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Erasmus+ Programme
of the European Union

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Occupations and Qualifications Generated by New Technologies for the Digitalization and Sustainable Development of the Air Transport Industry

Co-funded by the
Erasmus+ Programme
of the European Union
2022-1-RO01-KA220-HED-000086424

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Occupations and Qualifications Generated by Digitalization and Sustainable Development in Aviation Industry

Editura JUNIMEA
2025

This publication is a result of the Creative Digital Teaching and Learning for Green Air Transport and Logistics (AVIONIC) Project 2022-1-RO01-KA220-HED-000086424.

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Preface

The aviation sector stands at a critical juncture, shaped by two transformative forces: digitalisation and the imperative of sustainable development. As new technologies redefine operations, logistics, and passenger experience, they simultaneously prompt a re-evaluation of the knowledge, skills, and qualifications required across the industry. Against this dynamic backdrop, the Creative Digital Teaching and Learning for Green Air Transport and Logistics Project (AVIONIC) has been initiated to explore and respond to these evolving needs.

The AVIONIC project has been developed to equip the air transport sector with forward-looking tools, curricula, and training resources that respond to the dual transition towards digitalisation and sustainability. Its main objectives are: (1) to identify the impact of digital and green technologies on aviation jobs; (2) to foster innovative, IT-enabled teaching and learning practices; (3) to co-develop new training content and qualifications with industry actors; and (4) to promote international collaboration for a skills-oriented, modernised aviation education system. Through these aims, the project supports the development of a resilient, skilled workforce capable of contributing to a more sustainable and competitive aviation industry.

This report, titled *Occupations and Qualifications Generated by Digitalisation and Sustainable Development in Aviation Industry*, was developed as part of the AVIONIC project and reflects a joint commitment by academic institutions, industry partners, and training providers from Romania, France, Finland, and Spain. It presents the findings of a systematic inquiry into how digital and green transitions are reshaping workforce profiles in the air transport ecosystem.

This report was produced within the framework of Work Package 2: Identification of new occupations and qualifications generated by digitalisation and sustainable development in aviation. This work package focuses on researching future workforce needs, analysing the relationship between emerging technologies and occupational shifts, and mapping relevant qualifications and skills gaps. The work presented in this report confirms the achievement of these objectives by: (1) identifying new occupational profiles shaped by digital and green transformations; (2) analysing the competencies required for those roles; and (3) assessing the adequacy of existing qualifications in relation to sectoral expectations. In doing so, it provides the evidence base necessary for designing updated curricula and training pathways aligned with the AVIONIC project's overarching goals.

Our work draws on a combination of literature analysis, expert consultation, and qualitative surveys involving key stakeholders: managers, employees, and

educators. This methodology enabled us to identify emerging occupations, assess competency gaps, and recommend updates to educational programmes aligned with current and future labour market demands. By closely examining the intersection of qualifications and industry expectations, the report provides strategic insights for curriculum design, workforce planning, and policy innovation.

The report is structured in two interconnected strands. The first analyses the global drivers and challenges reshaping the aviation sector, while the second examines how these transformations reverberate through the workforce. It highlights the emergence of new and hybrid job profiles, persistent skills shortages, and the growing demand for green and digital competences. The analysis underscores the importance of aligning qualifications with evolving labour market needs and stresses the urgency of rethinking education and training systems to better integrate interdisciplinary and practice-oriented learning. By mapping both the challenges and opportunities of workforce transformation, the report calls for a stronger connection between academia, industry, and policy. Ultimately, it argues for smarter qualifications and agile training pathways that prepare aviation professionals to navigate a future defined by innovation, resilience, and sustainability.

This work was carried out by a multidisciplinary team of researchers and practitioners dedicated to supporting a more adaptive, inclusive, and forward-looking aviation sector. We hope that this report will serve as a practical and strategic reference for building a resilient, innovative, and future-ready aviation workforce, capable of supporting the sector's green and digital transition.

More information and deliverables of the project are available at https://www.avionic.upb.ro/

About the Authors

Sorin Eugen ZAHARIA has a PhD in Mechanics, Aerodynamics and Aircrafts Engineering awarded by POLITEHNICA of Bucharest and a European PhD in Management obtained in France at Rouen University. He initiated, designed, developed and managed more than 45 research and training projects under various European programmes (Phare, RICOP, Jean Monet, Socrates, Leonardo da Vinci, Erasmus+, Horizon 2020 and European Social Fund) and in a multi-cultural environment. He has more than 200 publications.

By this way he accumulated a vast and very good experience in project management, especially in the fields of education and qualifications framework development. In the field of aviation, he oriented his research in management of higher education towards entrepreneurial university, qualifications framework and interactive teaching and learning methods. He published more than 30 articles on qualifications topic in Romanian and international scientific publications. He also published 7 chapters in books on the same topic and participated in more than 25 international events EQF or national qualifications framework development.

Within the 2001 and 2012 he has important responsibilities in Romanian Ministry of Education: General director of National Qualifications Authority (NQA) of Romania, General director of Executive Unit of the National Council of the Qualifications and Adult Training, Director National Agency for the Qualifications and the Partnership between Universities and the Economic and Social Environment – ACPART. He was involved in ESCO development, being member of ESCO Reference Groups: “Transportation and Storage” and Cross sector.

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Adina Petruța PAVEL is a lecturer at the UNESCO Chair "Engineering for Society" at the National University of Science and Technology Politehnica Bucharest. She holds a PhD in Business Administration, with a specialisation in Quality Management, awarded in 2015. With over 15 years of experience in higher education, research, and EU-funded project management, she brings together academic expertise and applied practice across sectors.

She teaches in several interdisciplinary master’s programmes, covering areas such as transport marketing, quality management, project management, economic and financial analysis in transport, and data analysis. Her research interests focus on

organisational culture, air transport systems, education quality, and higher education reform.

Dr. Pavel is the author or co-author of more than 40 scientific publications. She has contributed to the development of strategic educational resources, including the Methodology for the Sectoral Qualifications Framework in Air Transport and reports on digital and green skills in aviation. She is an active member in international projects promoting innovation in education, digital learning, and sustainable mobility.

Adina-Roxana MUNTEANU is a lecturer and researcher affiliated with the UNESCO Chair "Engineering for Society" at the National University of Science and Technology Politehnica Bucharest. She holds a PhD in Business Administration, with a focus on business models and strategic management. With over 12 years of experience in financial analysis, project management, and corporate reporting, she integrates applied industry knowledge into her academic work.

She teaches and researches in the areas of project and risk management, economic analysis, environmental accounting, and aviation sustainability. Her academic portfolio includes participation in the development of the Sectoral Qualifications Framework in Air Transport and contributions to EU-funded research in digital resilience and sustainable development.

Dr. Munteanu is the author or co-author of over 30 academic publications, with topics ranging from organic agriculture certification to strategic planning in transport and education systems, reflecting her interdisciplinary contributions to both economics and educational policy.

Steliana TOMA is an Emeritus Professor at the Technical University of Civil Engineering Bucharest and holds a PhD in Sciences of Education. She is also an associated researcher at the UNESCO Chair "Engineering for Society" at the National University of Science and Technology Politehnica Bucharest.

She is widely recognised for her contributions to higher education and educational policy, serving as a member of international editorial boards for three scientific journals and participating in various academic and national advisory bodies. Professor Toma has initiated and coordinated three master's programmes and six postgraduate programmes in areas such as Technological Education, Educational Management, Informatics, and Computer-Assisted Technologies.

Her contributions to policy and methodology include co-authoring the "*National Qualification Framework of Qualification for Higher Education Methodology"*, and the "*Sectoral Qualifications Framework in Air Transport Methodology"*. She is also a recognised expert in academic evaluation and

accreditation, having coordinated or participated in 35 international and national research and development projects.

Her scholarly work includes authorship, coordination, or co-authorship of over 160 scientific publications (books and articles), primarily focused on: curriculum development and evaluation, competence-based learning and assessment, professional and occupational standards, academic quality assurance, initial and continuous teacher training and technological education.

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AI	Artificial Intelligence
ANSP	Air Navigation Service Providers
AVIONIC	Creative Digital Teaching and Learning for Green Air Transport and Logistics Project
CEDEFOP	European Centre for the Development of Vocational Training
EASA	European Aviation Safety Agency
EC	European Commission
ECTS	European Credit Transfer and Accumulation System
EQF	European Qualifications Framework
ESCO	European Skills, Competences, Qualifications and Occupations
GHG	Greenhouse gas
HE	Higher Education
HEI	Higher Education Institution
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICT	Information and Communication Technology
IHLG	Industry High Level Group
IT	Information Technology
LCC	Low-Cost Carriers
LOs	Learning Outcomes
NQF	National Qualifications Framework
QF	Qualification Framework
SQF	Sectorial Qualifications Framework
SQFAT	Sectorial Qualification Framework for the Air Transport
VET	Vocational Education and Training

Executive Summary

The Future of Work in Aviation – Powered by Digitalisation and Sustainability

The aviation sector is undergoing significant transformation, driven by technological advancements, digitalization, and the growing emphasis on sustainable development. This report aims to identify emerging occupations and qualifications necessary for digitalization and sustainability in the aviation industry, as well as to analyse the evolving competency demands.

87.7 million

Jobs supported by aviation pre-pandemic, reflecting its status as a **global economic engine**.

4.3x

Jobs in aviation were, on average, **4.3 times more productive** than other sectors due to catalytic effects of connectivity and innovation

1.1% of Global GDP

Equivalent to **$961.3 billion**, generated directly by aviation in 2019.

The AVIONIC Project is managed by the National University of Science and Technology Politehnica Bucharest with the collaboration of key partners: the University of Strasbourg (France), Airport College International (Finland), Menzies Aviation (Romania), and the Polytechnic University of Madrid (UPM). It aims to mirror the transformations in aviation, where technological and ecological drivers, such as equipment, services, logistics, and environmental protection, play a key role.

The project seeks to strengthen Europe's innovation capacity by developing new curricula and modules that enhance skills in sustainable development and digital air transport. The transnational cooperation between Finland, France, Romania, and Spain focuses on improving knowledge in digitalization, cybersecurity, decarbonization, and sustainable development for the evolving air transport ecosystem.

AVIONIC Project: Skills for Twin Transitions

The project catalyses curriculum change

Prepare learners for smart, green aviation jobs by integrating **cross-disciplinary competencies**.

The project provides a holistic approach to integrating green and digital technologies in aviation. Through the extensive use of ICT tools for teaching and

learning, it aims to develop cross-disciplinary skills, ensuring the aviation sector can support the global economy while generating social benefits and promoting environmental responsibility.

The report serves multiple key purposes. First, it identifies new occupations emerging in aviation, particularly due to advances in digitalisation and sustainability. These roles combine aviation expertise with information technology and environmental knowledge, reflecting a shift towards interdisciplinary skills. The report also conducts a thorough analysis of the competencies needed for these future roles, with a special focus on skills related to digitalisation and the green transition within the air transport sector.

Moreover, the report provides valuable feedback for higher education institutions, by highlighting how study programmes and curricula could be updated to align with the evolving demands of the labour market. Additionally, it evaluates how qualifications align with frameworks like the European Qualifications Framework (EQF) and the European Skills, Competences, Qualifications and Occupations (ESCO), examining how well these qualifications match the skills required by employers.

Digital Transformation at Full Thrust

Importance of Skills in Aviation: The workforce in aviation is increasingly reliant on digital skills, with 54% of respondents identifying them as crucial. However, the development of green skills remains underemphasized, pointing to a need for broader institutional focus on environmental sustainability.

Skills Shortages and Recruitment Challenges: Despite recognition of the importance of sustainability, there is a lack of comprehensive green skills development.

54% of aviation employees

rated digital skills as essential

+60% of directors

foresee new occupations driven by **AI, cybersecurity, big data, and automation** in the next 5–10 years

Digitalization, big data analytics, and air traffic control (ATC) are identified as key areas for future skill development. The demand for interdisciplinary expertise—merging ICT, aviation, and sustainability—continues to grow.

Emerging Smart Occupations: New technological and environmental demands are giving rise to "smart" occupations that require high-level interdisciplinary qualifications. Future professionals will need a blend of digital, environmental, and management skills to navigate the rapidly evolving aviation landscape.

Emerging roles:

Digital Twin Engineers, Cyber-Resilience Specialists, Remote Systems Operators.

As aviation moves toward a more sustainable and digital future, the sector faces significant skills shortages, especially in green and digital competencies. The AVIONIC project serves as a crucial effort to address these gaps by fostering collaboration among HE, VET, industry, and research institutions across Europe. The development of cross-disciplinary curricula and training p

rograms will better prepare the workforce for emerging occupations, ensuring the aviation industry remains adaptable, innovative, and capable of addressing the dual challenges of technology and sustainability.

Education in Descent or Climb?

The alignment between higher education programmes and the evolving demands of the aviation sector remains a critical concern. According to the findings, only 43% of respondents believe that current higher education institution (HEI) programmes effectively address the skills required by emerging occupations in air transport.

Only 43% of respondents

found current HEI programmes aligned with aviation's emerging skill needs

This gap highlights a pressing need for academic institutions to reevaluate and adapt their curricula in response to technological and environmental transformations within the industry.

Over 70% of educators acknowledged the necessity to integrate new thematic areas into existing training structures, particularly in relation to environmental sustainability, digital competencies, and transversal soft skills.

+70% of educators

saw the need to embed environmental, digital, and soft skills in future curricula.

These additions are essential not only for technical roles but also for fostering adaptability and innovation across the sector. The growing complexity of aviation

systems demands professionals who are not only technically proficient but also capable of collaborative problem-solving and ethical decision-making.

In terms of preferred delivery methods, both employees and educators pointed to the importance of flexible, practice-oriented learning. On-the-job training and blended learning models emerged as the most effective approaches, indicating a shift away from traditional lecture-based methods.

Delivery preferences:

on-the-job learning and blended models

These insights call for a more agile and modular education framework—one that blends academic rigour with real-world application to ensure that future aviation professionals are fully prepared for the twin transition towards digitalisation and sustainability.

Strategic Insight: A Sector at a Crossroads

The aviation industry is undergoing a profound transformation, with over 75% of industry leaders anticipating major shifts in occupational profiles by 2030. These changes are being driven by the dual forces of digitalisation and sustainability, reshaping the competencies required across all levels of the workforce.

As the sector navigates this transition, technical expertise alone is no longer sufficient. Aviation professionals must now develop a broader skill set that includes adaptability, systems thinking, and resilience in the face of rapid technological and environmental change.

Over75% of industry leaders

anticipate profound occupational shifts by 2030

Transitioning aviation workforces need more than technical know-how—they need resilience, adaptability, and system thinking.

The demand for interdisciplinary capabilities—combining aviation knowledge with digital fluency and environmental literacy—is expected to intensify across operational, managerial, and strategic roles.

In response to these emerging demands, the AVIONIC project plays a pivotal role in equipping Europe's aviation ecosystem for the future.

Through transnational collaboration and research-driven curriculum development, AVIONIC supports higher education institutions (HEIs), vocational education and training (VET) providers, and policymakers in aligning qualifications with labour market needs.

AVIONIC helps position **Europe at the forefront of this transformation,** guiding HEIs, VET providers, and policymakers with actionable intelligence.

By offering actionable intelligence and strategic guidance, the project ensures that Europe remains a leader in fostering an agile, sustainable, and future-ready aviation workforce.

1 Introduction

1.1 Creative Digital Teaching and Learning for Green Air Transport and Logistics (AVIONIC) Project

The AVIONIC project is designed to address the evolving needs of the air transport industry by providing a comprehensive understanding of green and digital technologies. The project's primary aim is to equip future professionals in the industry with cross-disciplinary skills and the competencies required to manage innovative and sustainable systems. By integrating ICT tools for teaching and learning, the project seeks to better prepare the aviation sector to support the global economy, while ensuring that it operates safely, efficiently, and in an environmentally responsible manner.

To achieve these goals, the project implements a series of activities, including sharing knowledge on innovative teaching methods, identifying key green and digital skills, and developing new curricula. In addition, the project will create new digital tools for interactive teaching and learning as Open Educational Resources. The outcomes include reports on occupations and qualifications related to digitalisation and sustainability, improved study programmes, and the development of online tools for international teaching. The project fosters transnational cooperation, ensuring that the air transport ecosystem gains advanced green and digital expertise.

The AVIONIC project is closely aligned with the key objectives set for the future of aviation, which include environmental awareness, economic development, safety, capacity and efficiency, carbon footprint reduction, enhanced service, security, and global cooperation.

One of the core goals of the AVIONIC project is to understand the importance of digitalization and green technologies for the sustainable development of aviation. By developing cross-disciplinary skills and implementing ICT tools for teaching, the project contributes to lowering the industry's carbon footprint, which aligns directly with the aviation industry's future objective of enhancing environmental awareness and reducing carbon emissions.

By preparing the aviation workforce with skills in digitalisation and ICT, the AVIONIC project supports the enhancement of safety and security in the aviation sector. Digitalisation brings improved systems for monitoring, automation, and safer operations, which are essential for the future of aviation.

The project’s emphasis on international cooperation and developing new curricula ensures that aviation professionals are better equipped to offer enhanced

services globally. Additionally, the AVIONIC project promotes world alliances by fostering transnational cooperation and sharing best practices across countries, reinforcing the need for global collaboration in aviation's sustainable future.

The AVIONIC project is managed by the Politehnica Bucharest with the participation of the University of Strasbourg (France), Airport College International (Finland), Menzies Aviation (Romania) and the Polytechnic University of Madrid (UPM).

Future occupations in aviation are mirroring transformations, and the drivers of change are partly technology-based, involving equipment, services, logistics and infrastructure, but also emphasizing the ecological/environmental protection dimension. These projections emanate the purpose of the project to strengthen Europe's innovation capacity by developing new curricula and modules which will enhance the skills in sustainable development and digital air transport through a comprehensive partnership from HE, VET, air transport industry, research institutes and local communities. The transnational cooperation between Finland, France, Romania, and Spain leads to a higher performant knowledge and skills on digitalization, cybersecurity, decarbonization and sustainable development for the new air transport ecosystem.

The aim of the project is to provide a holistic understanding of green and digital technologies in aviation and to promote the extensive use of ICT tools for teaching and learning. It also focuses on developing cross-disciplinary skills and the competences needed to enhance and manage innovative, sustainable systems in the air transport industry.

This way the air transport industry will be better prepared to support the global economy, generating social benefits while ensuring a safe, efficient and environmentally responsible pathway.

1.2 Report Objectives

Within this context, the current report aims to identify new occupations and qualifications adequate for digitalization and sustainable development in aviation. It has therefore a set of sub-objectives:

- identification of the occupations and qualifications generated by new technologies for digitalization and sustainable development of aviation contains in the first part;
- analysis of the future occupations in terms of competences asked by new occupations for digitalization and greenisation of air transport;

- identification the relationship between occupations and qualifications, as a key input to the future improvement of HEIs study programs, update of curricula and courses syllabus based on feedback from the labour market.

This Report on occupations and qualifications generated by new technologies for digitalization and sustainable development of aviation contains the description of occupations and an analysis of the fast-changing demands of the labour market and AT industry. The inventory of occupations considers new and future interdisciplinary occupations encompassing aviation, ICT and environmental skills and knowledge. It also analyses the LOs of qualifications provided by project partners and identifies the gaps between their LOs and new competences for interdisciplinary occupations identified in the first part.

We analyse the needs in terms of up-skilling and re-skilling, the new skills required by the change of technology, the digitalization and sustainable development to develop a mix between initial education and training programs.

1.3 Methodological Approach

This report aims to identify new occupations and qualifications necessary for digitalization and sustainable development in aviation. The methodology begins with identifying the occupations and qualifications generated by new technologies in these areas. The second step involves analysing future occupations in terms of the competencies they require and understanding the relationship between occupations and qualifications. This serves as a key input for improving study programs in higher education institutions (HEIs), including curriculum and course updates based on feedback from the labour market.

To achieve the study's objectives, it is crucial to understand the current and future demands of the aviation industry. These requirements fall into two main categories: *technological transformations* and *sustainability parameters*. Technological transformations refer to identifying future technologies and trends that will shape the industry, while sustainability parameters focus on analysing expectations for sustainable aviation, including regulatory frameworks and environmental goals.

The input from stakeholders working in the aviation sector is vital for understanding their perspectives on future job roles and qualifications. This includes both industry-specific technical knowledge and broader skills needed for sustainable development.

Research Methods

Three distinct methods were employed to achieve the aims of the study: literature review, expert consultation and qualitative surveys (see figure 1.1).

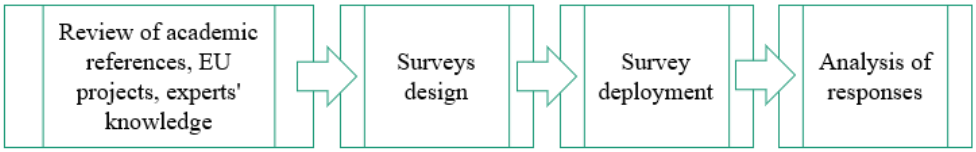

Fig. 1.1 Sources for the identification of occupations and qualifications related to digitalization in air transport

The literature review resulted in a comprehensive analysis of relevant studies on new occupations, qualifications, and the digitalisation of aviation. This helps establish a foundation, ensuring that research builds on existing knowledge and does not begin from scratch.

The expert consultation involved experts from The National University of Science and Technology Politehnica Bucharest, Universidad Politécnica de Madrid, University of Strasbourg, Menzies Aviation, and Airport College International. These experts contributed their knowledge on digitalisation in air transport, identifying emerging occupations and the competencies required for the future.

The qualitative surveys were designed and distributed to key stakeholders, including educators, employees, and managers from companies across Europe. These surveys aimed to capture the perspectives and needs of various stakeholders within the aviation sector, particularly in relation to digitalisation and sustainability.

Each of these methods complements the others, integrating multiple sources of knowledge to identify future occupations and the associated qualifications required in a digitised air transport sector.

Survey Target Groups

To obtain comprehensive insights, surveys were directed towards three key target groups:

- **Managers/ Directors**: As key decision-makers, managers influence the direction of their organisations, especially in driving digitalisation. Understanding their perspective is critical to predicting how the sector will evolve.
- **Employees**: Employees, who are instrumental in implementing changes, possess hands-on experience with the current industry and can offer insights into emerging trends.

- **Educators/ Trainers**: Educators are responsible for training future aviation professionals. Their ability to stay current with industry trends is essential to imparting relevant knowledge to students and ensuring that the future workforce is well-prepared.

Survey Structure and Purpose

The surveys were designed to collect information on current sector requirements, as well as to identify emerging occupations and key competencies needed in the evolving aviation industry figure 1-2 illustrates the structure of the surveys, which were tailored to three distinct target groups: educators, employees, and directors. Each group had a unique focus, but the surveys shared a common structure to ensure consistency in gathering data across the sector.

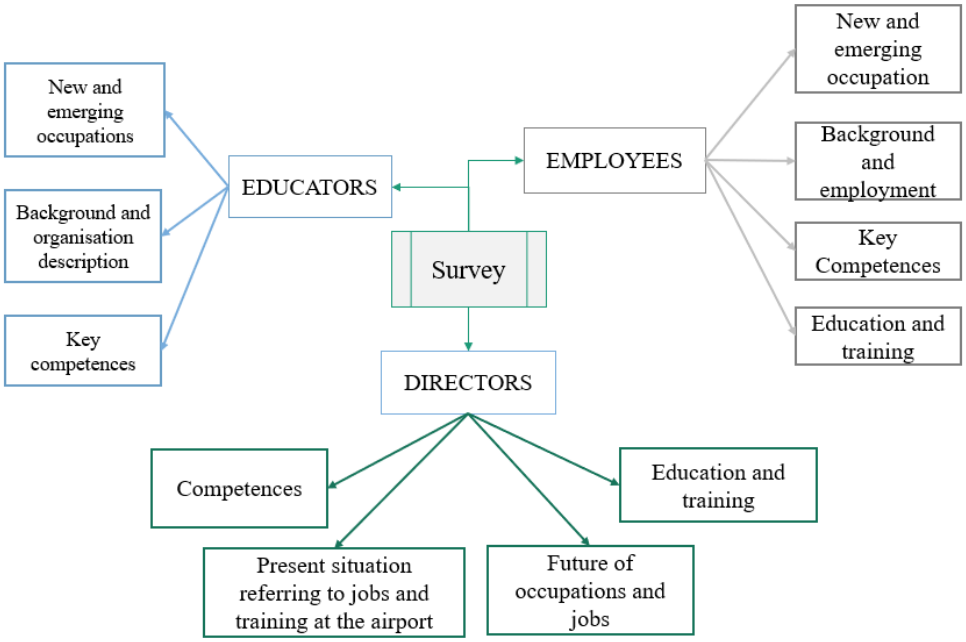

Fig. 1.2 The survey's structure by target group

The surveys, regardless of the respondent group, had two main areas of focus: *identification of competencies* and *emerging occupations*.

Identification of Competencies: Questions in this section were designed to help respondents identify the key competencies required in their specific roles. By targeting the unique experiences of each group—educators, employees, and

directors—the surveys aimed to capture a comprehensive understanding of the competencies critical to the industry's digital transformation and sustainability goals.

Emerging Occupations: This section focused on gathering insights about new and emerging occupations within the aviation sector. Respondents were asked to reflect on how technological advancements and sustainability initiatives are shaping new roles and to identify potential future occupations that will become essential to the industry.

Based on the target group-specific focus, the surveys were designed slightly different for educators, employees and directors. For educators, the survey addressed their perspective on new and emerging occupations, as well as background information on their organisations and the competencies they believe are critical for future aviation professionals. Given their role in training the next generation, educators provided valuable insights into the skills required to align academic curricula with industry demands.

The employee survey was focused on the current employment landscape, asking respondents to detail their background and work experience, as well as their views on new and emerging roles. Additionally, employees provided feedback on key competencies and how their roles are being shaped by digitalisation and sustainability.

Directors were asked broader questions regarding the future of jobs and competencies within their organisations. This included identifying areas where there are skill shortages, the present and future situation of jobs and training, and the types of education and training they expect to become essential. The survey also gathered information on how directors view the integration of technology and sustainable practices within their organisations. In addition to the core questions, the director survey included sections on respondent identification and contact information, which were not as relevant for employees or educators. Directors were also asked about the current situation regarding job roles and training at airports, providing a high-level view of industry-wide trends.

This structured approach ensured that the data collected from each target group would contribute to the overall objective of identifying emerging occupations and necessary competencies. The surveys, designed to take 15-20 minutes, balanced questions on sustainability and technology, ensuring that a broad range of industry perspectives was captured. By engaging with educators, employees, and directors, the study aimed to produce a well-rounded understanding of future needs in the aviation sector.

Data Collection and Analysis

Following survey deployment, the collected responses were analysed using a methodology that integrated literature review**,** expert consultation, and qualitative survey data**.** This approach enabled the identification of future job roles, and the competencies required to meet the needs of a transforming aviation industry.

The data provided strategically targeted insights from the three respondent groups: educators, employers and directors. Educators, with their dual perspective as academic experts and often former industry professionals, contributed knowledge on how educational institutions can adapt training to current and anticipated requirements. Moreover, employees shared operational insights into how digitalisation and sustainability are reshaping job responsibilities and skill sets in real time. Finally, directors offered a strategic view on organisational priorities, current skill gaps, and projections for future training and workforce needs. They identified specific areas with talent shortages and highlighted critical skill domains across departments.

This analysis resulted in a comprehensive list of emerging occupations and the skills and qualifications most relevant to each. These findings will guide the development of updated curricula and training programmes within the AVIONIC project.

Survey Respondent Profile

The diverse range of sectors represented by the survey respondents is presented in Figure 1.5. A portion of 25% comes from the airport sector, reflecting the project's focus on airports. The handling sector accounts for 17%, reflecting a partnership with Menzies Aviation and training providers also make up 17% of the respondents. The air traffic control (ATC) and airline sectors each contribute 8%, while national authorities and international bodies within air transport represent 4% each. The variety and the high number of managers who decided to participate shows the importance of the project for the future of the air transport industry and education.

In summary, the survey respondents are from airports (25%), handling (17%), training providers (17%), air traffic control (8%), airlines (8%), and national authorities (4%), underscoring the breadth of the industry and the wide-reaching importance of this research.

