ACARE

Safeguarding Europe's competitive edge in global aviation

A sectoral approach to aviation technology roadmaps and product vision (2028–2034)

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Advisory Council for Aviation Research and Innovation in Europe

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About ACARE

The Advisory Council for Aviation Research and Innovation in Europe (ACARE) serves as a unique, independent expert platform representing the collective voice of all European aviation stakeholders. Since 2001, its primary mission has been to provide scientific and knowledge-based foresight to policymakers, specifically by convening cross-sector expertise, producing long-term strategic roadmaps and research agendas, and contributing to informed regulatory and investment decisions that form the basis for both European and national research programs.

This position paper was developed under the leadership of the European Expert Platform (EEP), an advisory committee within the ACARE organisation, and subsequently endorsed by the ACARE General Assembly. The findings and recommendations in this position paper reflect the collective technical expertise of the Chair team, the EEP, Working Groups, Special Groups, the General Assembly and an extensive group of contributors. The result is intended to inform the strategic direction of the next Multiannual Financial Framework (MFF) and Framework Programme 10 (FP10) and presents a comprehensive and neutral view of the priorities within the European aviation sector.

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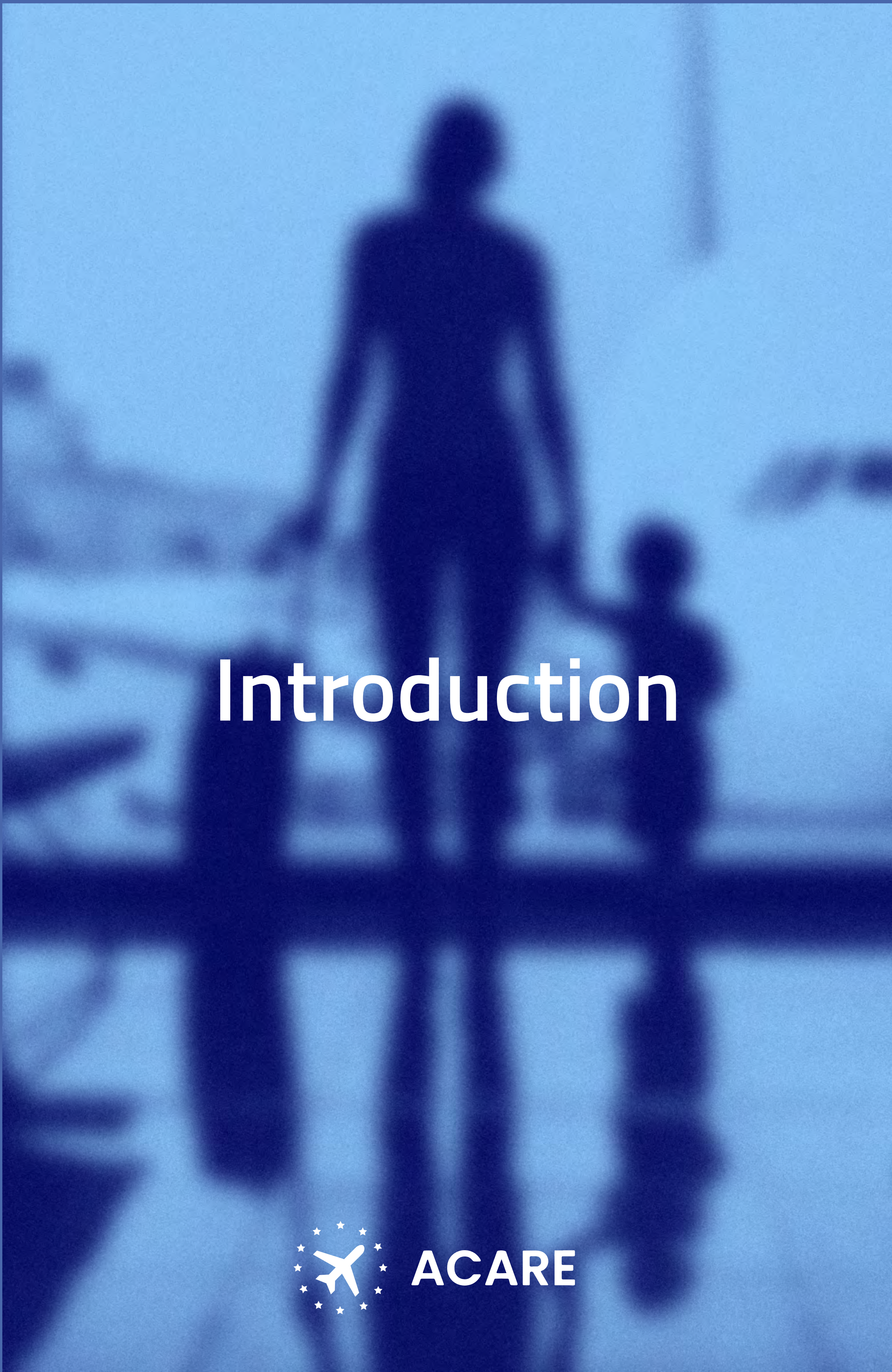

Introduction

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Executive Summary

The European Commission (EC) is pursuing an ambitious new era of sustainable societal prosperity, competitiveness and sovereignty. The EC proposal for the next Multiannual Financial Framework (MFF)[1] places research and innovation at the heart of the economy to ensure Europe leads the global race for frontier technologies and clean technologies. Key to this effort is the continuation of the well-known and highly successful Horizon Europe funding programme for research and innovation. The proposal for the next MFF also lays out the creation of a European Competitiveness Fund (ECF) which aims to leverage the budget of the European Union (EU) to de-risk private investment in strategic technologies. The EC draws heavily on the recommendations of the Draghi report on EU competitiveness[2] to inform this work, especially regarding the urgent need to boost productivity and launch industrial innovation projects for decarbonisation. In addition, the EC is prioritising the reduction of administrative red tape, the removal of structural brakes that hinder European competitiveness, and simplification. A main component of this effort involves an extensive reform and rationalisation of the public funding landscape, in particular European Partnerships. This shift towards a "policy-based" budget from a "programme-based" budget aims to optimise efforts and provide the long-term stability necessary for high-stakes industrial innovation in critical sectors.

To achieve this new momentum towards an investment capacity in research, innovation, and deployment, Europe must continue to safeguard one of its main industrial strengths: the aviation sector. This position paper aligns diverse European stakeholder perspectives around a comprehensive product vision and technology roadmap for 2028–2034 that orients this investment capacity. By highlighting the most critical future trends by air vehicle platform and identifying the enabling technologies and levers that must accompany these trends, this position paper provides a blueprint to secure Europe's global leadership in aviation in the medium and long term. By offering a coherent framework to guide investment priorities within the next MFF it underscores the importance of the European aviation sector working together with the European Commission and Member States to foster:

Economic growth and societal readiness.

Beyond the macroeconomic contributions from the manufacture of aircraft and related parts, and from actual air transport and airport operations, the European aviation sector is vital for the integrity of the European economy and society, the EU single market, and global connectivity, meeting high Societal Readiness Levels (SRL). Furthermore, a commitment to sustained funding will be essential for the cultivation of human capital, as it secures a consistent pipeline of Science, Technology, Engineering, and Mathematics (STEM) talent and maintains a world-leading research workforce capable of developing and operating Europe's advanced research and technology infrastructures.

Strategic autonomy, industrial sovereignty and global competitiveness.

The future of Europe's aviation sector depends on its ability to retain sovereign industrial and technological capabilities across the full value chain. This requires continued investment in advanced aircraft technologies as well as in the industrial foundations that make deployment possible like critical raw materials, advanced materials, semiconductors, batteries, power electronics, digital systems, manufacturing capacity, test infrastructures and skilled labour. Additionally, aviation supply chains are increasingly exposed to the adverse effects of geopolitical volatility, foreign dependencies, and resource constraints. Europe must therefore reduce these strategic vulnerabilities, reinforce domestic capability where it matters most, and ensure that the transition to climate-neutral aviation strengthens rather than weakens its industrial base.

[1] European Commission. *A dynamic EU Budget for the priorities of the future - The Multiannual Financial Framework 2028-2034.* COM(2025) 570 final, 16 July 2025.

[2] Draghi, M. (2024). *The Future of European Competitiveness — A Competitiveness Strategy for Europe.* European Commission.

In this context, European leadership will depend on the ability to transform breakthrough research into certified products that are manufactured and supported at scale within Europe. This includes preserving key competences along the value chain, including in design, systems integration, industrialisation, production ramp-up, maintenance and digital operations. As emphasised in the Draghi report[3] public policy must therefore support both technological leadership and industrial resilience, recognising that technological sovereignty in aviation is achieved not only through invention, but also through the capacity to certify, produce, operate and continuously improve within Europe. This pursuit of technological sovereignty is deeply intertwined with the EU's economic security as for example advanced materials for the aviation sector are now officially designated as one of ten critical technology areas essential to the EU's strategic interests[4]. In addition, by fostering dual-use synergies the EC can support innovations with simultaneous civil and military applications thereby enhancing both strategic autonomy and regional security.

However, maintaining global leadership for Europe while working with like-minded and long-standing partners, requires a decisive effort to close the "competitiveness gap" towards international competitors, especially in the case of for instance emerging technologies for the development of electric aircraft and super high-performance batteries.

> *"Technological sovereignty in aviation is achieved not only through invention, but also through the capacity to certify, produce, operate and continuously improve within Europe."*

Technological leadership across the full spectrum of products and air vehicle platforms.

Europe's aviation sector stands at a critical and strategic juncture necessitating a unified and ambitious approach to maintain its global leadership in sustainable, safe, and secure flight. To navigate this juncture, the EC must integrate sustained collaborative research with targeted European Partnerships up to TRL[5] 6 while ensuring a deliberate balance between visionary "bottom-up" research and "top-down" industrial initiatives that address immediate and medium-term challenges. This collaborative research must be seamlessly linked to accelerated industrial demonstrations spanning TRL 6 to TRL 9 and be supported by a reinforced and highly capable network of research and technology infrastructures.

Achieving the "Smart and Clean Aviation Moonshot".

To achieve the vision laid out in ACARE's "Fly the Green Deal"[6] of a climate-neutral air mobility system by 2050 consistent public funding through Framework Programme 10 (FP10) together with the ECF will be indispensable. Such a financial commitment is required to support high-risk, high-reward research necessary to effectively bridge the gap between initial laboratory research and full-scale industrial deployment. Furthermore, targeted public funding will be essential for modernising Europe's fragmented airspace into a unified, automated 4D trajectory-based air traffic management system which will optimise flight routes to significantly reduce both CO_2 and non-CO_2 emissions.

Achieving the "Smart and Clean Aviation Moonshot" will require a stable and coherent implementation architecture across the next MFF. In particular, FP10 and the ECF

[3] Draghi, M. (2024). *The Future of European Competitiveness — A Competitiveness Strategy for Europe*. European Commission.

[4] European Commission. *Recommendation on critical technology areas for the EU's economic security for further risk assessment with Member States.* C(2023) 6689 final, 3 October 2023.

[5] Technology Readiness Level.

[6] ACARE (2022). *Fly the Green Deal, Europe's Vision for Sustainable Aviation.* European Commission.

must operate as complementary instruments within a single strategic logic. FP10 must continue to support collaborative research, technology maturation and pre-competitive capability building across TRL 1 to TRL 6, while the ECF and related deployment instruments must accelerate industrialisation, large-scale demonstration, certification readiness and market uptake across TRL 6 to TRL 9. To be effective, these instruments must provide predictable, long-term strategic, ring-fenced, and complementary support across the entire innovation lifecycle, thereby bridging the gap between fundamental discovery and market-ready industrial application to secure Europe's technological and economic sovereignty. Without such continuity, Europe risks weakening the conversion of research excellence into industrial leadership.

Addressing market limitations.

Public investment is necessary due to the inherent limitations of private-sector research and development. While major industrial leaders allocate significant amounts to research and development, these commercial investments are balanced across the business cycle to ensure delivery of products and capabilities to the market while securing long-term competitiveness. Consistent public funding is critical for steering the European aviation sector towards the breakthrough innovations necessary for a climate-neutral future.

"Consistent public funding is critical for steering the European aviation sector towards the breakthrough innovations necessary fora climate-neutral future."

ACARE recommends as the working hypothesis for the European aviation sector a total investment of €66 billion over the 2028–2034 timeframe as also outlined in other industry policy reports[7]. This total investment is to be split as follows:

- €18 billion (roughly 25%) for research and innovation (i.e. activities covering TRL 1 to TRL 6) to break new efficiency barriers and develop novel architectures.
- €48 billion (roughly 75%) for product development and industrialisation (i.e. activities from TRL 6 upwards) to bridge the gap between research and deployment and achieve market readiness.

Using dual-use innovation as a driver of sovereignty.

As highlighted in the EC's "Readiness 2030" whitepaper[8] Europe faces an unprecedented deterioration of its security environment marked by high-intensity conflict on its borders, accelerating technological competition, and increasing geopolitical fragmentation.

