Up2Circ – Boosting the Uptake of Circular Business Model, Product and Process Innovation

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Sectorial Catalogue: Aerospace and Defence

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Short Introduction to Aerospace and Defence Industries

According to New Industrial Strategy of EU, 14 industrial ecosystems spanning across the EU have been identified based on their economic and technological relevance, and for their expected contribution to the decarbonisation, digitalization and resilience of the EU economy. They represent approximately 70% of the EU economy and 80% of the business economy (as a share of value added). Aerospace and Defence sector is considered as one of these sectors.[1] To achieve climate neutrality, the European Green Deal sets out the need to reduce transport emissions by 90% by 2050 (compared to 1990-levels). The aviation sector will have to contribute to the reduction.

The sector, including companies in **Aeronautics, Space and Defense, Space Operators and Data and Service Providers**, plays a critical role in global technological advancement, mobility, national security, and economic growth. However, the sector also generates substantial waste and environmental impact through resource-intensive production processes, emissions, and disposal of end-of-life products. In the context of the growing awareness of environmental sustainability and resource scarcity, transitioning towards a circular economy is imperative for the industry.

A circular economy approach promotes the reduction of waste, optimal resource utilization, and the maximization of product lifecycles. It emphasizes principles such as product reuse, recycling, remanufacturing, and the design of products with the ability to be easily disassembled and recycled. By adopting a circular economy model, the Aerospace and Defence sector can unlock opportunities for sustainability, cost-efficiency, innovation, and long-term resilience.

This sectoral catalogue aims to explore the opportunities and challenges presented by the application of circular economy principles in the Aerospace and Defense industry. It will analyze the potential benefits of embracing a circular economy approach, including resource efficiency, reduced waste, enhanced competitiveness, and the positive environmental impact. Additionally, it will highlight the obstacles that organizations within this sector might face, such as technological constraints, regulatory compliance, and cultural shifts. Ultimately, this catalogue aims to provide insights that can guide stakeholders in making informed decisions for a sustainable and circular future in the aerospace and defence sector.

Key characteristics:

- Relatively small in economic numbers in EU – 376 BEUR, 1.5M employees, 44 000 companies, 1,6% EU value-added
- Strategically important
- Globally competitive EU companies with complex supply chains
- High-tech, R&D intensive
- Largest companies in EU: Airbus (NED/FRA), Safran (FRA), Thales Alenia Space (FRA), Leonardo (ITA), Saab (SWE) and Rheinmetall (GER) (https://people.defensenews.com/top-100)

Source: DG DEFIS presentation at European Cluster Conference 2020[2]

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021SC0351

[2] https://clustercollaboration.eu/sites/default/files/2021-02/ecosystem-aerospace-defence.pdf

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Challenges for the sector regarding sustainability demands

Below in the table there are key challenges of the sector based on EU working document for resilient, sustainable and digital aerospace and defence industrial ecosystem, that is mapping scenarios for transition pathway.[3]

Challenge Category	Description
Global Supply Chains	The sector has experienced disruptions in global supply chains due to geopolitical issues like Russia's aggression against Ukraine, and the COVID-19 pandemic, resulting in price hikes, increased costs, and unreliable supply of materials.
Workforce Availability	The unavailability of a skilled workforce has been a significant challenge, impacting the sector's ability to ramp-up production and meet order demands.
Economic Impact	The pandemic has caused substantial economic losses with turnovers reducing significantly across aeronautics, defence, and space segments. Additionally, cash-flow shortages and global supply chain disruptions have affected the sector.
Production Challenges	The aeronautics industry faces difficulties in ramping up production rates due to supply chain disruptions, inflation, labour shortages, and sourcing issues, such as acquiring raw materials like Titanium.
Investment & Finance	After years of underinvestment, the defence industry faces challenges in ramping up production and adjusting to structural changes. Access to finance remains a limiting factor for companies in the defence sector.
Geopolitical Dependencies	EU's geographical proximity to conflict zones and heavy reliance on gas imports from Russia expose it to additional risks. The conflict also has direct implications on aerospace industry through sanctions and airspace restrictions.
Technological Advancements	The need for advancing in areas of joint procurement and technological bases to strengthen the European defence industry.
Energy Prices	Rising energy prices, exacerbated by geopolitical tensions, impact the highly energy-intensive aerospace and defence manufacturing, affecting their profitability and cash flows.
Strategic Autonomy	The events have underscored the need for the EU to enhance its strategic autonomy, particularly in reliable and cost-effective access to space, secure connectivity, and overcoming dependencies on non-EU entities.
Innovation & Resilience	The sector should focus on accelerating innovation, attracting new players, supporting scaling up, and enhancing resilience to overcome identified vulnerabilities and strategic dependencies.