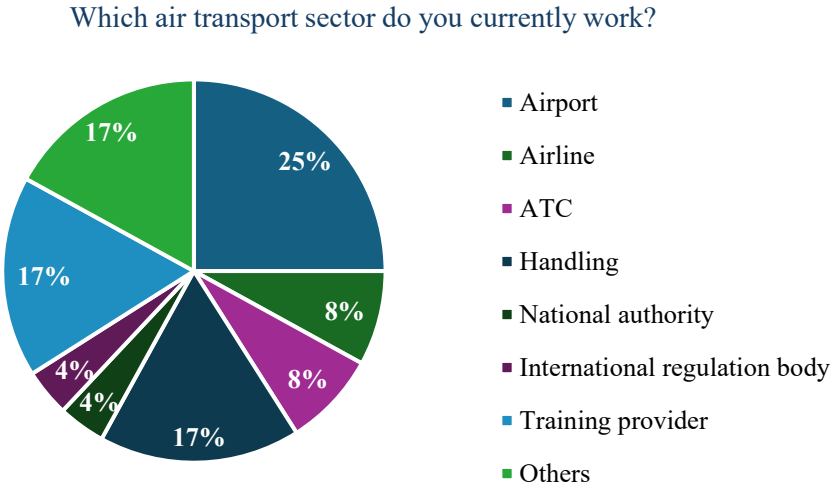

Fig. 1.3 Distribution of respondents by sector

Additionally, figure 1.6 shows the distribution of organizational sizes among the respondents. The results reveal a well-balanced representation, with 33% of managers working in companies with fewer than 250 employees, 29% in organizations with 251 to 1000 employees, and 38% in large companies with more than 1000 employees. This balance ensures that the insights reflect a variety of organizational needs, from the agility of smaller companies to the complex operational requirements of larger corporations.

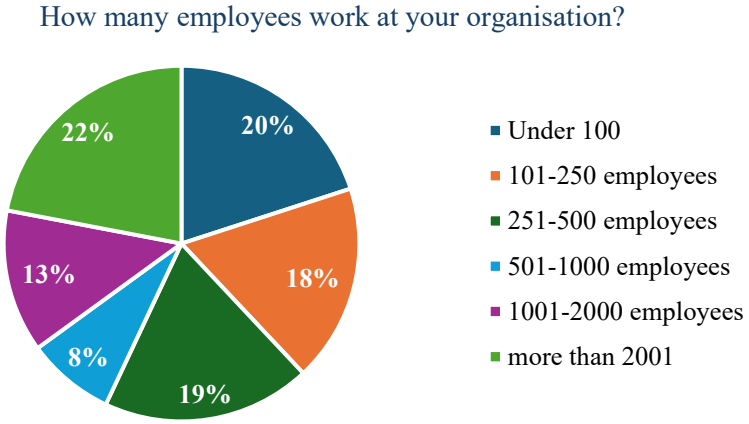

Fig. 1.4 Distribution of respondent's organization by number of employees

Information about the respondent's highest level of qualification completed and field of highest educational qualification are available in figure 1.7. Looking at

the highest level of qualification completed, we could note that most of the respondents (51%) have completed an undergraduate degree (Bachelor's), indicating a strong educational foundation at the university level. Moreover, a significant portion of respondents (37%) have pursued higher education, with a Postgraduate Degree (Master's), showing that many individuals have advanced qualifications beyond the undergraduate level.

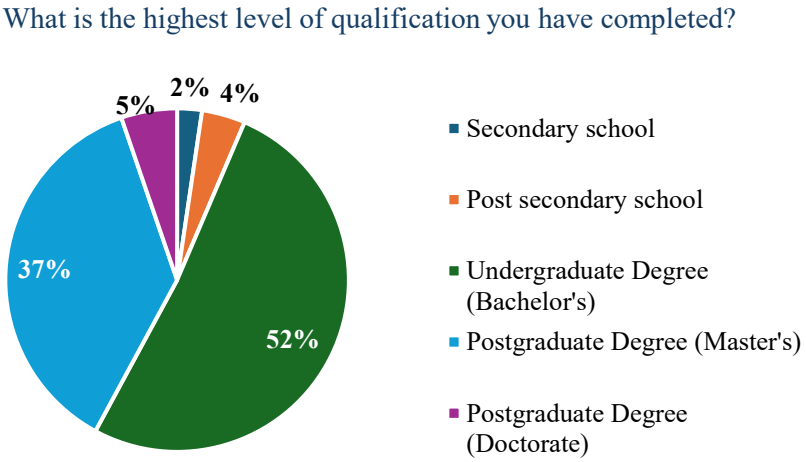

Fig. 1.5 Respondents' highest level of qualification

Regarding the field of highest educational qualification, the most common field of education among respondents is Aircraft Engineering, which accounts for 40% of the qualifications (see figure 1.8). This suggests a strong representation of individuals directly involved in technical roles related to aviation. Other notable fields include Economics (11%) and Mechanical Engineering (7%), indicating that respondents are not only focused on the technical side but also on the economic and operational aspects of aviation.

Overall, the respondents are highly educated, with a significant number holding bachelor's and master's degrees. Technical fields, particularly Aircraft Engineering, dominate the educational background of respondents, reflecting the technical nature of the aviation industry. There is a strong presence of individuals with Management and Economics backgrounds, which indicates that leadership and business roles are also essential in this field. Moreover, a smaller percentage of respondents come from fields like Law, Sciences, and Communications, which suggests a more limited, but still important, role for these disciplines in the industry.

The methodology employed in this study combines a robust literature review, expert consultation, and qualitative surveys to identify future occupations and competencies in aviation. By engaging with a broad range of stakeholders and incorporating international perspectives, the study provides valuable insights into the changes that digitalisation and sustainability will bring to the sector. The results will inform the development of future educational strategies, ensuring that the next generation of aviation professionals is equipped to navigate an industry in transition.

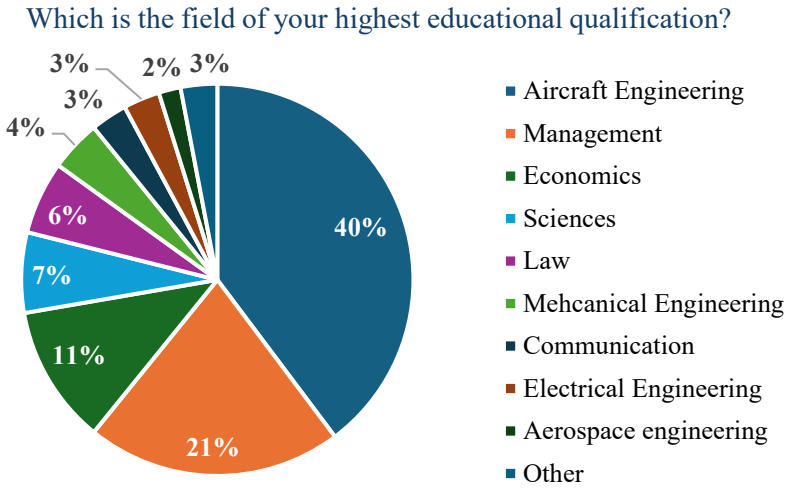

Fig. 1.6 Domain of highest level of qualification of respondents

This research underscores the importance of strategic workforce planning in aviation and highlights the need for ongoing collaboration between academia, industry, and policymakers to ensure a sustainable and innovative future for air transport.

1.4 Report Structure

This report is structured in two interconnected parts, each providing a comprehensive view of how digitalisation and sustainability are reshaping the aviation industry and its workforce.

Part 1, *Aviation Industry at a Crossroads: Global Shifts and Strategic Challenges*, examines the sector's evolving landscape. It begins by exploring aviation's global impact and its role as a driver of connectivity and growth. It then investigates key challenges—including demographic change, urbanisation, globalisation, climate change, digitalisation, and safety. This part further outlines the trends that are reshaping the sector, such as artificial intelligence, green innovation,

smart technologies, and emerging training approaches. It concludes with an analysis of strategic sustainability initiatives and societal responsibility programmes, highlighting the growing emphasis on just transition and key competencies for responsible transformation.

Part 2, *The Future Workforce: Jobs, Skills and Qualifications*, focuses on how employment in aviation is evolving. It starts by analysing current occupations, skills gaps, and organisational shortages, before addressing how emerging technologies and sustainability trends are transforming job roles. This part forecasts workforce demands over the next decade and identifies how qualifications must align with future labour market needs. It also maps the emergence of new "green" and "smart" occupations, categorised by drivers such as ICT, sustainability, and the twin transition. The final section assesses how education and training systems can respond effectively to these shifts, ensuring the workforce is equipped with the necessary skills.

The report concludes by synthesising the key trends in occupations and qualifications, outlining urgent priorities for upskilling and collaboration between industry and education.

1.5 Uses of the Report

This report serves as a strategic resource for key stakeholders across the aviation ecosystem, offering data-driven insights into how technological innovation and sustainability imperatives are transforming occupations and qualifications.

For higher education institutions and vocational education and training providers, the report offers guidance for curriculum renewal and programme design. By identifying emerging roles and associated skillsets, it supports the development of interdisciplinary learning pathways that combine aviation, digital, and environmental literacy. It also informs the design of modular learning units and micro-credentials, supporting flexible, skills-oriented education aligned with lifelong learning goals. The report's analysis of qualification gaps provides a foundation for integrating new modules that respond to the twin transitions in aviation: digitalisation and sustainability.

For aviation employers, the report acts as a roadmap for workforce transformation. It identifies current skills shortages, maps evolving job profiles, and outlines the competencies required in new and hybrid roles. This enables organisations to better target their recruitment, upskilling, and reskilling strategies, ensuring alignment with future operational and technological demands. The report also underscores the need to embed green and digital skills across all occupational levels, reinforcing the strategic value of workforce agility and continuous learning.

In this context, it supports the design of internal training frameworks and partnerships with education providers to co-create responsive learning solutions.

For policymakers and regulatory bodies, the report offers evidence to support workforce planning, policy formulation, and the advancement of sustainable development goals in aviation. The alignment with European frameworks such as EQF and ESCO, along with the project's transnational scope, provides a replicable model for policy innovation and cross-border coordination. It further contributes to Erasmus+ goals of fostering interconnected higher education systems and stimulating digital transformation in teaching and learning. These insights can inform initiatives aimed at building a future-ready, resilient aviation workforce that drives competitiveness, social inclusion, and environmental responsibility.

Part 1. Aviation Industry at a Crossroads: Global Shifts and Strategic Challenges

- The Global Impact of Aviation Industry Aviation as a Global Driver of Connectivity and Growth
- Challenges in the Aviation Industry
- Trends Reshaping the Aviation Industry
- Strategic Programs for Sustainability and Societal Responsibility

This section provides an overview of the aviation sector, addressing its global influence and the various challenges it faces today. It begins by discussing the global impact of the aviation industry, noting its critical role in connecting countries, facilitating international trade, and contributing to the global economy. The section underlines how air transport is a driving force behind globalisation, trade, and tourism, making it a key player in global development.

The report moves on to highlight key challenges within the aviation industry. These include demographic shifts, as the workforce ages and new talent needs to be attracted to replace retiring professionals. It also covers the impact of urbanization and how increasing populations in cities put pressure on aviation infrastructure. Additionally, the industry faces the continuous pressures of globalization, which necessitates constant adaptation to the needs of a globalized economy. One of the most pressing challenges is climate change, where the industry is under growing pressure to reduce its environmental footprint. The digital transformation of aviation is also explored, focusing on the integration of digital technologies to enhance operational efficiency. Lastly, issues around safety and security in a more digitally connected and globalized world are addressed, especially as the sector grapples with growing cybersecurity threats.

The section on trends reshaping the aviation industry provides insights into current and emerging trends. The rise of artificial intelligence and digitalization is transforming the way airlines operate, bringing automation and data-driven decision-making into the core of aviation practices. Alongside this, sustainable development is becoming increasingly important as aviation companies aim to reduce carbon emissions and adopt eco-friendly practices. The report also discusses innovations in materials and technologies, such as lighter, stronger materials and more efficient propulsion systems, which are driving the industry's push towards sustainability. The evolving managerial strategies required to navigate these technological shifts are explored, as well as the need for new training approaches to equip the aviation workforce with the skills necessary to thrive in a digitalized environment.

Lastly, the report emphasizes societal responsibility in air transport. This section discusses the role of the aviation industry in contributing to broader societal goals, particularly through strategic programs for sustainable development. It explores the concept of a just transition, ensuring that as the industry embraces sustainability and digitalization, the workforce and affected communities are not left behind. The section also identifies key competencies for societal responsibility, highlighting the skills and expertise needed to align the aviation industry with its social and environmental responsibilities.

2 The Global Impact of Aviation Industry Aviation as a Global Driver of Connectivity and Growth

The global air transport industry plays a vital role in facilitating international connectivity and economic integration. It functions through a complex network of interdependent stakeholders, including airlines, airports, air navigation service providers (ANSPs), and manufacturers of aircraft and related components. As such, the aviation sector enables the movement of people and goods across vast distances, supporting international trade, tourism, and cultural exchange. To sustain its growth and maximise benefits, collaboration among all stakeholders is essential.

Historically, the aviation industry has demonstrated strong resilience and adaptability. Despite facing numerous crises, including economic downturns, geopolitical conflicts, and more recently, the COVID-19 pandemic, aviation has shown a capacity for recovery and long-term expansion. The industry has traditionally doubled in size approximately every fifteen years, consistently outpacing growth in many other sectors.

Nevertheless, the sector continues to face a broad range of challenges. These include demographic shifts, urbanisation, climate change, rapid digitalisation, and mounting environmental and regulatory pressures. Recent global events, such as the pandemic and the escalation of military conflicts, have further underscored the vulnerability of international air transport systems. In addition, the industry must navigate fluctuating fuel prices, infrastructure constraints, evolving consumer expectations, safety and security demands, and growing skills shortages. Addressing these issues requires strategic innovation and cross-sector collaboration.

Aviation's economic contribution is multifaceted, encompassing direct, indirect, induced, and catalytic effects. Direct impacts include jobs and revenue generated by airlines, airports, ANSPs (i.e. activities related to check-in, baggage handling, on-site retail, cargo, and catering facilities), and aircraft manufacturers. Indirect impacts involve supply chain contributions, while induced impacts arise from the broader economic activity generated by aviation employees. Most significantly, catalytic impacts refer to the wider enabling effects of air transport on global tourism, trade, and productivity.

In 2019, the global aviation sector comprised 1,478 airlines that collectively transported 4.5 billion passengers to 3,780 commercial airports worldwide and moved 61 million tonnes of freight. Supporting this activity, the industry generated 11.3 million direct jobs and contributed $961.3 billion to the global gross domestic

product (GDP), equivalent to 1.1% of global GDP, a figure comparable to the basic metals industry ($968 billion) [1].

According to the Aviation Benefits Report and supporting ATAG data, the industry in 2019 supported 87.7 million jobs and contributed approximately $3.5 trillion to global GDP, representing 4.1% of the world economy [1]. Of these, 11.3 million were direct jobs across airlines, airports, manufacturing, and related services. As shown in figure 2.1, employment across all four categories (direct, indirect, induced, and tourism catalytic) had increased steadily from 2004 to 2018 [1] tourism catalytic jobs. In 2018, such roles represented more than 50% of the total aviation-related employment, underscoring aviation's critical role in enabling downstream sectors such as hospitality, transport, and services.

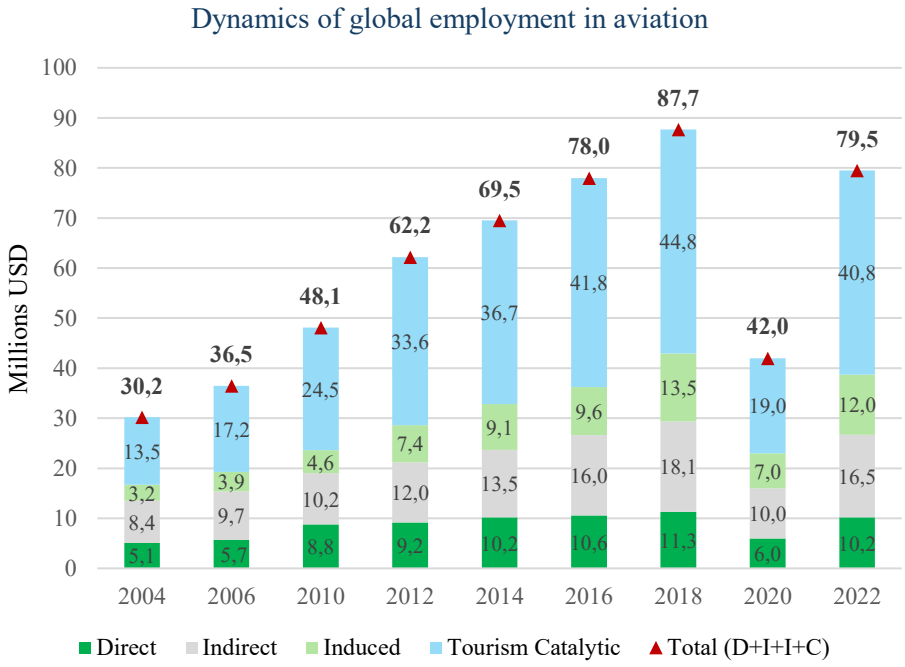

Fig. 2.1 Aviation's global employment impact evolution [1–3]

These four categories represent different levels of economic impact generated by the aviation industry. *Direct jobs* refer to employment within core aviation activities such as airlines, airports, and aircraft manufacturing. *Indirect jobs* are those in supporting industries, including fuel supply, construction, and catering. *Induced employment* results from the spending of incomes earned in direct and indirect jobs, for example in retail and housing. Finally, *tourism catalytic jobs* arise from aviation's enabling effect on international tourism, supporting sectors like accommodation, food services, and cultural industries. Figure 2.1 reflects how all

four categories contributed to the overall growth in aviation-related employment before the COVID-19 crisis, highlighting aviation's extensive value chain and economic multiplier effect.

However, the COVID-19 crisis triggered an abrupt contraction. As depicted in figure 2.2, total employment in the sector declined to 42 million in 2021, and direct jobs fell to 6.5 million, down from 11.3 million in 2018 [2,3]. The corresponding GDP contribution was halved, dropping from $3.5 trillion in 2018 to $1.7 trillion in 2021[2,3]. Figure 2.2 demonstrates the proportional loss across employment categories, with catalytic jobs experiencing the largest drop due to plummeting international tourism. The data also show that the GDP contribution from induced and indirect effects decreased significantly, reflecting the interconnected vulnerability of the aviation supply chain and its extended economic footprint.

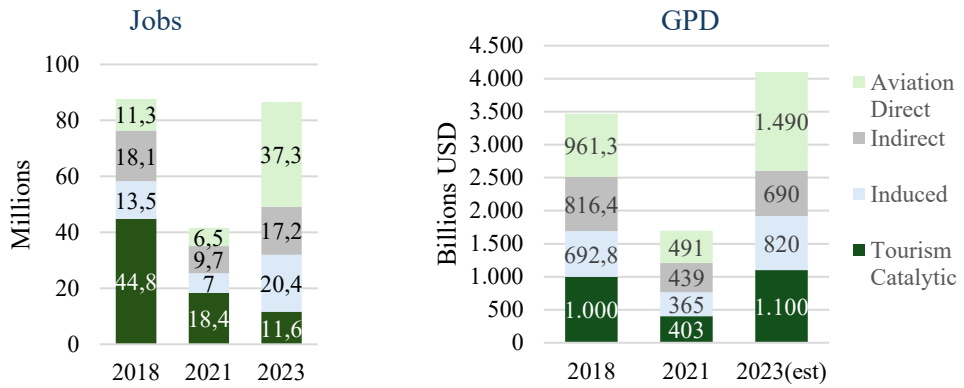

Fig. 2.2 GDP and jobs in aviation, before and after Covid-19 [1–3]

Recovery began in 2022 and accelerated into 2023. By 2022, global aviation employment had recovered to 79.5 million jobs, and by 2023, GDP contribution returned to an estimated $4.1 trillion [3]. Direct employment rose to 11.6 million, as shown in figure 2.3, with significant growth across all components: 5.9 million in airlines and airports, 1.7 million in civil aerospace manufacturing, and 4.0 million in other airport-related activities such as ground services and retail [3]. The data highlight how recovery was not uniform, other on-airport services rebounded more quickly than manufacturing roles, which still faced supply chain delays and production bottlenecks.

Figure 2.3 further reveals that airport and airline-related employment formed the core of direct aviation jobs across the historical series. From 2004 to 2023, this category increased from 1.9 million to 5.9 million jobs, reflecting the rapid expansion of global airport infrastructure and network coverage. The sharp rise in other on-airport jobs, from 0.3 million in 2004 to 4.0 million in 2023, demonstrates the

increasing commercialisation of airport environments, driven by passenger services, security, logistics, and retail demand.

Fig. 2.3 Evolution of direct jobs in aviation by sectors 2004-2023 [1,3]

Airline-specific data also confirm this trend. As illustrated in figure 2.4, the number of airline employees declined sharply in 2020 but rebounded by 1.8% in 2021 and by 5.7% in 2022 [4]. Overall, airline employment in 2022 was estimated to have reached approximately 95% of pre-pandemic levels [4].

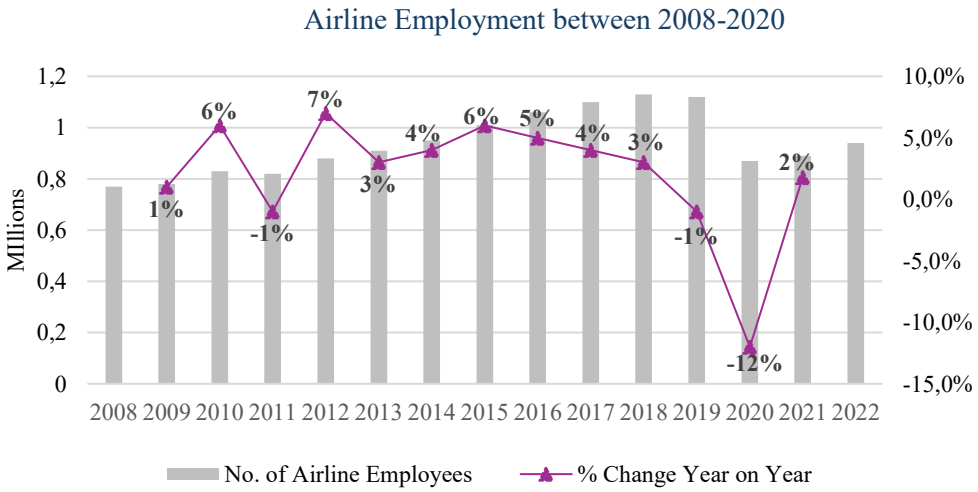

Fig. 2.4 Developments in airline employment 2008-2020 [4]

Despite these promising signs, recovery has varied widely by region and business model. Some airlines restored staffing more rapidly than others, and many continue to adapt to evolving demands in digitalisation, sustainability, and passenger expectations. According to IATA's Business Confidence Survey, 60% of airline respondents anticipated increasing employment in the next year, while 37% planned to maintain current staffing levels [4].

Aviation remains a foundational pillar of the global economy. Although the sector experienced unprecedented disruption during the COVID-19 pandemic, recent data reflect a resilient rebound in both employment and economic contribution. Going forward, the industry's ability to sustain growth will depend on continued innovation, investment in workforce development, and robust collaboration among global stakeholders.

3 Challenges in the Aviation Industry

The aviation industry is undergoing a profound transformation driven by long-term societal trends that include demographic shifts, urbanisation, globalisation, climate change, digitalisation, and evolving safety and security requirements. These megatrends are reshaping the structure of work, the nature of occupations, and the competencies demanded across all segments of the air transport sector. Recent research highlights that the emergence of new technologies, combined with the imperative for sustainable development, requires substantial changes in workforce skills, qualifications, and training approaches [5].

The study of Zaharia et al. [5] identified these six societal challenges as central to the development of green and digital skills in aviation, highlighting the need for new curricula and professional pathways adapted to future occupations in sustainable air transport.

Focusing on the aviation industry, and keeping in mind the list of challenges mentioned, we may identify the factors that are actively reshaping air transport workforce (see figure 3.1).

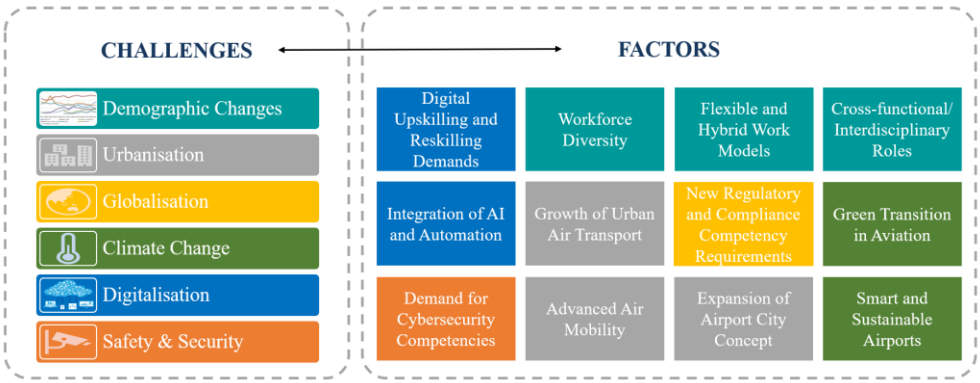

Fig. 3.1 Long-term societal challenges and factors

This section of the report will focus on the long-term societal challenges (see figure 3.1 - left side) and associated factors (see figure 3.1- right side) that are reshaping the aviation workforce. Each broad challenge influences multiple "reshaping factors," which in turn drive aviation workforce transformation. We explore each challenge in detail. Notably, these challenges do not exist in isolation, each interacts with others, collectively laying the foundation for how the aviation labour market is evolving. This interplay means, for example, that demographic shifts can amplify the impact of digitalization, or that advances in technology create new

security concerns. The result is a complex, interwoven context in which aviation organizations must adapt their workforce strategies to stay resilient.

3.1 Demographic changes

Demographic shifts are redefining the aviation workforce landscape by influencing who enters, exits, and thrives in the sector. Key workforce-related challenges associated with demographic change include:

- an aging professional population nearing retirement [6];
- generational shifts in values and work expectations (Millennials and Gen Z) [7];
- underrepresentation of women and minorities across technical and leadership roles [8];
- rising demand for cross-functional and interdisciplinary capabilities across roles [9,10].

These trends are converging to reshape how aviation organisations recruit, train, and retain personnel. Broader labour market analyses also confirm that demographic change is intertwined with digital transformation, longer working lives, and evolving skill needs [11]. This section explores the implications of these demographic changes, drawing direct links to the factors listed in figure 3.1, such as workforce diversity, flexible and hybrid work models, and the emergence of interdisciplinary roles.

Aging Workforce and Knowledge Transfer

A significant portion of the global aviation workforce, including pilots, air traffic controllers, and maintenance engineers, is approaching retirement age. This presents a dual challenge: the need to replace large numbers of skilled professionals and the risk of losing institutional knowledge critical to safety and operational continuity. Boeing projects that 674,000 new pilots will be required globally by 2043, with over two-thirds of this demand driven by retirements rather than expansion[12]. This challenge is compounded by a skills gap: as veteran employees exit, there is an urgent need to transfer knowledge and upskill younger professionals. The urgency of this transition also underscores the growing need for cross-functional roles, where employees can span multiple areas of expertise to ensure workforce flexibility in the face of attrition.

Generational Shifts and Expectations

Millennials and Generation Z comprise an increasing proportion of the aviation workforce, bringing with them distinct preferences that challenge traditional employment models. These cohorts value workplace flexibility, purpose-driven roles,

continuous learning opportunities, and flatter organizational structures. As such, rigid hierarchies and linear career paths are often viewed as outdated or misaligned with their aspirations[12].

In response, aviation organisations have begun integrating flexible and hybrid work models, particularly in corporate, administrative, planning, and ITC related functions. For instance, Gama Aviation has adopted a structured hybrid approach, allowing employees in eligible roles to work remotely three days per week, striking a balance between flexibility and operational needs [13]. Similarly, Delta Air Lines has introduced a range of adaptable working options, including job-sharing and part-time arrangements, while reinforcing career development through mentorship and leadership programmes [14].

