of Civil Aviation (ENAC) in Toulouse aims to train students in satellite-based positioning and space telecommunications systems; and the GEM Master offered by a consortium of European universities provides students with information on satellite remote sensing in relation to specific topics in which students can specialise.[10]
- The juridical, economic, social sciences, and space macro-area represents 2% of all bachelor and master level study programmes, mainly distributed across the countries that offer the highest share of space-related curricula in Europe. Luxembourg represents an exception since it has a limited offer of space-related bachelor and master programmes. Nevertheless, **Luxembourg is an important European hub for both space law and multidisciplinary space-related education**.

Most space-related bachelor and master programmes are taught in English

Language-related statistics highlight the strong European and international dimension of the space sector. Indeed, programmes offered entirely in English represent 51% of all mapped bachelor and master programmes. 34% are the non-English programmes and 15% the multi-language ones, with the majority being offered in both English and the country's domestic language.

Out of the programmes offered entirely in English, 40% are hosted by English-speaking countries, and particularly by the UK. The remaining **60% of English-taught programmes are offered by countries where English does not constitute the main domestic language**. Additionally, to appeal to a wider audience, many students and academics seek to conduct their work and publish their research in English.

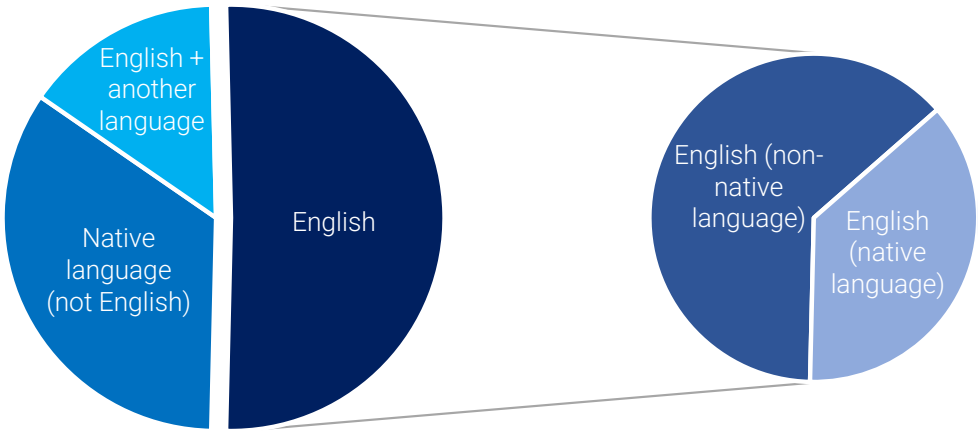

Figure 5: Language of instruction for space-related programmes

25 countries, including Ireland and the UK, have at least one high-institution offering a programme entirely taught in English. France, Germany, Italy, and the Netherlands offer, each, more than 20 programmes in English. Additionally, France hosts approximately 20 programmes taught in both English and French. Among the other countries, Belgium, Cyprus, Denmark, Estonia, Finland, Lithuania, Luxembourg, Malta, Sweden, and Switzerland offer the majority of their first and second cycle degrees entirely in English or as

[10] Master in Aerospace Systems - Navigation and Telecommunications (MSc AS-NAT). ISAE, ENAC. 2021. Additionally, the Geo-Information Science and Earth Observation for Environmental Modelling and Management (GEM) Master is offered by four European universities, which are the Lund University, the University of Tartu, the Catholic University of Louvain, and the University of Twente. The Master allows students to graduate with a double degree from two of the offering universities. Geo-Information Science and Earth Observation for Environmental Modelling and Management (GEM). Lund University. 2021.

multilanguage programmes, combining instruction in English and another language. For instance, Cyprus offers all its space-related programmes exclusively in English and the University of Helsinki offers a master in Particle Physics and Astrophysical Sciences in Finnish, Swedish, and English.[11]

Additional considerations arise when the intersections of language of instruction is analysed by programme level or macro-area, including:

- There is a significant difference between the number of bachelor and master level programmes entirely taught in English. Outside of the United Kingdom and Ireland, English is the teaching language of only 6% of bachelor programmes, whereas approx. **93% of master level programmes are taught in English.**
- Among other countries, in France, Germany, Italy, and Spain the highest number of bachelor and master programmes entirely or partially taught in English are **offered in the aerospace engineering macro-area**.

Internship requirements for space-related bachelor and master programmes vary

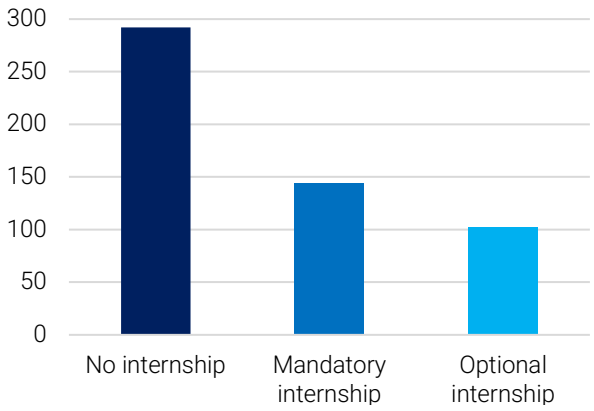

Figure 6: Internship requirements for space-related programmes

The majority of space-related educational programmes at bachelor and master level in Europe do not include a mandatory or optional internship.[12] However, it is important to note that students in these programmes may still pursue internship opportunities outside of their study programmes. Particularly, **54% of bachelor and master programmes do not include an internship**, 27% require a mandatory internship and 19% offer an optional internship. The shares of bachelor and masters including an internship, mandatory or optional, are respectively 26% and 74%.

Internship requirements vary considerably also based on the macro-areas and the national educational systems. Statistics show that:

- Compared to the total average, France, Germany, Italy, Spain, and the UK have a higher number of bachelor and master programmes including optional or mandatory internships. Among the mentioned countries, France has the largest share of programmes requiring or offering an internship opportunity (28%).
- Internship requirements differ by fields of study. **Aerospace engineering (44%) and multidisciplinary (23%) programmes represent the highest share of curricula offering optional and mandatory internships** when compared to the other macro-areas identified. Within the aerospace engineering field, approximately 45% of programmes require an internship, and approx. 54% offer an optional internship. Within the multidisciplinary macro-area, 81% of programmes require an internship, and 19% offer an optional one. On the other end of the spectrum, **only 2% of the programmes in the juridical, economic, social sciences and space macro-area require or offer an internship opportunity**. In the space sciences field, 20% of curricula require or offer an internship and within this share, 57% require a mandatory internship and 43% offer an optional one.

[11] Master's Programme in Particle Physics and Astrophysical Sciences. *University of Helsinki*. 2021.
[12] Internships are mandatory when they are considered a requirement for the diploma/degree. Research projects, theses, and year in industry are not categorised as internships for the purpose of this study.

- Internship requirements may also differ based on the country's educational system. Germany, for example, hosts many scientific space-related programmes which include two internships. The first is a technical internship and is considered a module of the study programme. The second is an external internship which is completed independently of the university curriculum. For instance, the bachelor programme in Physics and Technology for Space Travel Applications offered by the University of Giessen and the Technical University of Central Hessen includes a technical internship in the third semester and an external internship prior to graduation.[13]
- Some study programmes allow students to select an internship to fulfil specific requirements. For example, the Bachelor of Science and Engineering in Transport Industry: Aeronautics, Space, Automotive, Rail and Naval at ELISA Aerospace allows students to select either an internship or a final thesis.[14] The Master in Space and Astronautical Engineering at Sapienza University in Rome allows students to complete an internship as an alternative to presenting a degree thesis.[15]

2.1.2 Space-related PhD programmes in Europe

In addition to a wide range of first and second cycle degrees, European countries also offer a wide range of PhD programmes which represent 31% of the total offer.

PhDs represent the second highest share of space-related programmes in Europe and this statistic confirms the statement that space education is a specialisation level education.

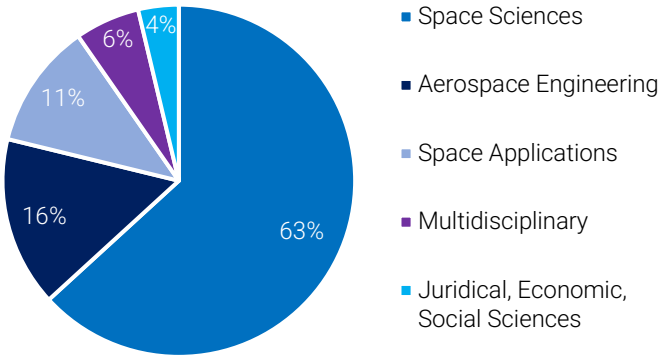

Figure 7: PhD distribution by macro-area

Doctoral programmes vary not only based on the national education system but also on the institutions offering them. Higher education institutions can offer PhDs as structured doctoral programmes with admission processes similar to first and second cycle degrees; as calls for projects to which doctoral candidates can apply with a PhD proposal; or in a hybrid format. Additionally, some education systems allow doctoral candidates to spontaneously present PhD projects to the competent high-institution.

Selected examples highlighting these differences at national level are France and Germany.

- France's doctoral programmes are mainly hosted by doctoral schools which are affiliated with universities and collaborate with associated research centres and laboratories. Some of these doctoral schools are specialised in space-related disciplines, such as the Doctoral School Astronomy and Astrophysics for Paris Area while others cover more general topics and offer research opportunities in the space domain, as well. France has the highest number of doctoral programmes in Europe, which represents approx. 23% of the total European offer at PhD level. When PhD

[13] This programme is offered in cooperation with DLR and Ariane Group. Physics and Technology for Space Travel Applications. *Justus-Liebig-Universität Giessen*. 2021.
[14] Cursus bachelor. *ELISA Aerospace*. 2021.
[15] Master Course in Space and Astronautical Engineering. *Sapienza University*. 2021.

programmes are considered in addition to bachelor and master programmes, France has the highest European number of space-related programmes.

- Germany invests heavily in research at doctoral level. In 2020, a total of 26.220 doctoral students completed their PhDs in all study programmes.[16] Germany's doctoral system is mainly based on individual proposals. Many higher education institutions in the country require students to submit proposals for individual doctoral positions or projects. The database approach does not allow to capture the country's higher education. In ESPI database, Germany's doctoral offer represents approx. 29% of the total national offer and only 8% of the European doctoral offer.

