
# D3.1 *Analysis report of skills demand and capabilities across sector*


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## Abstract

The European space sector is evolving rapidly, driven by advances in technology, increasing commercialisation, and strategic imperatives around sustainability, autonomy, and global competitiveness. In this context, ensuring a resilient, future-ready workforce is a strategic priority. This report delivers a comprehensive overview of the current state of space education and workforce capabilities across the EU and UK. It integrates evidence from educational program reviews, demographic and mobility data, employer surveys, and skills taxonomy frameworks to assess alignment between academic outputs and industry needs. The findings reveal persistent technical and soft skill gaps, mismatches in pedagogical approaches, regional disparities, and underdeveloped vocational pathways. The report also identifies emerging skills linked to innovation and sustainability and provides forward looking recommendations for educational institutions, industry stakeholders, and policymakers. It serves as a strategic guide to inform future training initiatives, curriculum design, and cross sector collaboration to strengthen Europe's space workforce ecosystem.

## Keywords

Space education, space workforce, skills gap, industry academia collaboration, vocational training, pedagogical innovation, space sustainability, future skills, EU space sector, ASTRAIOS, MOOCs, digital learning, workforce mobility, space curricula, EUTaSK, soft skills, systems engineering, policy alignment, cross-sector collaboration.

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# 1. INTRODUCTION

## 1.1 Background and Context

The European space sector is undergoing rapid transformation, driven by advancements in technology, increasing commercial participation, and evolving policy frameworks at both national and European levels. As the sector expands, so does the demand for a highly skilled workforce capable of addressing emerging challenges and opportunities in space-related industries. Ensuring that the European workforce meets these evolving demands requires a comprehensive understanding of existing skills, educational offerings, and potential gaps within the sector.

The space sector is a critical component of the European economy, functioning as both a high-tech industry and a strategic asset. According to the 2023 Eurospace[1] industry report, despite facing various market challenges, the European space manufacturing industry achieved final sales of approximately €8.2 billion in 2022, representing a 4% decline from the previous year. This contraction is primarily attributed to structural slowdowns in certain segments, notably within commercial satellite and launcher markets, and increased competition from global industry leaders such as SpaceX.

However, the employment figures tell a more positive story, with the European sector employing more than 57,000 people in 2022[2], an 8% increase from the previous year. This growth is largely driven by new entrants in the space sector, particularly startups, which are contributing to an increase in workforce numbers, though not yet significantly impacting overall productivity or sales. The report also underscores the significance of institutional programmes in sustaining the European space sector, with steady demand from government programmes across Europe. Nevertheless, the commercial market is struggling, particularly in areas like geostationary satellites (GEO) and launch services, which are under pressure from lower demand and competitive pricing from international competitors. Furthermore, the European space industry is a net contributor to the European economy, consistently providing a trade surplus of approximately $900 million annually over the past decade. European exports of space systems and launch services, though challenged, remain significant in contributing to the trade balance.

Overall, the space sector remains an essential driver for Europe's economic and strategic interests. Its importance is underscored by its contributions to high tech manufacturing, job creation, and the maintenance of a favourable trade balance. Nevertheless, sustained support, innovation, and enhanced collaboration are vital to maintaining its global competitiveness, especially in the increasingly challenging commercial space marketplace.

Education plays a critical role in addressing these challenges. Recognizing the integral link between education, skills development, and sector growth, the European Space Policy Institute (ESPI) highlighted, in its March 2022 report, the significant impact of education and student mobility on the European space sector. The ESPI report emphasizes that specialised educational programmes and international student mobility foster sector growth and innovation by training skilled professionals, encouraging multidisciplinary collaboration, nurturing entrepreneurship, and promoting international cooperation.

Moreover, the ESPI report provides comprehensive insights into student mobility trends within Europe's space education sector, illustrating the sector's diverse international opportunities and reflecting broader patterns of internationalization across European higher education institutions. These educational and mobility

[1] https://eurospace.org/wp-content/uploads/2023/07/press-release-ff-2023-final-release-v2.pdf

[2] Press Release F&F 2023 FINAL RELEASE V2

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dynamics are fundamental to ensuring the continued growth, resilience, and innovation of Europe's space workforce.

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## 1.2 The ASTRAIOS Project and this report

The ASTRAIOS Analysis of Skills, Training, Research, And Innovation Opportunities in Space project, funded under Horizon Europe, aims to provide a structured approach to understanding the skills landscape of the European space sector. ASTRAIOS focuses on identifying current educational offerings, workforce capabilities, and industry demands, ultimately leading to actionable recommendations for aligning training and education with the needs of the future space workforce.

This report examines the current and future skills landscape of the European space industry. It assesses workforce trends, compare employer demand with the availability of skills, and identify gaps in both technical and soft skills. By analysing hiring patterns, workforce demographics, and the distribution of talent across the upstream, midstream, and downstream sectors, this study provides insights into key challenges affecting the space workforce. Additionally, it explores the impact of student and professional mobility, investigating geographical disparities and their implications for talent retention and workforce sustainability. The findings are informed by previous ASTRAIOS deliverables, industry surveys, and demographic analyses, offering a comprehensive evaluation of how well the European space sector's talent pool aligns with market demands.

The primary objective of this report is to provide evidence-based recommendations for improving workforce readiness and ensuring alignment between education and industry needs. It evaluates the effectiveness of existing educational programs in preparing professionals for careers in space, identifying both strengths and gaps in training. Furthermore, it projects future workforce needs based on industry trends and technological advancements, offering strategic insights for education providers, policymakers, and industry leaders. The recommendations focus on strengthening industry academia collaboration, refining curricula to incorporate emerging competencies, and addressing mobility related challenges to ensure a well distributed and adequately skilled space workforce across Europe. Ultimately, this report contributes to the broader ASTRAIOS initiative by guiding efforts to create a more resilient, competitive, and future ready space sector.

### 1.2.1 ASTRAIOS Project Tasks

One of the primary objectives of ASTRAIOS is to deliver a comprehensive understanding of the current and future landscape of space curricula and courses offered across the EU-27 and UK. Through this effort, the project will assess the needs of the European space industry and work towards improving the alignment between educational offerings and the skills required by the evolving space sector. This alignment is crucial for fostering innovation and enhancing the EU's competitiveness in the global space industry.

For these ambitious goals to be effectively achieved, ASTRAIOS operates through a series of interlinked work packages (WP). Figure 1 elaborates on the project workplan and the workflow starting with Status-Quo Analysis (WP1000), followed by Trends and Challenges (WP2000), then Gap Analysis and Recommendations (WP3000) leading to Initiatives that will pinpoint keyways forward.

Specifically, WP3000 focuses on identifying gaps that hinder the development of the European space industry. It aims to offer actionable recommendations and support for pilot programmes, initiatives, and existing working groups both within and outside the EU-27 and UK. By analysing data from WP1000 and WP2000, WP3000 will provide socio demographic insights into space education and issue recommendations to policymakers at both the EU and national levels, as well as to educational institutions.

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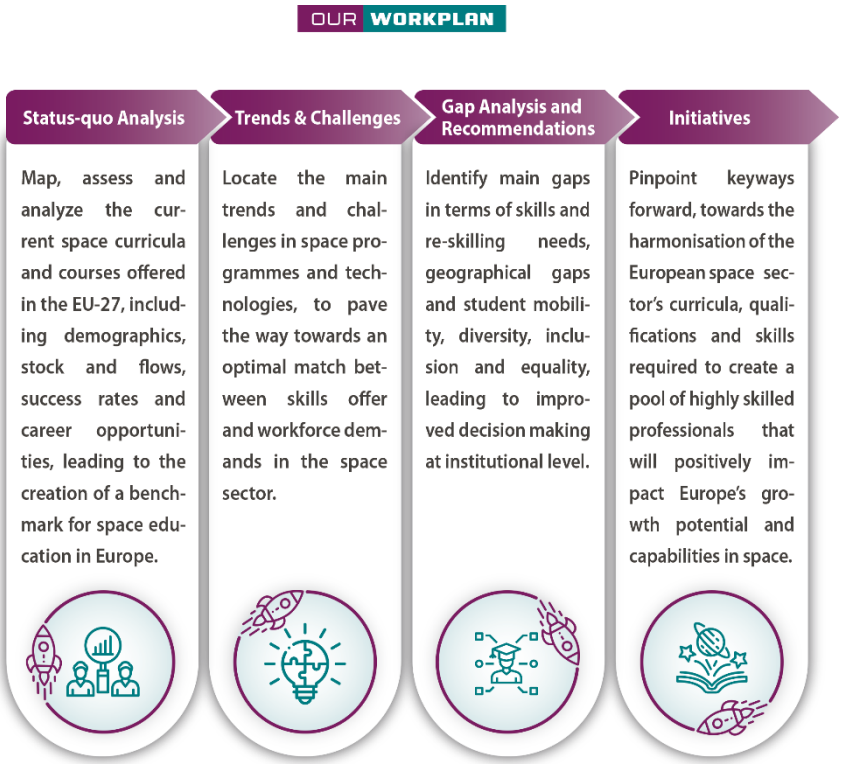


Figure 1: ASTRAIOS Workplan

WP3000 integrates and builds upon the analyses conducted in WP1000 and WP2000, leveraging the comprehensive understanding of the current state ("Status-quo") established in WP1000 and the future-oriented insights ("Trends & Challenges") provided by WP2000. The relationship among these work packages ensures that WP3000's gap analysis and subsequent recommendations are informed by both existing conditions and emerging developments within the European space sector. This structured and systematic approach enables ASTRAIOS to deliver strategic and actionable insights for educational institutions, policymakers, and industry stakeholders, ensuring the alignment of educational offerings with industry demands.

This report, "Analysis Report of Skills Demand and Capabilities Across the Sector", serves as a key component of the ASTRAIOS initiative. It examines the alignment between workforce competencies and employer demand, assesses skills gaps both technical and soft skills and evaluates the effects of mobility and demographic trends within the space workforce. The findings build on new data analysis and previous ASTRAIOS outputs:

- D1.1 Structured data set of HEIs and other institutions/organisations and offered space relevant curricula/courses [1]
- D1.2 Developing a European Taxonomy of Space Knowledge EU-TaSK [2]
- D1.3 EU Space Sector Demographics Report and Database [3]
- D2.1 Overview of the Trends and Challenges for the European Space Sector [4]
- D2.3 Space Sector Soft Skills Report [5]
- D3.2 Analysis Report on Geographical Gaps & Student Mobility Characteristics [6]
- D2.8 Workforce demand evolution and distribution

By consolidating research from multiple work packages within ASTRAIOS, this report aims to provide a holistic view of workforce trends, employer expectations, and the educational pipeline feeding into the European

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space sector. The insights presented will inform strategies for improving skills development, strengthening industry academia collaboration, and ensuring Europe remains competitive in the global space domain.

### 1.2.2 Scope and Objectives

This report examines the current and future skills landscape of the European space industry. It aims to assess workforce trends, compare employer demand with the availability of skills, and identify gaps in both technical and soft skills. By analysing hiring patterns, workforce demographics, and the distribution of talent across the upstream, midstream, and downstream sectors, this report provides insights into key challenges affecting the space workforce. Additionally, it explores the impact of student and professional mobility, investigating geographical disparities and their implications for talent retention and workforce sustainability. The findings are informed by previous ASTRAIOS deliverables, industry surveys, and demographic analyses, offering a comprehensive evaluation of how well the European space sector's talent pool aligns with market demands.

The primary objective of this report is to provide evidence-based recommendations for improving workforce readiness and ensuring alignment between education and industry needs. It evaluates the effectiveness of existing educational programs in preparing professionals for careers in space, identifying strengths and gaps in training. Furthermore, it projects future workforce needs based on industry trends and technological advancements, offering strategic insights for education providers, policymakers, and industry leaders. The recommendations focus on strengthening industry academia collaboration, refining curricula to incorporate emerging competencies, and addressing mobility related challenges to ensure a well distributed and adequately skilled space workforce across Europe. Ultimately, this report contributes to the broader ASTRAIOS initiative by guiding efforts to create a more resilient, competitive, and future ready space sector.

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# 2. METHODOLOGY

This section outlines the methodological framework and approaches utilised in the preparation of this report. The analysis predominantly builds upon previous deliverables and existing databases from the ASTRAIOS project. Leveraging comprehensive source documents, including internal project deliverables and external references, the methodology integrates structured background research, demographic and workforce databases, employer interviews, and surveys conducted throughout various ASTRAIOS tasks. This integrative approach ensures a robust foundation for analysing the European space workforce landscape, identifying skills gaps, evaluating workforce trends, and examining the alignment between educational provisions and industry demands.

The methodological approach incorporates both qualitative and quantitative data sources to provide a comprehensive and balanced analysis. These sources include:

- **ASTRAIOS internal reports**: Such as EU-TaSK [2], Workforce Demographics Report and Database [3], Space Sector Soft Skills Analysis [5], and Geographical Gaps & Student Mobility Analysis [6].
- **External literature and industry reports**: Including the latest trends and challenges highlighted in *Overview of Trends and Challenges for the European Space Sector* [4], WIA-Europe white paper on Skills gap in the aerospace sector [7] and The Accreditation of Higher Education Programmes (AHEP) [8].
- **Database and analytics tools**: Utilising detailed databases such as LinkedIn Talent Insights, QS Rankings & Higher Education data, and Erasmus+ mobility datasets, among others.

The structured process involves initial background research, comprehensive data collection, structured reviews of previous outputs, and careful integration of data through analytical tools. This methodology ensures consistency, reliability, and relevance of insights generated for subsequent analysis.

## 2.1 Background Research Analysis

The background research analysis served as a foundational step for this report, drawing upon a diverse range of previous studies, reports, and initiatives within the European space sector. The analysis involved a thorough literature review of existing internal ASTRAIOS deliverables and external projects and initiatives that significantly influenced the current understanding of skills demand, educational alignment, and workforce development within Europe's space industry.

Several influential projects and initiatives have been instrumental in providing context and foundational insights for this study:

- **EO4GEO**: An Erasmus+ Sector Skills Alliance focused on bridging the skills gap between the supply and demand for education and training in the Earth Observation (EO) and geographic information sectors. EO4GEO developed a comprehensive Body of Knowledge (BoK) that systematically categorized competencies and educational needs, providing a structured understanding of skill requirements and educational alignment within the EO domain. [9]

- **STARSEU**: Funded by the European Commission, STARSEU supported policymaking in education and skills development specifically targeting the space sector. It performed detailed analyses of existing educational programmes, highlighted skill needs, and proposed new strategies for aligning education with the evolving industry demands, serving as a valuable reference for skill gap identification and curriculum alignment. [10]

- **SPACESUITE**: Part of Erasmus+, SPACESUITE aimed to enhance university-industry collaboration through innovative educational strategies, including internships, practical training, and cross border

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exchanges. This project highlighted effective practices for industry-academic collaboration, vocational training, and curriculum design, which informed the pedagogical strategies analyzed in this report. [11]

- **UNIVERSEH**: An Erasmus+ European Universities initiative, UNIVERSEH emphasized mobility, multilingualism, and interdisciplinary education. It promoted innovative curricula and pedagogical methods specifically tailored to the space sector, including joint degrees and virtual classrooms. Insights from UNIVERSEH informed our understanding of internationalization, diversity, and innovative educational practices in higher education for space. [12]

- **Space4All**: An association-based initiative aimed at enhancing public access to space-related educational resources and promoting widespread awareness of space opportunities. Space4All's approach highlighted the importance of informal education, public outreach, and broad-based engagement, providing a complementary perspective on skill development and public engagement. [13]

- **Copernicus Academy**: An educational network established to foster knowledge transfer and skill development in Earth Observation through structured academic cooperation and public-private partnerships. The Copernicus Academy's methods of collaborative learning, resource-sharing, and public engagement were particularly relevant for examining effective educational and training practices in specialized space domains. [14]

- **ESA/Space Academy**: The European Space Agency's educational initiatives, often consolidated under the term "Space Academy," provide extensive professional development and educational opportunities through specialized training courses, workshops, internships, and competitive events. This initiative underscores practical, hands-on experiences, and direct engagement with current industry practices, offering critical insights into vocational training, mentoring, and informal learning processes within the sector. [15]

Collectively, these projects have significantly influenced the landscape analysis by providing insights into educational structures, competency frameworks, effective industry-academic partnerships, and innovative pedagogical methodologies. By reviewing and synthesizing the outcomes of these previous initiatives, the background research phase of this report was able to create a robust foundation for analyzing current workforce competencies, identifying critical skill gaps, and formulating evidence-based recommendations. This integration ensures that findings and recommendations are grounded in established practice, informed by successful strategies, and aligned with ongoing European initiatives aimed at enhancing the space workforce.

## 2.2 Data sources and collection process

To ensure a robust and comprehensive analysis, multiple integrated data sources and repositories were leveraged, encompassing both internal project resources and external databases. These sources collectively provide rich insights into workforce characteristics, educational provisions, industry requirements, and emerging trends within the European space sector.

**ASTRAIOS Internal Data Sources:**

- **Skills & Competencies Taxonomy (EUTaSK)** provided a structured classification system detailing key knowledge domains and competencies required by employers, enabling a comprehensive assessment of skills gaps across the sector.

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- **Space Sector Workforce Demographics** included datasets derived from LinkedIn Talent Insights and industry surveys, offering granular demographic details on workforce growth, hiring trends, major employers, and geographic distributions.
- **Soft Skills Analysis** integrated qualitative insights gathered through structured interviews with employers and human resource managers within the space sector, highlighting expectations around interpersonal, communicative, and leadership skills.

**External Databases and Analytics Tools:**

- **QS Rankings & Higher Education Data** were utilized to evaluate academic standards, program availability, and institutional capabilities across Europe, crucial for aligning educational outcomes with workforce needs.
- **Erasmus+ Mobility and Curriculum Data** provided valuable insights into educational mobility patterns, internationalization, and curriculum structures, highlighting their implications on workforce competencies and geographic skill distribution.

**Industry and Sectoral Databases:**

To further enrich the analysis and ensure comprehensive coverage of the sector's corporate landscape, additional industry-specific databases and repositories were consulted, including:

- **ESA STAR (ESA's System for Tendering and Registration)** provided a detailed registry of entities actively participating in ESA projects, essential for identifying key industrial stakeholders and competencies.
- **International Astronautical Federation (IAF)** and **International Academy of Astronautics (IAA)** databases contributed insights into global aerospace activities, research initiatives, and international collaborative frameworks.
- **American Institute of Aeronautics and Astronautics (AIAA)** and **Aerospace Defence Security Group (ADS)** databases offered extensive industry-specific datasets, including corporate memberships, project involvements, and technical competencies across global aerospace sectors.
- **SME4Space** provided specialized information on European Small and Medium-sized Enterprises (SMEs) active in space-related industries, highlighting their workforce capabilities, innovation capacity, and regional distribution.
- **PwC Stakeholders Database** offered a comprehensive view of European and global space industry stakeholders, including business profiles, financial data, emerging market trends, and strategic insights critical for understanding current workforce needs and future skills trajectories.

The structured process of data collection entailed meticulous extraction, validation, integration, and synthesis across these various sources. Each dataset was rigorously verified and cross-referenced to ensure accuracy and relevance, creating a rich and multidimensional understanding of the European space workforce landscape. This integrative approach ensured the reliability of subsequent analyses, laying a solid foundation for informed conclusions and strategic recommendations outlined in this report.

### 2.2.1 Skills & Competencies Taxonomy

A clearly structured taxonomy of skills and competencies is foundational for systematically analyzing workforce requirements and educational alignment within the European space sector. To achieve this, the

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ASTRAIOS project developed the European Taxonomy of Space Knowledge (EUTaSK), documented comprehensively in [2]. This taxonomy provides a coherent framework that categorizes and defines essential knowledge domains (KDs), knowledge areas (KAs), and specific competencies relevant to the various segments of the European space industry.

The EUTaSK taxonomy was developed through a rigorous multi-step process involving extensive literature review, stakeholder consultations, workshops, and iterative validations by academic, industry, and policy stakeholders. Its primary objective was to harmonize and standardize definitions of competencies and skills across the European space ecosystem, thereby facilitating clear communication among educational institutions, employers, policymakers, and students.

Structurally, the taxonomy delineates space sector competencies across three primary segments:

- **Upstream Segment**: Covering skills related to spacecraft design, development, manufacturing, launch vehicles, and associated technologies.
- **Midstream Segment**: Including skills related to ground systems operations, mission control, spacecraft operations, and data management processes.
- **Downstream Segment**: Encompassing competencies required for Earth observation, satellite communications, satellite navigation services, space data analytics, and end-user applications.

Each segment includes detailed knowledge domains further divided into specific knowledge areas and associated competencies. For example, the "Satellite Technology and Systems Engineering" domain encompasses detailed areas such as "Satellite Platform Systems", "Payload Design", and "Space Mission Architecture", each defined through explicitly articulated skills and knowledge sets. Similarly, domains focused on "Space Data Analysis" define competencies such as data acquisition, processing, geospatial analytics, and space-based application development.

In addition to technical and scientific competencies, the EUTaSK also includes an extensive classification of transversal skills—often referred to as soft skills—including project management, teamwork, leadership, adaptability, problem-solving, and communication. These transversal skills were identified through employer consultations as critical across all industry segments, highlighting their indispensable role in professional effectiveness and career progression.

The EO4GEO Body of Knowledge (BoK) has informed the structure of EU-TaSK. More information: D1.2 - Developing a European Taxonomy of Space Knowledge (EU-TaSK). [2]

The structured, hierarchical, and detailed nature of the EU-TaSK provides a robust foundation for the ASTRAIOS project's subsequent analytical phases, particularly for evaluating the alignment between educational offerings and workforce needs, as well as for identifying significant gaps between employer expectations and existing educational programs. The taxonomy thus serves not only as an analytical tool but also as a strategic guide for curriculum development, workforce training initiatives, and informed policymaking.

To enhance understanding and facilitate communication among stakeholders, the link to the live interactive ASTRAIOS KD/KA can be found here. This accessibility ensures that educational institutions, industry partners, and policymakers can effectively utilize the taxonomy for their strategic planning and decision-making processes.

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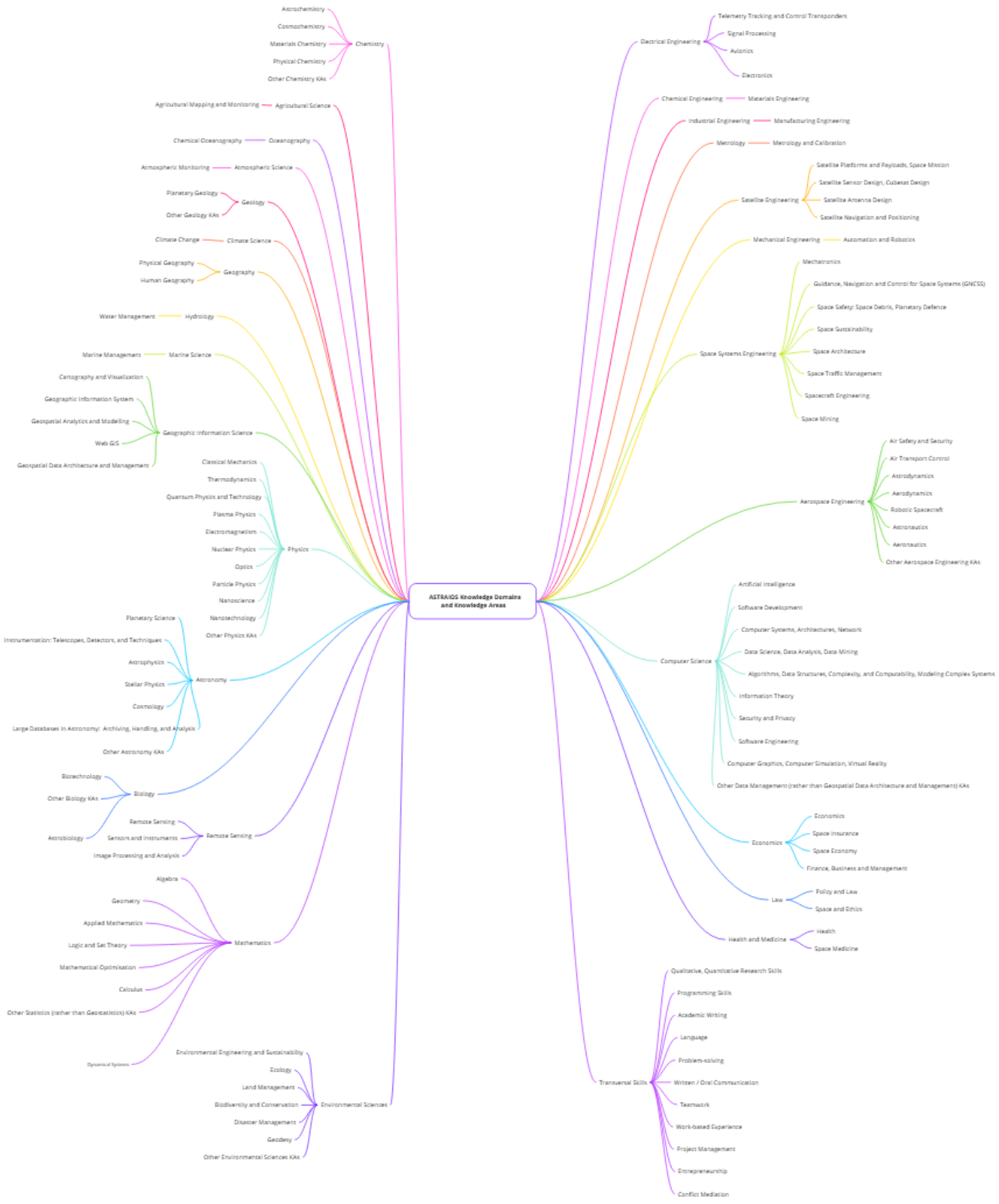


Figure 2: The structure of ASTRAIOS KD/KA. A larger version can be found here.

Figure 2 provides a concise visual representation of the KD/KA collected for the ASTRAIOS structure, clarifying how knowledge domains and areas interrelate within each segment of the taxonomy.

### 2.2.2 Space sector workforce demographics

Understanding the demographic structure of the European space workforce is essential for identifying current capabilities, diversity trends, and areas where targeted interventions may be needed to address gaps in

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representation, skills, or regional distribution. In the ASTRAIOS project, these insights were derived primarily through a multi-source approach documented in D1.3: EU Space Sector Demographics Report and Database [3] . The methodology combined quantitative data from LinkedIn Talent Insights, publicly available databases, and custom industry surveys to map workforce characteristics across the EU-27 and the UK.

The demographic analysis encompassed over 170,000 LinkedIn profiles identified as working in the space sector, offering granular data on geographic location, job functions, seniority levels, educational background, gender, and employer type. These data were further enriched by custom surveys and sector-specific databases contributed by ASTRAIOS partners and stakeholders, enabling a multidimensional picture of the European space workforce.

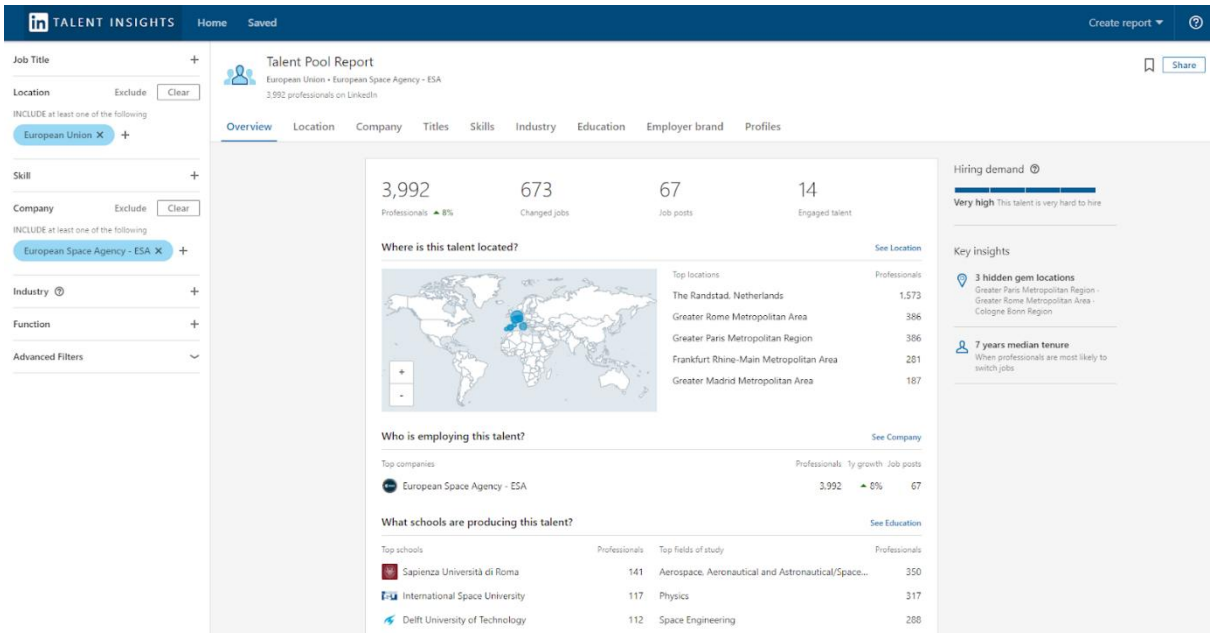


Figure 3: Example LinkedIn Talent Insights search for the workforce of the European Space Agency.