A particularly instructive example is Lufthansa Systems FlightNav AG, which trialled a 50/50 hybrid model across its Swiss operations. The initiative was grounded in trust-based work policies and feedback mechanisms, showing that autonomy and schedule flexibility are critical for attracting and retaining digital-native talent [15].

Beyond location flexibility, younger professionals increasingly seek interdisciplinary exposure, cross-training opportunities, and work environments that support agile teaming. These preferences are reflected in the rise of cross-functional roles that combine digital, operational, and customer-facing competencies (see figure 3.1). As such, talent management strategies must now prioritise adaptive learning, hybrid skill development, and inclusive work cultures that meet evolving generational expectations.

Workforce Diversity and Inclusion

Aviation has historically struggled with diversity, particularly in technical and leadership positions. In 2021, only 4% of commercial pilots and approximately 3% of aircraft maintenance technicians globally were women [8]. Moreover, ethnic and cultural diversity in regulatory and operational leadership remains limited.

Expanding access to aviation careers through targeted recruitment and inclusive training pathways can help alleviate persistent talent shortages. A more diverse workforce enhances organisational performance by introducing a broader range of perspectives, improving decision-making and innovation capacity. In turn, this aligns with the industry-wide trend towards greater workforce diversity.

Cross-functional and Interdisciplinary Role

As the aviation industry undergoes digital and organisational transformation, there is a marked rise in demand for cross-functional and interdisciplinary roles that combine technical expertise with capabilities in data analytics, sustainability,

regulatory knowledge, and customer engagement. This evolution reflects the sector's increasing complexity and the need for personnel who can navigate overlapping operational domains.

For instance, maintenance engineers are now expected to interpret predictive maintenance data, while flight operations staff engage with real-time analytics tools and AI-supported scheduling systems. Similarly, customer service representatives may need familiarity with multilingual digital interfaces and travel apps.

Organisational structures are adapting accordingly. Many aviation organisations are shifting towards agile work environments that foster multidisciplinary collaboration and rapid adaptation to disruptions. Cross-functional teams, comprising experts in logistics, IT, environmental compliance, and customer experience, are becoming a strategic model for resilience and innovation. A recent industry review by Dviation Group underscores this shift, noting that employers increasingly seek professionals with hybrid profiles, such as licensed aircraft engineers who also understand quality systems and regulatory procedures [10].

At the operational level, traditional roles are being reshaped. Maintenance engineers, for example, must now interpret predictive analytics from aircraft health monitoring systems. Flight operations teams work with AI-based scheduling software, while customer service personnel engage with multilingual mobile platforms and integrated digital tools. These evolving roles reflect not only technological convergence but also the changing expectations of a younger, digitally native workforce.

Academic research confirms the effectiveness of cross-functional integration. Recent research of Littlepage et al. demonstrated that targeted team training for airline operational centres significantly improved coordination, transactive memory, and overall performance in high-complexity environments [9].

Correspondingly, training methodologies are evolving. Beyond classroom-based models, organisations are investing in immersive technologies such as virtual reality (VR), augmented reality (AR), and simulation-based learning. These tools enable aviation professionals to operate fluidly across departmental boundaries and to respond effectively to dynamic operational challenges.

Demographic changes are catalysing a transformation in the aviation workforce. Meeting the twin pressures of experienced staff attrition and new generational expectations requires investment in inclusive, interdisciplinary, and future-ready workforce models. Cross-functional roles represent a key strategy for building organisational agility and ensuring long-term competitiveness in the face of a rapidly changing industry landscape. These pressures are reshaping workforce

strategies across the aviation sector, creating a labour market that is simultaneously more complex and more capable, if aviation organisations invest in flexible, inclusive, and innovation-oriented workforce models.

3.2 Urbanization

Urbanisation is reshaping the landscape of global aviation, with profound implications for infrastructure, mobility patterns, and the future of work in the sector. As of 2023, over 55% of the global population resides in urban areas, a figure projected to reach 68% by 2050, creating new challenges for airspace management, infrastructure planning, and workforce development [16].

The key aviation-related challenges associated with urbanisation include:

- increased airport congestion and infrastructure strain;
- expansion of airport-centric developments (Airport Cities);
- emergence of Advanced Air Mobility (AAM);
- urban environmental pressures and regulatory constraints;
- evolving workforce requirements in urban aviation hubs.

These challenges are driving transformation across aviation systems, particularly in workforce roles that now intersect with urban planning, smart mobility, and sustainability.

Airport Cities and Workforce Transformation

Urbanisation intensifies the role of airports as economic hubs. The evolution of "airport cities" or aerotropolises, integrated complexes with retail, hospitality, logistics, and business functions, is reshaping workforce profiles. These developments demand a multidisciplinary talent pool that includes urban planners, environmental engineers, digital infrastructure specialists, and professionals in real estate and customer service.

Prominent examples include Amsterdam Schiphol and Incheon International Airport, which have embraced the Airport City model. These hubs foster regional development and require workforce models capable of supporting commercial operations beyond aviation. Proximity to major urban populations further enhances access to diverse labour markets, accelerating the urbanisation of the aviation workforce.

Advanced Air Mobility and Emerging Job Profiles

Urbanisation is also accelerating the development of Advanced Air Mobility (AAM) systems, including electric Vertical Take-Off and Landing (eVTOL) aircraft, drone-based logistics, and urban air taxis [17]. AAM aims to alleviate surface

congestion and introduce sustainable short-range transportation. The global market for urban air mobility is projected to exceed $20 billion by 2030 [18].

AAM systems are being tested and gradually implemented in cities to support fast, short-range, low-emission travel. Major urban centres like Paris, Singapore, and Dubai are already piloting AAM use cases, and the global market for urban air mobility is projected to exceed $20 billion by 2030 [18]. This trend brings forward entirely new roles and skills in drone fleet management, vertiport operations, low-altitude airspace control, and aircraft electrification.

Infrastructure and Environmental Pressures

Urban growth exerts significant pressure on existing aviation infrastructure and operational systems. As population density increases, airports face rising demand, leading to congestion, noise pollution, and limited runway and terminal capacity. This intensification of air traffic in densely populated areas not only reduces efficiency but also amplifies environmental concerns. Air Navigation Service Providers (ANSPs) must therefore adopt advanced airspace management tools, such as smart traffic control systems and noise abatement procedures, to maintain safety and community acceptance.

In parallel, the integration of emerging technologies, such as electric short take-off and landing (eSTOL) aircraft and unmanned aerial vehicles (UAVs), adds a new layer of complexity. eSTOL platforms, with their capacity to use compact runways and consume less energy during take-off and landing, offer promising solutions for dense urban environments. However, their integration requires careful consideration of infrastructure compatibility, flight path planning, and energy supply systems. Similarly, the rapid expansion of drone operations, especially near urban airports, raises serious challenges in terms of low-altitude traffic management, cybersecurity, and public safety.

These pressures are not isolated. Urbanisation affects aviation across multiple dimensions: it disrupts traditional patterns of airspace usage, drives demand for new infrastructure such as vertiports, and accelerates the need for environmentally conscious development. Cities like Singapore, Dubai, and Los Angeles are leading the way in establishing hubs for AAM, yet smaller or less-resourced urban centres often face significant regulatory, financial, and spatial barriers.

As these systems evolve, the industry will require a workforce equipped with highly specialised skills. Professions in urban air traffic control, drone fleet coordination, infrastructure design, and community engagement will become increasingly essential. Moreover, the dynamic nature of urbanisation necessitates agile regulatory frameworks and interdisciplinary collaboration between planners,

technologists, and policymakers to ensure equitable and sustainable aviation development.

The intersection of urban expansion, infrastructure constraints, and technological innovation presents a complex set of challenges. Meeting these demands requires integrated strategies that balance operational efficiency, environmental stewardship, and workforce adaptability in an increasingly urbanised aviation landscape.

Urban Aviation Labour Market Dynamics

Urban centres offer expansive employment opportunities in aviation, including roles in operations, logistics, maintenance, and digital mobility services. The concentration of aviation-related industries in cities fosters innovation and workforce diversity but also requires ongoing investment in training and cross-sector coordination.

The demand for interdisciplinary skills is rising, especially in roles that integrate smart city development and digital transport ecosystems. As urban labour markets evolve, workforce strategies must increasingly respond to non-traditional employment patterns, such as gig work, which includes flexible, task-based arrangements often mediated by digital platforms, and digital nomadism, where professionals leverage remote work technologies to operate across borders without a fixed workplace. These trends, along with hybrid task models that span multiple sectors and domains, require a rethinking of skills development, social protections, and regulatory frameworks in both public and private sectors.

In summary, urbanisation presents both operational challenges and strategic opportunities for aviation. From airport city development to AAM integration and evolving workforce models, the sector must engage urban planners, regulators, and education providers in shaping a resilient, future-ready workforce ecosystem

3.3 Globalization

The aviation sector has long been a catalyst and beneficiary of globalisation, enabling the rapid movement of people, goods, and knowledge across borders [19,20]. Today, aviation professionals operate in an increasingly integrated global environment shaped by transnational networks, cross-border mobility, and complex supply chains. Air transport supports over 86.5 million jobs worldwide, including 11.6 million direct jobs, illustrating its scale as a truly global employer [3].

This global reach introduces multiple workforce-related challenges. First, managing culturally diverse and geographically dispersed teams has become the norm. Multinational airlines and airports must foster intercultural communication,

implement inclusive HR strategies, and navigate different labour laws. Flexible and hybrid work models, accelerated by the COVID-19 pandemic, have allowed organisations to hire talent from around the world and decentralise non-operational functions such as IT, customer support, planning, and training. According to recent industry reports, over 75% of aviation companies plan to maintain or expand remote or distributed work structures in the coming years [3].

However, this operational flexibility also requires new leadership models and digital collaboration skills. Aviation managers must now oversee cross-functional, cross-border teams while upholding consistency in safety, service quality, and regulatory compliance. The global talent market adds further complexity: experienced aviation professionals, pilots, engineers, air traffic controllers, are increasingly mobile and in demand worldwide. Talent shortages are exacerbated by competition between countries and organisations, requiring effective retention strategies and internationally portable qualifications.

Regulatory Competency in a Global Context

As aviation operations extend across jurisdictions, regulatory compliance has become both more critical and more challenging [20]. Airlines, airport operators, and aviation service providers must comply with national laws, bilateral agreements, and international frameworks from organisations such as ICAO, IATA, EASA, and national civil aviation authorities. New layers of complexity have emerged in health safety (e.g. post-pandemic travel protocols), security (e.g. passenger data handling and screening technologies), and climate-related mandates (e.g. carbon offset schemes and sustainability disclosures).

This evolving landscape necessitates new workforce competencies in global regulatory navigation. Employees must understand and implement a patchwork of standards while adapting to continuous regulatory change. The growing need for "regulatory literacy" is not limited to legal or compliance departments but extends to frontline staff, managers, and technicians. These emerging competency requirements, framed by the intersection of globalisation and societal responsibility, will be further analysed in Section 4.3 Key Competencies for Societal Responsibility.

Systemic Pressures and Infrastructure Demands

Globalisation places systemic pressure on aviation infrastructure [20]. Increased international travel, trade, and tourism have led to overcrowded hubs, overburdened air traffic systems, and expanded ground handling operations. Global interconnectedness requires robust coordination between national air navigation service providers, uniform safety practices, and interoperable technologies to ensure operational efficiency.

At the same time, global aviation contributes to environmental pressures such as carbon emissions, noise, and habitat encroachment [21]. These challenges intensify as aviation activity expands in developing regions and urbanised corridors. Aviation professionals must be equipped to manage environmental impact assessments, implement green technologies, and comply with global sustainability goals.

Globalisation and Workforce Transformation

Global integration influences how aviation organisations recruit, train, and retain employees. On one hand, it creates opportunities for career mobility, professional exchange, and international collaboration. On the other, it amplifies workforce disparities, training gaps, and legal complexities surrounding immigration, work visas, and cross-border certification.

Finally, globalisation accelerates the adoption of advanced technologies such as automation, biometrics, and artificial intelligence. Keeping pace with such changes requires dynamic training systems, interoperable credentials, and industry-wide standards. Aviation organisations must therefore invest in continuous workforce development, leveraging digital platforms, simulations, and global curricula, to prepare staff for evolving roles in a highly networked global environment.

Globalisation reshapes the aviation workforce through increased mobility, regulatory complexity, technological integration, and environmental responsibility [20]. To remain competitive and resilient, aviation organisations must cultivate globally competent, technologically agile, and culturally aware professionals capable of operating in a dynamic and demanding international context.

3.4 Climate Change

Climate change has emerged as one of the most urgent and transformative challenges for the global aviation industry. As a carbon-intensive sector, aviation contributes approximately 2–2.5% of global CO_2 emissions, with 2023 emissions rebounding to over 950 million tonnes, exceeding 90% of pre-pandemic levels [22]. In response, industry stakeholders, including the International Civil Aviation Organization (ICAO), have committed to achieving net-zero carbon emissions for international aviation by 2050 [23].

This global ambition reflects not only environmental urgency but also the sector's increasing exposure to climate-related risk, including policy pressures, stakeholder expectations, and operational disruptions due to extreme weather events. Achieving decarbonisation will require a comprehensive green transition, spanning new fuels, technologies, infrastructure, and workforce competencies [21].

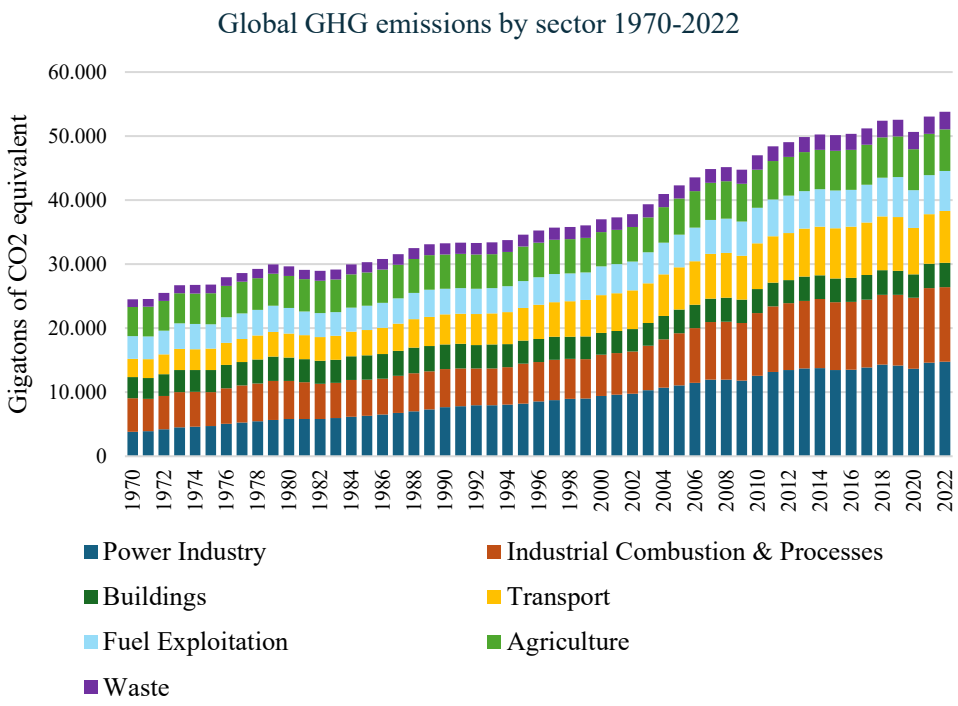

Fig. 3.2 Global GHGs emissions by sector between 1970-2022 [24]

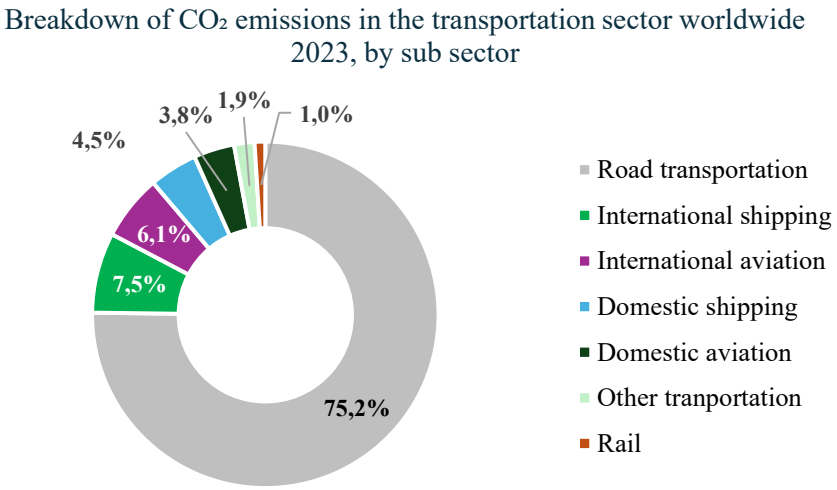

Fig. 3.3 Breakdown of CO_2 emissions in the transportation sector worldwide 2023, by sub sector [25]

Recent systematic reviews highlight that aviation's environmental footprint extends beyond carbon emissions, encompassing life cycle impacts from aircraft manufacturing, fuel production, airport infrastructure, and waste generation. These findings underscore the need for holistic decarbonisation strategies that account for resource depletion, ecosystem effects, and air pollution associated with aviation operations [26].

Figure 3.2 illustrates the global greenhouse gases emissions by sector between 1970 and 2022. The transport sector noted between 1970 and 2022, increases of up to 6% year on year. Exceptionally in 2019, the level is maintained compared to 2018, and in 2020, the overall decrease reached 14% compared to 2019. The rising trend picks up again in 2021 with an increase of 7,2%.

Figure 3.3 further breaks down transportation emissions in 2023, showing that aviation, both domestic and international, accounts for approximately 10% of total transport-related GHGs emissions. These figures underscore the imperative for aviation to play a leading role in global climate mitigation.

The leaders of aviation industry have decided to engage to net-zero CO_2 emissions in 2050, this is the first industry that committed to this type of change [27]. One of the greatest efforts the world will have to overcome is the progression from using fossil fuels to alternative energy such as solar energy, mainly because almost ¾ of global CO_2 emissions come from the use of fossil energy [28].

Workforce Implications of the Green Transition

The path to net-zero emissions is not solely technological, it also demands a significant evolution in workforce capabilities. As new decarbonisation strategies are implemented, they generate demand for professionals with interdisciplinary expertise across environmental science, sustainable engineering, operations, and regulatory compliance.

For instance, the adoption of Sustainable Aviation Fuels (SAFs), electric propulsion, and hydrogen-based systems requires technicians and engineers to acquire new technical proficiencies. Maintenance crews must be trained in handling novel fuel types and energy systems, while safety officers must update protocols for new propulsion technologies.

In parallel, the development of “Smart and Sustainable Airports” is reshaping workforce structures. Airports are increasingly implementing green infrastructure, such as solar-powered terminals, energy-efficient buildings, and AI-optimised waste management systems. These changes require collaborative, cross-functional teams composed of IT specialists, environmental engineers, facility managers, and sustainability analysts.

Moreover, airlines and airports are hiring sustainability officers and carbon analysts to design and manage emissions reduction programmes. As ICAO's Innovation for a Green Transition report outlines [29], critical workforce needs include:

- environmental Compliance Specialists, to navigate tightening emissions regulations and ensure accurate reporting under schemes such as CORSIA;
- sustainable Aviation Technologists, to lead R&D in electric and hybrid propulsion, advanced materials, and aircraft design innovations;
- carbon Management Professionals, who support emissions accounting, offsetting, and participation in voluntary or mandatory carbon markets.

These roles reflect an emerging demand for regulatory sustainability competencies, intersecting with globalisation and discussed further in Section 4.3 Key Competencies for Societal Responsibility.

Intersections with Digitalisation and Resilience

The climate transition is deeply intertwined with digitalisation. Data analytics, AI, and digital twins are now used to optimise flight trajectories, reduce fuel consumption, and predict maintenance needs—all contributing to emissions reductions. This convergence of sustainability and technology redefines traditional aviation roles and places a premium on hybrid skill sets.

Simultaneously, climate change introduces new risks requiring adaptive planning. More frequent extreme weather events demand enhanced resilience across operations. Cross-sector coordination between meteorologists, air traffic controllers, ground operations teams, and emergency planners is becoming essential to anticipate and respond to climate-induced disruptions.

The aviation industry's commitment to climate action will be measured not only by its investments in technology, but also by its ability to cultivate a workforce capable of leading this transformation. Addressing the climate challenge requires embedding sustainability across the sector's talent pipeline, through new curricula, upskilling initiatives, and interdisciplinary collaboration. In doing so, aviation can not only reduce its environmental footprint but also position itself as a model for innovation and resilience in the face of global environmental change.

3.5 Digitalization in aviation

Digitalization is revolutionizing the aviation industry by transforming operational processes, customer engagement, and workforce requirements. Emerging technologies such as artificial intelligence (AI), machine learning (ML), big data analytics, the Internet of Things (IoT), and blockchain are being deployed to enhance efficiency, safety, and sustainability across the aviation ecosystem.

Airlines and airports are increasingly adopting AI-driven applications, from predictive aircraft maintenance to chatbots in customer service. Many major airports have implemented automated baggage handling systems, biometric check-in, and autonomous ground vehicles. Notably, 45% of North American airlines identified AI as their top IT priority, reflecting a significant commitment to digital transformation [30]. Larger airports and carriers with substantial resources are leading these innovations, while smaller operators are incrementally integrating technology due to financial and staffing constraints.

Digital Skills and Workforce Implications

Digital transformation is reshaping workforce demands across all functions. Frontline staff such as pilots, technicians, and controllers are now expected to work with advanced digital tools and decision-support systems. Pilots interface with increasingly automated cockpits, maintenance crews use predictive analytics for proactive servicing, and air traffic controllers leverage AI to enhance safety. As a result, aviation professionals require continuous upskilling.

To address this, many aviation organizations are developing internal academies or partnering with universities to deliver training in data science, software development, and digital project management. These initiatives aim to bridge the digital skills gap and prepare staff for technology-enabled roles. Moreover, the rise of hybrid and remote work models, enabled by cloud platforms and collaboration tools, has expanded the talent pool but necessitates training in cybersecurity and digital communication.

Artificial Intelligence Applications

AI has deepened its footprint in airport operations and passenger services. From the early introduction of automated baggage systems and e-ticketing to today’s smart airports, the transformation has been continuous. Concepts like the "connected traveller," "collaborative decision-making" (CDM), and "self-service airport" represent the modern AI-powered travel experience.

According to IATA’s Digital Data Think Tank [31], AI applications now span the entire airline enterprise, including:

- demand forecasting and disruption management;
- personalized retail offers and payment processing;
- flight planning and aircraft maintenance;
- digital identity and seamless passenger engagement;
- back-office and procurement systems;
- baggage handling and turnaround coordination.

AI also enhances environmental monitoring. Airlines use AI to model and track operational efficiency, emissions, and fuel consumption, thereby aligning environmental strategies with real-time data insights. AI-powered platforms now analyse historical, partner, and market data to generate actionable recommendations, improving both customer experience and operational reliability.

Big Data and Analytics

Big Data Analytics (BDA) is becoming integral to airport operations. While many airports already use BI tools for performance dashboards and forecasting, the future lies in real-time 3D operational visualization and AI-driven automation. These systems are expected to manage airport functions autonomously, removing bottlenecks and enhancing service quality.

As aviation increasingly relies on data, the demand for data scientists, AI engineers, and analytics professionals has surged. These experts build predictive models, optimize resource use, and support decision-making at scale. From improving safety margins to customizing passenger interactions, data analytics is redefining the aviation landscape.

Skills Gaps and Talent Development

Digital transformation also exposes talent shortages in key areas such as software engineering, cybersecurity, IoT systems, and digital marketing. Aviation organizations must invest strategically in recruitment, upskilling, and talent retention to stay competitive. This includes developing immersive training platforms, simulation tools, and certification programs that align with technological advancements.

Digitalization is not just a technological shift but a systemic transformation of aviation business models. It requires a future-ready workforce equipped with specialized digital competencies. Addressing these needs through coordinated training, flexible work structures, and continuous learning will be essential to sustaining aviation's digital evolution.

3.6 Safety and security

Safety and security have always been foundational pillars of the aviation industry. Traditionally, safety management focused on accident prevention, adherence to operational standards, and improving human factors through rigorous training and a robust safety culture. While these remain core components of aviation operations, the scope of safety and security has expanded significantly in recent years, especially in light of digital transformation, geopolitical instability, and public health crises.

Cybersecurity Threats and Workforce Implications

The rise of digitalisation has introduced a new domain of risk: cybersecurity. As aviation systems become increasingly interconnected, from aircraft avionics to airport networks and operational databases, the industry faces escalating cyber threats. In fact, reported cyberattacks on aviation organisations rose by 131% between 2022 and 2023, affecting airlines, ticketing platforms, and even air traffic control systems [32]. These incidents can lead to substantial financial losses, safety hazards, and reputational damage.

In response, aviation organisations are investing heavily in cybersecurity talent. New roles such as cybersecurity analysts, ethical hackers, and digital risk managers are becoming integral to operational resilience. Moreover, cybersecurity awareness training is being extended beyond IT departments to frontline and administrative staff to reduce human vulnerabilities. The goal is to cultivate a "human firewall" capable of recognising and mitigating cyber threats at all organisational levels.

Physical Security and Regulatory Evolution

In parallel with digital risks, physical security remains an evolving concern. The industry continues to face challenges related to terrorism, geopolitical conflict, and unauthorised access to restricted zones. To mitigate these risks, aviation stakeholders are implementing advanced passenger screening technologies, biometric identification systems, and drone detection solutions.

Additionally, international agencies frequently revise safety and security regulations to address emerging threats. Compliance with these evolving standards necessitates continuous workforce training. Notably, new competency frameworks have been introduced for managing unmanned aircraft systems (UAS), ensuring that their integration into airspace does not compromise safety. Cross-functional safety teams are now common in major airports and airlines, bringing together experts in operations, security, ITC, and human factors to manage risk holistically.

Crisis Management: Lessons from the COVID-19 Pandemic

The COVID-19 pandemic exemplified the vulnerability of global aviation systems to non-traditional threats. At the height of the crisis in April 2020, global flight volumes dropped by nearly 75%, and Revenue Passenger Kilometres (RPKs) plummeted by 94% compared to April 2019 [1]. The economic repercussions were severe: the aviation industry supported 87.7 million jobs globally before the pandemic, including 11.3 million direct jobs across airlines, airports, and civil aviation manufacturing [1]. The sudden collapse of demand forced a reassessment of crisis response strategies, highlighting the need for adaptable workforce models and comprehensive risk management frameworks.

Interdependencies and Broader Security Considerations

Modern aviation security is interdependent with other global trends. The digitalisation of operations increases efficiency but also exposes organisations to cyber vulnerabilities. Globalisation amplifies the consequences of localised security incidents, necessitating harmonised international standards [19,20]. Climate change introduces new safety challenges, including extreme weather events that demand enhanced operational preparedness.

In this interconnected context, the aviation workforce must evolve beyond traditional competencies. Future aviation professionals will need to be not only technically proficient but also digitally literate, security-conscious, and capable of cross-functional collaboration. The industry's security paradigm now rests on agility, continuous training, and proactive threat anticipation, factors essential for ensuring resilience in a rapidly changing global environment.

4 Strategic Programs for Sustainability and Societal Responsibility

Organizations around the world and their stakeholders are becoming increasingly aware of the benefits and the need for a socially responsible behaviour. The objective of societal responsibility is to contribute to sustainable development. An organization's commitment to the welfare of society and the environment has become a central criterion in measuring its overall performance and its ability to continue operating effectively.

In 2015, the United Nations announced the 2030 Agenda for Sustainable Development [33], which was accompanied by a set of 17 Sustainable Development Goals (SDGs) (see figure 4.1) and 169 targets. These 17 objectives can be grouped in economic, social, and environmental issues, but can no longer be dealt separately. These objectives must be approached in an interdisciplinary way, with all actors assuming their share of responsibility (individuals, companies, private and public organizations and institutions, and governments).