To account for these country- and institution-level differences, **ESPI mapped PhDs based on the research areas in which the higher education institutions specialise and carry-on research.**

Investigating the relation between PhDs and study fields, statistics show that:

- **63% of space-related PhD programmes in Europe fall into the field of space sciences**. ESPI identified more than 160 space science PhD offerings. Notable PhD offerings beyond traditional space science topics in astrophysics and astronomy include topics in aeronomy, astrobiology, space weather, solar terrestrial physics, and astroparticle physics. Additionally, approximately 15% of doctoral programmes are offered in the field of aerospace engineering and approx. 11% in space applications.
- PhD topics in the **juridical, economic, social sciences and space macro-area are the least represented in Europe.** However, doctoral studies in these fields are often conducted in the framework of other study programmes such as political sciences, law, and economics. 60% of PhDs in this macro-area are offered in the field of Space Law. Examples include the University of Lapland PhD in Air and Space Law and the PhD in Space Law offered by the University of Public Service in Ludovika.[17] The University of Luxembourg also offers relevant research fellowships supported by SES.
- **Greece hosts the highest number of PhD programmes in the space applications field and particularly targeting space applications and services in the agriculture domain**. Selected examples are the Space Applications for Agricultural Engineering PhD and the Remote Sensing and GIS Applications in Geology PhD both offered by the Agricultural University of Athens. The University of the Aegean also offers a PhD programme in Spatial Analysis and GIS in Rural Areas.[18]
- **Multidisciplinary PhD programmes are offered across Europe, with most programmes hosted by universities in Toulouse and Athens.** For example, the National and Kapodistrian University of Athens houses two space-related laboratories, including one on Satellite and Space Missions Organology which offers research opportunities in related topics.[19] Among the other countries, the University of Naples Federico II houses a PhD in Cosmology, Space Science, [20] and Space Technology, and the Technological University Dublin in deep learning for astronomical data.

[16] Number of doctorates passed at universities in Germany in the examination years from 1993 to 2020. *Statista Research Department*. 2022.
[17] Institute of Air and Space Law. *University of Lapland*. 2021. Also, Outer Space and Social Sciences Research Group. *The University of Public Service in Ludovika.* 2021.
[18] About Us. *Agricultural University of Athens*. 2021. Additionally, Department of Food Science and Nutrition. *University of the Aegean*. 2021.
[19] Department of Aerospace Science and Technology. *National and Kapodistrian University of Athens*. 2021.
[20] PhD Program in Cosmology, Space Science, and Space Technology. *SSM*. 2021. Additionally, About Us. *TU Dublin*. 2021.

2.1.3 Other space-related educational initiatives and opportunities in Europe

Online courses, short courses, summer and winter courses, summer schools, and professional training offered by high-institutions are also included in ESPI's analysis.

These educational initiatives and courses are analysed as one category. Platforms offering online education have not been considered. Educational initiatives included in this category represent 7% of the overall offer.

Most of non-degree educational initiatives are offered in space sciences (46%). Many training courses are offered in aerospace engineering and space applications, often as short courses in GIS. Overall, the juridical, economic, social sciences and space, and the aerospace engineering macro-areas are the least represented among the mapped non-degree initiatives.

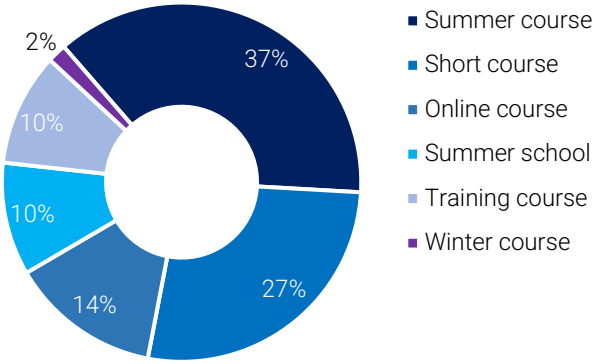

Figure 8: Non-degree space-related educational programmes

Additionally, **there are many opportunities within this category for students to engage in multidisciplinary educational courses or initiatives, which represent 25% of the total non-degree offer, such as:**

- The Space Mission Design summer course offered by the Technical University of Berlin allows its participants to choose a space mission and conduct a feasibility study covering an entire scenario and spacecraft configuration.[21]
- The EUSPACE - European Union in Space: Law and Technology Summer School organised by the University of Genova focuses on legal and technical matters and issues connected to the EU's activity in the space sector.[22] It is a multidisciplinary initiative financed by the EU and Erasmus Plus Jean Monnet Programme and is open to students and young professionals with backgrounds in law, political science, and engineering.
- The Alpbach Summer School in Austria consists of a workshop dedicated to space travel topics. The initiative is open to PhD students, scientists, and engineers.[23] Austria also houses the Summer University "Graz in Space". Its activities take place every two years in September and focus on astronomy, astrophysics, and space research.[24]

Selected examples of other educational initiatives are the five-week online winter course in Archaeoastronomy offered by the Polytechnic of Milan, which provides a background knowledge in astronomy as well; the part-time online programme of one year in Astrobiology of the University of Central Lancashire; the two-month course on the Governance and Geopolitics of Outer Space housed by the University of Porto; and the European Centre for Space Law (ECSL) Summer Course on Space Law and Policy.[25]

[21] About Us. *TU Berlin*. 2021.
[22] European Union in Space: Law and Technology. *EU Space*. 2021.
[23] Comparative Plasma Physics in the Universe. *Summer School Alpbach*. 2021.
[24] Graz in Space. *KFU Graz*. 2020.
[25] Archeoastronomy. *Politecnico Milano*. 2021. Also, Astrobiology. *University of Central Lancashire*. 2021. Additionally, The Governance and Geopolitics of Outer Space. *University of Porto*. 2021. Also, Summer Course on Space Law and Policy. *ECSL*. 2021.

2.2 National space education landscapes

This chapter aims to further investigate selected countries offering space-related education in Europe and highlight some specificities of these countries' educational systems. Space-related programmes are grouped in main city hubs. PhDs and Other are excluded from the following figures.

Space Education in France

France hosts over 3500 public and private universities and higher educational institutions. Among them, nearly 3000 of higher education institutions offer specialised education in specific sectors, such as engineering, medicine, journalism, agronomy, political science, etc.[26] **A little over 40 high-institutions offer space-related bachelor and master programmes.**

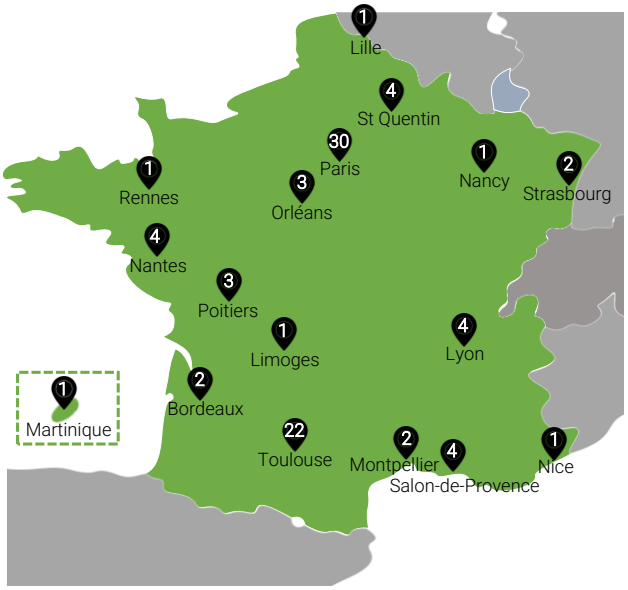

Figure 9: Distribution of space-related programmes in France

Unsurprisingly, space education hubs are located nearby major space industry spots. The city hubs housing most of France`s space-related programmes are Paris and Toulouse, hosting respectively 30% and 26%. **Paris and Toulouse are also the two cities hosting the highest number of bachelor and masters at European level**. Programmes are hosted by public universities such as the University of Toulouse - Paul Sabatier or the University of Paris-Saclay, as well as private specialised institutes mostly in the field of engineering.

France has Europe's highest share (34%) of multidisciplinary programmes. Some universities combine studies in the field of aerospace engineering and business. For instance, the Second Level Master in Aeronautical and Space Project Manager offered by the Arts et Metiers Institute of Technology. Additionally, France is home to the International Space University which hosts the interdisciplinary Master of Space Studies Program (MSS), among other educational initiatives.[27] Multidisciplinary programmes also represent France's highest educational offer, accounting for approx. 38% of the total bachelor and master programmes. Additionally, France holds Europe's highest share (45%) of bachelor and master in the juridical, economic, social sciences and space macro-area, which represents approx. 6% of the national offer.

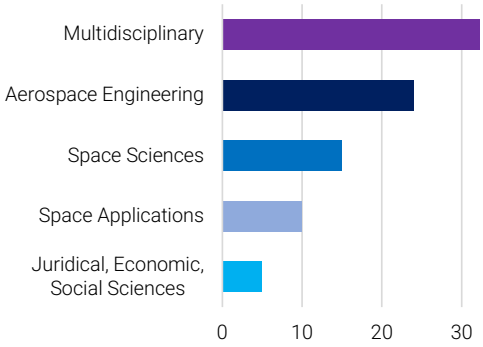

Figure 10: French space education by macro-area

The French higher education system offers many integrated Bachelor-Master programmes, in particular in private specialised institutes. Bachelor's degrees are usually offered on more general fields, while masters are more specialised. Space-related fields are usually a specialisation domain addressed at master level. France's space-related bachelor's degrees represent approx. 7% of the national offer while masters are 46%.

[26] France`s higher education system encompasses universities, Grandes Ecoles, schools of art or architecture, as well as Doctoral Schools. The different types of institutes of higher education in France. CAMPUS FRANCE. 2022.
[27] Master of Space Studies. *International Space University*. 2021.

Space Education in Italy

Figure 11: Distribution of space-related programmes in Italy

The Italian education system is characterised by higher education institutions with many faculties and departments within them. Italy has 245 higher education institutions and **almost 20 of them offer space-related programmes**.[28]

The Italian space education is characterised by more general bachelor programmes and more specialised masters. Selected examples are astronomy and astrophysics typically offered at master level or as singular courses within a degree in physics. Italy's space-related masters represent the highest share (43%) of the total national offer, while bachelor's degrees are 17%. Additionally, Italy hosts no programme in the juridical, economic, social sciences, and space macro-area, but some of these disciplines are thought in the framework of other space-related or more general educational programmes. For instance, Sapienza University offers a course on space law and institutions within the Faculty of Political Sciences. SIOI hosts the interdisciplinary Master in Space Institutions and Policies, which offers modules in space institutions and law, as well as space economy and industry, besides the technical and scientific module.[29]

Italian regions particularly active in the space sector are also hubs for space-related higher education. The Lazio region, for instance, hosts important space companies such as Thales Alenia Space and Avio, as well as the Italian Space Agency (ASI), ESA's Centre for Earth Observation (ESRIN), and an ESA BIC. At higher education level, the city hub of Rome houses 12 programmes at bachelor and master level, 11 of which in Rome itself. Rome is the sixth city housing the highest number of space-related bachelor and masters in Europe. Within Rome, Sapienza University offers most of the space-related educational programmes. Among the other regions, Tuscany and Lombardy also host many programmes.