Key Findings from the Demographic Analysis:

- **Workforce Concentration**: The analysis revealed that the workforce is heavily concentrated in a few core countries, namely France, Germany, Italy, and the UK, which together host the majority of Europe's space-related employment. This reflects the location of key institutions such as ESA centres, national space agencies, and large aerospace manufacturers.

- **Gender Representation**: A notable gender imbalance persists across most job categories and seniority levels. While female representation in early-career positions has improved modestly, significant disparities remain at senior, leadership, and technical roles, particularly in upstream sectors.

- **Educational Background**: The majority of space professionals hold degrees in aerospace engineering, mechanical engineering, electrical engineering physics, computer science, and geospatial sciences. However, growing demand is also observed in data science, AI, systems engineering, and cybersecurity—indicating evolving workforce requirements beyond traditional technical domains.

- **Seniority and Experience**: The space sector shows a strong distribution in mid-career professionals, but notable gaps exist in early-career pipelines and PhD-level specialization in certain countries, especially in Eastern and Southern Europe. This imbalance can affect innovation capacity and generational knowledge transfer over time.

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- **Employer Types**: Large organizations—including ESA, Airbus, Thales Alenia Space, and OHB—remain the primary employers. However, a rising number of SMEs and startups are beginning to influence hiring patterns, particularly in software, EO downstream services, and NewSpace domains.

- **Geographic Disparities**: Regional disparities were a key theme. Several EU member states show limited representation in the space workforce, often due to the absence of strong national space programs or dedicated industrial clusters. This results in a talent migration toward Western European countries, contributing to brain drain effects.

Integration with WP1000 and WP2000: The demographic data from D1.3 [3] serves as a foundational dataset for interpreting trends identified in WP1000 and WP2000. It enables correlation between educational offerings (D1.1 [1]), identified skills gaps (D1.2 [2] and D2.1 [4]), and the actual professional landscape. This integration is critical for understanding whether workforce development is keeping pace with industry needs, and where interventions are most urgently needed.

### 2.2.3 Soft skills analysis from employer interviews

As part of the ASTRAIOS methodology to assess the evolving needs of the European space workforce, a dedicated task was undertaken to evaluate soft skill requirements through direct engagement with employers. This methodological component is documented in D2.3: Space Sector Soft Skills Report [5], and represents a qualitative complement to the project's broader analysis of technical skill gaps.

The soft skills analysis was grounded in two primary data collection methods:

1. **A targeted survey**, designed and distributed by the International Space University (ISU) and the Space Skills Alliance (SSA), targeting HR professionals and hiring managers across industry, academia, and government.
2. **Online workshops**, structured as a focus group, involving selected participants from various segments of the space sector. Attendees included representatives from ESA, OHB, Airbus, D-Orbit, Thales Alenia, ESRIC, Leanspace, Maana Electric, HESpace, and others.

The aim of these interactions was to gather structured, experience-based insights on the soft skills most valued by employers and to understand how these skills influence recruitment, retention, and team performance in the space sector. This approach ensured that the project captured perspectives directly from those engaged in talent identification and organizational development.

The methodology followed a participatory, industry-driven model with the following characteristics:

- **Questionnaire Design (Appendix A** [5]**)**: Co-created by ISU and SSA to align with prior literature and EU-wide skill classification standards (e.g., ESCO). Questions covered soft skills required for early- and mid-career roles, perceptions of skill gaps, training needs, and recruitment practices.

- **Workshop Facilitation**: The workshop used interactive digital tools to collect real-time feedback on perceived skill gaps, hiring practices, and future training requirements. It also allowed for breakout discussions where employers could elaborate on challenges they face in evaluating and developing soft skills among candidates and employees.

- **Data Processing and Thematic Analysis**: Survey responses and workshop transcripts were thematically analyzed using qualitative coding techniques. Categories such as communication, teamwork, leadership, adaptability, digital fluency, and cultural awareness emerged as key themes. This analysis provided the basis for identifying soft skills clusters and their relative importance in different space sector contexts (e.g., upstream engineering vs. downstream data services).

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Importantly, this methodological strand focused on validating and enriching quantitative findings from other ASTRAIOS deliverables (such as job postings and curriculum analysis) by adding an industry-led perspective. The inclusion of diverse organization types—startups, multinationals, agencies, and academia—ensured that findings reflect sector-wide priorities.

Although the detailed results of this analysis are presented in Section 4.5 of this report, the methodology outlined here establishes the foundation upon which the insights were generated and interpreted.

### 2.2.4 QS Ranking & HE Data

In addition to the core datasets gathered from ASTRAIOS deliverables, this report integrates complementary data on higher education institutions (HEIs) sourced from the QS World University Rankings and other structured HE datasets. This data was collected, cleaned, and processed using customized Python scripts, developed as part of ASTRAIOS analytical support activities.

The purpose of this dataset is twofold:

1. To contextualize the quality and global positioning of European universities offering space-relevant degree programmes.
2. To cross-reference institutional-level insights with curriculum and mobility data gathered from D1.1 [1], D1.3 [3], and Erasmus+ databases—supporting analysis of institutional contribution to space workforce development.

**Data Acquisition and Processing**

A list of universities across the EU-27 and the UK was assembled from publicly available sources including:

- QS World University Rankings
- Erasmus+ Institutional Participation Lists
- University datasets linked to D1.1 [1] and Erasmus+ mobility records.

The dataset was programmatically gathered, cleaned and standardized using Python (Pandas, FuzzyWuzzy, and OpenPyXL libraries), with particular care taken to:

- Normalize university names across multiple databases (e.g., remove special characters, unify abbreviations).
- Match ranked institutions with their participation in Erasmus+ space-related exchanges.
- Tag institutions based on indicators such as global rank, national prominence, research reputation, and STEM program availability.

This process enabled the identification of high-ranking HEIs actively contributing to space education and mobility, and also helped to highlight regions or institutions underrepresented in global rankings but active in student exchange or curriculum development.

**Role in Methodology**

Although not a primary dataset within ASTRAIOS deliverables, the QS-based institutional ranking data plays an important supportive role in triangulating findings:

- It helps assess whether leading institutions in rankings are also major contributors to workforce pipelines in the space sector.
- It supports identification of institutional quality disparities across countries, contributing to the understanding of geographical workforce imbalances and potential barriers to mobility or access.

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- It informs recommendations regarding policy support and curriculum investment in mid-tier institutions that may lack visibility but demonstrate strong activity in mobility and space education.

This supplementary methodology provides added depth to the demographic and educational analyses conducted in other sections of the report and will be further integrated in cross-referencing findings related to workforce trends, skills development, and regional disparities.

### 2.2.5 Erasmus (+) Mobility and Curriculum Data

As a critical component of the ASTRAIOS methodology, the Erasmus(+) mobility dataset was analyzed to understand patterns in student movement, international collaboration, and the accessibility of space-related education across Europe. This data is particularly relevant for examining geographical disparities, institutional involvement, and the role of mobility in shaping the future European space workforce.

The analysis builds on the work conducted for ASTRAIOS Deliverable D3.2: Analysis Report of Geographical Gaps & Student Mobility Characteristics, and was enhanced through an independent data processing pipeline developed in Python. The raw data, obtained from official Erasmus+ public records, contained more than 5.8 million mobility records across the academic years 2013–2014 to 2022–2023.

**Data Processing and Normalization**

Given the scale and complexity of the dataset, a custom Python-based framework was developed to:

- Expand aggregated rows based on participant counts (i.e., normalize entries where multiple participants were stored under a single row).
- Standardize institutional names and map them to countries, cities, and postal codes.
- Categorize institutions into 28 key countries of interest (EU-27 + UK), with all others grouped under "Other".
- Address missing or undefined fields, including gender, degree level, or destination country, using inclusive data processing logic.

This effort produced a clean, structured, and analysis-ready dataset which enabled consistent, comparative study of both sending and receiving mobility patterns, institutional involvement, and mobility duration trends.

**Curriculum Relevance and Challenges**

While the Erasmus+ dataset is not discipline-specific, the ASTRAIOS team developed inference models to approximate the space relevance of a given mobility pathway. This included:

- Cross-referencing Erasmus+ institutions with those listed in ASTRAIOS D1.1 (Structured Curriculum Catalogue) [1].
- Tagging universities with space-related course offerings, as defined through the EU-TaSK framework (D1.2 [2]).
- Matching universities involved in Erasmus+ exchanges with space-relevant curriculum providers to assess the intersection of mobility and domain specialization.

Although Erasmus+ does not formally tag study programs by discipline (e.g., "space sciences" or "aerospace engineering"), this methodological approach allowed for the indirect estimation of space-related student mobility flows and helped identify gaps in participation or curriculum availability in key European regions.

**Methodological Contribution**

The Erasmus+ dataset provides a foundation for several strands of analysis throughout this report, especially in:

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- Assessing the distribution of space-related education and mobility opportunities across Europe.
- Identifying underrepresented countries or institutions in student mobility related to space disciplines.
- Supporting evidence of brain drain or talent concentration patterns observed in D3.2 [6] and echoed in workforce data (D1.3 [3]).

While the full analytical results are presented in later sections (especially in relation to mobility-driven workforce challenges), the methodological rigor applied to Erasmus+ data ensures that ASTRAIOS recommendations are grounded in real-world participation patterns.

## 2.3 Surveys, interviews, and secondary data analysis

In addition to database-driven and literature-based inputs, qualitative and mixed-method approaches were incorporated into the ASTRAIOS methodology to gain richer insight into industry practices, stakeholder expectations, and perceived workforce challenges. These methods included targeted surveys, semi-structured interviews, and the systematic analysis of secondary data from both ASTRAIOS deliverables and external strategic reports.

Surveys and interviews were primarily conducted with representatives from industry, academia, government, and space-sector networks. These inputs provided essential validation of findings from data-driven analyses (e.g., workforce demographics, curriculum coverage, and soft skills needs), and revealed qualitative dimensions—such as hiring preferences, skill mismatches, and pedagogical limitations—that are not captured through quantitative data alone. Secondary data sources, including national space strategies, ESA and EC reports, and sectoral studies (e.g., Eurospace and PwC analyses), further reinforced the reliability and contextual depth of ASTRAIOS findings.

### 2.3.1 Employer surveys

As part of the methodological framework to understand the evolving demand for skills in the European space sector, employer surveys played a pivotal role in capturing firsthand insights into industry needs, recruitment practices, and workforce development challenges. The data gathered from these surveys, as documented in ASTRAIOS D2.1 [4], formed one of the core pillars of qualitative analysis in the project.

The survey targeted a wide range of stakeholders, including large system integrators, SMEs, startups, research centres, and institutional actors across upstream, midstream, and downstream segments of the space value chain. The questionnaire was designed to elicit both quantitative and qualitative feedback on multiple dimensions, such as:

- Current and projected hiring trends across engineering, operations, software, and data-related roles.
- Perceived technical and transversal skills gaps in recently hired graduates or mid-career professionals.
- Challenges in identifying or retaining talent with critical domain knowledge or interdisciplinary expertise.
- The impact of technological transformation (e.g., AI, cybersecurity, autonomy) on skill requirements.
- Opinions on the adequacy of current academic curricula and training pathways for space-specific competencies.

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While the detailed trends and thematic insights from employer responses are presented in Section 4.1 and 4.2, the survey methodology itself enabled a high-resolution view into the day-to-day realities of talent acquisition and the longer-term strategic needs of Europe's space sector.

### 2.3.2 Job market analysis

To investigate job market dynamics in the European space sector, ASTRAIOS leveraged LinkedIn Talent Insights as a core data source. This tool offers one of the most comprehensive datasets currently available on workforce characteristics by aggregating over 12 billion data points across global user profiles. Through LinkedIn, ASTRAIOS assessed job titles, skill declarations, company affiliations, and geographical mobility to map trends within the space labour market

The Talent Insights methodology used in ASTRAIOS focused on a curated list of space-related companies rather than relying on LinkedIn's default industry classifications. This approach was necessary due to inconsistencies in self-categorisation—many companies relevant to the space domain were classified under broader categories such as "Information Technology & Services" or "Aerospace"

Workforce analytics from LinkedIn included indicators such as full-time employment numbers, workforce turnover, and one-year growth rates. Importantly, the dataset excluded interns, contractors, and part-time roles, focusing strictly on full-time professionals. These limitations were acknowledged, as they may underrepresent certain populations like recent graduates or temporary staff.

Job functions were classified using LinkedIn's taxonomy of 26 standard functions. For the European space sector, engineering, IT, and operations emerged as the dominant categories. Specific insights into fast-growing job roles, gender distribution, and workforce mobility patterns are discussed in Section 3.2. These findings are complemented by external surveys and ASTRAIOS's own database structuring, ensuring alignment with curriculum analysis and employer expectations explored in subsequent chapters.

Table 1: Some examples of standard functions

| Function | Description |
|---|---|
| Engineering | Includes positions involving the development and implementation of products and solutions of their company. Software developers are included. Some example job titles would be – Aeronautical engineer, software developer, petroleum drilling engineer, software engineer, coding engineer. |
| Information Technology | Includes the deployment, administration, and support of Information and computing infrastructure within the firm. Includes contractors and consultants. Example job titles: Chief Information Officer, Database developer, IT Auditor, SAP Consultant, Telecommunications Manager. |
| Operations | Roles involved in the internal operations of a firm. This includes activities that directly produce the firm's products. They are also responsible for the deployment, operation, maintenance, management of infrastructures, site operations, and manufacturing activities. An important note here is that this might include marketing operations, IT operations and IT infrastructure too. Job functions might overlap depending on the nature of the job role. So always keep testing. |
| Education | Includes teaching roles like professors, primary and secondary school teachers, teaching assistants, instructors, and coaches. This likely does not include corporate trainers as that could fall under the Human Resources function. |

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| | |
|---|---|
| Human Resources | Includes recruiting, staffing, comp and ben administration, personnel & employee wellness management, organisational development, internal corporate trainers. |
| Product Management | These roles tend to be responsible for defining, developing and delivering specific products or groups of products according to the company's business goals. |
| Program and Project Management | Positions involved in the operational management of projects, processes, schedules and coordination of activities across teams. Example of job titles: project manager, program manager, project administrator, business process management, agile consultant. |
| Quality Assurance | Testing and quality control roles. This could involve software or hardware QAs. Example titles would be business analyst, healthcare QA, tester, software tester, penetration testing engineer. |
| Research | Includes scientific research, business or market research and data analytics. Job title examples: chemist, healthcare research, research analyst, product manager, data scientist. |

## 2.4 Database Design and Integration

As part of the ASTRAIOS project's methodological foundation, a structured and relational database is developing to integrate and manage diverse datasets collected across multiple work packages. This database supports efficient storage, querying, and linkage of data relevant to skills, education, demographics, institutions, and companies within the European space sector. The aim was to enable comprehensive analysis, facilitate cross-referencing, and create a standardized basis for workforce and curriculum assessment.

The architecture of the database allows for modular and scalable data input while maintaining referential integrity across entities such as degree programmes, higher education institutions (HEIs), companies, demographic data, and skills taxonomies.

### 2.4.1 Architecture and Schema

The ASTRAIOS database follows a normalized relational schema consisting of ten main tables, each representing a core entity: Degree Program, Degree Name, Higher Education Institution, Company, Demography, Geography, Mobility, Taxonomy, Data Source, and Year. Foreign key relationships ensure consistent linkage between tables. The design supports longitudinal analysis across academic years, allowing future updates and time-series tracking.

Data fields within each table are aligned to support standardized analytics. For instance, the Degree Program table links program-level metadata (e.g., delivery mode, taxonomy alignment, gender ratio) to both the HEI and the geographic location, ensuring full traceability.

### 2.4.2 Interfaces and Functional Connections

Each table in the ASTRAIOS database is designed to enable connection with other tables via a foreign key index , allowing relationships and integrations For example:

- Degree Program Table is linked to Higher Education Institution, Geography, and Taxonomy Tables.
- Demography Table is linked to Geography and Company tTables.
- The Taxonomy Table provides ASTRAIOS-specific knowledge area identifiers that are linked in both Degree Program and Demography.

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This interconnected architecture enables complex queries, such as mapping space-related programs to company hiring trends or analysing regional demographic shifts alongside educational provision.

### 2.4.3 Database Modules structure and definition

The ASTRAIOS database is structured around a modular architecture designed to support integrated analysis of the European space workforce and education landscape. The core modules include datasets on annual timeframes, degree program classifications, geographic identifiers, institutional profiles, curriculum content, knowledge taxonomy (EUTaSK), demographic trends, and company-level characteristics. Each module is linked through standardized identifiers, enabling cross-sectional and longitudinal data analysis across multiple dimensions such as curriculum alignment, mobility flows, graduate output, and employer demand. This structure forms the analytical backbone for current work and will be further detailed in a forthcoming technical documentation, which will provide full schema definitions, data governance protocols, and usage examples for stakeholders and project partners.

## 2.5 Analytical Framework

The analytical framework used in this report defines how quantitative and qualitative data sources are systematically interpreted to assess the alignment between education provision and workforce needs within the European space sector. This framework integrates methodologies from skills mapping, labour market intelligence, curriculum analysis, and education policy research—applying them through a consistent lens to ASTRAIOS datasets and findings from Work Packages WP1000, WP2000, and WP3000.

### 2.5.1 Definition and Typology of Skills Gaps

One of the central analytical objectives of ASTRAIOS is the identification and interpretation of skills gaps, which are defined as discrepancies between the competencies supplied by education and training systems and those demanded by employers in the space sector.

In ASTRAIOS, skills gaps are categorized as follows:

- **Technical Skills Gaps**: Absence or insufficiency of domain-specific knowledge such as propulsion engineering, satellite systems integration, space law, cybersecurity, or EO data analytics.
- **Transversal (Soft) Skills Gaps**: Deficiencies in competencies such as communication, teamwork, adaptability, intercultural awareness, and problem-solving—especially in international, interdisciplinary project settings.
- **Digital and Emerging Skills Gaps**: Shortages in data literacy, AI application, cloud computing, and systems thinking—often critical in downstream and service-driven domains.
- **Structural or Institutional Gaps**: Misalignments caused by outdated curricula, poor industry-academic collaboration, or lack of access to mobility and upskilling opportunities.

Each type of gap is traced through cross-referencing job market demand (Section 2.3.2), employer surveys (Section 2.3.1), and curriculum mapping (from [1] and [2]).

### 2.5.2 Pedagogical Concepts and Models

To assess the ability of educational institutions to deliver relevant skills, ASTRAIOS applies a review of underlying pedagogical models and delivery formats in European space-related education. Drawing from [1] and [5], the following frameworks are emphasized:

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- **Traditional Lecture-Based Instruction**: Still predominant across STEM curricula but often insufficient for applied skill development.
- **Project-Based and Design-Based Learning**: More aligned with space systems engineering approaches; allows simulation of real-world mission design and teamwork under constraints.
- **Vocational and Modular Training**: Delivered via short courses, stackable micro-credentials, or industry certification schemes to support reskilling and upskilling.
- **Digital Learning and MOOCs**: Used to address accessibility and regional disparities in education, though often lacking personalization and mentorship.
- **Mentoring and Extracurricular Practice**: Such as competitions, space camps, and student projects (e.g., CubeSats), which serve as informal but highly impactful learning environments.

These pedagogical approaches are evaluated in WP3000 using a combination of qualitative assessments (interviews and surveys) and comparative curriculum mapping (linked to [1] and [5] outputs).

### 2.5.3 Data Integration and Comparative Logic

The framework relies on the structured database described in Section 2.4 to link skills taxonomies (EU-TaSK, ESCO) with:

- Degree programme content and delivery (from [1])
- Workforce characteristics and gaps (from [3])
- Employer expectations and recruitment behaviour (from [4] and [5])
- Regional educational access and mobility trends (from [6])

By aligning these data sources across thematic pillars (e.g., curriculum, demand, workforce), ASTRAIOS enables both vertical integration (within each theme) and horizontal comparison (across stakeholders and regions), thus ensuring that conclusions and recommendations are evidence-based, context-sensitive, and actionable.

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# 3. CURRENT STATE OF THE SPACE WORKFORCE

The European space sector continues to evolve in both its technological focus and its workforce composition. As demand for innovation grows, so does the need for a skilled, adaptable, and diverse workforce capable of responding to emerging challenges in upstream engineering, downstream services, and the midstream operational layer. Understanding the current state of this workforce is essential to identifying strengths, gaps, and opportunities for future alignment between education, mobility, and market needs.

This section consolidates evidence from past and ongoing projects and initiatives—both within and outside ASTRAIOS—that have addressed various aspects of space workforce development, education systems, and stakeholder collaboration. It highlights lessons learned, effective practices, and persistent gaps revealed by earlier efforts.

## 3.1 Previous project results

Over the past decade, several EU-funded projects, Erasmus+ initiatives, and educational associations have laid the groundwork for understanding and improving Europe's space workforce. These efforts have focused on mapping skills and job profiles, harmonizing space-related curricula, strengthening university-industry collaboration, promoting mobility, and identifying transversal competencies.

In particular, initiatives funded under EC grants such as EO4GEO and STARSEU have been instrumental in developing structured knowledge frameworks, skills taxonomies, and training tools. Similarly, Erasmus+ projects such as SPACESUITE and UNIVERSEH have emphasized international academic cooperation and curriculum innovation. Finally, a variety of associative platforms like Space4All, Copernicus Academy, and ESA's Space Academy have fostered community-building, outreach, and informal training across Europe.

While these initiatives differ in scope, structure, and audience, they collectively contribute valuable insight into the challenges and opportunities facing Europe's space education and workforce ecosystem. The following subsections synthesize the core contributions and limitations of each.

### 3.1.1 EC Grants

Under the European Commission's funding frameworks, several multi-partner initiatives have addressed the evolving skills landscape of the space sector. These projects have contributed to the development of educational frameworks, conducted gap analyses, and piloted training programmes to improve alignment between workforce competencies and industry needs. Among the most relevant are EO4GEO and STARS*EU, both of which offer valuable insights into skills development and capacity-building efforts across different segments of the European space value chain.

#### 3.1.1.1 EO4GEO

EO4GEO, one of the most comprehensive skills initiatives funded by the European Commission under Erasmus+ Sector Skills Alliances, focused on addressing workforce needs in the Earth Observation and Geoinformation (EOGI) sector—a key component of the space downstream segment. Running from 2018 to 2022, the project brought together a consortium of 25 core partners from 12 countries, including academic institutions, private industry, and public agencies, many of whom were active members of the Copernicus Academy. [9]

The project aimed to support the uptake of Copernicus services and related geospatial applications by building a skilled workforce that could deliver actionable insights from Earth observation data. At the heart of EO4GEO was the development of a formal, ontology-based Body of Knowledge (BoK), which defined the key concepts, skills, and competencies needed in the EOGI domain. This BoK became the foundation for a full suite of training

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and curriculum development tools that were later made publicly available to universities, training centres, and companies.

EO4GEO's activities were grounded in a robust methodology combining expert-driven gap analysis, curriculum co-design with industry, and real-world pilot testing. The project conducted a detailed comparison of academic offerings against labour market needs, identifying shortages in critical areas such as data analytics, geospatial application development, and the integration of AI and big data in EO services. To address these, EO4GEO produced modular, flexible learning resources—including curricula, case studies, and exercises—that aligned closely with Copernicus programme goals and employer requirements. [16]

The project's pedagogical approach emphasized experiential and collaborative learning, favouring methods like case-based instruction, "learning by doing" through living labs, and co-creation of content with industry professionals. Three thematic curricula were piloted—focusing on integrated EO applications, smart cities, and climate-related services—demonstrating the value of project-based learning in enhancing job-readiness among graduates and early-career professionals.

A major legacy of the project is its contribution to structural capacity-building in the space sector. Beyond producing tools and training resources, EO4GEO developed a Sector Skills Strategy and Action Plan, offering a long-term roadmap to address workforce development challenges in the EOGI domain. The plan emphasized the need for continuous curriculum updates, deeper engagement with industry, and better coordination between educational providers and policy frameworks at the EU level.

To ensure sustainability beyond the project's lifecycle, EO4GEO facilitated the creation of the EO4GEO Alliance—a permanent, community-driven network now responsible for maintaining and expanding the Body of Knowledge, supporting tool updates, and continuing engagement with stakeholders. This alliance operates in close collaboration with the Copernicus Academy and contributes to new EU policy instruments such as the Pact for Skills in the space sector.

Despite its strong achievements, EO4GEO also encountered some limitations. Its focus remained largely on the downstream segment, with limited application to upstream engineering or manufacturing-related competencies. The challenge of maintaining tools and knowledge structures in a rapidly evolving technological environment was also noted, along with the persistent issue of limited curriculum flexibility in higher education institutions. Additionally, the project observed low diversity in the EO workforce and called for greater inclusion in future training and recruitment efforts.

Overall, EO4GEO made a substantial contribution to the European space education and skills ecosystem. It provided a structured, replicable model for aligning education with labour market needs, and it set a precedent for other domain-specific skills alliances. Although targeted at the EO and GI sector, its methods and tools offer a transferable foundation for broader space-related workforce initiatives, including those addressing climate monitoring, smart infrastructure, urban resilience, and the digital and green transitions. Its integration of technical and transversal skills within modular training packages offers valuable insights for any future effort aimed at building a more agile, inclusive, and industry-relevant European space workforce. [17]

#### 3.1.1.2 STARS*EU

STARS*EU (Space Technology And Research Support Europe) was a coordination and support action funded by the European Commission (DG DEFIS) that made a significant contribution to the understanding of Europe's space research and innovation (R&I) competencies, with a strong focus on education, training, and workforce development. Launched in 2021 and aiming to span until 2027, the project was designed to assess skills supply and demand across the space value chain and to identify gaps between the qualifications provided by education systems and the capabilities required by employers in both research and industry contexts. [10]

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At its core, STARS*EU sought to provide a foundation for "skills for an innovative EU space ecosystem," ensuring that European educational and training pathways are aligned with emerging needs in satellite engineering, space services, and the broader application of space technologies. It approached this through an extensive stakeholder consultation process, which included a pan-European workforce and skills survey targeting universities, research institutions, SMEs, large space companies, and public sector entities. The survey received 71 responses and was complemented by a structured analysis of 150 job advertisements, enabling the project to extract trends in degree requirements, skill expectations, and hiring priorities. [18]

The findings of this dual-track analysis revealed several important patterns. Employers across the sector reported persistent difficulty in recruiting candidates with the right mix of technical and soft skills. While Europe's educational systems were generally considered robust, many graduates were found to lack practical experience and applied engineering competencies. Particularly in the upstream and midstream segments, a preference for candidates with hands-on capabilities and multidisciplinary profiles was noted. At the same time, the study emphasized that soft skills such as teamwork, communication, and problem-solving were valued on par with technical expertise—a sentiment strongly echoed by both industry and research organizations.

STARS*EU also highlighted a mismatch between the educational output and the industry's entry-level expectations. A notable divergence emerged between universities—often producing research-oriented profiles, especially PhDs—and employers, who frequently seek candidates with more applied skills at Master's level. Furthermore, gender imbalance was flagged as a systemic challenge, with the sector remaining male-dominated across most roles. The project quantified this disconnect by noting that 91% of employers felt that graduates required significant on-the-job training before becoming operational.

To support better education-to-employment transitions, STARS*EU developed the Space Career Launchpad, a publicly accessible online platform offering job and internship listings, as well as guidance materials for students and graduates. This initiative, launched in partnership with DG DEFIS, aimed to facilitate earlier engagement between learners and employers, thereby reducing onboarding time and improving retention in the sector. [19]

In addition to its research activities, STARS*EU organized a high-level policy workshop on "Skills for an Innovative EU Space Ecosystem" in Brussels (October 2023), bringing together representatives from industry, academia, and policymaking. This event served as a forum to validate survey findings and generate concrete proposals for addressing identified gaps. Outcomes included calls to strengthen university-industry collaboration, standardize space-related qualifications across Europe, increase multidisciplinary course offerings, and better integrate non-STEM domains such as space law, policy, and business into educational planning.

A key recommendation emerging from STARS*EU was the need to sustain workforce adaptability through continuous professional development and reskilling initiatives. The project underscored the importance of emerging skill areas—including AI, cybersecurity, and regulatory strategy—and the growing demand for hybrid professionals who combine technical knowledge with policy or entrepreneurial acumen.

While STARSEU provided a valuable strategic overview, it was primarily a coordination and research action rather than an implementation project. It did not directly develop or deliver training modules but rather served as a foundation for subsequent actions, such as the design of the Erasmus+ SpaceSUITE project, which expanded the findings into concrete educational programming for downstream skills. STARSEU's diagnostic findings also directly informed the direction of ASTRAIOS, especially in terms of its focus on curriculum mapping, taxonomy building, and aligning mobility with labour market needs.

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Overall, STARS*EU delivered an integrated, cross-sector snapshot of skills demand and supply across the European space domain. By combining quantitative evidence with expert stakeholder dialogue, it provided a baseline for understanding where the education system excels and where critical gaps remain. Its recommendations have since been taken up in European Commission policy discussions and provide a reference point for current and future skills-focused initiatives in the space sector.