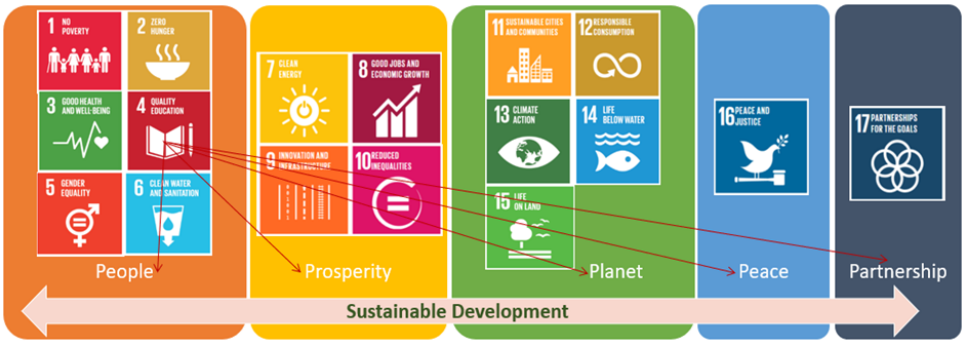

Fig. 4.1 Sustainable development pillars and goals [34]

The definition of *Corporate Societal Responsibility* (CSR) can be broken down into three main aspects: equity–social concerns, ecological–environmental considerations, and economic mergers [35]. The World Business Council on Sustainable Development (WBCSD) has proposed a more extensive definition of CSR: "Corporate societal responsibility is the continuing commitment by business to contribute to economic development while improving the quality of life of the workforce and their families as well as of the community and society at large" [36].

Common aspects of societal responsibility include environmental sustainability, community involvement and ethical marketing [37]. Environmental sustainability refers to recycling, waste management, water management, renewable

energy, reusable materials, 'greener' supply chains, reducing paper use and adopting Leadership in Energy and Environmental Design (LEED) building standards.

Community involvement includes raising money for local charities, providing volunteers, sponsoring local events, employing local workers, supporting local economic growth, engaging in fair trade practices, etc.

Companies that ethically market to consumers are placing a higher value on their customers and respecting them as people who are ends in themselves. They do not try to manipulate or falsely advertise to potential consumers. This is important for companies that want to be viewed as ethical.

The dimension of societal responsibility of an organization refers to the areas and scope of the application of this as a business agenda. It is all about the social, ethical and the environmentally friendly responsibilities a company should consider in their business. The societal responsibility of an organization is a multi-dimensional concept in terms of its objectives as it involves the interests of different types of stakeholders.

The internal dimension of societal responsibility includes human resource management, health and work safety, management of environmental impacts, and natural resources [38]. A general challenge for enterprises, and those in air transport industry are not an exception, is to attract and retain skilled workers and achieve the well-being of the employees. Since knowledge is a significant resource in our current society and the demand for more highly skilled workers has increased, employees became the most important and in fact the only remaining realistic challenge of competitiveness.

The workplace wellbeing refers to mental, psychological or emotional aspect of employee's life. The awareness of management on the employees' wellbeing which takes into consideration the employees' satisfaction, health and professional development is an effective approach in strengthening of an organizational performance. In this context, relevant measures could include lifelong learning, empowerment of employees, better information throughout the company, better balance between work, family, and leisure, greater work force diversity, equal pay and career prospects for women, profit sharing and share ownership schemes, and concern for employability as well as job security. For this component of societal responsibility, the people involved in these activities need to have knowledge and skills in communication, education, human resource and career counselling.

Corporate societal responsibility extends beyond the doors of the companies into the local community and involves a wide range of stakeholders in addition to employees and shareholders (see figure 4.2): business partners and suppliers,

customers, public authorities, and NGOs representing local communities or the environment. The external dimension of societal responsibility includes communication based on sustainable development with local communities, with business partners, suppliers, consumers. For this component of societal responsibility, the persons involved in these activities need to have knowledge and skills in sustainability, communication, environment, and energy issues.

Fig. 4.2 Corporate societal responsibility pillars [34]

The societal responsibility strategy can be centred around four pillars: environment, customer experience (marketplace), employees (workplace) and local development (community) (see figure 4.3). These pillars should support the company's business model. With the initiatives and activities centred toward these outcomes, a company/ organization can have a positive impact on society and contribute to the achievement of UN Sustainable Development Goals.

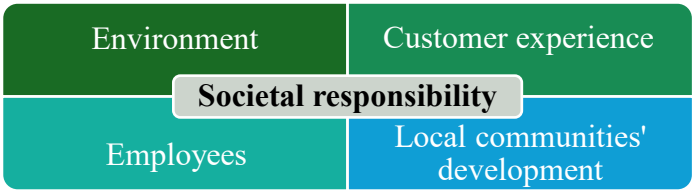

Fig. 4.3 Pillars of societal responsibility [34]

As an example of good practice, The Air France-KLM Group (www.airfranceklm.com) has a very well-developed strategic plan for societal responsibility within the group, which describes all the necessary actions and steps for achieving proper results on all the mentioned categories and on the overall performance of an organization. Another very good example of is the strategy of Aéroports de Paris (ADP - www.parisaeroport.fr) for societal responsibility.

4.1 Global and European Initiatives Sustainable Development

The aviation sector faces significant environmental challenges, including carbon emissions, noise pollution, and the depletion of natural resources. To address these issues, a range of strategic programs for sustainable development has been launched by global organizations, governments, NGOs, and private industry. These initiatives aim to reduce aviation's environmental footprint while fostering technological innovation, sustainable practices, and job creation. Below we mention a summary of some of the most relevant ones.

United Nations Initiatives and Frameworks

The United Nations (UN) plays a central role in shaping the global sustainability agenda. The UN plays a central role in coordinating global efforts on sustainability through initiatives such as the Sustainable Development Goals (SDGs) and the Paris Agreement on climate change. UN agencies, such as the United Nations Environment Programme (UNEP), the International Labour Organization (ILO), and the International Civil Aviation Organization (ICAO), develop policies, guidelines, and programs to address specific sustainability challenges in their respective areas of expertise.

One of the most critical frameworks is Agenda 2030, which introduced the Sustainable Development Goals (SDGs) [33]. Among the 17 goals, several are particularly relevant to aviation:

- SDG 7 (Affordable and Clean Energy) aims to increase the use of renewable energy in aviation, such as biofuels and sustainable aviation fuels (SAF);
- SDG 11 (Sustainable Cities and Communities) relates to the development of sustainable transportation systems, including air transport;
- SDG 13 (Climate Action) targets the reduction of greenhouse gas emissions, with a specific focus on reducing the aviation sector's carbon footprint;
- SDG 17 (Partnerships for the Goals) emphasizes the importance of collaboration among governments, industries, and civil society to achieve these sustainability goals[33].

The UN has also spearheaded the Paris Agreement [39], which aims to limit global temperature rise to below 2 degrees Celsius. As part of this effort, ICAO launched the C*arbon Offsetting and Reduction Scheme for International Aviation* (CORSIA). CORSIA seeks to stabilize international aviation emissions at 2020 levels by requiring airlines to offset excess emissions through investment in sustainable projects [23]. The program has had positive results in raising awareness about carbon emissions in aviation, though full implementation and measurable reductions in emissions are still in progress.

European Green Deal and Flightpath 2050

The European Green Deal[40] is a flagship initiative introduced by the European Commission in 2019. Its objective is to make the European Union's (EU) economy climate-neutral by 2050. For aviation, this involves significant efforts to reduce emissions, adopt sustainable aviation fuels (SAF), and promote innovation in green technologies. The European Climate Law, adopted under the Green Deal framework, legally commits the EU to reach net-zero emissions by 2050 [40].

Fig. 4.4 European Green Deal Focus Points [40]

One of the key aspects of the Green Deal for aviation is the development and use of SAF (see figure 4.4). These fuels, derived from renewable biomass and waste materials, have been shown to reduce carbon emissions by up to 80% compared to conventional jet fuel [41]. Major airlines and airports in the EU have begun integrating SAF into their operations, although challenges remain in scaling production and reducing costs.

The *Flightpath 2050* initiative, developed in collaboration with stakeholders in the aviation industry, outlines a vision for sustainable aviation in Europe (see figure 4.5). The program sets ambitious goals for reducing carbon emissions and noise pollution while promoting growth and competitiveness in the sector [42]. F*lightpath 2050* highlights the importance of research, innovation, and education to achieve these objectives, emphasizing the development of cross-disciplinary skills and expertise in areas such as cybersecurity, sustainable technology, and digitalization [42].

Fig. 4.5 Flightpath 2050: Europe's vision for aviation [42]

Sustainability & Smart Mobility Strategy

In parallel with the Green Deal, the Sustainability & Smart Mobility Strategy focuses on reducing environmental impact across all transportation modes, including air transport. This strategy emphasizes the need for cleaner transport technologies, investment in infrastructure, and the development of supportive policies. One key goal is to integrate sustainable mobility into urban transport systems, which includes improving connectivity between air, rail, and other modes of transport to reduce the carbon footprint of intermodal journeys [43].

Industry Associations' Role in Sustainability

Several industry associations are deeply involved in promoting sustainable development within the aviation sector. For example, the Airports Council International (ACI) and the International Air Transport Association (IATA) have launched various programs to encourage sustainability: *Airport Carbon Accreditation* (ACA), *Airport Excellence* (APEX) *in Environment Program* and *IATA's Carbon Roadmap.*

A*irport Carbon Accreditation* (ACA): Developed by ACI Europe, ACA is a voluntary program that encourages airports to measure, manage, and reduce their carbon emissions. The main requirements for accreditation are summarised in figure 4.6. The program consists of four levels: Mapping, Reduction, Optimization, and Neutrality. As of 2022, more than 300 airports worldwide have been accredited,

demonstrating their commitment to reducing their environmental footprint. For example, Heathrow Airport has reduced its carbon emissions by 93% since joining the ACA program, primarily by transitioning to renewable energy sources [44].

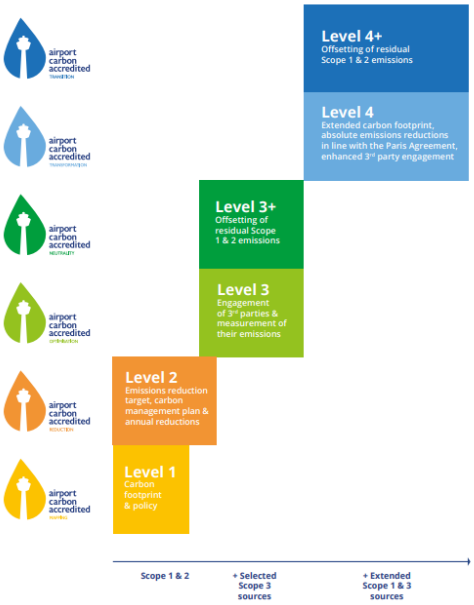

Fig. 4.6 Main requirements for accreditation [44]

Airport Excellence (APEX) in Environment Program: This initiative, also launched by ACI, recognizes airports that demonstrate best practices in environmental sustainability. The program helps airports address challenges such as air quality, waste management, noise reduction, and biodiversity conservation [44].

IATA's Carbon Roadmap: IATA developed a roadmap to achieve net-zero emissions by 2050, outlining strategies such as increasing the use of SAF, improving operational efficiency, and developing next-generation aircraft technologies. IATA reports that transitioning to SAF could create thousands of new jobs in biofuel production, research, and development [41].

Airport Carbon and Emissions Reporting Tool (ACERT) is a software tool developed by ACI to help airports monitor and report their greenhouse gas emissions. It provides airports with a standardized methodology for collecting data on emissions from various sources, including energy consumption, ground transportation, and aircraft operations. By using ACERT, airports can track their environmental performance over time and identify opportunities for emissions reduction.

ACI's Carbon Management Handbook was published to assist airports in developing and implementing effective carbon management strategies. The handbook provides guidance on setting emissions reduction targets, conducting emissions inventories, implementing mitigation measures, and engaging stakeholders. It serves as a valuable resource for airports seeking to address their environmental impact and contribute to sustainability efforts.

These ACI-related programs and initiatives demonstrate the organization's commitment to promoting environmental sustainability within the aviation industry. By providing tools, resources, and guidance to airports, ACI plays a crucial role in advancing the adoption of sustainable practices and mitigating the environmental impact of air transport. Including these programs in discussions of international efforts to address sustainability in air transport highlights the important role that airports play in achieving global environmental goals.

Academic and Research Institutions' Role in Sustainability

Academic and research institutions are pivotal in advancing the sustainability agenda by producing the knowledge, expertise, and innovative solutions necessary to address complex global environmental challenges. These institutions play a crucial role in providing scientific evidence, offering technical assistance, and conducting policy analysis that shapes decision-making at local, national, and international levels. Through research initiatives, education programs, and capacity-building efforts, universities, research centres, and think tanks contribute to the development of sustainable practices in various sectors, including aviation.

The University of Cambridge is home to the Aviation and Environment Research Group (AERG), which focuses on analysing the environmental impacts of aviation and developing strategies for reducing emissions. The group's research includes studies on SAFs, aircraft efficiency improvements, and emissions management. By working closely with industry stakeholders and regulatory bodies such as ICAO, the AERG contributes to policy recommendations aimed at reducing aviation's environmental footprint [45].

At the Massachusetts Institute of Technology (MIT), the Laboratory for Aviation and the Environment conducts interdisciplinary research on the environmental effects of aviation and how technology and policy can mitigate these impacts [46]. The lab's key focus areas include air pollution, noise pollution, climate impacts of aviation, and the economic implications of emissions reduction strategies. One prominent research project is the *Partnership for Air Transportation Noise and Emissions Reduction* (PARTNER), a collaboration with NASA and FAA, aimed at creating solutions for reducing aviation emissions and noise, including fuel-efficient aircraft designs and sustainable fuel alternatives [46].

The Stockholm Environment Institute (SEI) is an international research institute that provides critical insights into sustainable development through policy analysis, climate modelling, and research on energy transitions. SEI's work on aviation includes research on the carbon footprint of air travel, the development of carbon offset programs, and the integration of low-carbon technologies into the aviation industry. SEI's aviation-related projects offer policy recommendations to international organizations such as ICAO and the European Union on how to reduce aviation's contribution to climate change [47].

The University of Oxford's Oxford Martin School has launched several research programs focused on addressing sustainability challenges, with the Oxford Martin Programme on the Future of Cooling being a prime example. While not limited to aviation, this initiative tackles the increasing global demand for cooling technologies and their environmental impact, including aviation cooling systems. The research explores how to design energy-efficient cooling systems for aircraft and airports, reducing their energy consumption and carbon footprint [48].

Horizon Europe, the EU's flagship research and innovation program, provides funding for a wide array of sustainability-focused research projects[49]. Within aviation, Horizon Europe has sponsored projects such as Clean Sky 2 and SESAR (Single European Sky ATM Research). Clean Sky 2 is a public-private partnership that brings together academia, industry, and public authorities to develop breakthrough technologies aimed at reducing CO2, NOx, and noise emissions from aircraft. Universities across Europe collaborate with private sector partners in Clean Sky to drive innovation in aircraft designs, engine technologies, and sustainable aviation fuels [50].

Educational Programs and Capacity Building

Many academic institutions have also established degree programs and training initiatives that focus specifically on sustainable development and green technologies within aviation. These educational programs are essential for fostering a workforce capable of driving the aviation sector's sustainability transition. Some key examples include:

- TU Delft in the Netherlands offers a master's in aerospace engineering with a focus on sustainable aviation technologies, including courses on renewable energy, biofuels, and carbon reduction strategies;
- the University of California, Davis offers a Sustainable Aviation Research and Education Program (SARE), where students can specialize in areas such as SAF production, electric aviation, and climate policy;

- Cranfield University in the UK provides specialized programs in Aerospace Engineering, with modules on low-carbon aviation and environmental impact assessment.

These programs are designed to equip future aviation professionals with the knowledge and skills required to address sustainability challenges and contribute to the sector's transition toward greener practices.

Collaborative Approach

Overall, global programs on sustainability rely on a multi-stakeholder approach, with partnerships among governments, international organizations, industry stakeholders, civil society, and academia being essential for addressing complex sustainability challenges. By working together, these actors can develop innovative solutions, mobilize resources, and drive collective action towards a more sustainable and equitable future. Academic and research institutions continue to play a key role in shaping the sustainability landscape, producing the knowledge, technologies, and policy frameworks necessary to transition to a sustainable aviation industry.

The role of academic and research institutions in promoting sustainability is vast and varied. These institutions contribute not only by conducting research and innovation but also by educating the next generation of professionals and offering policy guidance. Whether through initiatives like MIT's Laboratory for Aviation and the Environment[46], the Tyndall Centre for Climate Change Research, or EU-funded projects like Clean Sky 2, the contributions of these institutions are critical to the successful implementation of sustainable practices in the aviation sector and beyond.

Education and Job Creation

Sustainability initiatives in aviation are not only reducing the sector's environmental impact but also fostering education and job creation. For instance, programs like *Flightpath 2050* and the *Sustainability & Smart Mobility Strategy* emphasize the need for a skilled workforce that can navigate the complexities of green and digital technologies [42]. The European Green Deal aims to create 1 million green jobs by 2030, many of which will be in sectors related to sustainable aviation and air transport infrastructure [40].

The transition to a sustainable aviation industry also underscores the importance of vocational education and training (VET) programs that can equip workers with the interdisciplinary skills needed in the future. As aviation companies adopt new technologies, higher education institutions (HEIs) are expected to integrate sustainability modules into their curricula to prepare students for emerging roles. For example, universities in partnership with industry associations have started offering

specialized courses on SAF production, carbon management, and sustainable airport operations, which are critical for addressing skills shortages in these areas [28,51].

In conclusion, the aviation industry's sustainability efforts are multifaceted and involve collaboration across governments, international organizations, industry associations, and academic institutions. Programs such as CORSIA, the European Green Deal, Flightpath 2050, and ACI's Airport Carbon Accreditation have shown measurable success in reducing carbon emissions and advancing sustainable practices. However, further efforts are required to scale up the adoption of Sustainable Aviation Fuels, improve carbon management, and develop a skilled workforce capable of driving the industry towards net-zero emissions. Importantly, the integration of sustainability into education and training programs will be crucial in ensuring that the aviation workforce is prepared for the green jobs of the future.

4.2 Just Transition in the Context of Air Transport

The concept of a "just transition" is grounded in the recognition that the shift towards sustainability and environmentally friendly practices carries significant social and economic implications for specific industries, communities, and workers. At its core, the just transition framework ensures that this movement towards sustainable practices is equitable and inclusive, leaving no one disproportionately disadvantaged [52]. This is particularly important for industries heavily reliant on carbon-intensive activities, such as fossil fuel extraction and energy production, as they undergo transformations to align with climate targets and sustainable development objectives.

The just transition framework, although broad in scope, is largely concerned with mitigating the adverse effects of environmental policies on workers and communities that depend on sectors undergoing significant change. For industries like coal mining, oil and gas extraction, and heavy manufacturing, the transition to greener alternatives can disrupt livelihoods, requiring comprehensive strategies for job retraining, financial assistance, and economic diversification [53]. These strategies are designed to ensure that the workers and regions affected by the transition are not left behind, with targeted investments in new sectors and a strong emphasis on social dialogue between stakeholders.

Just Transition in the Air Transport Sector

In the context of air transport, the challenges posed by a just transition are both unique and multifaceted. The aviation industry, as a significant contributor to global greenhouse gas emissions, faces increasing pressure to decarbonize and shift to more sustainable practices (International Air Transport Association, 2021). However, the transition to greener aviation technologies—such as electric or

hydrogen-powered aircraft—is still in its nascent stages, with many technological and infrastructural barriers to overcome. For instance, these new technologies require extensive development and significant investment before they can be commercially viable, and the current infrastructure to support electric and hydrogen-powered aircraft is limited [54].

This transition will likely have profound implications for the millions of workers employed in the aviation industry, ranging from pilots and ground crew to fuel production workers and maintenance staff. The shift away from traditional aviation fuels could potentially result in job losses in sectors such as fuel production, distribution, and aircraft maintenance. To ensure a just transition within the air transport sector, it is essential to develop comprehensive retraining programs and job placement initiatives for these workers. Additionally, regions and communities reliant on aviation-related industries must receive targeted investments to avoid economic disadvantages caused by the industry's structural changes [7].

The Role of International Agreements and Initiatives

While there is no international program solely dedicated to the concept of a *just transition*, its principles are increasingly integrated into various global agreements and frameworks aimed at addressing climate change. One of the most prominent agreements in this regard is the Paris Agreement, adopted in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC). Although the Paris Agreement does not explicitly mention just transition, it highlights the importance of considering the specific needs and circumstances of different countries in the shift to low-carbon economies, particularly in terms of social and economic considerations [39].

The International Labour Organization (ILO) has played a critical role in promoting the just transition agenda [7]. It advocates for policies that support decent work, social protection, and inclusive economic growth in the context of environmental sustainability. The ILO has published guidelines and recommendations aimed at helping governments, employers, and workers navigate the challenges associated with transitioning to more sustainable economic models, ensuring that workers in affected sectors are not disproportionately impacted [52]. The ILO's Guidelines for a Just Transition towards Environmentally Sustainable Economies and Societies for All provide a comprehensive framework for policymakers and stakeholders, emphasizing the importance of social dialogue, decent work, and social protection [53].

Regional Approaches to Just Transition

In addition to global frameworks, regional and national strategies for just transition are becoming more common. The European Union's Green Deal includes a dedicated Just Transition Fund, designed to support regions heavily reliant on carbon-intensive industries in their shift towards a low-carbon economy. The fund, worth €17.5 billion, provides financial assistance to affected communities and workers, enabling investments in new technologies, renewable energy, and sustainable infrastructure[40]. Moreover, the Sustainable Development Goals (SDGs) adopted by the United Nations in 2015 serve as a broader framework for promoting inclusive and sustainable economic growth. Specifically, Goal 8 calls for the promotion of decent work and economic growth, objectives that align closely with the principles of a just transition [33].

A Path Forward for Air Transport

Achieving a just transition in air transport will require careful coordination between governments, industry stakeholders, labour unions, and environmental organizations. This transition must be supported by robust policies that facilitate research and development in cleaner aviation technologies while also providing adequate support for workers in the current industry. For instance, investing in skills development programs for aviation workers, focusing on emerging areas such as SAFs, green technologies, and electric aviation, can help ensure that the workforce is equipped to meet the challenges of a decarbonized aviation industry [54].

Ultimately, a *just transition* in the air transport sector requires addressing the social, economic, and environmental dimensions of sustainability in a holistic manner. This means creating opportunities for new employment, fostering innovation in green technologies, and ensuring that no worker or community is left behind. The growing emphasis on just transition in international climate frameworks reflects the recognition that economic transformation must be inclusive and fair, ensuring a sustainable future for both the planet and its people.

4.3 Key Competencies for Societal Responsibility

All industries and sectors require people with competences for societal responsibility. Depending on the relevant laws and regulation and the voluntary commitments that an organization assumes, societal responsibility implies the creation and updating of a series of job descriptions. Given the complexity of the areas that fall under the umbrella of societal responsibility, currently there is no alignment of the stakeholders regarding the necessary competences and qualifications for such jobs.

Societal responsibility of an organization may be implemented within the human resources, business development or public relations departments of an organization, or may be a separate unit reporting to the Chief Executive Officer (CEO) or the board of directors.

Although there is no universally agreed definition of corporate societal responsibility at a global level, the concept has been settled and recognized as a long-term business strategy balancing corporate rights and ever-growing list of obligations towards stakeholders. It requires consideration of the social, environmental, and economic impacts of its business operations while considering the needs and expectations for each of its stakeholders.

There are no specific qualifications required for societal responsibility field but there is an increasing number of qualifications becoming available at master's level and as part of MBA courses. However, because it is relatively new, transferable skills and knowledge from other related specialisms such as environmental management, ethical finance, marketing, and human resources are valued.

The education for sustainable development requires people to shift the mindset and work towards a sustainable future. A major impact is created by reorienting education as to support the development of knowledge, skills, values, and behaviours needed for sustainable development and so, creating a new learning culture. The role of universities in this context is significant not only because their research and teaching generate and transfers knowledge about sustainability, but because they also educate future professionals to enable them to contribute to a sustainable future [55].

In the context of the European Qualification Framework (EQF), each of the eight levels is defined by a set of descriptors indicating the learning outcomes relevant to qualifications at that level in any system of qualifications, in term of *knowledge, skills and responsibility and autonomy*. Responsibility and autonomy are described as the ability of the learner to apply knowledge and skills autonomously and *with responsibility*. Therefore, there should be a connection with the necessary competences for a person who will develop and implement societal responsibility actions.

The AVIONIC project aimed to contribute to the discussion regarding the competences needed by those who will design and implement societal responsibility actions. Based on the interactions with the representatives of companies, the following key competences emerged:

- teamwork: people working in societal responsibility for a organization are required to work across departments and are responsible for collaborating with others;
- communication: good verbal and written communication skills are a critical must-have ability for a career in corporate societal responsibility, as it involves external and internal communication tasks and the need to be able to tailor the message to different audiences and stakeholders;
- systems thinking and connecting the dots: societal responsibility is cross-sectoral and often requires partnerships with other organizations, to be able to see the big picture and explain how the organization fits into the greater cause;
- business acumen: strategic thinking, sustainability, research, analytics, and marketing are some of the most common skill sets looked for in a societal responsibility role (dependent on the organization);
- knowledge in the field: particularly, to understand the business and current issues in the air transport industry and the world.

More clarity is needed regarding the skills and competencies required for a societal responsibility role due to the interdisciplinarity of the issue and, consequently, to define the profile of a specific employee. In any case, the skills required are interdisciplinary, and these could be categorized into:

- *business/ professional skills* - including building insight, decision making, commercial awareness, IT, innovation, strategic awareness, leadership, handling complexity and problem solving);
- *soft skills* - including communication skills, adaptability and empathy, developing others, teamwork, open minded, critical thinking, integrity, self-development and learning, building partnerships, team working, positive attitude, work ethic;
- *technical skills* - including technical expertise, understanding impacts, stakeholder dialogue, internal consultancy, selling the business case, understanding human rights and understanding sustainability.

Given the importance of societal responsibility and the complexity of its implementation, any organisation aiming for efficiency and sustainable growth must take deliberate steps to build, develop, and maintain internal knowledge and capacity in this area.

Part 2. The Future Workforce: Jobs, Skills and Qualifications

- Jobs In the Aviation Industry: Evolution and Outlook
- Skills Gaps and Labor Market
- New Occupations in Aviation
- Education And Training for New Skills

5 Jobs in the Aviation Industry: Evolution and Outlook

This section explores the evolution of jobs in the aviation industry, highlighting key trends in workforce demand, skills gaps, emerging job roles, and the integration of new technologies and sustainability measures. The discussion provides both a global and European perspective on how these changes impact the sector.

5.1 Current Occupation Categories and Employment Data

The aviation industry is one of the most complex and interconnected global sectors, employing millions of individuals in a wide variety of roles that extend far beyond flight operations. From aircraft manufacturing and maintenance to airport services, air navigation, safety oversight, and digital infrastructure, the sector supports a wide array of professions that are increasingly dependent on both technical and transversal competencies.

The aviation industry encompasses a diverse range of occupations, each playing a critical role in ensuring the safety, efficiency, and advancement of air travel. The aviation sector significantly contributes to Europe's economy, supporting approximately 13.5 million jobs and generating around one trillion euros in economic activity, accounting for 3.6% of all employment and 4.4% of GDP in Europe [56].

In 2022, European air traffic surged by 132% compared to 2021, leading to a rebound in industry turnover and employment. Civil aeronautics turnover reached €114 billion, an 11.1% increase over the previous year, reflecting the sector's resilience and recovery trajectory [57].

Despite recovery, the industry faces staffing challenges. Reports indicate recruitment difficulties across various roles, including ground handlers, airline staff, and air traffic controllers, leading to operational disruptions in several countries since 2022 [51]. Understanding the current occupational categories and employment data is essential for grasping the industry's evolution and outlook.

Current occupation categories include traditional roles such as pilots, flight attendants, aircraft mechanics, air traffic controllers, and airport ground personnel. However, modern aviation also includes highly specialised jobs in aircraft design, environmental compliance, cybersecurity, and simulation-based training.