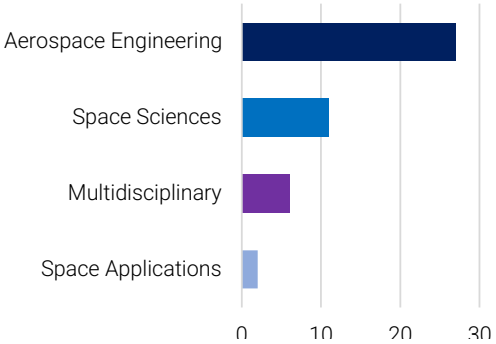

Figure 12: Italian space education by macro-area

Students in Italy have opportunities to engage in partnerships with a variety of space-related institutions. For example, several trainings, research fellowships, as well as PhDs and post-doc fellowships are provided through collaboration agreements with ASI, the National Institute of Nuclear Physics (INFN), the National Institute of Astrophysics (INAF), and the National Council of Research (CNR). In partnership with universities and the Conference of Italian University Rectors (CRUI), ASI supports specific national and international programmes.

[28] The Italian university system comprises 68 state universities (6 of which awarding only doctoral qualifications), 20 state-recognised universities and 11 state-recognised online universities. The AFAM, Institutes for Art, Music and Dance, higher education institutions are also included in the counting. Supporting Entrepreneurship and Innovation in Higher Education in Italy. *OECD/European Union*. 2019.
[29] Master in Space Institutions and Policies. *SIOI (Societá Italiana per l'Organizzazione Internazionale)*. 2021.

Space Education in Germany

Currently, Germany is home to 397 higher education institutions. Among them, universities tend to offer "the whole range of academic disciplines", while the universities of applied sciences focus their educational offer in engineering and other technical study fields, business-related studies, social work, and design.[30] **Just over 20 German universities offer space-related study programmes.**

Germany's higher education system is characterised by very general bachelor's degrees and more specialised masters. This system also applies to space education. Germany's space-related bachelor programmes represent 15% of the country's total offer, while space-related master programmes are 48%.

Some universities in Germany offer the possibility to undertake dual study programmes, which combine paid practical work in a company and theoretical classes at a higher education institution within the same study cycle and based on a regular alternation between the two.[31] For space-related study programmes, this option is mainly offered in engineering. Selected examples of universities offering this option in aerospace engineering are the University of Applied Sciences Bremen, the University of Applied Sciences Munich, and the University of the Federal Armed Forces Munich.

Figure 13: Distribution of space-related programmes in Germany

Germany's educational offer is peculiar compared to France, Italy, Spain, and the UK, whose space sciences programmes are the second or third most popular study field in the country. **Germany's bachelor and master programmes in space sciences account for 11% of the national offer**. Germany's most represented study field is aerospace engineering (49%), followed by the multidisciplinary programmes (24%). For instance, one notable university in the field of aerospace engineering is the University of Bremen, which hosts the Centre of Applied Space Technology and Microgravity, as well as DLR's Institute of Space Systems. The University of Cologne hosts a particular LLM in Public, Air and Space Law, whose macro-area accounts for 2% of the German bachelor and master level offer, which is specifically open to law graduates who obtained their degrees abroad and are interested in acquiring knowledge about the German legal system.[32]

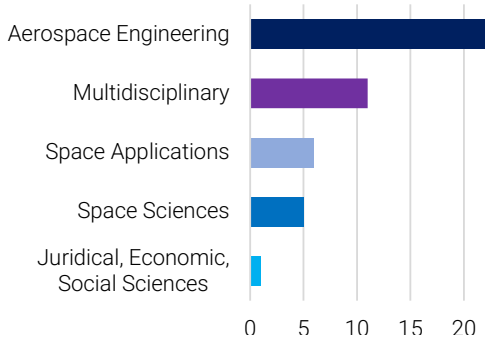

Figure 14: German space education by macro-area

Munich is the city hub offering Germany's highest share (approx. 20%) of space-related study programmes at bachelor and master level, followed by Bremen and Stuttgart.

[30] The total number of higher education institutions comprises 115 universities or similar, 217 universities of applied sciences, 57 colleges of art or music, and 8 thatdo not belong to one of these three categories. Higher Education in Germany. *HRK German Rectors` Conference. The Voice of the Universities*. 2022.
[31] The dual study program – all information at a glance. *Sign post dual study*. 2021.
[32] LLM in Public, Air and Space Law. *University of Cologne*. 2021.

Space Education in the Netherlands

The Netherlands have more than 70 higher education institutions but only **10 host space-related bachelor and master programmes**.[33]

In the Netherlands, 88% of space-related bachelor and master programmes are offered in English. The remaining programmes are taught in Dutch. For instance, both the universities of VU Amsterdam and University of Amsterdam host a bachelor programme in Physics and Astronomy in Dutch.

Figure 15: Distribution of space-related programmes in the Netherlands

Overall, the city hubs with universities offering the highest number of space-related educational programmes include **Leiden, Amsterdam, and Delft**, followed by Groningen, Enschede, and Wageningen. Both the Universities of Leiden and Delft, among others, are involved in the week-long LDE NL Space Campus Summer School.[34] The programme offers instruction about various space programmes, developments, and research activities at the universities, as well as tours of space agencies, institutes, and industries.

In terms of **spreading awareness about the Dutch space sector**, various initiatives exist to target students of different ages. The Netherlands Space Society aims to increase knowledge and interest about space activities for young professionals and students.

The Netherlands host 12% of bachelor programmes and 49% of master programmes. **Most of the Netherlands' universities tend to offer highly specialised educational opportunities.** For instance, the Delft University of Technology offers bachelor and masters, as well as PhD programmes, in aerospace engineering, while Leiden University and the University of Groningen are mainly specialised in space sciences.

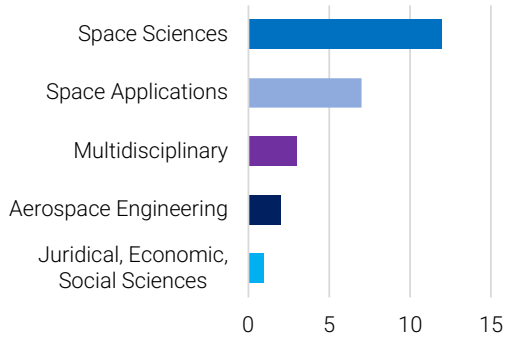

Figure 16: Dutch space education by macro-area

At the bachelor and master level, the macro-area distribution in the Netherlands is unique compared to France, Germany, Italy, Spain and the UK. **The country's higher education is indeed characterised by a strong focus on space sciences, which represent 48% of the programmes at bachelor and master level**. Half of the higher education institutions of the country houses at least one programme in the field of space sciences. **The second most represented study field is space applications, which accounts for 28% of the national offer**, while the offer of study programmes in the field of aerospace engineering is rather limited.

[33] The overall number of higher education institutions encompasses 18 research universities, 39 universities of applied sciences, 3 institutes for international education (IE) and 10 other institutes offering specific higher education in English. Additionally, some Dutch universities have colleges and business schools, which can also be marked as separate groups, but are not comprised in this counting. Universities in Holland: types and specifities. *Eurogates*. 2022.
[34] LDE NL Space Campus Summer School. *NL Space Campus*. 2021.

Space Education in Spain

Spain`s higher education system encompasses 87 public and private universities, in addition to 480 research institutes and 67 science and technology parks.[35] **Approximately 30 of them offer space-related programmes at bachelor and master level**.

Bachelor programmes in Spain represent 18% of the total national offer, while masters are 62%.

Figure 17: Distribution of space-related programmes in Spain

Madrid and Barcelona, which also host an ESA BIC, are the two city hubs offering the largest number of bachelor and master programmes in Spain, followed by Valencia. The rest of the Spanish city hubs offer between one and two programmes each. Programmes in Madrid and Barcelona represent respectively 41% and 21% of the national offer at bachelor and master level. Both Madrid and Barcelona are in the top six European cities in terms of number of programmes, respectively third and fifth. Spain and France are the only countries with two cities in the top six ranking.

Spain's aerospace engineering educational offer represents the highest share of bachelor and masters in the country (49%), while the rest of the bachelor and master programmes are mainly distributed across the space sciences (19%), space applications (15%) and multidisciplinary (13%) study fields.

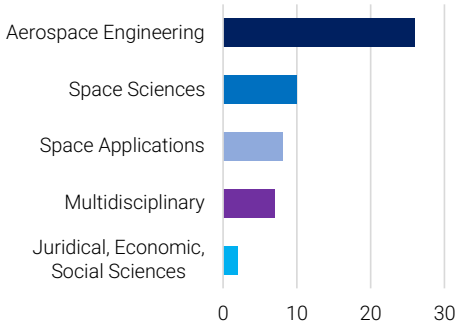

Figure 18: Spanish space education by macro-area

Madrid houses most of the bachelor and master programmes in the aerospace engineering study field, which also represent approx. 54% of Spain's aerospace engineering bachelor and masters. These programmes are mainly offered by the Carlos III de Madrid University and the Polytechnic University of Madrid. The Carlos III de Madrid University is specialised in aerospace engineering and offers programmes such as the Double Master in Telecommunications Engineering and Space Engineering.[36] Additionally, the Carlos III de Madrid University houses international double degrees (IDD), such as the DTI in Degree in Mobile and Space Communications Engineering with the French engineering school IMT Atlantique.[37]

Barcelona, mainly through the Autonomous University of Barcelona (UAB), hosts 30% of the bachelor and master programmes in space sciences, followed by Santander. The rest of the space sciences curricula are distributed across other city hubs, such as Madrid, Granada and Santa Cruz de Tenerife.

[35] Among the universities, 50 are public and 37 are private. What to study in Spain? *sepie*. 2022.
[36] Double Master Degree in Telecommunications Engineering and Space Engineering. *Carlos III de Madrid University*. 2021.
[37] DTI in Degree in Mobile and Space Communications Engineering with IMT Atlantique. *Carlos III de Madrid University*. 2021.