### 3.1.2 Erasmus+

Under Erasmus+, the European Union has supported dedicated alliances and partnerships to innovate space education and training. These projects typically unite higher education institutions, industry, and other stakeholders to modernize curricula, promote mobility, and create new learning opportunities aligned with the space sector's evolving needs. Two significant Erasmus+ initiatives in this context are SpaceSUITE (an Erasmus+ Blueprint project focused on space skills) and UNIVERSEH (a transnational European University alliance dedicated to space). Each tackles workforce development from a different angle – one through sector-wide skills cooperation, and the other through deep academic integration – but both contribute substantially to preparing a future-ready space workforce.

#### 3.1.2.1 SPACESUITE

SpaceSUITE (Space Skills for a United and Innovative Europe) is an Erasmus+ Blueprint Alliance launched in 2024 with the goal of addressing the growing demand for skills in the space downstream sector. Building on the legacy of EO4GEO, this initiative expands its focus to cover not only Earth Observation (EO) but also Satellite Navigation (GNSS) and Satellite Communications (SatCom)—three domains central to Europe's evolving space economy. SpaceSUITE operates within the broader framework of the Space4GEO Alliance, and its primary objective is to bridge the gap between the supply of training and education and the actual skills demanded by industry, while also supporting lifelong learning and career development for existing professionals. [11]

Coordinated by GISIG (Italy) and involving a consortium of universities, research institutions, companies, and public agencies, SpaceSUITE takes a comprehensive and multidisciplinary approach to workforce development. From the outset, one of its key activities has been the updating and expansion of the EO4GEO Body of Knowledge to include GNSS and SatCom. This effort involves expert working groups mapping domain-specific knowledge—such as GNSS signal processing or telecom payload operations—into an integrated ontology that aligns with European qualifications frameworks and ESCO occupational classifications.

The project adopts a skills intelligence-led methodology, conducting both demand-side (job market) and supply-side (education programme) analyses. This includes the review of job postings, employer surveys, and curriculum mappings across Europe. Preliminary findings have revealed skills gaps in areas such as satellite cybersecurity, secure SatCom networks, and the integration of downstream data streams. These insights directly inform the design of new curricula and training modules being developed by the consortium, which range from university-level courses to vocational and secondary-level learning resources.

SpaceSUITE emphasizes a co-creation model, ensuring that training content is developed in collaboration with industry and service providers. For example, its Open Schools programme in Italy offers applied training in precision agriculture using Copernicus data, while its "Great Disaster Challenge," initiated by the Norwegian Space Agency, introduces secondary students to EO-based problem-solving. In parallel, professional development modules are being created and deployed via platforms like EO College, including courses on flood mapping, satellite navigation for emergency response, and satellite communications systems for IoT applications.

An important feature of the project is the enhancement of digital tools, particularly the curriculum design platform inherited from EO4GEO. SpaceSUITE is expanding this tool to accommodate cross-domain integration

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and modularity, allowing educators to align training content with recognized competence standards and adapt it to new application areas. These tools are delivered through an online portal where educators can access and repurpose open-licensed content, fostering sustainability and uptake.

Strategic alignment with EU institutions is a key strength of the project. SpaceSUITE engages closely with EUSPA (for GNSS), ESA Academy, and the Copernicus Academy network, contributing to forums such as the EU Space Networks Assembly. The project's outputs have been positioned as inputs to initiatives like the Pact for Skills and national space education strategies, demonstrating its policy relevance.

Despite its early successes, the project faces several challenges. The scope is broad—spanning EO, GNSS, and SatCom, and targeting audiences from secondary school to lifelong learners—which requires careful prioritization to ensure depth and quality. Moreover, curriculum innovation depends on institutional adoption, which can be slow due to administrative inertia or disciplinary silos. SpaceSUITE's engagement with university networks, including the European University Association, will be essential for broader integration.

Sustainability is another concern. As with EO4GEO, maintaining and updating the Body of Knowledge and supporting tools beyond the project's life will require institutional commitment and possibly new funding mechanisms. SpaceSUITE's incorporation into the Space4GEO Alliance is intended to support long-term continuity, but its effectiveness will depend on ongoing stakeholder engagement.

The project's primary focus is downstream, meaning that upstream engineering skills are not addressed directly. However, many of its activities—such as fostering cross-domain thinking and building interoperable knowledge frameworks—offer indirect benefits to midstream and upstream sectors by ensuring that application developers and service providers are equipped to communicate requirements upstream and across systems. [11]

SpaceSUITE's relevance to the European space workforce agenda is considerable. The downstream sector is a major driver of economic value, and its success depends on a well-trained workforce capable of leveraging data from Copernicus, Galileo, and future constellations like IRIS². By equipping learners with integrated skills in EO, navigation, and communications, SpaceSUITE ensures that investments in space infrastructure translate into meaningful applications across agriculture, emergency response, environmental monitoring, and more. The project's efforts to attract new talent—including women and underrepresented groups—also address the pipeline challenge, ensuring a more inclusive and future-ready workforce.

In summary, SpaceSUITE represents a major step forward in creating a cohesive and responsive education and training ecosystem for the European space downstream sector. Its modular, open, and policy-aligned outputs—combined with a strong focus on skills intelligence and industry collaboration—position it as a cornerstone for Europe's efforts to remain globally competitive and strategically autonomous in the space domain.

#### 3.1.2.2 UniversEH

UNIVERSEH (European Space University for Earth and Humanity) is a flagship Erasmus+ European Universities Alliance, established in 2020, that aims to create an integrated, transnational "space university" dedicated to educating the next generation of space professionals. The alliance brings together leading universities from across Europe to offer a uniquely interdisciplinary, international, and future-focused model of space education. Its mission is to modernize higher education in the space sector by embedding mobility, multilingualism, diversity, and innovation into all levels of academic training. [12]

The UNIVERSEH alliance is built on the principle that no single university can cover the full spectrum of space-related disciplines alone. Through close collaboration, its partner institutions co-develop curricula, share resources, and offer students access to a much broader and richer learning environment than any could

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provide individually. The alliance began with five core universities—Université Fédérale de Toulouse (France), Heinrich Heine Universität Düsseldorf (Germany), Luleå University of Technology (Sweden), University of Luxembourg, and AGH University of Science and Technology in Kraków (Poland)—and has since expanded to include institutions from seven European countries. Together, these partners represent a student body of over 130,000.

Central to UNIVERSEH's approach is mobility. Students enrolled at one university can take courses at others within the alliance, both physically and virtually, thanks to an integrated recognition and diploma framework. A dedicated mobility platform helps students navigate course offerings, short-term exchanges, and thematic programs such as the Arctic Winter School. The alliance also fosters multilingualism through initiatives like the "Languages for Space" programme, where space-related content is taught in multiple European languages to promote intercultural fluency in future professionals.

Curriculum development is guided by joint course mapping and skills foresight, informed by employer surveys and advisory boards. UNIVERSEH offers a wide variety of new course modules—ranging from technical subjects like space vehicle dynamics to interdisciplinary minors such as space entrepreneurship and space resources. These modules are delivered through blended learning formats that include challenge-based projects, hybrid labs, and the use of virtual and augmented reality for simulation and problem-solving.

UNIVERSEH also places strong emphasis on embedding social sciences, arts, and humanities into the space education framework. This multidisciplinary model reflects the complex, interconnected nature of the space domain, where technology, policy, economics, and culture intersect. For instance, courses like "Space and Society," co-developed by humanities departments, and electives in space law and policy demonstrate how the alliance is preparing graduates to engage with the ethical, legal, and socio-political dimensions of space activity.

Entrepreneurship and innovation are integral to the UNIVERSEH vision. Through the "Beyond UNIVERSEH" stream, students participate in hackathons, start-up incubators, and entrepreneurial coursework. One notable output is the Space Innovation Challenge, where students from different universities collaborate on real-world start-up ideas, supported by mentoring and incubation opportunities. These activities complement academic content by fostering creativity, business acumen, and cross-disciplinary teamwork.

The alliance also focuses on inclusivity and accessibility. It offers additional support for students from disadvantaged backgrounds, including language resources, flexible mobility funding, and bridging programs for those entering space studies from unrelated fields. Initiatives like "Women in Space Careers" events and mentorship schemes promote gender balance, helping address persistent equity gaps in the sector.

UNIVERSEH has produced several important outputs to date. These include jointly delivered courses, short programs like the Human Spaceflight Summer School, and intensive workshops on emerging fields such as space sustainability and traffic management. A unique contribution is the Multilingual Illustrated Dictionary of Space Concepts, which harmonizes terminology across the alliance's languages and supports both linguistic and domain literacy. Another output is the internal employer survey report, which identified key technical (e.g., AI, systems engineering) and soft skills (e.g., project management, teamwork) needed by space companies—insights that were used to adjust course design in real time. [20]

The alliance's digital learning and collaboration platform hosts courseware, project tools, and student-created content. By embracing open educational practices, UNIVERSEH ensures that its innovations benefit not only its members but also the broader European higher education landscape. Its influence is further amplified through policy engagement, with regular briefings to the European Commission on issues such as qualification recognition and the design of joint degrees.

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Despite its successes, UNIVERSEH faces several challenges. Harmonizing credit systems, assessment policies, and administrative processes across countries remains complex, slowing the development of fully joint degrees. Securing long-term funding is another concern; while the alliance has received a second phase grant (2023–2027), its sustainability beyond the Erasmus+ framework will depend on institutional integration or external support. There are also areas for expansion—such as further inclusion of disciplines like materials science or manufacturing, and the involvement of more non-member students through open access to programs.

UNIVERSEH is primarily oriented toward high-skilled roles—engineers, scientists, researchers, managers—which aligns with the mandate of European universities. However, it does not directly cover vocational training needs, which must be addressed in parallel by other initiatives such as SpaceSUITE or national VET programmes. Moreover, while UNIVERSEH's offerings are open to all enrolled students, there remains a need to ensure broader reach and avoid exclusion of learners less able to participate in intensive, mobile, multilingual settings.

The relevance of UNIVERSEH spans the entire space value chain. Its graduates are equipped for upstream careers in engineering and mission design, midstream roles in systems operations and mission planning, and downstream applications involving data exploitation, entrepreneurship, and public policy. The alliance's curricular alignment with future-oriented topics—space sustainability, ethics, innovation—ensures that students are prepared for roles in emerging fields such as space traffic management and commercial New Space services. Its commitment to interdisciplinary, multilingual, and real-world education cultivates graduates who can operate across traditional boundaries and thrive in collaborative international environments.

In summary, UNIVERSEH is a transformative force in European space education. It models how academic institutions can pool expertise, innovate pedagogy, and align with industry needs to produce a new generation of space professionals. Its open, inclusive, and forward-looking approach contributes directly to building a strategic and sustainable talent pipeline for Europe's space sector—supporting upstream technical excellence, downstream service innovation, and cross-sectoral policy engagement alike.

### 3.1.3 Associations

Beyond formal projects and university alliances, the development of Europe's space workforce is strongly supported by various associations, networks, and collaborative initiatives. These range from public-private campaigns to professional and educational networks, and they play crucial roles in advocacy, knowledge sharing, and capacity building. Unlike time-bound projects, these associations often provide ongoing platforms for engagement, best practice exchange, and outreach to new audiences. Below we examine three such initiatives: Space4All (a broad STEM awareness campaign with international significance), the Copernicus Academy (a network to foster skills and user uptake in Earth observation), and the ESA Academy & Space Academy programs (education and incubation initiatives led by ESA and EU to prepare students and entrepreneurs). Each of these contributes in different ways to building a robust and inclusive space workforce pipeline.

#### 3.1.3.1 Space4All

Space4All (Space STEM Awareness Campaign) is a large-scale awareness campaign launched in 2024 to address the growing space workforce gap by inspiring and preparing the next generation of space professionals. Though not a European initiative, its mission and structure offer valuable insights for global efforts aiming to improve workforce inclusivity, increase STEM enrolment, and connect citizens with space opportunities. Led by the U.S. National Space Council and Department of Education, the campaign is a public-private partnership

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supported by over 150 organizations—including Women in Aerospace (WIA), AIAA, the Space Foundation, and Blue Origin's Club for the Future—all unified by a shared goal: to show that "space is for everyone." [21]

Space4All's activities are structured as a five-year public engagement campaign (2024–2028) with national visibility and high-level political support. Its core message emphasizes relevance and accessibility—demonstrating how space careers benefit society and are within reach for diverse populations, particularly underrepresented groups. It aims to broaden the talent pipeline by creating clear pathways into space education and jobs and by fostering early interest in STEM subjects through schools, community events, and online platforms. [13]

Key campaign components include national and local outreach events—such as space fairs, astronaut Q&As, and industry open houses—as well as an expansive digital engagement strategy using social media challenges, videos, and virtual content. A major focus is placed on empowering educators: the campaign provides school toolkits, lesson plans, and guidance to teachers and counselors to help them promote space STEM pathways. Through its mentorship and role model programs, Space4All facilitates direct interaction between students and professionals from its partner organizations, with particular emphasis on outreach to minority-serving institutions and underserved communities.

Space4All's network of over 150 "Space Champions"—comprising corporations, government agencies, universities, and science centers—serves as a multiplier for campaign reach. These partners integrate Space4All messaging into their own initiatives, host thematic exhibitions, sponsor internships, or develop challenge-based learning programs. The campaign's integration into a broader Interagency Roadmap for STEM Education and Space Workforce ensures that it aligns with national workforce strategies and tracks outcomes over time. [13]

As of early 2025, Space4All has generated significant visibility through national announcements and community engagement, with tangible deliverables such as a unified public message, educator toolkits, and potentially a public portal linking students to internships, scholarships, and job opportunities. Among its early outputs are student activity badges, virtual learning materials, and a Multilingual Space Dictionary to harmonize educational resources. The coalition itself—uniting government, education, and industry—is a unique structural innovation, positioned to create systemic impact over time.

Space4All reflects several effective practices relevant to European workforce planning. Chief among these is its strong public-private partnership model, bringing together government leadership with the networks and expertise of industry and nonprofit actors. Its emphasis on diversity and equity—by proactively engaging underserved populations and highlighting role models from varied backgrounds—addresses one of the root causes of long-term workforce underrepresentation. It also benefits from policy alignment: its goals are nested within a national strategy and are supported by sustained federal attention.

Additionally, Space4All's framing of space as part of everyday life—linking it to internet access, climate monitoring, disaster response, and exploration—helps demystify the sector and strengthen public engagement. The campaign's emphasis on storytelling and community relevance could serve as a model for how Europe communicates the value of space to its citizens and young learners. [21]

As a communications and awareness effort, Space4All does not itself create curricula or jobs, and its success depends on follow-on action from partners and institutions. Measuring its long-term impact—especially whether it translates into STEM enrolments and workforce retention—will require time. Furthermore, the decentralized nature of its 150+ partners presents coordination challenges. Yet, its centralized leadership, dedicated messaging, and data-driven rationale (e.g. citing demographic workforce statistics) provide a strong foundation for systemic influence. [13]

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For Europe, the Space4All model highlights how strategic, high-visibility engagement campaigns can complement more technical skill-building programs. The need to attract more young people into STEM, particularly women and minorities, is as urgent in Europe as it is in the U.S. A European campaign inspired by Space4All could mobilize ESA, EU institutions, education ministries, and industry associations to launch coordinated public engagement and STEM pathway initiatives—building on the work of ESERO, SGAC, and national actors.

Ultimately, Space4All underscores that tackling workforce shortages begins not only with curriculum reform or technical training, but also with public inspiration, early exposure, and accessible role models. As Europe seeks to sustain leadership across upstream, midstream, and downstream space activities, the lessons of Space4All may serve as a timely reminder: an inclusive and motivated generation is the essential starting point for long-term workforce resilience.

#### 3.1.3.2 Copernicus Academy

The Copernicus Academy is a voluntary network of universities, research institutions, training centres, and innovation stakeholders launched by the European Commission in 2016 as part of its Copernicus User Uptake strategy. Its core objective is to bridge the gap between the availability of Copernicus Earth Observation (EO) data and the skills required to exploit it effectively. By strengthening training and education in the geospatial domain, the Academy supports the wider uptake of Copernicus data and services across public, private, and academic sectors. [22]

The network promotes interdisciplinary curricula—particularly at Master's and vocational levels—that embed Copernicus data use into course content. It supports the upskilling and reskilling of professionals through continuous training, and encourages collaboration between academia and industry by facilitating internships, co-designing projects, and stimulating entrepreneurship. The Academy also plays a vital role in disseminating knowledge beyond traditional EO communities, fostering outreach to new user groups, and raising awareness of Copernicus's societal value. [23]

While it does not provide funding to its members, the Copernicus Academy offers a framework for collaboration, mutual support, and alignment with European space policy goals. Coordinated by the Copernicus Support Office, the network has grown to include over 200 member organizations—primarily in Europe—with members committing to activities that advance the Academy's mission. These include curriculum development, professional training, workshops, hackathons, and the creation of teaching resources using Sentinel data. Members frequently collaborate to develop shared resources, such as tutorials, exercises, and case studies hosted on open platforms, covering topics like flood monitoring, agriculture, air quality, and urban planning. [14]

The Academy has fostered a strong knowledge-sharing culture, with members regularly exchanging best practices and forming thematic clusters (e.g. marine, climate, urban analytics). These interactions are facilitated by the annual Copernicus Academy General Assembly and through links with the Copernicus Relays—another network focused on awareness and business engagement. Many members also participate in other EU initiatives (e.g. EO4GEO, SpaceSUITE), allowing the Academy to amplify and disseminate results from complementary projects. Members submit annual action plans outlining their educational contributions and are encouraged to track engagement and outputs, such as student participation or materials developed.

A notable example of impact is the Academy's role in promoting the Copernicus Massive Open Online Courses (MOOCs), launched by the European Commission to provide free, accessible training in EO data usage. Many Academy members were content creators or facilitators for these MOOCs, contributing to a wide global reach. In Italy, members formed a national consortium (CICA) to coordinate activities and successfully introduced

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Copernicus into school curricula. Similar efforts across Europe have supported the integration of EO into vocational education, and even informed school-level educational initiatives. [22]

The Academy also enables university-industry partnerships. For instance, some institutions have facilitated internships in user sectors like agriculture, insurance, and disaster management, where students apply EO techniques in real-world contexts. These collaborations promote practical experience and, in some cases, have led to start-ups or spin-offs that commercialize Copernicus-based solutions. The Academy's multiplier effect thus extends beyond academia, contributing to Europe's growing geospatial economy.

Several best practices have emerged from the Copernicus Academy. One is its clear identity and flexible participation model: by setting expectations without funding obligations, the Academy enables wide engagement while promoting accountability through action plans and progress monitoring. Another is its synergy with other EU projects—Academy members often localize or adapt outputs like EO4GEO's Body of Knowledge, allowing faster dissemination of tools and content across contexts. The Academy's emphasis on interdisciplinarity is also a key strength, reflecting the integrated nature of modern EO applications that often require skills spanning IT, environmental science, and social impact assessment.

Despite its achievements, the Academy faces challenges. Participation levels vary, and the reliance on voluntary engagement can lead to uneven activity across the network. Measuring the network's direct contribution to workforce outcomes is difficult, as tracking employment trajectories of students is beyond its scope. Additionally, the Academy's thematic focus on EO means that other space domains (e.g. GNSS, SatCom) remain underrepresented, although some members address these areas informally. Calls have been made—e.g. through STARS*EU and SpaceSUITE consultations—for a broader "European Space Academy" model to integrate and coordinate training across all segments of the space value chain.

The Academy must also keep pace with rapidly evolving technologies, such as cloud platforms and AI integration in EO analysis. Without core funding, the updating of training content relies on members' initiative. Local language and curriculum differences also require adaptations, particularly for members outside the EU who may face additional coordination hurdles. Nevertheless, the network's openness, flexibility, and focus on cross-sector knowledge sharing continue to make it a highly effective instrument for geospatial capacity building.

The Copernicus Academy's relevance lies primarily in supporting Europe's downstream workforce—preparing data-savvy professionals capable of transforming EO data into actionable insights for sectors like climate adaptation, agriculture, energy, and urban development. It indirectly supports upstream and midstream segments by stimulating user demand for EO services, which in turn drives satellite development and data processing infrastructure. The Academy also promotes entrepreneurship and public sector innovation, making it a critical enabler of the EU's Green Deal and digital transition strategies.

In conclusion, the Copernicus Academy is a key pillar in Europe's space skills ecosystem. Its decentralized, collaborative structure allows it to rapidly scale awareness, education, and training across the continent. By continuing to evolve and connect with complementary initiatives, it has the potential not only to sustain Europe's leadership in EO but also to serve as a model for domain-specific networks in other space sectors, reinforcing a holistic and future-ready space workforce across Europe.

#### 3.1.3.3 ESA/Space Academy

ESA Academy is the European Space Agency's flagship education programme for university students, designed to bridge the gap between academic learning and the practical skills needed in the space sector. Since its official launch in 2016, the Academy has offered students from ESA Member States and cooperating countries

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structured opportunities to gain hands-on experience, technical training, and professional insight into the functioning of the European space ecosystem. [24] [25]

The programme is built around three interrelated pillars: Hands-on Projects, Training and Learning, and Academic Engagement. Under the Hands-on Projects pillar, ESA Academy offers initiatives such as *Fly Your Satellite!*, *REXUS/BEXUS* (in collaboration with national agencies), and *Drop Your Thesis!*. These programmes allow university teams to participate in the full lifecycle of a space project—design, integration, testing, and in some cases, actual launch and operations—under the guidance of ESA experts. This immersive approach introduces students to professional standards, teamwork, and project management methodologies rarely covered in traditional academic settings. [24]

The Training and Learning component consists of intensive one-week workshops delivered at the ESA Academy's Training and Learning Facility in ESEC-Galaxia (Belgium), or virtually. Topics cover a wide range of space disciplines, from satellite communications and mission analysis to space law, systems engineering, and product assurance. The training methodology includes simulations of real-world scenarios such as concurrent engineering exercises, with sessions taught by ESA staff and industry professionals. ESA Academy also emphasizes soft skills such as communication, leadership, and multidisciplinary teamwork. [15]

Academic Engagement strengthens links with universities through co-supervised student projects, participation in conferences, and support for integrating ESA content into degree programmes. The Academy provides guidance to universities seeking to set up CubeSat programmes and shares technical handbooks and educational resources across its network. Through these channels, ESA Academy serves as a consistent entry point into the space workforce, equipping students with practical tools, ECSS standards exposure, and an understanding of ESA's operational culture. [26]

The impact of ESA Academy is substantial. Thousands of students have participated in its training sessions, many of whom have gone on to pursue careers at ESA, national agencies, or space companies. CubeSats developed through Academy-supported programmes have been successfully launched into orbit, and student-led experiments have contributed to peer-reviewed scientific research. Alumni frequently cite ESA Academy participation as critical to accelerating their transition from student to professional.

Best practices from ESA Academy include its balanced focus on theory and practice, use of dedicated facilities that simulate professional environments, and emphasis on inclusivity—ensuring that students from a wide range of universities can participate regardless of location or institutional prestige. The Academy's merit-based selection process, coupled with travel support, promotes equity and diversity. Knowledge transfer is institutionalized through expert-led sessions that share hard-won lessons from past ESA missions. ESA Academy's model of combining project experience, technical training, and soft skills development has become a reference for structured, high-impact space education.

While the Academy is highly effective, its reach remains limited in scale: most workshops serve ~30 students, and major projects like *Fly Your Satellite!* are competitive and resource intensive. Efforts to expand capacity through virtual training have helped, but demand continues to exceed availability. The Academy's focus also remains primarily on upstream and mission-driven skills, with limited (though growing) inclusion of downstream themes like EO application and service innovation. Long-term engagement with alumni is informal, though ESA programmes such as the Young Graduate Trainee, (ESA Graduate Trainees) scheme often serve as the next step.

In parallel with formal education, European efforts to build a dynamic space workforce have also included entrepreneurship-focused initiatives under the "Space Academy" branding. A key example was the SpaceUp project (Horizon 2020, 2018–2021), which organized *Space Academy* events—intensive workshops targeting

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space start-ups and SMEs. These events provided business coaching, investor matchmaking, and personalized consulting to early-stage companies.

Space Academy events addressed gaps in business skills among technically trained founders by offering tailored sessions on investment readiness, intellectual property, financial planning, and EU funding mechanisms. Participating start-ups engaged in one-on-one sessions with experts, received strategic advice on scaling and go-to-market strategies, and pitched to investors in structured forums. Outputs included an Investment Readiness Checklist, a funding guide for space SMEs, and the *Space Academy Handbook*—resources that continue to inform entrepreneurial training in Europe.

The impact of these events was tangible: dozens of start-ups gained funding, formed new partnerships, or accelerated their market entry. The events also strengthened the ecosystem by connecting founders with mentors, investors, and support organisations. Although SpaceUp concluded in 2021, its methodology has influenced ongoing programmes, including ESA's Business Incubation Centres (BICs) and the European Innovation Council's entrepreneurship support efforts.

Together, ESA Academy and entrepreneurship-oriented *Space Academy* initiatives address complementary needs. ESA Academy supports the technical and project-based development of future engineers and scientists—often in upstream and midstream segments—while Space Academy-style workshops empower innovators and entrepreneurs in the downstream domain. The combined effect ensures that Europe cultivates both skilled professionals ready to contribute to institutional missions and entrepreneurial talent capable of driving the growth of New Space services and applications.

This dual-track approach—technical readiness and business innovation—aligns with Europe's strategic objectives for space sector growth. ESA Academy helps meet immediate workforce demands in satellite design, systems engineering, and mission operations. Meanwhile, the entrepreneurship track contributes to long-term sustainability by building companies that will generate future employment and value creation. As the space sector becomes increasingly commercial, integrated with digital technologies, and user-driven, both tracks are essential for a resilient, adaptable, and competitive European space workforce.

### 3.1.4 Summary of Findings

The landscape of space workforce development in Europe is shaped by a broad array of initiatives targeting various segments of the space value chain. These projects have addressed upstream engineering, midstream operations, and downstream service applications, reflecting the sector's growing complexity and importance.

Among the most impactful initiatives are EO4GEO, STARSEU, SpaceSUITE, and UNIVERSEH. EO4GEO laid a foundational framework for skills development in Earth Observation, delivering a comprehensive Body of Knowledge and tools to support curriculum design. STARSEU, though more research-oriented, provided strategic insights into industry expectations and gaps in academic training. SpaceSUITE has built on this foundation, expanding to GNSS and SatCom domains while enhancing digital tools and industry co-creation. UNIVERSEH, in parallel, exemplifies academic integration and mobility, fostering interdisciplinary and innovation-driven education across European universities.

Other complementary actors such as the Copernicus Academy and ESA Academy contribute by scaling outreach, enabling hands-on training, and linking academia to space. These ecosystems have helped improve curriculum relevance, promote mobility, and offer pathways for education-to-employment transitions.

Table 2 below offers a snapshot of these major initiatives:

Table 2: Comparative overview of past projects

| Project Name | Period | Funding Source | Focus Segment | Target Audience | Key Outputs | Identified Gaps |
|---|---|---|---|---|---|---|

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| | | | | | | |
|---|---|---|---|---|---|---|
| EO4GEO | 2018–2022 | Erasmus+ | Downstream | Students, Educators, Professionals | Body of Knowledge, Curricula, Tools, Alliance | Limited upstream focus, curriculum rigidity, diversity |
| STARS*EU | 2021–2027 | EC | All (emphasis on Up/Mid) | Universities, Industry, Policymakers | Skills Survey, Space Career Launchpad, Policy Workshop | Mismatch of academic output vs. industry need |
| SpaceSUITE | 2024–2028 | Erasmus+ | Downstream | Students, Vocational Learners, Professionals | Expanded BoK, Training Modules, School Programmes | Integration across domains, sustainability |
| UNIVERSEH | 2020–2024 | Erasmus+ | Full Value Chain | University Students, Researchers | Joint Courses, Mobility Platform, Innovation Challenges | Joint degree complexity, funding, reach |
| Copernicus Academy | Since 2016 | EC | Downstream | Academia, Professionals, Trainers | Curricula, MOOCs, Training Resources, Hackathons | Varied engagement, thematic limits to EO |
| ESA Academy | Since 2016 | ESA | Upstream | University Students | Hands-on Projects, Technical Training, Workshops | Limited scale, downstream integration |

To provide additional perspective, the timeline below visualizes the chronological rollout and overlap of these projects, highlighting how recent and legacy efforts have collectively evolved Europe's space education strategy.