In this context, Europe must rapidly reinforce its industrial and technological sovereignty while ensuring long-term resilience of its critical supply chains. Aviation, as one of Europe's strongest industrial pillars, is uniquely positioned to serve this ambition. Many of the technologies driving the next generation of climate-neutral, digitally enabled civil aircraft are also essential for military readiness. By fostering dual-use synergies Europe could ensure that investments in research, innovation, and industrialisation simultaneously reinforce strategic autonomy, security of supply, and economic competitiveness. Such an alignment could not only reduce dependencies on foreign systems but also accelerate capability development, strengthen Europe's deterrence posture, and support a coherent and sovereign technological base across both civilian and military domains. In this respect, the European aviation sector becomes a cornerstone of Europe's broader security-economy nexus, fully aligned with the objective of safeguarding European prosperity, resilience, and freedom of action.

[7] See e.g. Clean Aviation Joint Undertaking; SESAR Joint Undertaking (2025). *Aviation Research & Innovation Strategy (ARIS) — A pathway to competitive and sustainable aviation supporting Europe's sovereignty.*

[8] European Commission (2025). *White Paper for European Defence — Readiness 2030.*

1. Introduction

Securing European leadership in a competitive global landscape.

Air transport plays a vital role in Europe's mobility, economic prosperity, and social cohesion. As one of the most economically developed regions in the world, Europe depends on efficient and reliable flight connections. The benefits of aviation encompass tourism, trade, social and cultural exchange, education, innovation, competitiveness and employment, making aviation an indispensable part of modern European life. Beyond the pure economic outcome and the sector's contribution to European prosperity, aviation fosters cultural understanding and exchange.

The economic benefits of air transport comprise direct, indirect and induced value added, as well as employment in the sector's own value chain. The direct effects of the European aviation sector are defined as the sector's own contribution to European employment, output, gross value added, and wages and salaries. Indirect effects are defined as the impacts on employment, output, gross value added, and wages and salaries resulting from the European aviation sector's purchase of goods and services from other European firms further upstream in the value chain, such as aircraft manufacturers and component suppliers. The induced impact of the European aviation sector's direct and indirect economic activities is the contribution to the economy resulting from spending by employees in the sector's value chain. According to the second global assessment of the Clean Sky 2 Technology Evaluator[9] the European aviation sector supported over 5.2 million direct, indirect and induced jobs across the EU and the UK in 2019.

The European aviation sector is undergoing a profound transformation, propelled by a rapid market growth, and geopolitical, environmental and technological shifts. While these drivers offer significant opportunities for global leadership, they also introduce systemic risks within a context of heightened volatility.

Rising global population and economic growth are sustaining a strong demand for air travel, driving an increase in aircraft deliveries, expanding services revenues, and creating new business opportunities that are attracting both established industrial players and new entrants. Notably, this surge in demand is expected to see the global commercial fleet nearly double over the next 20 years from roughly 25,000 today to over 49,000 aircraft by the mid-2040s[10]. This growth is intensifying competition across the value chain and reshaping the market landscape, thereby challenging Europe to conserve and strengthen its global leadership.

At the same time, Europe's leadership cannot be assessed solely through current market position since it is in no way a guarantee for Europe's future leadership in aviation. Europe must therefore put in place all means to secure the future of the European aviation sector. One of the decisive questions will be whether Europe will continue to command the critical capabilities required to shape the next generation of aviation systems and to industrialise them at scale. This includes the ability to master all relevant new or fast-evolving technologies and processes like advanced materials, electrification, hydrogen-related technologies, software-defined aircraft systems, automation, digital manufacturing, certification methods, and resilient supply chains. With global competitors investing not only in products but also in full industrial ecosystems, Europe must respond with an equally comprehensive and systemic approach.

In parallel, escalating political tensions and armed conflicts are reshaping the European defence sector as the pursuit of strategic autonomy drives renewed investment in sovereign capabilities. In addition, inconsistent and fast changing tariff and trade restrictions are destabilising commercial markets and thus increasing the risk of supply chain disruptions. In an extreme scenario, a multipolar world dominated by geopolitics and restricted markets outside Europe could constrain growth, intensify supply chain vulnerabilities, and bias commercial decisions towards political interests over competitiveness.

However, the defining challenge remains the climate crisis with the global aviation industry committed to a 2050 net-zero trajectory alongside the development of climate-resilient infrastructure and providing emergency services to citizens in case of natural disasters. Additionally, resource scarcity across the value chain, driven by shifting global power dynamics, is compelling the aviation sector towards higher levels of efficiency and circular design. Advancing disruptive low-emission technologies is therefore a strategic

[9] Clean Aviation Joint Undertaking (2024). *Clean Sky 2 Technology Evaluator — Second Global Assessment 2024.*

[10] Airbus Global Market Forecast 2025.

necessity to fulfil environmental commitments while at the same time ensuring enough resources to safeguard the production systems and operational freedom of the European aviation ecosystem.

Finally, rapid advancements in key emerging technologies are reshaping entire sectors, including aviation, and redefining the competitive landscape. For instance, breakthroughs in artificial intelligence (AI), advanced data analytics, supercomputing, quantum and cybertechnologies are disrupting existing operations and business models.

Therefore, to maintain its status as a global leader, Europe must draw on both its own industrial and innovation capabilities and, through appropriate partnerships, those of global competitors. While the focus on productivity and market-readiness is critical, it must be supported by continued investment in the full research and innovation lifecycle. This is the only pathway ensuring that "Made in Europe" technologies continue to make a strategic contribution to the global aviation ecosystem.

Aviation as a strategic pillar for European competitiveness.

Far more than travel and logistics, aviation is a structural pillar of the European project underpinning the fundamental principles of the internal market through seamless regional connectivity. The civil aeronautics industry serves as a primary driver of European economic stability providing direct employment for over 406,000[11] highly skilled professionals and sustaining nearly 5.2 million jobs across the continent[12]. With annual revenues reaching nearly €130 billion in 2024, including a formidable €108.6 billion in exports, the European civil aviation sector functions as a high-velocity engine for productivity, international trade, and pioneering research and innovation[13].

"Far more than travel and logistics, aviation is a structural pillar of the European project underpinning the fundamental principles of the internal market through seamless regional connectivity."

To secure Europe's future, the European aviation sector must be explicitly recognised as a strategic sector for the EU. Its importance goes far beyond mobility, with it being a high-value industrial ecosystem combining diverse domains like system integration, advanced manufacturing, digital technologies, materials science, certification capability, infrastructure and services. The European aviation sector sustains a dense network of primes, equipment manufacturers, mid-tier suppliers, small and medium enterprises (SMEs), research organisations (RTOs) and universities across Europe. As such, it is one of the rare sectors in which Europe still combines technological excellence, industrial depth, export strength and global market relevance.

The European aviation ecosystem must be preserved and modernised as a matter of strategic policy. In the coming decade, Europe's position will depend on whether it can continue to lead not only in aviation research, but also in certification, industrial ramp-up, deployment of the Digital European Sky (DES), Sustainable Aviation Fuels (SAF), advanced manufacturing, and the qualification of new materials and energy systems, side-by-side with excellent Air Traffic Management (ATM) capabilities. A fragmented or overly short-term approach will weaken the conditions for sustained European leadership. By contrast, a coherent European strategy will enable Europe to achieve the transition to climate-neutral aviation while also reinforcing European competitiveness, industrial resilience, and economic security.

European leadership within the global aviation sector is sustained by massive investments; for example, in 2024 alone €2.7 billion was invested in research and development to advance aerodynamics, propulsion, and operational efficiency[14]. These investments are backed by Maintenance, Repair, and Operations (MRO) and manufacturing innovations that secure the

[11] ASD (2025). *A European industrial strategy for civil aeronautics.*

[12] Clean Aviation Joint Undertaking (2024). *Clean Sky 2 Technology Evaluator — Second Global Assessment 2024.*

[13] ASD (2025). *A European industrial strategy for civil aeronautics.*

long-term profitability and operational performance of the current fleet. Maintaining this leadership is essential for the EU's strategic autonomy. A strong European aviation sector ensures the EU remains competitive in a globalised world with a worldwide aviation sector workforce of 15 million people today; a figure projected to grow to 21 million by 2043 as global demand for new commercial aircraft reaches 43,420 units[15].

Aviation remains an irreplaceable element of modern society reflecting the European continent's degree of development and ensuring critical services to the population. While the vital contribution of the European aviation industry to European growth and social cohesion is well-recognised, the sector faces unprecedented economic and societal headwinds. The aftershock of COVID-19 and the following recovery remains a defining challenge for the entire European aviation supply chain. A key lesson from this period is the necessity of building a more resilient sector; a sector that can withstand global shocks while accelerating the transition towards a sustainable and competitive future.

Furthermore, the European aviation sector is currently undergoing a radical evolution to align with the European Green Deal. This transition is supported by a 54% reduction in fuel consumption per passenger since 1990 and the ongoing deployment of Sustainable Aviation Fuel (SAF) as promoted by ReFuelEU aviation requiring 20% of all aviation fuel in EU airports to be SAF by 2035 and 70% by 2050. The success of this transition is inextricably linked to the competitiveness of the European civil aviation industry. Sustaining this evolution therefore requires a well-structured and long-term EU strategy that incentivises the deployment of technological advancements while safeguarding the upskilling of the workforce and the preservation of European intellectual capital.

Therefore, through fostering cross-sector innovation and maintaining strong political will, the European Commission can and must ensure that the European aviation sector continues to be a driving force for prosperity, resilience, and global leadership.

Defining a path for a "Smart and Clean Aviation Moonshot".

Imagine, over the next two decades the fundamental ways in which aircraft are conceived, manufactured, and operated will undergo a radical shift, resulting in 2050 with journeys across Europe that are highly coordinated and offer a seamless experience. A journey will no longer begin with the friction of fragmented schedules but with a fluid transition from high-speed ground transit to the departure gate. At airports, traditional hurdles like security lines will have been replaced by non-intrusive sensors that verify identities as passengers move through the terminal. The aircraft themselves will have adopted radical, integrated designs that glide through the air with significantly less drag, less noise, and using sustainable energy. Design, manufacturing, maintenance and repair will be strongly linked. Inside, the cabin will be a modular, adaptive space built from ultra-light, bio-based materials that prioritise both passenger wellness and environmental health. These aircraft will be designed using a circular approach that allows every component, from the seats to the airframe, to be easily disassembled and recycled at the end of its service.

Behind the scenes, the sky will be managed by a digital network that coordinates all movements of aircraft with mathematical precision, virtually eliminating delays as well as contrails. Pilots and controllers will have transitioned into strategic supervisors, supported by highly automated systems that act as a digital nervous system, optimising the flight in real-time.

With global commercial aviation traffic volumes expected to have doubled by 2044[16] flight safety has been improved at (at least) the same pace to prevent an increase in accidents. The required safety innovations in technology, operations, and human performance, will depend on and be supported by a revolution in certification. Instead of years of physical trials, new technologies will have been validated through

[14] Airbus Global Market Focus, 2025.

[15,16] Airbus Global Market Forecast 2025.

"digital twins", allowing for rigorous, virtual testing that speeds up innovation while maintaining the highest safety standards.

On the ground, airports will function as energy-neutral hubs that generate their own power from renewable sources.

This vision of the future reflects a Europe that has successfully harmonised advanced engineering with a commitment to a waste-free and resilient transport system.

The Clean Aviation Moonshot identified in the FP10 draft regulation alludes to this "smart and clean future" that has been outlined in several aviation-focused policy recommendations including "Fly the Green Deal"[17], "Destination 2050"[18], ARIS[19] and "A European industrial strategy for civil aeronautics"[20].

Considering shifting geopolitical dynamics, rising global competition, and the need to revitalise the European single market, the EC has recognised that competitive aviation decarbonisation must be achieved in tandem with economic resilience. A "Smart and Clean Aviation Moonshot" must therefore balance carbon abatement with the necessary transformation of the European aviation sector. Sustained development of technologies in support of such a "Smart and Clean Aviation Moonshot" will require a healthy and resilient European aviation sector that is able to quickly bridge the TRL gap from recent development to exploiting technology for short-term evolutionary improvements. Sustainability must also be about balancing societal goals, such as those of decarbonisation, with a strong competitiveness position such that those goals become attainable and differentiate European supply chains.

Central to the Competitiveness Compass[21] and the Clean Industrial Deal[22], a "Smart and Clean Aviation Moonshot" positions the European aviation sector as a strategic pillar of transition. To achieve the objectives of this "Smart and Clean Aviation Moonshot", the European aviation sector must invest in advancements from applied research and early-stage development as well as bridge the valley of death that often emerges during technology transfer between research and deployment. In short, the goal must be to support collaboration and partnership that will convert research excellence into world-class products and services.

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[17] ACARE (2022). *Fly the Green Deal, Europe's Vision for Sustainable Aviation.* European Commission.