Space Education in the United Kingdom

Figure 19: Distribution of space-related programmes in the United Kingdom

The United Kingdom has an extensive educational system comprising higher education institutions, colleges and similar, further education colleges and private institutions. Only in England there are more than 1900 higher education institutions.[38] **In the UK approximately 40 higher education institutions offer space-related bachelor and master programmes.**

The UK has a broad education system, which involves several types of degrees, such as integrated masters and double degrees with a major and a minor, as well as several specialisations and trainings. Many of UK's programmes are flexible in terms of scope and duration and give students the possibility to do foundation years and part-time study, for instance.[39] This system also applies to space education. **The UK offers the largest share of space-related bachelor and master programmes in Europe (19%)**.

In the UK, space-related bachelor and master's degrees represent respectively 23% and 47% of the national offer. **The UK has Europe`s largest share of programmes in the field of space sciences (27%)**, which also represent 43% of the national offer. UK's largest study field is aerospace engineering which accounts for 44% of the national offer.

The UK offers many space-related opportunities for students also through specific programmes and organisations. For instance, the Space Placement in INdustry (SPIN) programme, which provides undergraduate students with the opportunity to complete internships in industry; or the **UKSEDS**, which is an organisation dedicated to promoting careers in the space sector through a variety of initiatives.[40]

The major hubs in the UK are Greater London, South Hampshire, Greater Manchester and Southend. London hosts the largest number of space-related bachelor and masters in the country, accounting for 18% of the national offer. London is also Europe`s fourth city in terms of number of programmes at bachelor and master level.

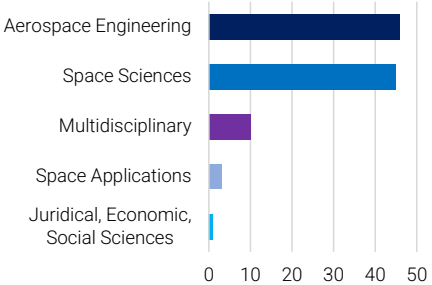

Figure 20: British space education by macro-area

[38] In England, higher education institutions comprise universities, institutions conducted by a higher education corporation, and institutions designated as eligible to receive support from funds administered by the HEFCE. Additionally, there are over 700 colleges and similar institutions "which do not have degree awarding powers but provide complete courses leading to recognised UK degrees"; over 250 further education colleges; and "an increasing number of independent private institutions, including both for-profit and not-for-profit organisations, which receive no direct government funding". England Higher Education System. *EuroEducation.net The European Education Directory*. 2022.

[39] Foundation years give students "the opportunity to get an understanding of their field of interest before progressing to the full three-year degree programme. As well as subject knowledge, students will get used to the higher education context and gain the skills needed for higher level study". Why you should consider a foundation year. *PROSPECTS*. 2021.

[40] UK Space Education Strategy. *UKSA*. 2016. Additionally, About. *UKSEDS, UK students for the exploration and development of space*. 2021.

3 A View from Students and Young Professionals

3.1 About the survey

ESPI conducted a survey targeting students and young professionals who have personal experience and insight into space-related education in Europe, to better understand their perceptions on the challenges and opportunities related to the European space-related educational landscape as well as the bridge between education and employment in the space sector.

Eligible respondents included:

- Young professionals who studied space-related programmes or work in the space sector,
- Graduates who recently completed their programme,
- Students currently enrolled in a space-related programme,
- Students in the process of enrolling in a space-related programme.

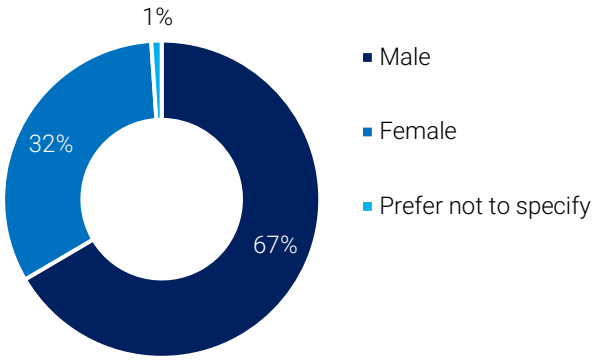

Figure 21: Respondents' gender distribution

The survey consisted of approximately 30 questions including both multiple choice and open questions.

ESPI received more than 350 responses.

After review, the final sample included **284 individual qualified responses** from students and young professionals. The average age of the respondents is 26 years old, and 67% of the respondents are male.

85% of the respondents are citizens of European countries, with majority of EU Member States, and most ESA Member and Associate Member States represented in the survey. ESPI did not receive any survey responses from countries indicated in grey in the figure. The remaining 15% of the respondents have non-European nationalities but are either studying space-related programmes in Europe or working in the European space sector. Regarding the respondents' country of residence, the countries with the highest number of respondents include Italy, the United Kingdom, Sweden, Germany, and France, with approximately 68% of survey respondents residing in one of these five countries. The majority of **non-European respondents reside in the UK,** with 45% of respondents with non-European citizenship studying or working in the space sector in the UK.

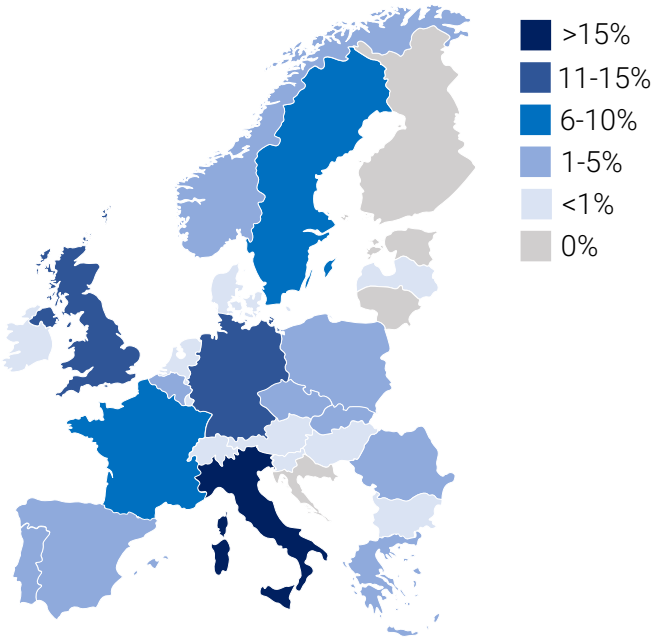

Figure 22: Respondents' nationalities by percentage

3.2 About space-related studies and the space sector

Students studying space-related programmes who are not yet employed in the space sector represent 57% of the sample, whereas young professionals with different employment situations and educational backgrounds represent the remaining 43% of the survey sample. The young professionals include respondents who completed their space-related studies and are working in the space sector, respondents who are working in the space sector and continuing their space-related studies, respondents who completed their space-related studies but are not currently working in the space sector, and respondents who studied a programme not focused on space but work in the space sector.

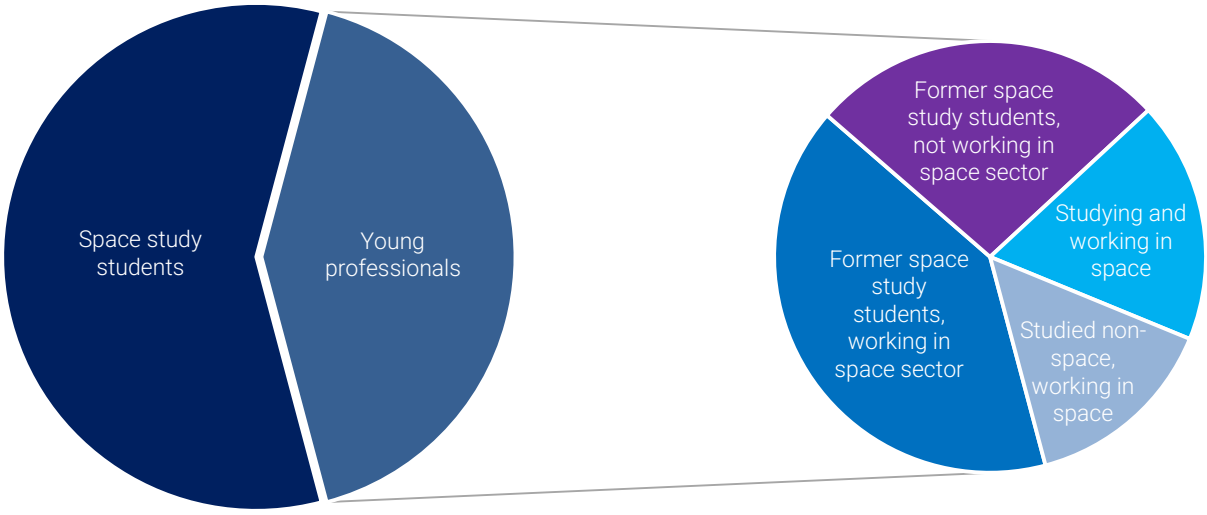

Figure 23: Breakdown of respondents' studies and employment

To analyse different aspects of space-related study programmes in Europe, responses from students currently studying a space-related programme and young professionals who studied a space-related programme in the past are considered. This sample constitutes 267 survey respondents and excludes the respondents who are currently working in the space sector but did not study a space-related programme prior to entering the workforce. Among respondents who have personal insight into the space education landscape, 66% are currently enrolled or have most recently completed a master's degree.

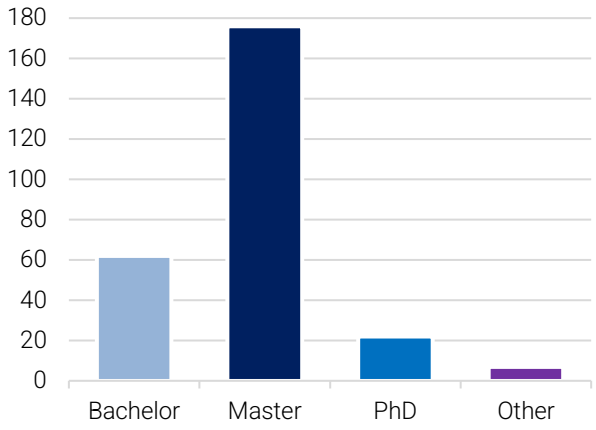

Figure 24: Respondents' level of degree

The respondents' levels of degree mirror the level of degree programmes available in Europe, as highlighted in the Space Education Landscape. In particular, the significant number of master-level respondents confirms that space education is a specialisation-level education that prepares students for employment in the space sector. 23% of survey respondents are pursuing or hold bachelor level degrees, 8% constitute PhD level respondents, and 3% of respondents study or studied space in the context of a different type of programme, such as post-graduate diploma programmes and certificates, among others.