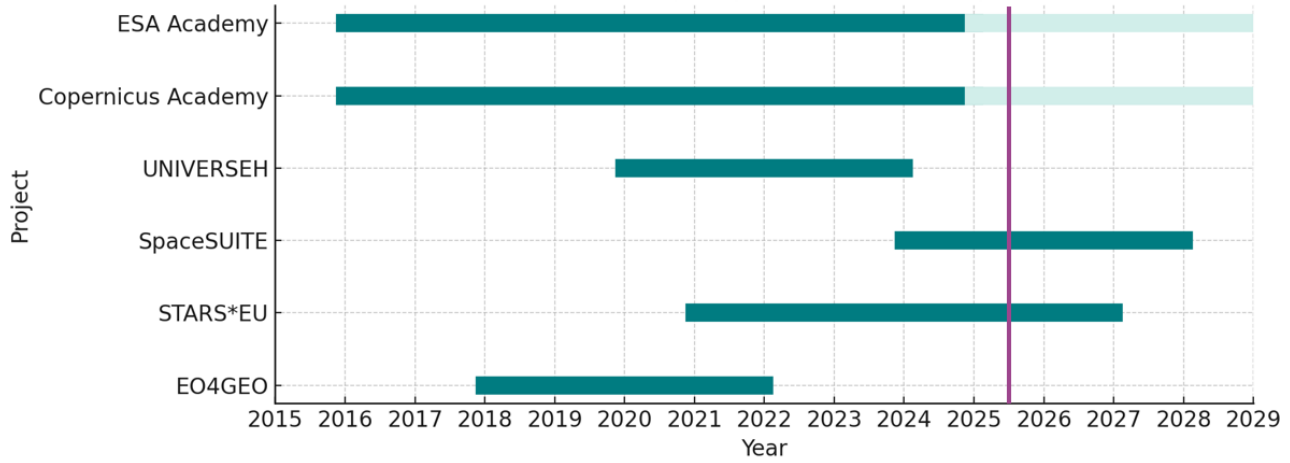


Figure 4: Timeline of past/ongoing major projects analysing the state of the space workforce

Lastly, the heatmap below illustrates skills gaps across the upstream, midstream, and downstream segments. Key deficiencies persist in areas such as cybersecurity, EO application development, and interdisciplinary soft skills like communication and project management. Notably, the downstream sector shows the greatest need for EO application skills and integrated data analytics, while upstream segments emphasize engineering and systems design expertise.

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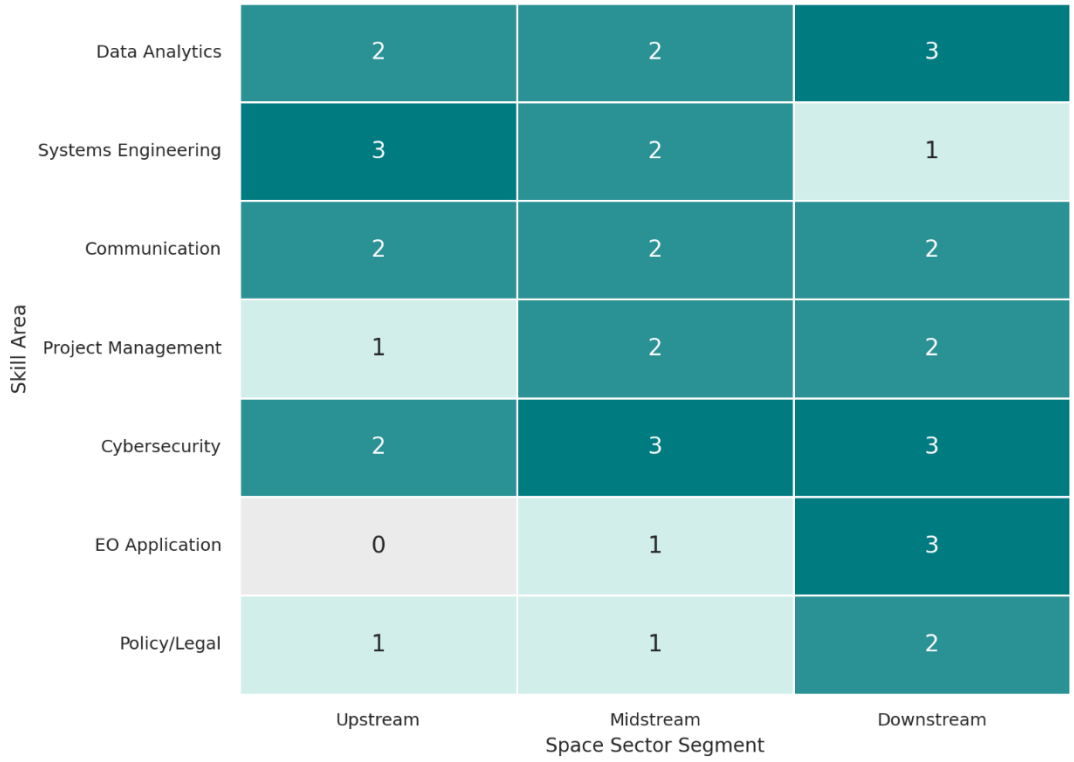


Figure 5: Heatmap of analysis activities across space sector skill areas and segments.

Together, these visualizations and findings emphasize the importance of continued investment in modular, inclusive, and industry-aligned education and training efforts. Bridging current gaps will require coordinated action across projects, institutions, and policy bodies to sustain Europe's competitiveness in the rapidly evolving space economy.

## 3.2 Findings from ASTRAIOS previous results

Building on the landscape of previous and parallel initiatives explored in Section 3.1, this section presents key findings generated within the ASTRAIOS project through the work of WP1000 (Status Quo Analysis) and WP2000 (Trends and Challenges). These work packages formed the analytical foundation of ASTRAIOS, systematically examining Europe's space-related educational offerings, workforce characteristics, and labour market signals through the integration of surveys, LinkedIn Talent Insights, curriculum catalogues, and institutional databases.

The evidence compiled under WP1000 and WP2000 provides a comprehensive, data-driven overview of the current state of the space education and workforce pipeline across the EU-27 and the UK. It captures the diversity of academic programmes, the distribution of talent across countries and career stages, and the alignment—or misalignment—between education supply and employer demand. This section focuses on three interlinked areas of insight:

- The mapping of existing space-related degree programmes and training activities across higher education institutions ( [1]);
- The evolution of the space workforce, including hiring trends and leading employers ( [3]);

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- A demographic analysis of the space labour force, covering aspects such as gender, geography, and academic background ( [3]).

Together, these findings offer a clear view of where the European space sector currently stands in terms of skills supply and structural dynamics. They also help to identify where gaps remain and where strategic action is needed to better align training systems with workforce requirements.

### 3.2.1 Mapping of Space-related Training and Education

One of the central goals of ASTRAIOS WP1000 was to establish a clear and structured overview of the current landscape of space-related education across Europe. This was accomplished through the development of a curated database of Bachelor's and Master's degree programmes offered by higher education institutions (HEIs) across the EU-27 and the UK, as reported in Deliverable [1].

The mapping exercise focused on identifying degree programmes that are explicitly dedicated to or strongly aligned with the space domain, including subjects such as aerospace engineering, satellite communications, Earth observation, space systems design, and space policy. The analysis also extended to interdisciplinary programmes that incorporate space-related modules—reflecting the increasing relevance of space technologies across diverse fields such as climate science, data analytics, and remote sensing.

The dataset includes over 350 distinct Bachelor's and Master's degree programmes identified across more than 200 institutions. Each programme was classified according to thematic focus, educational level, country, and language of instruction. Metadata fields included keywords, academic credits, delivery mode, and connections to research activities or external partnerships. The Figure 6 is bubble chart visualises shows the relative number of space-related academic programmes by country, with larger bubbles indicating higher concentrations.

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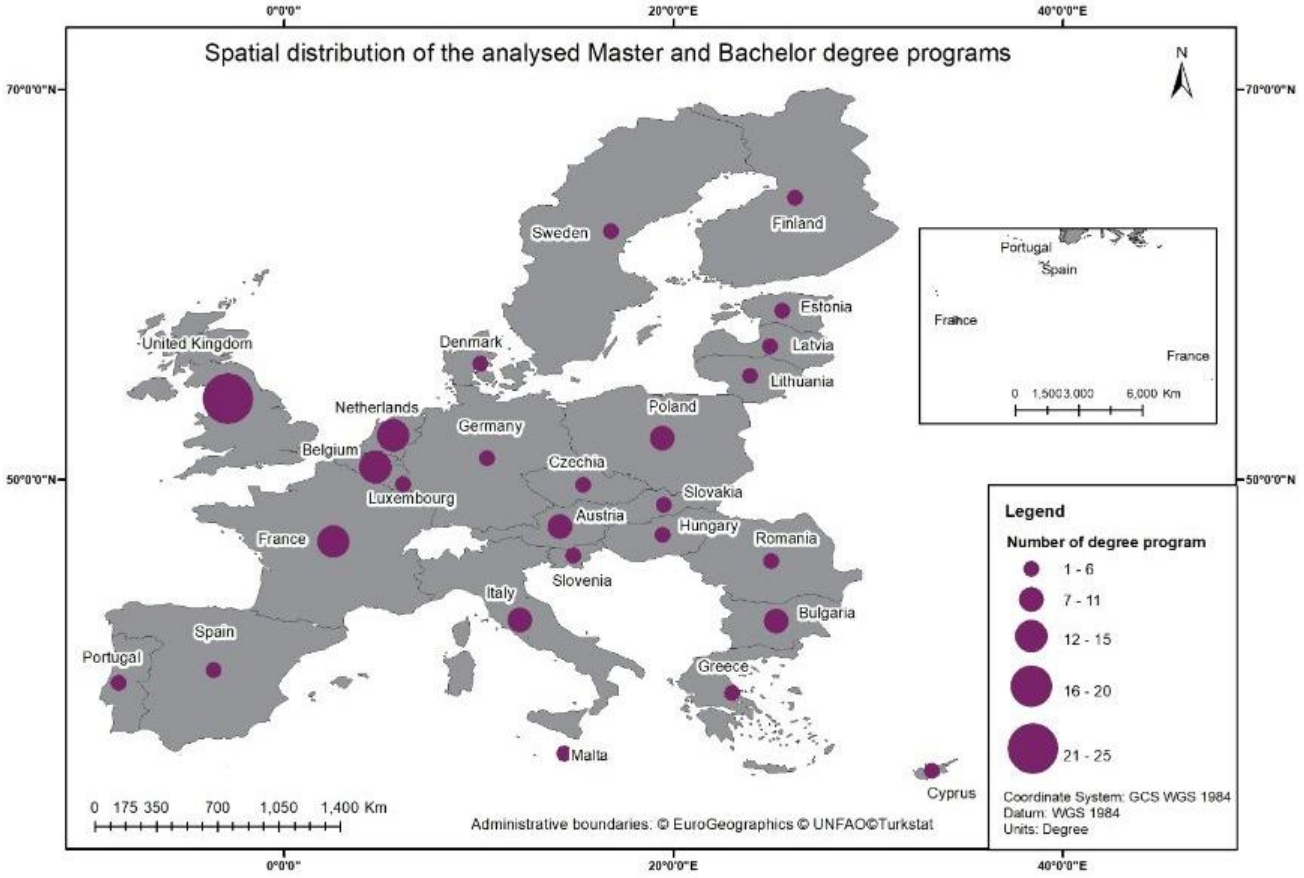


Figure 6: Spatial distribution of the analysed Master and Bachelor degree programs

Key findings reveal a concentration of space-related degree programmes in a subset of countries—notably France, Germany, Italy, and the United Kingdom—where national space agencies and established aerospace industries contribute to robust academic ecosystems. Conversely, several countries in Eastern and Southern Europe offer fewer specialized programmes, highlighting regional disparities in access to space-related education.

In terms of programme content, a clear emphasis was observed on upstream disciplines such as aeronautics and systems engineering, while midstream and downstream areas (e.g., data analytics, satellite applications, or space entrepreneurship) are less commonly covered. This points to an opportunity for curricular innovation, particularly in programmes intended to prepare students for roles in the growing space services economy.

Another important observation concerns the level of integration with international frameworks. While some programmes are aligned with ECSS standards or offer internship pathways with ESA or national space agencies, this remains inconsistent across the landscape. Language of instruction also plays a role in accessibility: English-taught programmes are more common at the Master's level and tend to be clustered in institutions that already have strong international visibility.

This mapping effort not only provides a benchmark for understanding where and how space-related education is currently delivered in Europe, but also sets the stage for strategic recommendations around curriculum harmonisation, increased interdisciplinary integration, and targeted support to underrepresented regions.

### 3.2.2 Workforce growth, hiring trends, and Major employers

The ASTRAIOS D1.3 [3] report provides a data-driven overview of the European space workforce using a combination of LinkedIn Talent Insights and multiple industry surveys. Covering the period from December

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2022 to December 2023, the analysis yielded a unique and comprehensive dataset of 171,852 LinkedIn profiles associated with the space sector across the EU-27 and UK.

This LinkedIn-derived sample serves as a valuable proxy for workforce trends, although it is acknowledged that it may overrepresent individuals in upstream and midstream roles, men, those with university qualifications, and professionals based in Western Europe.

#### 3.2.2.1 Workforce Size and Distribution

The largest national workforces identified through LinkedIn Talent Insights are: United Kingdom: 41,350 people (24% of total), France: 36,411 people (22%), Germany: 20,014 people (12%). These three countries together account for nearly 60% of the space workforce visible through LinkedIn. Countries with large public agencies or mature upstream industry—such as Italy, Spain, and the Netherlands—also show high workforce concentrations, though the report cautions against direct comparison due to varying levels of LinkedIn usage. Details number of people in the European space workforce in each country show in Figure 7.

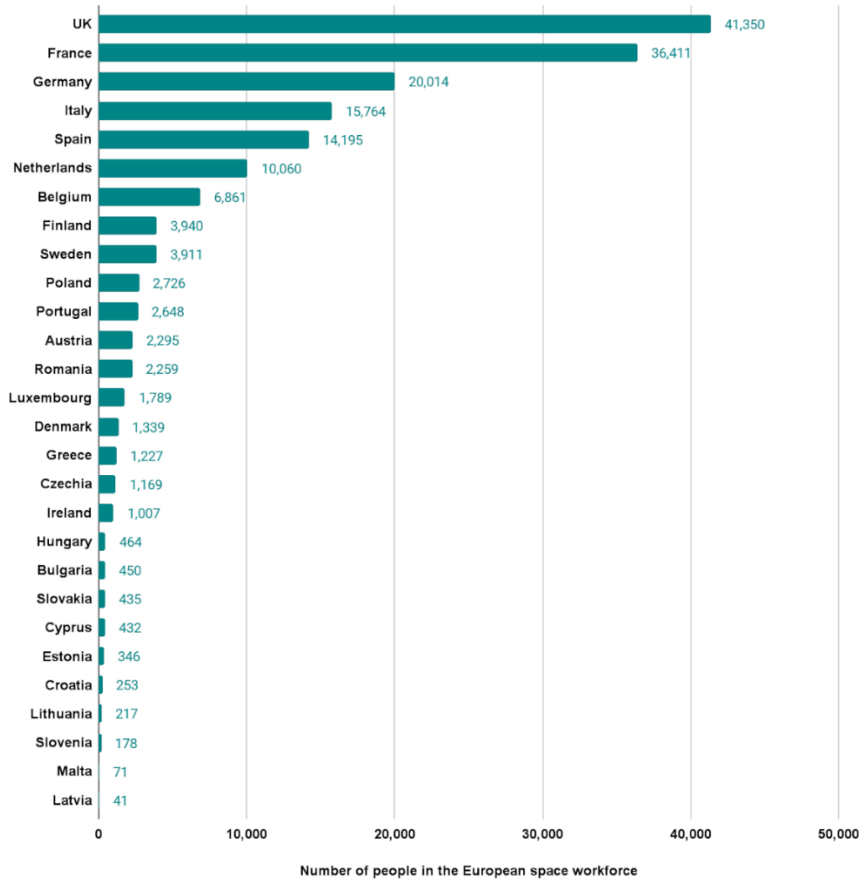


Figure 7: Number of people in the European space workforce by country.

#### 3.2.2.2 Growth Trends

Although not quantified as a specific annual growth percentage across the board, the report documents year-on-year workforce expansion in most countries. For example: Lithuania exhibited a workforce growth of +10.2%, Spain at +5.5%, and Germany at +4.8% over the 12-month period, the full list can be found in Figure 8. The findings suggest that smaller and emerging space nations are rapidly developing talent pools, even if starting from a lower base.

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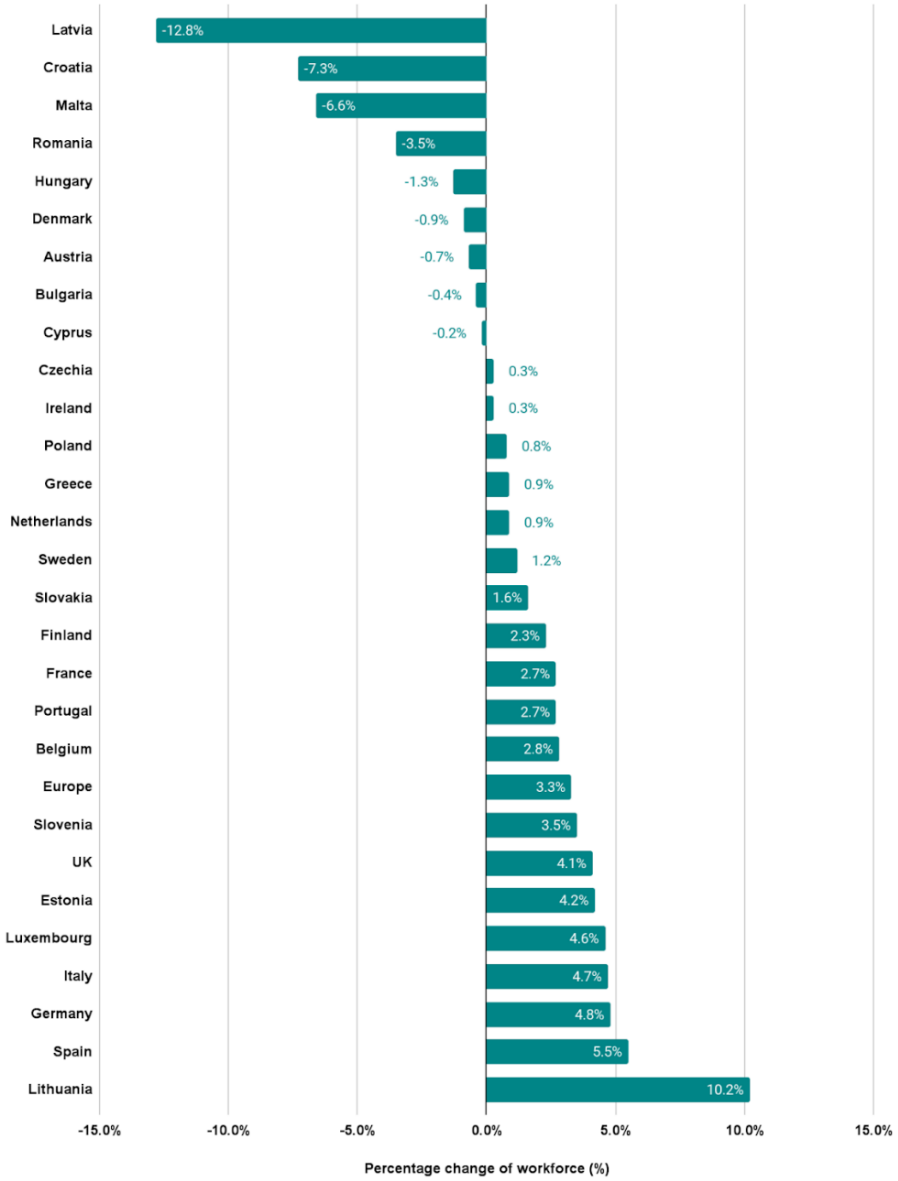


Figure 8: Percentage growth of the European space workforce by country

#### 3.2.2.3 Top Job Functions

The dominant job roles in the European space workforce as categorized by LinkedIn are: Engineering: 26%, Information Technology: 13%, Operations: 9%, the full list show in Figure 9.

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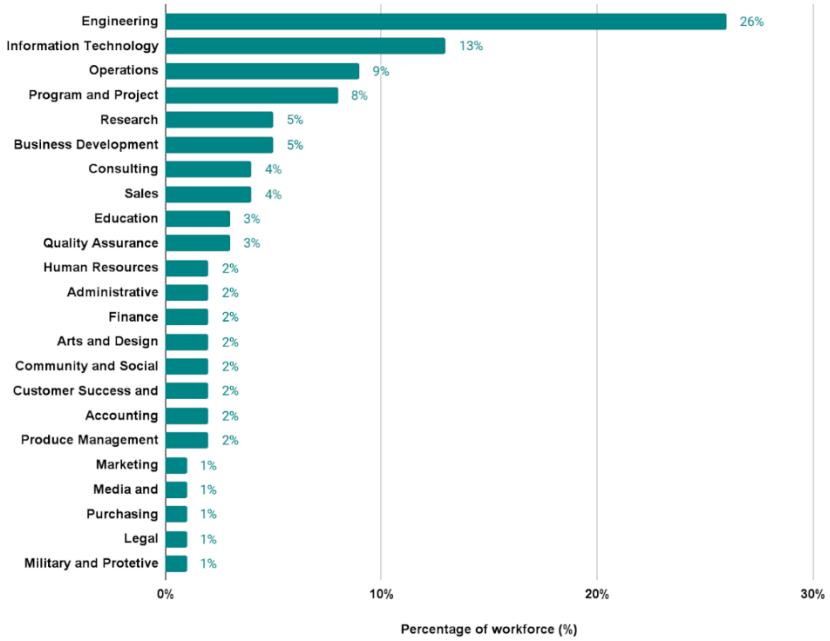


Figure 9: Percentage of European space workforce in each job function.

This figure aligns with the structural demands of upstream manufacturing and mission operations. Comparisons to national surveys (e.g., the UK's Space Sector Skills Survey) further support this distribution.

#### 3.2.2.4 Skills and Competencies

The most frequently listed skills among space professionals are: Engineering: 31%, MATLAB: 19%, Telecommunications: 18%, Python: 16% of profiles, the Figure 10 shown Ten most common skills in the European space workforce.

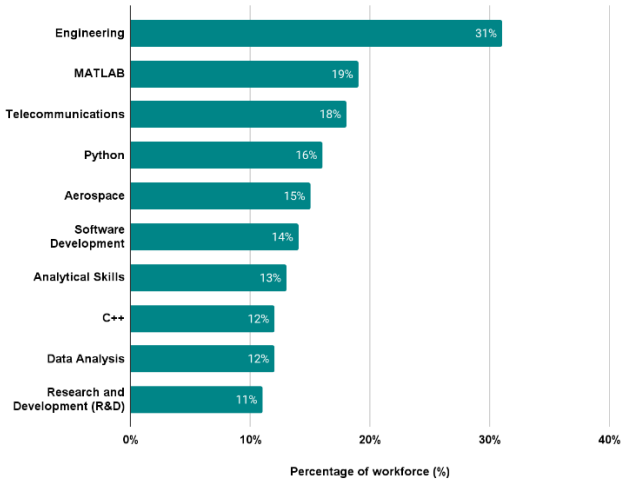


Figure 10: Ten most common skills in the European space workforce.

This reflects the continued importance of technical and software-based capabilities, particularly in upstream and midstream roles. Notably, fast-growing skills include SOLIDWORKS (+11%), Ansys (+9%), and Computer-Aided Design (CAD) (+8%), indicating an increasing need for multidisciplinary technical proficiency in system design and simulation.

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#### 3.2.2.5 Labour Market Dynamics

As a result of our research in ASTRAIOS, we can note a growing cross-sector hiring pattern, with professionals entering the space sector from adjacent fields like IT, telecommunications, and aviation/aerospace, though also leaving for the same sectors. For every 100 people entering from aviation/aerospace, 68 exit the space sector, pointing to strong but porous labour market dynamics.

This dynamic suggests that while the space sector is expanding, it competes for talent with other high-tech industries. Workforce retention may require targeted interventions, including clearer career pathways, continuous upskilling, and better integration between education and employment ecosystems.

### 3.2.3 Demographics by Gender, Geography, and Background

The demographic composition of the European space workforce, as analysed in ASTRAIOS D1.3 and D3.2 highlights persistent patterns in gender balance, geographical concentration, and academic backgrounds. These patterns have significant implications for workforce equity, educational outreach, and regional policy interventions.

#### 3.2.3.1 Gender Representation in the Space Workforce

According to LinkedIn Talent Insights data analysed in the D1.3 report, women represent 27% of the European space workforce. Gender distribution varies considerably across countries: Latvia leads with 47% female representation, whereas The Netherlands records the lowest at 21% [3]. Despite awareness and initiatives aimed at improving gender equity, longitudinal data indicates little change in these ratios since 2006, especially in upstream roles. Eurospace estimates that women represent 23% of the upstream workforce, while EARSC data shows a slightly higher 36% in the downstream Earth Observation (EO) sector.

Additional data from national agencies illustrates higher representation in administrative roles than technical ones: for example, Women made up 29% of the European Space Agency workforce in 2021[3], 34% of the German Aerospace Center (DLR) workforce in 2021[4], and 50% of the UK Space Agency in 2022[5]. The latest data for the UK estimates that women make up between 24-29% of the space workforce[6,7].

[3] Eight steps to advance ESA diversity, ESA, 2022, https://www.esa.int/About_Us/Corporate_news/Eight_steps_to_advance_ESA_diversity
[4] DLR in numbers, DLR, 2021, https://www.dlr.de/en/dlr/about-us/dlr-in-numbers
[5] UK Space Agency Annual Report 2022 - 2023, GOV.UK, 2023, https://www.gov.uk/government/publications/uk-space-agency-annual-report-and-accounts-2022-2023
[6] The Size and Health of the UK Space Industry 2022, GOV.UK, 2023, https://www.gov.uk/government/publications/the-size-and-health-of-the-uk-space-industry-2022
[7] Women in the UK space sector, Space Skills Alliance, 2021, https://spaceskills.org/census-women

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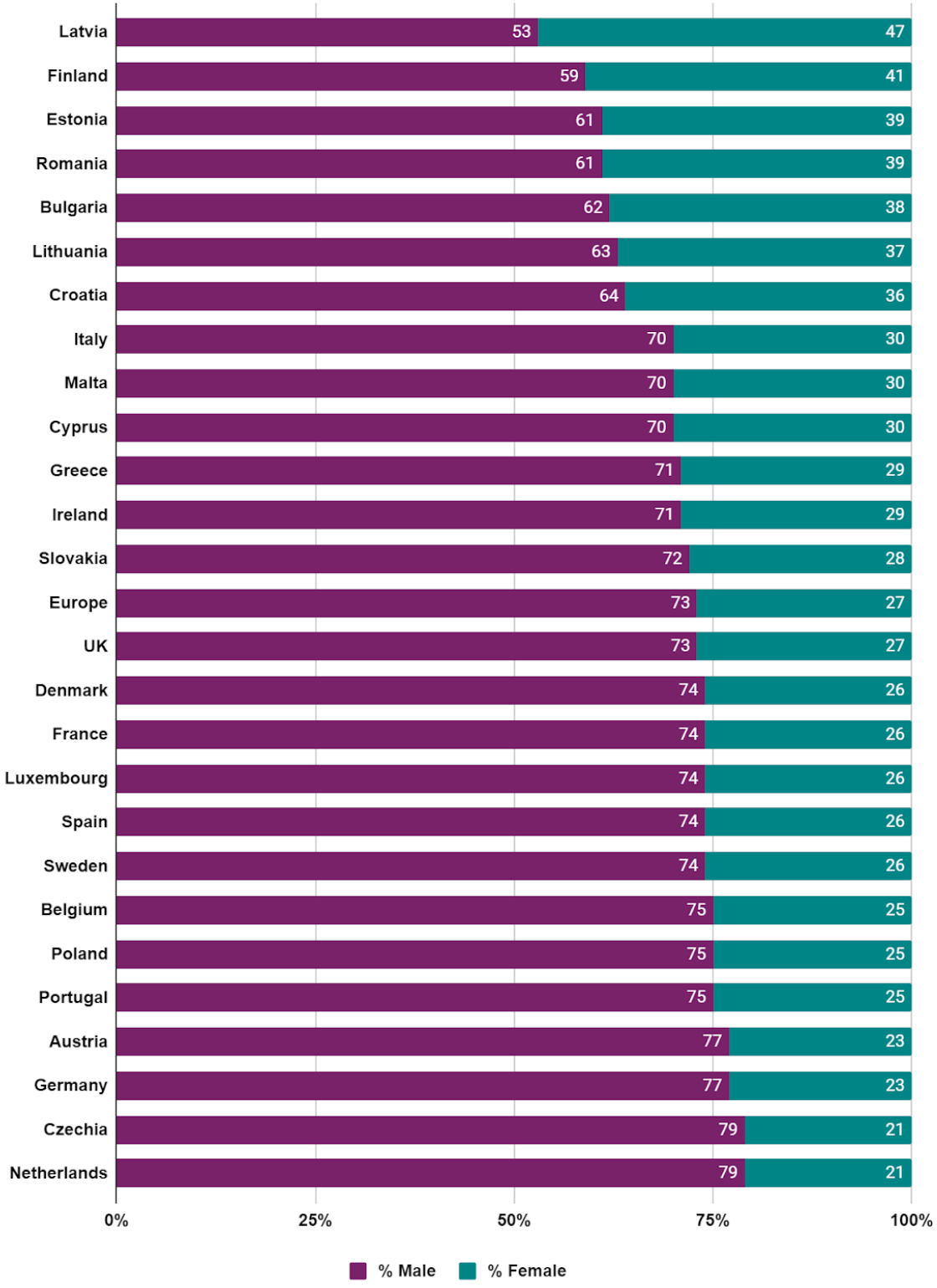


Figure 11: Breakdown of the European space workforce by gender.

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### 3.2.3.2 Geographical Distribution and Regional Gaps

The D3.2 report highlights a notable concentration of space workforce and education infrastructure in Western Europe, particularly in France, Germany, and the UK. In contrast, Eastern and Southern European countries such as Bulgaria, Romania, and Greece remain underrepresented in both education and employment terms, limiting their ability to retain or attract talent. This geographical disparity is associated with risks of brain drain, as students from these countries migrate to stronger ecosystems and often do not return post-graduation.