[18] Destination 2050 (2025). *Destination 2050 roadmap 2025-2050 — A route to net zero European aviation.*

[19] Clean Aviation Joint Undertaking; SESAR Joint Undertaking (2025). *Aviation Research & Innovation Strategy (ARIS) — A pathway to competitive and sustainable aviation supporting Europe's sovereignty.*

[20] ASD (2025). *A European industrial strategy for civil aeronautics.*

[21] European Commission. *A Competitiveness Compass for the EU.* COM(2025) 30 final, 29 January 2025.

[22] European Commission. *The Clean Industrial Deal: A joint roadmap for competitiveness and decarbonization.* COM(2025) 85 final, 26 February 2025.

The figure below shows the different lifecycle phases for an air vehicle platform with the related relative funding intensity for each phase across its lifespan.

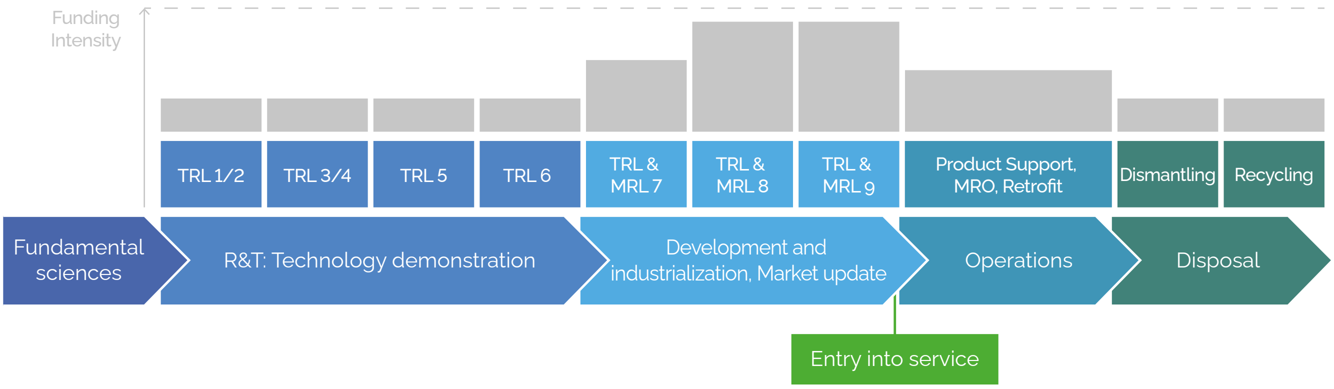

Figure 1 The different air vehicle platform lifecycle phases with the relative funding intensity for each phase.

The transition towards a competitive and decarbonised European aviation industry will require significant investments in aircraft technologies, airport infrastructure, and air traffic management from the private sector. Moreover, this industry-wide transformation occurs with clear threats to today's market share of the European aviation industry. Therefore, in addition to accelerating advancements in new technologies for a smart, sustainable, and competitive future, public support for research and innovation must also contribute to improvements in the current fleet. This will ensure that the European aviation industry remains competitive today while offering decarbonisation potential for the short and medium term. Additionally, public support will also be required to modernise, and in some cases completely reimagine, industrial capabilities, supply chains, aircraft operations, air traffic management, and airport infrastructures.

Achieving this "Smart and Clean Aviation Moonshot" hinges on a multi-faceted approach, including the implementation of a dedicated EU industrial strategy for SAF, and in the long term also for hydrogen, the acceleration of funding for research and innovation towards climate impact reduction, innovative and differentiating aviation technologies, and the deployment of a seamless ATM system. Finally, the European aviation ecosystem must evolve to support new modes of flight while expanding its environmental scope to include e.g. rigorous noise mitigation and circular economy principles.

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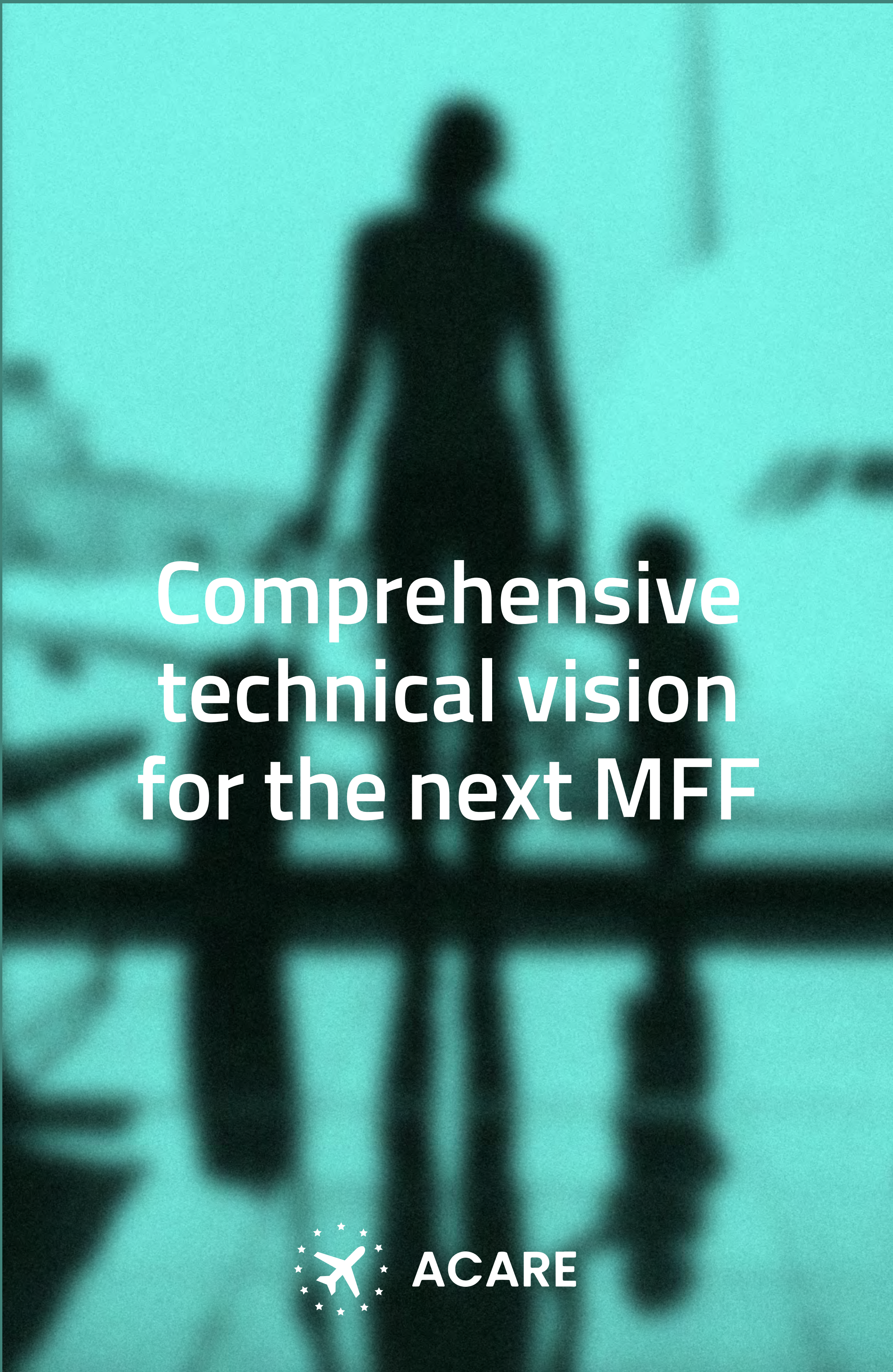

Comprehensive technical vision for the next MFF

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2. Comprehensive technical vision for the next MFF

2.1. Air vehicle platform related technologies

2.1.1. Introduction

The following sections provide insight into a wide range of air vehicle platforms in order to recognise their contribution to European competitiveness and to identify the relevant areas of focus for the next Multiannual Financial Framework (MFF), covering research and innovation, industrialisation, and deployment. Innovation for each air vehicle platform cannot be viewed solely through the lens of individual technologies but also needs to be viewed through holistic aircraft level architectural improvements where advanced materials, refined aerodynamic concepts, and optimised propulsion and systems integration can together unlock transformative performance benefits.

The following sections do not present the air vehicle platforms in any order of precedence or priority. Rather, the air vehicle platforms are presented with the intention to provide high-level evidence for the relevance of potential activities that may be supported via instruments in the next MFF. It will be for subsequent activities to provide more precise and perhaps selective guidance on necessary actions.

In considering the next MFF and the described activities it is also worth noting that, as a general principle, innovation in the aviation sector will continue beyond 2034 and many of the described activities are intended to ensure that continuity.

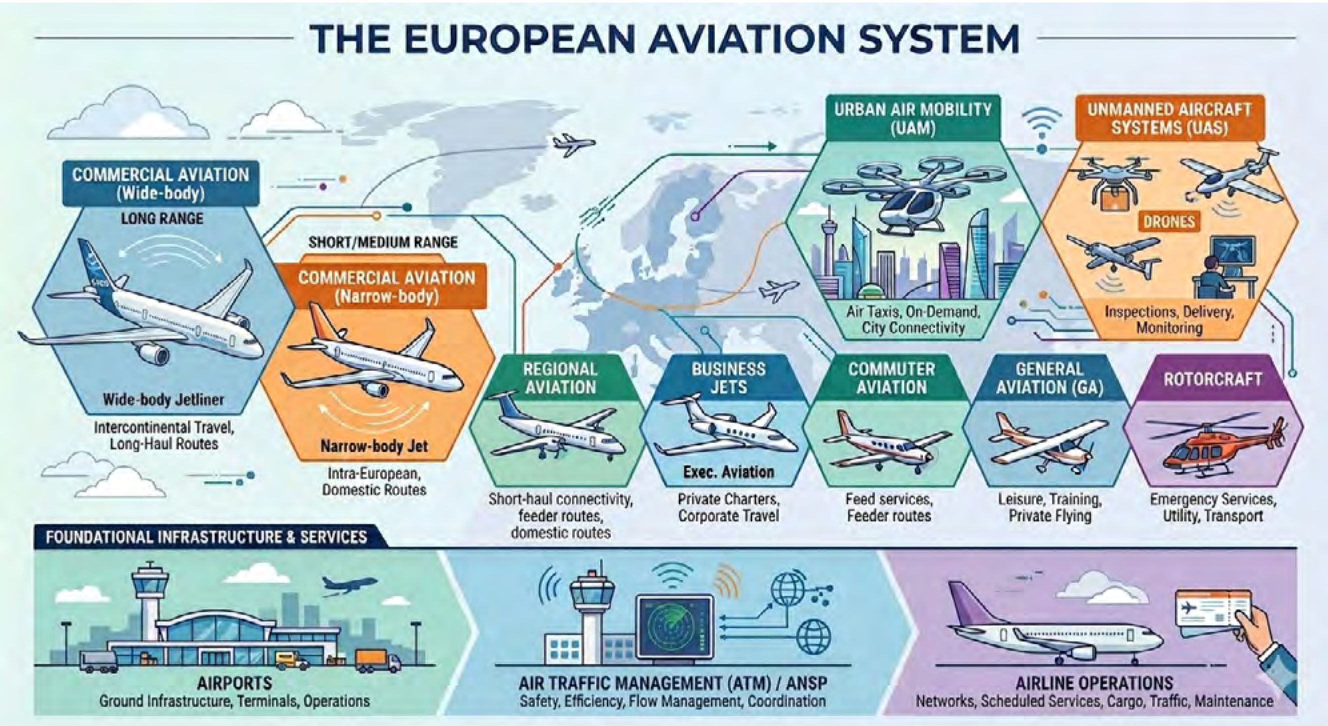


Figure 2 *An overview of the European Aviation System described in this position paper (generated using Google Gemini).*

2.1.2. PLATFORM 1 – Long range / Widebody

Market forecast and impact on EU competitiveness

There exists currently a duopoly for long range/wide-body (WB)[23] aircraft between Europe and the US with approximately 40%[24] of in-service aircraft and those on order being of European origin. US WB aircraft typically have a significant percentage of their value based on European content from propulsion, aerostructures, interiors, landing gear, avionics and electrical systems[25]. Furthermore, a significant share of MRO services for WB aircraft are performed in Europe or by European industry.

Looking to 2044 there is demand for 8,200 new WB aircraft during this period, with 5,600 being in open demand (i.e. not in backlog)[26]. This increase is being primarily driven by growth in Gross Domestic Product (GDP), urbanisation and a desire to travel globally, especially across Asia. Europe is well-positioned to progressively increase its market share with a range of competitive aircraft types able to replace US types as they retire.

However, with regards to the global market landscape there are several threats that must be recognised, namely geopolitical tensions, impact of tariffs, and trade disputes. China has ambition as an emerging player with significant government support, technological capabilities, availability of highly skilled workers and lower prices. On the other side, the US is driving step-change innovation with government support, e.g. through bold investments in new concepts like the blended-wing body which could disrupt this segment by eroding increasing European market share in the mid-long term.

Assuming air travel compound growth of 3.8% a year worldwide[27], WB aircraft production is expected to double from around 250 a year to over 550 a year by 2044. In the mid-2030's this would represent approximately 400 aircraft a year; anticipating a 50% share for European WB aircraft means a doubling of output from 90 a year to over 200 a year (i.e. from 8 per month to 17 per month).

