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# Transition pathway for the aerospace ecosystem

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# TRANSITION PATHWAY FOR THE AEROSPACE ECOSYSTEM

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# ABBREVIATIONS AND ACRONYMS

| Acronym | Description |
|---|---|
| **AI** | Artificial intelligence |
| **ADS-B** | Automatic dependent surveillance |
| **ASD** | Aerospace and defence |
| **ATM** | Air traffic management |
| **AZEA** | Alliance for zero-emission aviation |
| **CEF** | Connecting Europe Facility |
| **CRM** | Critical raw materials |
| **CRMA** | Critical Raw Materials Act |
| **CSPs** | European cloud service providers |
| **EASA** | European Aviation Safety Agency |
| **ECCP** | European Cluster Collaboration Platform |
| **EDF** | European Defence Fund |
| **EISF** | EU Industry and Start-ups Forum |
| **EO** | Earth observation |
| **ESA** | European Space Agency |
| **ESG** | Environment, sustainability, governance |
| **EU** | European Union |
| **EUDIS** | The European Defence Fund innovation scheme |
| **EUSL** | EU Space law |
| **FDI** | Foreign direct investment |
| **eVTOL** | Electrical vertical take-off and landing aircraft |
| **HPC** | High performance computer |
| **GNSS** | Global navigation satellite system |
| **IAM** | Innovative air mobility |
| **IATA** | International Air Transport Association |
| **ICAO** | International Civil Aviation Organisation |
| **IoT** | Internet of things |
| **LCA** | Lifecycle assessment |
| **NACE** | European statistics classification of economic activities |
| **NZIA** | Net-Zero Industry Act |
| **OCT** | Observatory of Critical Technologies |
| **OECD** | Organization for Economic Co-operation and Development |
| **PNT** | Positioning, navigation and timing |
| **R&D** | Research and development |
| **R&I** | Research and innovation |
| **RRI** | Responsible research and innovation |
| **SAF** | Sustainable aviation fuel |
| **SATCEN** | EU Satellite Centre |

| | |
|---|---|
| **SDGs** | United Nations Sustainable Development Goals |
| **SMEs** | Small and medium-sized enterprises |
| **SSA** | Space situational awareness |
| **SST** | Space surveillance and tracking |

# 1. INTRODUCTION

This policy report outlines the main challenges and actions to be taken to accompany the aerospace ecosystem in its transition to become greener, more digital and more resilient and to boost its competitiveness.

The transition pathway follows the 2021 updated **EU industrial strategy**[1], which introduced the concept of transition pathways as co-creation exercises that involve EU Member States, industry and other relevant stakeholders to guide and support the twin transition of 14 EU industrial ecosystems, including the aerospace and defence (ASD) ecosystem.

In preparation for the pathway, the European Commission published a **staff working document** titled "For a resilient, sustainable and digital aerospace and defence industrial ecosystem: Scenarios for a transition pathway"[2]. The document accompanied a **public consultation** to identify avenues that support the green and digital transitions as well as the resilience of the ecosystem. In line with input received, the transitions for the defence industry part of the ASD ecosystem are covered by the *European defence industrial strategy*[3]. Therefore, this pathway covers exclusively the aerospace part of the ecosystem.

Through its two components – civil aeronautics and space – the ecosystem has a **strategic importance** for the **economic and security interests of the** EU and its Member States.

The EU Council Conclusions on the EU Space Strategy for Security and Defence[4] of November 2023 reiterate the **strategic nature** of space, and the necessity for the EU, as **global space power**, "to address current and upcoming security challenges linked to the recent intensification of irresponsible and hostile behaviours in the space domain." The Conclusions also note that "space-related data and technologies are drivers of research, technological development and innovation, creating job opportunities and economic growth, increasing European competitiveness, supporting the green and digital transition, protecting and safeguarding the EU and its citizens, and enhancing EU resilience and security."

Regarding **aeronautics**, the EU industry matters because of its **leading role** in innovation and in the production of civil aircrafts. It also supports the protection of the security interests of the EU and Member States through its dual nature and its contribution to the development of military aerial solutions. At the same time, the EU aeronautics sector is heavily investing to develop technologies that reduce the climate impact of aircraft operations, setting the path for a sustainable air transport sector.

The ecosystem is **already engaged** in the EU's efforts to achieve a modern, resource-efficient and competitive EU economy, which is an essential step towards ensuring the EU's strategic autonomy. By advancing in its green and digital transformation and becoming more sustainable, the ecosystem will **maximise its impact** to ensure economic stability, a competitive and resilient EU single market and supporting the EU's economic security goals.

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[1] COM(2021) 350 final.

[2] SWD_2023_280_1_EN_document_travail_service_part1_v3_0.pdf (europa.eu).

[3] Defence industry (europa.eu).

[4] https://data.consilium.europa.eu/doc/document/ST-14512-2023-INIT/en/pdf.

During the consultation process several **priority actions** were identified setting the **main parameters for the ecosystem's modernisation**. Putting them into practice will rely on the involvement and **commitment** of all stakeholders concerned.

# 2. THE AEROSPACE ECOSYSTEM

## 2.1 A complex ecosystem

The 2021 **EU industrial strategy** defines the ecosystem as "covering manufacturing companies in aeronautics, space, space operators, data and service providers, and research institutes."

The ecosystem generated an **annual turnover of EUR 126.4 billion in 2022** (aeronautics EUR 114 billion, space EUR 12.4 billion) and more than 400 000 jobs (aeronautics 348 013; space 57 510)[5].

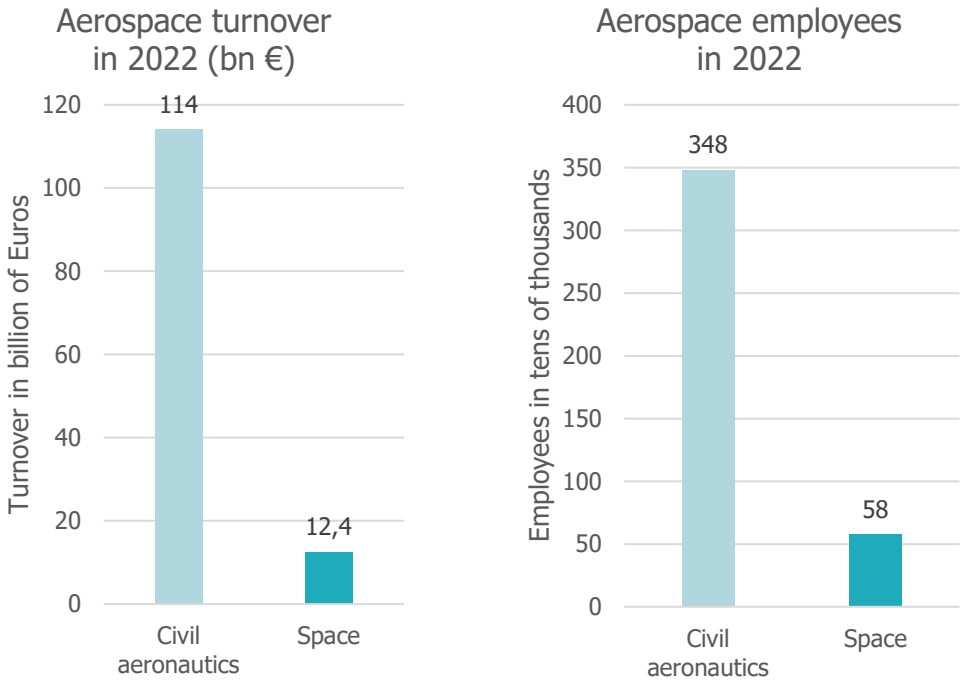


**Figure 1: Employees and turnover in 2022 of the European civil aeronautics and space sector (Source: ASD Europe Facts & Figures 2023[6])**

The two main components of the ecosystem are:

- **Civil aeronautics**: one of the EU's most successful high-tech sectors, encompassing a network of thousands of businesses, with small and medium-sized enterprises (SMEs) constituting around 80% of the sector. The European industry excels globally in manufacturing civil aircraft, including helicopters, aircraft engines, parts and components. Spread across Europe, it spans all market segments – from general aviation to business jets and commercial aircraft, rotor-wings, unmanned aerial vehicles, as well as electrical vertical take-off and landing aircraft (eVTOL), training and simulation services,

[5] Based upon ASD Europe Facts & Figures 2023.

[6] 'ASD EU': countries that are represented among the ASD membership and that at the same are EU Member States: Austria, Belgium, Czechia, Denmark, Finland, France, Germany, Greece, Italy, Poland, Portugal, Spain, Sweden, and the Netherlands. 'ASD NON-EU': countries that are represented among the ASD membership and that are not EU Member States: Norway, Türkiye, and the United Kingdom.

maintenance repair & overhaul and air traffic management systems (ATM). Several startups have joined major airframe manufacturers in innovating air mobility solutions, including drones, often employing new propulsion technologies.

- **Space**: the EU holds an important autonomous position among global space powers that it intends to maintain and enhance, as stated in the *EU space strategy for security and defence*[7]. The EU owns and operates space assets for positioning, navigation and timing (PNT - Galileo) and Earth Observation (EO - Copernicus). The EU will also launch a third programme for secure communications, the Union security connectivity programme (IRIS² constellation[8]). The EU Member States own and operate national space assets, including assets that serve security and defence purposes. The EU Satellite Centre (SatCen) provides a unique geospatial intelligence analysis capability to support decision-making and actions of the EU and its Member States. Through the data and information they are constantly providing, space infrastructure, services, and applications are vital not only for Europe's security and resilience but also for its green and digital transitions[9]. Moreover, the European space sector is expanding to the private sector. One of its specificities are complex supply chains, composed of a wide range of companies, from large system operators and integrators to specialised small and medium-sized enterprises (SMEs) and highly innovative startups, often with strong links to other ecosystems (such as electronics). The Commission and the Member States play a major role through their institutional demand, including the development of space assets, their deployment, maintenance, and the use of space data and services.

The ecosystem is based on intertwined relations between large companies[10] and SMEs and startups. **Large companies** often act as architects and integrators for major development and production programmes which structure the ecosystem. **SMEs and startups** are positioned at the core of the ecosystem and serve as key collaborators, providing expertise, niche technologies and agile solutions. They play a critical role in the supply chain, contributing with components, subsystems, software, engineering services and research to the broader aerospace ecosystem. Their agility and innovation prowess often result in groundbreaking advancements, especially in areas like avionics, materials, propulsion and satellite technology. Startups have proven to be the main contributor to the Innovative air mobility (IAM)[11].

Embracing not just technological advancements but also pioneering new business models, **SMEs play a pivotal role in driving the transformative shift**. The essence of the so-called "New Space", marked by the privatisation and commercialisation of the once state-dominated aerospace industry, predominantly revolves around dynamic contributions of various startups and SMEs across the EU.

[7] A EU Space Strategy for Security and Defence for a stronger and more resilient EU (europa.eu).
[8] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32023R0588.
[9] Analysis and data on the contribution and impact of the Earth Observation (EO) and Global Navigation Satellite System (GNSS): euspa_market_report_2024.pdf (europa.eu).
[10] According to Eurospace data, 30 companies make up 80% of the revenue in the manufacturing and R&D part of the space sub-sector in Europe (Eurospace Facts & Figures - Eurospace)
[11] Innovative Air Mobility Hub - The platform for sustainable Drone and Air Mobility in Europe | EASA (europa.eu).

Particularly in the area of Earth Observation, SMEs haven proven themselves as reliable and innovative powerhouses. SMEs are constantly underscoring their significance in not just capturing but also exploiting and processing Earth Observation data into readily deployable and cross-sectoral solutions for the EU increasingly data-driven economy. Many of them support the implementation of the United Nations Sustainable Development Goals (SDGs)[12] with their solutions and applications. Lately, SMEs are increasingly active in the domain of small-launcher solutions, offering European-made alternatives for small and medium-scaled launcher activities that contribute to supporting the EU's autonomy and resilience.

## 2.2 The ecosystem in a competitive and evolutive environment

The **COVID-19 pandemic has had a big impact on the ecosystem**, with a turnover drop of up to EUR 50 billion for aeronautics (40%) and EUR 3 billion for space (25%)[13]. Manufacturers faced cash-flow shortages and severe disruptions in global supply chains that durably affected the industrial base supporting complex manufacturing. In the space sector, institutional demand and long-term budgets acted as buffers against the impact of COVID-19. In the aeronautics area, the dual nature and related orders can help navigating low cycles in production and demand, be it on the civilian side or military one, and with global total traffic (measured in revenue passenger kilometres) reaching the pre-pandemic level beginning of 2024[14], a **significant rebound in the sector's turnover** can be observed.

The ecosystem was also **affected by Russia's war of aggression against Ukraine**.

The **aerospace** industry has been directly impacted by the EU sanctions[15] against Russia, in addition to the airspace closures and rerouting of flights and aircraft not returned to their owners. Aerospace manufacturers are moreover heavily reliant on energy and therefore vulnerable to rising energy prices and in need of viable alternative energy sources.

The **space** industry depends on materials (e.g. nickel, palladium, vanadium, boron, gallium, germanium) and technologies on which the EU is still dependent today on external providers. In addition, due to the small size of the space industry in many EU countries and the complexity of substituting these materials, disruptions can have a greater impact on the space sector. The impact has also been felt on space launchers when the Soyuz launches from French Guiana were suspended by Russia in response to the EU sanctions. Other space activities have also been impacted, with technologies for satellites, spacecraft and the space industry falling under restrictive measures with very limited exceptions and exemptions.

All this shows that the ecosystem is **vulnerable to external shocks** and needs to build resilience in a volatile and unpredictable environment.