While ESPI survey mainly reached individuals partaking in higher education programmes, it is important to note that other educational backgrounds can also lead to a career in the space sector, including

technical education, for instance. Students involved in such programmes are likely underrepresented in the sample. From a space field perspective, **aerospace engineering degrees are the most represented in the survey sample.** Indeed, 66% of master-level respondents are studying or have studied aerospace engineering, and similar is the case for bachelor level respondents. **The share of female respondents who study or have studied aerospace engineering is 22%**, against 77% of male respondents, while all other fields of study have a higher percentage of female students. The juridical, economic, and social sciences, and space macro-area has the highest percentage of female respondents (72%). Female respondents who are studying or have studied in space sciences are 59%.

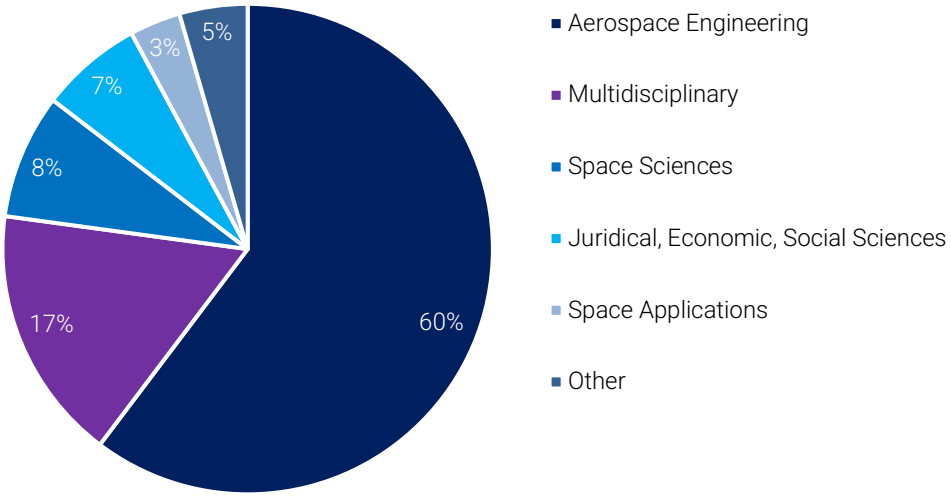

Figure 25: Macro-areas of respondents' study programmes

The sample also contains respondents who have completed their studies and entered the workforce. This category is comprised of the young professional respondents, including 85 respondents who are actively working in the space sector, 17 of whom are working in the space sector but did not complete a fully space-related degree programme. The young professional category also includes 31 respondents who have completed a space-related degree and are not currently working in the sector.

39% of the respondents currently employed in the space sector are working in industry, 22% in government or space agencies, as well as in educational institutes or universities, 6% in think tanks, and 9% in other organisations, such as NGOs, non-profit entities, and start-ups, among others. The majority of respondents who are currently working in industry studied a space-related programme in the aerospace engineering field. Additionally, almost all respondents employed in the space sector hold master-level degrees or higher.

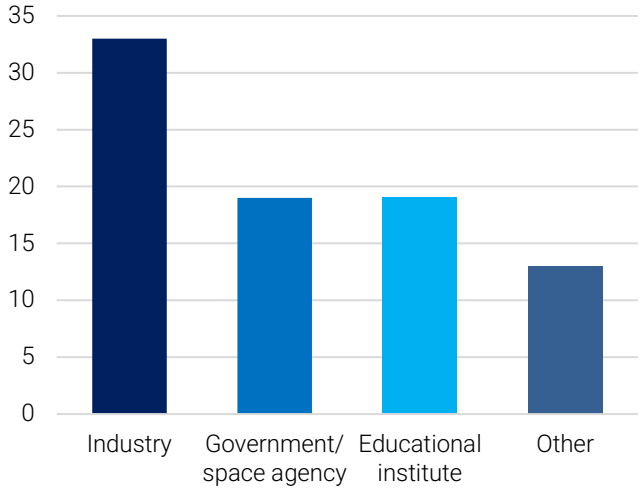

Figure 26: Young professional respondents' employers

Internships and international opportunities are an integral component of space education

67% of the respondents have completed internships during their study programmes, either as a mandatory part of the programme (26%) or as a voluntary activity (41%). Most internships were completed by students who are studying or have studied aerospace engineering and multidisciplinary programmes.

Respondents confirmed that most space-related programmes offered international options, such as Erasmus, international training, international competitions, and international exchanges. The high number of international opportunities for students is not unique to the space sector and stems from an increasing internationalisation of the European higher education landscape as a whole. The same is true for internships as many university programmes promote their students' participation in internship activities, especially in the aerospace engineering and multidisciplinary areas, within the space sector as well as in other sectors. However, despite this general trend, the spread of these opportunities confirms the international dimension of the space sector.

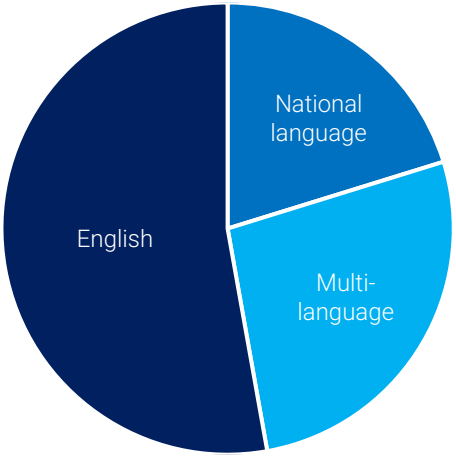

Figure 27: Respondents' instruction language

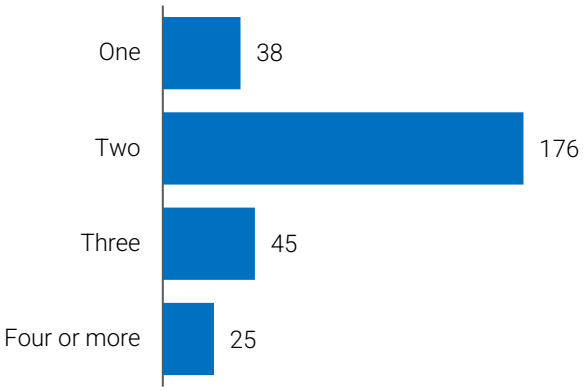

Figure 27: Languages spoken by respondents

Despite students partaking in a multitude of international activities within their programmes, the majority of survey respondents are studying or studied in their home country. 65% of the students who moved to a foreign country for their study programme pursued degrees in aerospace engineering.

In regard to language skills of the respondents, most respondents speak two languages, with approximately 24% speaking three or more. 53% of the respondents reported that their study programmes are taught in English. 52% of the English language programmes are hosted by English-speaking countries. Most programmes taught in English outside of the United Kingdom and Ireland are masters and PhDs, while the majority of bachelor programmes are taught in the country's domestic langauge. Additionally, 27% of programmes are taught in multiple languages and usually combine instruction in English and the domestic language.

Most students do not receive financial aid

Respondents were asked to provide information on the financial aid they received to help pay for their space-related study programmes. 21% of the respondents indicated that they had received scholarships, with the majority coming from the universities or from government. 25% of the students who received scholarships are non-European. Additionally, 22% of the respondents took out loans to pay for their studies. Of these students, approximately 30% are from the United Kingdom. 16% of the respondents indicated that their space-related study programmes were tuition-free.

Inspiration remains the main driver for pursuing a career in space

Respondents are mostly motivated to pursue a career in the space sector by their passion, interest, or fascination, as well as the multifaceted challenges and opportunities the space sector provides. Many respondents emphasised their desire to play a role in the societal impact of the sector. Notably, 14% of the respondents selected wanting to start a business in the space sector as a main motivator. Some respondents even indicated that they already have their own start-ups or business plans.

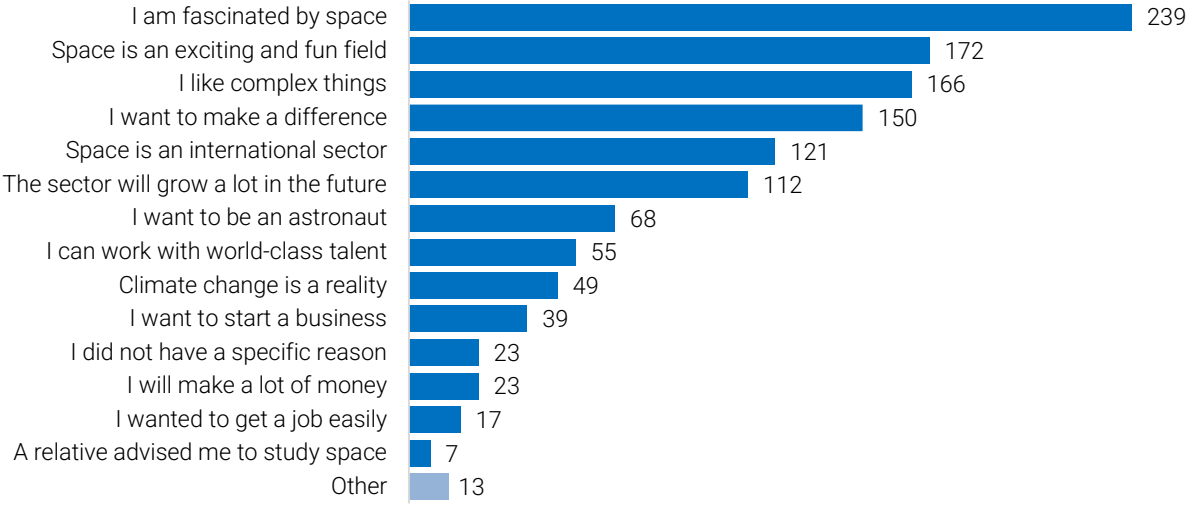

Figure 28: Respondents' motivations for pursuing careers in the space sector

Students and young graduates are worried about career opportunities in the space sector

Students were asked about their expectations regarding the transition to the professional environment. 65% indicated that they think it will be difficult to find a job in the space sector and 8% think they will not find a job in the space sector. Only three respondents will search for a job in a different sector.