Data from platforms such as European Aviation Safety Agency (EASA), Groupement des Industries Françaises Aéronautiques et Spatiales (GIFAS), International Civil Aviation Organization (ICAO), Aviation Job Search, and

Aerospace & Defence Industries Association of Europe (ASD) highlight how aviation employment is evolving to include more roles in digital engineering, predictive maintenance, and smart airport operations.

EASA plays a pivotal role in Europe's aviation sector, not only as a regulatory body but also as an employer and facilitator of employment opportunities within the industry. The agency offers a wide range of career opportunities beyond traditional aviation roles, and they are advertised on their career portal (https://careers.easa.europa.eu/). With its headquarters in Cologne, Germany, EASA provides a dynamic work environment that brings together experts from various backgrounds, fostering diversity and innovation. They actively seek professionals in fields such as law, finance, human resources, communications, and information technology. Positions range from entry-level to experienced roles, including traineeships for those beginning their careers (see figure 5.1).

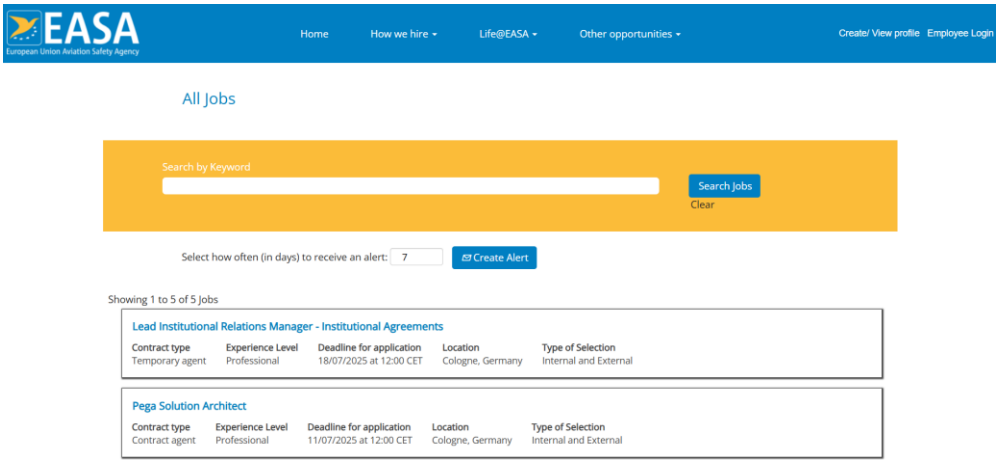

Fig. 5.1 EASA Job portal (careers.easa.europa.eu/)

EASA's influences the aviation job market outlook through its safety and training standards and their regulatory roles. Through its establishment of safety and training standards, EASA aims to enhances the quality of aviation professionals in Europe. This elevation in standards can lead to increased demand for qualified personnel, positively impacting job opportunities across the sector. Moreover, through its regulatory and standardization roles, EASA supports the growth and competitiveness of the European aviation industry. A thriving industry often correlates with a robust job market, offering various employment opportunities in both technical and non-technical fields.

French Aerospace Industries Association- GIFAS (https://gifas.asso.fr) alone lists job offers across diverse employment categories, including R&D engineering, testing and simulation, quality control, program management, and support functions

(see figure 5.2). These reflect both the diversity and the technical sophistication of contemporary aviation employment. Meanwhile, ICAO and the Airports Council International (ACI) provide access to jobs in aviation policy, security, sustainability, and training, further demonstrating how international organisations are also contributing to employment growth.

The French aerospace industry, represented by GIFAS (Groupement des Industries Françaises Aéronautiques et Spatiales), has been experiencing significant growth, leading to substantial recruitment needs. In 2023, the sector employed nearly 200,000 individuals in France, with 28,000 new hires, including 30% women and 6,000 young apprentices [58]. This upward trend is expected to continue, with projections of 25,000 to 30,000 new positions in 2024, among which 6,000 to 7,000 are anticipated to be apprenticeships.

Fig. 5.2 L'aero recrute website (laerorecrute.fr/)

AeroEmploiFormation (www.aeroemploiformation.com) is a specialized job board dedicated to recruitment and training in the aerospace, space, and defense industries. It was established in 2000 through a collaboration between GIFAS (Groupement des Industries Françaises Aéronautiques et Spatiales) and the French Ministry of National Education to support employment and training development in the French aerospace sector (see figure 5.3).

The platform offers thousands of job listings across various domains, including production, research and development, support functions, testing and simulations, maintenance, and program management. It serves as a comprehensive resource for individuals seeking employment or training opportunities in the aerospace sector.

Fig. 5.3 Aero Emploi Formation website (aeroemploiformation.com)

ICAO actively recruits professionals for various positions within its organization and facilitates employment opportunities in the aviation industry.

As direct employment opportunities**,** ICAO offers positions across multiple categories, including Professional and Higher Categories, General Service, Consultancy, and Internships. Current openings are listed on their Vacancies page (https://inspira.icao.int/Careers/Home/Vacancies), with roles in locations such as Montreal, Paris, Cairo, and Bangkok. The internships and the ICAO Programme for Aviation Volunteers (IPAV), providing opportunities for individuals to contribute to international civil aviation projects, are advertised on the same page.

Moreover, ICAO maintains a Roster of Experts (https://inspira.icao.int/Careers/?ReturnUrl=Posts) comprising professionals from various civil aviation fields. These experts are deployed globally to support aviation projects, serving as advisers, instructors, or operational personnel.

Aviation Job Search (https://recruiting.aviationjobsearch.com/) is a prominent online platform specializing in connecting aviation professionals with employers worldwide. Established in the United Kingdom, the platform has evolved into a significant player in aviation recruitment, offering a comprehensive range of services for both job seekers and employers.

This platform has job postings (listings) and provides employer services. The platform features a wide array of job categories, including pilot positions, aircraft maintenance roles, cabin crew opportunities, and more. Job seekers can browse through numerous listings, filter by location, role, and other preferences, and apply directly through the site. Moreover, Aviation Job Search provides employers with tools to post job vacancies, search a vast candidate database, and manage applications efficiently. Employers can also create detailed company profiles to enhance their visibility and attract potential candidates.

Aviation Job Search and the Aerospace & Defence Industries Association of Europe (ASD) play significant roles in the aviation industry's employment landscape.

Aviation Job Search (www.aviationjobsearch.com) is a dedicated platform for aviation job listings, featuring roles such as pilots, aircraft maintenance engineers, cabin crew, and ground staff (see figure 5.4). The platform allows users to filter job searches by category, location, and other preferences.

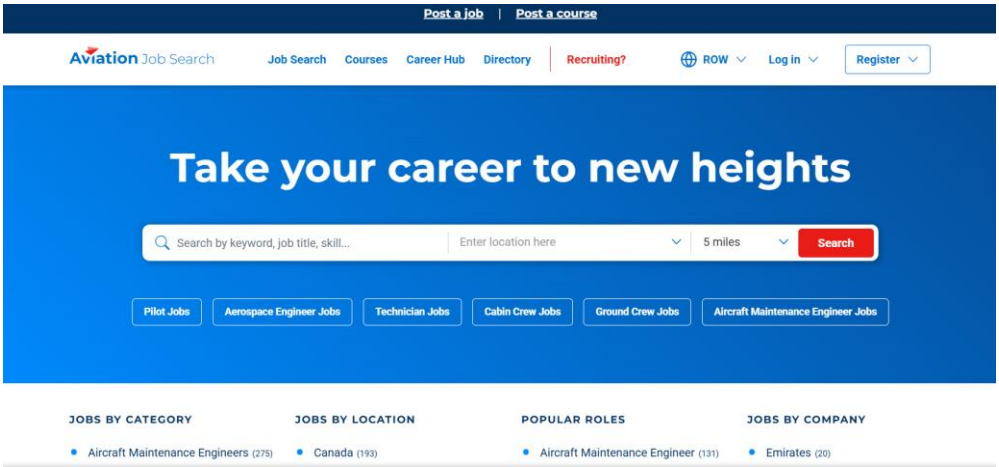

Fig. 5.4 Aviation Job Search website (aviationjobsearch.com)

With a substantial following of over 500,000 on social media, Aviation Job Search is a prominent player in aviation recruitment. It collaborates with top employers to provide a wide range of job opportunities, catering to various aviation-related professions (www.aviationjobsearch.com).

Beyond listing job opportunities, Aviation Job Search offers services for employers to post vacancies, search a comprehensive candidate database, and manage applications effectively. Employers can also create detailed company profiles to enhance visibility and attract suitable candidates.

These statistics point to an aviation labour market that is both expansive and rapidly changing. The employment ecosystem now integrates advanced ICT systems, environmentally responsible practices, and interdisciplinary skills that cut across traditional industry boundaries.

5.2 Skills Gaps and Labour Market Needs

The global aviation sector is poised for steady growth over the next decade, fuelled by surging passenger demand, innovations in urban air mobility, and a strong post-pandemic rebound [59]. Forecasts indicate that this growth will translate into substantial workforce needs. A recent industry outlook by CAE projects that over 1.3

million new aviation professionals will be needed by 2032 [60], including roughly 252,000 pilots and 328,000 maintenance technicians in commercial aviation alone. By 2034, the numbers rise even further, about 300,000 new pilots and 416,000 new maintenance engineers are expected to be required worldwide [60].

These figures underscore a looming skills shortage i.e. demand for qualified personnel is outpacing supply in many key operational areas. Notably, commercial airlines in Europe are cautiously forecasting pilot shortfalls toward the latter half of this decade despite a current balance, anticipating a potential deficit of approximately 19,000 pilots in Europe by 2032 if training capacity doesn't increase [61].

Similar gaps are emerging for aircraft technicians, air traffic controllers, and other skilled roles, as large cohorts of the workforce approach retirement age (the "silver tsunami" of retirements) without enough newcomers to replace them. The European labour market reflects these strains: over half of EU small-and-medium aviation enterprises report difficulty finding workers with the right skills, with 52% calling it "very difficult" and another 26% "moderately difficult" to recruit qualified staff [62]. This mismatch is especially problematic in high-skill roles requiring extensive training and experience.

Globally, emerging markets in Asia and Africa are driving a surge in aviation employment, compounding the demand for talent. For example, India's airline fleet is forecast to double by 2035 to accommodate a burgeoning middle class of travellers, and China's fleet is expected to expand by about 40% in the next decade [63].

Africa and the Middle East are also witnessing rapid traffic growth (in Africa, passenger traffic has even exceeded pre-2019 levels [63]), leading to increased hiring needs, yet these regions often face shortages of qualified instructors and infrastructure for training. Europe's growth is more modest (approximately 2% annually in-flight activity through 2030) [61], but it too faces a *qualitative* skills gap: many seasoned professionals are retiring, and younger workers are either insufficient in number or lack the new competencies that modern aviation roles demand.

In North America and parts of Latin America, a similar picture emerges of acute labour shortfalls (e.g. a persistent deficit of 12,000–18,000 aviation maintenance workers over the next 10 years [64]), suggesting the skills gap is a global challenge, not confined to any one region.

The skills shortages are particularly pronounced in certain operational and technical domains. Traditional roles like pilots, aircraft maintenance engineers, air traffic controllers, and ground handling staff remain in high demand, but now they require augmented skillsets due to digitalisation and sustainability pressures [65].

Aviation employers report difficulty recruiting experts proficient in emerging technologies – for instance, cybersecurity analysts who can secure increasingly digital aircraft and airport systems, or drone (UAS) traffic managers capable of handling unmanned aerial vehicles in newly opened airspace ("U-space") [65]. Similarly, roles in sustainable aviation are growing exponentially: airlines and airports need specialists in sustainable aviation fuels (SAF) development, green infrastructure management, and carbon emissions auditing to meet climate targets. However, talent with combined aviation and environmental expertise is scarce.

This disconnect is evident in recruitment trends, companies often receive too few qualified applicants for roles like AI systems engineers, data scientists, or regulatory compliance officers who understand both aviation operations and complex new regulations (e.g. in safety, cybersecurity, or emissions) [64]. The outcome is that many organizations struggle to keep critical positions filled.

According to a recent Eurobarometer survey, 74% of SMEs in Europe report skill shortages in at least one job role, and over one-quarter say it significantly limits their business growth [66].

In aviation, such shortages can jeopardize service levels and slow down innovation: for example, a lack of qualified maintenance technicians has contributed to longer turnaround times and even flight cancellations [64,67], while insufficient IT specialists can impede the rollout of digital solutions like remote towers or AI-driven analytics.

5.3 Organizational Areas Experiencing Shortages

Managers were asked to identify the *areas of their organization where they perceived shortages regarding people's skills.* The chart in figure 5.5 illustrates the areas where organizations experience the most significant shortages in people's skills across different occupational categories: high-skilled non-manual occupations, skilled non-manual occupations, and skilled manual occupations.

Based on the responses, we may highlight several key insights emerge, regarding technological progress in air transport industry, green issues and environmental protection, information and communications technology, new management approaches and ethical and societal responsibilities.

Regarding technological progress in air transport industry, 60% of respondents report skill shortages in high-skilled non-manual occupations, making this the most significant area of shortage. Both skilled non-manual and skilled manual occupations are equally in demand, with each at 20%. This indicates that while

technological progress requires specialized high-skilled talent, operational and manual roles are also affected.

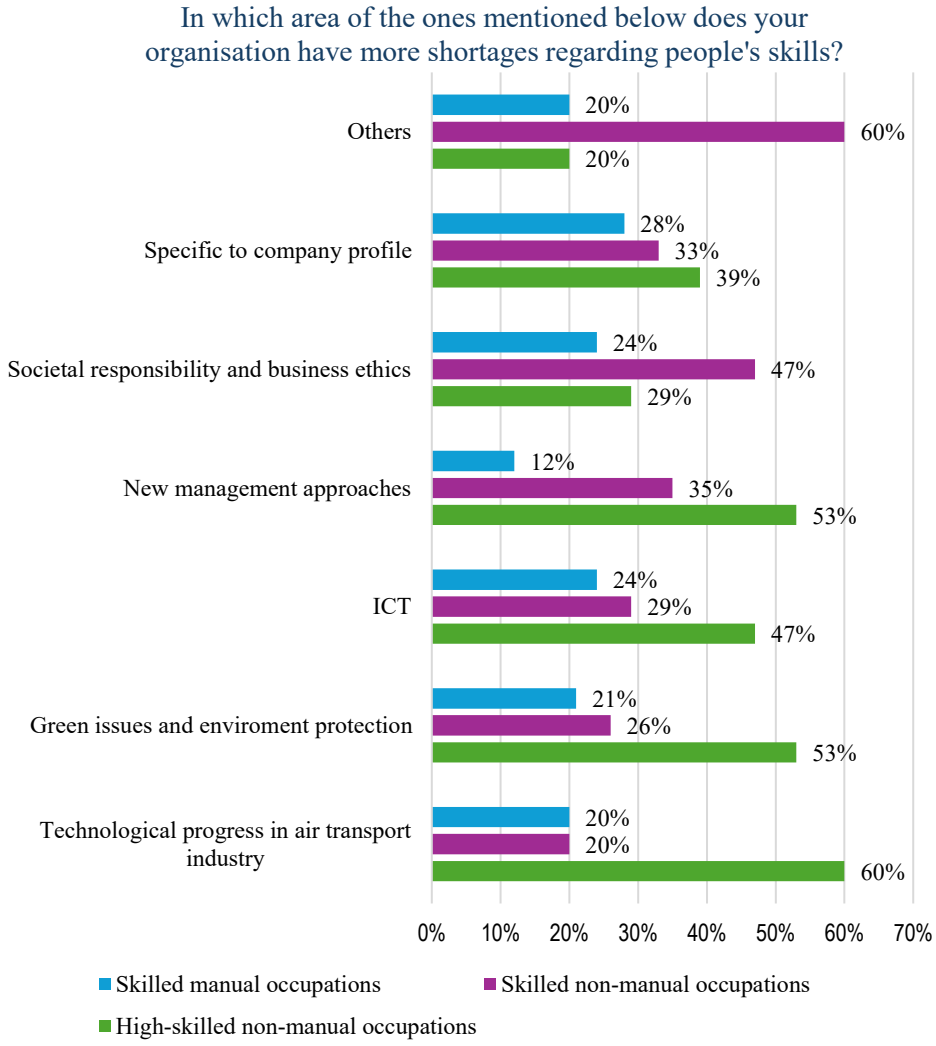

Fig. 5.5 The number of skilled manual occupations the directors' respondents have in their organizations

For green issues and environmental protection, 53% of organizations report a shortage in high-skilled non-manual occupations, indicating a growing need for expertise in sustainability and environmental practices. Skilled non-manual and manual occupations account for 26% and 21%, respectively. This shows a smaller but notable demand for roles that support environmental sustainability efforts.

Regarding information and communications technology (ICT) we notice a balanced demand across all categories: high-skilled non-manual (47%), skilled non-manual (29%), and skilled manual (24%) occupations. This highlights a comprehensive need for expertise at various levels to support digital transformation.

For the area of new management approaches 53% of organizations see a shortage in high-skilled non-manual occupations, emphasizing the need for leaders who can implement new management frameworks. Skilled non-manual roles (35%) are also in demand, showing that management transformations require both strategic leadership and hands-on execution, while skilled manual roles are less of a concern in this area (12%).

Regarding ethical and societal responsibilities, the shortage of skilled non-manual occupations (47%) indicates that mid-level roles are crucial in addressing ethical and societal responsibilities. High-skilled non-manual (29%) and skilled manual (24%) occupations are also necessary, though to a lesser extent, suggesting that ethical compliance spans various job roles.

In areas specific to the company there is a relatively even spread of shortages across all categories, with high-skilled non-manual (39%), skilled non-manual (33%), and skilled manual (28%) occupations. This suggests that company-specific roles require a diverse skill set, depending on the organization's unique operational demands.

The "Others" area shows the same pattern as the technological area, with most shortages in high-skilled non-manual occupations (60%) and lower but equal demand for skilled non-manual and skilled manual roles (20%).

In summary, figure 5.5 highlights that the largest skill shortages are found in high-skilled non-manual occupations, particularly in areas related to technological progress and new management approaches. However, the need for skilled non-manual and manual occupations remains significant across various areas, particularly in ICT and company-specific operations. Addressing these gaps will require a multi-tiered approach, focusing on both high-level strategic roles and operational capacities.

The data gathered from our surveys with managers, employees, and educators in the air transport sector reveals several significant trends in skill shortages and emerging competencies. The findings indicate that technological advancements, such as information technologies, Big Data, and cooperative systems, are playing a critical role in shaping current job functions. These technologies demand a high level of expertise across multiple organizational levels, particularly in high-skilled non-manual roles. While newer technologies like smart buildings, augmented reality, and

gamification have not yet made a significant impact, they present opportunities for future adoption.

Competences related to teamwork, responsibility, and communication were identified as the most important for current occupations, reflecting the aviation sector's collaborative and high-stakes environment. Technical and regulatory skills, particularly digital competence and compliance with safety regulations, are also essential. While innovation and leadership are valued, they are slightly less prioritized compared to the immediate demands of operational efficiency and safety. Green competences, although currently rated as less critical, represent a potential area for future development as sustainability initiatives gain traction in the industry.

When examining skill shortages, the most critical gaps are found in high-skilled non-manual occupations, particularly in areas like technological progress and new management approaches. However, the need for skilled non-manual and manual roles remains significant, especially in ICT and sectors that require specific company-based operations. The data underscores the necessity for a comprehensive, multi-tiered approach to workforce development in the air transport sector, focusing on both strategic leadership and operational skills to meet current and future demands.

5.4 Evolving Job Profiles: Digitalisation and Sustainability in Aviation

Digitalisation and sustainability represent twin forces of transformation, disrupting and redefining occupational profiles across the aviation value chain. While automation, artificial intelligence, and big data are reshaping how operational and managerial tasks are performed, sustainability is introducing new roles aimed at reducing aviation's environmental footprint.

Among the most affected job profiles are those in aircraft maintenance, air traffic control, ground handling and airport facility management. The digital shift is transforming traditional roles, requiring workers to adapt to new technologies and methodologies. For instance, Aircraft Maintenance Technicians must now navigate digital diagnostic tools, sensor-based systems, and AI-supported maintenance prediction, replacing traditional manual techniques. Similarly, Air Traffic Controllers are transitioning from analogue systems to digital remote towers and satellite-based navigation tools, enabling them to manage air traffic more efficiently and safely.

Ground Handling Staff is increasingly using automated baggage systems, biometric identity verification, and autonomous transport vehicles to streamline operations and enhance passenger experience. Airport Facility Managers are adopting

digital twin models to optimise energy use, passenger flow, and predictive maintenance, ensuring airports remain efficient and environmentally sustainable.

At the same time, sustainability pressures are creating new demands for expertise in green technologies and sustainable practices. This includes roles focused on green airport infrastructure, sustainable aviation fuel (SAF) deployment, carbon offset management, and environmental monitoring. These changes require not only technical retraining but also a shift in mindset towards lifelong learning, systems thinking, and collaborative problem-solving.

As these technological and environmental transformations unfold, education and training systems must align with the new skill sets demanded by the labour market. Without such alignment, the sector risks falling short in supplying qualified professionals capable of navigating this dual transformation. Educational institutions and industry stakeholders must collaborate closely to ensure the workforce is prepared for the future challenges of a digital and sustainable aviation industry.

5.5 The Impact of Emerging Technologies on Job Roles

Certain technologies have a particularly strong impact on current job functions in aviation. As digitalisation accelerates, the integration of advanced technologies such as information systems, big data analytics, and cooperative platforms has significantly reshaped how work is conducted across various aviation sectors.

Figure 5.6 presents the extent in which various approaches and technologies affect your current occupation of the respondents. Information technologies and applications are seen as highly influential across the industry. Nearly 77% of respondents indicated that these technologies have a very high impact on their roles, while another 71% noted a high level of influence. This underscores the critical role that IT plays in shaping modern job functions, from air traffic management to airline operations and airport logistics. Big Data methods, essential for predictive maintenance, operational efficiency, and customer insights, are similarly impactful, with 57% a high level of impact and 66% of respondents reporting a very high influence.

Cooperative systems and interfaces are another key technological shift, with 78% of respondents acknowledging a high impact and 58% reporting a very high influence. This highlights the growing importance of systems that facilitate collaboration and coordination in the workplace, essential for streamlining operations, improving safety, and enabling effective communication between stakeholders, such as ground crews, air traffic controllers, and airlines.

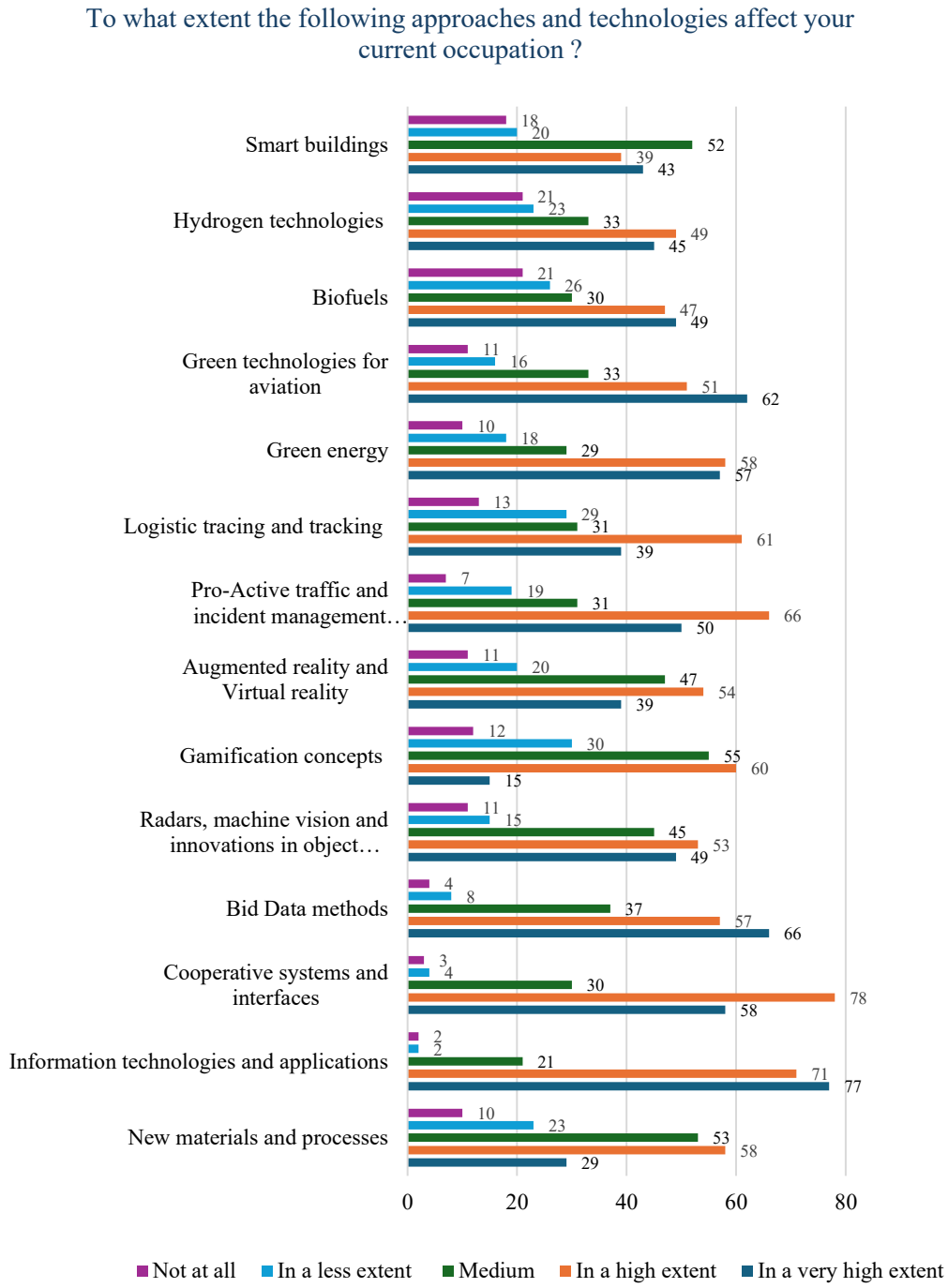

Fig. 5.6 Employees' perception on the approaches and technologies affecting their current occupation

Technologies related to logistics tracking and green energy are also pivotal. 62% of respondents reported that logistics tracking technologies, vital for cargo operations, have a very high impact, while 58% recognised a high level of influence. Similarly, green energy technologies are becoming more integrated, with 58% reporting a very high impact and 51% recognising a high impact. This reflects the industry's increasing focus on sustainability and the need for green technologies to meet environmental targets.

However, not all technologies have had the same level of penetration or impact. Biofuels and smart buildings are examples of technologies with a more moderate influence. While biofuels are recognised as important by 47% of respondents, only 49% considered them highly relevant to their roles. Smart building technology shows mixed results; although 43% of respondents reported a very high influence, 52% indicated no impact at all, suggesting that smart building technologies are not yet universally adopted or relevant to all occupations in aviation.

Finally, emerging technologies like gamification concepts and augmented/ virtual reality are still in the early stages of adoption. 15% of respondents reported that gamification had a very high influence, and 55% rated its influence as medium to low. While AR/VR is recognised by 39% of respondents as having a very high impact, the technologies have not yet seen widespread integration across all aviation job roles, with 54% of respondents noting only some influence from these technologies.

In summary, the data (figure 5.6) indicates that information technologies, big data, and cooperative systems are the most impactful technologies on current aviation job roles. These technologies are reshaping operational workflows, improving efficiency, and enabling innovation across the industry. On the other hand, emerging technologies such as smart buildings, AR/VR, and gamification are still evolving and will likely see more widespread adoption in the coming years as the sector continues to modernise and adapt.

5.6 Competences for Current Occupations

The perceived importance of competences for current occupations in the aviation sector varies significantly across different roles. Based on survey data, certain competences stand out as essential for ensuring safety, compliance, and efficiency in the aviation industry figure 5.7 provides an overview of these competencies.