Mobility patterns reinforce this imbalance. Attractive curricula, robust industry linkages, and English-taught programs tend to cluster in Western Europe. Economic constraints and language barriers further discourage mobility from or to underrepresented regions. Even where student mobility exists, it frequently results in long-term migration rather than cyclical or return movement. Key Findings from D3.2 report have further been compiled into the useful set of **EU & UK Factsheet on Space Skills & Workforce in 2023** which systematically explore the distribution of space-related curricula across the EU-27 countries and the UK, providing a standing-alone factsheets per EU country and the UK, and also a general factsheet summarizing the overall EU-27 and the UK.

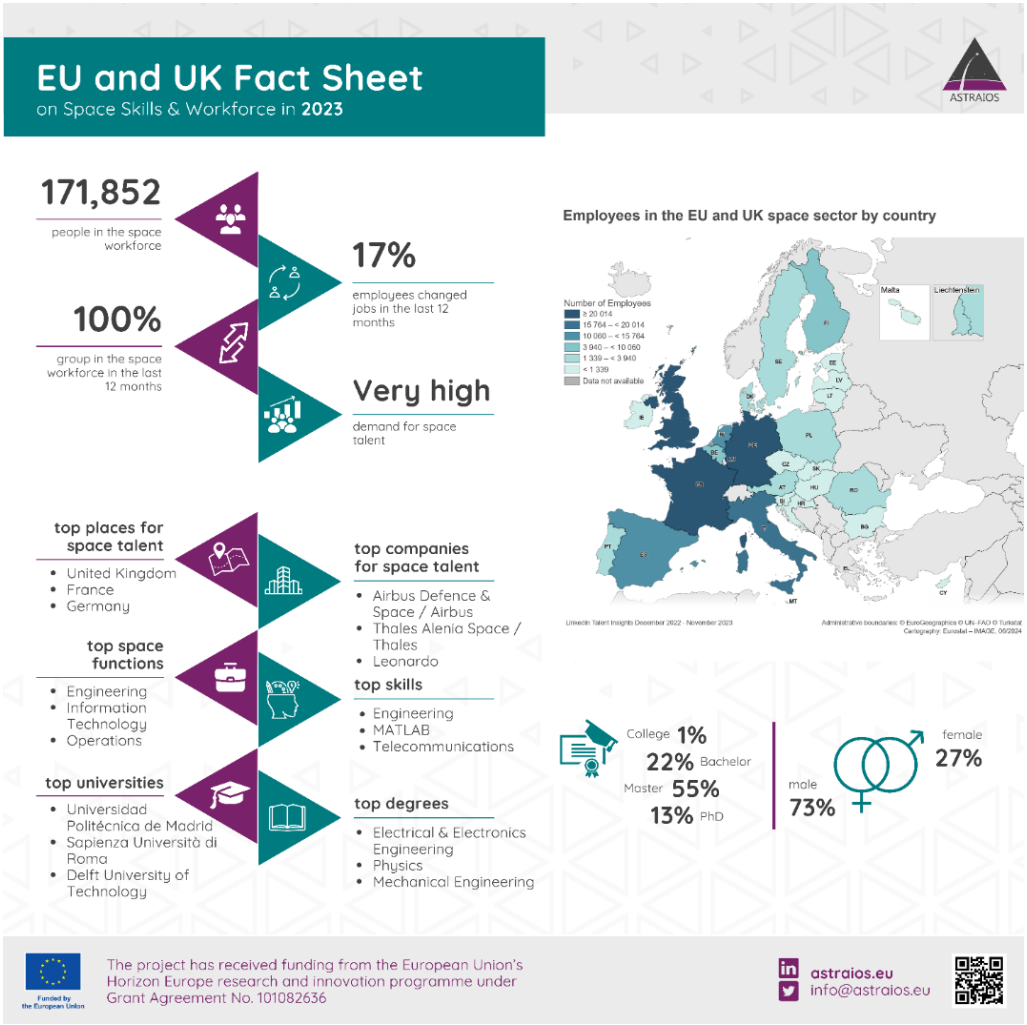


Figure 12: EU & UK Factsheet on Space Skills & Workforce in 2023

The analysis of the general factsheet on EU and UK-level data regarding space skills and workforce development is presented in Table 3. The findings emphasize the need for targeted policies to enhance

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regional balance in educational offerings, financial incentives to improve access, and cultural and informational initiatives to address barriers to student mobility.

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Table 3: Analysis of the general factsheet on EU and UK-level data

| | Geographical gaps | Identifying underrepresented regions | Student mobility and immobility characteristics | Key mobility and immobility trends: factors of curricula, location, economics, and culture |
|---|---|---|---|---|
| **Overall EU and UK** | Uneven geographical distribution of educational offerings in space-related disciplines. Larger urban centers, particularly in the UK and more developed EU member states, show a concentration of institutions offering advanced curricula in space sciences and engineering. In contrast, smaller or economically weaker regions in both the UK and EU often lack specialized programmes, indicating a regional imbalance in accessibility to space-related education. | The document identifies several underrepresented regions, particularly in Eastern Europe and rural parts of the UK. The scarcity of institutions providing space-related education in these areas correlates with their lower levels of industrial activity and research infrastructure in the space sector. Addressing these gaps would require targeted investments and policy interventions to encourage educational institutions to develop such curricula in these regions. | Student mobility trends indicate that a significant number of students from underrepresented regions migrate to urban and developed regions to pursue specialized space-related studies. However, economic barriers, lack of awareness, and cultural factors contribute to high immobility rates among students in some regions, particularly in less affluent EU countries and parts of the UK. | The key trends in mobility reflect the influence of economic disparities and the geographic concentration of institutions with advanced curricula. Students from economically weaker regions face challenges such as higher costs of relocation and insufficient financial aid. Culturally, language barriers and the allure of studying in globally recognized institutions also shape mobility decisions, favoring regions with a long-standing reputation in space studies. |

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Following the analysis of the EU and UK Factsheets, a thorough look and study of the country-specific factsheets and individual country data was completed, and we can further highlight the following key understandings:

#### 3.2.3.3 Academic Background and Qualification Trends

Data from D1.3 reveals that the space sector remains a highly educated field, with 55% of professionals holding a Master's degree, 22% a Bachelor's, and 8% holding a PhD. Common fields of study include computer science (19%), general engineering (16%), and electronics engineering (11%), though emerging trends show aerospace engineering gaining popularity among recent graduates.

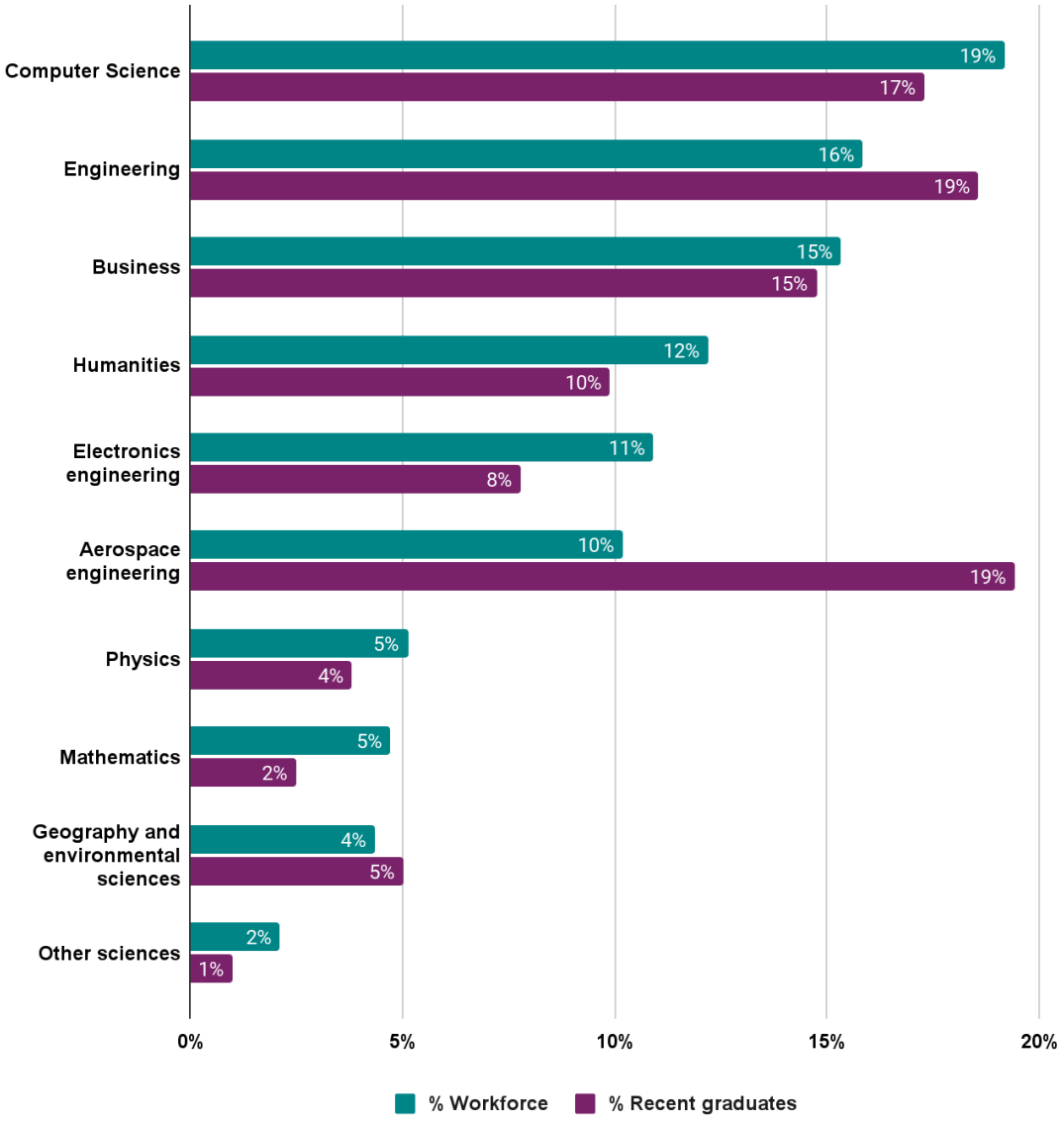


Figure 13: Qualifications of the space workforce compared to those of recent graduates. 'Other' is made up of all other humanities subjects.

These qualification trends also reveal potential mismatches. For instance, aerospace engineering has doubled in popularity among under-35s, while electronics engineering has declined—despite being a difficult-to-recruit skill area, as highlighted in the UK Space Sector Skills Survey.

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## 3.3 Summary of Findings and Reflections

The review of existing projects (Section 3.1) and the ASTRAIOS-led analyses (Section 3.2) reveals a wide range of activities and data illuminating the current state of Europe's space workforce. These include increased educational mobility, expansion of space-related curricula, and targeted training initiatives through projects like EO4GEO, UNIVERSEH, and SpaceSUITE. However, recurring challenges persist—most notably, the widely acknowledged gap between educational outputs and industry expectations.

Across reports and stakeholder engagements, the perception of a "skills gap" frequently emerges, particularly where employers report that graduates are insufficiently prepared for immediate integration into technical roles. This concern spans both technical and soft skills and is most acute in systems engineering, standards like ECSS, mission operations, and domain-specific knowledge (e.g. GNSS, payload development). Yet, as reflected in employer interviews and academic reviews, the interpretation of this "gap" requires critical nuance.

As highlighted by ASTRAIOS stakeholders, including senior academic reviewers, the root of this disconnect is often not curriculum neglect, but rather a mismatch in expectations. Universities—especially at the undergraduate level—are structured to provide broadly applicable, foundational education. They are not designed to produce role-specific specialists immediately ready for deployment into highly customized industrial environments. For example, it is unrealistic and pedagogically inappropriate to expect graduates to emerge from BSc programmes fully fluent in company-specific tools, proprietary software, or tightly scoped workflows. These are typically—and appropriately—acquired through graduate training schemes, MSc specialisation, Continuing Professional Development (CPD), or in-house onboarding.

Furthermore, industry often seeks candidates with 3–5 years of specialist experience, even for entry-level roles. This reflects a hiring market dynamic rather than a systemic educational failing. Bridging this gap is not solely the responsibility of universities; rather, it should involve a shared commitment from employers, education providers, and policymakers. Effective strategies include increased support for internships, industry-academia partnerships, modular MSc courses, and recognition of vocational or on-the-job training as valid and necessary components of workforce development.

In conclusion, the skills gap is not merely a deficit but a misalignment. Universities should remain focused on imparting widely transferable competencies, while industry must recognise the value—and limits—of formal education. There is strong potential to build bridges through better integration of design-based, interdisciplinary education, clearer pathways into specialised roles, and more transparent communication of expectations from both sides.

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# 4. SKILL GAPS AND WORKFORCE CHALLENGES

While the European space sector is experiencing growth across upstream, midstream, and downstream segments, this momentum is accompanied by significant skill-related challenges. The findings from ASTRAIOS Work Packages 1000, 2000, and 3000 consistently point to a widening gap between the competencies cultivated through academic and training systems and the evolving needs of employers. These gaps are not only technical but also extend into transversal and soft skill domains, impacting the sector's ability to adapt, innovate, and compete globally.

This section synthesizes evidence from key ASTRAIOS deliverables ( [2], [4], [5], [6], [27]) to provide a consolidated view of the main challenges facing the space workforce. It outlines where mismatches exist between workforce supply and demand, what types of skills are missing or underdeveloped, and how structural factors such as curriculum design, mobility patterns, and demographic imbalances contribute to the problem.

In particular, we examine:

- How employer needs differ from the competencies produced by universities and training programmes;
- The imbalance between technical (hard) and non-technical (soft) skills;
- Root causes of persistent gaps, such as outdated curricula, lack of hands-on learning, and unequal access to educational pathways;
- The impact of mobility and brain drain on regional skill development;
- And a summary of employer expectations, particularly in relation to non-technical skills such as communication, project management, and adaptability.

Together, these insights reveal not only what is missing in the current workforce pipeline but also what structural adjustments are required—from both education providers and policy stakeholders—to build a resilient, inclusive, and future-ready space sector.

## 4.1 Workforce Competencies vs. Employer Demand

One of the central challenges identified across ASTRAIOS is the persistent misalignment between the competencies supplied by the education and training system and the dynamic requirements of the space industry. This section synthesizes the findings from the EU-TaSK Taxonomy [2] and the Trends and Challenges Report [4] to assess the degree of alignment and highlight priority areas for intervention.

The EU-TaSK taxonomy provides a foundational vocabulary for defining and structuring knowledge areas relevant to the space sector, organized into upstream, midstream, downstream, and supporting segments. It builds upon ESCO, EO4GEO's BoK, and other sources to offer a coherent classification of space-related knowledge domains, but explicitly states that it focuses on *knowledge areas*, not competencies or applied skills. As such, while EU-TaSK is invaluable for understanding what is taught, it does not fully capture how well these knowledge areas translate into job-readiness or workplace effectiveness.

In contrast, other reports like [4] identifies specific gaps between industry needs and the current workforce supply. Through job advertisement analysis, interviews, and CV reviews, the report uncovers patterns of unmet demand, particularly in technical domains such as systems engineering, software and automation, space law and regulation, cybersecurity for space systems, and AI/data science for satellite applications. These areas are increasingly essential for both traditional aerospace roles and emerging commercial applications, yet remain underrepresented in formal curricula across Europe.

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Findings from the ASTRAIOS previous reports note that although graduates often enter the space workforce with strong technical foundations, there is a recurring concern regarding their readiness for complex, multidisciplinary environments. In particular, industry stakeholders highlighted the importance of enhancing exposure to systems-level thinking and integration competencies—areas not always emphasized in formal academic training

One major insight from [4] is that employers see the need for hybrid profiles—professionals who combine core technical expertise with domain-specific knowledge (e.g., EO + agriculture, or GNSS + urban mobility) and business acumen. Yet such profiles are rarely produced by current university programs, which tend to operate in disciplinary silos. Additionally, while curricula often emphasize theoretical learning, industry places growing value on hands-on experience, team-based project delivery, and interdisciplinary communication, which are frequently missing or insufficiently integrated in academic environments.

This divergence suggests the need for closer co-design of curricula with industry partners, enhanced exposure to real-world scenarios, and greater emphasis on practical and transferable skills. In ASTRAIOS deliverables, there is a recognized need to encourage more modular, interdisciplinary learning models that integrate technical training with transferable skills such as teamwork, project management, and adaptability. In our research, these needs emerge through employer feedback and the soft skills gap analyses.

## 4.2 Analysis of missing skills in the industry (Technical vs. Non-Technical Skills)

A detailed analysis by ASTRAIOS has uncovered significant skill gaps in both technical and non-technical domains, affecting the European space sector's capability to sustain growth and innovation. Leveraging insights from the European Taxonomy of Space Knowledge (EUTaSK, D1.2) and the Soft Skills Report (D2.3), we delineate critical areas where discrepancies between workforce competencies and industry expectations are most pronounced.

### 4.2.1 Technical Skills Gaps

The technical skills gaps identified across the space sector relate particularly to advanced and highly specialized areas of knowledge. According to the EUTaSK taxonomy, skills are categorized into technical themes including Aero/mechanical design, Electronics design, Maintenance/manufacturing & materials, Software & data, and Systems engineering.

Among these, specific skills consistently highlighted by employers as lacking include:

- Software engineering and data analytics: Particularly skills involving advanced AI, machine learning, and big data processing required for downstream satellite data exploitation.
- Systems engineering and integration capabilities: Essential for multidisciplinary project execution and effective mission development.
- Spacecraft operations and electronics engineering: Highlighted by industry respondents as especially challenging roles to fill due to a shortage of experienced professionals

Employers specifically identified difficulties in hiring professionals adept in advanced technical domains such as cybersecurity for satellite systems and advanced software development for satellite operations, citing prolonged recruitment times as evidence of these challenges

### 4.2.2 Non-Technical (Soft Skills) Gaps

Parallel to technical deficits, substantial gaps exist in non-technical or soft skills, which are critical for efficient teamwork, management, and adaptability in an evolving technological landscape. The ASTRAIOS [5] report emphasizes that soft skills are perceived by employers as indispensable, equally crucial as technical abilities, yet significantly deficient within the workforce. A major sector-wide survey conducted as part of the ASTRAIOS

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project highlighted In Figure 14, which was shown results on early career space jobs adverts (study of over 800 space adverts in the UK)[8] and on the top competencies 'Soft' skills are in very high demand together with transferable skills.

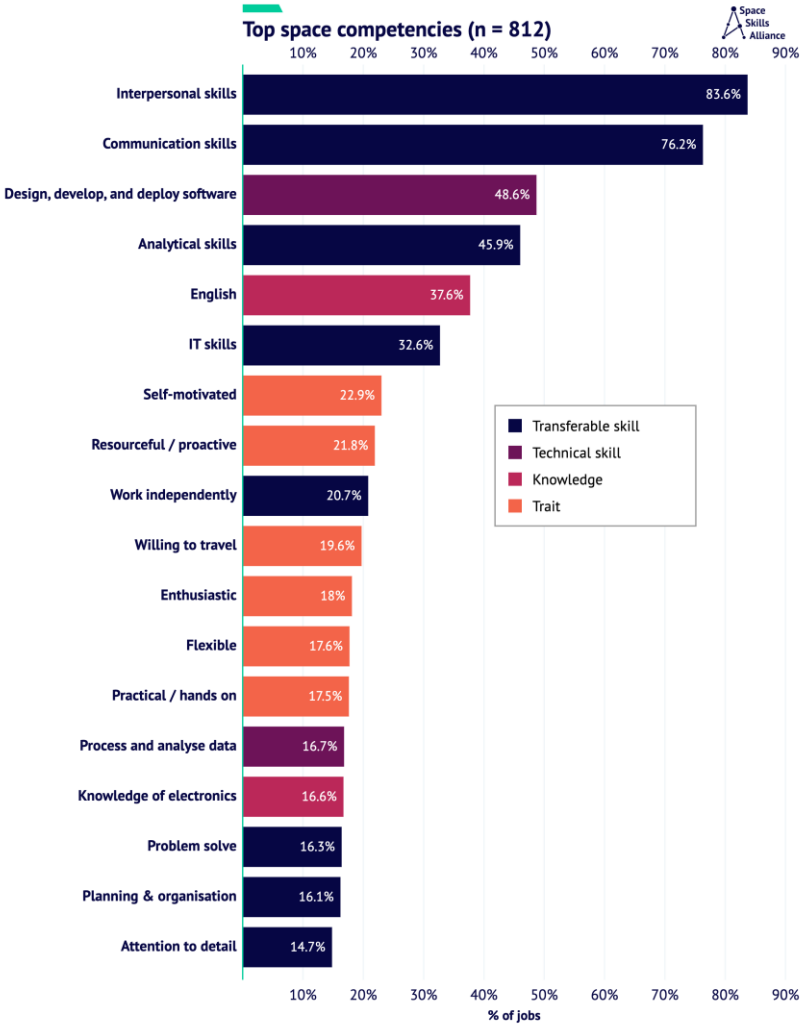


Figure 14: Top space competencies demand for all jobs

The soft skills identified as particularly lacking include:

- **Communication and interpersonal skills**: Essential for cross-disciplinary collaboration and effective project management.
- **Adaptability and flexibility**: Required in response to rapidly changing technologies and market demands.
- **Leadership and problem-solving capabilities**: Crucial for managing increasingly complex projects and diverse teams

Industry representatives at dedicated workshops and focus groups consistently emphasized the need for embedding these competencies into education and training at all levels, advocating for closer collaboration between academia and industry. They suggest soft skills must be incorporated explicitly into university

[8] https://www.gov.uk/government/publications/space-sector-skills-survey-2023/space-sector-skills-survey-2023-report

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curricula, starting from primary and secondary education, to prepare individuals effectively for the demands of a professional space environment.

### 4.2.3 Integration and Recommendations

The identification of technical and soft skill gaps clearly demonstrates that educational approaches must evolve significantly to accommodate industry needs. Recommendations emerging from ASTRAIOS research call for the integration of practical, experiential learning into existing educational programs, alongside systematic inclusion of soft skill training in curricula. In this report we can advises:

- Promoting interdisciplinary teamwork and project management training within technical degrees.
- Embedding soft skills exercises such as negotiation, conflict resolution, and effective communication into academic curricula.
- Encouraging ongoing collaboration between industry and academia to continuously refine and update curricula based on real-world needs and technological developments

## 4.3 Hard skills vs. soft skills mismatch

The mismatch between hard (technical) and soft (non-technical) skills represents a significant workforce challenge in the European space industry. While technical expertise remains foundational, ASTRAIOS research underlines that insufficient emphasis on soft skills significantly hampers organizational effectiveness and the overall performance of space professionals. Employers consistently report difficulties due to employees who, despite robust technical backgrounds, lack essential interpersonal and managerial skills such as communication, teamwork, adaptability, and leadership. Consequently, this imbalance not only impacts individual career growth but also organizational productivity, quality outcomes, and innovation potential within the sector.

The ASTRAIOS soft skills analysis [5] highlights that interpersonal competencies often distinguish candidates during recruitment and significantly influence workplace dynamics and project success. Employers increasingly recognize soft skills as equally critical to technical capabilities for maintaining effective team operations, solving complex problems, and adapting to industry changes

### 4.3.1 Common Root Causes of Skill Gaps

ASTRAIOS research has identified multiple underlying causes of skill gaps affecting the European space workforce. These causes span across educational structures, curriculum content, training methodologies, workforce mobility, geographical distribution, and vocational training systems. Each of these areas contributes uniquely to the existing mismatch between industry expectations and the available talent pool.

#### 4.3.1.1 Curriculum Mismatch and Educational Gaps

One of the most prominent causes of skill gaps is the misalignment between educational curricula and industry requirements. Academic training often places excessive emphasis on technical skills, neglecting equally critical soft skills development. ASTRAIOS findings emphasize that soft skills education is notably underrepresented in technical curricula at universities. This results in graduates who are technically competent but often inadequately prepared for the complexities of multidisciplinary teamwork, project management, and leadership roles in the space sector.

#### 4.3.1.2 Lack of Practical Training

The second major cause identified is the limited integration of practical, vocational or hands-on training in education and professional development programs. Also, vocational training, a crucial component of workforce development, often remains underdeveloped or inadequately aligned with space sector needs.

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ASTRAIOS reports reveal a clear consensus that practical experience is crucial for developing effective soft skills. Current academic approaches, often theoretical and classroom-bound, fail to sufficiently incorporate experiential learning scenarios that mirror real-world job environments. Without adequate practical exposure, professionals frequently struggle to translate theoretical knowledge into effective workplace practice, diminishing their potential to immediately contribute meaningfully in professional settings.

#### 4.3.1.3 Underrepresentation

A further challenge contributing to the skills gap is the underrepresentation of specific groups, particularly women and minorities, within the European space sector. ASTRAIOS analysis consistently indicates that limited diversity reduces the sector's ability to leverage a broader range of interpersonal skills, perspectives, and innovative capacities. Additionally, underrepresented groups may face barriers to accessing targeted training programs, exacerbating existing skills gaps. The absence of diverse perspectives within teams can hinder creativity, adaptability, and problem-solving abilities, which are critical soft skills in the rapidly evolving space sector.

#### 4.3.1.4 Mobility, Geographical Imbalances and Regional Disparities

Workforce mobility, though beneficial in some respects, poses substantial retention challenges for certain regions. Economic factors, cultural and language barriers, and institutional constraints restrict mobility for students and young professionals from underrepresented areas. Financial constraints and limited availability of scholarships significantly impact students' ability to pursue advanced education in better-resourced Western European institutions, hindering balanced skill distribution across Europe. Moreover, mobility patterns tend to favour Western European countries, causing uneven growth and skill concentration, thereby reinforcing regional inequalities.

Geographical imbalances within the EU further exacerbate skill gaps, driven by uneven distribution of high-quality educational programs. Regions such as Eastern and Southern Europe face significant shortages in specialized space education infrastructures. Limited educational offerings in countries like Romania, Bulgaria, Portugal, and Greece lead to local talent migrating towards better-equipped countries such as Germany, France, and the UK, intensifying regional talent shortages (brain drain) and compounding skill disparities.

#### 4.3.1.5 Recommendations from ASTRAIOS Research

To effectively address these root causes, strategic actions are recommended:

- **Curriculum Enhancement**: Integrating interdisciplinary teamwork, time management, negotiation, and problem-solving exercises into university curricula from undergraduate levels onwards.
- **Addressing Geographical Disparities**: Targeted investments and policies to expand educational infrastructure and mobility programs in underrepresented regions, supported by financial aid and language accessibility improvements.
- **Vocational Training Expansion**: Strengthen vocational training pathways through close collaboration with industry, adopting successful practices from sectors with established vocational training systems.
- **Promoting Diversity**: Enhancing policies and practices aimed at improving diversity in recruitment and retention to benefit from a richer, more varied skill set that diverse teams inherently bring.

Implementing these targeted interventions can significantly mitigate the identified root causes and contribute to building a more robust, balanced, and future-ready European space workforce.

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## 4.4 Effects of workforce mobility and brain drain

Workforce mobility within the European space sector significantly impacts the regional distribution of talent, influencing both brain gain and brain drain across various European countries. This phenomenon has created notable regional disparities, with distinct implications for workforce sustainability and sector competitiveness.

Brain drain predominantly affects Eastern and Southern European regions. Countries like Poland, Romania, and Bulgaria experience substantial losses as skilled professionals frequently migrate to Western Europe, North America, and increasingly to Asian markets seeking better economic opportunities and advanced resources. This outflow exacerbates regional inequalities, weakening local industries and making it difficult for these countries to develop independent capabilities in advanced space technology sectors. Similarly, Southern European nations such as Italy, Spain, and Greece encounter what the report describes as a "double drain," losing talent both to Western European hubs and to global destinations outside Europe. Limited local opportunities drive this persistent migration, leaving these countries reliant on external expertise to sustain their space initiatives.

Conversely, Western European nations, including France, Germany, and the United Kingdom, predominantly benefit from the intra-European mobility, experiencing considerable brain gain. France and Germany, despite losing some high-calibre talent to global competitors like the US and Canada, effectively offset these losses through substantial inflows from less-developed European regions. This pattern solidifies their positions as major talent hubs, significantly enhancing their domestic capabilities and maintaining their competitive edge in the global space sector.

Specific countries maintain balanced mobility flows, notably Luxembourg and the Netherlands, which attract talent from smaller or less developed countries while simultaneously losing talent to larger, more established economies. This equilibrium helps these nations sustain a competitive and resilient space sector despite their smaller scale.

The Figure 15 shows Workforce Migration Outwards Internationally as a one of ASTRAIOS mobility analysis results, for more information please see the [6] Report.

Overall, the impact of workforce mobility and brain drain significantly shapes the European space industry landscape. High mobility hubs benefit greatly from talent inflows, enhancing innovation and sustaining competitive advantages, whereas regions suffering from consistent brain drain face significant barriers to developing robust, self-sustaining space industries. Addressing these mobility patterns through targeted policies, enhancing local educational infrastructure, and providing competitive career opportunities is crucial for fostering a more balanced and sustainable European space workforce ecosystem.