The aerospace and defense sector faces several significant challenges when it comes to meeting the sustainability demands posed by the global shift towards environmental responsibility and circular economy

[3] https://defence-industry-space.ec.europa.eu/system/files/2023-07/SWD_2023_280_1_EN_document_travail_service_part1_v3.pdf

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principles. These challenges encompass various aspects, including technological barriers, regulatory frameworks, supply chain complexities, and cultural shifts within the industry. Compared to US and China, EU is supporting the industry less**, thus the long-term competitiveness of the sector is under constant pressure.**

The advancement and integration of sustainable technologies in aerospace and defense systems often pose considerable challenges. Innovations in sustainable materials, energy-efficient propulsion systems, and recyclable components **require substantial investments** into research and development. The transition to new technologies also necessitates retraining the workforce and addressing intellectual property concerns, which can slow down the adoption of sustainable practices.

Additionally, Aerospace and Defense sector operates within a highly regulated environment due to **safety, security, and environmental concerns**. Meeting sustainability demands involves aligning with an evolving set of stringent environmental regulations at both national and international levels. Compliance with these regulations requires substantial financial investments, alterations in existing manufacturing processes, and continuous monitoring to ensure adherence.

The **complexity of the aerospace and defense supply chain**, which involves numerous components and suppliers globally, adds to the challenge of adopting a circular economy model. Coordinating efforts across the supply chain to incorporate sustainable practices, ensuring traceability of materials, and managing end-of-life product recovery in a consistent and sustainable manner is an intricate task.

Regarding **other environmental challenges**, COVID impact provided a blow to the commercial airline industry as well as the defence sector. From around 29 000 aircrafts in commercial sector, more than 16 500 were grounded during COVID, leading to airline bankruptcies. Aircraft production fell as a result. The sector is recovering slowly, as COVID had an impact on the entire ecosystem. In the defence sector, COVID caused fall in the defence spending in EU and there was a reduction in export demand as well. However, since Russia attacked Ukraine in 2022, the defence spending is rising rapidly across EU.

Overall, shifting towards a circular economy requires a change in organizational culture, mindset, and stakeholder engagement. This involves educating and involving employees, suppliers, and customers in understanding the value and benefits of sustainable practices. Overcoming resistance to change and fostering a culture of sustainability is vital for successful integration of circular economy principles within the sector. Addressing these aforementioned challenges and fostering a proactive approach to sustainability within the sector is essential to meet the demands of a rapidly evolving global landscape and to create a more sustainable and resilient future.

CE opportunities for the sector

Embracing circular economy principles within the Aerospace and Defense sector offers a multitude of opportunities that can lead to sustainable growth, reduced environmental impact, and increased competitiveness. By rethinking product design, material usage, manufacturing processes, and end-of-life strategies, organizations can unlock these opportunities and make substantial contributions to a circular economy.

Forward-looking assessment from the New Industrial Strategy of EU states, that the EU Aerospace and Defence industry is currently highly competitive on the global market but needs a stronger investment capacity to continue the development of the disruptive technologies necessary to deliver on the green deal (the greening of aviation) and address digital challenges of Europe. It also requires a less fragmented home market in defence and space.

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From the EU **legislative perspective**, the New Industrial Strategy proposes supportive regulatory environment to support the sector in circularity efforts, incl.

- Reducing Single Market barriers to open up defence supply chains, e.g. Directives on Defence and Sensitive Security Procurement (Directive 2009/81/EC) and on intra-EU transfers of defence-related products (Directive 2009/43/EC).