Among the top-ranked skills, teamwork and collaboration stand out with the highest score of 4.59, highlighting the critical need for professionals to work effectively within teams. This reflects the collaborative nature of aviation operations,

where coordinated efforts across various roles are vital for smooth and safe operations. Responsibility, focus on quality, and communication also scored highly, each at 4.51, underscoring the importance of accountability, maintaining high standards, and ensuring clear and effective communication in high-pressure environments.

Other competences that rank highly include planning and critical thinking, scoring 4.50 and 4.48, respectively. These skills are critical for professionals to anticipate challenges and analyse complex situations. Decision-making, with a score of 4.43, and understanding and applying safety measures (4.38) are also recognized as important. These skills reflect the aviation industry's reliance on making informed decisions and adhering to stringent safety protocols to maintain operational standards.

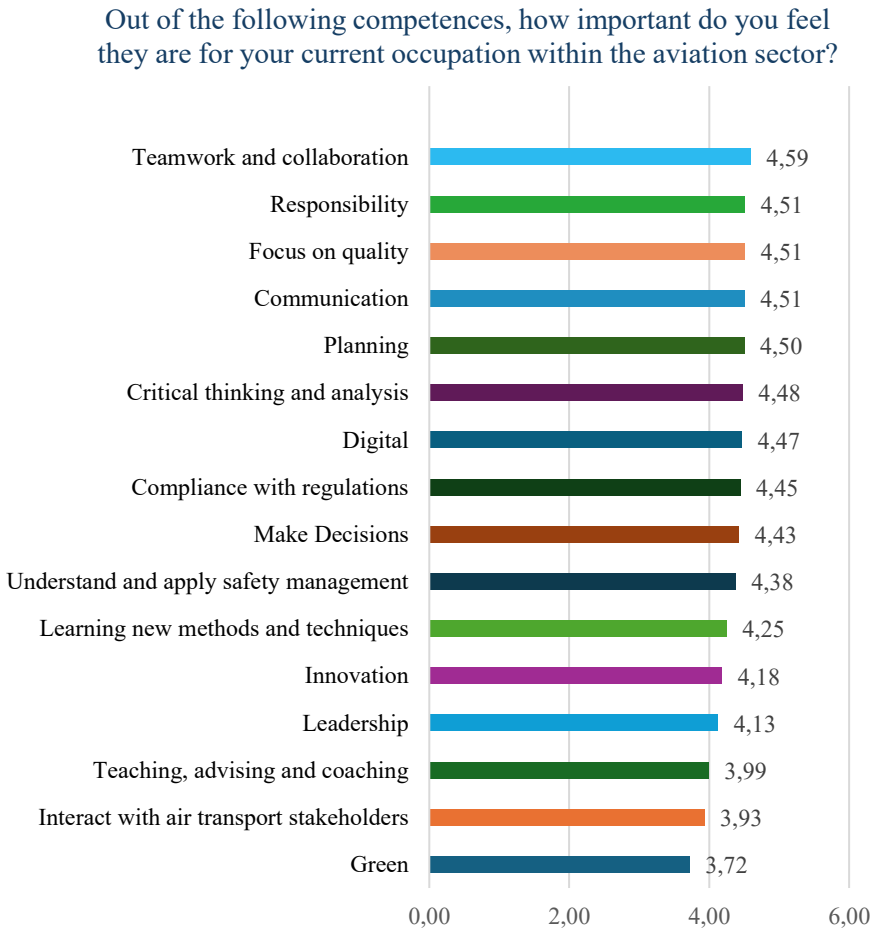

Fig. 5.7 Importance of competences for current occupations in the aviation sector

In addition to fundamental interpersonal skills, technical proficiency and regulatory compliance are highly valued in aviation. Digital competence (4.47) and adherence to safety regulations (4.45) underscore the sector's reliance on technology and its commitment to operational standards. While innovation (4.18) and leadership (4.13) remain important, they are slightly less prioritised than core concerns such as safety, compliance, and efficiency.

Moderately important competences include the ability to learn new methods and technologies (4.25), reflecting a need for adaptability in a dynamic sector. Teamwork, responsibility, and communication emerge as the highest-rated competences overall, highlighting the collaborative and high-stakes nature of aviation, where coordination and clarity are essential.

At the lower end of the scale, competences such as teaching, advising, and coaching (3.99), and interaction with air transport users (3.93) are seen as less essential to immediate operational roles. Green competences, with the lowest score of 3.72, suggest that while environmental awareness is acknowledged, it is not yet central to daily aviation functions. Nevertheless, this points to a potential area for growth as sustainability becomes a stronger focus in the sector.

In summary, aviation professionals are expected to demonstrate strong collaborative and technical abilities, with operational safety and compliance taking precedence. While softer skills and green competences are currently less emphasised, they may grow in importance as the industry evolves to meet emerging challenges and sustainability goals.

5.7 Addressing Skills Gaps: Aligning Qualifications with Market Needs

To address the forecasted workforce demand, concerted efforts in education and training are essential to ensure that the supply of skills meets the labour market needs of the aviation industry. A first step is to map existing Higher Education (HE) and Vocational Education and Training qualifications against the industry's emerging competency requirements.

Currently, many aviation-related degree programs and certifications focus primarily on conventional aeronautical knowledge and operational procedures. For example, an avionics engineering diploma or an air traffic management course may emphasize traditional technologies and regulations, with relatively little coverage of newer areas like artificial intelligence, cybersecurity, data analytics, or sustainability practices.

This misalignment leads to gaps between the learning outcomes (LOs) of graduates and the competences now expected in evolving job roles. Recent analyses have highlighted these misalignments, revealing that *digital skills* are often under-represented in many pilot and maintenance training syllabi, while *environmental topics* such as carbon emissions management or green energy systems are often only marginally addressed in aviation management programs[68]. As a result, new hires frequently require substantial on-the-job training to manage modern systems like e-enabled aircraft, automation in air traffic control, or sustainable operations.

To close these gaps, educational institutions and industry bodies are working to update aviation qualifications. This includes introducing or expanding courses on areas such as data science for aviation, AI in air traffic management, drone operations, and environmental sustainability in aviation. Some universities have already started offering specialised modules on aviation cybersecurity and green aerospace technologies, often in collaboration with aerospace companies. Furthermore, professional training organisations, including regulators like EASA and ICAO's Global Aviation Training, are revising their competency frameworks to integrate digital and green skills into certification standards [64].

The learning outcomes of new or revamped programs are increasingly defined not just by technical know-how, but by broader skills such as systems thinking, adaptability, and continuous learning, reflecting the need for an agile workforce that can keep pace with rapid industry changes.

A critical consideration in modernizing qualifications is ensuring their integration with established frameworks like the European Qualifications Framework (EQF), the European Skills, Competences, Qualifications and Occupations (ESCO) framework, and emerging sector-specific frameworks such as the *Sectoral Qualifications Framework for Air Transport (SQFAT)* [69]. Aligning aviation training programs to the EQF levels helps standardize the meaning of qualifications (e.g. defining whether a new "aviation data analyst" certification corresponds to a Level 5 or Level 6 qualification in terms of complexity and autonomy).

This alignment facilitates the recognition of qualifications across EU countries, making it easier for skilled workers to have their credentials accepted internationally. Using the ESCO taxonomy to describe program outcomes and job profiles is equally important. ESCO provides a common language for skills and competences, so mapping a course's outcomes to ESCO terms (e.g., linking a training in "autonomous aircraft systems management" to the standardized ESCO skill description) ensures that the skills taught match the skills employers are seeking. This mapping also helps identify missing competences; for example, if emerging skills like

“blockchain applications in aviation logistics” have no equivalent in current curricula, this signals a gap that needs to be addressed.

Meanwhile, the SQFAT methodology is being developed in initiatives like the EU-funded Knowledge Alliance in Air Transport project [69] to classify and benchmark aviation-specific qualifications. The SQFAT methodology aims to harmonise new “smart” qualifications for digital and green aviation roles with the broader EQF, so that a micro-credential in drone traffic coordination or a professional diploma in sustainable airport management can be understood uniformly across Europe. Integrating these frameworks streamlines the addition of micro-credentials and other flexible learning pathways into the qualifications landscape.

The European Council’s 2022 Recommendation on micro-credentials explicitly encourages their uptake to complement formal education and support lifelong learning [70]. In the aviation sector, micro-credentials, short, focused courses often delivered online, have huge potential to quickly upskill or reskill workers in niche areas. They can be used to certify discrete skills like *“Airbus A350 predictive maintenance data analysis”* or *“Cybersecurity for avionics systems”*, which might not require a full degree but are invaluable competences for certain jobs. By stacking these micro-credentials, professionals could build a portfolio of skills that keeps them aligned with the industry’s evolving needs [70].

Major European aviation employers and training schools are increasingly recognising such credentials. For instance, an aircraft technician could supplement their traditional *Part-66 [71]* license with micro-credentials in advanced composite materials or electric propulsion systems. To meet the forecasted labour demands, the aviation community must embrace education and workforce development strategies that are agile and future oriented. This involves strengthening collaboration between universities, vocational institutes, and industry. Industry stakeholders (airlines, airports, ANSPs, manufacturers) can provide crucial input on which emerging skills are most needed, allowing academia to update program content proactively. In turn, academic researchers can help anticipate future trends through studies, scenario analyses, and advising industry on preparing for these changes – a symbiotic relationship.

The AVIONIC project exemplifies this cooperative approach: it has brought together universities and aviation companies to jointly forecast future occupations and skills in air transport and to design responsive curricula [68]. Through surveys and expert consultations, AVIONIC identified digital and green skill requirements and is developing “smart” learning modules to address them, including modular courses that can be integrated into both higher education and continuous professional training.

Recommendations for Addressing Skills Gaps

To effectively close the skills gaps within the aviation industry and address the projected workforce demand, the following targeted actions should be implemented:

- targeted training and development programs;
- upskilling for future technologies;
- focus on sustainability and green skills;
- strengthening leadership and strategic skills;
- building collaborative industry-education partnerships;
- implementing succession planning and talent retention strategies.

To bridge the skills gaps, organizations should implement specialized training programs focusing on high-demand areas such as information technology, Big Data analytics, and sustainability practices. Partnerships with educational institutions and online learning platforms can facilitate continuous learning and skill upgrades for existing employees. Developing modular training courses will allow aviation professionals to stay up-to-date with rapidly evolving technologies.

As emerging technologies such as augmented reality (AR), virtual reality (VR), and smart building innovations become more relevant, companies should begin preparing their workforce for these technologies. This can be achieved through the introduction of pilot programs and innovation hubs, where employees can experiment with and learn how to apply these technologies in real-world aviation scenarios.

Although green competences are currently rated as less critical, this may change as the industry faces increasing regulatory pressure and evolving global environmental standards. Companies should explore ways to integrate green technologies and practices into their operations and encourage employees to gain expertise in areas such as renewable energy and environmentally friendly technologies. Developing specialized green skills training programs will ensure the workforce is prepared for future regulatory changes and environmental challenges.

To address the shortage of skills in new management approaches and strategic leadership, leadership development programs must be implemented. These programs should equip current and future leaders with the necessary skills to manage technological transformation and handle complex operational environments. By combining technical and soft skills development, such as decision-making, critical thinking, and emotional intelligence, leadership programs will create a more adaptable and effective leadership pipeline.

Closing the skill gaps will require stronger collaboration between the air transport sector and educational institutions. Developing structured programmes such

as apprenticeships and industry-integrated placements will help ensure that graduates enter the workforce equipped with the competencies needed to address current shortages. In addition, regular dialogue between industry stakeholders and academic providers can help keep curricula aligned with evolving technological trends and labour market demands.

To address both current and future personnel shortages, companies must implement robust succession planning strategies. Identifying and nurturing high-potential employees for leadership and specialized technical roles will ensure continuity in key areas. Furthermore, offering competitive career development opportunities, mentorship programs, and flexible work arrangements can help retain valuable talent in an increasingly competitive labour market.

By establishing a framework to anticipate labour market shifts, the AVIONIC project supports upskilling and reskilling initiatives so that current employees can adapt to new technologies and processes rather than being left behind. Notably, it also emphasises the recognition of prior learning – valuing the experience of mid-career professionals and providing pathways for them to obtain credit or qualifications for skills gained informally on the job.

This approach can help accelerate the filling of roles; for example, an experienced military avionics engineer might transition into a civil drone maintenance role more easily if their prior competencies are formally recognized and only the gaps are addressed through short courses.

5.8 Workforce Demand Forecasts (5–10 Years)

Looking ahead, the global aviation sector is expected to grow steadily, driven by increased passenger demand, innovations in urban air mobility, and recovery from pandemic-related disruptions. In 2023 forecasts by CAE predict a global demand for over 252,000 new pilots and 328,000 aircraft maintenance technicians in commercial aviation by 2032 [60].

Additionally, CAE's 2025 Aviation Talent Forecast indicates that the aviation industry will need 1,465,000 new professionals over the next decade, including 300,000 pilots and 416,000 aircraft maintenance technicians, due to fleet expansion, rising travel demand, and high retirement rates [72]. These figures highlight the significant demand for aviation professionals in the coming years, emphasizing the need for targeted training and development programs to address potential skill gaps.

Emerging markets in Asia and Africa, along with ongoing expansion in Europe and the Middle East, will contribute to a dynamic and increasingly complex employment landscape. However, while demand is rising, the availability of skilled

personnel is not keeping pace. This disconnect is already evident in recruitment challenges, especially in specialised fields such as AI systems management, regulatory compliance, and sustainability auditing.

To meet this demand, aviation stakeholders must invest in education and workforce development strategies that are agile, future-oriented, and closely aligned with labour market realities. This includes integrating microcredential pathways, enabling modular learning systems, recognising prior learning, and fostering stronger cooperation between Higher Education Institutions (HEIs), Vocational Education and Training (VET) providers, and industry actors. By aligning qualifications with the skills needed for emerging roles, the sector can address current and future skill shortages effectively.

The skills shortages in air transport have become a critical issue, particularly in the post-pandemic landscape. This shortage spans various operational roles, including pilots, maintenance technicians, and air traffic controllers, significantly impacting the industry's ability to maintain service levels, adopt digital technologies, and drive sustainability initiatives.

Factors contributing to the shortage of skills include an ageing workforce and limited interest among younger generations. One major challenge is the demographic shift, as a significant share of experienced aviation professionals approach retirement. The pace at which younger workers are entering the field has not kept up, resulting in growing pressure on talent pipelines. Training new personnel, especially for highly specialised roles such as aircraft maintenance and piloting, also demands substantial time and investment [53,68,73].

A recurring challenge is the aviation sector’s ability to attract young talent. Fields like maintenance, repair, and operations (MRO) are experiencing a significant gap between demand and supply due to a lack of interest from younger people. Surveys show that younger generations tend to view aviation as a high-stress and costly field in terms of training, which discourages them from pursuing careers in the sector [74,75].

Moreover, the rapid adoption of digital technologies and sustainable solutions further complicates the situation. Aviation companies are looking for workers with digital skills and expertise in automation, artificial intelligence (AI), and green technologies. However, there are few professionals with the specialised skills needed to implement these new technologies, leading to delays in innovation [74].

Organizations within the air transport sector face ongoing challenges in both recruiting and retaining skilled workers. These difficulties span across various

operational roles and have a significant impact on core business activities, sustainability efforts, and the adoption of digital technologies. A report by the European Commission investigating recruitment and retention strategies in SMEs reveals that 52% of these organizations find it "very difficult" to hire workers with the right skills, while 26% describe it as "moderately difficult" [62].

Our surveys with managers, employees and educators in the air transport sector focused on identifying current skill structures, any existing shortages, and expectations for future roles and skill requirements. The objective was to gather insights on which roles within their organizations might face shortages and what new skills might be needed in the coming years.

In summary, the aviation sector faces a growing demand for skilled professionals in both traditional and emerging roles. However, the sector is struggling to meet this demand due to training delays, skill shortages, and the increasing complexity of new technologies and regulatory requirements. The key to bridging this gap lies in innovative education and training programs, collaboration between industry and academia, and a shift towards flexible learning pathways, such as micro-credentials and modular learning. By proactively addressing the skills gap, the aviation industry can prepare its workforce for the challenges of the next decade and beyond.

The next 5–10 years will see robust growth in aviation employment worldwide, accompanied by significant challenges in ensuring a skilled workforce. Both globally and in Europe, there is a clear need for tens of thousands of new pilots, technicians, and other specialists, far beyond the current training output [61,64] . The skills gap manifests not only in quantity but in quality: new competencies related to digital innovation and sustainability are rapidly becoming indispensable, yet the labour supply has not kept pace with these evolving demands. To bridge this gap, the aviation sector must modernize education and training ecosystems. This involves updating qualifications and curricula to reflect emerging technologies, fostering closer industry-academia cooperation, and leveraging tools like micro-credentials and sectoral frameworks to deliver training in a flexible, targeted manner.

Encouragingly, policy and industry responses are underway, from global initiatives by ICAO’s Next Generation of Aviation Professionals [76] to attract and train young talent, to European efforts under the European Skills Agenda and projects like AVIONIC to future-proof aviation skills. The workforce demand forecast thus serves as both a warning and a roadmap: without intervention, skill shortages could hinder aviation’s growth and sustainability goals; but with proactive upskilling, reformed qualifications, and strategic workforce planning, the industry can cultivate the human capital needed to thrive in the coming decade [59,64].

The challenge for aviation stakeholders (regulators, educational institutions, and companies alike) is to ensure that the next generation of aviation professionals is ready in time, equipped not only with the foundational knowledge of their predecessors, but also with the digital acumen and environmental awareness that twenty-first century aviation demands.

Investing in people**,** through agile learning pathways and international standards for skills recognition, will be pivotal in closing the gap between labour market needs and workforce capabilities, thereby securing a safe, innovative, and sustainable future for aviation.

6 New Occupations in Aviation

Aligned with the overarching goal of the AVIONIC Project, our objective is to enhance the quality and relevance of skills and knowledge for the next generation of air transport professionals. This will be achieved by designing, refining, and implementing interdisciplinary study programs across Europe that address the evolving needs of the air transport labour market, particularly focusing on digitalization, sustainable development, and societal responsibility.

This section compiles and summarizes the occupations identified through survey data, highlighting new roles and qualifications emerging because of digitalization and sustainable development in air transport. In addition, we also mention existing occupations that are expected to evolve or transform in response to future changes.

Drawing from both literature and survey data, we have identified a variety of new occupations that span across different areas of the sector. The diverse backgrounds of the survey participants have allowed us to collect a broad range of occupations of great interest. These emerging roles have been categorized into key areas within the industry, such as intermodal transport, ICT-related occupations, green energy, new management approaches, and societal responsibility.

Additionally, we will discuss occupations that are likely to undergo significant changes or potentially disappear as a result of ongoing developments. Many of these new roles are not only the product of sector-specific transformations but also reflect broader structural shifts in the global nature of work such as automation, demographic change, and the green transition. These dynamics are also giving rise to entirely new professional profiles that did not previously exist [77].

Key examples include:

- Digital Twin Engineers- responsible for building and maintaining real-time virtual models of aircraft and airport systems to optimise performance and maintenance;
- Cybersecurity Analysts for Aviation Systems- protecting interconnected digital systems such as aircraft avionics, reservation platforms, and airport control systems;
- Remote Tower Operators and U-Space Coordinators- managing drone traffic and unmanned air vehicles through real-time data and AI-supported platforms;
- SAF Infrastructure Specialists- supporting the deployment and regulation of sustainable aviation fuel systems;

- Green Compliance Officers:- monitoring environmental regulations, emissions, and sustainability initiatives across airline and airport operations;
- Smart Airport Technicians- handling the integration of Internet of Things (IoT), biometric systems, and AI-based automation in airport facilities.

These occupations are not just hypothetical, they are already taking shape, with employers seeking professionals who can operate at the intersection of aviation, digital innovation, and sustainability. Platforms such as AviationCV, JobsInAviation, and ICAO GAT show growing interest and opportunities in these hybrid roles, yet education systems remain underprepared to deliver the necessary qualifications.

There is a clear and urgent need to map these occupations, define their learning outcomes, and integrate them into formal and non-formal training pathways, including the use of microcredentials and modular learning models.

In the following paragraphs, we explore the new occupations that are expected to emerge over the next 10 years in intermodal transport, green energy, informatics and communication systems, new management approaches, and marketing, based on the insights provided by directors and employees in the air transport sector.

Table 1 provides a detailed look into the perspectives of directors on new and emerging occupations that are either currently being developed or anticipated within the next decade. These occupations are divided into six categories: intermodal transport, green energy, informatics and communication systems, new management approaches, marketing, and others.

In the Intermodal Transport category, roles such as AAM propulsion system developers and remote pilots reflect the sector's growing emphasis on advanced air mobility. The need for experts in optimising passenger flow, cargo handling, and capacity management is essential as transportation systems integrate traditional aircraft with new technologies like unmanned aerial vehicles and air taxis.

The Green Energy sector highlights the increasing relevance of sustainability. Occupations such as green energy engineers, specialists in hydrogen system maintenance, and sun panel experts indicate a shift towards renewable energy solutions. The role of a Director of Sustainable Aviation further underscores the need for leadership to drive sustainable practices in aviation and airport operations, aligning with the sector’s commitment to reducing carbon emissions.

Table 1 Directors' opinions on how new occupations which their organisations have or they envisaged to have in some groups of occupations in the next 10 years

Area	Occupations
Intermodal transport	• AAM propulsion system developer. • Remote pilot. • Cargo dispatcher. • Safety and security specialist. • Optimization researcher. • Experts in passenger flow optimization, ground handling optimization, cabin and gate capacity optimization, air and airport capacity.
Green energy	• Current gas turbine development profiles. • Green energy engineer. • Maintenance of hydrogen system and new equipment for renewable energy. • Director of Sustainable Aviation. • Lead airport operations manager. • Sun panels expert.
Informatic and communications systems	• AI engineers. • Data analyst. • Developers and integrators of blockchain and virtual technology OiT. • Secure Communications Supervisor
New management approaches	• Mindful and servant management. • Experts on flight procedure design, RNP APCH down to LPV (including at non-instrument runways and heliports/vertiports). • Managers for implementation of ACDM. • CDAs and space optimization specialist.
Marketing	• E-marketing experts
Others	• International relations and education experts

In the Informatics and Communication Systems sector, the rise of AI engineers, blockchain and virtual technology integrators, and data analysts signifies the growing reliance on digital technologies for operational efficiency, security, and communication. Roles like Secure Communications Supervisor highlight the critical need to address cybersecurity challenges, ensuring that the air transport industry maintains secure and efficient information systems.

The category of New Management Approaches also points to a shift towards innovative and human-centred management practices. Directors identified roles such

as mindful and servant management experts, and specialists in flight procedure design and space optimisation, reflecting the sector's focus on operational and procedural efficiency. Airport Collaborative Decision Making (ACDM) systems managers are crucial in fostering collaboration between airport stakeholders to improve decision-making and efficiency.

In Marketing, the inclusion of e-marketing experts shows that the industry acknowledges the importance of digital marketing, especially in an increasingly competitive environment. These specialised roles are necessary to promote aviation services and products effectively.

Lastly, in the Others category, roles such as international relations and education experts point to the recognition of the need for global collaboration and the continuous development of educational programmes, ensuring that the workforce remains adaptable in response to evolving challenges within the sector.

In summary, Table 1 illustrates a clear focus on digitalisation, sustainability, and innovative management practices in the air transport industry. The new and emerging occupations listed highlight the sector's preparation for future challenges, particularly in areas such as advanced mobility, green energy, digital technologies, and management optimisation.

As the air transport sector responds to the evolving labour market, technological advancements, environmental protection concerns, and ICT developments, organisations are constantly redefining and creating roles. Directors have identified several key occupations that they expect to emerge within the next five and ten years, as depicted in figure 6.1.

A notable finding is the prominence of green issues and environmental protection, with 84% of directors expecting the creation of new roles in this area within the next five years, while 16% anticipate these roles to emerge over the next decade. This highlights the sector's short-term focus on sustainability initiatives, reflecting a pressing need for expertise in managing environmental concerns.

Technological progress in air transport is another crucial area where new occupations are expected to emerge. Over 67% of directors believe new roles related to technological advancements will be needed in the next five years, with 33% anticipating these occupations will be established within the next ten years. This reflects the rapid pace of technological innovation and the need for specialized roles to support and manage these advancements in the industry.

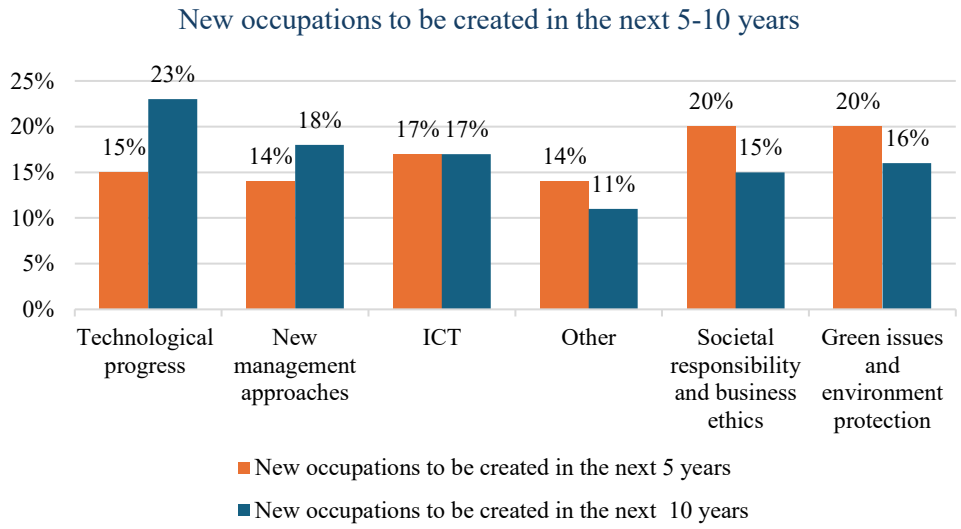

Fig. 6.1 Perspective of directors on the new occupations to be created in their organizations in the next 5 to 10 years

Technological progress in the air transport industry is a key driver of future job creation, with 67% of directors expecting the need for roles related to technological advancements to emerge within the next five years, and 33% anticipating these roles to materialise over the next decade. This highlights the swift pace of innovation in the sector and the immediate need for specialised roles to support and manage these technological developments. Additionally, it points to a sustained, long-term demand for expertise in this area as technology continues to evolve.

Societal responsibility and business ethics are also gaining significant attention, with 76% of directors identifying it as a priority area for new occupations within the next five years, and 24% anticipating these roles to emerge over the next decade. This shift underscores the growing emphasis on ethical practices and societal impact in shaping the future workforce, as organizations increasingly strive to meet broader social expectations and align their operations with responsible business practices.

New management approaches and ICT are viewed as critical areas for future job creation, with 72% of directors expecting new positions in these fields to emerge within the next five years, and 28% anticipating these roles within the next decade. This reflects the growing need for organisations to adapt to shifts in management practices, likely spurred by digital transformation. The demand for more agile, technology-driven leadership and enhanced communication strategies is becoming

essential as businesses navigate an increasingly complex and connected global landscape.

Lastly, the "Others" category also shows significant relevance, with 75% of directors predicting the need for new roles in areas not explicitly covered by the main categories within the next five years, and 25% expecting these roles to emerge over the next decade. This suggests that there may be additional emerging trends or niche roles that will shape the future workforce, but these roles have not yet been fully defined. This indicates a readiness to adapt to unforeseen developments in the industry.

In summary, figure 6.1 highlights the key areas for future job creation in the air transport sector as identified by directors. The data shows a strong focus on sustainability, with 84% of directors expecting new roles related to environmental protection and green issues to emerge within the next five years. Technological progress is also a crucial area, with 67% of directors anticipating the creation of roles in this field in the same timeframe. Additionally, societal responsibility, business ethics, new management approaches, and ICT are expected to drive job growth, with most roles projected to be established within the next five years. The "Others" category indicates potential for additional, yet undefined roles, reflecting the sector's adaptability to unforeseen trends and developments.

As new energy sources for aviation become more prominent, several roles will emerge. For example, systems engineers will need to develop competences to design, produce, certify, operate, and maintain various types of aircraft. Airports will need technical experts, engineers and managers specialised in new energy sources to supply new fuels for the aircraft of the future. Electric and hydrogen aircraft challenge airport infrastructure, design, safety and operation, and this requires new skills and competencies in areas such as new electric and hydrogen aviation. Airport master plans must take hydrogen and other "new" fuels into account, and these issues cannot be postponed, as hydrogen aircraft, could be in service for more than a decade over a 25-year planning horizon.