Whilst WB aircraft represent only 7% of flights, their long range application generates CO_2 and NOX emissions in the region of 50% of total sector emissions[28]. Therefore, building upon activities in Clean Sky 2 and Clean Aviation, they represent a key area of attention for the European aviation sector to deliver near-to-medium term reduction in climate impacts. In addition to longer-term novel architectural solutions, these reductions will have to be delivered via efficiency improvements, improvements in fuel and energy usage, improvements in operations, and via ATM improvements. Targeted actions for this air vehicle platform will deliver future economic and environmental impact for Europe at scale.

Growing the European share of the WB segment will require close consideration of market demands balanced with technological maturity to deliver the necessary step change in efficiencies and operating costs required for new product launch. Equal consideration must be given to ensuring greater European manufacturing and MRO capabilities and a stronger, more resilient supply chain to achieve the necessary production rates.

Main research and innovation targets (TRL, MRL[29] and CRL[30] 1-6)

Airframe: Light materials and manufacturing processes, such as composites, and aerodynamics improvements, including laminarity, in combination with higher aspect-ratio wings, will be required to deliver efficiency improvement on the next generation of WB aircraft. Anticipating future generation aircraft will require attention to novel architectures, such as the blended-wing body, to unlock further flight cycle efficiencies. To achieve optimum efficiency gains, it will be necessary to consider the overall interaction of the technologies for airframe, propulsion, systems and fuel.

Propulsion: Advanced geared ultra-high bypass turbofans coupled with very high-pressure ratio cores, required to deliver a step-change in fuel-burn, emission and noise reductions, will need high-temperature, lightweight, and longer-life materials, advanced hybridisation and more-electric and lightweight design solutions with increased functionality, advanced manufacturing, MRO improvements, and digital engine

[23] For convenience, this position paper uses 'long range', 'long-haul', and 'wide-body' interchangeably to refer to the same air vehicle platform even when technically these terms do not have the same exact meaning.

[24] Boeing Vs. Airbus: Who's Winning The Widebody Battle In 2025? https://simpleflying.com/boeing-airbus-widebody-battle/ (retrieved 21 March 2026).

[25] Boeing 787 Dreamliner. https://en.wikipedia.org/wiki/Boeing_787_Dreamliner (retrieved 21 March 2026).

[26] Airbus Global Market Forecast 2025.

[27] ATAG (2026). *Waypoint 2050 Third Edition.*

[28] EASA (2025). *European Aviation Environmental Report 2025.* (https://doi.org/10.2822/1537033)

[29] Manufacturing Readiness Level.

[30] Certification Readiness Level.

controls. More radical engine solutions will have to be initiated with next generation ultra-efficient and low emissions core demonstrators for post-2040 engines, highly integrated into new airframe architectures, with high-power dense auxiliary power units (APUs), addressing complex installation challenges.

Systems: Modern digital systems and on-board capabilities will need to deliver a reduction of weight and power consumption of all components, ensuring lower mission energy consumption. New mission benefits and emission reduction will be unlocked through increased integration and interoperability, driven by new electrical architectures at higher voltage levels and hybridisation. Novel health monitoring functions will be implemented to ensure in-flight safety via advanced safety nets and improved cockpit monitoring, in addition to supporting through-life cost reduction for the operator. Integration of advanced cockpit and ATM, with higher level functions in automation and autonomy, will enable more efficient flight trajectories reducing energy consumption and noise. This will need to be supported by advances in AI-based systems, bringing computational intelligence on-board to reach automation levels beyond traditional systems due to the implementation of machine learning algorithms.

Fuel and energy: The potential benefits of hydrogen, other cryogenic fuels, and power distribution in SMR aircraft is expected to create synergies with WB aircraft. Consequently, WB specific requirements need to be integrated into research and innovation programmes. Due to the disruptive benefits these new energy vectors could bring they need attention during this period to lead the way for impact beyond 2050.

Main industrialisation and deployment targets (TRL, MRL and CRL 6+)

The deployment of advanced geared turbofan ultra-high bypass ratio propulsion systems will accompany WB aircraft optimisations in wing and propulsion aerodynamics during late-stage demonstrations and certification readiness assessments. Additionally, a strengthening and creation of differentiation in the European supply chain capability, especially through the adaptation of innovations in integrated design, raw and part-processed material supply, automation of manufacturing and MRO, will ensure that European industry can manufacture and maintain products at scale and competitive cost.

2.1.3. PLATFORM 2 – Short and Medium Range (SMR)

Market forecast and impact on EU competitiveness

Comprising nearly 80% of all new commercial aircraft, the Short and Medium Range (SMR)[31] remains the undisputed cornerstone of global aviation. The latest Airbus Global Market Forecast[32] identifies single-aisle aircraft as the primary engine of industry growth. By 2044, the world will require 34,250 new deliveries in this category alone[33]. European leadership in the SMR segment is strategically vital for Europe because it underpins the continent's high-frequency, point-to-point connectivity which directly supports roughly 4.5% of European GDP. By facilitating rapid transit between cities and major hubs, these aircraft act as a primary catalyst for international trade and labour mobility. The SMR segment is the largest segment by value in aviation; maintaining and growing the European leadership position will automatically deliver economic value and increased competitiveness. This needs to be considered in the context of the emergence of a new entrant in the SMR segment, the Chinese COMAC company with the C919, which introduces a competition challenge for Europe.

Furthermore, the SMR is the central laboratory for Europe's decarbonisation goals, given that global SMR aircraft emissions account for roughly 50% of total emissions for commercial aviation[34]. Therefore, in addition to longer-term novel architectural solutions, the SMR represents a key area of attention to deliver near-to-medium term reduction in climate impacts via efficiency improvements, improvements in fuel and energy usage, improvements in operations, and via air traffic management improvements. This is one of the reasons why programs like Clean Aviation focus specifically on the SMR segment to integrate ultra-efficient propulsion and hydrogen technologies, ensuring that Europe remains at the global frontier of sustainable aviation. Targeted actions for the SMR will deliver future economic and environmental impact for Europe at scale.

The expected surge in demand for SMR aircraft over the coming decades will significantly bolster European competitiveness by driving a massive expansion in the high-value services and MRO activities therefore requiring technologies in this part of the lifecycle as well. Future SMR developments will need to prioritise optimised lightweight storage systems and advanced diagnostic tools to ensure the highest levels of reliability and maintenance. As airlines replace older jets with "digital-native" SMR aircraft, the rise of new-generation aircraft in service will solidify Europe's leadership in digital flight operations and predictive maintenance, securing hundreds of thousands of highly skilled jobs and maintaining a dominant share of the global aviation export market.

Main research and innovation targets (TRL, MRL and CRL 1-6)

Airframe: While new propulsion concepts offer significant gains in fuel efficiency, they introduce new challenges related to weight, aerodynamic drag, and noise that must be offset through superior system integration. The further evolution of the SMR segment will rely on the integration of novel powertrains and will also fundamentally reshape traditional aircraft design by demanding a deep integration of all functions and highly efficient space allocation. This balance will need to be achieved through radical changes to energy storage and the adoption of novel wing architectures, which will contribute significantly to cutting total energy consumption. Aligning these technological ingredients will represent a major milestone in the roadmap towards a viable, climate-neutral air transportation system. In addition, a truly high-performance product must also incorporate principles of circularity and a more efficient, end-to-end integration of the fuselage and cabin to support an industrial model that is both financially viable and environmentally sustainable.

Propulsion: The strategic maturation of SMR propulsion systems represents a critical pillar in achieving the aviation industry's net-zero ambitions, necessitating a synchronised evolution of breakthrough technologies, radical aircraft designs, and sustainable energy carriers. Achieving ambitious energy efficiency goals will depend on the evolution of thrust generation, ranging from advanced geared novel high-bypass ducted fans to unducted architectures. By pairing these configurations with high-performance core systems and novel components, developers can create power plants that simultaneously address climate impact, operational efficiency, local air quality, noise constraints, and competitiveness. Full exploitation of the optimisation potential of these novel architectures to bridge the TRL gap to ensure further future improvements, will require further research into advanced digital design as well as

[31] For convenience, this position paper uses 'short and medium range', 'single-aisle', and 'narrow-body' interchangeably to refer to the same air vehicle platform even when technically these terms do not have the same exact meaning.

[32] Airbus Global Market Focus, 2025.

[33] Airbus Global Market Focus, 2025.

[34] See e.g. EASA (2025). *European Aviation Environmental Report 2025*. (https://doi.org/10.2822/1537033)

multidisciplinary optimisation within all the constraint areas. Realising the full potential of these systems will also require a sophisticated physical and energetic transition, moving towards a holistically optimised integration between the propulsion unit and advanced airframe designs.

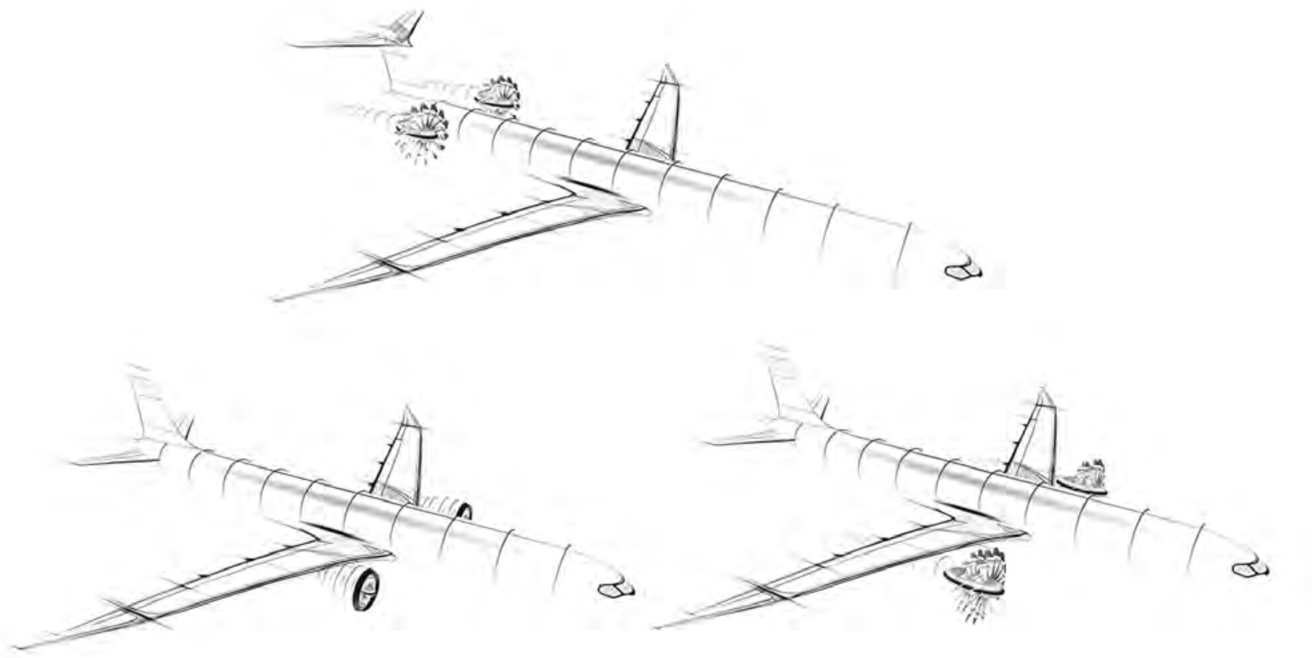
Electrification and hybridisation: Hybridisation – i.e. the strategic integration of SAF driven gas turbines with more electrical power system implementation – represents a critical pathway for optimising energy efficiency and reducing fossil fuel consumption for fixed-wing aircraft. Hybrid systems reduce the mechanical load on the engine by transitioning secondary functions, such as cabin pressurisation and air conditioning, to electrical power with the potential for higher voltage levels thereby creating further benefits in sub-system weight, structural requirements and overall aircraft weight.

To operationalise these gains, priority will need to be given to the development of modular and upgradable architectures that maximise synergies across the entire commercial aircraft spectrum, from SMR to long range. By fostering these industrial commonalities, the European aviation sector should be able to accelerate the maturation of propulsion systems while reinforcing European strategic autonomy and securing Europe's leadership in the transition towards climate-neutral flight. Research into electrification should further catalyse these advancements by offering significant potential for cross-platform synergies and therefore enabling shared technological breakthroughs to benefit all other commercial aircraft.

Achieving full systems electrification will be essential for ensuring propulsive energy is dedicated primarily to thrust. The progressive adoption of power-by-wire flight controls will reinforce this shift, enabling fully electric architectures that eliminate hydraulic dependencies and will boost energy efficiency. This transition will be a critical step towards realising the long-term vision for more-electric aircraft and a more sustainable aviation sector.

Hydrogen: Research and innovation activities regarding high-pressure fuel systems for SMR will need to focus on gas turbines and power density improvements for fuel cells. Further improvements of low-temperature proton-exchange membrane systems and heat exchangers will be key for a first commercial application (e.g. increased power-to-weight ratio and efficiencies as well as simplified system components). On the fuel cell side, scaling for the SMR also offers the potential to expand the technology into larger aircraft.