[12] THE 17 GOALS | Sustainable Development (un.org).

[13] SWD_2023_280_1_EN_document_travail_service_part1_v3_0.pdf (europa.eu) quoting COM(2021)350 final, 5.3.2021.

[14] IATA data - Air Travel Reaches 99% of 2019 Levels as Recovery Continues in November.

[15] https://finance.ec.europa.eu/eu-and-world/sanctions-restrictive-measures/sanctions-adopted-following-russias-military-aggression-against-ukraine_en.

Against this background, the **space** budget in several non-EU countries has considerably increased (e.g. United States of America, China, Japan and India, led by their national governments' budget[16]) and a new generation of entrepreneurs ready to engage in a bold era of space development has emerged. Some of the world's richest people now organise private programmes for "conquering space". The EU makes its voice heard in the global arena by promoting responsible behaviour in space, safety and sustainability, freedom of action and by taking measures to protect the EU space assets and ensure that everyone can benefit from space services.

A similar competition is also present in the **civil aeronautics** area, with the entry into market and increase in related spending in various non-EU countries, a trend expected to continue.

Addressing these complex and interwoven challenges is crucial for the industry to increase production and meet demand. Since many of these headwinds are likely to persist, the Commission presented in September 2023 a SMEs Relief Package[17] with the aim to provide short-term relief, boost long-term SMEs competitiveness and resilience, and foster a fair and SME-friendly business environment.

[16] https://www.csis.org/analysis/space-threat-assessment-2023.

[17] https://single-market-economy.ec.europa.eu/document/download/8b64cc33-b9d9-4a73-b470-8fae8a59dba5_en?filename=COM_2023_535_1_EN_ACT_part1_v12.pdf.

# 3. THE TRANSITION PATHWAY CO-CREATION PROCESS

The co-creation process started with the launch of an open **public consultation**, based on the **Staff working document** "For a resilient, sustainable and digital aerospace and defence industrial ecosystem: Scenarios for a transition pathway"[18]. Stakeholders were invited to answer several questions and to propose specific actions, commitments, and investments essential for the ecosystem's transformation. The public consultation took place between 26 July and 3 November 2023 and received more than 30 contributions.

This was complemented by **several workshops** organised with stakeholders in October and November 2023 on the topics of resilience and capacity to act during war and crises, green transition, digitalisation, competitiveness and access to resources. A final workshop was organised on 17 November 2023 with the Commission's expert group on policies & programmes relevant to EU space, defence and aeronautics industry, based on the results of consultations held until then. To ensure that the specificities of civil aeronautics and space are duly reflected in the pathway, further targeted stakeholder consultations were organised at the beginning of 2024.

Stakeholder input collected during the co-creation process resulted in the identification of proposed actions, forming the backbone of the pathway. Each area of the transition pathway includes specific actions together with a timeframe for implementation: short-term, medium-term, or long-term. Indicatively, short-term indicates activities that should start as soon as possible; medium-term indicates activities that should start in the medium-term (i.e. by 2030); while long-term indicates activities that should be launched by 2040.

Core actors or owners (industry, Member States, EU) are also assigned to each action. Where relevant, other stakeholders, such as trade unions and social partners, should also be involved in the implementation.

[18] The Staff working document builds on the input provided by the ASD expert group taskforce in July 2022.

# 4. REGULATION AND PUBLIC GOVERNANCE

The ecosystem transformation takes place amid a dynamic legislative and regulatory context linked to the green and digital transition, at EU level, but also at national and regional level.

Several normative acts play an **enabling role** for the ecosystem's transformation. The implementation of the Fit for 55 package[19], the REPowerEU Plan[20], ReFuelEU Aviation[21], the Green Deal Industrial plan[22], the Circular economy action plan[23], the Zero-Net Industry Act (NZIA)[24] and the Critical Raw Material Act (CRMA)[25] will offer the ecosystem the basis needed to continue its green transition and reach the goal of net-zero emissions by 2050. The EU sustainable finance framework is also relevant for the aerospace ecosystem, for example through the identification of sustainable activities that make a substantial contribution to at least one of the six environmental objectives set out in the **Taxonomy Regulation**[26], that 'do no significant harm' to any of the other objectives, and that are in compliance with minimum safeguards regarding labour and other human rights. When it comes to the **access to renewable and low- carbon energies**, the shift to these energies across the ecosystem is happening. To support this, in addition to the implementation of relevant legislation, such as the Renewable Energies Directive (2009/28/EC), stakeholders in the co-creation process asked for a consistent approach to regulation and certification standards on the green transition, both within the EU and beyond.

In **space**, the 2023 *EU space strategy for security and defence* offers the guidance needed to boost the EU's resilience in space and protect space systems and services in the EU. The strategy states that "the Commission will consider proposing an **EU Space Law**" (EUSL), meant to provide a clear and predictable legal framework and help to address the safety, resilience and environmental measures of space activities and to boost the competitiveness of the EU's space industry. The Commission is leading a wide and transparent consultation process with Member States and industry on drawing up such a law.

The co-creation process emphasised that the ecosystem has made progress in complying with the legal requirements linked to the green and digital transitions. While commitment to continue implementing present and future legislation is there, in some cases the ecosystem's players face difficulties in ensuring compliance with evolving environmental standards and industry-specific regulations. SMEs are also often noted as being confronted with this challenge, e. g. when it comes to the environmental, social and governance (ESG) reporting. While not in scope of most reporting ESG requirements, they can in practice be requested to provide information by their value chain partners (such as their larger customers or banks who have obligations under ESG rules).

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[19] Fit for 55 - The EU's plan for a green transition - Consilium (europa.eu).
[20] REPowerEU (europa.eu).
[21] Regulation (EU) 2023/2405 of the European Parliament and of the Council - Level playing field for sustainable air transport (ReFuelEU Aviation) | EASA (europa.eu).
[22] EUR-Lex - 52023PC0161 - EN - EUR-Lex (europa.eu).
[23] EUR-Lex - 52020DC0098 - EN - EUR-Lex (europa.eu)
[24] Net Zero Industry Act - European Commission (europa.eu).
[25] European Critical Raw Materials Act - European Commission (europa.eu).
[26] eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0852.

The co-creation process underlined that, although a consistent regulatory framework is in place in the **digital area**, its modernisation will need to continue, in order to accompany the emergence of new digital technologies, including the use of artificial intelligence (AI). The ecosystem will also be impacted by the increasing number of regulations on cybersecurity, and predictability and coherence are needed.

Given the strong international character of the ecosystem, compliance with international norms and regulations is very important. In the context of the green and digital transition, regulatory developments at global level need to be taken into account. This will help to ensure that the market for products and services developed as part of this transition is not limited to Europe. In some areas, the EU's industrial players emerge as first movers, which is an opportunity to shape new regulatory requirements at international level according to the EU's standards, including the EU's commitment to reach net-zero emissions by 2050.

The need for coherence in implementing various ESG instruments has also been highlighted in the co-creation process. An important starting point is the implementation of the Directive on corporate sustainability reporting[27] and the delegated act on sustainability reporting standards[28], which will also apply to aerospace companies and entities.

Overall, there is the need to further **streamline EU legislation** to improve stakeholders' compliance, by making regulations simpler and easier to apply[29], while also establishing **clear guidelines** for the green and digital transitions, particularly in the space sector. To this end, the future EU Space Law will offer additional support. The EU legislation should also ensure coherence among various goals related to resilience, green and digital transitions and competitiveness. Stakeholders highlighted the importance of building resilience within the ecosystem, which should be included among strategic sectors in future resilience-related legislation.

During the co-creation process, it was also noted that, at EU level, the Commission has put forward an initiative to rationalise and simplify reporting requirements that will also benefit the ecosystem[30].

Continued and increased **dialogue between the public and private sectors** is essential to establish the right parameters to successfully transform the ecosystem. The co-creation process encourages EU institutions, in particular the Commission, to maintain and develop partnerships with industries to discuss relevant policy proposals and standards for the ecosystem. Under these frameworks, SMEs need to be given special attention.

As is the case for other ecosystems, SMEs in the **aerospace** area often struggle with limited visibility and recognition compared to larger, established entities within the ecosystem. This is particularly challenging for SMEs active in the niche aerospace sector that wish to expand their business solutions to non-space players (such as smart farming solutions for agricultural

[27] Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting: Publications Office (europa.eu).

[28] Commission Delegated Regulation (EU) 2023/2772 of 31 July 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards: Delegated regulation - EU - 2023/2772 - EN - EUR-Lex (europa.eu).

[30] Factsheet_CWP_Burdens_10.pdf (europa.eu).

corporations, or de-forestation tracking solutions for timber companies). The lack of visibility may prevent them from attracting partnerships, investments, or opportunities for growth.

SMEs and startups therefore need to be integrated in collaborative platforms to develop their potential and make an impact. Initiatives such as the **EU Industry and Start-ups Forum (EISF)**[31] in the space area are an example of such an inclusive and cooperative approach.

Stakeholder participation in various **industrial alliances**, such as the Renewable and Low Carbon Fuels Value Chain Alliance[32], the European Clean Hydrogen Alliance[33] and the Alliance for Zero-Emission Aviation (AZEA)[34], was highlighted as being of particular relevance. At the same time, the alliances between industries and research institutes and academia need to be encouraged and strengthened.

The following actions have been identified as priorities:

| Action | Actors | Timeframe |
|---|---|---|
| 1. Continue dialogue and exchanges with stakeholders in order to identify and reduce regulatory burdens and make legislation and regulation simpler and easier to understand by the ecosystem's players. | EU/MS/Industry | S/M |
| 2. Support SMEs and smaller firms to participate in collaborative platforms and to fully benefit from all the opportunities linked to the ecosystem transformation, including in terms of access to funding at EU, national, regional and local levels.<br>Encourage active involvement of research institutes and academia in collaborative platforms together with industries. | EU/MS/Industry | S/M |
| 3. Facilitate sharing best practices and sustainability reporting guidance with smaller suppliers to ensure compliance with relevant national and EU regulations, encouraging environmentally sound practices across the supply chain. | Industry/EU/MS | S |

[31] EUSST_EUISF.pdf (europa.eu).
[32] Renewable and Low-Carbon Fuels Value Chain Industrial Alliance - European Commission (europa.eu)
[33] European Clean Hydrogen Alliance - European Commission (europa.eu).
[34] Alliance for Zero Emission Aviation (europa.eu).

# 5. THE PATH TOWARDS A MORE RESILIENT ECOSYSTEM

The co-creation process put a specific focus on resilience. Stakeholders recalled that the **ecosystem supports resilience of the EU as a whole**, which has implications for other industrial sectors. Its role is similar to the one of the European defence industries, that, as stated in the *European defence industrial strategy*[35], represent "a crucial contributor to resilience, security, and social sustainability."

To increase its resilience, the ecosystem needs to strengthen or reconfigure the supply chains, reduce dependencies and ensure access to sustainable energy while allocating sufficient financial resources and securing a robust workforce. Achieving resilience is complex. This complexity arises from the fact that resilience is interlinked with the other areas of the transition, notably green, digital and competitiveness. At the same time, the ecosystem has several specificities (depth of supply chains, long market cycles and relatively small volumes ordered compared with other ecosystems), which have an impact on the way resilience is achieved.

Ensuring a strong and resilient industrial base is a precondition for an autonomous EU space policy and for maintaining the EU's leadership role in civil aeronautics. **Supply chains and energy** were identified as priority areas. Recent global events have shown that the ecosystem's supply chains might at any point face sudden strain and are **vulnerable to strategic dependencies,** including on energy, as well as critical raw and advanced materials, components and technologies such as batteries. For instance, during the COVID pandemic, airplane manufacturing companies have suffered a consistent drop in actual production compared to the expected figures due to supply issues. The success of the European aeronautics industry also puts the supply chain under pressure, as it must cope at all levels with strong ramp-up of production rates. In the space sector, sometimes there is not enough supply and supply options remain limited. **High energy prices** are also affecting the ecosystem's competitiveness. Promoting a forward-looking approach limiting future risks of energy dependencies through sustainable aviation fuels (SAF) and hydrogen will be essential, also in ensuring the transformation of air transport towards climate neutrality.

Stakeholders underlined that a successful strategy to **protect supply chains** should be based on anticipation and prevention of possible disruptions, but also rapid recovery after disruption. At the same time, **diversification of supplies** and improvement in their **local production** must be pursued.

The on-going implementation of the 2023 **European economic security strategy**[36] represents an opportunity for the ecosystem. It can leverage and boost its resilience through concerted actions and measures formulated under that framework, to identify and reduce strategic dependencies and supply chain bottlenecks. Work in this regard has already started and the ecosystem stands to benefit from it, as space and propulsion technologies are one of

[35] Defence industry (europa.eu).

[36] An EU approach to enhance economic security (europa.eu); IMMC.JOIN%282023%2920%20final.ENG.xhtml.1_EN_ACT_part1_v8.docx (europa.eu).

the 10 critical technology areas for the EU's economic security[37] where actions could be envisaged following a risk assessment with Member States.

Critical Raw Materials (CRMs) have an important role in ensuring the robustness of the ecosystem. Their demand within the ecosystem (and not only) will increase in the context of the implementation of the green and digital transition and sufficient supply needs to be ensured from within the EU and beyond.