From the employees' perspective, the anticipated new occupations are like those identified by directors. Figure 6.2 shows that Big Data Analysts are expected by 43% of employees to be a key emerging role. This reflects the growing importance of data analytics in decision-making, optimising operations, and driving innovation in the sector. With the increasing volume of data generated, the demand for specialists to analyse and extract insights is critical.

Artificial Intelligence (AI) experts are expected by 16% of respondents to become an important new occupation. This points to the increasing role of AI in automating processes, improving operational efficiency, and enabling more

advanced, data-driven solutions. AI is set to transform various aspects of the aviation sector, from customer service to operational management, and the demand for AI professionals reflects this trend.

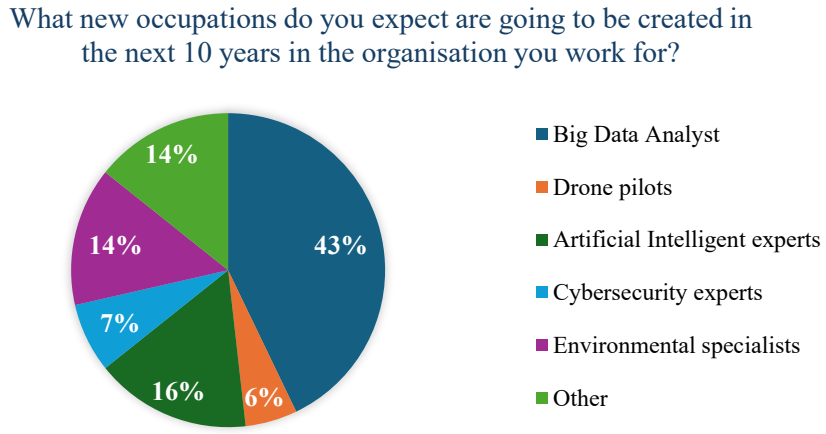

Fig. 6.2 Occupations expected to be created in the next 10 years, identified by employees

Drone Pilots, expected by 6% of respondents, represent another emerging role, driven by the growing adoption of unmanned aerial vehicles (UAVs) in logistics, security, and monitoring. As air transport integrates more drone technology into its operations, the need for trained professionals to manage and operate these drones will rise, especially in areas like cargo delivery and air traffic management.

Cybersecurity Experts (7%) are also expected to play a significant role in the future workforce. As the aviation sector becomes increasingly reliant on digital systems and data, ensuring the security of these systems is critical. The rise in cyber threats means that cybersecurity will remain a top priority, and organizations will need skilled professionals to safeguard sensitive data and protect against breaches. Alongside data analysts, employees also agree that specialised *cybersecurity positions* (7%), skilled in protecting systems, databases and technology programmes, should be carried out. Today, cyber-attacks can lead to the destruction and modification of confidential company information.

Environmental Specialists are another key emerging role, with 14% of respondents identifying it as a likely future occupation. This reflects the growing focus on sustainability and the need for expertise in environmental protection within the aviation sector. As industry grapples with reducing its environmental footprint, roles that focus on managing emissions, implementing green technologies, and ensuring compliance with environmental regulations will be increasingly necessary. Environmental management and so-called green technologies are of great interest with 14%.

Lastly, 14% of respondents expect the creation of occupations categorized as **Other**, indicating that there may be additional emerging roles that have not yet been fully defined but are recognized as important for the future of the industry. In this category a group of occupations associated with the *supervision of digital equipmen*t such as computers, robots or control centres were included.

In summary, chart 6-2 underscores the expectation that data analytics, AI, cybersecurity, drone operation, and environmental management will be central to the air transport industry's future workforce needs. These occupations reflect the industry's focus on digital transformation, sustainability, and security as it adapts to new challenges and opportunities over the next decade.

Our findings seem to in line with OECD's forecast projected that within the next 15 to 20 years, new automation technologies are expected to eliminate 14% of existing jobs globally and radically transform another 32% [78]. This prediction highlights the profound impact that automation, particularly artificial intelligence and robotics, could have on the global workforce. Many of these transformations will involve significant changes to job roles, with some disappearing altogether, while others will evolve to incorporate new technological tasks and requirements. These shifts are expected to affect over a billion people worldwide.

6.1 New Occupations Driven by ICT

Technological progress in air transport is another major factor that impacts new occupations. From the perspective of educators. Educators' opinion on new occupations regarding technological progress is presented in figure 6.3. These projections reflect the increasing influence of technology in reshaping the industry, with a notable focus on cybersecurity, artificial intelligence (AI), and Internet of Things (IoT) roles.

In the short term, educators foresee that the most prominent new role will be IoT professionals, representing 29% of projected occupations. This is driven by the aviation sector's increasing adoption of IoT technologies to enhance predictive maintenance, real-time data tracking, and efficient resource management across airlines and airports [79]. Cybersecurity experts account for 18%, underscoring the critical need to protect aviation's digital infrastructure as it integrates more connected technologies.

Similarly, AI professionals make up 17% of projected occupations, reflecting the growing reliance on AI to improve flight scheduling, customer experience, and operational efficiency [80]. AI will replace many of the activities previously performed by people, meaning that IA is largely primarily responsible for automating

processes and activities. Thus, respondents consider that the position of IA specialists should be needed in the short term.

Green technologies engineers (12%) indicate the rising importance of sustainable solutions within industry as airlines adopt cleaner and more energy-efficient technologies. The small representation of automation engineers (6%) highlights the emerging role of robotics and automation in areas like baggage handling and airport security.

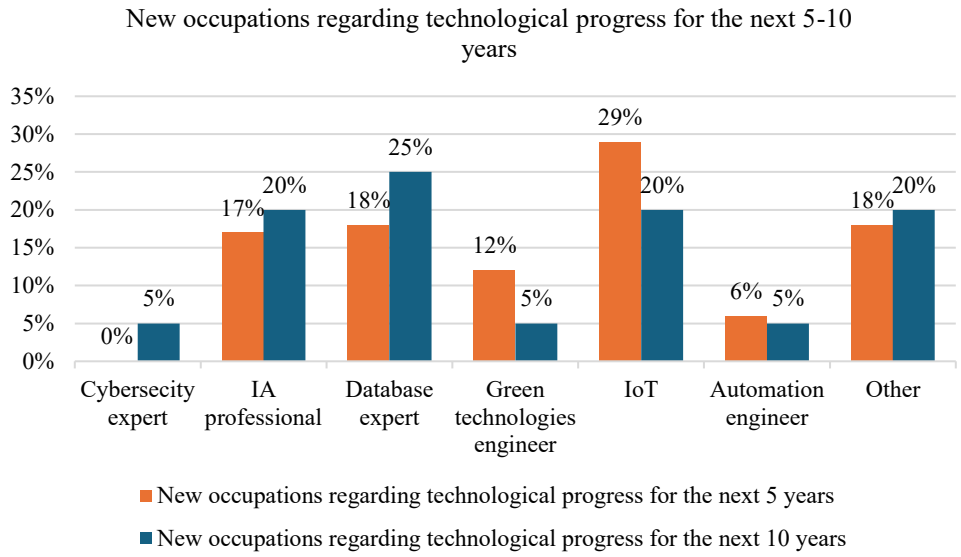

Fig. 6.3 Educators' perspective on new occupations involving technological progress in the next 5 to 10 years

When asked about *other occupations* that have the possibility of emerging but are not associated with the previous approaches. The list of answers obtained refers to the following occupations was Airport technical consultant, Experts in reducing energy consumption at consumers' level, UX manager, UI designer, CR manager.

Looking further ahead, database experts are expected to account for 25% of new occupations in 10 years, reflecting the growing importance of managing and analysing large volumes of data to improve decision-making and operational efficiency. Cybersecurity experts and AI professionals remain critical, both representing 20% of future roles, as the industry continues to secure and optimize its increasingly digital infrastructure [81].

Interestingly, IoT professionals drop to 5%, likely indicating that these roles may become more integrated or automated as technology matures. Similarly,

automation engineers and green technologies engineers also remain low at 5%, suggesting that while important, these roles may evolve into more hybrid positions that incorporate multiple technological competencies [79].

In short, figure 6.3 highlights the aviation sector's reliance on new technologies and the subsequent demand for professionals skilled in cybersecurity, AI, IoT, and data management. As the industry embraces digital transformation and sustainability initiatives, educators predict that these occupations will become vital in driving progress, improving safety, efficiency, and environmental performance across the sector.

Future occupations that will lead the air transport in 5 - and 10-years concerning ICT and sustainable development are presented in figure 6.4. The analysis highlights several key roles, with a particular focus on Big Data Analysts and Collectors, Artificial Intelligence (AI) specialists, and Cybersecurity Supervisors.

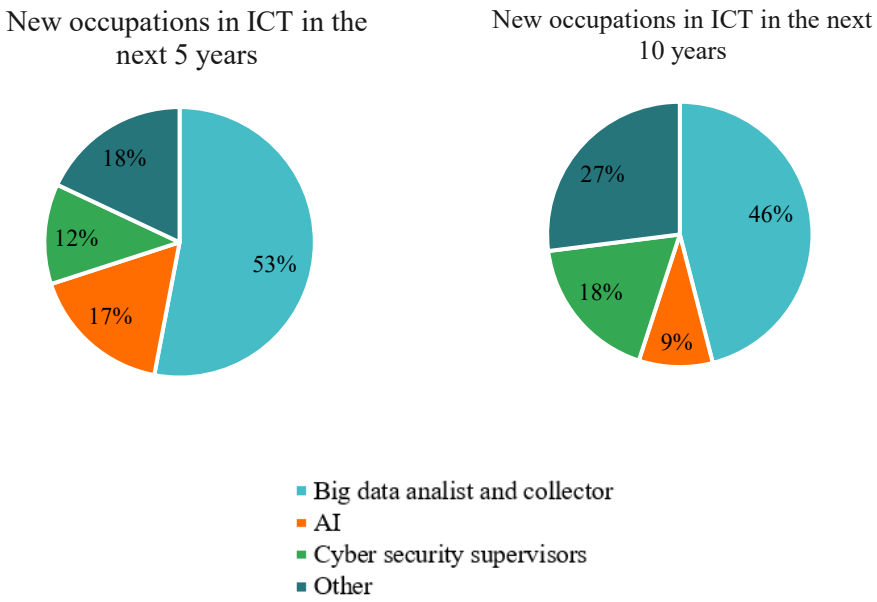

Fig. 6.4 New occupations in ICT to be created in the next 5 to 10 years

In the next 5 years, the demand for big data analysts and collectors is expected to dominate, accounting for 53% of new ICT roles. This is aligned with broader industry trends, where the analysis of large datasets is becoming central to decision-making in aviation, particularly for improving operations and enhancing customer

experiences. Data science continues to grow rapidly, driven by the need for insights derived from increasingly complex and large datasets [82].

AI specialists are projected to make up 17% of new roles within this timeframe. AI is expected to be adopted by nearly 75% of companies globally, as AI technologies continue to reshape functions such as predictive maintenance, flight optimisation, and customer service automation [83]. However, while AI plays a critical role, its growth in this period is slightly slower than data analytics.

Cybersecurity Supervisors, accounting for 12%, highlight the industry's ongoing focus on securing digital infrastructures. As aviation adopts more advanced digital solutions, including automation and AI, protecting systems from cyber threats is becoming more crucial, especially in the wake of increasing cyber-attacks globally [30].

Over the next decade, the demand for professionals specialising in data analytics within aviation is expected to remain strong, driven by the sector's ongoing pursuit of operational efficiency and predictive decision-making. The global market for big data in flight operations is projected to grow from USD 4.9 billion in 2024 to USD 15.9 billion by 2037 [84], while aviation analytics more broadly is forecast to expand at a compound annual growth rate of approximately 10% through 2030 [85]. These projections underscore the central role that data-driven strategies will play in addressing both operational performance and sustainability challenges.

In parallel, the growing digitalisation of aviation systems has intensified the focus on cybersecurity. As information and communication technologies (ICT) become more deeply embedded in aircraft and airport operations, the need for cyber-resilience has become increasingly critical. Recent reviews highlight the growing sophistication of cyber threats and the corresponding rise in demand for cybersecurity supervisors to protect aviation’s digital infrastructure [86]. This trend reflects a structural shift in workforce requirements, with cybersecurity roles poised to gain greater strategic importance across the aviation industry.

Interestingly, the role of AI specialists is projected to decline to 9%. This could be due to the increasing integration of AI into automated systems, requiring less direct human oversight, or perhaps due to the maturity of AI systems that will require fewer dedicated AI professionals by 2033. Meanwhile, the *Other* category grows to 27%, likely signalling the emergence of unforeseen roles tied to future technological advances such as quantum computing or blockchain applications in aviation [82].

The projected growth in these roles reflects the broader trends in technology adoption within aviation, particularly the critical importance of data management,

cybersecurity, and AI. As the industry continues to digitalise and prioritise sustainability, new ICT roles will be essential in supporting the transformation. To address this demand, investments in training and education for these emerging technologies are crucial, particularly in fostering the necessary skills for the future aviation workforce.

One major factor that will impact the dynamic of occupations in the next 10 years is digitalization. Figure 6.5, highlights the importance of digitalisation in shaping new occupations in the air transport industry, based on responses from company directors. The respondents were asked to rate the impact of digitalisation on future occupational profiles, with 42% indicating a "high" impact and 37% marking it as "very high". This indicates that a vast majority (79%) of directors believe digitalisation will play a critical role in defining the future of work within their organisations over the next decade.

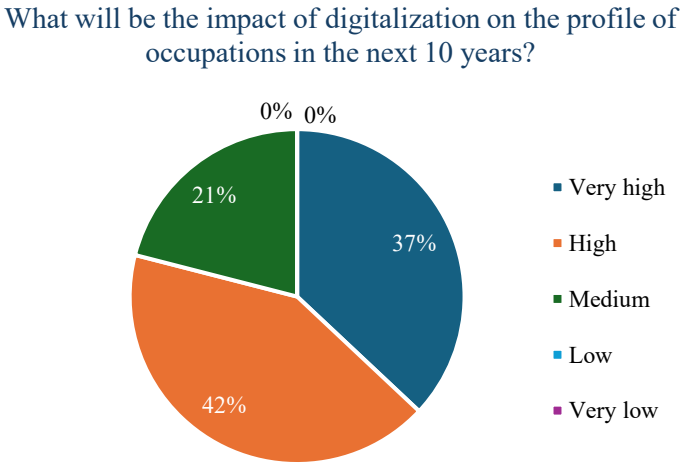

Fig. 6.5 The director's perspective on the impact of digitalization on the profile of occupations in the next 10 years

This trend reflects broader industry transformations, where digital technologies such as big data analytics, automation, and AI are reshaping traditional roles across aviation [87]. For example, digitalisation is streamlining flight operations, improving aircraft maintenance through predictive analytics, and enhancing passenger experiences via automation and IoT applications. Many aviation companies are investing heavily in cloud computing, data centres, and digital customer service tools to meet post-pandemic demands, allowing operations to become more flexible and cost-efficient [88].

The need for digital skills, including cybersecurity, AI integration, and data management, is growing rapidly. As airlines and aerospace manufacturers continue to adopt digital twins and automation, the workforce will need to adapt by developing the technical skills necessary to manage, interpret, and secure these advanced technologies [89]. Additionally, cybersecurity remains a critical concern as digital systems become more interconnected, highlighting the necessity for trained professionals to safeguard aviation infrastructures from cyber threats [87].

These findings align with industry-wide trends that underscore the urgency of digital transformation in aviation. Companies that successfully integrate digital tools are better equipped to streamline their operations, optimise resources, and remain competitive in an increasingly digital world.

As technology continues to evolve, many occupations in the aviation industry are undergoing significant transformation, while some may even become obsolete by 2030. The responses gathered from aviation directors in Table 2 reflect their perspectives on which roles will experience drastic changes or disappear entirely due to advancements in digitalisation, automation, and sustainable technologies.

Table 2 Occupations that are going to drastically change or disappear by 2030 (Directors' opinion)

Changing	Disappear
• Energy and maintenance engineer: thermal, solar • Electric engineer/ Alternative vehicle developers • Aviation Data Analyst • Electric Aircraft Technician • ATC • Pilot • SMS specialist • Customer service desk.	• Cashier • On-board co-pilot • Security control • Ground handling drivers. • Companies counter for checking • Manual data input occupations.

Occupations such as energy and maintenance engineers (with a focus on thermal and solar technologies), electric aircraft technicians, and aviation data analysts are anticipated to evolve significantly in response to technological innovation and sustainability imperatives. Conversely, roles like cashiers, security control personnel, and manual data input jobs are likely to vanish, largely due to automation, digitalisation, and changing operational models within the industry. This shift reflects a broader reconfiguration of the aviation workforce, with emerging technologies both displacing traditional roles and creating demand for new skillsets.

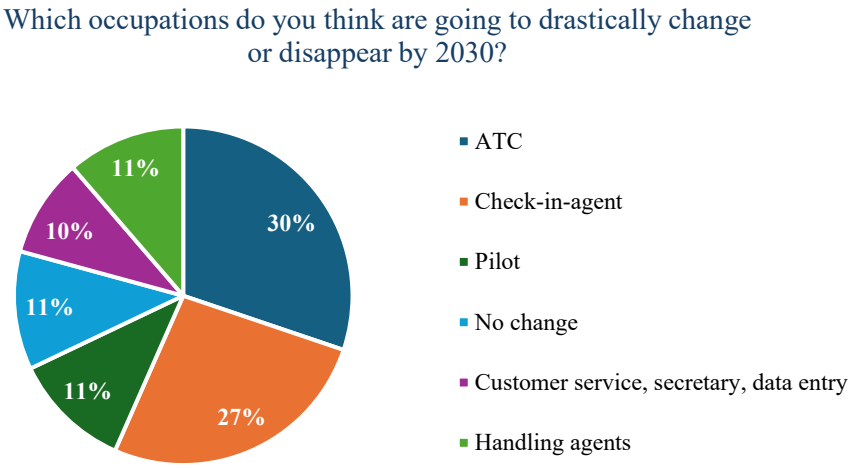

Fig. 6.6 Occupations that are going to drastically change or disappear by 2030 (employees' perspective)

Figure 6.6 reflects the employees' perspectives on occupations they believe will drastically change or disappear by 2030, aligning with Table 2, which showcases the directors' opinions on this issue. Both groups highlight roles in air traffic control (ATC), piloting, and customer service as vulnerable to significant changes due to digitalisation and automation.

Changing Occupations

Air Traffic Control (ATC): From both the employees' and directors' perspectives, ATC roles are projected to undergo substantial changes. With the introduction of AI and automation, ATC functions could become increasingly automated, improving efficiency but reducing the need for human controllers [87]. This evolution could reshape the nature of the ATC profession, reducing the demand for traditional skillsets while requiring a new focus on managing and supervising automated systems.

Pilot: Similar sentiments are echoed for pilots. As automation technology advances, including autonomous aircraft, there is potential for single-pilot operations or even fully autonomous flights in the future. Both employees and directors foresee that pilot roles will shift or even diminish significantly[87]. These advancements in autopilot systems and AI will likely redefine pilot responsibilities, focusing more on supervision rather than manual control.

Electric Engineer/ Alternative Vehicle Developers: The move towards sustainable aviation and electric vehicles will require engineers to develop and maintain advanced alternative energy systems. The transition from traditional fuel-

powered aircraft to electric and hydrogen-powered vehicles will create new opportunities but will also phase out certain skills related to fossil-fuel systems, as identified by directors.

Aviation Data Analyst: As big data and predictive analytics become integral to aviation operations, roles such as aviation data analysts will be transformed. While this role is not expected to disappear, directors foresee that its tasks will evolve with increased reliance on AI-driven insights, which may reduce the need for manual data analysis.

Occupations Expected to Disappear

Cashier and Customer Service Desk: Both employees and directors agree that occupations like cashiers and customer service roles are likely to become obsolete due to the widespread adoption of self-service kiosks, biometric check-ins, and mobile apps for customer interactions. The growing presence of automation in customer-facing services suggests these roles will no longer be necessary in the future [88].

On-Board Co-Pilot: As autonomous technology becomes more reliable, the role of the co-pilot may disappear entirely, with airlines increasingly exploring single-pilot or fully autonomous aircraft operations for commercial flights. Both groups expect this role to be heavily impacted.

Ground Handling Drivers: Ground handling roles, including baggage transport and aircraft towing, are expected to be replaced by autonomous vehicles and robotics. Automated ground handling systems are already being tested and will likely become widespread by 2030, reducing the need for human drivers.

Manual Data Input Occupations: With the aviation industry moving towards digital systems that automate data input and processing, jobs requiring manual data entry will likely disappear. Directors predict that this trend will accelerate as digital tools become more sophisticated and widely adopted.

Both employees and directors foresee those technological advancements, especially in AI, automation, and sustainability, will drive major changes across many traditional aviation occupations by 2030. While some roles, like pilots and ATC, will adapt and evolve, others such as customer service and manual data input may disappear altogether, reflecting the industry's ongoing digital transformation.

6.2 New Occupations Driven by Sustainability

Sustainable development drives innovation and creates opportunities for a diverse range of occupations within the air transport industry. From technical roles

focused on green technology to managerial positions emphasizing sustainability strategies, the shift towards eco-friendly aviation opens new avenues for job growth and specialization.

The shift towards sustainable development in the aviation sector is creating opportunities for a variety of new roles, particularly focused on environmental protection and the adoption of green technologies. Figure 6.7 highlights several key occupations identified by educators as crucial for the next 5 to 10 years, reflecting the broader industry trends towards decarbonisation and sustainable aviation practices.

In the shorter term (5 years), the role of Green Airport Manager is seen as the most likely to emerge, with 37% of responses highlighting its importance. This role will focus on integrating sustainable practices into airport operations, from energy use to waste management and emissions control. With airports being significant contributors to environmental impact, the introduction of dedicated managers to oversee green initiatives is a logical step towards achieving the industry's sustainability goals [83].

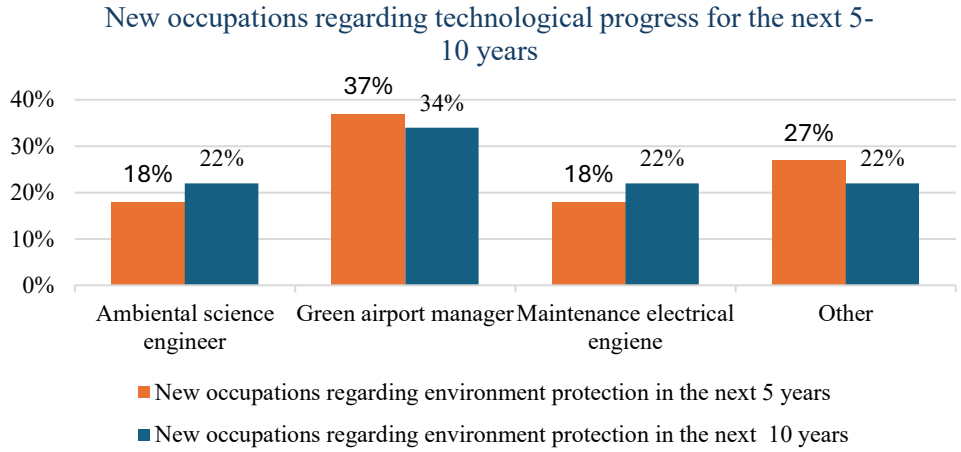

Fig. 6.7 Educators' perspective on new occupations in environment protection to be created in the next 5 to 10 years

Occupations such as Ambiental Science Engineer and Maintenance of Electrical Engines are also identified as critical, with 18% of responses each. As aviation shifts towards electric propulsion systems and cleaner energy sources, these technical roles will become vital for maintaining and advancing green technology adoption within the sector. Environmental science engineers will play a pivotal role in assessing and mitigating the environmental impacts of aviation operations, while electrical engine maintenance specialists will be essential in managing new fleets of electric aircraft.

Looking further ahead (10 years), the role of Green Airport Manager remains central but slightly diminishes in prominence to 34%, indicating that it will evolve as the position becomes more integrated into airport management practices. The roles of Ambiental Science Engineer and Maintenance Electrical Engines gain further importance, each representing 22% of expected future occupations. These roles will continue to drive the industry's focus on eco-friendly technology and sustainable aviation infrastructure, reflecting the industry's commitment to long-term environmental goals.

Moreover, 22% of responses in the "Other" category over both periods highlight additional emerging roles such as Environmental Supervisors, Air Traffic-Air Quality Moderators, Decontaminator and Environmental Researchers. These occupations will focus on monitoring and improving air quality, managing environmental compliance, and driving research into new sustainable aviation solutions, further supporting the industry's overall environmental objectives.

The aviation industry's commitment to sustainability is shaping the future job landscape, with new roles emerging to support green technologies and environmental protection efforts. As airports and airlines strive to meet stricter environmental regulations and embrace eco-friendly innovations, occupations like Green Airport Manager, Environmental Science Engineer, and Electric Engine Maintenance Specialists will be crucial. Over the next decade, these roles will continue to evolve and expand as the industry works towards its goal of reducing its carbon footprint and embracing sustainable aviation.

6.3 New Occupations Driven by Twin Transition

The concept of twin transitions, focusing on both green and digital developments, is integral to shaping the future of occupations in the aviation industry. According to the report *Towards a Green Digital Future* [90] by the European Commission, these twin transitions are expected to drive a variety of interdisciplinary roles that integrate expertise in aviation, ICT, and sustainability. This shift reflects the broader efforts within the EU to harness digital technologies to support environmental goals, such as reducing carbon emissions and increasing operational efficiency across industries.

In the aviation sector, the need for advanced digital and green skills is particularly pronounced. Roles like Specialist in Sustainable Aviation Policy, Climate Change Specialist, Air Quality Analyst, and Green Fuels Researcher are identified as emerging jobs essential for promoting eco-friendly aviation practices [91]. This reconfiguration of roles aligns with broader analyses of how twin transitions are

simultaneously reshaping labour markets across sectors, including aviation, demanding hybrid competences and agile training systems [77].

Moreover, positions such as Battery Technicians and Electric Aircraft Technicians are anticipated to support the shift towards electrification and sustainable energy systems in aviation, which aligns with the EU's green agenda [38]. With the growing push towards electrification and green energy in aviation, jobs involving the maintenance and development of electric and hydrogen-based aircraft systems will become more critical over the next decade.

The twin transition is not only about technical jobs but also encompasses management roles like Sustainable Airport Planners and Sustainable Aviation Engineers, whose responsibility will be to ensure that aviation infrastructure is designed and operated sustainably, leveraging digital tools for optimal performance and minimal environmental impact [91].