On the gas turbine side, the focus will need to be on achieving high propulsive power. This is expected to be a long-term activity, starting with extensive ground tests to demonstrate the required performance before getting to flight. In parallel, shorter-term research and innovation activities will be required for thermal engine conversion to hydrogen burn (i.e. fuel system, flex-fuel concepts, combustion chamber, emissions, etc.) as well as onboard hydrogen storage. These will potentially involve ground tests and in-flight experimentation.



Systems: The next generation of flight represents a profound paradigm shift in aviation engineering, moving beyond traditional physical excellence to become digitally-native, software-defined platforms. This vision reimagines the aircraft as a smart node within a seamless and integrated "Air-Ground-Space" ecosystem where connectivity across multi-constellation networks ensures constant collaboration. At the heart of this evolution is an SMR aircraft targeted for entry into service by the middle of the next decade, which will serve as a blueprint for advancements across all aircraft segments

Rather than remaining static after delivery and throughout the MRO cycle, these SMR aircraft will need to be designed for a continuous evolution of capability. Through the integration of advanced technologies introduced throughout their lifecycle, the SMR fleet will benefit from sophisticated communications, navigation and surveillance systems and the deployment of intelligent autonomous functions. Furthermore, a data-driven approach will accelerate the transition towards a sustainable future, significantly increasing the application of high voltage battery and electrification technology for both airborne operations and ground-based manoeuvres. By merging smart automation with a fully collaborative architecture, the European aviation industry will be defining a future where the aircraft is as much a sophisticated data processor as it is a vehicle. Furthermore, the advancements in AI-based systems will be bringing the necessary computational intelligence on board for smart automation by leveraging advanced machine learning algorithms.

Main industrialisation and deployment targets (TRL, MRL and CRL 6+)

Preparing for the next generation of aircraft demands an end-to-end overhaul of how parts, components and integrated airframe assemblies are built and serviced to ensure Europe remains the leader in a competitive global race. The goal for Europe must be to move beyond simply reacting to competitors and instead set a new international standard for how aircraft and their components are manufactured and maintained. This is a matter of industrial sovereignty, ensuring that the European supply chain and MRO network stay ahead of the curve by producing more efficient products at a much lower turnaround-time and cost.

To be able to achieve this target, the focus must shift towards an "integrated design", where the way a part is shaped, and the ways the part is built, maintained and repaired, are decided at the exact same time to avoid the inefficiencies of the past. This transformation will rely heavily on the "Factory of the Future" and on using AI and digital tracking to manage the complete supply chain throughout the lifecycle, including assembly and maintenance. This way, the European aviation industry can strip away the hidden, wasted time and extra steps that currently make up the bulk of manufacturing and maintenance costs. Combined with high-tech robotics that can handle complex advanced materials with precision, these upgrades will turn the factory floor into a competitive edge, ensuring that European aviation remains the most efficient and technologically advanced in the world.

2.1.4. PLATFORM 3 – Regional

Market forecast and impact on EU competitiveness

Regional[35] aviation (20–90 seats[36]) is a mature, industrial and cost driven market, where technology adoption must be aligned with airline economics and operational reliability. It is primarily driven by cost competitiveness, Direct Operating Costs (DOC), reliability and scale. It is a fundamental enabler of territorial cohesion across Europe. More than one third of the world's commercial airports rely exclusively on turboprops, making it the sole means of ensuring reliable air connectivity. Regional aircraft play an indispensable role in linking islands, and other remote regions to the rest of Europe, where no viable alternative transport modes exist.

Market forecasts[37] predict a demand for 2,100 passenger turboprop and 500 freight turboprop aircraft over the next twenty years, primarily driven by a growing need for regional fleet renewal in the coming decade and increasing global air traffic. Asia Pacific and India represent 50% of that passenger turboprop aircraft market, confirming the need for effective mobility solutions where modal shifts create new transport opportunities for citizens when options of moving people and goods are limited.

Europe is well positioned in this market segment as the current sole global producer of civilian turboprop regional aircraft. However, new entrants to this segment, proposing aircraft with advanced propulsion, energy management and new aerodynamics, are expected to come from China and the Americas, and to a lesser extent from Europe. On the other hand, new integrated propulsion architectures enabling disruption could also create opportunities for Europe to increase market share relative to other global propulsion suppliers. Dual-use capability is also highly relevant with European manufacturers producing turboprop aircraft for tactical transport, government agencies and firefighting.

Due to a shared CS-25 certification framework and comparable integration challenges, technologies matured on regional aircraft can also de-risk future developments for the SMR. Regional aviation will also provide the first commercially relevant scale for hybrid-electric system-level demonstration, underscoring its strategic value within Europe's aviation landscape. Ongoing initiatives within Clean Aviation also aim to accelerate the adoption of next-generation propulsion technologies.

Main research and innovation targets (TRL, MRL and CRL 1-6)

Airframe: Research on breakthrough aircraft architectures will be needed for applications on new aircraft equipped with innovative propulsions. With a focus on airframe shape for aerodynamics improvement, drag reduction, and better performance and efficiency, this research will contribute to further fuel burn reduction. Furthermore, research and development of next-generation materials and related manufacturing processes, including re-use and recycling technologies for sustainability throughout the aircraft lifecycle ensuring improved operating costs, will be needed. These materials and related manufacturing processes will also need to increase reliability and simplify maintenance in combination with mature industrial capabilities, while being supported by a digital thread. Additionally, research and development to assess the relevance of distributed propulsions based on hybrid combinations of SAF, hydrogen and electricity, including ground and wind-tunnel testing, and scale model flight testing, will be necessary. These different energy carriers, with their system integration opportunities, will need to be considered based on different key drivers e.g. related to mission, size and entry-into-service.

Propulsion: Multiple energy generators, via some combination of thermal, hybrid, electric assist and hydrogen (fuel-cell and hydrogen burn), will need to be integrated at propeller interface or earlier within the on-board energy chain, enabling flexible hybrid drivetrain systems, optimised for a wide variety of mission profiles. A new generation of hybrid regional demonstrators targeting higher levels of hybridisation up to 50% will require advanced battery and fuel-cell drivetrain technologies, improving specific energy and power density, matched by significant cost improvements. In addition, a full electric propulsive system of more than 4MW will require significant progress in improving the specific energy density (per mass and per volume) of batteries, and thermal efficiencies of fuel cells with improved system integration. Larger aircraft are also expected to benefit from large, low-loaded (or distributed) fan systems for gas turbines or other power plants to address efficiency breakthroughs and installation challenges.

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[35] For the purposes of this position paper, regional jets are considered as part of the SMR.

[36] Literature has a range of passengers for this type of air vehicle platform. For instance, for ATAG it is 50-100 whereas for Destination 2050 it is 20-100. In this position paper, the CS-23 applicability to a maximum 19 passengers is used as the primary differentiator between Regional and Commuter air vehicle platforms. Other effects such as mission type and flight duration will be further considerations of differences within an air vehicle platform description.

[37] ATR Turboprop Market Forecast 2025-2044.

Systems: Due to a common CS-25 framework, innovation in regional aviation can be used to accelerate the implementation on SMR and WB aircraft with appropriate changes to consider different energy sources and architectural solutions. Of note are the higher levels of electrification at higher voltages to meet an increased power demand, requiring attention to issues such as partial discharges, arcing, wiring capability and broader thermal management solutions. Reliable high voltage power distribution and conversion including isolation and protection systems will be required.

Fuel and energy: Regional aircraft, with its variety of missions, passenger and freight capacity, and entry-into-service windows, will need to have solution options for SAF, hydrogen and other cryogenic fuel, and electricity as the primary energy carrier.

Main industrialisation and deployment targets (TRL, MRL and CRL 6+)

Creating large-scale, certifiable demonstrators will be essential to secure European industry competitive positioning and maintaining its leadership in the regional market. There will have to be a focus on maturing and validating these technologies at full scale, including a TRL 8 demonstrator with improved aerodynamics, advanced airframe, integrating a hybrid propulsion system with the associated non-propulsive power storage and transmission systems.

Additionally, a strengthening and creation of differentiation in the European supply chain capability, especially through integrated design, raw and part-processed material supply, automation of manufacturing and MRO, will ensure that European industry can manufacture and maintain products at scale and competitive cost.

2.1.5. PLATFORM 4 – Commuter

Market forecast and impact on EU competitiveness

Commuter aircraft cover the flight length of an average of less than 300km and are often referred to as Regional Air Mobility (RAM). RAM has the potential of offering fast and affordable connections between currently underserved regions making use of small (9 to 19 passengers[38]), highly efficient aircraft[39]. Aircraft designed for this segment offer great efficiency, lower cost and fast door-to-door mobility relative to other ground-based transport modes due to their ability to operate from smaller airfields. The commuter segment has been challenged over the past years as airlines have shifted to bigger aircraft and larger airports. Studies show the potential economic impact of RAM, with a market projection of at least 18,000 new and retrofitted aircraft globally by 2035[40], due to advances in technology, the rise of mobility as a service, and further indirect benefits through the opening of underserved regions.

The commuter segment has the potential for aircraft configurations supporting Vertical, Conventional, and/or Short Take-Off and Landing (VTOL, CTOL, and/or STOL), or a combination thereof. There is also the possibility for a range of propulsion type configurations, primarily electric, hybrid-electric, and hydrogen fuel cell propulsion, although SAF remains an option in some scenarios. This can create a bridge between the General Aviation and the commuter segments, demonstrating scale up of new propulsion architectures and energy carriers.

The future vision for commuter aircraft is to be in continuous commercial service in all European regions, fully integrated into the European transport system with frictionless transfer between transport modes. A further potential for this segment lies in dual-use synergies with defence, utilising autonomous systems, which at this aircraft scale, will have lower demonstration costs.

Due to the point-to-point character of this segment it represents a promising application for the deployment

[38] Literature has a range of passengers for this type of air vehicle platform. For instance, for ATAG it is 50-100 whereas for Destination 2050 it is 20-100. In this position paper, the CS-23 applicability to a maximum 19 passengers is used instead as the primary differentiator between Regional and Commuter air vehicle platforms. Other effects such as mission type and flight duration will be further considerations of differences within an air vehicle platform description.

[39] AZEA (2026). *Roadmap for the deployment of hybrid, electric and hydrogen flights in Europe.*

[40] Short-haul flying redefined: The promise of regional air mobility. https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/short-haul-flying-redefined-the-promise-of-regional-air-mobility (retrieved 21 March 2026).

of a first hydrogen aircraft. The operation of such aircraft at a limited number of airports reduces the effort significantly, e.g. for operations, fuel distribution and maintenance capabilities.

Main research and innovation targets (TRL, MRL and CRL 1-6)

Airframe: Enhancing European competitiveness with significant efficiency gains will rely on improved aerodynamics, light-weight airframe structures and industrialisation for low-cost production. Airframe architectures will need to assess a broad range of energy carriers from SAF, to hydrogen and other cryogenic fuels and electricity. New cabin developments will be needed using advanced materials to increase cabin height, approaching Regional and SMR standards, improve the passenger experience and increase passenger capacity. These materials will also need to support new manufacturing methods and recycling potential. CS-23 standards will need to be reviewed (e.g. MTOW[41] limits) to enable new energy carriers and propulsion system concepts like hydrogen fuel-cells.

Propulsion: There are multiple options for propulsion architecture and energy carrier for commuter aircraft, with the research and innovation focus being a function of the target mission length and load. This will need to include further optimisation of gas turbine propulsion, including in turbo-generator mode, relevant for longer range capabilities. Hydrogen fuel-cells will also require further attention to enhance cell performance, system integration, thermal management and reduction in system weight. Research and innovation will have to improve battery specific energy density, battery performance through-life, and electric machine specific power density for mid-range RAM, anticipating a full-electric capability.

Systems: The narrative for long range and SMR is relevant for this segment as well, with appropriate adaptations recognising the different energy carrier and architecture solution space. Novel avionics and propulsion systems will need to include electric energy distribution systems with intelligent load management and fail-operational capabilities. Advanced power electronic systems and modular power distribution units (PDUs) will be necessary to safely handle high currents. CS-23 standardisation activities will need to provide an entry point for new energy carriers and voltage architectures. Additionally, capabilities beyond today's CS-23 standard will need to be established, further increasing safety of flight and the implementation of a single-pilot cockpit capability. Integration of RNP/LPV/GLS[42] capabilities and landing performance for small airports will be required to enhance competitiveness and societal accessibility.

Fuel and energy: Commuter aircraft, with its variety of missions, passenger and freight capacity, and entry-into-service windows, will need to have solution options for SAF, hydrogen and other cryogenic fuel, and electricity as the primary energy carrier.

Main industrialisation and deployment targets (TRL, MRL and CRL 6+)

To ensure investments are going to where they have the most significant impact, network-level feasibility studies will be required to show where RAM improves and does not improve regional accessibility, where it can be profitable, and how it would achieve mobility interoperability.