Stakeholders recalled the **EU CRMA**, which lays down the basis for an integrated approach based on diversifying CRM primary sourcing. Several practical steps have been identified so that the ecosystem fully benefits from it: **auditing CRM supply chains** to improve their resilience by performing stress tests, promotion of diversification, and creation of **circular economy approaches and networks** under the European Raw Materials Alliance (ERMA). Moreover, applying technologies such as additive manufacturing could reduce CRM waste during production both in aeronautics and space. Improving **supply chain visibility** could also boost the ecosystem's resilience. To this end, stakeholders proposed employing new technologies for supply chain tracking, such as blockchain-powered systems, and improving communication with supply chain stakeholders. Stakeholders also pointed at the need to respect relevant international conventions and guidelines[38], noting that the EU CRMA sets ambitious targets on extracting, processing and mining.

| **Coordination on critical technologies at the EU level** |
| --- |
| The example of the Commission's **Observatory of Critical Technologies** has been identified as a best practice for identifying critical dependencies. Its monitoring methodology can help to scrutinise value chains, supply chains and potentially mitigate their vulnerabilities.<br><br>Additionally, it can support the creation of EU technology roadmaps to improve the resilience of supply chains and lower dependencies. |

There is a need for a steady dialogue between EU policymakers and Member States' representatives to **increase the visibility of institutional demand** within the ecosystem. Increased agility and adaptability of the ecosystem will also help to ensure increased resilience. This can be achieved by developing the capacity to promptly shift production and volumes. Stakeholders expressed the view that the industry can improve its resilience by stockpiling and by creating **redundancies in production**. However, the space sector's tendency towards specialised, small-batch production, such as satellite components, unique propulsion systems, and intricate avionics, can sometimes make stockpiling difficult. Securing a sufficient European semiconductor supply is also essential to guaranteeing continued and high-quality production. This requires the support of other industrial segments including

[37] Commission Recommendation of 03 October 2023 on critical technology areas for the EU's economic security for further risk assessment with Member States - European Commission (europa.eu).

[38] International Labour Organization core conventions and international guidelines noting the United Nations Economic Commission for Europe work to align critical raw materials with the UN SDGs and the Organization for Economic Co-operation and Development (OECD) Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas.

foundries, test and design houses, and specialised manufacturers, which could be supported through initiatives such as the **EU Chips Act**[39].

The ecosystem provides advanced surveillance systems, secure communication networks, and reliable transportation that boosts the EU's capacity to monitor and respond to threats swiftly and effectively. Therefore, **access to these critical assets** must remain readily available for European actors. The co-creation process stressed the need to **improve communication** with the authorities on producing and providing these goods and services. This may include sending **early notifications of supply shortages or disruptions** through appropriate warning mechanisms. Contingencies for permanent or temporary asset loss, including plans for rapidly replacing damaged critical systems, should be envisaged.

The co-creation process highlighted that the ecosystem companies gather **data** which are important for coordinating the response to challenges from natural disasters to cyber incidents. Sharing earth Observation (EO), Global Navigation Satellite System (GNSS) and Space Surveillance and Tracking (SST) data is, on many occasions, crucial for achieving this. To respond appropriately to incidents undermining European security, the ecosystem's players should **promptly share data** with the relevant authorities.

The **aerospace** sector remains vulnerable to a **wide variety of grey zone operations** (such as cyberattacks, disinformation, reckless orbital rendez-vous and proximity operations), with potential targets being testing and production facilities, supply chains, transport, or strategic private assets, such as certain satellites, launchers and some components of the ground segments of space infrastructure.

In the **space** area, stakeholders highlighted that appropriate satellite disposal mitigates space debris threats, safeguards the environmental sustainability of outer space, and reduces collision risks. Companies could also continue and improve their support and participation in emerging (institutional and commercial) solutions for space situational awareness (SSA) or space traffic/debris management, or actions supporting debris removal such as those undergone by ESA's Cleanspace office.

The **access to launchers** has been highlighted during the co-creation process. There is the need to **strengthen European launching capabilities** to boost self-reliance and resilience. At the same time, it has been pointed out that the latest generation of institutional European launchers are yet to contribute to the space sector's needs, and they need to be developed and supported.

Steps in this direction are being taken, through the emergence of a more service-oriented approach within the EU, the encouragement of open competition on launch services and the promotion of the European preference. This will lead to the creation of a **European approach on launching capabilities** and will incentivise industries to become more involved and assume more responsibilities in the launching domain.

The topics of foreign direct investment (FDI) and export control areas were also raised during the co-creation process.

[39] Regulation - 2023/1781 - EN - EUR-Lex (europa.eu).

First, a careful management of the **FDI** in order to ensure protection against aggressive economic actions. This includes the conclusion of robust legal contracts and non-disclosure agreements with foreign partners and investors. Governmental agencies and authorities play a key role in scrutinising investments. Their collaboration should be improved, in parallel with developing the related national legal frameworks. Similar measures should be applied to manage the risk of investors buying innovative aerospace firms and performing exits into non-EU country markets. The current review of the **FDI Regulation**[40] and the possible follow-up measures to the **white papers**[41] on outbound investments, export controls, and dual-use research will help preventing and reducing technology-related risks for the aerospace sector.

Second, **export controls** should be stepped up by complying with the international and national rules to prevent system misplacement and by sharing export control best practices. The ecosystem's companies could further support export controls by committing to monitor illegal trade, for instance by combining Earth Observation data and machine vision to identify illegal trade routes or implementing blockchain-powered systems to track components.

The co-creation process also found that **climate change** poses significant risks for the resilience of the ecosystem. Flooding can **damage infrastructure**, reduce operational capacity and hinder supply chains. The effects of such disruptions could compromise security by **delaying the delivery of systems** and inflating costs. Additionally, extreme weather events such as higher temperatures and drought conditions will increase energy demands for cooling and water scarcity, putting further strains on the resources needed for the smooth running of the ecosystem.

The growing unpredictability and severity of weather patterns could lead to **delays in launches**, testing, and space technology development, and threaten the delicate balance between the **safety and efficiency of air transport**. The aeronautics industry should help to address these challenges by designing systems capable of dealing with the more extreme environments brought about by changes in climate systems.

[40] resource.html (europa.eu).
[41] WHITE PAPER on Outbound Investments - Publications Office of the EU (europa.eu).

The following actions have been identified as priorities to promote the **resilience** of the ecosystem.

| Action | Actors | Time frame |
|---|---|---|
| **Relevant for aeronautics and space** | | |
| 4. Establish redundancies in production capacity and stockpiles, especially in critical systems such as satellite components, advanced avionics, propulsion technologies, and secure communication systems, to allow efficient response in case of need.<br>Work to create the necessary market to ensure that production is sustainable. | MS/EU/Industry | S/M |
| 5. Recognise the vulnerability of current sourcing practices, actively diversify the Critical Raw Materials (CRMs) sources and promote stockpiling to reduce dependence on a single supplier and mitigate risks associated with supply chain and geopolitical dynamics.<br>Continue to streamline the ecosystem in the implementation of the European economic security strategy. | Industry/MS/EU | S |
| 6. Perform audits on supply chains, including: (a) mapping where the strategic raw materials used are extracted, processed or recycled; (b) stress test of the supply chain for strategic raw materials, consisting of an assessment of its vulnerability to supply disruptions by estimating the impact of different scenarios that may cause such disruptions and their potential effects.<br>Participate in strengthening supply chains and early warning mechanisms for supply chain disruptions.<br>Use tools like the EU Observatory of Critical Technologies (OCT) to inform and coordinate future actions. | Industry/MS/EU | S/M |
| 7. Improve supply chain resilience by supporting SMEs within supply chains, promoting collaboration, and ensuring the stability of key actors. | Industry/EU/MS | S |
| 8. Innovate in export controls by using technologies such as distributed ledgers to strengthen supply chain control, prevent corruption, and facilitate transparent reporting of export control processes. | Industry/EU/MS | S/M |
| 9. Plan for temporary and permanent contingencies in the face of potential asset loss, involving rapidly replacing damaged systems and implementing corporate crisis management exercises to boost business security and resilience. | Industry | S/M |
| 10. Exercise caution and careful consideration when investing in initiatives abroad, particularly those involving | Industry/MS/EU | S |

| Action | Actors | Time frame |
|---|---|---|
| dual-use technologies, to avoid losing control over projects or technologies. | | |
| **Space focus** | | |
| 11. Support the shaping of an EU approach to launching capabilities by actively following and participating in the proposed next steps. | EU/MS/Industry | S/M |
| 12. Adopt and support emerging solutions for space situational awareness (SSA) or space traffic/debris management (STM/SDM) to contribute to minimising space debris and ensuring a safer environment for space activities. | Industry/MS/EU | S |
| 13. Ensure the availability of critical assets (such as EO, GNSS and SSA) by promptly sharing data with appropriate authorities, facilitating effective management of situations that could undermine European security. | Industry | S/M |

# 6. THE PATH TOWARDS A GREENER ECOSYSTEM

The green transition is a challenge for the ecosystem, which needs to balance ambitious targets with performance, efficiency and capacity to meet demand.

The ecosystem already takes measures to **implement the green transition**, aware of the fact that this transition is an opportunity to achieve self-sufficiency and get fit for the major advancements that are taking place in the international arena in terms of green production and expansion of green technologies and standards.

For example, the **space** sector is already engaged in discussions on orbital sustainability. One of its objectives is to limit orbital debris. Additionally, initiatives such as the first workshop on life cycle assessment of space transportation systems hosted by the University of Stuttgart with the support of the German Aerospace Centre are seeking to improve the ecosystem's understanding of the environmental impacts of space transportation systems. Such information is crucial for creating a more sustainable space sector.

On the **aeronautics** side, the aeronautics industry is called to green its own production processes and to achieve a step change in the environmental performances of its products. One key challenge is to increase the use of **renewable and low-carbon energies**. The use of **sustainable aviation fuels (SAFs)** and the development of **new propulsion technologies based on electricity and hydrogen** are important and necessary steps to promote renewable and low carbon energies and reduce the climate impact of aircraft emissions, with effect within the EU and beyond. The aeronautic industry is heavily investing in these new technologies (conventional engines that are 100% SAF compatible, electric and hydrogen propulsion, etc.) supported by national and European funding, including trough initiatives such as the Clean Aviation Joint Undertaking[42]. This effort is not only focused on reducing or removing $CO_2$ emission but also addressing non-$CO_2$ emissions[43].

Moving towards new energy sources as electricity and hydrogen for the operation of aircraft has significant implications for the ecosystem as it exists today. The aeronautics industry is therefore closely cooperating, within the **AZEA**, with other stakeholders of the aviation ecosystem like airports and airlines to ensure the readiness of the aviation sector to integrate such new aircraft and to support the market demand for these technologies, being committed to implement the ambitious targets set out under **Destination 2050 report and its under accompanying roadmap**[44]. AZEA and its members are major assets to set the ground for electric and hydrogen flight and to support that investments made by the aeronautics sector to produce greener aircraft and infrastructure will pay off and final products will find a market. The planned AZEA report "Flying on electricity and hydrogen in Europe" will put forward the ambitious objective of having **up to 70% of intra-EU flights** operated by these new aircraft configurations by 2050, and describe how they would progressively penetrate the market.

[42] Home | Clean Aviation (clean-aviation.eu).

[43] The non-$CO_2$ overall impact on global warming is estimated 2.6 times the effect of $CO_2$ alone due to the emissions of nitrogen oxides, sulphate aerosols, particulates and water vapour, although the level of uncertainty from the non-$CO_2$ effects is 8 times larger than that of $CO_2$ (source: European Environmental Agency, 2022; Crewe, 2021; Lee, 2021; Klöwer, 2021; Brazzola et al., 2022).

[44] Destination2050_Report.pdf.

Having brought together relevant industry stakeholders, the Alliance's recommendations should serve as a tool to inform decision-making and for implementation. AZEA plays therefore an important role in ensuring the existence and the readiness of the market for the new product developed by the aeronautics industry. Cooperation through AZEA should be harnessed to support further actions, such as creating novel energy hubs in airports. At the same time, a dedicated workstream for aeronautics within the European Battery Alliance[45] to support the implementation of electric-powered aircraft could be envisaged.

For what concerns SAFs which can be produced in different ways, there are currently multiple barriers hindering their adoption. These barriers are, however, not linked to the performance of the aircraft, as new models are already certified to operate with 50% of SAF. Instead, stakeholders underscored the **limited supply of SAFs** and **hydrogen**, and their **high cost** as a result. This highlights the importance of investing in SAF development, related infrastructure and production, a mission which ReFuelEU is currently spearheading. Building upon the work of **SAF alliances**, such as the Renewable and Low Carbon Value Chain Industrial Alliance[46], can also boost production. Ensuring a sufficient production and supply of hydrogen is a key enabler of the decarbonisation of the ecosystem.

The development of green propulsion technologies together with innovative aircraft configurations like electric vertical take-off and landing vehicles (eVTOLs) will enable the development of new air mobility offers, as exemplified by the Innovative Air Mobility (IAM).

At the same time, stakeholders recalled the need for greater ambition at international level on decarbonisation, including from members of the International Civil Aviation Organisation (ICAO), as true decarbonisation of the ecosystem is only possible if all international stakeholders come together to agree on ambitious and binding commitments.

Emissions from **space launchers** and general pollution related to space asset production and operations are expected to rise due to the projected expansion of space activities. Developing and adopting greener propulsion technologies, such as **low-carbon propulsion systems**, will also positively impact the sector's environmental footprint, but a consensus on the life cycle assessment (LCA) method to use to measure it is yet to be established. The ecosystem could benefit from conducting further research on the impact of re-usable launch systems on the environment.

The implementation of a **circular economy** approach to the aerospace industry and its products is another priority area for the green transition of the ecosystem. This can lead to **net material cost reductions** for European industries by reducing resource usage and waste while boosting **resilience against supply chain disruptions**. The aim is to reach a high degree of circular economy throughout the whole value chain, with the understanding that for some products or services this cannot be achieved (such as consumption of fuels for the propulsion of launchers, satellite/spacecraft materials which may partly or totally burn up in the atmosphere during controlled re-entry).