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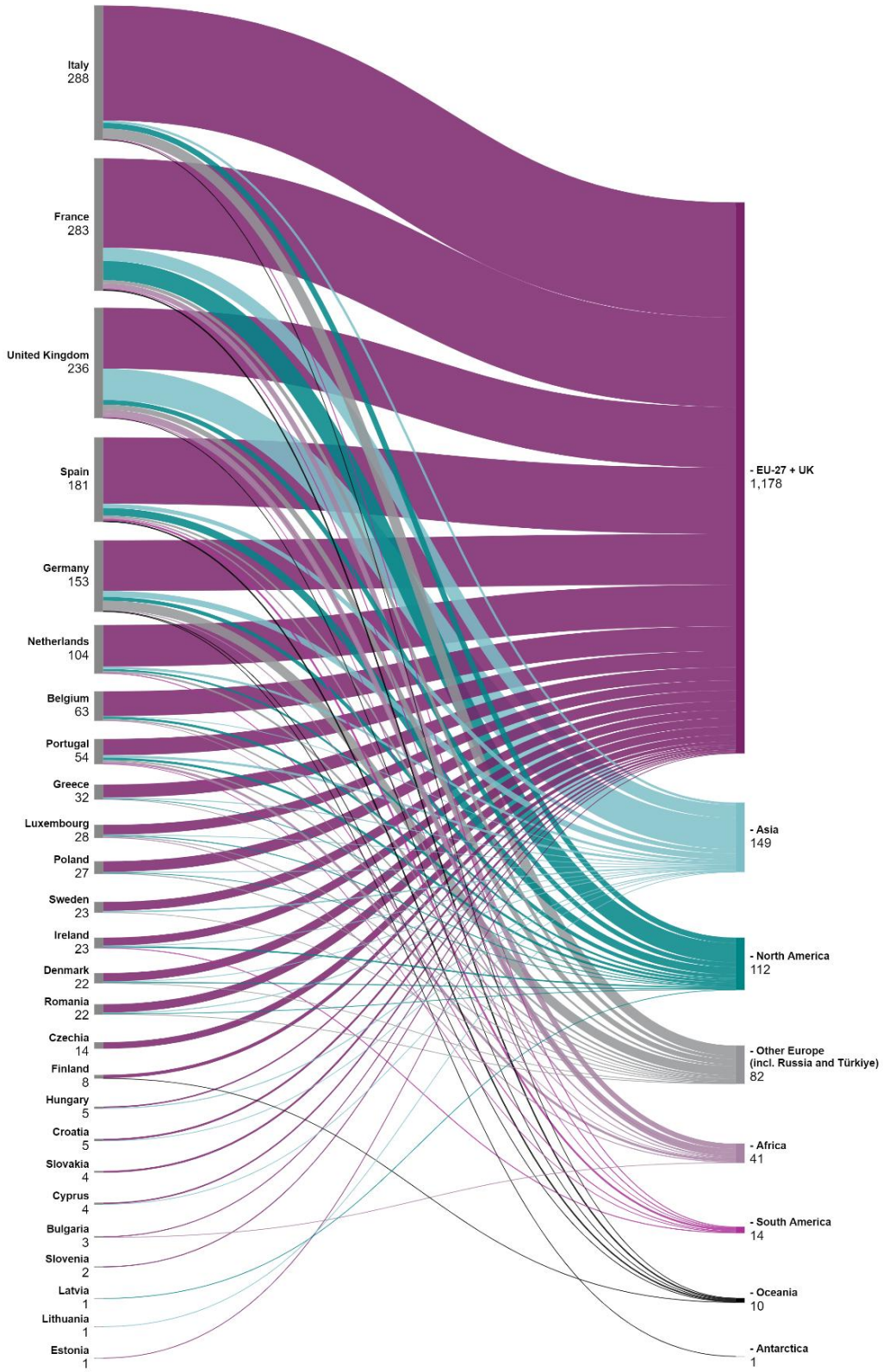


Figure 15: Workforce Migration Outwards Internationally

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## 4.5 Summary of skill gaps and workforce challenges

This section synthesizes the key skill gaps and workforce challenges identified by the ASTRAIOS project, summarizing insights from the comprehensive analyses in preceding sections (4.1–4.4). It underscores critical areas for intervention, illustrating the broader implications of these gaps for the sustainability and competitiveness of the European space sector.

### 4.5.1 Technical and Non-Technical Skills Mismatch

A fundamental challenge consistently highlighted across ASTRAIOS deliverables is the pronounced mismatch between industry requirements and the competencies produced by academic and training institutions. On the technical side, significant gaps have emerged in areas such as advanced software engineering, data analytics (AI, machine learning, big data), systems engineering, and cybersecurity for satellite and space infrastructures (D1.2, D2.1). Employers specifically report extended recruitment cycles and difficulties filling critical technical roles due to shortages of adequately trained and experienced professionals.

Non-technical (soft) skills deficits are equally problematic. ASTRAIOS research shows that despite the high value employers place on soft skills—such as communication, teamwork, adaptability, leadership, and problem-solving—there remains a widespread deficiency in these competencies among graduates and professionals alike (D2.3). Sector-wide surveys indicate that a considerable percentage of job applicants lack essential soft skills, severely impacting team effectiveness, project delivery, and innovation capacity within space organizations.

### 4.5.2 Root Causes of Skills Gaps

The skill gaps identified by ASTRAIOS are deeply rooted in several interconnected issues:

- **Curriculum Mismatch**: Traditional educational curricula often inadequately reflect industry demands, emphasizing theoretical knowledge over practical application and neglecting essential interdisciplinary and soft-skill training. This results in graduates who are technically proficient but unprepared for real-world complexities and multidisciplinary environments (D2.3).
- **Insufficient Practical Training**: A lack of hands-on training opportunities within academic and vocational programs has consistently limited the development of practical competencies. Employers regularly note that graduates, while academically strong, often struggle with applying theoretical knowledge effectively to complex and dynamic professional situations.
- **Underrepresentation and Diversity Challenges**: The underrepresentation of women and minorities remains a critical challenge within the sector. This imbalance restricts the talent pipeline, limits the diversity of perspectives and skills available, and undermines efforts to foster inclusive and adaptive teams capable of innovative problem-solving and creativity (D1.3, D2.3).

### 4.5.3 Workforce Mobility and Brain Drain

The analysis conducted in ASTRAIOS (D3.2) highlights that workforce mobility significantly influences regional disparities and skill availability within the European space sector. Eastern and Southern European countries face substantial brain drain, losing talent to Western Europe and beyond, thus exacerbating regional skill shortages and undermining local industry growth. Conversely, Western European hubs (France, Germany, UK) and select balanced mobility countries (Luxembourg, Netherlands) benefit from significant brain gain, bolstering their competitive advantage and innovation capacity.

This uneven mobility contributes to persistent regional inequalities and hampers Europe's overall capacity to build a balanced, resilient, and equitable space workforce.

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# 5. PEDAGOGICAL STRATEGIES, TRAINING & EDUCATION INNOVATIONS

## 5.1 Alignment of Higher Education with Industry Needs

A frequent narrative within discussions on the European space workforce is a perceived skills gap between higher education outputs and industry requirements. While this gap is often attributed to outdated curricula within universities, deeper analysis reveals that the issue lies more in mismatched expectations between academia and industry. Universities, particularly at the undergraduate level, are fundamentally tasked with providing broad, foundational, and transferable knowledge and skills rather than highly specialized, industry-specific training [8]. Specialized competencies and familiarity with proprietary tools, standards (such as ECSS), and specific operational procedures typically fall within the domain of postgraduate degrees, targeted training, internships, or on-the-job experience. Industry expectations often include immediate productivity on highly specialized systems, leading to a perception of inadequacy among new graduates, despite their general competence in fundamental principles [28].

Indeed, a recent survey of UK aerospace education demonstrated the varying levels of skills provided in university curricula, highlighting an emphasis on theoretical, conceptual, and analytical competencies rather than specific system or software proficiencies [7]. This expectation mismatch underscores the necessity for clear delineation of responsibilities, where universities focus on foundational education and critical thinking, and industries commit to targeted, specialized professional training and internships to bridge specific gaps.

## 5.2 Overview of Teaching Practices across Europe

The evolving European space sector demands pedagogical approaches that not only impart solid technical foundations but also foster interdisciplinary, practical competencies aligned with industry expectations. Traditional education in space-related fields, emphasizing theoretical lectures and structured labs, while strong in foundational concepts, has shown limitations in addressing dynamic industry needs. Consequently, innovative methodologies such as Design-Based Learning (DBL) and Project-Based Learning (PBL) are increasingly implemented across European institutions like the International Space University, Technical University of Delft, and University of Strathclyde. These approaches involve interdisciplinary, real-world projects closely aligned with professional aerospace scenarios, enhancing students' practical, problem-solving, and teamwork skills.

Experiential and hands-on programs such as ESA Academy's "Fly Your Satellite!" and "Drop Your Thesis!" further complement traditional learning, offering students direct involvement in authentic mission scenarios, thereby enriching their skills in systems engineering, project management, and operational procedures. Additionally, advancements in virtual reality (VR) and augmented reality (AR) technologies offer immersive learning experiences, enabling students to safely engage in complex simulations like spacecraft assembly and satellite operations, significantly reinforcing their practical competencies.

The integration of Massive Open Online Courses (MOOCs) and blended learning platforms, notably through initiatives developed by ASTRAIOS, has expanded educational access and flexibility across Europe, offering specialized training in critical areas such as Earth Observation and satellite navigation. Furthermore, modern space education increasingly embraces multidisciplinary and cross-sectoral approaches, exemplified by programs like UNIVERSEH, which integrate STEM with social sciences, humanities, entrepreneurship, and multilingual training, equipping graduates with the versatile skills required for international collaborative environments.

Despite these advancements, significant challenges persist, including sustaining student engagement in digital environments, continuously aligning curricula with rapidly evolving technologies, and addressing regional disparities in educational resources. To overcome these issues, ASTRAIOS strongly recommends promoting

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widespread adoption of active learning methodologies like DBL and PBL, investing further in VR/AR and blended learning technologies, strengthening industry-academia collaborations, and providing targeted support for regional institutions through collaborative networks, funding, and policy initiatives. By implementing these strategic pedagogical innovations, European higher education institutions can effectively cultivate a well-equipped workforce ready to address the complex, interdisciplinary challenges of the evolving global space industry.

## 5.3 Pedagogical strategies to bridge skill gaps

The rapid evolution of the European space sector underscores the critical need for pedagogical strategies that effectively bridge foundational academic knowledge and industry-specific skills. A significant discrepancy often observed between higher education outputs and employer expectations necessitates innovative educational approaches that move beyond traditional lectures and theory-based coursework.

Innovative pedagogies such as Project-Based Learning (PBL), Design-Based Learning (DBL), and interdisciplinary education are increasingly recognized as essential to address these gaps. ASTRAIOS research highlights that PBL, widely adopted in leading aerospace institutions, substantially enhances students' practical competencies by involving them in real-world industry-relevant projects. Institutions such as the University of Strathclyde, Technical University of Delft, and the International Space University have demonstrated notable success in integrating structured design reviews, concurrent engineering exercises, and cross-disciplinary projects within their curricula. These methods effectively prepare graduates for dynamic industry environments by developing critical skills such as teamwork, problem-solving, and project management.

Further analysis from the ACE Survey (2025) [28] underscores the significant value of hands-on projects, notably highlighting modules such as Strathclyde's ME512 and ME517. These courses simulate staged design reviews and interdisciplinary collaboration, directly mirroring professional industry scenarios—an approach that remains relatively rare across comparable aerospace programs. The evidence supports that project-based methodologies lead to improved retention of complex concepts and better preparation for real-world tasks. Figure 16 and Figure 17 Illustrating detailed teaching methods and project-based learning approaches by academic year, clearly showing the progression from foundational learning to industry-ready practical application.

Moreover, cognitive scaffolding frameworks such as Bloom's Taxonomy [29] provide structured guidance in designing educational experiences that progressively move students from foundational knowledge through analytical and application-based skills, culminating in complex evaluative and creative competencies. Incorporating Bloom's structured learning outcomes ensures educational alignment with industry-required cognitive and practical abilities, significantly improving graduates' readiness for professional integration.

The COVID-19 pandemic accelerated the widespread adoption of digital and remote learning modalities, leading to valuable insights and emerging pedagogical challenges. Although flexible, asynchronous Massive Open Online Courses (MOOCs) have demonstrated mixed effectiveness, notably marked by decreased student engagement, motivation, and performance compared to traditional in-person or structured hybrid learning. Empirical evidence indicates that structured, face-to-face learning environments, or blended formats combining online flexibility with interactive, instructor-led experiences, yield superior outcomes in knowledge retention, skill acquisition, and learner engagement. These findings are notably supported by observed declines in student performance during the pandemic, underscoring the importance of carefully balancing flexibility and structured interactivity in educational delivery.

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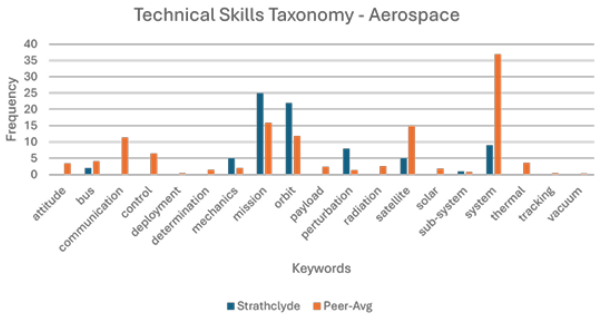
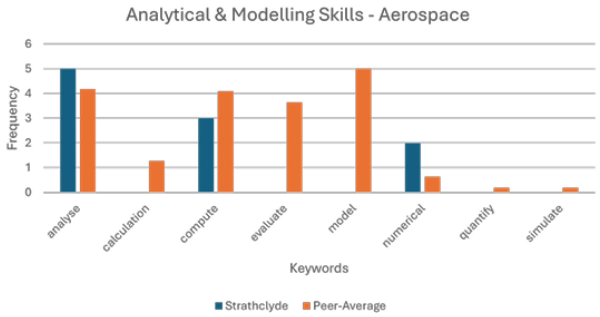
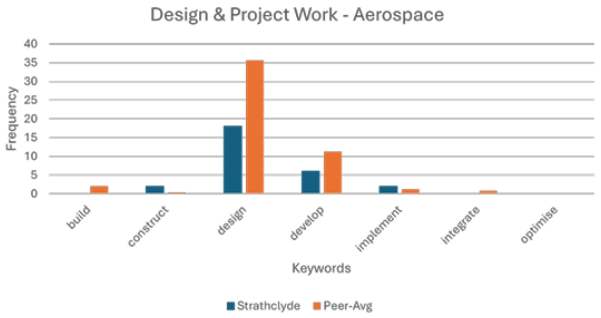


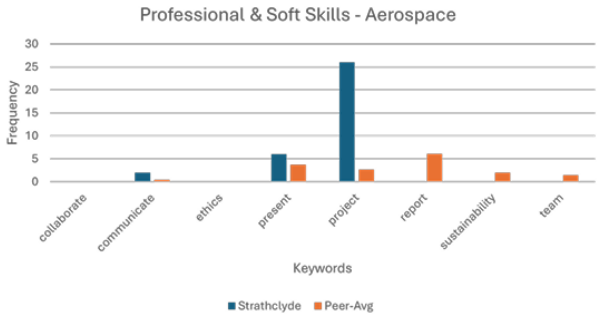

(a) Technical skills




(b) Analytical and modelling skills

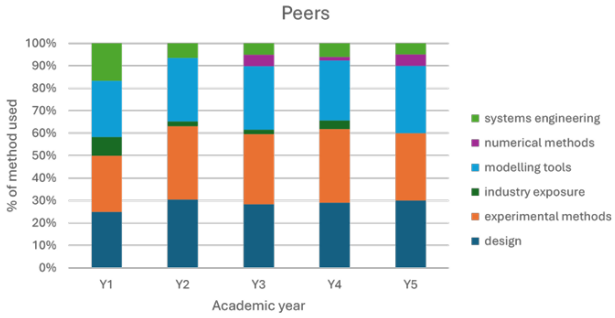



(c) Design and project-based skills

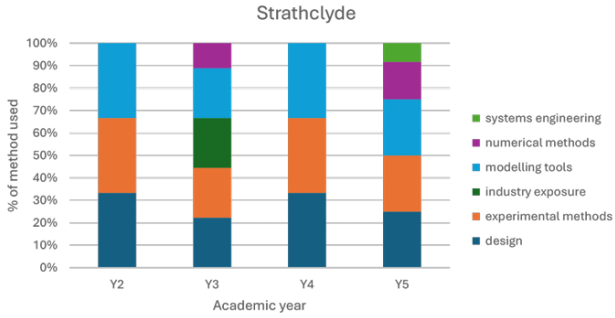



(d) Professional and soft skills

Figure 16: Skill coverage across Aerospace modules by domain, as sampled through 43 module descriptors across 13 courses case study. [28]




(a) At Peers




(b) At Strathclyde

Figure 17: Per academic year distribution of teaching methods utilised in Aeronautics and Aerospace modules. [28]

Recognizing these challenges, ASTRAIOS specifically recommends further investment in modular, flexible, and blended educational frameworks. Such approaches enable rapid adaptation to emerging industry trends and facilitate targeted upskilling and reskilling of professionals. MOOCs remain valuable for delivering specialized knowledge efficiently across diverse geographical regions, provided they are integrated within a structured, interactive framework that includes direct student engagement, real-time feedback, and collaborative learning components.

A key recommendation from ASTRAIOS emphasizes fostering robust industry-academia collaborations. Structured interactions—including internships, industry-sponsored projects, joint curriculum development, and regular guest lectures—significantly enhance the alignment of educational outcomes with real-world industry demands. Strengthening these collaborations ensures that students acquire immediately applicable skills and professional insights, facilitating smoother transitions from academia to professional roles.

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Additionally, experiential learning methods, exemplified by programs like the ESA Academy's "Fly Your Satellite!" and "Drop Your Thesis!", are strongly advocated. By involving students directly in authentic mission scenarios, such experiential activities provide critical insights into practical systems engineering, project management, and industry-standard operational procedures. These experiences significantly enhance student preparedness for professional challenges, directly addressing recognized industry skill gaps.

In summary, bridging educational outcomes with industry expectations requires a coordinated, innovative approach that integrates project-based learning, interdisciplinary curricula, robust industry collaboration, and balanced use of digital tools. By implementing these pedagogical strategies, educational institutions across Europe can substantially enhance their capacity to produce highly skilled graduates, ready to navigate the complexities and interdisciplinary nature of the contemporary space sector.

## 5.4 Vocational training, upskilling, and reskilling initiatives

Vocational training and continuous professional development (CPD) are central to maintaining a highly skilled, adaptable workforce capable of meeting the dynamic demands of the European space sector. While traditional university education provides foundational knowledge and theoretical expertise, vocational training systems bridge critical practical gaps, equipping professionals with specific, hands-on competencies directly aligned with industry requirements.

The dual-track vocational training model in Germany, combining structured classroom education with extensive industry placements, is often recognized as a European exemplar of effective vocational education. This dual approach significantly enhances workforce preparedness by closely integrating theoretical concepts and practical experience, ensuring direct applicability and immediate professional utility upon completion. However, such structured vocational programs remain relatively rare elsewhere in Europe, resulting in uneven vocational preparedness and skill consistency across the continent. As highlighted in the WIA-Europe White Paper [7], other countries—including the UK—primarily rely on fragmented, employer-driven upskilling initiatives that often lack centralized coordination and standardized outcomes, ultimately leading to variability in training effectiveness and professional readiness across regions.

Given these disparities, ASTRAIOS research underscores the critical need for a more coherent, scalable vocational framework at both national and European levels. Best practices from other high-technology sectors advocate for industry experts' active involvement in vocational curriculum development, ensuring that training aligns closely with clearly defined industry competency frameworks. Courses explicitly targeting satellite operations, maintenance, ground segment support, and emerging technologies should be developed, providing practical skillsets directly matched to industry demands.

Europe-wide efforts, notably the EU "Pact for Skills" [30] aim to significantly strengthen vocational training and continuous professional development by targeting substantial workforce upskilling within a five-year timeframe. This ambitious initiative explicitly intends to upskill approximately 30% of the EU aerospace workforce, highlighting the EU's strategic commitment to closing skill gaps and enhancing professional adaptability.

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| | |
|---|---|
| **Automotive Skills Alliance** | Ensuring 5% of the supply chain workforce is trained each year on new sustainable and digital technologies. |
| **Skills partnership for Microelectronics** | Securing investment of €400 million Euros to reach 50,000 trainees and students. |
| **Skills partnership for Aerospace and Defence** | Forecasting the sector's skills needs for the next decade. |
| **Skills partnership for Offshore Renewable Energy** | Developing new training capacity to meets the needs of a rapidly growing industry. |
| **Skills partnership for Shipbuilding and Maritime Technology** | Has created a new Sustainable Ship and Shipping master's degree with the Erasmus Mundus programme. |
| **Textiles, Clothing, Leather and Footwear Skills Alliance** | Developing attractive and sustainable training pathways for an evolving workforce and SME employers. |
| **Skills partnership for Retail** | Enhancing knowledge of skills needs and promoting the retail sector as an attractive place to work. |
| **Pact for Skills in Tourism** | Supporting regional training opportunities for seasonal employees and SME employers. |
| **Pact for skills in construction** | Supporting skills for 30% of the workforce by 2030, including attracting workforce from underrepresented backgrounds. |
| **Skills partnership for the Agri-food Ecosystem** | Supporting mobility of learners, and partnerships between training providers and employers. |
| **Skills partnership for the Cultural and Creative Industries Ecosystem** | Promoting the mutual recognition of training for creative professionals across Europe. |
| **Skills partnership for the Proximity & Social Economy Ecosystem** | Enhancing knowledge of future skills needs to guide up- and reskilling 5% of the workforce each year. |
| **Skills partnership for the Digital Ecosystem** | Contributing to equipping the wider population with basic skills and aiming to have 20 million ICT specialists employed in the EU by 2030. |
| **Skills partnership for the Health Ecosystem** | A partnership that represents one of the largest employment sectors in the EU (15 million people). It will develop a European Skills strategy for the health workforce and pilot training programs for health professionals. |
| **Skills partnership for long-term care** | Addressing the skills needs of 6.3m care workers and 100,000 providers in the EU to meet the sector's current and future challenges. |
| **Large Scale Partnership on Space Data, Services and Applications** | Identifying the skills required in the downstream space and geoinformation sector, supporting access to quality training, and encouraging citizens' engagement to attract new talents. |
| **Renewable Energy Skills Partnership** | Striving for a well-trained and sufficient workforce as a key condition for the manufacturing, deployment and management of renewable energy technologies to achieve the EU energy and climate objectives. |
| **Skills partnership for the Energy Intensive Industries** | To dynamically detect and adjust future skills demands in line with the ambitions of the Process Industries European Strategies. |
| **Digitalisation of the Energy System** | Supporting the digitalisation of the European energy sector through collaborative actions and knowledge sharing on education and training opportunities. |
| **European Health Industry** | Addressing the critical skills gaps in the industry through collaboration, assessment, research, education, and partnerships. |

Figure 18: The EU Pact for Skills [30]

Structured CPD programs, industry-specific certifications, and tailored training modules increasingly complement formal educational systems, ensuring continuous learning aligned with rapid technological evolution. ASTRAIOS specifically identifies targeted professional training in emerging technologies—including

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artificial intelligence (AI), cybersecurity, quantum communication systems, and space debris mitigation—as critical areas requiring immediate vocational attention. Structured training sessions, online modules (MOOCs), industry workshops, and postgraduate certificate programs all play vital roles in systematically addressing these identified skill requirements.

Moreover, reskilling and upskilling initiatives must accommodate professionals at various career stages, addressing specific needs such as career transitions, gaps created by career breaks, and mid-career migrations between sectors. ASTRAIOS emphasizes the importance of structured career-development pathways, mentorship schemes, and industry collaboration to support such workforce mobility, ensuring sustained professional relevance in a rapidly changing technological landscape.

An essential consideration within vocational training and professional development initiatives is inclusivity and accessibility, particularly for diverse and underrepresented demographic groups. To effectively broaden participation, vocational programs must incorporate targeted outreach efforts, flexible learning schedules, multilingual course offerings, and financial support mechanisms. This inclusive approach is vital for mitigating geographical disparities, enhancing workforce diversity, and supporting balanced skill development across Europe.

## 5.5 Digital Tools, AI, and MOOCs in Higher Education

Digital educational tools, including Massive Open Online Courses (MOOCs), virtual and augmented reality (VR/AR), and artificial intelligence (AI)-driven learning platforms, have profoundly impacted space education, enhancing accessibility and providing scalable solutions for specialized learning. MOOCs effectively offer targeted training in niche areas such as Earth Observation (EO) data analysis, GNSS applications, and cybersecurity fundamentals, providing flexible educational opportunities for a broader demographic [2].

However, these digital modalities carry inherent challenges. Primary among these is maintaining student engagement and achieving effective learning outcomes remotely. Despite initial enthusiasm for flexible learning, data from post-COVID education analyses indicate lower student performance and decreased retention rates compared to traditional in-person or blended learning formats. Ensuring quality, assessment rigor, and learner motivation in digital environments remains a significant hurdle, emphasizing a continued role for structured, face-to-face, and hybrid learning models in comprehensive educational strategies.

### 5.5.1 Opportunities for Integration

#### 5.5.1.1 Massive Open Online Courses (MOOCs)

MOOCs represent a critical pedagogical innovation within the ASTRAIOS project, allowing flexible, scalable delivery of high-quality educational content across the European Union and beyond. ASTRAIOS explicitly incorporates the development of several thematic MOOCs hosted on platforms such as FutureLearn. These courses cover a range of specialized space-related topics, including Earth Observation (EO), Global Navigation Satellite Systems (GNSS), and satellite communication applications, tailored to address identified skill gaps across the space sector. The MOOCs developed by ASTRAIOS facilitate continuous professional development, upskilling, and reskilling of the existing workforce, alongside providing entry-level opportunities for new learners, significantly expanding the reach and impact of space education.

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Figure 19: Sample 1 of MOOCs, developed by ASTRAIOS project


Figure 20: Sample 2 of MOOCs, developed by ASTRAIOS project

#### 5.5.1.2 AI and Virtual and Augmented Reality (VR/AR) in Education

The integration of Artificial Intelligence (AI) and Machine Learning (ML) within space education offers profound opportunities to optimize curriculum design, personalize learning experiences, and enhance engagement. In ASTRAIOS we utilized advanced AI tools to automate data collection and analysis processes, providing structured insights into curricula across European universities and training providers. Such AI-driven tools facilitate real-time curriculum mapping, adaptive learning pathways, and targeted content recommendations, significantly enhancing educational relevance and responsiveness to real-time sector needs.

Virtual and augmented reality technologies are identified as promising digital tools, providing immersive, interactive learning environments crucial for experiential education. VR and AR simulations allow students to

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virtually engage in realistic scenarios such as satellite operations, spacecraft assembly, or emergency management protocols, drastically reducing risks, costs, and logistical barriers. These technologies enable the creation of compelling educational scenarios that significantly improve students' practical and operational skills, aligning closely with industry practices and real-world application demands.

#### 5.5.1.3 Online Collaboration and Community Building

Digital tools enable extensive collaboration across geographical and institutional boundaries, crucial for fostering a robust educational community in space-related disciplines. ASTRAIOS highlights the importance of online platforms and collaboration tools such as webinars, digital workshops, and virtual conferences, which support ongoing knowledge exchange among educators, students, and industry experts. Such digital infrastructure strengthens community building and continuous dialogue between academia and industry, ensuring education remains aligned with evolving industry needs.