- Developing hybrid civilian-military standards to reduce cost burden for EU industry.

- As the EU industry lacks a reliable and predictable home market for space and defence, in the form of large demanding anchor customers, strategic public procurements are key industrial policy tools on both EU as well as Member State level.

- For aeronautics, the transition to carbon-free aviation will proceed along multiple paths, including the introduction of sustainable aviation fuels, efficiency gains, more flexible routing and the introduction of new propulsion technologies (notably electric, hydrogen or emerging new sources of energy).

It is worth noting, the aircraft production industry has been working on standardising the recycling and material recovery processes for the end-of-life of products. https://www.icao.int/environmental-protection/Documents/EnvironmentalReports/2019/ENVReport2019_pg279-284.pdf

Below a few ideas to address the challenges and create opportunities on company scale:

Product Design for Reusability and Durability

Designing products with reusability and durability in mind is a fundamental aspect of a circular economy. In the Aerospace and Defense sector, this translates to creating aircraft, spacecraft, and defense systems with modular components that can be easily replaced, upgraded, or reused. A focus on designing for durability ensures a longer lifecycle for these products, reducing the need for frequent replacements and minimizing waste.

Best Practice: Modular Design

Implementing modular design principles allows for the interchangeability of components, reducing the overall waste generated and facilitating efficient maintenance, repair, and upgrade processes.

Material Recycling and Closed-Loop Supply Chains

Optimizing material usage and incorporating recycling into the supply chain can significantly reduce the sector's environmental footprint. The Aerospace and Defense industry can collaborate with material suppliers to promote closed-loop systems, where materials are continuously recycled and repurposed for new products. This can include recycling metals, composites, and other materials used in manufacturing.

Best Practice: Closed-Loop Aluminum Recycling

Aluminum is a widely used material in the Aerospace industry. Implementing closed-loop aluminum recycling involves collecting and reprocessing scrap aluminum from manufacturing processes and end-of-life aircraft to create new aluminum components, reducing the need for extracting raw aluminum.

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For example, according to a report by Airbus, 92% of an aircraft's total weight and more than 99% of its engine parts can be recycled. In the case of A320 aircraft, 92% of the total weight of the aircraft is recovered. The A320's airframe is composed mainly of aluminum and alu-Li alloys (72%) steel (9%) and titanium (6%). All these metals are recycled at the end of the aircraft's life. They will be valorised by specialised channels and once melted will be used to form new parts for non-aeronautical applications. Source: https://aircraft.airbus.com/en/newsroom/news/2022-11-end-of-life-reusing-recycling-rethinking

Remanufacturing and Refurbishment

Remanufacturing involves restoring used products to their original specifications or better, extending their lifecycle and reducing the demand for new manufacturing. In the Aerospace and Defense sector, remanufacturing components such as engines, can be a sustainable alternative to producing entirely new parts.

Best Practice: Engine Overhauls and Refurbishments

Engines are a significant component of aircraft and defense systems. Implementing a comprehensive engine overhaul and refurbishment program can extend the operational life of engines, reducing the need for new engine production and minimizing resource consumption. Use case example: ELS (NED, https://aels.nl) buys end-of-life aircraft, then carefully disassembles them and the removed parts are then placed in inventory, recertified and returned to the market.

Overview of tech-savvy SMEs that develop/offer solutions to increase circularity in the sector

According to New Industrial Strategy of EU[4], SMEs and start-ups represent an important part of the Aerospace and Defence ecosystem since they perform many niche, complex and innovative tasks in the manufacturing supply chain. In civil aeronautics, they represent more than 80% of all companies, providing, amongst others, high-tech material processing and engineering services. In addition, SMEs are strongly represented in the downstream space sector and New Space start-up companies are developing at a fast pace, where innovative applications are developed. Defence-related SMEs are also key enablers of innovation and growth of the defence sector as a whole. More than 2,500 SMEs play a central role in the complex defence supply chains across Europe.

Below just some examples relevant to the sector (will be updated with examples as the Up2Circ project proceeds).