Stakeholders underlined the positive impact of using **LCA** within the ecosystem. Common space LCA tools and methodology should be shared within the supply chain to facilitate

[45] European Battery Alliance - European Commission (europa.eu).
[46] Renewable and Low-Carbon Fuels Value Chain Industrial Alliance - European Commission (europa.eu).

interoperability between its different actors and ensure the traceability of the impact assessment. The co-creation process found that performing LCA in the space sector is particularly difficult as there is no sector-specific LCA methodology that includes certain phases (such as re-entry of satellites and launchers). Therefore, aerospace players should support institutional efforts to work towards **harmonisation of LCA practices.**

**Design** and its **subsequent phases**, including testing, can also play an important role in reducing the ecosystem's products environmental footprint, since a big percentage of a product's environmental impact is determined during its design. Industries can benefit from adopting design choices that appropriately consider environmental impacts, such as **ecodesign**[47] and social science informed methodologies which monitor the way the ecosystem's products will be used, to ensure that consumption habits align with sustainability. Design choices and increased focus on innovation are particularly relevant for products with long life cycles, and these are many within the ecosystem. A proactive approach to prevent the production of systems causing significant environmental harm is recommended. Overall, this efficiency and optimisation strategy will lead towards a gradual elimination of old technologies through substitution.

The co-creation process also found that **end-customer requirements** for aerospace products or services could be reconfigured to include cost-efficiency, modularity, reparability, and robustness, in support of the green transition. This can, for example, be done through the promotion of design of lighter components that will positively impact the conduct of operations and avoid or minimise harmful effects on the environment.

Other steps in supporting the green transition are the reduction of **material usage** that can lead to **lowering life cycle costs**, the promotion of **additive manufacturing** that can improve waste reduction within circular processes and **reusing or retrofitting existing systems**. Moreover, the somewhat unexpected commercial success of re-usable launch vehicles, for example, showcases that this last approach may be possible even within a sector that operates under circumstances typically considered unsuitable for reusability. Developing more robust and adaptable systems might decrease individual unit sales over time. However, it presents a chance to establish consistent revenue streams by adopting models like X-as-a-service[48] or through-life engineering services.

**Recycling** is of high relevance in the aeronautics sector. Up to 85% of the components of commercial aircraft could be recycled (see box below), reflecting the fact that both re-usable parts and recycled materials present significant residual value. However, recycling must be considered already at the design stage to be efficient, given that production techniques and the use of certain materials can profoundly impact future recycling. Recycling and reusing orbiting satellites could mitigate space debris.

[47] https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/sustainable-products/ecodesign-sustainable-products-regulation_de .

[48] X-as-a-service is a concept of being able to call up re-usable, fine-grained software components across a network. The most common and successful example is software as-a-service (SaaS), but the term as-a-service has been associated and used with many core components of cloud computing including communication, infrastructure, data and platforms.

**Leveraging EU funding for a more sustainable aeronautics industry**

With the increasing number of retired aircraft – more than an estimated 6 000 within the next 20 years – the safe management of their end-of-life, both in terms of the environment and for public health, has become a key issue.

In 2005, Airbus became a pioneer in aircraft recycling when it launched **project PAMELA**[49] (2005-2007, EUR 1.16 million EU contribution). The project demonstrated that up to 85% of each aircraft's components could be safely and effectively reused, recovered or recycled, compared to just 60% before the project's inception. With support from the Commission, the research applied recycling techniques from other industries and managed to reduce landfill waste to less than 15% instead of 40%-50%[50]. The project's success led to the creation of Tarmac Aerosave[51], a follow-up project in partnership with the Safran company that **now recovers materials making up 90% of an aircraft's weight** and aims to commercialise the practice.

**Coordination among stakeholders** within and beyond the ecosystem is important to advance in greening production.

The co-creation process found a great need to improve and build a **strong European recycling value chain** adapted to the sector's needs.

Participation in **circular economy loops** is needed and encouraged, as they create interconnected networks that facilitate the implementation of green practices, such as recycling and reusing. These loops also promote cooperation with other industries like manufacturing, materials science, renewable and low-carbon energy and transportation. Among the barriers towards circular economy uptake identified by stakeholders are technological, organisational and regulatory aspects. Examples include limitations in manufacturing lightweight, durable and sustainable materials, difficulty in coordinating multiple players across different sectors and regulation on recycling standards and processes.

On waste, stakeholders argued that monitoring the effectiveness of **waste management** initiatives and sharing the results with the public, even when not required by legislation (for instance for small companies), improves **transparency and accountability**. The space sector must also consider effects of waste produced by ground segment elements, satellite production and launcher production on the Earth itself.

Ensuring **lower energy consumption** by increased use of cleaner energy sources was also underscored in the co-creation process. For this, there is a need to identify energy consumption hotspots and subsequently **reduce energy usage** by improving efficiency through technologies, such as additive manufacturing. Furthermore, access to and demand for cleaner energy sources by the aerospace sector should be reflected in energy deployment strategies for other industries.

The co-creation process also found that space sector activities, including Earth Observation, are linked to increasingly **large amounts of digital data, particularly in the downstream segment**. These large datasets must be stored and/or processed, with the

[49] LIFE 3.0 - LIFE05 ENV/F/000059 (europa.eu).
[50] See footnote 53
[51] Tarmac Aerosave / Transition Expert.

corresponding energy consumption to power the required hardware. The sector could benefit from assessing its data centres and by developing **greener data centres**.

The following actions have been identified as priorities to promote the **green transition** of the ecosystem.

| Action | Actors | Timeframe |
|---|---|---|
| **Relevant for aeronautics and space** | | |
| 14. Actively embrace sustainable aviation fuels (SAFs) and novel propulsion technologies to reduce climate impact of emissions (including non-$CO_2$) and support the transition to greener air transport (for instance through implementation of the recommendations of the Alliance for Zero-Emission Aviation). | Industry/MS/EU | S/M/L |
| 15. Conduct assessments of value chain sustainability, utilising tools like life cycle assessments (LCA) with an economic, environmental, and social focus to identify opportunities for optimisation in the context of circular economy principles. | Industry/MS | S |
| 16. Recognise sustainability as one of priorities during product design and subsequent stages, recognising that a significant share of a product's environmental impact is determined during these pivotal stages. | Industry/EU | S |
| 17. Strategically consider recycling viability in design choices from the outset, ensuring materials can be successfully recovered for circular economy practices. | Industry/MS/EU | S |
| 18. Design products for reuse or retrofitting existing systems (such as refuelling of satellites or green retrofitting of aircraft) showcasing innovation possibilities, offering opportunities for stable revenue streams through models like X-as-a-service or through-life engineering services. | Industry/MS | S |
| 19. Adopt a strategic, integrated circular approach to products' lifecycles across the ecosystem, incorporating principles of sharing, leasing, reusing, repairing, refurbishing, and recycling to optimise resource utilisation and reduce environmental impacts. | Industry/MS/EU | S/M |
| 20. Actively support or contribute to research on quantifying the impacts of different waste management practices and disposal solutions, | Industry/MS/EU | M |

| Action | Actors | Timeframe |
|---|---|---|
| fostering a better understanding of environmental consequences. | | |
| 21. Identify and reduce hotspots in energy and water consumption by improving efficiency and reducing waste. | Industry/MS/EU | S/M |
| 22. Embrace renewable and low-carbon energy sources, as initiated by the REPowerEU programme, to contribute to achieving a greener and more resilient ecosystem.<br>Explore possibilities to increase hydrogen production and utilisation. | Industry/MS/EU | S/M |
| 23. Prioritise purchasing EU-produced, green-by-design components to support environmental compliance and advance the aerospace green transition. | Industry/MS/EU | S |
| 24. Embrace a paradigm shift by recognising sustainability not as an obstacle but as an opportunity. Cultivate a mindset of continuous improvement, encourage collaborative innovation, adopt green technologies, and set metrics for on-going environmental impact assessment. | Industry/MS | M |

# 7. THE PATH TOWARDS A DIGITALISED ECOSYSTEM

The digital transition, powered by the **EU Digital decade policy programme 2030**[52], is an important opportunity for the aerospace sector. The ecosystem has already started to harness opportunities to realise its digital transformation.

For example, on **civil aeronautics**, the digital European sky initiative by the SESAR Joint Undertaking[53] leverages technologies that can increase the levels of automation and data sharing in ATM. The transition towards an increasingly digital ATM requires aircrafts to be fully compatible with such novel operational environments, where hyper-connectivity between all stakeholders is at the core.

**Data gathering** is a core aspect for the ecosystem's digital transition. For example, the data collected by secondary surveillance radar transponders mandated by the Automatic dependent surveillance (ADS-B) requirements is a clear step in developing data gathering. Advanced sensors and devices based on Internet of Things (IoT) technologies have potential for facilitating predictive maintenance, monitoring production, Greenhouse gas emissions and supply chains, and allowing the remote control of aerospace equipment while respecting the General Data Protection Regulation. IoT plays a central role in complex aerospace operations, and these devices can work in tandem with distributed ledger technologies to improve **monitoring during transition stages**. However, there are hurdles to implementing these technologies at the high quality required by the ecosystem and this calls for further support.

| **Integrating IoT across the ecosystem** |
| --- |
| **Aeronautics:** IoT sensors allow airlines to **monitor the performance** of aircraft in real time via onboard sensors. This can support the use of **predictive maintenance**, improving safety and reducing down times. Additionally, IoT systems can help to improve flight efficiency by collecting data on engine performance, fuel usage, and in-flight conditions. This leads to increased safety, reduced operational costs, and improved passenger experience. IoT devices also contribute to the modernisation of **airports** by improving situational awareness and increasing safety. Devices supporting compliance with ADS-B data link are also key in supporting safe European skies.<br><br>**Space**: on-the-ground satellite data enhanced IoT sensors can gather **high-value, real-time data** which, when deployed alongside data gathered from space, can provide important **insights for a variety of applications** and can be used to **build powerful AI models**. IoT enables the deployment of networks of interconnected devices on spacecraft and satellites facilitating real-time data collection and transmission. |

In this context, gathering data regarding SSA can contribute substantially to the **safety and sustainability of space assets**. The European Space Programme's space surveillance and tracking (EUSST)[54] component addresses this issue by listing in-orbit objects and forming a data hub. Additionally, the European Union Industry and Start-ups Forum on STM (EISF) is

[52] Europe's digital decade: 2030 targets | European Commission (europa.eu).
[53] SESAR Joint Undertaking | Delivering the Digital European Sky (sesarju.eu).
[54] EU SST – EU Space Surveillance and Tracking.

contributing to European SST commercial sector. The availability of space weather data is crucial for the protection of space and ground-based infrastructure, such as power grid communications. The space weather event subcomponent of the EU Space Programme[55] will implement a service under one of these user domains.

The need for standardisation of **data collection and sharing** was also underlined in the co-creation process. This facilitates data exchange and integration between different products, supports research, improves monitoring and decision-making and promotes interoperability.

The improvement of **common digital standards** and architectures in production can be a starting point for wider sectoral digitalisation. This would represent an evolution from the current situation, in which players design proprietary in-house production management software, rather than software products which can be employed across firms and that can facilitate SMEs digitalisation. The co-creation process found that some stakeholders are willing to shift towards a more **collaborative approach** in their creation of digital products. There is willingness to consider the needs of smaller players, provided they receive appropriate support. Member States can play a part in improving digital interoperability among themselves and by **coordinating digital architectures and standards** more widely.

Industrial Partnerships such as the SESAR 3 Joint Undertaking are already working in this sense and should be continued. The European Aviation Safety Agency (EASA) has started to operate a regulatory framework for the establishment of performance requirements and conformity assessment of ground and space-based ATM infrastructure, in addition to their activities in relation to aircraft. This will greatly foster systems integration and add value to industry standards as acceptable means of compliance. Having industrial standards for ground systems should open up the ATM market for systems manufacturers and providers. Additionally, this new EASA certification process for ATM ground systems and design and production organisations will improve the competitiveness of the European industry in the global market.

The establishment of best practices for structuring data can potentially pave the way for a possible **common digital architecture** for each category of EU aerospace products.

| **Pilot project to create a common data infrastructure** |
| --- |
| A total of 11 Member States are currently working together, as part of the "**European common data infrastructure and services**" multi-country project[56], to deliver the next generation cloud and edge infrastructure and services, which may take the form of an Important Project of Common European Interest (IPCEI). Such a project could eventually support some of the first industrial development of next generation climate-neutral and highly secure edge nodes. It could also help to support a higher cloud and edge uptake among companies and public entities as positive externalities. |

Stakeholders emphasised the need for global interoperability in the aeronautics industry, urging continued collaboration to **promote EU-favoured standards** worldwide through

[55] EU Space Programme - European Commission (europa.eu).

[56] Cross border and multi-country projects - European Common Data Infrastructure and Services - European Commission (europa.eu).

engagement with ICAO and other international fora. This is also valid for other relevant areas, such as quantum communications and space traffic management.

**Data sovereignty** is another important issue when it comes to the digital transition, to which all players of the ecosystem have the interest to participate, by supporting and promoting an EU approach and EU data sovereignty principles. Data sovereignty has a role in preventing data breaches and unauthorised access. It also supports the development of domestic data infrastructure, and expertise in cybersecurity and related capabilities, which are important in countering disruptive technologies. Stakeholders called for the EU to establish a secure, confidential channel between EU institutions and the aerospace players to share data. This can range from data required by specific regulations to voluntary contributions to ecosystem-wide studies.

Stakeholders also called on the EU to develop and launch a **common European aerospace & defence data space**. Participation in such an initiative is subject to ensuring data security, including anonymising data when relevant. It was suggested that the Commission could serve as a fair broker in the management of this system.