The digitalisation and the sustainability are a cross-sectorial action which suppose advanced skills and competences in aviation, ICT, and sustainability simultaneously. In this area the list of the new occupations seems to include *Specialist in environment, Sustainable Aviation Policy, Sustainable Aviation Engineer, Sustainable Airport Planner, Climate change specialist, Consumer energy analysts, Air Quality Analyst, Sustainable Aviation Educator, Green Fuels Researcher, Battery technicians, Solar flight specialists, Pilots for UAV, Drone Traffic Manager.*

Table 3 Interdisciplinary occupations: Aviation and ICT/ Marketing / Sustainable development

Categories of occupations	Groups	Occupations
Aviation and ICT	Big Data applied in aviation	Big Data Architect, Data Scientist, Data Analyst, Chief Data Officer, Data Protection Officer
	Cybersecurity	Auditor, Crisis Management Specialist, Expert intrusion tests, Head of the Information Systems Security, Secure communication supervisor
	Data Storytelling	Data Storyteller, Data Scientist, Business Analyst, Web Analyst
	Data Science	Chief Data Officer, Data Steward, Data Analyst, Data Scientist, Data-Miner, Developers and integrators of

Categories of occupations	Groups	Occupations
		blockchain and virtual technology, AI engineer
	Piloting	Remote pilot
	New management approaches	Expert in flight procedure design, managers for ACDM and APOC implementation
Aviation, ICT and Marketing	Search Engine Optimization (SEO)	SEO Manager, SEO Consultant, Content Manager, Traffic Manager
	E-CRM (Electronic Customer Relation Management)	CRM Responsible, Consultant, CRM Manager, Project Manager, Data Analyst
	E-reputation	E-reputation Manager, E-reputation Consultant, Advisor / Watchman in e-reputation, Community Manager, Content Manager
	User eXperience (UX) / User Interface (UI) design	Service Designer, UX Manager, UI Designer, UX Designer, Ergonomist Designer
Aviation and sustainable development	Sustainable aviation research	Sustainable experts. Green energy researchers, Climate Change Reversal Specialist, Green Fuels Researcher
	Circular economy management	Alternative energy engineer, circular economy manage
	Electrical engineers	Battery technician, Energy and maintenance engineers, electrical GSE engineers, Energy and maintenance engineer: thermal, solar; electric aircraft technician, engineer for maintenance hydrogen systems
	Sustainable aviation experts	Sustainable airport engineer, Airport environmental system manager, Sustainability consultant, green lead airport operation manager, environment al risk manager, Sustainable Aviation Policy, Air Quality Analyst, Solar flight

Categories of occupations	Groups	Occupations
		specialists, Director for sustainable aviation
	Biofuels	Chemistry engineer, Biology experts
Aviation, ICT and sustainable development	Airport operations optimization	Air traffic manager, chief operations officer, Sustainable Airport Planner. Consumer energy analysts, Optimization researcher or expert
	Alternative vehicle developer	Project Manager, Data Analyst, Designers of autonomous vehicles Safety officers for unmanned systems, Pilots for UAV
	Management of vertiports	Vertiport operation officer, CEO vertiports, Advanced ATC officers
	Maintenance of new IT equipment based on green energy	Technicians/ engineers for green energy equipment

Combining the literature, current studies and own data collections, we summarize the following list of interdisciplinary occupations, grouped in the following categories (see table 3) Aviation and ICT, Aviation, ICT and Marketing, Aviation and sustainable development and Aviation, ICT and sustainable development.

Overall, these trends show that green and digital transitions are not just a challenge but also an opportunity for the aviation industry to lead in sustainability while enhancing its competitiveness and resilience.

6.4 The Main Skills Demanded by New Occupations

The rapid evolution of industries and technologies has led to the emergence of new occupations that demand a diverse set of skills. These new roles often require higher levels of expertise and competencies, ranging from high-skilled non-manual occupations to skilled manual and elementary occupations, such as labourers. To better understand the skill demands of these emerging occupations, directors were

surveyed to provide their insights into the required skills and their levels across various types of occupations. The results, as presented in Table 4, outline the key skills necessary for these new roles and categorize them into technological, non-technological, and cross-sectorial skills.

As also noted in studies regarding instruments for career development in the air transport industry [77], future-ready occupations increasingly require integrated skill sets that combine technological fluency with systems thinking and sustainability awareness.

Table 4 Directors' opinions on skills level do these new occupations require

Technological skills	Non-technological skills	Cross sectorial skills
• Connectivity • IoT • Network • Interoperability • Security of data • Virtual and augmented reality • Solve problems • Innovation • Energy nonconventional sources • Green technologies	• Knowledge management • Sharing information • Teamwork and collaboration • Autonomy and responsibility • Initiatives and decision making • Creativity • Communication	• Project management • System Engineering • Quality of life at work (wellbeing) • Social networks

The technological skills identified include advanced capabilities in areas such as connectivity, Internet of Things (IoT), network infrastructure, interoperability, data security, virtual and augmented reality, problem-solving, and innovation. Additionally, there is a growing emphasis on green technologies and energy from non-conventional sources, reflecting the broader industry trend towards sustainability and eco-friendly practices. These technological skills are essential for workers to successfully adapt to and implement cutting-edge systems, products, and services.

Non-technological skills, while equally crucial, focus more on interpersonal and organizational abilities. Directors highlighted the importance of knowledge management, information sharing, teamwork, collaboration, autonomy, responsibility, creativity, communication, and the capacity for initiative and decision-

making. These competencies are foundational to navigating the complexities of modern workplaces, where collaboration and innovation are key drivers of success.

Lastly, cross-sectorial skills are indispensable for new occupations, as they promote the integration of knowledge and practices across different industries. These skills include project management, systems engineering, ensuring workplace wellbeing, and leveraging social networks. Given the interconnected nature of today's economy, professionals must be equipped to operate effectively in multiple sectors, making cross-sectorial skills critical for sustainable career growth.

The importance of green competences

Green competences, which refer to the skills and knowledge required to promote sustainability, have become highly valued in the current labour market. According to the employee questionnaire, the importance of these competences is expected to grow significantly in the future as industries place greater emphasis on sustainable development. These competences are pivotal in fostering a workforce capable of addressing environmental challenges while supporting the transition to a resource-efficient and eco-friendly economy.

Figure 6.8 highlights the evolving significance of green competences over time, as seen from the data comparing the past five years and the projected next ten years. Regarding the past five years, the chart shows that 69% of respondents believe the importance of green competences has increased in the last five years. Meanwhile, 30% indicated that the importance has remained the same, and only 1% reported a decrease in importance. This suggests a general trend toward recognizing the relevance of sustainability in various occupations, although a notable portion of respondents felt no significant change over this period.

For the next ten years, 87% of respondents expect the importance of green competences to increase in the next ten years. Only 11% believe that the importance will remain the same, and a small 2% foresee a decrease. This sharp projected rise reflects the growing urgency of sustainability concerns and the increasing integration of green practices across all sectors.

Overall, the data clearly indicates a strong and continuing upward trajectory in the perceived importance of green competences, which will likely shape the future workforce as industries adopt more sustainable practices.

At the core of green competences are several key components:

- green skills, which represent the ability to apply environmental knowledge and expertise to solve problems related to sustainable development;
- green competences (or sustainability competences), which are the demonstrated ability to use green knowledge, skills, and personal or

methodological abilities in professional and personal contexts to support sustainability;

- Green learning outcomes, which are the expected achievements of learners at the conclusion of a learning process, defined by their mastery of green knowledge, skills, and autonomy in fostering a resource-efficient society.

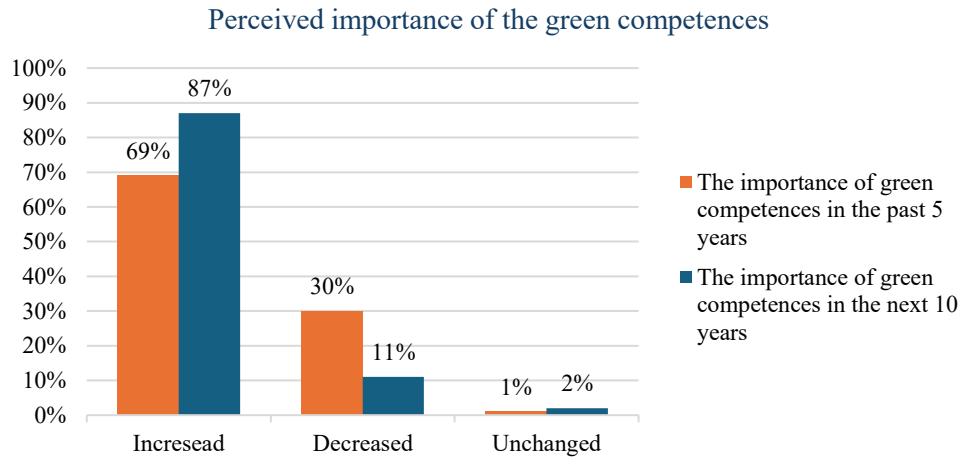

Fig. 6.8 The perceived importance of green competences in the past and future

From a technical perspective, green competences enable individuals to adapt or implement standards, processes, services, and technologies aimed at protecting ecosystems, conserving biodiversity, and reducing resource consumption. These technical skills may be specific to occupations or applicable across various sectors, further underscoring their relevance in today's labour market.

In addition, transversal skills related to green competences are essential for promoting sustainable thinking and behaviour. These skills are relevant across all economic sectors and occupations, encouraging workers to integrate sustainability into their everyday tasks and decisions. As digitalization and sustainability increasingly intersect, advanced skills in both domains are becoming essential for professionals, particularly in industries such as aviation, ICT, and sustainable development.

The growing importance of green competences is clearly reflected in figure 6.8, which depicts a strong upward trend in the recognition of their value over time. In the past five years, 69% of respondents reported an increase in the significance of green competences, while a staggering 87% anticipate further increases in the next 10 years. This data highlights the critical role that green competences will play in shaping the future workforce and driving the sustainable transformation of industries.

7 Education and Training for New Skills

The aviation sector is undergoing a profound transformation driven by digitalisation, automation, and environmental sustainability imperatives. These developments are reshaping the competencies required across the industry and prompting a re-evaluation of how education and training systems support workforce preparedness. This section explores the current state of education and training in aviation, identifies gaps and perceptions among stakeholders, and proposes future-oriented approaches to upskilling and reskilling.

In this section we discuss strategies for upskilling and reskilling, training models: microcredentials, modular learning and preferred delivery formats and educational innovation.

7.1 Strategies for Upskilling and Reskilling

The traditional structure of education and training in aviation combines formal qualifications, delivered primarily through higher education institutions (HEIs), with practical, on-the-job learning. This dual approach remains foundational, particularly in roles such as piloting, air traffic control, and aeronautical engineering, where both theoretical knowledge and technical proficiency are critical. Complementing this, vocational education and training and certification programmes support operational roles such as ground handling, customer service, and aircraft maintenance [51].

Statistics indicate a significant portion of the aviation workforce benefits from both formal education and on-the-job training. According to global data from IATA, approximately 40% of aviation employees receive their training through vocational programmes, while approximately 30-35% gain their qualifications through higher education, particularly in technical fields [51,75]. For example, the UK's Future Aviation Skills Strategy emphasises the growing importance of apprenticeships and practical training, as these helps meet the evolving technological and sustainability demands within the sector.

Airport operations particularly depend on continuous on-the-job training for roles such as ground operations, security, and customer service, which require real-time adaptation and learning. Real-time problem solving, compliance with dynamic regulatory standards, and frontline decision-making require up-to-date skills that often exceed what is provided in formal education. However, higher education remains significant for positions such as air traffic control and airport management, where formal qualifications are mandatory. Managerial and technical roles related to

airport environmental systems or digital transformation also demand a mix of higher education and continuous on-the-job learning to keep up with technological advancements and regulatory changes [75].

This blended approach ensures that aviation workers remain adaptable and are equipped with the skills necessary for an industry undergoing rapid digital and environmental transformation.

To assess the current effectiveness of training practices, this study surveyed aviation professionals regarding their induction experiences. As illustrated in figure 7-1, 66% of respondents considered their initial workplace training either extremely helpful or very helpful. However, a combined 34% rated it as only somewhat helpful or not helpful at all, raising concerns about the alignment between educational background and job-specific requirements. This underscores the need for closer coordination between education providers and employers to ensure training relevance and responsiveness.

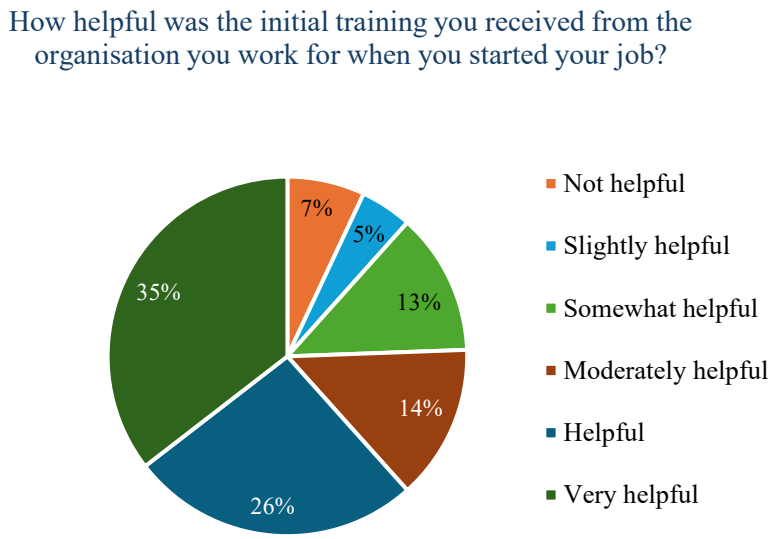

Fig. 7.1 Effectiveness of initial training received from employer upon job entry

In a related enquiry, respondents were asked whether their organisation collaborates with HEIs or other training institutions. As shown in figure 7.2, 62% confirmed such cooperation exists, while 18% stated it does not. A further 21% were unaware, suggesting limited visibility or communication regarding these partnerships.

Although there is mentioned a good collaboration between the education providers and companies, it is not always a mutually beneficial relationship, as 18%

of individuals state that the current education provided by the centres does not meet the requirements of the companies.

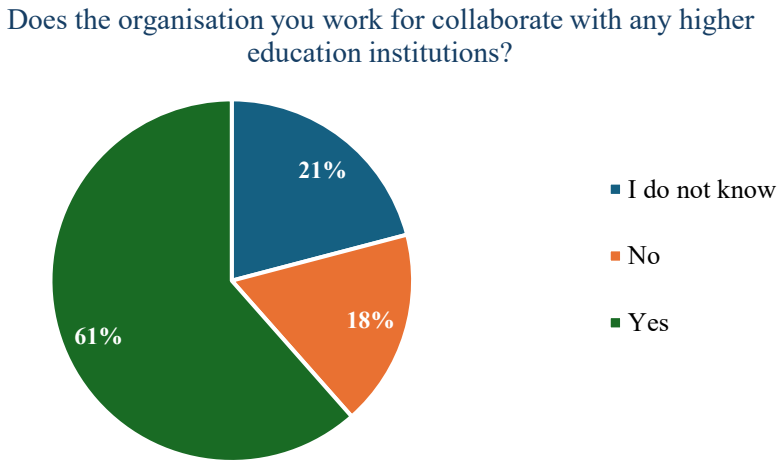

Fig. 7.2 Collaboration between companies with higher education institutions

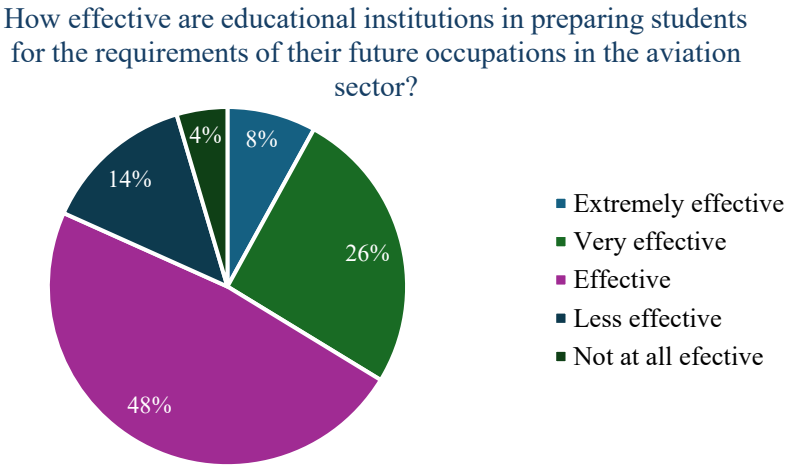

Fig. 7.3 Effectiveness of educational institutions in preparing students for the requirements of their future occupations in the aviation sector

Importantly, while collaboration between the education providers and companies is reportedly widespread, its perceived quality varies. Figure 7.3 shows that while 26% of respondents found educational institutions “very effective” and 48% “effective” in preparing graduates for aviation careers, 14% considered them “less effective” and 4% “not effective”, pointing to gaps in curricular relevance and adaptability.

The 8% of respondents rate the programs as extremely effective, reflecting the success of some specialised programs that have adapted well to current industry requirements, particularly in areas like technical skills and aviation management.

These insights align with broader industry reports. Reports by ICAO and ATHENA Research Centre emphasise the urgency of integrating sustainability, digitalisation, and systems thinking into aviation training. ICAO stresses the need for educational institutions to focus more on emerging trends like digitalisation and sustainability to meet the evolving demands of the aviation sector [29,76]. Similarly, the Twin Skills for the Twin Transition Report underlines the importance of integrating new curricula that address the sector's digital and green transformation [91].

While some institutions are adapting well, reflected by the 8% of respondents who rated their programmes as “extremely effective”, the general trend highlights a lag between evolving sector demands and the pace of educational reform.

7.2 Training Models

To bridge this gap, educational models must become more modular, flexible, and competency oriented. In this context, the rise of microcredentials offers a promising solution. These short, targeted learning units allow professionals to rapidly acquire new competencies in response to specific job requirements. They are particularly well suited to aviation’s evolving needs, where continuous upskilling in areas such as AI, cybersecurity, green innovation, and compliance is crucial.

The use of the European Credit Transfer and Accumulation System (ECTS) enables the integration of microcredentials and modular learning into formal higher education structures. This facilitates academic recognition and labour mobility across European countries, reinforcing alignment with EQF and ESCO frameworks.

Survey data further underscore the need for targeted training in emerging domains. Considering that HEIs should provide the education that the employees really need, we asked the employees about their education preferences in topic and in the way the education is given.

When asked about new training topics considered essential for their current occupations, respondents prioritised technical and transversal skills. Figure 7.4 shows that 36% of participants identified programming as the most critical skill, followed by management (17%) and digital competences (16%).

As 36% of respondents believe that training in programming is the most valuable or essential for their role, we interpret this to reflect the increasing

importance of coding and software development skills in modern industries, particularly as digitalization continues to impact various sectors.

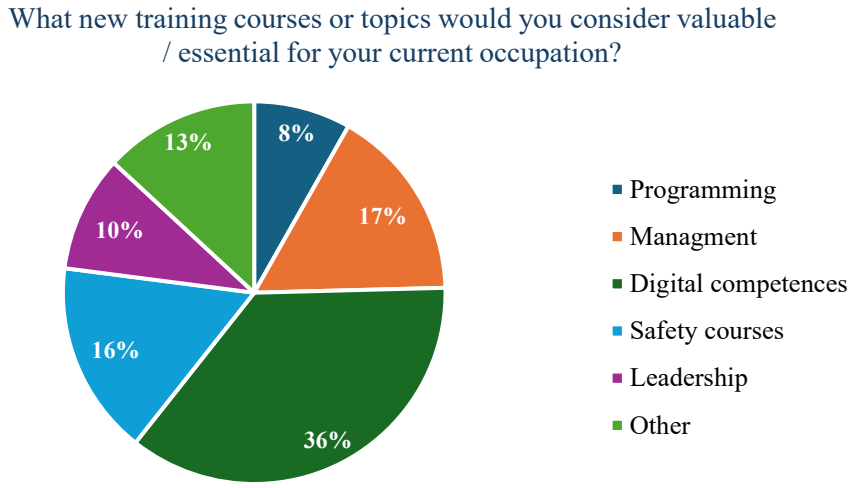

Fig. 7.4 New training courses or topics essential for current occupation

Moreover, the 17% of respondents that identified management as a crucial area for training, seems to suggest that leadership and organizational skills remain highly relevant, especially for those in supervisory or administrative roles.

Also noteworthy, 16% of respondents consider digital competences essential, indicating a strong need for proficiency in digital tools, platforms, and technologies, which aligns with the growing digital transformation across sectors.

These results highlight the growing demand for ICT proficiency, data handling, and software engineering across aviation roles, not only in technical domains but also in management, logistics, and regulatory compliance.

Overall, the data reveals a strong demand for technical and managerial skills, particularly in programming and digital competencies, alongside traditional leadership and safety training. This reinforces the need for continuous professional development to adapt to the evolving demands of the workforce.

Collectively, these insights demonstrate the need for a multi-tiered education system where long-cycle degrees are complemented by short-cycle, industry-responsive modules. Such an approach will enhance agility, ensure lifelong learning, and support aviation's green and digital transitions.

We have also asked our respondents regarding the preferred responsibility for providing training in various competence areas (such as: digital, innovation, green,

leadership, planning, make decisions, teamwork and collaboration, focus on quality, communication, teaching, advising and coaching, learning new methods and techniques, critical thinking and analysis, responsibility, interact with air transport users and other stakeholder, compliance with regulations, understand and apply safety management) , several key insights emerge.

7.3 Preferred Delivery Formats and Educational Innovation

The effectiveness of training is also closely tied to its mode of delivery. Respondents were asked to indicate their preferred training formats. As illustrated in Figure 7.5, 36% favoured face-to-face training, citing benefits such as real-time interaction and immediate feedback. Interactive, practical training was the second-most preferred option (23%), reflecting the hands-on nature of many aviation roles. Online training was preferred by 19%, pointing to a growing acceptance of digital learning environments, especially for theory-based modules or when flexibility is a priority.

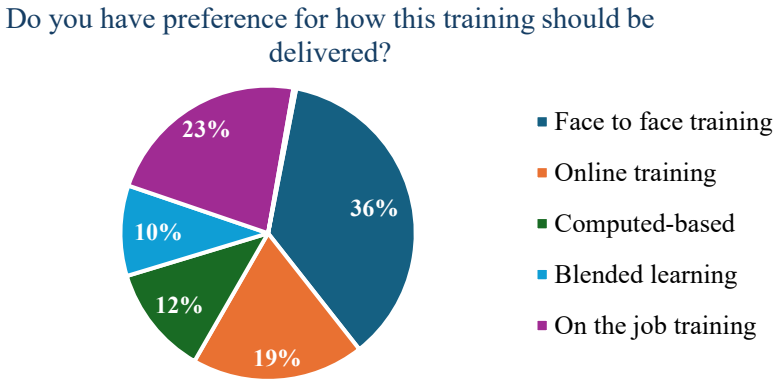

Fig. 7.5 Training delivery preferences

In the sample there is a clear preference for interactive practical training (23%). This indicates a demand for training that allows employees to practice real-world skills in a controlled environment, which can be particularly effective in technical or safety-related fields.

Also noteworthy, 19% of respondents favour online training, reflecting the growing acceptance of digital platforms for learning. Online training offers flexibility and accessibility, which may appeal to employees balancing professional and personal commitments.

All in all, figure 7.5 reflects a clear preference for traditional face-to-face and interactive, practical training methods, though there is also considerable support for online and computer-based training. This suggests that while employees appreciate the flexibility of digital learning options, many still value the direct engagement and hands-on experience offered by in-person training.

These findings indicate a weak preference for blended learning solutions (10%) that combine digital accessibility with experiential and collaborative methods. This is particularly relevant for aviation, where safety, precision, and teamwork are core competencies that often benefit from immersive and interactive training environments.

Furthermore, the research explored perceptions regarding the responsibility for delivering training across various competence areas. Results indicate a differentiated view:

- higher education institutions are considered most effective for developing competencies in leadership, communication, and critical thinking;
- vocational and on-the-job training were preferred for operational skills such as planning, decision-making, stakeholder interaction, and regulatory compliance;
- internships and self-directed learning were seen as especially valuable for fostering innovation, critical thinking, and real-world application of safety principles.

A notable trend in responses was the frequent selection of **"**more than one choice**"** as the preferred training method across different competencies. This reflects the recognition that no single format can adequately address the multifaceted nature of aviation skill requirements. Instead, a blended, multi-provider approach, combining formal education, workplace training, and self-guided learning, is essential to building a resilient and future-ready workforce.

High Education's Dominant Role. Across multiple competencies, high education institutions are viewed as a key player. Competencies such as leadership, communication, and critical thinking are areas where respondents largely agree that formal education plays a crucial role in training. This is consistent with the wider aviation industry, where structured learning paths are critical for developing core technical and soft skills.

Vocational Education & Training and On-the-Job Training. For practical and technical competencies such as planning, making decisions, and interacting with stakeholders, there is a considerable preference for vocational education and training

as well as on-the-job training. This aligns with industry practice, where technical skills are often best honed through real-world applications and in workplace environments, especially in operational sectors like aviation [51].

Internships and Self-Training: There is significant support for internships and self-training for competencies such as innovation, critical thinking, and applying safety regulations. These responses highlight the importance of experiential learning and individual initiative in developing both technical and non-technical skills. The aviation sector often encourages hands-on learning experiences to complement formal education [76].

None/Personal Experience: There are minimal votes for "None/Personal Experience" as a key training mechanism. This suggests that respondents recognise the need for structured educational frameworks rather than solely relying on informal or personal experiences, especially in highly regulated sectors such as aviation.

Multifaceted Approach to Training: One common theme throughout the responses is the preference for combining multiple modes of training ("More Than One Choice" appears frequently). This indicates a recognition that no single training method is sufficient on its own, and a blended approach incorporating formal education, on-the-job experience, and self-directed learning is likely to produce the best outcomes.

These insights align with broader trends in workforce development in the aviation industry, where both theoretical education and practical experience are critical for developing a well-rounded, highly skilled workforce [4,76].

Conclusions and Future Directions: Evolving Skills and Qualifications in Air Transport

The aviation sector is undergoing a profound transformation driven by the dual imperatives of digitalisation and environmental sustainability. These forces are reshaping occupational profiles, redefining skill requirements, and calling for new educational approaches across the air transport ecosystem.

We present below the main findings of the study and outlines forward-looking priorities for aligning workforce development with the demands of a smart and green aviation future.

1. Key Trends in Skills and Competence Needs

Digital skills have become foundational to the functioning of aviation institutions. Over 90% of survey respondents rated digital skills as important or extremely important, reflecting the sector's reliance on advanced ICT systems, automation, and data analytics. Likewise, 85% of respondents acknowledged the critical importance of innovation, signalling a workforce that must be adaptable, tech-savvy, and responsive to rapid change.

In contrast, green skills remain significantly undervalued. Only 26% of respondents considered them extremely important, and 34% deemed them important. This limited prioritisation suggests a cultural and strategic gap in how environmental responsibility is integrated into operational roles. While sustainability goals are prominent at the policy level, they are not yet fully embedded in human capital strategies or organisational practices.

The complexity of modern aviation operations increasingly requires interdisciplinary skill sets that cut across traditional domains. The need for hybrid profiles—such as professionals combining competencies in aviation and ICT, or sustainability and logistics—is growing. Current qualifications, however, often fail to reflect this convergence, resulting in mismatches between graduate output and labour market needs.

2. Skills Gaps, Recruitment, and Institutional Challenges

The sector continues to face pressing skills shortages in emerging roles, particularly in digital systems, data analysis, and sustainable operations. While 44% of employees identified digital training as essential to their work, and 43% cited big data analytics as a high-demand qualification, training provision remains inconsistent. Anticipated changes in occupations such as air traffic control (ATC) further underscore the urgency of reskilling initiatives.

Institutional responses have not kept pace. Many employers continue to adopt reactive or outdated approaches to workforce development, particularly in relation to green skills. Decision-makers across all functional levels must begin to internalise environmental responsibility as a key driver of operational performance and long-term resilience.

3. Strategic Priorities for Education and Training

Survey results show that 36% of employees prefer face-to-face training, while 23% value on-the-job learning. These preferences highlight the need for agile, blended training models that accommodate diverse learning styles. Modular approaches, including micro-credentials and flexible learning pathways, are essential for enabling continuous learning and timely skill acquisition in line with evolving technologies and regulatory demands.

The emergence of "smart" occupations—roles requiring integrated knowledge of aviation, ICT, and sustainability—demands advanced, adaptive qualifications. Study programmes must be redesigned to incorporate interdisciplinary content and to equip professionals with both technical and transversal competencies, including complex problem solving, leadership, and systems thinking. The Methodology of Sectoral Qualifications Framework in Air Transport (SQFAT) as developed in the Knowledge Alliance for Air Transport project [69], provides a foundational tool to support this shift.

4. Outlook: Building a Resilient and Future-Ready Workforce

The findings of this study reveal a critical window of opportunity for the aviation sector to realign its education [69] and training systems with future demands. The green and digital transitions are not merely technical challenges, they are human capital challenges that require proactive coordination between higher education institutions, vocational training providers, employers, and policy-makers.

By investing in future-ready qualifications, embracing flexible learning pathways, and integrating sustainability into all occupational levels, the aviation ecosystem can ensure its workforce remains innovative, inclusive, and globally competitive. The transformation of the sector depends not only on new technologies but on the people who design, operate, and improve them. Strategic workforce planning, lifelong learning, and international collaboration will be the cornerstones of a successful transition to smart and sustainable air transport.

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