ICEYE (https://www.iceye.com) Founded in 2014, ICEYE pioneered microsatellite radar imaging from space for real-time earth observation. Their constellation provides invaluable visibility day or night, through clouds, and independent of weather conditions. Key capabilities enabled by ICEYE's data include disaster response, maritime domain awareness, infrastructure monitoring, and detecting changes for defense applications. Their frequent coverage drives strategic decision making.

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021SC0351

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ZeroAvia (https://zeroavia.com) Founded in 2017, ZeroAvia develops hydrogen-electric power systems for aircraft to enable true zero-emissions flight. Their powertrains will first target smaller regional airplanes before advancing to narrow-body and larger aircraft over time. Key innovations include high-power fuel cell stacks, cryogenic hydrogen storage and refueling, and battery packs to supplement power. This proprietary system aims to match current jet fuel flight capabilities.

Nanoavionics (https://nanoavionics.com/) Founded in 2014 Kongsberg NanoAvionics is a small satellite mission integrator focused on delivering new generation satellite buses and their mission services for the satellite applications market. With facilities in North America and Europe, NanoAvionics' team consists of nearly 300 driven and skillful employees. We have over 120 successful satellite missions and commercial projects under our belt, and we are still counting.

Aurora Propulsion (https://auroraptfi/) Founded in 2018. Aurora propulsion specializes in miniature resistojet technology. Their product portfolio includes a device for any propulsion need, be it deorbiting, collision avoidance, attitude control, orbital control, or all of them combined in a single device. We also offer a thruster system which combines Hall-Effect and resistojet technologies, ideal for interplanetary missions.

Lilium (https://lilium.com/company) Founded in 2015. Lilium is developing sustainable, high-speed air mobility through its electric vertical take-off and landing aircraft, vertiports and digital service.

Neuraspace (https://www.neuraspace.com/company) In 2020, Neuraspace was founded with one purpose: fighting space debris with AI. Today we are another step closer to achieving our vision of a vibrant Circular Economy in Space, by empowering satellite operators, space agencies and other stakeholders to address Space Operations with AI, ensuring Space is both a Safe Environment and a Profitable Market.

Isar Aerospace (https://www.isaraerospace.com/about**)** Isar Aerospace was founded in 2018 to lower the entry barriers to space. By pushing the boundaries we are opening space as a platform for future technologies and competitiveness. As a launch service provider for small and medium-sized satellites we create easy access to space for global customers. Offering the first fully privately funded European solution to meet the growing global demand, Isar Aerospace is driving commercial space across all continents.

Links to sector specific online contents, including sector specific funding opportunities, further information sources and reports

Funding opportunities (will be updated during the Up2Circ project):

Horizon Europe - EU's key funding programme for research and innovation with a budget of €95.5 billion. It tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth. https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

Under Cluster 4 '**Digital, Industry and Space'**, topics on space can contribute to reducing strategic dependencies for strategic value chains; enhance the competitiveness of the EU space sector in fostering innovation and new technologies (New Space), and support start-ups (Cassini). The climate-neutral aviation objectives in Cluster 5 'Climate, Energy and Mobility' will support the development of a next generation of clean aircraft (ultra-high

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efficient, hybridelectric or hydrogen-powered aircraft). This will enable the European aeronautics industry to significantly contribute not only to achievement of the European Green Deal objectives but also to the greening of air transport worldwide.

Interreg programs – one of the key instruments of the EU supporting cooperation across borders through project funding. It aims to jointly tackle common challenges and find shared solutions in fields such as health, environment, research, education, transport, sustainable energy and more. https://interreg.eu

InvestEU programme (European Invest Bank) for highly risky projects with high policy added value eligible under the sustainable infrastructure and research, innovation and digitalisation policy windows. Top-up from Innovation Fund. https://investeu.europa.eu/index_en

Innovation Fund 2020 – 2030, 38 BEUR, Innovation in EII, reneweables, energy storage, carbon capture, use and storage, https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund_en

Further information sources and reports (will be updated during the Up2Circ project):

EU plans / transition pathway foreseen for each sector:

- https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021SC0351
- https://single-market-economy.ec.europa.eu/industry/transition-pathways_en

New Industrial Strategy for Europe
https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1593086905382&uri=CELEX%3A52020DC0102

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