Furthermore, investment in European battery production must aim at scale with associated supply chain and rare material priority access. Certification of battery packs for partial and full-electric RAM solutions will be essential

Demonstrators for commuter aircraft using improved fuel-cell with higher thermal efficiencies, and hybrid-electric technologies based on turbo-shaft engines will have to be developed. Passing those aircraft through certification, including real-world operational trials on short regional routes will be required to support new market deployment in "first adopter" scenarios.

Additionally, the creation of electrical charging infra-structure will facilitate the deployment of commuter aircraft across remote regional networks.

[41] Maximum Takeoff Weight.

[42] RNP: Required Navigation Performance; LPV: Localiser Performance with Vertical Guidance; GLS: Ground Based Augmentation System (GBAS) Landing System.

2.1.6. PLATFORM 5 – Business Jets

Market forecast and impact on EU competitiveness

The Business Jet segment covers a range of capabilities from light, mid-size to ultra-long range; overall this represents a significant portion of the European aviation economy. Europe has the full capability to manufacture long-range and premium business jets with currently 80% European content. The European supply chain capability in propulsion, systems, structures and components ensures that non-European aircraft manufacturers have 20%-40% of their content from Europe. Overall, this European supply chain and manufacturing is worth €100 billion per year[43].

Globally, approximately 8,500[44] new business jets are expected to be delivered through to 2035 with a global production rate of roughly 900 to 1,000 aircraft deliveries per year of which the European share is estimated to be up to 150 aircraft per year. Market drivers in this sector include new ownership models and growth in discrete global markets. Dual-use product capability also exists in platforms and systems with an active global market in conversion of business jets for military and special mission platforms enabling maritime surveillance, communications and signal intelligence capability.

EU competitiveness in this sector is driven by capability in design, manufacturing and production of aircraft, engines, environmental control systems, wing and fuselage carbon-fibre structures, equipment and landing gear. Hence, there are active technology flows from and to other air vehicle platform capabilities with respect to airframe, propulsion, systems and components.

Main research and innovation targets (TRL, MRL and CRL 1-6)

Airframe: Research and innovation in this segment will need to be focused on enhancing European competitiveness in aerodynamics, and airframe and wing structures, enabling lighter-weight, more fuel-efficient aircraft across an expanded mission envelope. At a broader platform level, design-studies will be needed to explore the application of new energy carriers in future business jet platforms.

Propulsion: The business jet segment will remain largely reliant on conventional turbofan engines, particularly in mid-size and ultralong range jets with ultra-efficient cores, increased electrical integration and reduced emission combustion capabilities. These often introduce new challenges related to weight, aerodynamics and noise that must be offset through superior system integration. Innovation arises from achieving efficiency and integration at a smaller scale compared to commercial aircraft. Hybrid-electric and fully electric propulsion may appear in light business jets. Hydrogen will continue to be of interest and will require further study, in particular for dual-fuel capability and modes of operation.

Systems: The narrative for long range and SMR is relevant for this segment as well, with appropriate adaptations recognising the different energy carrier and architecture solution space.

Fuel and energy: As business jets typically operate away from large commercial airports, they can provide a stimulus for increased availability and usage of SAF. From a research and innovation perspective, system integration of electrical capabilities and machines will be relevant. Hydrogen combustion via gas turbine will need to continue to be researched to enable potential first entrant of hydrogen via business jet, likely in some form of dual-fuel capability.

Main industrialisation and deployment targets (TRL, MRL and CRL 6+)

Gas turbine propulsion system flight testing and (pre-)entry to certification critical tests will be needed as well as activities to support the integration of non-propulsive energy systems to achieve prototype flight testing and (pre-)entry to certification critical tests. Additionally, a strengthening and creation of differentiation in the European supply chain capability, especially through integrated design, raw and part-processed material supply, automation of manufacturing and MRO will ensure that European industry can manufacture and maintain products at scale and competitive cost.

[43] EBAA.

[44] Honeywell Global Business Aviation Outlook.

2.1.7. PLATFORM 6 – General Aviation (GA)

Market forecast and impact on EU competitiveness

Europe manufactures around 20% of the 3,200 General Aviation (GA) aircraft built globally[45]. This European output is worth over €1 billion in revenue[46]. Incorporating aircraft used for commercial pilot training to 9-seat aircraft, European GA manufacturers are world class with their use of composites, cutting-edge aerodynamics and full-electric propulsion. In fact, Europe leads here with the only EASA certified, fully battery electric aircraft being used globally for pilot training.

The GA segment is well placed to act as a cradle of innovation for Europe's broader aviation manufacturing ecosystem. Given their smaller scale, GA aircraft provide a cost-effective instrument to demonstrate the increasing benefits and capabilities of new propulsion architectures. Several European companies are already working on bringing battery-electric, hybrid-electric and hydrogen-powered aircraft to market.

GA aircraft represent the first realistic deployment environment for innovative technologies thanks to shorter certification cycles, smaller risk envelopes, and the presence of highly innovative SMEs and historical GA airframers. These aircraft provide invaluable operational and certification insights that directly reduce the technological uncertainty enabling progressive scale up of disruptive architectures for larger segments. Hence, it has an inherent capability for supporting the EU's ability to demonstrate, validate and industrialise breakthrough energy architectures in the 2028-2035 timeframe.

Strong synergies also exist with the security and defence sector, notably in the development of drones, manned/unmanned teaming, and automation technologies that draw directly on GA expertise. Recognising synergies with dual-use and incremental approaches could directly reinforce the competitiveness and long-term viability of European manufacturers[47]. Additionally, the multiple societal roles of GA, ranging from civil protection and medical evacuation to territorial connectivity, underscore its direct value for European citizens and the strategic coherence of the broader European aviation ecosystem.

Main research and innovation targets (TRL, MRL and CRL 1-6)

Airframe: Research and innovation in this domain will need to support flight tests of next-generation technologies on GA aircraft, not only in the fields of advanced batteries or fuel-cell systems but across all innovations with scale-up potential for commercial aviation. These include lightweight structures, advanced aerodynamics, and integrated energy-management systems.

Propulsion: Due to the variety in GA aircraft size, mission range, and duration, future propulsion improvements will need to cover a broad spectrum. Full-electric solutions will need to continue to

[45, 46] GAMA (2025). *General Aviation Aircraft Shipment Report 2025.*

[47] GAMA (2026). *WINGS OF CHANGE: A Strategy for Competitiveness, Innovation, Industry, and Investment in Europe's Sustainable Aviation Sector.*

broaden their impact with improved battery specific energy, battery performance through-life and electric machine specific power density. More efficient thermal cores and higher levels of electrical hybridisation will need to provide scalability options and fuel-cell technologies will need to support the longer-range and higher capacity applications. The consistent theme across all solutions is increased performance, lower cost, integration benefits and reduced emissions.

Systems: Onboard capabilities will need to progressively deliver reductions in weight, volume and power consumption of all components, ensuring lower energy use across the mission. To unlock new mission benefits and emission reductions, an increased integration between airframe and propulsion will be needed, especially when using advanced energy carriers such as hydrogen. Through advanced cockpit functions, advanced health monitoring capabilities, navigation systems and ATM integration, these aircraft will also achieve enhanced safety and operational efficiency, supporting the broader integration of GA platforms into societal mobility. In parallel, the progressive introduction of advanced flight automation and autonomy capabilities, up to and including system-first logics typically associated with unmanned aircraft, will enable higher levels of operational autonomy, improved situational awareness and reduced crew workload.

Fuel and energy: GA aircraft, with its variety of missions, passenger and freight capacity, and entry-into-service windows, will need to have solution options for SAF, hydrogen and other cryogenic fuel, and electricity as the primary energy carrier.

Main industrialisation and deployment targets (TRL, MRL and CRL 6+)

Industrialisation and deployment of trainers and light aircraft will be needed to demonstrate their economic and operational viability in impactful deployments across flight schools and local and regional mobility.

Upgrades that enable civil-military duality through incremental evolution of existing certified platforms will be essential to meet the accelerated timescales of defence initiatives.

Furthermore, investment in European battery production must aim at scale with associated supply chain and rare material priority access. Certification of battery packs for partial and full-electric GA solutions will be essential.

Additionally, the creation of electrical charging infrastructure will facilitate the deployment of GA aircraft types for flight training and to encourage new mobility modes.

2.1.8. PLATFORM 7 – Rotorcraft

Market forecast and impact on EU competitiveness

Rotorcraft play an essential role in safeguarding people and supporting missions that no other aircraft category can perform with the same flexibility. They are used for civil protection such as disaster assessment after natural disasters, fire reconnaissance, water and retardant missions, search and rescue, and rapid deployment of emergency personnel. Their ability to take off and land vertically, operate without runway infrastructure, and access confined or isolated zones, including mountain areas, small islands and deep-sea oil and gas platforms, makes them uniquely suited to serve in any kind of territory. In other words, rotorcraft are not luxury assets but strategic public interest tools that are cost-efficient, highly responsive, and critical for civil protection.

In the current geopolitical and industrial context, and considering evolving operational demands, regulatory frameworks, and societal expectations, the need for investment in Europe to keep and develop these assets is key. The global commercial rotorcraft market, valued at $6.2 billion in 2023, is projected to reach $9.7 billion by 2033[48]. This expansion is primarily driven by an increasing demand for air ambulances and emergency medical services, alongside the growth of Urban Air Mobility (UAM). While the market faces restraints from operating costs and stringent safety regulations, emerging technologies like hybrid-electric propulsion and autonomous flight systems are creating lucrative new opportunities. Furthermore, rising investments in specialised aircraft for aerial firefighting and disaster response are expected to further bolster market development

Additionally, a structured modernisation effort would enhance safety, avionics integration, environmental performance, and digital connectivity, and reinforce Europe's strategic autonomy by sustaining local industrial capabilities, safeguarding high-value engineering skills, and ensuring that critical public-service dual-use fleets remain supported within a resilient European ecosystem, limiting external dependencies and export-control limitations. Therefore, maintaining and upgrading capacities and competences for designing and manufacturing rotorcraft is both an operational necessity and a strategic industrial policy choice aligned with long-term sovereignty objectives.

[48] Allied Research. *Commercial Helicopter Market by Size (Light Helicopters, Medium Helicopters, and Heavy Helicopters), Type (Piston Helicopters and Turbine Helicopters), Engine Configuration (Twin Engines and Single Engines), and Application (Oil and Gas, Transport, Medical Services, Law Enforcement and Public Safety, and Others): Global Opportunity Analysis and Industry Forecast, 2024-2033.*

Main research and innovation targets (TRL, MRL and CRL 1-6)

Airframe: The future evolution of rotorcraft is increasingly moving towards more performant rotorcraft architectures capable of combining the operational flexibility of rotorcraft with the speed and range traditionally associated with fixed-wing aircraft. To consider such disruptive architectures the market will need to address both para-civil and military application stemming from previous European funding frameworks (e.g. Clean Sky 2) and extended to dual-usage. In this context, new architectures such as tiltrotor and compound architectures represent the most promising solutions for so-called "fast rotorcraft", with the former already having been tested and proven. Further research into these technologies will be necessary especially since these technologies not only broaden mobility and transportation opportunities but are also capable of providing a low environmental impact (i.e. CO_2, NOX, noise) under demanding environmental conditions. Typically for Search and Rescue (SAR) operations, the fast rotorcraft advantage lies in its ability to cover larger areas swiftly, beyond traditional rotorcraft coverage and without the need to create large and expensive infrastructures.

Propulsion: The challenge of the aviation sector to become carbon neutral at the 2050 horizon also includes rotorcraft. Hybrid-thermal and electrical architectures will need to transition from mid-level laboratory validation to full-scale flight demonstrations. Integrating these hybrid power architectures natively in the design of a rotorcraft (by including for example specialised declutching and freewheel mechanisms) should not only bring many benefits to the fuel consumption but also from a safety operational point of view.

Hybrid-electric propulsion architectures will transform the rotorcraft industry. For civil rotorcraft, hybridisation offers two distinct, reciprocal advantages based on engine configuration. In single-engine models, an electric motor can provide a power boost that mimics twin-engine safety margins, potentially allowing these aircraft to operate in restricted urban environments by ensuring a controlled landing if the primary engine fails. Conversely, for twin-engine rotorcraft, hybridisation enables more efficient single-engine cruising by using an electric starter to guarantee an instantaneous in-flight restart of the dormant engine, thereby capturing the superior fuel economy typical of single-engine operations.

Looking forward, the next leap in environmental performance is expected to stem from a more integrated thermodynamic engine cycle designed to maximise fuel efficiency and minimise emissions at the platform level. Research and innovation efforts must therefore explicitly address fuel qualification, standards and SAF scale-up enabling economic adoption, in parallel with propulsion system decarbonisation developments.