The co-creation process underlined that **AI** already has and will continue to have an important role in the digital transformation of the ecosystem. AI is already being used within the ecosystem and many projects have started to implement AI. AI is particularly relevant when it comes to the analysis of data and management of operations within the ecosystem. For example, in **aeronautics**, AI-driven predictive maintenance systems can analyse vast amounts of data from aircraft and equipment sensors, allowing timely identification of potential problems and enabling predictive maintenance. AI is also applicable in the **space** sector, ranging from the optimising navigation systems of spacecraft, to supporting the creation of a digital twin of the Earth[57]. **Digital twins and model-based systems engineering** is another key application of AI that can improve efficiency, reduce costs and improve safety. Digital twins also facilitate accurate real-time monitoring of complex systems through IoT devices. AI utilisation within the ecosystem will only increase in the near future. Stakeholders need to be prepared and ensure its fair, transparent, safe, and secure utilisation, in line with the principles enshrined in the Artificial Intelligence Act[58] and other applicable laws and regulations in respect of fundamental rights and the principle of non-discrimination.

When it comes to **industry 4.0 and smart manufacturing**, they are enabled by their underlying hardware as well as data gathering, analytics processes and employing software that is fit for purpose. Ensuring the utilisation of state-of-the-art technology in manufacturing (such as IoT sensors and corresponding connectivity or AI, digital twins, virtual and augmented reality and other tools for data analytics) can lead to faster and more efficient production cycles, ramp-up capabilities in response to increasing demand, accelerated time to market and reduced costs. While the initial implementation of these technologies can be difficult, there are initiatives at EU level, such as the **Digital Europe programme** which offer the necessary support framework, and which need to be fully explored.

Moreover, integrating advanced robotics into manufacturing processes automates repetitive and labour-intensive tasks, increases efficiency, and reduces the potential for human errors.

[57] Destination Earth | Shaping Europe's digital future (europa.eu).
[58] EUR-Lex - 52021PC0206 - EN - EUR-Lex (europa.eu).

**Additive manufacturing (3D printing)** can also contribute to digitalisation, allowing the creation of complex components directly from digital models. This technology reduces lead time for producing prototypes, final components and spare parts, saving time and costs. Combining robotics and additive manufacturing streamlines assembly processes and improves customisation, automation and adaptability.

However, an overreliance on these systems could make the industry vulnerable to events, such as cyberattacks. To strike a balance, the aerospace sector should develop **contingency plans** for scenarios where digital manufacturing capabilities are compromised, including through backup production systems.

The co-creation process emphasised the importance of **cybersecurity** for the ecosystem, due to its strategic role. Ensuring cybersecurity will facilitate the digital transition and will boost the resilience of the ecosystem.

Stakeholders identified understanding of the cyber environment through **cyber intelligence** and **cyber situational awareness** as an important dimension to be addressed, as it leads to facilitating the identification of potential threats.

The more the ecosystem evolves on the path towards digitalisation, the more it will have to build its robustness on cybersecurity. Newer hardware and software solutions, such as IoT sensors or quantum computing can become targets for cyberattacks by connecting to cloud-based services and physical systems. Robust **cybersecurity measures in manufacturing operations** are therefore needed to prevent these risks. At the same time, when it comes to traditional applications, such as legacy systems, which are also used within the ecosystem, the aim is to upgrade them or to replace them with secure alternatives to mitigate possible risks. The existing Network and Information Security Directive (NIS2 Directive)[59] and the planned EUSL provide important guidance on how to address these cybersecurity risks.

To boost security related to **quantum computing**, a solution is to initially safeguard critical encrypted files through methods which do not rely on post-quantum encryption, such as compartmentalisation and honeypotting. The adoption of a suitable algorithm would involve adapting digital infrastructure for improved protection. Also, there is a need for an active participation in the EU's and like-minded partners' standardisation efforts for post-quantum encryption.

The **aeronautics industry** is concerned by **cybersecurity** because aircrafts and airports are getting more digital and connected. During the transition towards new digital solutions, operational continuity needs to be ensured. Threats can target safety, operations, intellectual property of manufacturers and national aerospace capabilities. Encompassing cybersecurity strategies is therefore needed to protect aircraft operations from cyber-attacks and IoT-related vulnerabilities, which could extend to onboard and in-flight systems. The increasing number of GNSS interference affecting aviation shows the need to improve the robustness of satellite services against cyberattacks to ensure safety and business continuity.

[59] Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 on measures for a high common level of cybersecurity across the Union, amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and repealing Directive (EU) 2016/1148 (NIS 2 Directive).

On **space**, there is the risk of cyberattacks against satellites, which are considered critical infrastructure. Implementing existing and future guidance on cybersecurity for space operations, including the NIS2 Directive and the upcoming EUSL, will benefit the sector.

Stakeholders shared their interest in collaborating with the Commission, Member States and other stakeholders in developing **sector-specific cybersecurity standards**. It is also important to continue to develop cybersecurity awareness and training programmes at all levels in the ecosystem, be it industries, relevant national institutions or at the EU level. The promotion of a **security-aware culture** is more and more acknowledged as an essential step to succeed in addressing cybersecurity risks.

The following actions have been identified as priorities to promote the **digital transition** of the ecosystem.

| Action | Actors | Timeframe[60] |
|---|---|---|
| **Relevant for aeronautics and space** | | |
| 25. Contribute to digitalisation efforts by exclusively engaging with digital services that meet EU data sovereignty principles, ensuring sensitive data remains within the EU's jurisdiction and control. | Industry | S |
| 26. Implement robust cybersecurity measures throughout the life cycle of aerospace products, from the manufacturing phase till end-of-life to mitigate the risks associated with cyber-physical threats.<br>Strengthen European autonomy in Electrical, Electronic and Electro-mechanical components. | Industry/MS/EU | S/M/L |
| 27. Carefully assess foreign direct investment in cybersecurity related systems and structures. | Industry/MS/EU | S/M/L |
| 28. Adopt new standards wisely, considering potential risks and benefits when transitioning from conventional public key encryption to post-quantum algorithms. | Industry/MS/EU | S/M/L |
| 29. Invest in developing skills and capabilities in quantum computing, either in-house or through collaborations, to harness the potential of quantum computers for specific tasks within the sectors. | Industry/MS/EU | S/M |
| 30. Develop hardened communication systems and assess dependence on connectivity, | Industry/MS/EU | S/M |

[60] S = short-term, actions to start as soon as possible, M = medium-term, actions to start by 2030, L = long-term, actions to be launched by 2040.

| Action | Actors | Timeframe[60] |
|---|---|---|
| conducting exercises with limited connectivity to identify and manage vulnerabilities in operations. | | |
| 31. Integrate IoT sensors for real-time monitoring and predictive maintenance.<br>Leverage digital twins and model-based systems engineering to streamline prototyping, reduce development time, and elevate overall efficiency in line with GDPR and data protection standards. | Industry/MS | S/M |
| **Space focus** | | |
| 32. Explore and promote innovative applications based on space data, including Copernicus and Galileo, for various end user purposes, expanding the utility of space assets. | Industry/EU | S |
| 33. Actively participate in initiatives such as the EU Space programme's space surveillance and tracking (EUSST) and EU Industry and Startups Forum (EISF) to contribute to a European SST commercial sector. | Industry/MS | S/M |

# 8. SUSTAINABLE COMPETITIVENESS

A more competitive and innovative ecosystem will strengthen EU's technological base and contribute to securing the EU's position internationally and boosting its credibility. The EU's ambitious targets on space and in the aeronautics sectors cannot be achieved without a highly performing industrial base. Stakeholders noted that one pre-requisite is gradually sharing competencies and capabilities in the aerospace domain among European partners. At the same time, difficulties persist in measuring the ecosystem, its performance and competitiveness through reliable statistics[61].

The co-creation process identified as **areas that underpin competitiveness**: robust research and innovation (R&I) and development of technologies, infrastructure, investment and funding. They are analysed in the following sub-chapters.

One way of boosting competitiveness is by **strengthening the EU's single market**. In this regard, efforts are being pursued to create a **single market for space**, by aggregating European institutional demand for launch services, promoting innovation and support to critical infrastructure while ensuring the needed level of competition. To support a more integrated market for space, the 2021 **EU space programme** set an ambitious agenda for a more dynamic, innovative and resilient sector, supporting industrial and scientific expertise in space and building an EU sovereign space infrastructure. Furthermore, this broadens out towards a wide array of economic sectors through downstream applications using space technologies, data and services.

Stakeholders underlined that, from an industrial point of view, it is relevant to continue building scale and better consolidate the demand at EU and Member States' level, while continuing efforts to reduce the fragmentation of the EU space market. It was noted that the EU space market is much smaller, fragmented, and much more open to external competition than its USA equivalent, which has been compounded by a big number of venture capital investment in the last years. The fragmentation of the EU space sector is especially strong when compared to the new vertical model of SpaceX-Starlink, with one player producing the launchers, the satellites, operating the constellations and selling services.

Boosting competitiveness of the ecosystem also relies on establishing stable and forward-looking **dialogues** and **partnerships**. These need to be developed within the EU and beyond, as the ecosystem is increasingly interconnected with similar ecosystems around the world.

Successful dialogues and partnerships are based on a win-win approach and can address clarification of the institutional demand, identification of current gaps in the EU's provision of materials, components, systems or services which serve to build the ecosystem's competitiveness as well as requirements, sourcing of raw materials and components. Dialogues and partnerships in the space domain will also serve to promote norms, rules and

[61] Developing a space economy thematic account for Europe - 2023 edition (europa.eu).

principles of responsible behaviours in outer space, as stated in the *EU space strategy for security and defence*.

Achieving a **more integrated ecosystem at EU level** is an important step towards increased competitiveness. Cooperation can take the form of joint ventures, industrial alliances and innovation clusters, such as the European Cluster Collaboration Platform (ECCP)[62], in support of joint production or co-development of certain systems such as advanced avionics, propulsion technologies, satellite systems, or integrated air traffic management solutions.

The mapping tool provided by the ECCP[63] enables the identification of clusters and related innovation agents that are directly or indirectly (cross-industrially) associated with the ecosystem. As of April 2024, out of the 35 clusters registered distributed throughout Europe, two Euroclusters[64] (Leviatad and Metastars) organise European cluster networks directly targeting the ecosystem.

Cross-border cooperation in dual-use projects is sometimes further complicated by the diversity of **export control regulations** within Europe, with stakeholders noting that complying with these laws can be complex and time-consuming and sometimes penalising for competitiveness. This is particularly relevant for SMEs and startups, which lack the legal experience and resources of bigger players.

The co-creation process also stressed the importance of broadening income sources through access to international markets. **International trade** with reliable partners could improve the sector's profitability and competitiveness while increasing its resilience by diversifying revenue sources. Active participation of the ecosystem in this framework is needed and encouraged.

## 8.1 Research and innovation (R&I), development of technologies

The importance of **R&I** was repeatedly raised during the co-creation process. R&I plays a central role in the ecosystem, which is largely technology-driven and needs to innovate in key technologies of the future, to become competitive and maintain a leading position on the international stage.

Pursuing innovation in fields such as AI, optical and quantum technologies, reusability, greenhouse emissions monitoring, SSA, electric and hydrogen propulsion, robotics, and material science, among others, is a priority for the ecosystem. To become more efficient, R&I must follow a bottom-up approach, focusing on encouraging the spirit of initiative and assuming responsibilities both at individual and at companies' level.

In the area of green transition, stakeholders underlined that the aerospace sector could benefit from setting **research priorities** aligned with the transition goals. In this regard, the Commission's support for such research activities through programmes such as Horizon Europe or InvestEU (see Annex A for a full list of relevant funding programmes) has been pointed out. Research topics such as clean energy-powered vehicles, material science, additive

[62] https://clustercollaboration.eu/.
[63] https://reporting.clustercollaboration.eu/zone/in-europe.
[64] https://clustercollaboration.eu/euroclusters.

manufacturing, green fuels, renewable and low- carbon energy and others should be explored with priority. In this context, members of the aerospace sector could benefit from interaction with other sectors. At the same time, increased cooperation between industries and research institutes and academia is seen as particularly relevant to boost innovation and drive the green transition of the ecosystem.

In the area of digital transition, participation in dedicated **Digital innovation hubs** can support partnerships and provide an additional boost to innovation. Players could explore opportunities related to key technologies such as AI, emphasising the need to meet ethical standards, applying the EU's guidelines for trustworthy AI[65] and the rules set out in the recent Artificial Intelligence Act. This is especially important when developing dual-use systems and designing human-machine interactions.

The co-creation process called for the **results of R&I** to be more **promptly implemented in new products**. More agile certification mechanisms need to be accompanied by adaptation in export control regulations to guarantee appropriate commercialisation and implementation. Current EU programmes, such as Horizon 2020/Europe, including the CASSINI entrepreneurship initiative[66], or the EU defence innovation scheme (EUDIS), have been **crucial tools** for supporting early-stage research and further development of products. They should continue and be improved. There is the need to increase the pace of product release and uptake, by further support provided to the **go-to-market** segment of product development. At the same time, in several Member States national programmes related to aerospace sustainability are being developed. At regional level, in the 2021-2027 Cohesion Framework 20 European territories have included aerospace and defence among their Smart Specialisation Strategies and 60 have mentioned the NACE Activity "H51 Air Transport". All these territories are investing Cohesion funds in developing their own policy mix related to aerospace and defence/ aviation (e.g. programmes for green aviation, unmanned aerial vehicles, space development)[67].

The co-creation process also underscored the importance of performing **foresight exercises** at the company, industry and European levels as an important tool for guiding innovation.