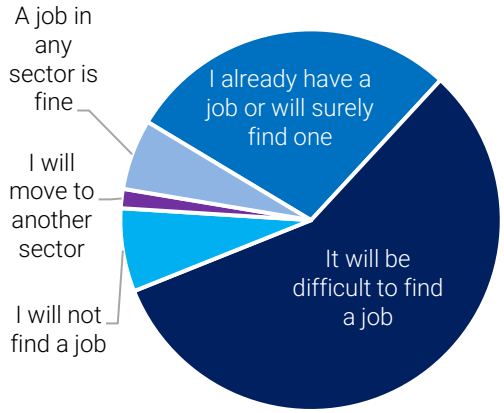

Figure 29: Students' perceptions of job prospects in the space sector

The survey also targeted responses from individuals who have completed space-related programmes, but do not work in the space sector. They represent 13% of the total respondents.

Most of these respondents are interested in working in the space sector, but currently do not, mainly because they graduated recently, were not able to find a job, or did not receive a satisfactory job offer within the sector.

Another category of respondents is young professionals working in the space sector who did not study a space-related programme. Almost all respondents in this group indicated that the transition to the space sector without a space-related educational background was difficult.

Many also indicated that they did not study a space-related educational programme because they were not aware it was a possibility, or they just did not think about it.

There is a high level of commitment to working in the space sector

Students and young professionals working in the space sector specified their long-term career goals. Less than 1% of respondents indicated that they want to move to another sector, with over **99% preferring to work in the space sector in some capacity**. Respondents are most interested in pursuing careers in **space-related industry (45%) and in governments or space agencies (37%). 10% are still unsure of their ultimate career goal.** The goal to work in government or space agencies has been selected mostly by respondents who are currently students (72%). The 7% of respondents who indicated they have other long-term goals either seek to start businesses or pursue unique opportunities within the space sector, for instance in space medicine or space psychology.

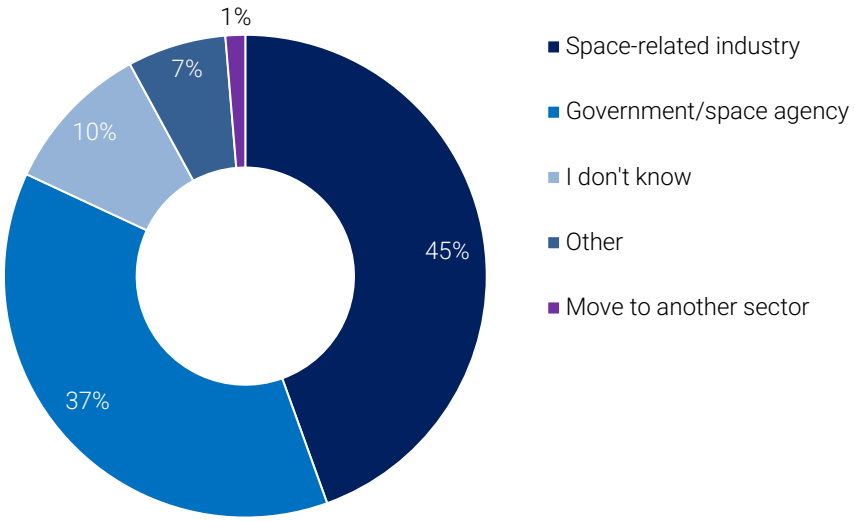

Figure 30: Respondents' long-term career goals

Overall, the results of the survey highlight some **important trends for space education in Europe**:

- **Space largely attracts potential students through inspiration**. Many students expressed their fascination for space and emphasised their desire to make a difference or to play a role in the societal impact of the space sector.
- Although the space sector is growing, **students seem to perceive a lack of opportunities in the sector**. Therefore, the space education sector needs to work on issues like disinformation and lack of advertisement, which may contribute to shape students' perception. Additionally, students who did not study an explicitly space-related programme find the transition to employment in the space sector difficult.
- Despite these perceptions, **students are motivated to pursue a career in the space sector**, with less than 1% of respondents seeking jobs in other sectors.

4 The Role of Academia Beyond Space Education

The role of academia in the space sector goes beyond training a skilled workforce. Academia has long played an important role in boosting research and development and has, more recently, also demonstrated an increasing role in fostering entrepreneurship.

4.1 Academia contribution to space research, development, and innovation

In "The Role of the University in Regional Innovation Ecosystems", the European University Association (EUA) highlights that "*the central role of knowledge creation in post-industrial economies and societies has given universities a pivotal role in society. This move has changed the role of the university as the traditional hub of knowledge production, giving it a new twist. The university's new centrality is inextricably intertwined with its role of orchestrating multi-actor innovation networks*".[41]

In the space sector, universities have been active contributors to innovation through in-house research and development, as well as partnerships and collaboration with public institutions. Additionally, in the last few years, interest from the private sector has grown regarding strengthening relations with academia to boost innovation through university channels.

Academia plays an active role in European space R&D&I programmes. For instance, approximately 45% of the universities and higher education institutes in ESPI database have participated in Horizon 2020 space-related projects.[42] Selected examples are the Polytechnic University of Valencia, which participates in SELECTOR, a project aiming to develop "Surface Mount Technology (SMT) compatible electromechanical switches for space sector high miniaturization"; the University of Coimbra coordinated FOCUS, which targeted the demonstration of "an innovative extension of an existing forest monitoring service using a combination of Copernicus Sentinel-2 imagery with hyperspectral data captured by UAV platforms"; and the University of Bern is participating in the NEO-MAPP project aiming to enhance technological and scientific capabilities and European scientists and engineers' expertise in planetary defence and asteroid exploration.[43] All European countries have at least one higher education institution that participated in a Horizon 2020 project and many of them actually contributed to multiple projects. Selected examples include the Polytechnic of Turin which participated in 9 projects, the University of Padova and the University of Leicester, which both participated in 8 projects.[44]

Additionally, approx. 68% of the identified universities and higher education institutes are currently collaborating or have established a past collaboration with space agencies, the EU, or governmental bodies in charge of space-related activities on R&D&I projects, programmes, and missions. For instance, Luleå University of Technology through its research group in Atmospheric Science built and developed HABIT (Habitability Brine Irradiation and Temperature), an instrument that will be sent to Mars with ExoMars and will monitor the formation and the conditions under which brines occur on the planet.[45] Additionally, the Centre Spatial de Liège (CSL) of the University of Liège participated in ExoMars Nomad, in ESA's Characterizing Exoplanet Satellite Cheops, as well as in the European Commission, ESA and European Environment Agency's (EEA) Global Monitoring for Environment and Security (GMES)

[41] The Role of Universities in Regional Innovation Ecosystems. *European University Association*. 2019.
[42] CORDIS. Horizon 2020 space-related projects. *European Commission.*
[43] Smt compatible ELECTroMechanical relay for cOmpact redundancy Ring. *Horizon 2020*. 2019. Additionally, Forest Operational monitoring using Copernicus and UAV hyperSpectral data. *Horizon 2020*. 2018. Also, Near Earth Object Modelling and Payloads for Protection. *Horizon 2020*. 2020.
[44] CORDIS. Horizon 2020 space-related projects. *European Commission.*
[45] HABIT (Habitability Brine Irradiation and Temperature). *Luleå University of Technology*.

programme.[46] CSL specialises in design, development, integration, qualification, and calibration of space instruments, and its environmental test facility is used by several stakeholders, such as ESA and space companies. As the University of Liège, other universities participate in multiple space-related projects of public institutions. Selected examples are Sapienza University, NTNU: Norwegian University of Science and Technology, and Aalto University.

These partnerships and collaborations are often carried out within the premises of universities since many are equipped with research facilities, such as research centres and institutes. High-institutions' research facilities are often specialised in specific research areas. However, they can also be multidisciplinary. For instance, the University of Luxembourg hosts the SnT – Interdisciplinary Centre for Security, Reliability and Trust, a research centre focusing on space systems as well as autonomous vehicles, cybersecurity, FinTech, Internet of Things, and secure and compliant data management.[47] Over the years, the SnT has collaborated with several institutions and industries, and participated in over 90 EU and ESA projects, although not all space-related. Many universities are also equipped with laboratories to conduct experiments and research on space-related matters. A selected example is the GNSS lab at the Delft University of Technology.

University research can spur innovation. In particular, university involvement in the development of CubeSats has increased significantly, and they are often developed in collaboration with public and private partners. **Approx. 40% of the universities and higher education institutes have participated or are currently participating in a CubeSat project in some capacity**. Selected examples are Pegasus and FSSCat A and B. Pegasus is the first 2U CubeSat built and launched by Austria. Pegasus was designed, manufactured, and qualified by the University of Applied Sciences (FHWN) and the Technical University (TU) of Vienna, together with other partners.[48] FSSCat A and B are two CubeSats developed by the Polytechnic University of Catalonia (UPC).[49] With the FSSCat mission, the UPC won ESA's Small Satellite Challenge and the top prize at the Copernicus Masters competition in 2017.

Identified high-institutions that participated in Horizon 2020 space-related projects	45%
Identified high-institutions that are currently collaborating or have established a collaboration with space agencies, the EU, or space-related governmental bodies	68%
Identified high-institutions that participated or are currently participating in a CubeSat project in some capacity	40%

Table 3: Percentages for identified universities and higher education institutes

Higher education institutions play an active role in space research and development to experiment, produce science, and support innovation.

Universities equipped with research facilities and actively participating in R&D projects and initiatives can be **more attractive** for students and researchers. On the one hand, students and researchers can benefit from the institution's facilities, instruments, and networks. On the other, the university can design study programmes offering both theoretical and practical teaching approaches. As a result, students can obtain practical, hands-on experience from the beginning of their studies. These opportunities create more educated, skilled, and prepared young researchers and professionals. Additionally, universities investing in their own research infrastructures can also create opportunities for partnerships between academia

[46] The Center Spatial de Liege (CSL). *University of Liege*.
[47] Interdisciplinary Centre for Security, Reliability and Trust. *University of Luxembourg*.
[48] Pegasus. *University of Applied Sciences (FHWN)*. Also, *Technical University (TU) of Vienna*.
[49] FSSCat A and B. *Polytechnic University of Catalonia (UPC)*.

and public and private stakeholders that can lead to technology demonstrations, prototype tests, new designs and innovative experiments. In the space sector, universities can collaborate with space agencies, space companies and other space-related organisations. These collaborations can prove advantageous both for public and private stakeholders, not only because they gain access to the university's infrastructures, but also because academic institutions offer more flexibility. It is common for higher education institutions to build partnerships on a "relationship model" rather than a "transactional model". The first allows a more dynamic and cooperative partnership since the outset of the research process, while the latter tends to slow down the collaboration process since it usually requires more formal negotiations.[50] The universities themselves can also benefit from external investment and improve their ranking position.

Collaborations and partnerships can also support students' and researchers' mobility, as well as the sharing of know-how and expertise between different institutions and stakeholders. Additionally, the multidisciplinary nature of such collaborations is increasingly seen as an added value, and as a resource to foster innovation and technology transfer.