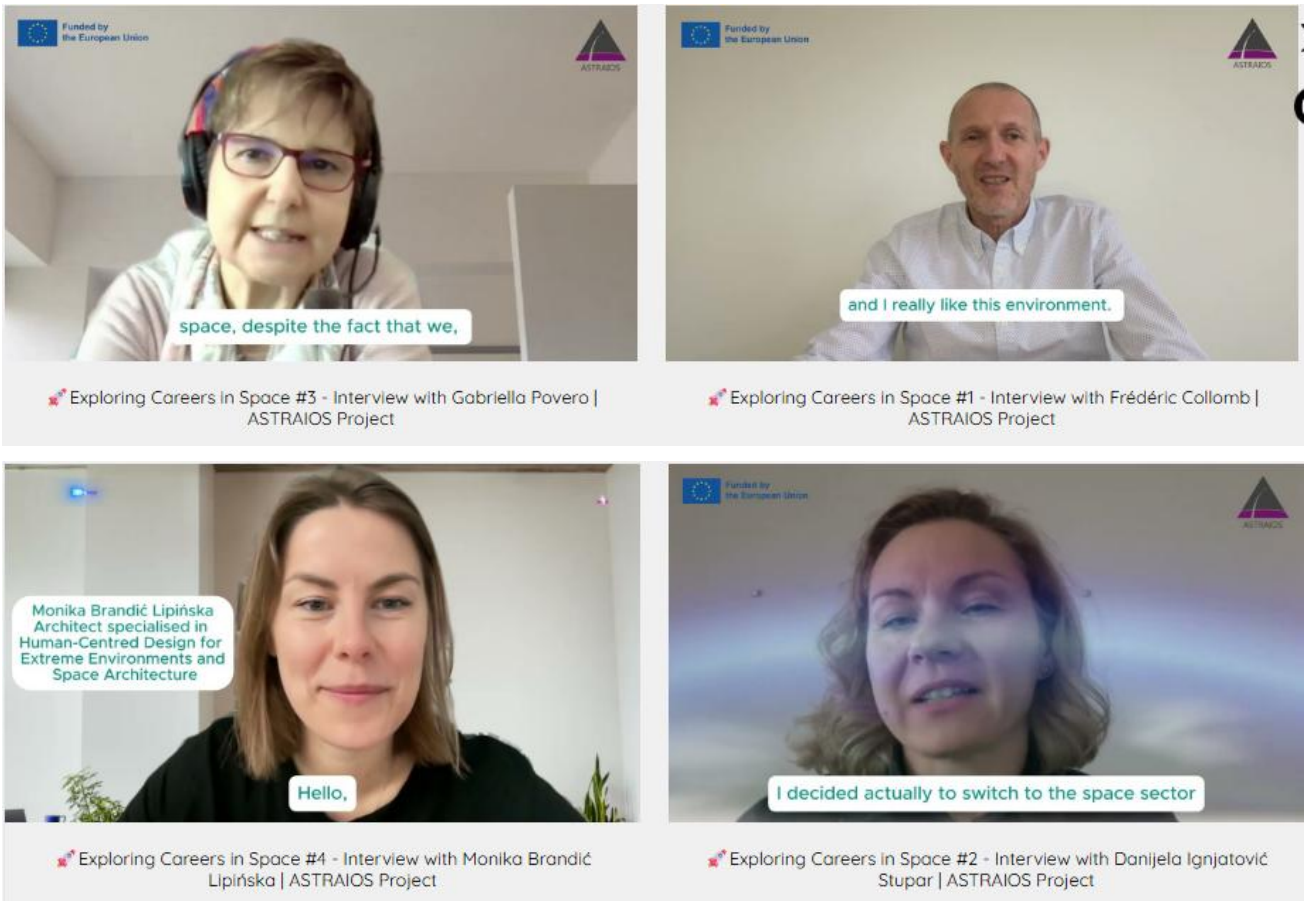


Figure 21: ASTRAIOS project interview as a sample of Digital Tools

### 5.5.2 Challenges for Integration

#### 5.5.2.1 Ensuring Consistent Quality and Credibility

One of the key challenges in integrating digital tools and MOOCs into higher education is maintaining educational quality and credibility. While MOOCs offer scalability and flexibility, ensuring consistent instructional quality, rigorous assessment, and industry validation across numerous courses and institutions remains challenging.

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#### 5.5.2.2 Technological and Infrastructure Disparities

Despite the substantial potential of digital tools, significant disparities exist across European institutions regarding technological capabilities and infrastructure readiness. Not all institutions possess the necessary resources or technical expertise required for deploying sophisticated AI and VR/AR technologies.

#### 5.5.2.3 Privacy and Data Management

The use of AI tools and digital learning platforms involves extensive data collection and analysis, raising concerns about privacy and data management.

#### 5.5.2.4 Engagement and Motivation Challenges

Maintaining sustained student engagement and motivation in online and virtual environments is another recognized challenge. While digital platforms and MOOCs significantly expand accessibility, they often struggle with higher attrition rates compared to traditional educational formats. ASTRAIOS suggests adopting interactive, collaborative, and immersive learning strategies, such as real-world case studies, peer-learning models, and gamification techniques, to mitigate these challenges and maintain learner motivation and participation.

### 5.5.3 Reflections on Learning Efficacy and the Impact of Digital Modalities

In recent years, there has been an accelerated adoption of digital tools and distance learning models across higher education, especially prompted by the COVID-19 pandemic. This shift has led to a growing interest in understanding how different teaching modalities impact learning outcomes, motivation, and long-term skill retention—particularly in technical domains such as space engineering.

While asynchronous digital education formats (e.g., MOOCs, online modules, self-paced tutorials) offer flexibility and scalability, early reflections suggest they may not be equally effective for all learners or contexts. Self-regulation, discipline, and access to support structures play a critical role in determining their success. Preliminary observations during the COVID-19 period (as noted by academic stakeholders within ASTRAIOS) revealed a possible decline in student performance and engagement, which may point to limitations in online-only models, especially for complex, project-based or interdisciplinary topics.

This highlights a gap between perceived convenience and actual educational effectiveness. While many learners express preference for remote or hybrid learning models, outcomes tend to vary widely depending on individual motivation and institutional support. There is a pressing need for further empirical research to quantify the impact of these modalities on skill acquisition, long-term retention, and readiness for professional environments.

Due to the limited availability of longitudinal data and the complexity of isolating variables post-pandemic, this topic remains out of scope for detailed analysis in the current deliverable, but is flagged here as a critical area for future work. Understanding the true pedagogical value of digital tools (and their limitations) will be vital to designing resilient and inclusive training systems for the space workforce of the future.

## 5.6 Accreditation and Curriculum Structure Differences (e.g., STEM vs. non-STEM)

Accreditation frameworks provide structured standards and benchmarks that higher education programs must meet to ensure consistent educational quality, employability of graduates, and industry alignment. Within STEM (Science, Technology, Engineering, and Mathematics) disciplines, clear accreditation guidelines—such as the Accreditation of Higher Education Programmes (AHEP)—define explicit learning outcomes across several core areas including foundational knowledge, engineering analysis, design and innovation, engineering practice, ethics, and societal and legal contexts [8].

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AHEP's comprehensive criteria detail expected learning outcomes at various qualification levels (Bachelor's, Master's), systematically guiding curriculum development and assessment practices. These criteria emphasize not only foundational disciplinary knowledge (e.g., mathematics and physics) but also capabilities in analysis, design, and real-world implementation. For example, students must demonstrate the ability to apply engineering techniques, understand sustainability considerations, and appreciate ethical and societal implications of engineering work.

In contrast, non-STEM space-related programs, such as space law, management, policy, or economics, often lack similarly standardized European-wide accreditation frameworks, leading to variability in curricula and learning outcomes. The absence of consistent accreditation standards in non-STEM fields complicates comparability and recognition across institutions, limiting graduate employability and mobility. This highlights the necessity for developing clear and consistent pan-European accreditation or standardization mechanisms for non-STEM space-related programs, ensuring their alignment with industry needs and facilitating greater workforce integration.

Research results, highlights differences in accreditation standards and curriculum structures between STEM (Science, Technology, Engineering, Mathematics) and non-STEM educational programs across Europe. These differences have direct implications for the consistency of educational outcomes and the mobility and employability of graduates in the European space sector.

## 5.7 Informal Learning: Competitions, Mentoring, Internal Programs

Informal educational initiatives, such as student competitions (e.g., ESA's "Fly Your Satellite!"), mentoring schemes, and internal training programs, complement formal education effectively. These initiatives significantly enhance practical skills, professional development, and industry readiness, fostering skills such as project management, innovation, and interdisciplinary collaboration.

Mentoring programs and structured industry-academia exchanges are particularly beneficial, providing students direct exposure to industry environments and expert guidance. Internal company training programs and internships directly address specific industry needs, ensuring a continuously updated workforce. ASTRAIOS recommends expanding such informal educational structures to further support holistic workforce development across Europe.

### 5.7.1 Competitions and Project-Based Initiatives

Student competitions and project-based initiatives provide essential experiential learning opportunities, promoting practical application of theoretical knowledge, fostering teamwork, innovation, and problem-solving skills. Initiatives such as CubeSat projects, space hackathons, and ESA's "Fly Your Satellite!" competition illustrate successful informal educational approaches, enabling students to engage directly with real-world challenges and industry standards. These activities often significantly improve students' hands-on experience and readiness for industry integration.

### 5.7.2 Mentoring and Professional Development Programs

Mentoring schemes and structured industry-academia exchanges significantly enhance students' professional development, providing direct exposure to real-world industry environments and expert guidance. ASTRAIOS has identified mentoring as a critical factor for successful workforce integration, recommending structured mentorship programs within universities and companies, particularly focusing on guiding students through career decisions and industry transitions. Industry-academia collaboration through mentoring is essential in ensuring alignment of academic training with real industry expectations.

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### 5.7.3 Internal Industry Programs

Internal training and development programs within space companies and organizations significantly contribute to workforce upskilling and continuous professional development. Internal programs, such as internships, graduate training schemes, and continuous education workshops, are pivotal in maintaining a skilled, up-to-date workforce. These programs are particularly effective in closing specific skill gaps, enabling targeted training that directly responds to organizational needs, technological advancements, and emerging market opportunities.

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# 6. Future Skill Demand & Training Needs

## 6.1 Workforce demand projections

Anticipating the future skill demands and training needs of the European space sector is critical for sustaining industry growth, competitiveness, and innovation. The ASTRAIOS project has systematically analyzed these demands through a multi-faceted methodology including quantitative surveys, job advert and CV analyses, and socioeconomic assessments, providing robust projections for workforce evolution and skill requirements.

The ASTRAIOS D2.8 report, "Workforce Demand Evolution and Distribution," [27] characterizes how technological advancements, market developments, and socioeconomic changes shape the demand for skills in the European space sector. This comprehensive study highlights significant trends and predicts the direction of skill demands, driven by innovations such as robotics, artificial intelligence, and increased commercialization of space technologies.

Analysis conducted through job adverts and CV reviews from key databases such as SpaceCareers.com and LinkedIn Talent Insights has shown clear shifts in the types of competencies required by industry, marking the increasing importance of AI engineering, cybersecurity, data analytics, and software engineering, alongside robust demand for non-technical skills such as adaptability, creative thinking, and interdisciplinary communication. A sample analysis has been shown in Figure 22.

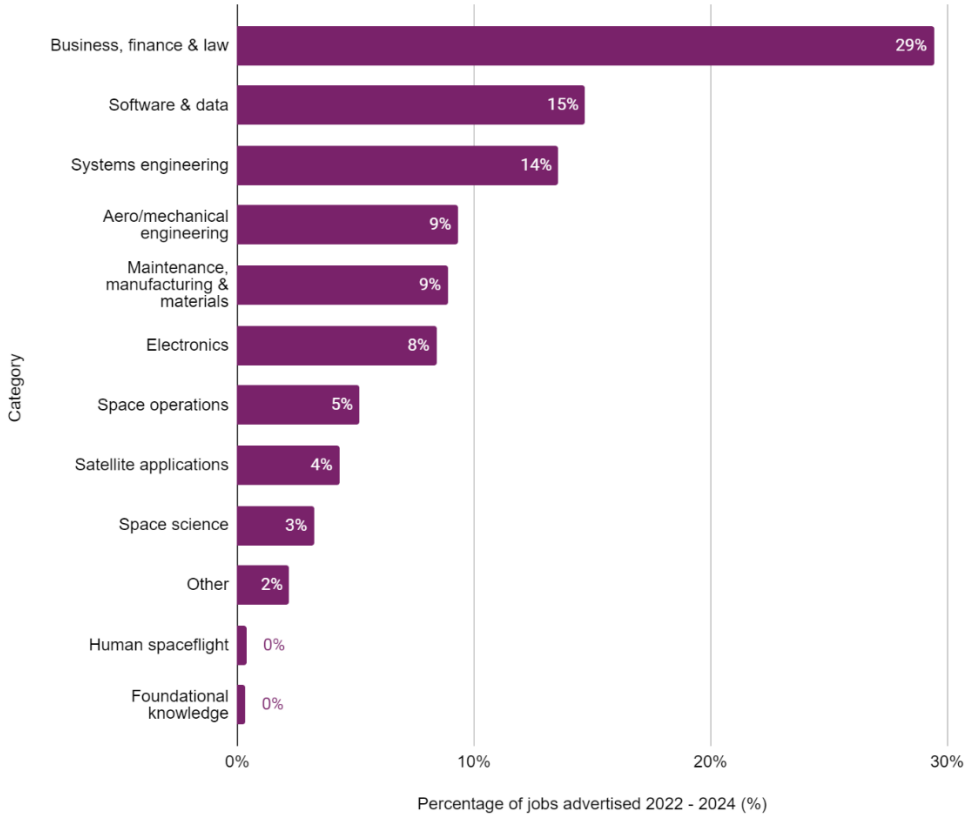


Figure 22: Percentage of jobs posted on SpaceCareers.uk between 2022 – 2024 classified by EU-TaSK theme (n=1,856).

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### 6.1.1 Projected Key Skill Demands

A notable outcome of the ASTRAIOS quantitative workforce survey identified general problem-solving capabilities and adaptability as critical future competencies. Employers emphasized the value of transferable, high-level skills, especially due to the rapidly changing technological landscape where specific technical knowledge quickly becomes obsolete. This indicates a clear sector preference towards graduates and professionals who exhibit strong foundational and adaptable skills over highly specialized, short-lived technical knowledge.

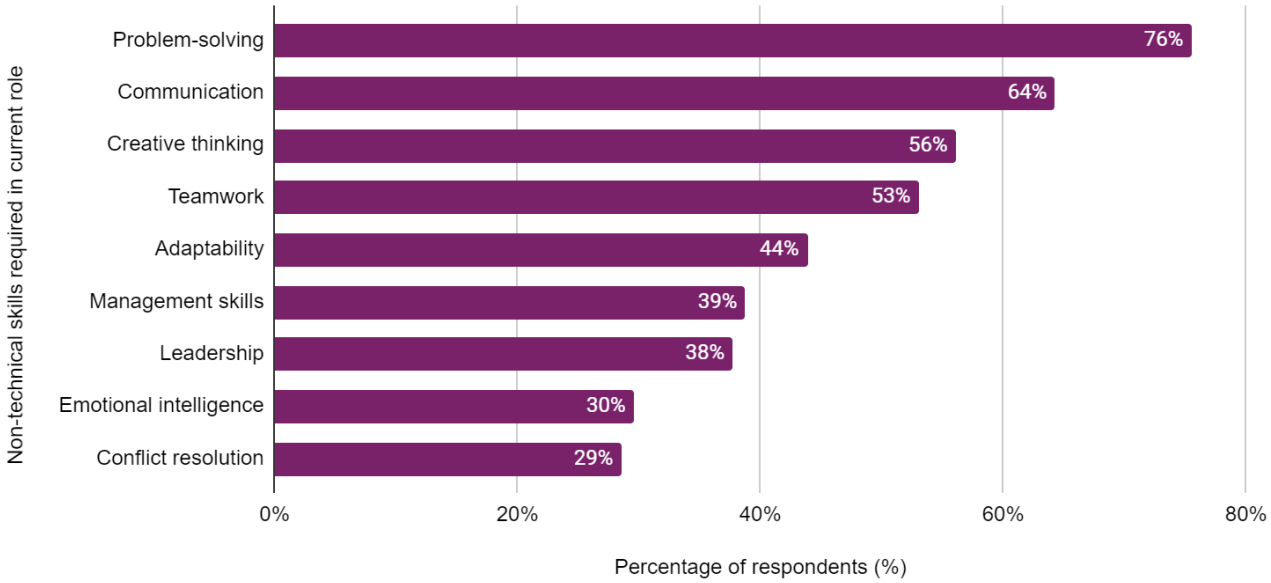


Figure 23: Most valuable non-technical skills for space job position (n=97).

The study found an oversupply of aero/mechanical engineering graduates compared to a growing demand in areas such as artificial intelligence, cybersecurity, and software development. The observed skill gap highlights the urgent need to redirect educational and training investments towards emerging technological areas to align supply more effectively with industry requirements.

### 6.1.2 Geographic Workforce Demand Trends

Geographically, workforce demand is not evenly distributed across the EU. A substantial portion of the workforce and job adverts is concentrated in major countries such as Germany, France, Italy, Spain, and the United Kingdom. These regions dominate both job opportunities and talent availability, creating potential imbalances and regional disparities within the broader European context (e.g., Figure 18 from ASTRAIOS D2.8 depicting workforce changes by country is recommended for inclusion in the report to visually demonstrate these geographic trends).

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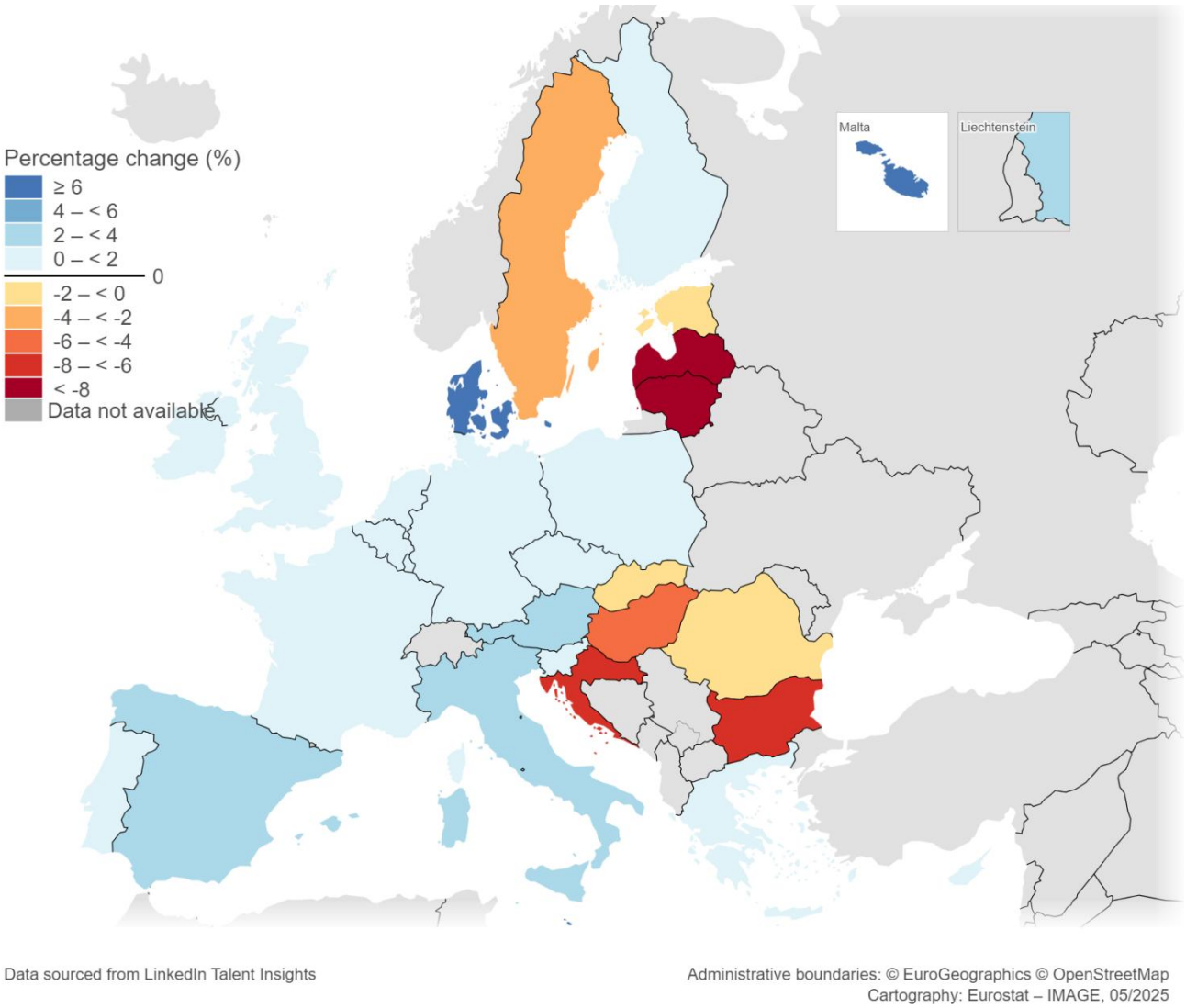


Figure 24: Percentage change in space workforce by country. (May 2024 - May 2025) [27]

Additionally, intra-European mobility significantly influences workforce dynamics, with countries such as Luxembourg, Belgium, and Germany gaining skilled professionals, often to the detriment of Eastern and Southern European states. This internal brain drain underscores the need for coordinated policies to mitigate regional imbalances and support balanced development across the EU.

### 6.1.3 Sectoral Employment and Retirement Trends

Private sector companies, especially SMEs, remain significant employers within the European space industry, accounting for approximately half of all sector employment. The ASTRAIOS results highlights concerns about the financial stability of these SMEs, pointing out potential vulnerabilities that could result in unwanted career moves and talent loss. The stability of the space workforce also depends partially on intrinsic motivation, reflecting the need for more supportive economic conditions to retain talent within the space sector.

Despite past concerns, no significant retirement wave was observed within the European space workforce. Data shows a stable age distribution, with the largest group of professionals aged between 35 and 49 years. This demographic stability suggests ongoing opportunities for knowledge transfer through mentoring and structured professional development programs rather than immediate workforce shortages due to retirement.

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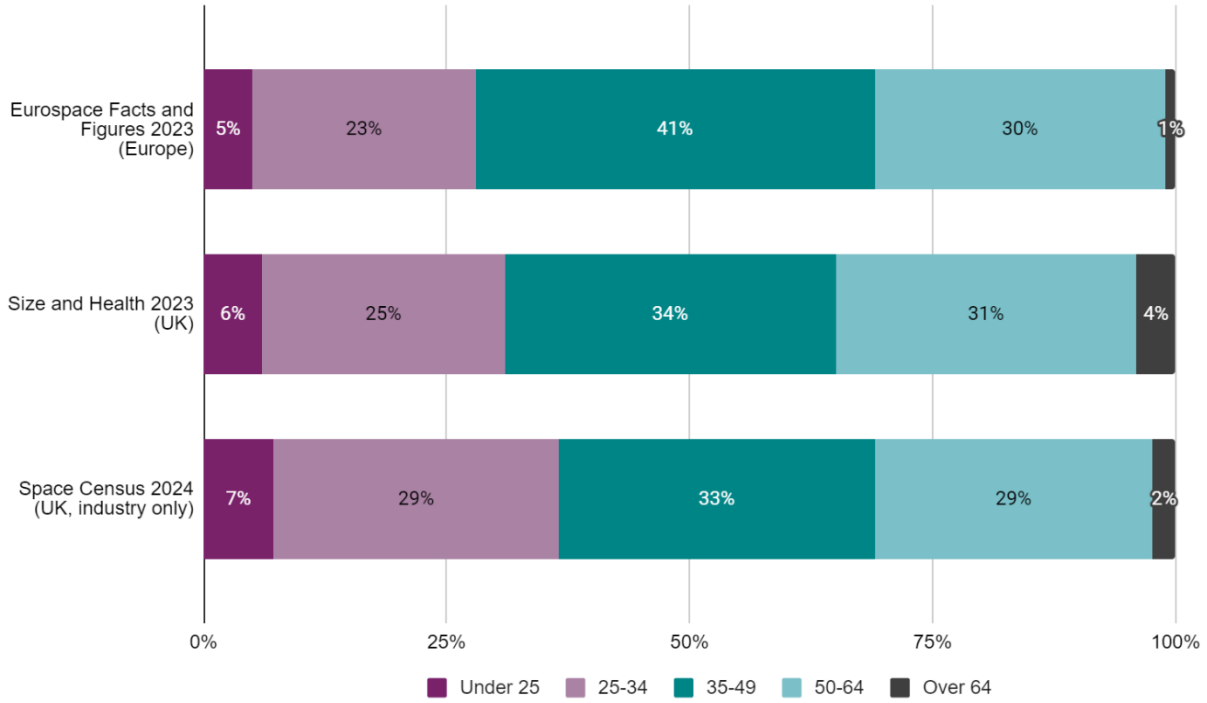


Figure 25: Age breakdown of the European space workforce[9].

## 6.2 Skills Needed for Emerging Technologies (AI, Autonomy, EO, autonomy, data-driven services)

As the European space sector undergoes a technological transformation driven by rapid advancements in artificial intelligence (AI), autonomy, Earth Observation (EO), and data-driven services, the demand for a highly skilled workforce adept in these emerging technologies is increasingly evident. Analysis conducted by ASTRAIOS underlines critical areas where substantial new skillsets are required to maintain Europe's competitiveness and technological leadership.

**AI and Data-Driven Services:** AI-driven data analysis and processing represent significant emerging areas of skill demand within the space sector. Earth Observation, for instance, leverages advanced AI technologies like onboard AI processing, deep learning models, and generative AI approaches to manage the vast volumes of satellite data efficiently and accurately. Skills in machine learning, deep learning, and data optimization are particularly critical, enabling professionals to enhance the speed, accuracy, and efficiency of satellite data interpretation and processing [27]

For downstream applications—such as climate monitoring, urban planning, and disaster management—proficiency in data fusion, geospatial data visualization, and geographic information system (GIS) integration is crucial. This skill set supports the development of integrated, actionable insights from satellite and auxiliary data streams, which is vital for effective decision-making across multiple sectors.

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**Real-Time and Cloud-Based Processing:** The rise of cloud computing in Earth Observation and space operations demands professionals proficient in cloud technologies and real-time data management. Skills in cloud infrastructure, real-time data transmission protocols, and remote data handling are increasingly essential, reflecting the industry's pivot towards more scalable and accessible data services. Professionals with combined expertise in remote sensing and cloud computing are especially valued for their ability to bridge technological domains effectively.

**Autonomy and Robotics:** Autonomous systems and robotics are reshaping the space domain by enabling advanced satellite servicing, active debris removal, and autonomous navigation systems. Professionals skilled in autonomous control systems, robotics engineering, sensor integration, and AI-driven robotics are therefore increasingly sought after. The industry requires expertise not only in designing these systems but also in managing and operating autonomous missions effectively. Specific skills include systems engineering for autonomy, embedded systems development, and robotic process automation (RPA) [27].

**Hyperspectral and High-Resolution Imaging:** Technological advancements in hyperspectral imaging and high-resolution satellite sensors significantly enhance the granularity and quality of satellite-derived data. As these technologies evolve, the sector increasingly requires specialists in hyperspectral sensor design, advanced remote sensing technologies, and space systems engineering to drive further innovation. Skill needs here are predominantly within engineering disciplines, focused on developing and deploying cutting-edge satellite instrumentation and sensors.

**Geospatial Integration and Augmented Reality:** Emerging technologies such as augmented reality (AR) integrated with geographic information systems (GIS) represent transformative opportunities for space data application. Professionals equipped to handle geospatial data integration across varied platforms and formats, combined with capabilities in AR and virtual reality (VR) development, are becoming highly valuable. These skills enable the creation of innovative applications, ranging from real-time environmental visualization to enhanced situational awareness tools.

**Sectoral and Regional Considerations:** Regional leadership, particularly in Germany, France, and other established European space hubs, reflects strong capabilities in EO research and operational activities. However, there is growing emphasis on developing these skills across the entire EU, suggesting that investments in specialized training and education initiatives should be geographically balanced to ensure broader European technological advancement and workforce capability.

## 6.3 Analysis of education-to-workforce pipeline

The education-to-workforce pipeline within the European space sector presents both opportunities and challenges, fundamentally influencing the sector’s capacity to sustain innovation and growth. ASTRAIOS research, supported by multiple studies, reveals key dynamics and gaps within this critical transition process.

Graduates predominantly enter the space industry via higher education institutions, with a clear preference for individuals holding Master’s degrees in STEM subjects, particularly aerospace engineering, computer science, and related disciplines. Aerospace engineering degrees, in particular, have grown in popularity as foundational qualifications for entering the sector, reflecting an increased emphasis on specialized technical knowledge. Conversely, traditional electronics engineering degrees have seen diminishing appeal among new entrants, hinting at a shifting skill preference within industry recruitment patterns. (Figure 26) [3]

Despite this strong educational foundation, significant gaps exist between the skills acquired during academic training and those demanded by industry. Industry stakeholders frequently highlight a disconnect where university courses may be either too theoretical or overly specific, inadequately aligning with the dynamic and evolving needs of the aerospace sector. This disconnect is evident in recruitment patterns, where new

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graduates are considered easily recruitable yet often fall short of industry expectations regarding practical skills and direct applicability to industry operations. [7]

Close collaboration between educational institutions and industry is crucial to resolving these gaps. The need for increased industry-academia partnership has been consistently emphasized, advocating joint curriculum development, structured internships, apprenticeships, and direct industry involvement in academic training. In Germany, for example, dual educational systems have effectively bridged the gap, integrating vocational and academic training with hands-on industry placements. This approach ensures graduates are equipped with market-relevant skills, significantly improving their employability and readiness. [7]

Across Europe, however, the adoption of such dual-track systems remains uneven, resulting in discrepancies in the effectiveness of education-to-workforce transitions. Countries with less developed vocational training infrastructure face significant hurdles, relying instead on fragmented, employer-driven initiatives that lack national coordination.