In the ecosystem, **dual-use technologies** often drive innovation in both civilian and military applications. While historically the military has been the primary driver of innovation, particularly in the space sector, now the market, especially the new space development, is propelling innovation in the civilian domain. The co-creation process pledged for a **holistic approach** in this regard and underlined that a combination of spin-ins and spin-offs, as well as Open Innovation, could lead to a **maximisation of the efficiency of R&D funding** for European companies. Stakeholders also argued that embracing Open Innovation resources[68] would boost even more innovation in the ecosystem.

Developing aerospace products and services requires addressing ethical considerations. **Responsible research and innovation (RRI)** is already included in initiatives by the EU

[65] Ethics guidelines for trustworthy AI | Shaping Europe's digital future (europa.eu).
[66] Cassini Space Entrepreneurship Initiative | EU Agency for the Space Programme.
[67] According to the data data of the S3 CoP Observatory, https://ec.europa.eu/regional_policy/assets/s3-observatory/index_en.html.
[68] Open innovation resources - European Commission (europa.eu).

and the UN. For instance, when developing autonomous aeronautics systems, RRI helps assess the societal implications of increased automation in air travel, considering safety, employment impact, and public acceptance. Additionally, RRI safeguards the aerospace ecosystem against reputational damage in the context of corporate social responsibility assessments by encouraging responsibility across the development cycle.

Ensuring **intellectual property protection** in the ecosystem, with a balanced approach between ensuring security and promoting cooperation and innovation, will support competitiveness and the EU's strategic advantage.

## 8.2 Infrastructure

**Energy infrastructure** is of particular relevance for the aerospace ecosystem. Several programmes at EU level, such as **REPowerEU** and **Connecting Europe Facility** (CEF)[69], promote renewable energies' infrastructure and upgrading and expanding the electricity grid infrastructure, which are particularly relevant for the ecosystem, as they provide sustainable energy sources for the production and for the operation of aircraft leveraging novel propulsion technologies. Developing infrastructure for energy storage, such as batteries and hydrogen storage, is another important element which will help to ensure a stable energy supply. Full benefit from the opportunities REPowerEU, CEF and other relevant EU programmes offer in terms of securing the EU's energy sector, including regarding its infrastructure, should be ensured. At the same time, the ecosystem should leverage the synergies between the REPowerEU research and aerospace-specific battery R&D to further boost its resilience, leading to a reduced reliance on fossil fuels.

REPowerEU and CEF also support **infrastructure for hydrogen,** including pipelines to transport hydrogen and storage facilities. Stakeholders in the co-creation process repeatedly called for liquid hydrogen airport hubs, which will play an important role in the development of sustainable air transport, as they enable and facilitate the deployment of novel aircraft, hence ensuring a market for the new products developed by the industry.

Significant objectives for the aviation sector include **reducing the price of SAF**, **hydrogen** and **electricity**, ensuring **price stability**, and **increasing production** where it is needed. The current maximum potential of SAF production capacity in the EU is estimated to be only 10% of the amount required to meet the targets set in the REFuelEU Aviation Regulation in 2030[70]. Hydrogen plays an important role in the future deployment of synthetic aviation fuels, and direct aircraft propulsion and scaling its production should be done in consideration of the aerospace ecosystem's needs. Significant and rapid dedicated investments and support at the EU and Member States' levels is needed to create and expand the necessary infrastructure for production and distribution which will also benefit the ecosystem. For the moment, fossil fuels are still a component of the EU's energy security and will have to be used while pursuing efforts, including through REPowerEU, CEF and others, to achieve an effective and resilient ecosystem's transition to renewable and low-carbon energy.

[69] Connecting Europe Facility 2021-2027 adopted - European Commission (europa.eu).
[70] Current landscape and future of SAF industry | EASA Eco (europa.eu).

Fundamental **transport infrastructure** such as airports, harbours, roads and railroad systems play an essential role in facilitating the flow of goods in the aerospace sector. In addition to their maintenance and development, institutions and industries have to ensure sustainable mechanisms to respond to the increased supply and increased projected demand for **spaceports.** In particular, airport infrastructure needs to be adapted to the hydrogen and new propulsion aircrafts, a strand of action in which AZEA is very active. In order to be successful, this ambition needs to be pursued with the active involvement of Member States and regional authorities.

The **digital transition** also requires development of related infrastructure. Enabled by the space sector, telecommunication satellites, including high-bandwidth laser communication systems, space relay networks, narrowband IoT constellations and institutional initiatives for secure broadband satellite connectivity, such as the planned European **IRIS² constellation**, are crucial for providing ubiquitous, secure, resilient and reliable networks. In this context, the importance of quantum communications and spectrum access has been highlighted. While improved connectivity boosts the productive potential of the aerospace sector, it also creates dependencies. To address this, **hardened communication systems** can be developed that reduce vulnerability by eliminating potential attack vectors[71]. Similarly, aerospace companies could assess their dependency on connectivity and simulate situations with restricted connectivity to identify vulnerabilities. Overall, there is the need that the EU boosts its autonomy also in information and communication hardware production.

Elements related to the digital transition, such as **cloud, fog and edge computing**, also require key infrastructure. The co-creation process recognised the worrying tendency of the cloud and data infrastructure market being led almost exclusively by non-European providers. There is, therefore, a need to boost capable, sovereign European cloud service providers (CSPs). Stakeholders argued that reliable non-EU country CSPs could support Europe in implementing these projects while considering the requirements set out in the upcoming **EU Cloud rulebook**[72]. Before deciding on which type of system to employ, aerospace companies could consider the risk of lock-in, as changing providers tends to be complicated. Moreover, suitable hardware at the edge, fog and cloud levels must be available to meet processing requirements.

Access to **quantum computers** and **high-performance computers (HPCs)** is another key infrastructure requirement. Engaging with the European High-Performance Computing Joint Undertaking (EuroHPC JU) can provide access to HPCs and quantum computers. The ecosystem could benefit from interacting with European innovation clusters developing quantum computers and HPCs to explore use cases. Developing in-house capabilities or investing in relevant R&I is also valuable for harnessing their potential and build cyber resilience.

As mentioned throughout the pathway, **production facilities and redundancies** are crucial for the sector. While digital twins have done much to reduce the need for physical testing of capabilities, analogue testing will remain a crucial part of development for the foreseeable

[71] By removing superfluous programmes, accounts functions, applications, ports, permissions, access, etc.
[72] https://digital-strategy.ec.europa.eu/en/policies/cloud-computing.

future. Therefore, the creation of test ranges for systems, such as rockets and other difficult-to-test systems, will remain an important infrastructural need for the industry.

In the same vein, the ecosystem needs to fully benefit from boosting EU's production capacity on **crucial semiconductors**, as outlined in the **EU Chips Act**.

## 8.3 Investment and funding

Ensuring **increased and eased access to both public and private funding** is a basic element for the ecosystem to succeed in its transition. The ecosystem often faces difficulties in accessing private funding, in part due to the perceived associated risks: high capital requirements and complexity of investments, the length of time taken to generate a return, and ultimately, the uncertainty that the investment will bring benefits. As regards space, investments might not yield direct returns, but it is clearly an area of substantial potential and likely to become highly profitable in the longer run. It is therefore important that the public sector acts as anchor customer for space and triggers investments and the development of the space industry.

Stakeholders agreed on the need to address these problems and reduce the risks and barriers. This is a **joint effort** that needs to be pursued at the level of the industries, the Member States and the EU institutions. It will lead to a better acceptance of the risks and the fact that some of the investments may not make positive returns. However, activities in space and aeronautics should be supported for the EU's long-term benefit. SMEs and startups were identified as the ones who face the biggest challenges concerning access to finance and to resources necessary for research, development, scaling up and industrialisation of innovative solutions and products. It is essential to explore better ways to address their needs. One solution would be promoting cooperation between SMEs, startups and large companies through institutional procurement mechanisms, which can also help lessen the negative effects of oligopolies in the ecosystem, particularly in the space sector. Moreover, smaller companies can benefit from the Commission's current efforts to facilitate advisory support and debt financing for European space companies[73].

Public institutions and authorities are seen as enablers of the dialogue with private institutions. Many stakeholders highlighted the positive examples of EU support and programmes, for instance, the **Horizon Europe** programme, the Emissions Trading System **Innovation Fund** and the **Clean aviation programme**[74]. Specific alliances, such as AZEA and the Renewable and Low-Carbon Fuels Value Chains Industrial Alliance have a positive impact due to their capacity to mobilise stakeholders in defining the objectives and the targets in terms of sustainability. These should be continued, further developed and consolidated by **streamlining the ecosystem in future EU programming**. The possibility of offering new blending incentives for private investors should also be considered. Further efforts should also be made to further develop and better integrate the EU's capital markets. This would unlock more funding for early-stage investments as well as enable larger financing rounds for companies in later stages of their lifecycle. According to some stakeholders, programmes in

[73] DEFIS - EIB- ESA partner to strengthen the European space sector (europa.eu).
[74] Programme overview and structure | Clean Aviation (clean-aviation.eu).

key areas related to space could have very beneficial effects for the whole ecosystem, in particular a positive consolidation effect. References were made to the successful example of Galileo and Copernicus programmes.

At the same time, there is the need to make better known to the industries all the existing public funding possibilities, such as the **Digital Europe programme**, from which companies can benefit when it comes to the digital transition of the ecosystem. Financial support requires appropriate supporting regulation to achieve its desired effects. Moreover, targeted investments in critical areas, such as digital and clean technologies can be supported through the **Strategic Technologies for Europe Platform**[75]. The aerospace ecosystem can benefit from it. The Commission provides tailor-made technical support through the **Technical Support Instrument** (TSI)[76] to design and implement reforms in the Member States. The support is provided upon Member State's request across a wide range of policy areas of the green and the digital transition. This framework could include support to Member States to meet the challenges identified in the Transition pathway for the aerospace ecosystem.

Strengthened financing is also achieved through promotion of innovation, resilience and sustainability in **procurement strategies** that can benefit an important share of ecosystem's stakeholders, including the new space actors. To this end, several initiatives have started at EU level and will be pursued, such as the Dynamic purchasing system of Copernicus[77], the flight ticket initiative[78] under the in-orbit demonstration / in-orbit validation programme and the concession model of IRIS².

Stakeholders underlined that the involvement of the public sector and Member States in procurement should be increased, in order to ensure a sufficient market for space technologies and contribute to reducing dependencies. Stakeholders also stressed that public funding to support the green and digital transition of the ecosystem should come with social conditionalities to ensure the creation and retention of quality jobs in Europe.

To ensure smoother access to investment and funding, there is the need to **continue the outreach to financial institutions**, including the European Investment Bank, and offer better explanation on the specificities of the ecosystem, its potential, and the impact a better access to finance will have on the ecosystem's green and digital transition. At the same time, the industry needs to advocate relevant on-going and future reforms in terms of sustainability.

Stakeholders welcomed the Commission's Delegated Act for the inclusion of specific activities in the aviation sector in the taxonomy for sustainable finance[79] to help underpin the sector's contribution to the climate change mitigation objective and proposed expanding the taxonomy's applicability to the whole aviation manufacturing sector. The Platform on Sustainable Finance, an independent expert group advising the Commission on sustainable finance, is developing recommendations for inclusion of digital solutions exploiting space-

[75] Strategic Technologies for Europe Platform - European Commission (europa.eu).
[76] Technical Support Instrument (TSI) (europa.eu).

[77] Dynamic purchasing system (DPS) for Copernicus contributing missions (CCM) - Category 2 - ESA Commercialisation Gateway.
[78] Launch of the European Flight Ticket Initiative - European Commission (europa.eu).
[79] Commission Delegated Regulation (EU) 2023/2486 of 27 June 2023 supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council - Publications Office of the EU (europa.eu).

based data and services in the taxonomy. Possibilities to include additional space-related activities (such as management of orbits) should be explored. Overall, stakeholders underlined a need continue to provide implementation guidance around the taxonomy criteria.

The following actions have been identified as priorities to ensure **sustainable competitiveness**.

| Action | Actors | Timeframe |
|---|---|---|
| **Relevant for aeronautics and space** | | |
| 34. Anticipate global supply chain challenges by aligning procurement frameworks with emerging European capabilities, as encouraged by initiatives such as the EU Chips Act or the Zero-Net Industry Act (NZIA) | Industry/MS/EU | S |
| 35. Make use of all R&D funding programmes and facilities, industrial alliances and instruments.<br>Coordinate to identify priorities in view of future EU funding schemes and programmes. | Industry/MS/EU | S |
| 36. Harness cooperation clusters and promote regionally coordinated consolidated demand initiatives. | MS/EU | S |
| 37. Encourage and facilitate stakeholders' dialogue with the financial sector actors to ensure easier access to financing. | EU | S/M |
| 38. Ensure continued guidance on EU taxonomy rules and, in this framework, continue to support investments in green innovative technologies. | EU | S/M |
| 39. Safeguard critical technologies and equipment by establishing solid partnerships with like-minded governments to navigate market complexities.<br>Associate at EU regional level and beyond to develop cooperation in this area. | Industry/MS | S |
| 40. Swiftly integrate R&I results and supporting infrastructure, such as liquid hydrogen airport hubs, into operational capabilities, encouraging a dynamic synergy between research advancements and real-world applications to boost industry agility and competitiveness. | Industry/MS | S |
| 41. Set research priorities aligned with the green transition, exploring topics such as clean energy-powered vehicles, material science, additive manufacturing, green fuels, and renewable and low | Industry/MS/EU | S/M/L |

| Action | Actors | Timeframe |
|---|---|---|
| carbon energy to encourage innovation in line with sustainability goals. | | |
| 42. Actively coordinate with Member States and the Commission to access procurement cooperation budgets. | Industry/MS/EU | S |
| 43. Make use of the possibilities offered through the Technical Support Instrument (TSI) to design and implement reforms in the area of green and digital transition | MS/ EU | S/M |
| 44. Embrace Open Innovation as a collaborative approach to innovation involving the sharing and integration of external ideas, technologies, and expertise to boost the development of aerospace products and services. | Industry/EU/MS | M |
| 45. Upgrade manufacturing and technology chains encouraging faster production cycles, improved capabilities, quicker time to market, and improved long-term competitiveness. | Industry/MS | S/M |
| 46. Building on the example of IRIS², explore possibilities to advance in connectivity technologies, such as telecommunication satellites and space relay networks, to ensure ubiquitous, secure, and reliable networks for various applications.<br>Promote an active implication of both public and private sectors, conducive to maintaining EU leadership role in this area. | Industry/MS/EU | S |

# 9. SOCIAL DIMENSION

The green and digital transition will continue to have a major impact on the ecosystem's labour market and workforce. This will be felt at every stage of the production process that needs to become more adapted to green and digital requirements. The impact of smart technologies and technological development also increases the need for experts in an ecosystem which already relies strongly on a specialised workforce. Therefore, it is important to pay attention to how this transition takes place and ensure that the social fabric is not affected, and that people are not left behind. A successful transition of the ecosystem also means a **successful social transition** to be achieved through regular dialogue and coordination among relevant stakeholders, with the participation of social partners and the application of instruments such as the Just Transition Fund.