To conclude, these trends show a widespread willingness from public and private actors to collaborate with universities and exploit these channels to foster innovation, as well as a significant interest from universities to be active and proactive in research, development, and innovation within the space sector.

4.2 Academia as a hub for space entrepreneurship

The growing relationship between academia and business, toward a more business-oriented mindset in academia has led universities to become major actors in the creation of new ventures. "*The European report of research and innovation program's (2018) goal of incubators stated that work should be at the outlines of the triple helix, where universities, industry and public sector reinforce each other by taking innovation and entrepreneurship in its account. Similarly, SMEs and multinationals often turn to the university to find solutions for their R&D needs, instead of performing the whole process themselves*".[51]

Firstly, universities carry out several initiatives aiming to bridge the gap between space education and the space business environment. For instance:

- Universities offer unique opportunities for students to network and connect with enterprises, such as internships, forum, company visits, career fairs, job portals, and so on. For instance, the University of Bremen hosts a Career Center with the objective to support students through the offering of career advice, a platform to find internships and jobs, and the organisation of workshops.[52]
- Some universities offer laboratories focusing on space economy. An example is the Space Economy Evolution Lab (the SEE Lab) of SDA Bocconi School of Management which offers information on business and investment opportunities within the space economy to non-space actors and financial companies. The lab also organises workshops and educational initiatives about space economy topics.[53]
- Among others, France offers space-related double degrees with management schools. The objective is for students to acquire both management skills, as well as space-related knowledge and prepare to manage a company within the space sector. An example is the HEC-ISAE SUPAERO engineer-manager double-degree (SAFRAN chair).[54]

[50] Why Companies and Universities Should Forge Long-Term Collaborations. *Harvard Business Review*. 2018.
[51] University business incubators as a tool for accelerating entrepreneurship: theoretical perspective. Emerald insight. 2020.
[52] Career Center. *University of Bremen*. 2021.
[53] SEE Lab. *SDA Bocconi*.
[54] Double degree HEC Paris/ISAE-SUPAERO. *HEC Paris*.

- Some countries, such as Italy and the UK offer the possibility to pursue **Industrial Doctorate**. Industrial Doctorates are an alternative to traditional PhDs for those who want to pursue a career in industry, mixing traditional courses and experiences in enterprises. Selected examples of universities offering them in the UK are Swansea University, the University College London, University of Bristol, and the University of Nottingham.

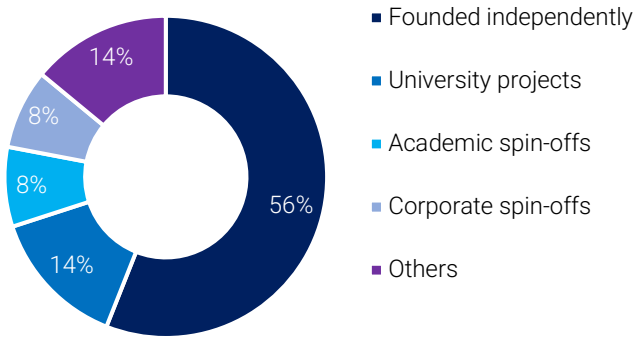

Figure 31: Start-up origins

Furthermore, academia and enterprises have increased their collaboration, as academia has become a hub for entrepreneurship. For example, academic incubators provide a physical environment in which universities can help students foster their entrepreneurial inspiration. Universities and laboratories are also increasingly exploiting their own research results by promoting and sustaining the creation of new ventures such as academic spin-offs. While incubated start-ups are built from scratch by students who start with an innovative idea and create a business, academic spin-offs are companies that transform technological inventions developed from university research into business products. **The survey conducted as part of the ESPI Space Venture Europe 2019 Report found that out of a sample of more than 100 start-ups, 14% of them originated from a university project and 8% were academic spin-offs.**[55]

Additionally, ESPI identified a large number of incubation systems within the universities included in its database. **Approximately 75% of the mapped universities have a close relationship with or host an incubator or accelerator in their campuses**. For instance, the University of the Bundeswehr hosts an Entrepreneurship and Intrapreneurship Programme and co-runs the Space Founders accelerator in collaboration with CNES.[56] In its first year, this programme welcomed ten start-ups from Germany, Spain, France, and Latvia. A successful example of such a spin-off is Isar Aerospace. This micro launcher company was founded in laboratories of the TU Munich and was awarded a contract by ESA in the framework of the ESA Boost! programme and won the first round of DLR's micro launcher competition.[57]

At the European level, the relation between space academia and entrepreneurship is incentivised by increasing collaboration between higher education institutions and EU and ESA through initiatives and programmes that aim to support entrepreneurs. In January 2021, the European Commission announced the establishment of a €1 billion European Space Fund to boost start-ups and innovation. The fund would cover the whole innovation cycle, from business ideas to industry growth. On this basis, the CASSINI initiative was established to support entrepreneurship among space-related businesses in the EU.[58] Even though CASSINI does not focus on academia, initiatives such as CASSINI's hackathons could provide relevant opportunities for students. For example, the 2021 Spring Hackathon was hosted in ten places simultaneously, including the Institute Pedro Nunes of the University of Coimbra in Portugal.[59]

Regarding ESA initiatives, ESA Business Incubation Centre (BICs) are centres for entrepreneurs, start-ups, SMEs, researchers, and students that allow them to develop and commercialise innovative space-enabled products and services in various areas of the economy. **15% of the ESA BICs are hosted by universities or**

[55] Space Venture Europe 2019. *ESPI.* 2020.
[56] Entrepreneurship Program. *Bundeswehr University Munich*.
[57] About us. *Space Founders*.
[58] CASSINI - Space Entrepreneurship Initiative. *European Commission*. 2021.
[59] Meet the 10 local organisers of the 1st CASSINI Hackathon. *CASSINI.* 2021.

educational institutes and around 60% have established a partnership with a university.[60] In particular, the ESA BIC Turin was inaugurated this year to improve the technological and business development of new innovative companies in the space economy sector.

ESA BIC	Hosting university
ESA BIC Barcelona	Polytechnic University of Catalonia
ESA BIC Portugal	University of Coimbra's Instituto Pedro Nunes University of Porto
ESA BIC Ireland	Athlone Institute of Technology Maynooth University
ESA BIC Finland	Aalto University
ESA BIC Denmark	Technical University of Denmark University of Aalborg University of Aarhus
ESA BIC Italy	Polytechnic of Turin

Table 4: ESA BICs located in universities

ESA also launched the "Space for Business" programme with three business schools, namely the University of St. Gallen, the Nova School of Business and Economics, and the Rotterdam School of Management.[61] The programme aims to share knowledge and understanding of the New Space Economy, to provide support on how to apply management ideas to space businesses, and on growing a peer network.

These trends and initiatives show the efforts made at national and European levels to bridge the gap and strengthen the connection between academia and entrepreneurship.

Both universities and enterprises, as well as businesses, increasingly see their connection as an asset. On the one hand, the valorisation of entrepreneurship through various initiatives and projects, the establishment of incubators, the creation of start-ups and spin-offs, the strengthening of relations with enterprises, and the building of a network are elements of attractiveness for universities. Higher education institutions can gain visibility and have the possibility to attract a very diverse pool of students and professionals. For instance, universities organising prototype workshops, fostering research environments, providing scientific advice, funding opportunities, and so forth, support entrepreneurship at large and are more likely to attract and retain entrepreneurial students who wish to launch businesses and start developing new products while still in academia.

On the other hand, academia's contribution to entrepreneurship can also produce positive effects on the space market. Enterprises will benefit from having a more trained, educated, and skilled workforce. Academic incubators can positively contribute to the creation of more positions and companies. Initiatives like entrepreneurship classes can contribute to the creation of new businesses. According to a study conducted by the University of Arizona, the rise of entrepreneurship classes is directly linked to the rise of creation of start-ups, and students with entrepreneurship classes are three times more likely to

[60] Figures about ESA BICs were calculated from ESA BIC public information.
[61] Home. *Space for Business*.

start new businesses compared to others.[62] Even though start-ups and academic spin-offs only represent a small share of the space market, the former still benefits from more competition and innovative projects emerging form high-technological breakthrough discovered in universities.

Academia is positively contributing to entrepreneurship in the space sector, offering students and professionals several opportunities to develop their businesses via space incubators, high-tech academic spin-offs, funding opportunities, space economy programmes, and others. Additionally, initiatives at EU and ESA level in space entrepreneurship demonstrate a broad understanding from all the stakeholders of the benefits of cooperation.

[62] The Impact of Entrepreneurship Education: An Evaluation of the Berger Entrepreneurship Programme at the University of Arizona, 1985-1999. *SSRN Electronic Journal*. 2000.

5 THE FUTURE OF SPACE EDUCATION IN EUROPE

ESPI consulted European stakeholders to assess their views on the state of the European space education system and on challenges ahead. Together with ESPI research findings, the consultation highlighted five key areas for future developments:

- The continuous adaptation of the space education system to the evolution of sector needs,
- The integration of academia in space sector developments,
- The internationalisation of space education to train and attract world talents,
- The place of inspiration in Europe's space culture and narrative as a driver for space education,
- The position of space education at the forefront of the diversity challenge.

Continuous adaptation of the space education system to the evolution of sector needs

The main challenge for the European space education system is to continuously adapt to the needs of the sector. In a context of transformation of the space sector at various levels, this challenge is particularly high. Despite the emergence of new educational programmes across Europe, various areas of development will require a sustained effort to ensure that the education system can actively contribute to addressing challenges ahead of the European space sector.

Technology developments in the space sector are increasingly shaped by other emerging fields such as artificial intelligence, machine learning, additive manufacturing, blockchain or quantum. The interconnection between the space sector and other domains raises the need to train multidisciplinary profiles able to strengthen synergies between different fields and areas of application. The growing relationship between space and other areas also concerns fields such as policy, business, and law. The integration of new competences in space study programmes as well as in extracurricular activities, which are also valuable tools of education, is increasingly required. These needs are not limited to higher education but also concern professional training programmes that are increasingly required to prepare the workforce to address emerging trends and to attract new professional profiles to the space sector.

In this context partnerships across educational programmes and between academia and industry are instrumental to build bridges between disciplinaries, to assess the main gaps to be addressed and to offer new training opportunities, both for students and professionals. This includes activities such as financing higher education programmes, incentivising collaborations and partnerships between high-institutions, implementing joint initiatives at regional level; enriching study programmes with extracurricular activities; reinforcing and creating collaboration schemes with industries; and so forth.