Another critical aspect influencing the pipeline is workforce mobility and geographical disparities. Highly mobile, skilled graduates tend to move towards regions with established space industry clusters and robust career opportunities, such as Germany, France, and the UK. This pattern exacerbates geographical imbalances and contributes to brain drain in countries or regions with less developed aerospace sectors. [6]

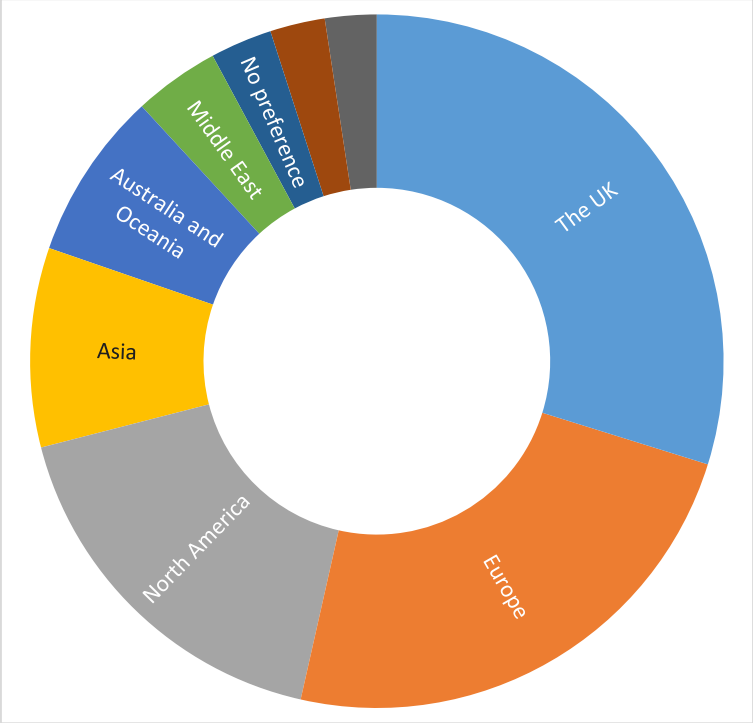


Figure 26: One of UKSEDS Mobility Survey's question *In which regions or countries would you be most interested in pursuing a space sector role?

Furthermore, projections indicate an expanding and diversifying space job market, driven significantly by new positions and roles arising from technological advancements in artificial intelligence, autonomy, Earth observation, and data-driven services. This trend underscores the necessity for educational institutions to proactively integrate emerging competencies and interdisciplinary approaches into curricula, ensuring alignment with future sector demands.

However, challenges persist, including uneven industry maturity across Europe, rapidly changing technological landscapes, and demographic shifts such as the impending retirement of a significant portion of experienced

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professionals. Approximately 44% of ESA's workforce is projected to retire by 2030, intensifying the urgency for effective succession planning, knowledge transfer, and accelerated development of junior talent. [7]

## 6.4 Industry perspectives from employer surveys and venture capital data

Industry perspectives gathered through surveys and analysis of venture capital trends provide essential insights into the European aerospace sector's current status and future directions. Employers across the sector highlight persistent challenges, notably the gap between academic curricula and industry needs, particularly the practical, real-life skills demanded in professional environments. According to recent surveys, companies report significant shortages in core technical skills such as engineering, IT, and emerging fields like artificial intelligence, machine learning, and data science. Additionally, leadership, communication, flexibility, and adaptability are increasingly recognized as vital skills by European aerospace organizations, reflecting the industry's evolving requirements [7].

An evident mismatch persists in the preparedness of recent graduates, with universities tending to emphasize theoretical knowledge rather than the practical competencies and soft skills that industry actively seeks. This gap underscores the necessity for higher education institutions to foster closer collaboration with industry, developing curricula that balance theoretical foundations with industry-specific, practical training.

Venture capital trends further illuminate the evolving aerospace landscape. Investment in aerospace startups, particularly within segments like micro-launchers and satellite applications, is markedly increasing. Europe has seen the emergence of numerous innovative firms such as Rocket Factory Augsburg, Orbex Space, and PLD Space, all engaged in developing cutting-edge micro-launch technologies. These companies benefit from venture capital investments, signaling robust investor confidence in European aerospace startups [4]. Despite these positive investment trends, smaller enterprises face substantial financial hurdles, notably when seeking moderate funding levels between one to five million Euros. Such amounts often fall into a financing gap—too large for banks yet insufficiently attractive for typical venture capitalists.

Companies frequently rely on internal training and professional development schemes to mitigate skill gaps, employing strategies such as on-the-job training, targeted workshops, and upskilling programs. Such initiatives, complemented by industry-academia collaborations, internships, and structured mentoring, significantly enhance workforce readiness and retention.

Surveys have also highlighted mobility and retention issues, notably mid-career talent leaving aerospace for more lucrative opportunities in sectors like finance and technology, resulting in challenges in retaining experienced talent. The high turnover among early-career professionals (about 67% within the first five years) further compounds workforce stability, creating reliance on experienced staff and underscoring the critical need for structured career development pathways and attractive employment conditions.

To summarize, the industry perspectives underscore a clear and urgent call for greater alignment between education and professional requirements, substantial investments in vocational and continuous professional development, and policies facilitating smoother capital access for SMEs. Addressing these focal points will be essential for sustaining and enhancing Europe's competitiveness in the global aerospace sector.

## 6.5 Evolution of job postings, CV trends, and LinkedIn insights

Recent analyses of workforce trends in the European space sector underscore dynamic shifts in employment patterns, CV submissions, and job postings, particularly illuminated by data from LinkedIn Talent Insights and industry reports.

LinkedIn Talent Insights and related databases reveal that job postings within the European aerospace and space sectors predominantly concentrate in Germany, France, the UK, Italy, and the Netherlands. Collectively,

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these five countries accounted for 78% of all job postings on LinkedIn over the past year. France and Germany, notably, present a disproportionate demand for aerospace professionals relative to the number of CVs actively submitted by candidates. France, for instance, accounted for around one-quarter of job postings, yet represented only 9% of total CV submissions. This suggests a significant talent shortage in France, highlighting challenges in meeting recruitment demands despite a substantial workforce presence. [27]

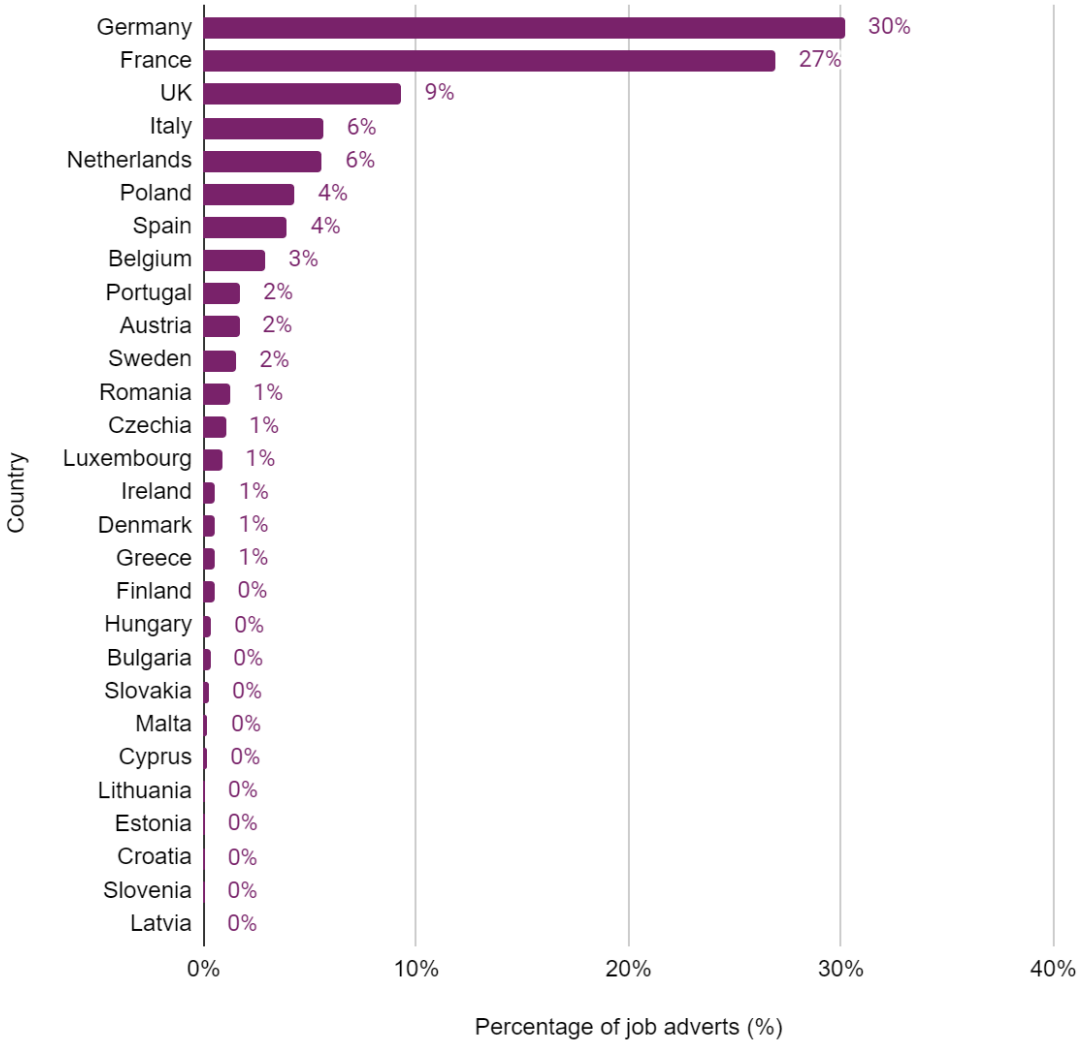


Figure 27: Percentage of job adverts posted by country. [27]

Conversely, Italy exhibits an opposite trend, with a higher proportion of CV submissions (22%) compared to its workforce share (10%) and job postings (6%). This indicates an oversupply of candidates relative to available positions, reflecting potential barriers to employment within Italy's aerospace sector.

The UK also demonstrates an imbalance, with 23% of the workforce but only 9% of job postings. The surplus of CVs from the UK indicates a competitive job market, further corroborated by the 2023 UK Space Sector Skills Survey, suggesting an oversupply of graduates relative to the number of available positions.

Age distribution insights further enhance our understanding of workforce dynamics. The largest demographic within the European space sector workforce falls in the 35–49 age range, accounting for approximately 41% across Europe. Notably, the UK space workforce is comparatively younger, with a higher proportion of professionals under 35 years, reflecting potentially stronger recruitment or retention strategies targeting younger cohorts.

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- More statistics available in reference [27] and [3] (Reports of ASTRAIOS project)

Skills data from CV and job postings analysis highlight a growing emphasis on advanced technical expertise, particularly in software engineering, cybersecurity, data analytics, and systems integration. This mirrors broader industry trends emphasizing innovation in satellite technologies, propulsion systems, and data-driven space services. Additionally, a pronounced demand exists for cross-disciplinary and transferable skills, including project management, systems thinking, and advanced engineering competencies, which underscores the increasing complexity and interdisciplinarity of modern aerospace projects.

Regional employment trends also indicate significant workforce fluctuations. For example, Denmark and Malta experienced notable employment growth of approximately 8%, likely due to targeted investments and expanding space initiatives. Conversely, Eastern European countries such as Lithuania, Latvia, and Bulgaria faced substantial workforce reductions, attributed to economic pressures, migration of skilled professionals, and limited domestic opportunities.

Data accuracy and representation in these trends are contingent upon several factors related to LinkedIn Talent Insights. For instance, the data might be biased towards younger demographics, as the majority of LinkedIn users are aged 25–34 [31], potentially skewing age distribution insights. Moreover, there is an acknowledged issue with data accuracy, as LinkedIn relies on self-reported and voluntary updates, which may lead to discrepancies in skills reporting or outdated employment statuses. [3]

In conclusion, the European space sector employment landscape is characterized by significant imbalances in supply and demand for talent, regional disparities, evolving skill requirements, and demographic nuances. These insights suggest that tailored recruitment strategies, continuous professional development programs, and targeted educational initiatives will be crucial to addressing these challenges and ensuring alignment between the evolving workforce capabilities and industry needs.

## 6.6 Skills for Sustainability and Innovation in Space Sector

The rapid transformation of the European space sector, driven by innovation and sustainability objectives, significantly reshapes the skills demanded by employers. Skills required in the industry increasingly extend beyond traditional technical competencies to encompass broader expertise in sustainability, innovation management, and cross-sector collaboration.

The European space sector currently places a heightened emphasis on skills related to sustainable development, driven by policy frameworks and the industry's commitment to environmental, social, and governance (ESG) practices. Sustainability-related skills include lifecycle analysis, advanced sustainable manufacturing techniques, recyclability, reusability of space systems, and emissions reduction strategies. These competencies align with broader European policy goals and are essential for addressing pressing challenges like space debris management and sustainable access to space.

Furthermore, innovation within the space sector demands specialized skills in emerging technologies such as artificial intelligence (AI), machine learning (ML), robotics, and advanced materials. These are particularly crucial for applications in Earth observation, autonomous systems, and data-driven services, areas rapidly expanding within the industry. For instance, companies involved in space safety and sustainability, such as Look Up Space, Aldoria, and ArianeGroup, have generated a growing demand for expertise in AI-driven data analytics, predictive sensing systems, and advanced propulsion technologies. The workforce is increasingly required to possess cross-functional expertise, integrating AI capabilities with traditional engineering roles to enhance collision avoidance systems, debris capture technologies, and space traffic management [27].

Soft skills, particularly adaptability, flexibility, and collaborative project management, have also gained substantial prominence. Employers in the sector emphasize the importance of multidisciplinary approaches

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and the ability to work within international, cross-sectoral teams. Leadership skills related to managing complex projects and innovation-oriented thinking are becoming as critical as technical proficiency [5].

Additionally, the French aerospace sector has highlighted significant recruitment challenges, especially in roles involving sustainability, energy efficiency, and environmental protection. The sector emphasizes the need for a workforce that is continuously updated in terms of technological innovations and sustainability practices. This reflects a broader trend within Europe, where technical, managerial, and leadership skills are identified as needing continuous development to maintain organizational competitiveness [7].

A crucial emerging issue is the anticipated retirement wave within the next decade, where approximately 44% of the current expert workforce, particularly at agencies like ESA, is expected to retire. This impending demographic shift underscores the critical need for succession planning, knowledge transfer, and strategic upskilling initiatives aimed at sustaining organizational knowledge and promoting workforce continuity [7].

To effectively support these evolving skill requirements, education and training initiatives within Europe must increasingly focus on flexible, modular approaches that allow rapid adaptation to new technological trends and sustainability practices. Active collaboration between academia, industry, and governmental bodies remains pivotal for addressing skill gaps and preparing the workforce for future demands. Initiatives such as the Pact for Skills highlight the necessity of coordinated efforts to upskill a significant portion of the aerospace workforce, focusing on areas like sustainability, digital transformation, and advanced technological competencies.

Overall, the convergence of sustainability objectives and innovative technological developments is fundamentally reshaping skill profiles required in the European space sector. Addressing these requirements through strategic education and training initiatives is crucial for sustaining Europe's competitiveness and leadership in the global space economy.

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# 7. RECOMMENDATIONS

## 7.1 Summary of key findings

Over the course of the ASTRAIOS project, extensive data collection and analysis have revealed recurring patterns, strengths, and weaknesses across Europe's space education and workforce development landscape. These findings, summarized in Table 4.

Table 4: Summary of Key Findings

| Row | Theme | Key Findings |
|---|---|---|
| 1 | Education-to-Workforce Alignment | Persistent mismatch between university curricula and employer needs—especially in hands-on systems skills and real-world tooling |
| 2 | Pedagogical Modernization | Uneven adoption of experiential, project-based learning methods across Europe; strongest in technical universities and ESA-linked initiatives |
| 3 | Vocational & CPD Systems | Some countries like Germany lead with dual-track model; most countries lack scalable vocational infrastructure and coordinated CPD strategies |
| 4 | Technical Skill Gaps | Shortages in software/data, systems Engineering, AIT, and standard based roles (ECSS); cybersecurity and AI especially difficult to hire for |
| 5 | Soft Skill Gaps | Communication, leadership, teamwork, adaptability frequently missing; not systematically embedded in curricula |
| 6 | Demographic Disparities | Gender imbalance (especially upstream), geographic concentration in Western Europe, limited mobility from underrepresented regions |
| 7 | Digital Tools & MOOCs | MOOCs and VR/AR are underutilised; success stories exist (e.g. ESA Academy, ASTRAIOS MOOCs), but wider adoption is limited by resources and quality |
| 8 | Curriculum Fragmentation | Lack of standardization, especially in non-STEM fields (e.g., space law, policy); STEM curricula benefit from frameworks like AHEP and EQF |
| 9 | Industry-Academia Feedback Loops | Employer engagement exists but is informal and inconsistent; weak curriculum feedback and shared teaching models |
| 10 | Sustainability & Innovation Skills | Curricula lag in emerging domains: green propulsion, in-orbit servicing, climate EO; anticipatory skill planning remains underdeveloped |
| 11 | Post-COVID Digital Learning Efficacy | Concerns about learner engagement and retention in fully online settings; hybrid models appear more effective but need empirical study |

These consolidated findings highlight both opportunities and urgent challenges. They serve as the foundation for the practical, stakeholder-specific recommendations in the following sections (7.2–7.5), guiding targeted action by educational institutions, industry, and policy actors across the EU space ecosystem.

## 7.2 Actions for educational institutions

Higher education institutions (HEIs) play a central role in shaping the future space workforce. As the ASTRAIOS analysis reveals, while many universities offer rigorous academic foundations, significant opportunities remain to better prepare students for the interdisciplinary, hands-on, and rapidly evolving nature of space careers. The Table 5 outlines targeted actions that HEIs can undertake to address the identified gaps and strengthen the education-to-employment pipeline.

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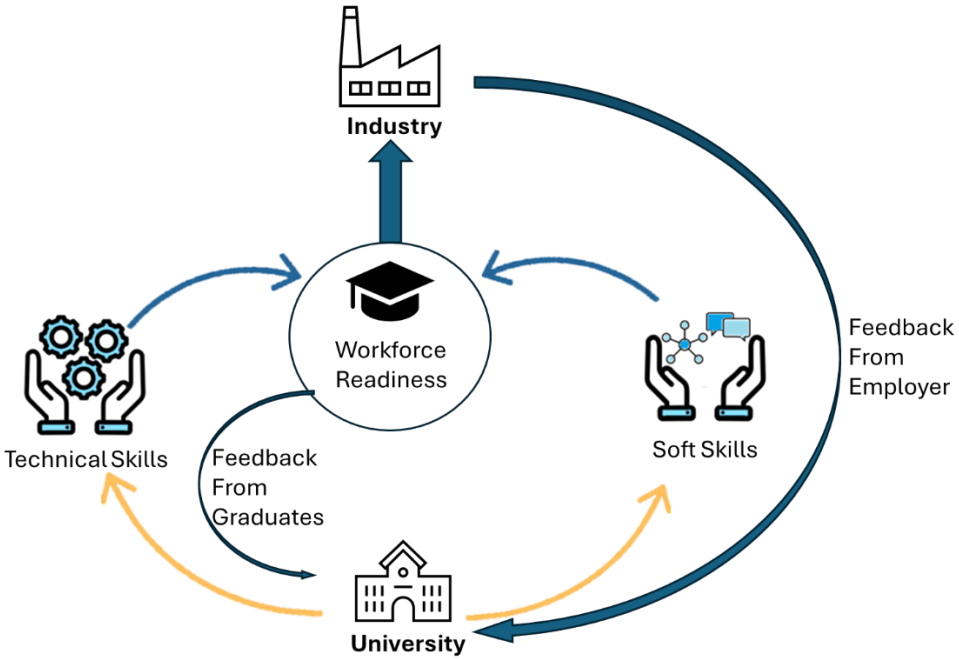


Figure 28: University Curriculum Reform Cycle

A simple schematic flowchart or infographic showing “University Curriculum Reform Cycle” has been shown in Figure 28.

Table 5: Priority Actions for Educational Institutions

| Row | Challenge | Recommended Action |
|---|---|---|
| 1 | Limited hands-on, systems-level training | Integrate project-based and design-based learning (PBL/DBL) across all levels of curriculum, including simulation-based group assignments, CubeSat development, or mission design courses. |
| 2 | Curriculum misalignment with real-world tooling | Introduce systems engineering, ECSS standards, mission analysis tools, and concurrent design workshops as embedded components in technical degrees. |
| 3 | Fragmented interdisciplinary education | Create cross-departmental modules that combine STEM with economics, law, policy, ethics, sociology, psychology and sustainability in space exploration and application domains. |
| 4 | Weak soft skill development | Embed soft skills into assessment strategies—e.g., teamwork rubrics, communication-based deliverables, leadership roles in group projects, and conflict resolution workshops. |
| 5 | Gaps in digital teaching innovation | Expand access to blended learning platforms, develop high-quality MOOCs, and invest in AR/VR labs for space systems training. |
| 6 | Uneven access to modern resources | Establish partnerships with national or regional centers (e.g., ESA Academy, university consortia) to share infrastructure and co-deliver practical modules. |
| 7 | Lack of employer co-design in curricula | Form structured advisory boards with industry members to review and update course content annually; co-develop elective modules with space companies. |
| 8 | Disconnect from graduate transitions | Improve career preparation through internship facilitation, industry guest lectures, CV/portfolio workshops, and mentoring programs embedded into curricula. |

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| Row | Challenge | Recommended Action |
|---|---|---|
| 9 | Insufficient faculty development | Provide continuous training for academic staff on emerging space technologies and pedagogical innovations (e.g., PBL methods, digital teaching tools). |
| 10 | Barriers to regional capacity building | Support institutions in underserved regions by creating faculty mobility programs, open-access training kits, and shared courseware repositories. |

A coordinated implementation of these strategies, tailored to institutional strengths and regional contexts, can significantly strengthen the relevance, inclusivity, and adaptability of Europe's space education system. As the sector moves toward new frontiers in sustainability, autonomy, and global cooperation, universities must lead in cultivating the agile, multidisciplinary talent required to support this transformation.

## 7.3 Strategies for Industry and Employers

Employers across the European space sector, from established integrators to emerging NewSpace ventures, are at the forefront of both innovation and workforce development. ASTRAIOS findings make clear that many of the most persistent skill gaps, particularly in systems integration, space product assurance, soft skills, and applied experience, cannot be resolved by educational institutions alone. Industry has a vital role to play in training, mentoring, and co-developing the workforce. The following table presents recommended strategies that employers can adopt to address current and future workforce challenges.

Table 6: Strategic Actions for Industry and Employers

| Row | Challenge | Recommended Action |
|---|---|---|
| 1 | High onboarding costs due to skill mismatches | Offer structured graduate schemes and earlycareer apprenticeships tailored to systems thinking, integration, and mission level workflows. |
| 2 | Lack of visibility into evolving education outputs | Establish formal partnerships with HEIs for curriculum codevelopment, student feedback loops, and shared access to training outcomes. |
| 3 | Insufficient in-house upskilling/reskilling | Develop internal CPD modules and microcredential pathways in areas such as AI, EO analytics, systems engineering, and ECSS compliance. |
| 4 | Weak SME training capacity | Partner with national agencies or ESA BICs to access modular training packages and staff development toolkits tailored for small and medium enterprises. |
| 5 | Disconnection from university soft skill formation | Provide structured mentoring, soft-skill coaching, and scenario-based workshops (e.g., mission simulations, conflict resolution) in collaboration with universities. |
| 6 | Gender and diversity imbalances | Actively recruit from underrepresented groups and support inclusive hiring, retention, and promotion policies backed by internal mentoring frameworks. |
| 7 | Missed opportunities for internships or placements | Create recurring, compensated internship cycles with well defined project scopes; align with academic calendars and credit systems to maximize uptake. |
| 8 | Fragmented engagement with schools and early talent | Support STEM outreach, sponsor space competitions, and co create teaching materials for secondary education to build early awareness of career paths. |
| 9 | Limited awareness of workforce mobility patterns | Analyze internal turnover and hiring trends (e.g., LinkedIn Talent Insights) to adjust workforce planning and tailor recruitment and retention strategies. |
| 10 | Underutilized alumni networks and training spillover | Engage former employees and interns in alumni training networks; facilitate knowledge transfer across project generations. |

Through strategic investments in early career training, in house development, and meaningful collaboration with education providers, space sector employers can reduce recruitment frictions and foster a highly

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adaptable workforce. Industry led efforts, when aligned with academic and policy frameworks, represent a cornerstone of Europe's long-term competitiveness and leadership in space innovation.

## 7.4 Recommendations for policymakers

Policy intervention remains essential to reinforce and coordinate the efforts of educational institutions and industry stakeholders across Europe. ASTRAIOS findings highlight the importance of harmonizing education frameworks, expanding funding mechanisms, and supporting long term workforce development through inclusive, evidence-based policies. Policymakers at EU, national, and regional levels can enable structural transformation in how the European space workforce is trained, reskilled, and mobilized, especially to address regional disparities, underrepresented groups, and emerging technology needs.

Table 7: Strategic Recommendations for Policymakers

| Row | Policy Gap or Challenge | Recommended Action |
|---|---|---|
| 1 | Fragmented space education standards across countries | Promote EU wide accreditation alignment using the European Qualifications Framework (EQF) and foster mutual recognition of space related credentials. |
| 2 | Uneven access to space education in underserved regions | Create targeted funding schemes (e.g., for regional HEIs) and mobility scholarships to increase participation from low access and remote areas. |
| 3 | Lack of standardized data on education to workforce flow | Support longitudinal data collection across Member States and mandate regular skills foresight studies in coordination with projects like ASTRAIOS. |
| 4 | Underutilized vocational education channels | Expand EU level initiatives (e.g., Pact for Skills) and co fund dual track vocational training schemes modeled on successful national systems. |
| 5 | Gender and diversity underrepresentation | Enforce inclusion targets in national space strategies; support mentoring and scholarship programs for women and underrepresented communities. |
| 6 | Skills lag in emerging technologies (AI, EO, autonomy) | Launch thematic reskilling and innovation grants in alignment with space priorities (e.g., EU Space Programme, Horizon Europe clusters). |
| 7 | Poor alignment between HEIs and labour market demands | Mandate regular policy HEI industry roundtables; support curriculum co design via funding incentives and strategic partnerships. |
| 8 | Weak STEM engagement at secondary education level | Develop a European Space Education Outreach Strategy supporting schools through ESA/EUSPA partnerships, local observatories, and online content. |
| 9 | Inefficient internship and mobility support mechanisms | Harmonize and simplify cross border internship frameworks; incentivize companies to host student placements via tax credits or direct subsidies. |

With coordinated support from policymakers, Europe can better leverage its existing academic and industrial strengths to ensure inclusive, agile, and future ready space workforce development. Effective policy does not only react to skills gaps, it anticipates them, guiding investments that will shape Europe's space leadership over the coming decades.

## 7.5 Cross Sector Collaboration and EU Policy Alignment

Europe's space sector operates within a complex ecosystem that spans government, academia, industry, and civil society. While siloed approaches have led to fragmented efforts in skills development, education, and innovation, the ASTRAIOS findings highlight the urgent need for integrated, cross sector collaboration backed by EU level policy coordination. Achieving sustainable growth and innovation in the European space workforce requires systemic mechanisms that align diverse actors, eliminate redundancies, and scale successful practices across the continent.

The Table 8 outlines key recommendations to enhance EU wide policy coherence, stimulate cross sector synergies, and align strategic goals across education, research, and industrial stakeholders.

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Table 8: key recommendations to enhance EU-wide policy coherence, stimulate cross-sector synergies, and align strategic goals across education, research, and industrial stakeholders

| Challenge | Recommendation | Target Stakeholder(s) | Expected Outcome |
|---|---|---|---|
| Fragmentation of national policies and skill initiatives | Establish an EU Space Skills Council to coordinate skill development agendas across Member States, aligning national actions with the EU Space Strategy | European Commission, DG DEFIS, National Ministries | Centralized coordination and strategic alignment across educational and industrial ecosystems |
| Weak collaboration between space and non-space sectors | Promote interdisciplinary collaboration hubs, encouraging joint initiatives between space, digital, environmental, and manufacturing sectors | EU funding bodies (e.g. Horizon Europe), industry clusters, EIT | Innovation through technology spillover and new cross-sector applications |
| Disparity in training and certification recognition | Develop an EU wide qualification framework for space related skills (linked to EUTaSK and EO4GEO BoK) | European Space Agency, Accreditation Bodies, Universities | Standardized skills recognition and easier mobility of professionals across Europe |
| Duplication of efforts in education and innovation | Create a shared knowledge repository (EU Space Skills Portal) integrating outputs from projects (e.g. EO4GEO, ASTRAIOS, SPACESUITE) | European Commission, HEIs, project consortia | Open access to validated training resources and project outcomes |
| Underutilized policy to practice feedback loops | Launch policy foresight workshops that engage academia and industry in shaping future EU policy priorities in space workforce development | DG RTD, ESA, industrial associations | More agile policy cycles informed by emerging skills, technologies, and job market needs |
| Unequal access to EU funding opportunities | Align funding mechanisms (e.g. InvestEU, Erasmus+, Digital Europe) to prioritize cross sector, inclusive, and regional partnerships | EC Program Managers, National Contact Points, SMEs | Improved participation of emerging actors and underrepresented regions |
| Lack of coordinated space innovation ecosystems | Institutionalize the Space Hubs Coordination Office as proposed in ASTRAIOS D2.2 to support pan EU cooperation among incubators and tech clusters | EC, ESA, EUSPA, Regional Innovation Agencies | Streamlined best practice sharing and long term capability development across Member States |

ASTRAIOS emphasizes that Europe's future competitiveness in the global space economy hinges on a paradigm shift from fragmented national actions to a unified, EU coordinated model. Embedding collaboration into the structural design of education, training, and industrial policies, while using tools like EUTaSK, the Space Skills Portal, and centralized hubs, will drive coherence, efficiency, and resilience across the space skills ecosystem.

t is noted that the insights and preliminary recommendations presented in this report will directly inform the final, consolidated set of actionable recommendations to be delivered in D3.5 – Final Recommendations report on continuing success of the European Space Sector. This ensures continuity and alignment of findings across the full ASTRAIOS project lifecycle.

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