The co-creation pointed to the fact that the strategic character of the ecosystem is not always well understood by the broader public. The EU's space activities are not known enough, the aeronautics sub-sector is often only seen as generating pollution, and its efforts to decarbonise are not fully understood. Stakeholders highlighted the need for **better communication**, **more transparency** and **improved outreach** to the public on the ecosystem's role and actions.

Targeted communication is also needed to inform workers on the impact of new technologies on their everyday work, especially those related to digital and the use of AI.

## 9.1 Skills

Stakeholders pointed to the fact that the green and digital transition is **already creating new types of jobs**, and this will further accelerate. In the aeronautics sector, steps have been taken to reshape profiles and recruitment of new members of the workforce. New jobs were created around the development of hydrogen-powered and (hybrid) electric aircraft and supporting infrastructure. Beyond research and production, these new systems require the creation of skills across the teams which operate, service and guarantee the safety of these aircraft. This process needs to be continued and improved. **New skills** in the aerospace industries are needed, and they are needed in real-time, triggered by the rapidly evolving technological landscape. Stakeholders felt that green skills were easier to acquire than those related to digital transition, data management or AI. In the digital sector, a wide range of required future skills has been identified, including on cybersecurity, robotics, data generation, information technologies, and data analysis/data application.

Both in the aeronautics and space areas, the need for workforce will increase. Civil aviation witnesses a revival after COVID-19, leading to good sales prospects in the **aeronautics** industry so far. In the **space** sector, the emergence of the new space, new technologies, industrial processes, business models, market and policy trends, coupled with EU priorities to drive fair green, digital and resilient transitions, also require new skills and a qualified and available workforce. Some concern was also expressed with this trend, as sometimes jobs created by smaller firms or startups are not secure, given the increased risk these firms face in continuing or expanding their activities. Combined with an economic crisis and competition

with other hi-tech sectors that rely on similar expertise, this trend could lead to substantial dismantlement of the ecosystem's workforce.

Stakeholders highlighted that there is a pressing need to have a **better understanding of the shortages** and establish an **analysis of the needs and requirements** of the market, with the active involvement of industries, Member States, social partners and academia.

Several proposals to create a successful holistic strategy[80] to promote and boost skills at various levels have been made.

- **Education phase**: sharing knowledge about aeronautics and space at school at early stages; developing dedicated aeronautics and space curricula at universities; developing specific teaching modules on clean aviation in the lifelong learning process; promoting the two sectors as a career pathway.
- **Targeted short-term trainings and dedicated courses:** providing the industry with the required specialists in real time.
- **Upskilling / reskilling of the existing workforce**: needing around 200 000 people over the next 5 years (see the Large-Scale Partnership for the Aerospace and Defence ecosystem). However, needs can evolve swiftly so preparedness is needed. Only joint efforts from industry and Member States can bring results.
- **Direct dialogue:** encouraging dialogue among industries, universities and schools.
- **Implementation of Member States' national strategies:** ensuring that Member States have national strategies dedicated to the development of competencies and skills that can benefit the ecosystem.
- **Awareness raising and better communication**: increasing public awareness of the benefits of pursuing a career in the ecosystem, for instance by raising awareness about opportunities for 'green' careers in aeronautics.

In this context, the Large-Scale Partnership for the **Aerospace and Defence** ecosystem under the Pact for skills is important and maintains its relevance for the ecosystem. Its implementation is supported by stakeholders. However, there is a need to **increase its level of ambition** in an effort to implement it through meaningful measures, building amongst others on the achievements of the ASSETS+[81] Erasmus Blueprint. Identifying future skills, creating new training programmes, and understanding the value of the Pact are relevant for the future work of stakeholders in the partnership. In the **space** sector, the successful initiative Space4GEO[82], including a Large-Scale Partnership under the Pact for Skills underpinned by an Erasmus Blueprint, should be continued and further developed.

In addition, the recent Commission blueprint for a European degree[83] to facilitate the recognition of higher education diplomas is of relevance for the ecosystem. The ecosystem

[80] See for instance IndustriAll paper: Urgency to invest in workers, training and quality jobs to loosen the tight labour market and meet the shortages - EN.pdf (industriall-europe.eu).

[81] Alliance for Strategic Skills addressing Emerging Technologies in Defence - ASSETs+ project (assets-plus.eu).

[82] SPACE4GEO – A large-scale Skills Partnership for the space sector dedicated to data, services and applications.

[83] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions a blueprint for a European degree (europa.eu).

can contribute to shaping future harmonisation and recognition of diplomas through active participation in the next steps proposed by this initiative.

Stakeholders noted that the surrounding environment is competitive, and other ecosystems are looking for the same skills. Retaining skills is **particularly important for SMEs**, which, compared to larger companies, have more difficulties attracting and retaining talent. This comes in addition to resource constraints, difficulties in obtaining and using emerging technologies, and sometimes a lack of awareness of available training programmes. SMEs need more support, and this can be provided through collaborative platforms in which the Member States should also participate and support.

The ageing of the space-related workforce is also an issue, as according to Eurospace 2021 Industry survey[84], most of the space workforce are between 49 and 58 years old.

## 9.2 Ensuring fairness, diversity and inclusion

A diverse workforce boosts the overall effectiveness, resilience, and ethical considerations of digital and green transitions. By encouraging an inclusive environment, organisations can tap into a wide range of perspectives and talents that contribute to the success and sustainability of these transitions.

Making the twin transition fair and inclusive can make its acceptance easier and gender-diverse companies are more likely to have above average profitability. More diverse workforce also has an impact in penetrating new markets.

Therefore, the successful green and digital transition of the ecosystem relies not only on skills, but also on ensuring **diversity of the workforce across the ecosystem**.

The ecosystem has historically had difficulties in achieving diversity among its ranks. For example, women represent less than 25% of the European space workforce[85]. A high proportion of professionals in the ecosystem who have disclosed having suffered from gender-based discrimination at work are women[86].

Promoting **diversity and inclusion** in the aerospace sector requires a proactive and comprehensive approach that goes beyond the existing legal requirements. Organisations can establish measurable diversity goals, implement training programmes, and encourage mentorship initiatives. Diverse recruitment strategies, inclusive leadership development, and employee resource groups support a varied talent pool. Flexible work policies and inclusive communication contribute to a balanced and welcoming environment. Supplier diversity, community engagement, and regular audits further enhance inclusivity. It is essential to recognise and reward inclusive efforts, ensure transparency, and to work across sectors. By adopting these actions, organisations can create an inclusive and innovative workplace, encouraging a positive culture and attracting diverse talent.

[84] Eurospace Facts & Figures - Eurospace.
[85] Data from Eurospace, 2022.
[86] DEFIS survey on equality, diversity and inclusion of the ASD ecosystem: https://defence-industry-space.ec.europa.eu/equality-diversity-and-inclusion-aeronautics-defence-and-space-industries_en.

Fairness, diversity and inclusion are seen as areas where the Commission has a role in advancing a forward-looking agenda and acting as a catalyst for better results.

The following actions have been identified as priorities to ensure the ecosystem's **social transition.**

| Action | Actors | Timeframe |
|---|---|---|
| **Relevant for aeronautics and space** | | |
| 47. Proactively engage in identifying emerging trends, technological advancements, and changing job roles to anticipate the skills that will be in demand, including entrepreneurship.<br>Identify and submit proposals for specific trainings and identify jointly with academia and research institutes best methods to put these into practice. | Industry/MS/ EU | S/M |
| 48. Improve working conditions, compensation, and job satisfaction while engaging in a social dialogue to boost labour retention, reduce recruitment expenses, and maximise returns on training investments. | Industry/MS/EU | S |
| 49. As part of a wider effort to communicate about the specificities of the ecosystem, collaborate with educational institutions, engaging in industry-academia partnerships to communicate skill needs and align educational programmes with industry requirements.<br>Contribute to ensuring targeted education from an early stage in the education process. | Industry/MS/EU | S |
| 50. Actively implement and increase the level of ambition of the Large-Scale Partnership for the Aerospace and Defence ecosystem under the Pact for skills, to address skills gaps, including by promoting continuous training and upskilling. | Industry/MS/ EU | S/M |
| 51. Promote specialisation of workforce through short-term trainings and dedicated education courses according to the industry's needs. To this end, identify relevant initiatives at university level across the EU.<br>Leverage inspirational success stories to attract new talent, showcasing the advantages of a career in the high-tech and strategic industry. | Industry/MS/EU | S |
| 52. Collaborate within the ecosystem to create and support reskilling programmes, ensuring a skilled and adaptable workforce. | Industry/MS | S/M |

| Action | Actors | Timeframe |
|---|---|---|
| 53. Promote fairness, diversity, and inclusion by implementing dedicated recruiting and retention strategies.<br><br>Create measurable diversity goals and a varied talent pool by offering innovative training programmes, flexible work policies, ensuring transparency, improved communication and interaction.<br><br>Establish regular audits.<br><br>Promote marketing recruitments campaigns presenting the benefits to have a career in the ecosystem that encourages the participation of women, young people and underrepresented groups. | Industry | S/M |

# 10. MONITORING AND CO-IMPLEMENTATION

The publication of the transition pathway marks the start of the **co-implementation phase**, which will involve all interested stakeholders from the industry, Member States and EU institutions.

A **call for commitments** will be launched on all the blocks and identified actions of the pathway. Stakeholders will be invited and encouraged to present their commitments.

The European Commission will facilitate the co-implementation, in cooperation with stakeholders, by taking stock of commitments and progress made.

To facilitate the commitment process, this transition pathway will benefit from the **Transition Pathway Stakeholder Support Platform**, a user-friendly, multilingual platform to facilitate the collaboration of all interested stakeholders.

Stakeholders are invited to make **extensive use of this platform**, submit commitments, exchange data and best practices, present initiatives and implement the identified priority actions.

The **EU Industrial Forum**, which oversees the transition pathways of all industrial ecosystems, will also be regularly updated on the progress of this transition pathway.

# ANNEX A. FUNDING PROGRAMMES

**Table 1: Overview of EU funding programmes with relevance for the aerospace ecosystem**

| 2021-2027 Funding programmes | Focus | MFF[87] (EUR bn) | NGEU[88] (EUR bn) | Total (EUR bn) |
|---|---|---|---|---|
| Horizon Europe[89] | Research and innovation, including space-specific funding opportunities[90]. | 86.1 | 5.4 | 91.5 |
| InvestEU[91] | Sustainable investment, innovation and job creation in Europe. | 3.1 | 6.1 | 9.2 |
| Digital Europe programme[92] | Bringing digital technology to businesses, people and public administrations. | 7.6 | - | 7.6 |
| LIFE programme[93] | Environmental objectives and climate action. | 5.4 | - | 5.4 |
| ERASMUS+ programme[94] | Education and young people. | 24.6 | - | 24.6 |
| Single market programme (SMP)[95] | A well-functioning, sustainable single market. | 4.2 | - | 4.2 |
| Innovation Fund (IF)[96] | Support for innovation in low-carbon technologies and processes. | 38.0 | - | 38.0 |
| Recovery and resilience facility[97] | Mitigating effects of the COVID-19 pandemic and boosting the resilience of European economies and societies. | - | 723.8 | 723.8 |
| European Regional Development Fund (ERDF) and Cohesion Fund[98] | Funding to public and private bodies in EU regions to reduce economic, social, and territorial disparities, including for research and development in the aerospace sector (if identified as priority in the national and regional programme). | 274.0 | - | 274.0 |

87 Multiannual financial framework
88 NextGenerationEU
89 Horizon Europe the EU's funding programme for research and innovation (europa.eu)
90 DEFIS_B2_existing_opportunities.pdf (europa.eu)
91 Home - European Union (europa.eu)
92 The Digital Europe Programme | Shaping Europe's digital future (europa.eu)
93 LIFE - European Commission (europa.eu)
94 What is Erasmus+? | Erasmus+ (europa.eu)
95 Overview - European Commission (europa.eu)
96 What is the Innovation Fund? - European Commission (europa.eu)
97 Recovery and Resilience Facility - European Commission (europa.eu)
98 Inforegio - European Regional Development Fund (europa.eu); Multiannual Financial Framework 2021-2027 (in commitments) - European Commission (europa.eu)

| 2021-2027 Funding programmes | Focus | MFF[87] (EUR bn) | NGEU[88] (EUR bn) | Total (EUR bn) |
|---|---|---|---|---|
| Just Transition Fund (JTF)[99] | Support for the regions most affected by the transition towards climate neutrality. | 8.5 | 10.9 | 19.4 |
| European Social Fund Plus (ESF+)[100] | Support for jobs and creation of a fair and socially inclusive society. | 99.3 | - | 99.3 |
| European Defence Fund (EDF)[101] | Support for collaborative defence research and development in order to foster an innovative and competitive defence industrial base. | 8.0 | - | 8.0 |