Integration of academia in space sector developments

Academia plays a major role beyond education. In the space sector, academia already contributes to research, development, and innovation (R&D&I), as well as to business entrepreneurship. This role should be further strengthened for the benefit of both the space education system and the space sector. On the R&D&I side, partnerships between universities and industry, for example to develop cubesats offering In-Orbit Demonstration opportunities are an interesting way to provide both hands-on experience to space technology students and new prospects for industry. The place of academia in business entrepreneurship is poised to take an increasingly relevant and necessary role in the space sector. Academia supports business and entrepreneurship for instance through academic incubators, start-ups accelerators, establishing partnerships with enterprises and business-related institutions. The integration of academia in the development of the space sector should be a central objective.

Internationalization of space education to train and attract world talents

Space education in Europe has a strong international dimension. It is characterized by many European and international educational initiatives such as mobility programmes, summer schools, international and inter-European degrees, international training, international competition, and so forth; and by a widespread use of English as singular teaching language or in combination with other languages. This dimension is essential in various respects: to grow a European culture of space and facilitate cooperation, to train international profiles aware of global space activities, markets and practices but also to attract foreign talents for the European space sector. This is a matter of educational opportunities for student mobility but also of establishing the excellence of European space education. An international ranking of space-related programmes on the model of what is already widely used in other areas could be an interesting option to consider.

The place of inspiration in Europe's space culture and narrative as a driver for space education

Survey and consultation results underline that inspiration remains the main motivation for students to enter space-related programmes and for young professionals to enter the space sector. Through inspiration, the European education sector should seek to address "all age groups" and "new audiences" by targeting non-traditional target audiences and among them non-STEM students (i.e., future farmers, architects, economists, lawyers, archaeologists, natural resources managers, etc.).

Although inspiration can be drawn from international feats in outer space, especially in the domains of space exploration, space science and human spaceflight, an adapted communication towards youth regarding European achievements in space is essential at all ages. Raising awareness about the usefulness of space to address great challenges such as climate change or sustainable development goals is another important area of communication to reach out to a generation particularly concerned by these issues. Efforts to raise the interest of new student profiles would also benefit from a communication highlighting new technology and business challenges in the sector that could motivate students from other areas to apply their training in the space sector. Finally, the European and international dimension of the space sector could be underlined to motivate a more mobile and internationally oriented generation.

The position of space education at the forefront of the diversity challenge

Awareness and efforts in addressing diversity issues have increased significantly recently, in particular in Science, Technology, Engineering, and Mathematics (STEM) disciplines which concern a vast majority of space-related programmes. Despite additional efforts to promote gender balance, the percentage of women in STEM has been stalling around 25% in Europe since 2015.[63] With 70% of STEM programmes, the space education system is at the forefront of the diversity challenge. The role of space in addressing this challenge is also related to the place of space feats and figures such as astronauts as a source of inspiration for future generations.

ESPI research provides evidence of a well-established, broad and diverse space education landscape in Europe which is nested in national educational landscapes but also has a strong European dimension. Space education is poised to continue to play a major role in shaping the future European space sector and contributing to address upcoming sectorial developments. Additional efforts from governmental and institutional actors to raise the place of education in the space policy agenda and to support the evolution of the European space education system in close relation with the transformation of the space sector would be welcome.

[63] Women in STEM | Percentages of Women in STEM Statistics. STEM Women. 2021.

ANNEX - METHODOLOGY

ESPI Space Education Landscape

The foundation of this study relies on the creation of a database that includes all Higher Education space-related programmes located in EU and ESA Member and European Associated States. In particular, the mapping includes programmes offered for the 2021/22 academic year by high-institutions (public and private universities, colleges, institutes, etc.); space agencies; governments; national, European, and international organisations as well as any other institutions offering space-related educational initiatives. In cataloguing the European space education higher education landscape, ESPI aims to be as comprehensive as possible. However, it is important to note that the data collection is affected by variations in website languages, available information, and rapidly changing educational offer. Additionally, the number of students for each programme has not been taken into consideration for the analysis.

In addressing the space-related education field, ESPI distinguishes between different categories, which show varied degrees of interlink with the space sector. Particularly:

- Fully related space curricula, which refer to any directly space-related education programme aiming to create "space specialists" in the different areas of the space sector. Aerospace engineering, astrophysics, astronomy, space law, and so forth, are considered fully related space curricula.
- Partially related space curricula, which refer to higher education programmes comprising space-related courses. An example could be a physics programme offering a course in astronomy or a bachelor's in law with a course on space law.
- Potentially related space curricula, which refer to any educational path with the potential to create professional figures who could actively work in the space sector, even without a space-related background. Therefore, it includes peripherical curricula which can be complemented either with space-related educational programmes taken in a later stage of the career or with training in the working sector. Selected examples are mechanical engineering, robotics engineering, biology, chemistry, geology, economy, political science, international relations, private and international law, and so forth.

Subjects of the mapping are only fully related space curricula.

In identifying study programmes across Europe, ESPI mapped: Bachelor, Master (including master, double master, LLM, 5Y degree, double degree, second level master, integrated master, etc.), PhD, and Other (including, summer course, winter course, online course, short course, summer school, etc.).

These curricula have been organised into five macro-areas:

- Aerospace engineering, "*field of engineering concerned with the design, development, construction, testing, and operation of vehicles operating in the Earth's atmosphere or in outer space*".[64]
- Space sciences, "*Any of the various science fields which relate to […] any phenomena occurring in space or on other planets*".[65]
- Juridical, economic, social sciences, and space, "*Juridical science is the academic study that focuses on research issues dealing with the law and legal institutions*", "*Economic science is the branch of social science that deals with the production and distribution and consumption of goods and services and*

[64] Aerospace engineering. *Britannica*.
[65] Space science. *Collins*.

their management" and "*Social science refers to any branch of academic study or science that deals with human behaviour in its social and cultural aspects*".[66]

- Space applications and services are the bridge connecting space and society, and space technologies the tool to build that bridge.
- Multidisciplinary programmes, "*are composed of or combine several usually separate branches of learning or fields of expertise*".[67]

Considering the existing and relevant differences in terms of structure and application process of PhDs, ESPI adapted its methodology in order to be as comprehensive as possible. PhDs can be offered as structured and organised doctoral programmes by the offering high-institution; they can be research projects spontaneously presented by the doctoral candidate to the competent higher education institution or submitted in response to a "call for projects"; they can also be offered in a hybrid format. These procedures impact on the structure, requirements, and development of the PhD, and vary considerably between countries and higher education institutions themselves. Therefore, PhDs have not been mapped individually but as "areas of interest" in which high-institutions carry out research in the space domain.

Additionally, multi-universities programmes have been counted for all involved universities. These programmes are offered in the framework of national or European partnerships and collaborations between higher education institutions. For instance, the double degree in Mobile and Space Communications Engineering offered by Spain and France has been counted for both Spain and France.

The following keywords have been used to build the database: Space, Aerospace, Astronautical, Aeronautical, Satellite, Orbit, Constellation, Earth observation, Astronomy, Astrophysics, Planetology, Cosmology, Universe, Cosmos, Galaxy, Planet, Star, Celestial body, Moon, Asteroid, Blackhole, Remote sensing, GIS.

Survey to Students and Young Professionals

A View from Students and Young Professionals relies on data gathered by ESPI through an online survey.

The survey ran for three weeks and was promoted on several platforms such as the ESPI website, LinkedIn, Twitter, as well as on several third-party platforms such as the ESA Space Education social media and university websites. The survey was sent to programme coordinators whose contact information was identified through the space education landscape mapping. The survey was conducted using the online platform *Alchemer* and targeted the following groups:

- Students currently enrolled in space-related educational programmes or in the process of enrolment,
- Students currently enrolled in a space-related educational programme and currently working in the space sector,
- Students who studied a space-related programme and currently working in the space sector,
- Students who studied a space-related programme and not currently working in the space sector,
- Students who did not study a space-related programme and currently working in the space sector.

Each target group was posed general questions about the space sector and space education, as well as questions related to their specific situations and involvement in space-related education and/or their transition to the work environment.

ESPI received 326 complete responses, which were filtered to address the European scope of the study. Responses from students and young professionals with connections to European space education or the European space employment sector were included in the final sample.

[66] Juridical science law and legal definition. *USLegal*. Additionally, Economic science. *The Free Dictionary*. Also, Social science. *Britannica*.
[67] Multidisciplinary. *Dictionary.com*.

The Role of Academia Beyond Space Education

Convinced of the role academia plays in the space sector beyond space education, ESPI investigated its contribution to research, development, and innovation (R&D&I), and to business and entrepreneurship.

The analysis was conducted based on a series of indicators selected for both sections. Three indicators have been taken into consideration for R&D&I:[68]

- The share of universities and higher education institutes included in ESPI database that have participated in at least one H2020 project,
- The share of universities and higher education institutes included in ESPI database that have developed/are developing or has participated/are participating in at least one CubeSat project,
- The share of universities and higher education institutes included in ESPI database that have/are carrying on at least one space-related scientific or technological collaboration with national space agencies, governmental bodies in charge of space activities, ESA, or the EU and its agencies.

Five indicators have been calculated for the business and entrepreneurship section:

- The share of start-ups originating from a university project based on a sample of more than 100 start-ups resulted from a survey that ESPI conducted in the framework of ESPI Space Venture Europe 2019 Report,
- The share of start-ups originating from academic spin-offs based on a sample of more than 100 start-ups resulted from a survey that ESPI conducted in the framework of ESPI Space Venture Europe 2019 Report,
- Share of universities included in ESPI database having a close relationship with, or hosting an incubator/accelerator in their campuses,
- Share of ESA BICs hosted by higher education institutions, and those having an established partnership with universities,
- Space-related initiatives carried on in parallel by or with higher education institutions (i.e., internship, forum, space economy laboratory, partnership between high-institutions, industrial doctorate, etc.).

Based on the indicators, ESPI identified space sector trends characterising the contribution of academia to R&D&I on the one hand, and to business and entrepreneurship on the other, and conducted an analysis for each section on the implications of these trends.

[68] To calculate the indicators for R&D&I, the ESPI Team considered 313 higher education institutions. Space agencies, the EU, and governmental bodies are not included in the sample.

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About ESPI

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ESPI is the European think-tank for space. The Institute is a not-for-profit organisation based in Vienna, World capital of space diplomacy, providing decision-makers with an informed view on mid to long-term issues relevant to Europe's space activities since 2003.

ESPI is supervised by a General Assembly of member organizations and supported by an Advisory Council of independent high-level experts.

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