Systems: Onboard systems are transitioning towards full situational awareness and high-performance automation, integrating enhanced flight control with refined piloting laws to manage complex mission manoeuvres and increase flight safety. At the heart of these capabilities are digital displays that overlay sensor data and computer-generated terrain to ensure rotorcraft can dodge obstacles and navigate safely in low-visibility urban or offshore environments. These features will need to be backed by an emergency "Fly me Home" self-piloting recovery mode and a specialised ground-proximity warning system that gives the operator a clear, 3D view of the landscape even when they cannot see out of the window. Information will need to be handled by powerful internal computers and flexible radio units that automatically adjust how they send data based on the weather and distance, while the traditional bundles of heavy wires need to be replaced by lightweight systems that transmit data through existing power lines or wireless signals. Modular power distribution units with "cognitive power electronics" to safely handle power and signal distribution, even in case of local failures, will need to be at the core of a fail-operational data and energy management system.

To maximise operational availability and slash lifecycle costs, the next generation of rotorcraft will need to utilise integrated health and usage monitoring systems that provide real-time assessment of structures and mechanical systems. These architectures will rely on advanced algorithms for flight regime recognition and vibration monitoring leveraging qualified AI and facilitating a shift from traditional scheduled maintenance intervals to precise and on purpose condition-based maintenance. This "design to TBO" (Time Between Overhaul) methodology will ensure that all components are continuously monitored during flight, allowing for reduction of maintenance burden and an extension of component's life. These native monitoring capabilities from the onboard systems will need to be completed by offboard computing technologies, aiding in the diagnostics and offering means to improve ground support activities (e.g. virtual and augmented reality and smart tooling connected logistics).

This evolutionary path will also need to utilise a modular and open system architecture, allowing the system to ingest future breakthroughs in electric motors or cryogenic fuel liquid hydrogen-cooled cryogenic propulsion systems, as they mature towards a further term horizon.

Manned-unmanned teaming: Manned-unmanned teaming or crew-uncrewed teaming refers to the collaboration between manned and unmanned systems and will become a standard and a central pillar in the rotorcraft usage for both civil, para-civil and military usages. This disruption requires significant investment in Europe to remain competitive against advanced technology competitors. The functions that need to be addressed are numerous and include the coupling of multiple drones with multiple rotorcraft, improving the pilot interfaces to manage the workload, the link with the ground station (i.e. the command and control linkage), the standard for embedded drones, Automatic Launched Effectors (ALEs), as well a rotorcraft protection against drones (i.e. counter UAS).

Main industrialisation and deployment targets (TRL, MRL and CRL 6+)

The transition to a high-rate, low-cost production model must be supported by a revolutionary reconsideration of manufacturing, focusing on highly automated tools and production-oriented design for large, complex composite and metallic structures, and adopting new materials and processes. This industrial system will need to utilise AI to oversee the adaptation of assembly lines, ensuring that precision robotics and advanced tooling maintain the highest quality standards while accelerating development cycles. A critical component of this industrialisation will be the establishment of new qualification standards for AI-based processes to guarantee the mandatory production quality for aeronautic standards. Additionally, industry must shift towards a more virtuous model by reducing its overall footprint; the entire industrial lifecycle will need to build on the principle of circularity, incorporating sustainability and disposal as key design parameters to ensure that materials are recovered and repurposed at the end of the aircraft's operational life. Additive manufacturing is expected to contribute to reducing the use of raw materials in comparison to current subtractive methods.

To prepare any scaled industrial product and secure supply chain capacity, the need for an industrial demonstrator is of the utmost importance. Beyond technology readiness at engine and aircraft level, market deployment will critically depend on the timely certification of fuels, including non-biological, or synthetic, SAF pathways, ensuring full compatibility with existing and future propulsion systems, supply chain robustness and verified lifecycle emissions performance.

2.1.9. PLATFORM 8 – Urban Air Mobility (UAM)

Market forecast and impact on EU competitiveness

Urban Air Mobility (UAM) is a worldwide emerging market segment for safe, secure and sustainable air mobility[49] operating over intracity, short intercity or urban-suburban routes roughly limited to 100 nautical miles[50]. With a capacity between 1-6 passengers or a freight capacity of several hundred kilograms (without passengers), its value proposition is being able to trans-navigate congested or convoluted ground routes.

The projected value of UAM highlights opportunities for long-term economic growth. Looking towards 2040-2050, the industry is focused on refining the technology and frameworks necessary for success. By navigating Europe's dense airspace with care today, the groundwork is being laid for a sophisticated, large-scale adoption that will redefine regional connectivity for the next generation. The Alliance for Zero Emission Aviation (AZEA) assumes a baseline scenario where roughly 24,000 aircraft will be delivered in support of UAM between now and 2050[51].

Due to operating within urban areas, UAM's are expected to use primarily electric Vertical Take-Off and Landing (eVTOL) aircraft configurations that do not require large aerodrome and runway infrastructure. These electric propulsion systems in the hundreds of kW to low MW range are expected to be the standard for commercial UAM, mainly due to batteries with improved energy density and lifecycles, high levels of system automation, and health monitoring.

By 2050, certified eVTOL aircraft are expected to be in regular commercial service in all large European urban areas, fully integrated into the European transport system with frictionless transfer between transport modes.

Main research and innovation targets (TRL, MRL and CRL 1-6)

Airframe: Next generation eVTOL aircraft will need to include a distributed electric propulsion power source, an architecture subject to mission parameters, an aircraft platform and technology progression based on higher capability batteries, fuel cells or hybrid turbogenerator systems. While emissions are largely avoided, new flight trajectories for this mode of transportation will impose additional stress to the community noise management of airports. Consequently, noise reduction at the source will be required to minimise annoyance due to UAM.

Propulsion: In synergy with UAS research and innovation targets, full-electric solutions will need to include improved battery specific energy, improved battery

[49] Clean Aviation Joint Undertaking; SESAR Joint Undertaking (2025). Aviation Research & Innovation Strategy (ARIS) — A pathway to competitive and sustainable aviation supporting Europe's sovereignty.

[50] Patterson et al (2018). *A Proposed Approach to Studying Urban Air Mobility Missions Including an Initial Exploration of Mission Requirement.* (https://doi.org/10.4050/F-0074-2018-12671)

[51] AZEA (2026). *Roadmap for the deployment of hybrid, electric and hydrogen flights in Europe.*

performance through-life and electric machine specific power consumption, and include more efficient, lighter weight, and compact turbogenerators and fuel cells. Overall, they will need to include all aspects enhancing safety requirements and enabling longer range UAM.

Systems: In synergy with UAS research and innovation targets, activities will need to include power electronics and high-voltage systems, advanced thermal management systems capable of dissipating the high heat density generated by electric motors, power electronics and batteries, as well as next-generation actuation based on electromechanical actuators for flight controls and secondary systems. ATM systems will need to be adapted to foster UAS integration in airspace and related traffic management.

Fuel and energy: UAM aircraft, with its variety of missions, passenger and freight capacity, and entry-into-service windows, will need to have solution options for SAF, hydrogen and other cryogenic fuel, and electricity as the primary energy carrier.

Main industrialisation and deployment targets (TRL, MRL and CRL 6+)

Europe will need to invest in a European battery production at scale with associated supply chain and rare material priority access. Certification of battery systems with a higher capability and a higher safety requirement will be essential. Demonstrators for UAM aircraft will have to be developed. Passing those aircraft through certification, including real-world operational trials will be required to support new market deployment in "first adopter" scenarios.

To support Air Navigation Service Providers (ANSPs) in their management of UAM, innovative operations and systems will need to be developed. Additionally, investment in the necessary UAM infrastructure like dedicated eVTOL vertiports will be necessary as well as the further integration of UAM in ATM.

2.1.10. PLATFORM 9 – Unmanned Aircraft Systems (UAS)

Market forecast and impact on EU competitiveness

Unmanned Aircraft Systems (UAS), commonly referred to as drones, refer to an aircraft that operates autonomously or that is remotely piloted without a human pilot on board[52]. UAS are set to bring a range of positive changes to the lives of European citizens[53] like facilitating express delivery, including up to high value medical deliveries, aiding in disaster management, and assisting in search and rescue missions or border surveillance. They also play a role in geographic mapping, infrastructure inspections and crop monitoring[54].

The European Drone Strategy 2.0 from 2022 estimates that with the right framework in place the drone services market in Europe could by 2030 reach a value of €14.5 billion, with a compound annual growth rate of 12.3%, and create 145,000 jobs in the EU[55], which is significantly higher than the originally estimated €7.5 billion to €10 billion in the 2016 European Drones Outlook Study[56]. Outside Europe, notably China, bold steps have already been taken to support a low-altitude economy, fostering domestic markets with significantly higher projected volumes. Their growing presence in Europe underscores their intent to pursue market penetration strategies while adapting to local EU regulations such as done recently with EASA.

A key potential for UAS lies in their clear dual-use synergies at both platform and systems level which could enhance European sovereignty and lower costs of demonstration, in particular by deriving new UAS variants from existing civil platforms like General Aviation. Leveraging the architectural proximity between full scale UASs and GA aircraft could enable European aircraft manufacturers and system integrators to accelerate design cycles, reduce certification uncertainty, and sustain competitive manufacturing costs. This approach could also broaden opportunities for diversification, allowing civil airframers to enter emerging defence and security markets through derivative unmanned variants of existing platforms.

[52, 53] Drones & Air Mobility Basics explained. https://www.easa.europa.eu/en/domains/drones-air-mobility/drones-air-mobility-landscape/basics-explained (retrieved 21 March 2026).

[54] Drones & Air Mobility Benefits for European Citizens and Air Transport. https://www.easa.europa.eu/en/domains/drones-air-mobility/drones-air-mobility-landscape/benefits (retrieved 21 March 2026).

[55] European Commission. *A Drone Strategy 2.0 for a Smart and Sustainable Unmanned Aircraft Eco-System in Europe.* SWD(2022) 366 final, 29 November 2022.

[56] SESAR Joint Undertaking (2016). *European Drones Outlook Study — Unlocking the value for Europe.*

The competitiveness of European drones depends heavily on their operational reliability and maintainability, with full sovereignty assumed and enabled through appropriate standards. Therefore, a European mass production capacity with controlled costs and high technological requirements will be essential for the European drone industry competitiveness and relevance for dual-use application. Only under these conditions will the European drone industry be able to reap the economic benefits of the low-altitude market in the face of global competitors. Strategies such as the recent EC action plan on drone and counter drone security[57] provide an ambitious blueprint for stronger EU cooperation and must be considered when informing future research and innovation needs.

Main research and innovation targets (TRL, MRL and CRL 1-6)

Airframe: Robustness to a range of human-generated and natural conditions must be recognised in the design and integration at drone level. Improvements in the tolerance to adverse conditions, such as HIRF/EMC[58], lightning, low visibility, and high winds, together with reducing noise and maintaining operability and performance will be required. Maintainability capability and functionality will also be important due to the range of vehicle sizes from small machines to full-scale fixed and rotary-wing aircraft, with a corresponding range of fleet volumes.

Propulsion: As with some of the other aircraft segments, UAS have a range of energy and propulsion solutions determined as a function of the mission requirements. Continued attention to battery performance as well as machines with reduced or zero critical materials, like e.g. magnets, will remain of strong relevance to a significant portion of the UAS segment. Use of hydrogen as a fuel will require further research and innovation activities, as will attention to combustion engines with the additional purpose of increasing mean time between failure to support higher risk operations whilst maintaining operational safety and reliability.

Systems: Autonomy is a cross-cutting priority for all UAS types. However, achieving the right level of autonomy required for seamless integration into shared airspace alongside other aircraft remains a challenge. For UAS, situational awareness is not just about operator assistance but a critical step towards full autonomous operations with only high-level human-in-the-loop (HIL) supervision. UAS are therefore the perfect testing environment for the future of AI certification, for new concepts of autonomy related to unmanned air traffic management (UTM), and for addressing the future sky challenges. Other areas of attention will remain Detect and Avoid (DAA) technologies for smaller UAS, command and control linkage and cybersecurity, unified standards, and simplifying system complexity and cost while meeting the highest safety levels for control electronics.

Main industrialisation and deployment targets (TRL, MRL and CRL 6+)

Europe will need to invest in a European battery pack production at scale with associated supply chain and rare material priority access. The same applies to electric motors with specific applications to UAS. To ensure that European industry can manufacture at scale and at competitive cost, it will be essential to build a European supply chain capability, in integrated design, raw and part-processed material supply, automation of manufacturing, and in inspection.

Increasing UAS specific certification process methodology and tools will be required to enable faster routes to market and full configuration traceability in digital systems whilst maintaining expected safety standards, including closer collaboration between civil and military airworthiness authorities. Additionally, the development of advanced and full services for U-space will be required, which includes technologies for tactical conflict detection and resolution allowing more efficient traffic as well as integration with non-UAS traffic, eventually allowing UAS and crewed traffic to fly together in a single integrated airspace.

[57] European Commission. *Action Plan on Drone and Counter Drone Security.* COM(2026) 81 final, 11 February 2026.

[58] HIRF: High-Intensity Radiated Field; EMC: Electromagnetic compatibility.


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2.2. Air Traffic Management (ATM)

Impact on EU competitiveness

The European ATM system is a cornerstone of safety and security-critical infrastructure, optimising flight safety and operational efficiency for all aircraft types. It is also of great economic value considering that European ATM technology manages nearly 70 % of global airspace (civil and military), underscoring Europe's leadership in aviation and ATM technologies[59]. However the European ATM system has been challenged by rising demand, increased complexity due to new types of aircraft, the impact of climate change, military requirements, geopolitical crises, staff shortages, security threats and natural events.