[99] Just Transition Fund - European Commission (europa.eu); JTF: Leaving no region behind in the climate transition | Data | European Structural and Investment Funds (europa.eu)

[100] European Social Fund Plus (europa.eu)

[101] The European Defence Fund (EDF) - European Commission (europa.eu)

# ANNEX B. LIST OF ACTIONS

| No. | Action | Actors | Timeframe |
|---|---|---|---|
| **REGULATION and PUBLIC GOVERNANCE** | | | |
| 1. | Continue dialogue and exchanges with stakeholders in order to identify and reduce regulatory burdens and make legislation and regulation simpler and easier to understand by the ecosystem's players. | EU/MS/Industry | S/M |
| 2. | Support SMEs and smaller firms to participate in collaborative platforms and to fully benefit from all the opportunities linked to the ecosystem transformation, including in terms of access to funding at EU, national, regional and local levels.<br>Encourage active involvement of research institutes and academia in collaborative platforms together with industries. | EU/MS/Industry | S/M |
| 3. | Facilitate sharing best practices and sustainability reporting guidance with smaller suppliers to ensure compliance with relevant national and EU regulations, encouraging environmentally sound practices across the supply chain. | Industry/EU/MS | S |
| **RESILIENCE** | | | |
| **Relevant for aeronautics and space** | | | |
| 4. | Establish redundancies in production capacity and stockpiles, especially in critical systems such as satellite components, advanced avionics, propulsion technologies, and secure communication systems, to allow efficient response in case of need.<br>Work to create the necessary market to ensure that the production is sustainable. | MS/EU/Industry | S/M |
| 5. | Recognise the vulnerability of current sourcing practices, actively diversify the critical raw materials (CRMs) sources and promote stockpiling to reduce dependence on a single supplier and mitigate risks associated with supply chain and geopolitical dynamics.<br>Continue to streamline the ecosystem in the implementation of the European economic security strategy. | Industry/MS/EU | S |
| 6. | Perform audits of the supply chains, including: (a) mapping of where the strategic raw materials used are extracted, processed or recycled; (b) stress test of the supply chain of strategic raw materials, consisting of an assessment of its vulnerability to supply disruptions by | Industry/EU | S/M |

| No. | Action | Actors | Timeframe |
|---|---|---|---|
| | estimating the impact of different scenarios that may cause such disruptions and their potential effects.<br>Participate in strengthening supply chains and early warning mechanisms for supply chain disruptions.<br>Use tools like the EU Observatory of Critical Technologies (OCT) to inform and coordinate future actions. | | |
| 7. | Improve supply chain resilience by supporting SMEs and smaller firms within supply chains, promoting collaboration, and ensuring the stability of key actors. | Industry/EU/MS | S |
| 8. | Innovate in export controls by using technologies such as distributed ledgers to strengthen supply chain control, prevent corruption, and facilitate transparent reporting of export control processes. | Industry/EU/MS | S/M |
| 9. | Plan for temporary and permanent contingencies in the face of potential asset loss, involving rapidly replacing damaged systems and implementing corporate crisis management exercises to boost business security and resilience. | Industry | S/M |
| 10. | Exercise caution and careful consideration when investing in initiatives abroad, particularly those involving dual-use technologies, to avoid losing control over projects or technologies. | Industry/MS/EU | S |
| **Space focus** | | | |
| 11. | Support the shaping of the EU approach on launching capabilities by actively following and participating in proposed next steps. | Industry/MS/EU | S/M |
| 12. | Adopt and support emerging solutions for space situational awareness (SSA) or space traffic/debris management (STM/SDM) to contribute to minimising space debris and ensuring a safer environment for space activities. | Industry/MS/EU | S |
| 13. | Ensure the availability of critical assets (such as EO, GNSS and SSA) by promptly sharing data with appropriate authorities, facilitating effective management of situations that could undermine European security. | Industry | S/M |
| **GREEN TRANSITION** | | | |
| **Relevant for aeronautics and space** | | | |
| 14. | Actively embrace sustainable aviation fuels (SAFs) and novel propulsion technologies to reduce climate impact of emissions (including non-$CO_2$) and support the transition to greener air transport (for instance through implementation of the recommendations of the Alliance for Zero-Emission Aviation- AZEA). | Industry/MS/EU | S/M/L |

| No. | Action | Actors | Timeframe |
|---|---|---|---|
| 15. | Conduct assessments of value chain sustainability, utilising tools like life cycle assessments (LCA) with an economic, environmental, and social focus to identify opportunities for optimisation in the context of circular economy principles. | Industry/MS | S |
| 16. | Recognise sustainability as one of priorities during product design and subsequent stages, recognising that a significant share of a product's environmental impact is determined during these pivotal stages. | Industry/EU | S |
| 17. | Strategically consider recycling viability in design choices from the outset, ensuring materials can be successfully recovered for circular economy practices. | Industry/MS/EU | S |
| 18. | Design products for reuse or retrofitting existing systems ( such as refuelling of satellites or green retrofitting of aircraft) showcasing innovation possibilities, offering opportunities for stable revenue streams through models like X-as-a-service or through-life engineering services. | Industry/MS | S |
| 19. | Adopt a strategic, integrated circular approach to products' lifecycles across the ecosystem, incorporating principles of sharing, leasing, reusing, repairing, refurbishing, and recycling to optimise resource utilisation and reduce environmental impacts. | Industry/MS/EU | S/M |
| 20. | Actively support or contribute to research into quantifying the impacts of different waste management practices and disposal solutions, fostering a better understanding of environmental consequences. | Industry/MS/EU | M |
| 21. | Identify and reduce hotspots in energy and water consumption by improving efficiency and reducing waste. | Industry/MS/EU | S/M |
| 22. | Embrace renewable and low-carbon energy sources, as initiated by the REPowerEU programme, to contribute to achieving a greener and more resilient ecosystem.<br>Explore possibilities to increase hydrogen production and utilisation. | Industry/MS/EU | S/M |
| 23. | Prioritise purchasing EU-produced, green-by-design components to support environmental compliance and advance the aerospace green transition. | Industry/MS/EU | S |
| 24. | Embrace a paradigm shift by recognising sustainability not as an obstacle but as an opportunity. Cultivate a mindset of continuous improvement, encourage collaborative innovation, adopt green technologies, and set metrics for on-going environmental impact assessment. | Industry/MS | M |
| **DIGITAL TRANSITION** | | | |
| **Relevant for aeronautics and space** | | | |
| 25. | Contribute to digitalisation efforts by exclusively engaging with digital services that meet EU data sovereignty | Industry | S |

| No. | Action | Actors | Timeframe |
|---|---|---|---|
| | principles, ensuring sensitive data remains within the EU's jurisdiction and control. | | |
| 26. | Implement robust cybersecurity measures throughout the life cycle of aerospace products, from the manufacturing phase till end-of-life to mitigate the risks associated with cyber-physical threats.<br>Strengthen European autonomy in Electrical, Electronic and Electro-mechanical (EEE) components. | Industry/MS/EU | S/M/L |
| 27. | Carefully assess foreign direct investment in cybersecurity related systems and structures. | Industry/MS/EU | S/M/L |
| 28. | Adopt new standards wisely, considering potential risks and benefits when transitioning from conventional public key encryption to post-quantum algorithms. | Industry/MS/EU | S/M/L |
| 29. | Invest in developing skills and capabilities in quantum computing, either in-house or through collaborations, to harness the potential of quantum computers for specific tasks within the sectors. | Industry/MS/EU | S/M |
| 30. | Develop hardened communication systems and assess dependence on connectivity, conducting exercises with limited connectivity to identify and manage vulnerabilities in operations. | Industry/MS/EU | S/M |
| 31. | Integrate IoT sensors for real-time monitoring and predictive maintenance.<br>Leverage digital twins and model-based systems engineering to streamline prototyping, reduce development time, and elevate overall efficiency in line with GDPR and data protection standards. | Industry/MS | S/M |
| **Space focus** | | | |
| 32. | Explore and promote innovative applications based on space data, including Copernicus and Galileo, for various end user purposes, expanding the utility of space assets. | Industry/EU | S |
| 33. | Actively participate in initiatives such as the EU Space programme's space surveillance and tracking (EUSST) and EU Industry and Startups Forum (EISF) to contribute to a European SST commercial sector. | Industry/MS | S/M |
| **SUSTAINABLE COMPETITIVENESS** | | | |
| **Relevant for aeronautics and space** | | | |
| 34. | Anticipate global supply chain challenges by aligning procurement frameworks with emerging European | Industry/MS/EU | S |

| No. | Action | Actors | Timeframe |
|---|---|---|---|
| | capabilities, as encouraged by initiatives such as the EU Chips Act or the Zero-Net Industry Act (NZIA). | | |
| 35. | Make use of all R&D funding programmes and facilities, industrial alliances and instruments.<br>Coordinate to identify priorities in view of future EU funding schemes and programmes. | Industry/MS/EU | S |
| 36. | Harness cooperation clusters and promotion of regionally coordinated consolidated demand initiatives. | MS/EU | S |
| 37. | Encourage and facilitate stakeholders' dialogue with the financial sector actors to ensure easier access to financing. | EU | S/M |
| 38. | Ensure continued guidance around better the EU taxonomy rules and, in this framework, continue to support investments in green innovative technologies in the two components of the ecosystem. | EU | S/M |
| 39. | Safeguard critical technologies and equipment by establishing solid partnerships with like-minded governments to navigate market complexities.<br>Associate at EU regional level and beyond to develop cooperation in this area. | Industry/MS | S |
| 40. | Swiftly integrate R&I results and supporting infrastructure, such as liquid hydrogen airport hubs, into operational capabilities, encouraging a dynamic synergy between research advancements and real-world applications to boost industry agility and competitiveness. | Industry/MS | S |
| 41. | Set research priorities aligned with the green transition, exploring topics such as clean energy-powered vehicles, material science, additive manufacturing, green fuels, and renewable and low carbon energy to encourage innovation in line with sustainability goals. | Industry/MS/EU | S/M/L |
| 42. | Actively coordinate with Member States and the Commission to access procurement cooperation budgets. | Industry/MS/EU | S |
| 43. | Make use of the possibilities offered through the Technical Support Instrument (TSI) to design and implement reforms in the area of green and digital transition | MS/ EU | S/M |
| 44. | Embrace Open Innovation as a collaborative approach to innovation involving the sharing and integration of external ideas, technologies, and expertise to boost the development of aerospace products and services. | Industry/EU/MS | M |
| 45. | Upgrade manufacturing and technology chains encouraging faster production cycles, improved capabilities, quicker time to market, and improved long-term competitiveness. | Industry/MS | S/M |

| No. | Action | Actors | Timeframe |
|---|---|---|---|
| 46. | Building on the example of IRIS², explore possibilities to advance in connectivity technologies, such as telecommunication satellites and space relay networks, to ensure ubiquitous, secure, and reliable networks for various applications.<br>Promote an active implication of both public and private sectors, conducive to maintaining EU leadership role in this area. | Industry/MS/EU | S |
| **SOCIAL DIMENSION** | | | |
| **Relevant for aeronautics and space** | | | |
| 47. | Proactively engage in identifying emerging trends, technological advancements, and changing job roles to anticipate the skills that will be in demand, including entrepreneurship.<br>Identify and submit proposals for specific trainings and identify jointly with academia and research institutes best methods to put these into practice. | Industry/MS/ EU | S/M |
| 48. | Improve working conditions, compensation, and job satisfaction while engaging in a social dialogue to boost labour retention, reduce recruitment expenses, and maximise returns on training investments. | Industry/MS/EU | S |
| 49. | As part of a wider effort to communicate about the specificities of the ecosystem, collaborate with educational institutions, engaging in industry-academia partnerships to communicate skill needs and align educational programmes with industry requirements.<br>Contribute to ensuring targeted education from an early stage in the education process. | Industry/MS/EU | S |
| 50. | Actively implement and increase the level of ambition of the Large-Scale Partnership for the Aerospace and Defence ecosystem under the Pact for skills, to address skills gaps, including by promoting continuous training and upskilling. | Industry/MS/ EU | S/M |
| 51. | Promote specialisation of workforce through short-term trainings and dedicated education courses according to the industry's needs. To this end, identify relevant initiatives at university level across the EU.<br>Leverage inspirational success stories to attract new talent, showcasing the advantages of a career in the high-tech and strategic industry. | Industry/MS/EU | S |
| 52. | Collaborate within the ecosystem to create and support reskilling programmes, ensuring a skilled and adaptable workforce. | Industry/MS | S/M |

| No. | Action | Actors | Timeframe |
|---|---|---|---|
| 53. | Promote fairness, diversity, and inclusion by implementing dedicated recruiting and retention strategies.<br><br>Create measurable diversity goals and a varied talent pool by offering innovative training programmes, flexible work policies, ensuring transparency, improved communication and interaction.<br><br>Establish regular audits.<br><br>Promote marketing recruitments campaigns presenting the benefits to have a career in the ecosystem that encourages the participation of women, young people and underrepresented groups. | Industry | S/M |

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