Transitioning towards a circular economy

By International Aerospace Environmental Group (IAEG)

Overview and Importance of Circular Economy

A circular economy is an economic system that aims to minimise waste and maximise the use of resources, which contrasts with the «take-make-waste» production model of the traditional linear economy. In a circular economy, emphasis is placed on maintaining the circulation of products, materials, and resources and their highest value in the economy for as long as possible, and minimising waste and pollution through design, maintenance, repair, reuse, refurbishment, remanufacturing, and recycling.

These core principles can be very impactful for the aviation sector, which deals with durable goods made of high value materials and is subject to strict safety regulations. Transitioning towards a circular economy is crucial for addressing global sustainability challenges, in the context of resource-intensive industries like aeronautics.

Evolution of the Regulatory Landscape

The global relevance of circular economy is reflected in the increasing number of country and region-specific regulations aimed at ensuring supply security, reducing environmental footprint and advancing towards sustainability commitments. While the European Union adopts a regional approach, most regulations remain country or state specific. Many countries and regions have published general frameworks, roadmaps, and plans that are not industry specific. Key focus areas include material traceability, resource efficiency (e.g. waste reduction and recycling), extended producer responsibility, eco-design, and the introduction of key performance indicators. For instance, the European Sustainable Product Regulation (ESPR) emphasises traceability through digital product passports.

As regulations shift from waste management and recycling to extended producer responsibility and eco-design, there is an increased demand for data gathering and transparency. The international ISO 59000 series of standards on circular economy have been published, aiming to guide organisations to transition from a linear to a circular economy, thereby promoting sustainability and resource efficiency.

Future regulations may become more industry-specific, with concrete product demands such as digital product passports. However, a global and coherent framework on circular economy would mitigate the trend of over-regulation and simplify compliance for aerospace companies facing fragmented and specific regulations.

What Circular Economy Means for Aviation, Why It Matters, Current Status, and Perspectives of the Industry

Transitioning toward a more circular model will enhance the aviation industry's resilience amid supply chain challenges and resource shortages.

Unlike a linear economy, where resources are extracted, used, and disposed of, a circular economy maximises the value of existing materials, reducing reliance on newly extracted raw materials. This shift requires lifecycle thinking—from design and manufacturing to operation and end-of-life management—focusing on recycling aerospace-grade parts from decommissioned aircraft and manufacturing scrap. By using renewably sourced feedstocks, the aviation industry can globally lower its material costs while minimising the long-term need for mining and refining.

The shift toward circular economy principles also helps address supply chain challenges, particularly the sourcing of critical materials like titanium, rare earth elements. Geopolitical risks and increased competition for these limited resources make circular approaches necessary. The aviation sector can reduce dependency on scarce materials but transitioning to new materials requires retesting, recertification and quality assessments to meet safety standards and performance specifications.

Although there is not yet an industry roadmap associated with circular economy, some of its principles are well embedded in current practices of commercial aviation. Aircraft are long-lasting products, designed for more than twenty-five years and operated for more than twenty on average. Buy-to-fly ratios[1] are continuously optimised during design and manufacturing to reduce the generation of scraps[2]. The recycling of manufacturing scraps is developed for critical metals and partially for composites, and the reuse of spare parts is a key contributor to the business model and a growing market (projected to double by 2032 to reach up to USD 93.5 billion[3]). Recovery rates at the end-of-service can go beyond 90%[4] for aircraft types currently being retired, which have a high proportion of metals in their structure. However, most materials, including high-value aeronautical grade metals, are downcycled and routed to other industries.

Existing industry efforts such as the Maintenance, Repair, and Overhaul (MRO) and the spares market can be leveraged today to advance circular economy in aviation. MRO providers extend the lifecycle of aircraft and components reducing the need for new materials, while the spares market offers refurbished parts that ease sourcing difficulties. Expanding MRO services supports a circular approach by increasing resource efficiency, enhancing supply chain resilience, and ensuring critical parts stay in circulation for longer. Pursuing efforts in eco-design is also crucial, building on the lessons learned from aircraft end-of-service treatment to ease disassembly, dismantling and recycling.

Many developing areas could further drive the sector's transition, making it more resilient and profitable: digitalisation, additive manufacturing, and modelling support circular economy practices by improving product design and manufacturing, traceability, and lifecycle management. Practices like products as a service and virtualisation (digital twins) extend product value through the engineering, testing, and customer support phases.

The aviation industry would also benefit from increased investments and technological developments to support its transition. Digital mock-ups could facilitate the dismantling of aircraft, where digital passports would significantly improve material traceability. Developing materials from circular feedstocks (such as materials with increased recycled content) could reduce dependency on finite materials. Composites, which are crucial to reduce aircraft weight and reduce emissions, would benefit from advanced recycling techniques to preserve material properties for remanufacturing. Augmented reality and virtual reality would facilitate disassembly training for workers, provide more detailed visualizations of aircraft components, and even allow simulations of the disassembly process. New technologies will also be needed at scale for disassembling and sorting materials.

1 Buy-to-fly ratio: weight ratio between the raw material (buy) used for a part and the weight of the finished part (fly)
2 Scraps: small pieces of materials (metal, composites, etc..) left over from parts manufacturing.
3 Source: Fortune Business Insights, "Aircraft Aftermarket Parts Market Size, Share & Industry Analysis,2025-2032" (2024)
4 Source: EASA, Assessment of the environmental sustainability status in the Aviation Maintenance and Production Organisation (M&P) Domain (2023)

Role of Stakeholders for a Successful Transition Toward a Circular Economy

Transitioning towards a more circular economy requires building new interactions and a new economic model for all industries, including commercial aviation. Several enabling conditions are required for a successful uptake of circular economy principles in aviation. This could start by working on a vision and indicators to monitor progress.

Experience from other industries highlights that collaboration is required between supply chain partners across the value chain, from material manufacturers to dismantlers and recyclers, but also key players from other industries such as the waste management sector, industry associations, and policy decision-makers. A global vision and indicators to monitor progress are also key success factors.

Data transparency and data exchange across players have an important role in facilitating material and equipment traceability through digital passports for components and systems, which are already in development. Challenges such as intellectual property and data sharing arise. Voluntary commitment and guidelines from industry stakeholders at a global level are required to establish a global playing field between key regions and create favourable conditions for the adoption of circularity principles.

By collaborating among stakeholders, the aviation industry can unlock the full potential of circular economy, ensuring its long-term profitability and success.