The European ATM Master Plan[60] details how the Digital European Sky (DES) aims to resolve the challenges to the European ATM network by 2045 by targeting optimised gate-to-gate flights thereby reducing fuel burn, CO_2, non-CO_2 emissions, noise, and improving local air quality, in parallel to increasing the global market share of European ATM technology. Given that non-CO_2 effects are estimated to account for roughly two-thirds of aviation's total climate impact[61] improvements in ATM efficiency must also explicitly support the avoidance and mitigation of these effects, for example through optimised trajectory management and the avoidance of atmospheric conditions conducive to persistent contrail formation. Scalable and resilient, the DES will allow a modernised European ATM system to be ready to adapt to future traffic demand, accommodate the growing diversity of aircraft, and maintain high levels of safety and security through automation, flexible staff usage, integration of cutting-edge technologies, and civil-military cooperation, while fully integrating ATM into a multimodal transport system.

The impact of aircraft using new power sources will continue to be considered in the future design and operation of the DES as well whereby different flight profiles in altitude and speed, and new aircraft operational envelopes remain to be assessed and integrated in an already dense airspace[62].

Main research and innovation targets (TRL, MRL and CRL 1-6)

During the 2028 to 2034 timeframe, research and innovation efforts are defined by the European ATM Master Plan and will be led by an appropriate partnership of scientific, operational and industry stakeholders. These efforts will be mainly directed towards the evolution of air navigation through advanced digitalisation and the development of automated concepts. A primary focus of industrial research will involve the transformation of ground platforms into more automated environments specifically targeting the certification of trajectory-based operations and the enabling of advanced air-ground integrated communication technology and infrastructure, as well as further exploring the feasibility of sector-less or flight-centric air traffic control. These next-generation systems will be designed to fully leverage aircraft capabilities and integrate automation, including AI, to enable high-speed data sharing and traffic synchronisation. Simultaneously, the innovation pipeline prioritises the development of AI and ML[63] supported solutions to assist humans in making complex decisions, thereby increasing productivity and enabling flexible licensing schemes. This highlights the need for advances in adaptive automation and real-time operator state assessment to ensure appropriate levels of human oversight and workload management, as well as advances in robust human-AI teaming concepts that enable transparent and resilient collaboration between controllers and intelligent systems.

Innovation also extends to the seamless integration of diverse new aircraft into the shared European airspace. Research activities will need to concentrate on defining advanced services for uncrewed aircraft, vertical take-off and landing vehicles, and higher airspace operations, particularly for missions in complex or congested environments. These efforts need to establish a common altitude reference and establish collaborative interfaces between unmanned air traffic management and traditional air traffic control.

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[59] Clean Aviation Joint Undertaking; SESAR Joint Undertaking (2025). *Aviation Research & Innovation Strategy (ARIS) — A pathway to competitive and sustainable aviation supporting Europe's sovereignty.*

[60] SESAR Joint Undertaking (2025). *European ATM Master Plan 2025 Edition.*

[61] One-third attributed to CO_2 emissions and two-thirds to non-CO_2 effects. https://www.dlr.de/en/research-and-transfer/featured-topics/climate-compatible-aviation/climate-impact-air-transport (retrieved 21 March 2026).

[62] The assessment of the impact on the DES of these aircraft using new power sources is expected to be performed as part of the activities developed by AZEA.

[63] Machine Learning.

Furthermore, research will need to be dedicated to the technical and operational challenges posed by the next generation of zero-emission aircraft. This involves exploring how battery-electric and hydrogen-powered vehicles, which have unique flight profiles, can be safely integrated into European air space as they begin to enter service.

The scientific foundation of the ATM system will need to be expanded through the development of a robust communications, navigation, and surveillance ecosystem based on zero-trust security principles. Researchers will need to work to refine and assess the feasibility of evidence-based optimisation algorithms and operational mitigation measures that can automatically balance the climate impact of flights, addressing for instance the reduction of non-CO_2 effects such as contrails. At the same time, the European aviation sector will need to research the development and certification of measures to optimise 4D trajectories even in the presence of volatile weather and climate-related constraints. These forward-looking efforts will also need to include the definition of digital flight rules necessary to govern a future environment characterised by significantly higher levels of machine autonomy and predictive digital security.

Main competitiveness and industrialisation targets (TRL6+) by 2034

Industrialisation activities, properly involving all deployment stakeholders, will need to focus on accelerating the market uptake of mature, high-readiness technologies that have already surpassed the validation stage, particularly the Strategic Deployment Objectives (SDOs) as defined in the European ATM Master Plan[64]. A central pillar of this effort will involve the large-scale rollout of trajectory-based operations which moves the network towards a fully collaborative environment where precise flight data is shared and maintained by all actors in real-time. To support this, stakeholders will need to implement enhanced conflict detection and resolution tools that utilise aircraft-derived data, such as extended projected profiles, alongside high-resolution wind models to optimise flight paths and safety. This shift will need to be further enabled through the deployment of advanced data link communications that allow for complex lateral and vertical clearances, reducing the reliance on voice communication and allowing controllers to focus on high-level management tasks rather than routine tactical interventions.

Simultaneously, the European airspace will be undergoing a structural defragmentation through the implementation of virtualisation and a new service-oriented delivery model. This defragmentation involves the decoupling of air traffic service provisions from local, physical infrastructure by leveraging data-driven and cloud-based architectures. By deploying virtual centres and remote tower modules, service providers could[65], within pre-agreed operational conditions, dynamically delegate air traffic services across borders or between units, which could significantly enhance the scalability and resilience of the European ATM network. Infrastructure changes will need to be complemented by the optimisation and modernisation of communication, navigation, and surveillance systems, including the establishment of a resilient operational network to protect against vulnerabilities such as signal jamming and spoofing. However, to fully realise the operational benefits of this increasingly flexible and distributed service architecture, adaptive, skill-based and competency-based controller endorsement will be essential.

At the airport level and within terminal manoeuvring areas, deployment actions will need to be taken to minimise the environmental footprint and improve capacity. Land-use planning and operational procedures will need to be implemented more consequently, while noise reduction at the source will need to be further pursued as well. This includes the rollout of land-use planning and noise abatement procedures such as optimised descent operations and advanced approach procedures designed to reduce fuel consumption and noise pollution for neighbouring communities. To accommodate the changing aviation landscape, the deployment strategy will also need to focus on the initial integration of UAM, RAM and drone operations. By implementing foundational U-space services and common interfaces, the system should be able to safely segregate crewed and uncrewed aircraft while allowing new vehicles like air taxis to operate to and from vertiports without disrupting traditional runway slots or airport traffic.

[64] SESAR Joint Undertaking (2025). *European ATM Master Plan 2025 Edition.*

[65] Air Navigation Service Providers (ANSPs) are ultimately left to decide on their preferred business model.

2.3. Airport Operations

With the push for improved inter-modality and the potential development of RAM and UAM, future airport operations are set to evolve from traditional terminal management into digitally managed mobility hubs that are fully integrated into the broader European transport network. To enable this transition, multiple challenges need to be addressed in fields such as sustainability and energy supply, airport operation and intermodal network organisation.

Main research and innovation targets (TRL, MRL and CRL 1-6)

During the 2028 to 2034 timeframe, a priority for airports will be to overcome existing infrastructure fragmentation by aligning local airport planning with coordinated European network and energy strategies. This alignment will need to involve integrating airports and regional smaller airfields into multimodal energy systems to support the diverse needs of SAF, electric charging, and hydrogen supply and storage. This could effectively resolve the current coordination deadlocks between aircraft manufacturers, airlines, airports, ground handling, and infrastructure providers. The impact on the ground time will need to be considered in the context of the airport operations, the operator, and, to some extent, the ANSPs.

Furthermore, in their transition towards intermodal mobility hubs and with the development of new types of aircraft, airports will need to maintain efficiency under increased complex conditions due to the management of different aircraft, increased traffic demand, staff shortages and competence gaps. At the same time, airports will need to ensure efficient airport and multimodal operations, including increased ground time, check-in time, baggage handling, passenger security, and flight and travel legs connection management, which are key factors for passenger satisfaction. Additionally, airports will need to manage congestion and disruption in a context of increased traffic and possibly more frequent weather events linked with climate change.

For airports to be able to handle these challenges, operational intelligence will need to be fundamentally transformed through the development and adoption of digital twin technology and AI to simulate and optimise real-time processes, from passenger flow and facility management to airside operations, aircraft turnaround, and air traffic movements. Additionally, predictive and prescriptive analytics will have to be introduced for anticipating congestion and managing irregular operations, while standardised aircraft handling procedures for electric and hybrid fleets will need to be defined to ensure efficient ground-power allocation and charging schedules. Furthermore, multi-stakeholder processes will need to be created for moving towards a seamless intermodality, where integrated digital platforms and cross-sector mobility partnerships enable advanced services like gate-to-gate baggage tracking and coordinated door-to-door passenger journeys.

To address the efficiency challenge and ensure long-term resilience, automated ground operations will need to be developed and validated alongside robust "security-by-design" architectures. The simultaneous development of standardised human-machine interfaces (HMI) supporting human and safe human–machine collaboration will be key for integrated airport management. Humans will remain central to future airport operations, but their focus will shift from operational routine to strategic management and complex problem-solving. Collaboration will be characterised by close human-machine collaboration (e.g. using cobots and AI), with technology acting as an assistant to increase efficiency and competitiveness.

All these systems will need to be developed securely to protect interconnected digital infrastructures from escalating cyber threats, GNSS[66] interference, drone intrusions and possible disruptions.

Resilience also means addressing the potential impacts of climate change, which may have multiple forms for airports such as increased temperatures affecting operations and runway health, increased risk of floods, more frequent severe thunderstorms disrupting airport operation and more severe hail. Research to characterise the actual impact of climate change on local conditions and atmospheric events will need to be intensified to evaluate risks and develop adaptation measures.

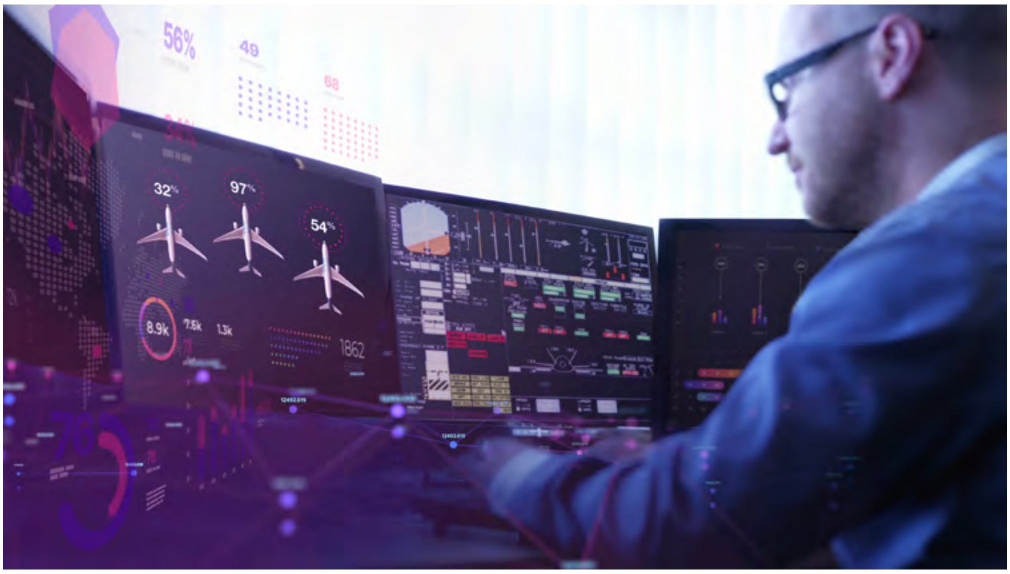
Main industrialisation and deployment targets

Airports and their ground handling service providers must continue targeting carbon-neutrality and economic efficiency in their ground operations by utilising renewable energy, electric and autonomous ground vehicles, and smart building retrofits. In addition, they must keep contributing to aircraft emissions reduction in the taxi and turnaround phases.

[66] Global Navigation Satellite System.

2.4. Enabling Technologies

2.4.1. Digitalisation, design, advanced manufacturing, integration capabilities and associated methods, tools and processes



Transitioning from the principles of competitiveness and sovereignty to an execution capacity

Digitalisation, design, advanced manufacturing and integration capabilities are strategic enablers for European industrial leadership, not merely support functions to product development. In the next aviation cycle, competitiveness will depend increasingly on Europe's capacity to design, manufacture, inspect, certify and ramp-up complex products with higher speed, lower cost, better quality and greater resilience. This capacity will require a systemic transformation of the industrial base through digital threads, model-based engineering, AI-enabled process control, automation, robotics, advanced inspection, predictive maintenance, digital twins and industrial data integration across the supply chain up to safety, training and certification and regulatory compliance.

The objective for transforming the industrial base is not only technological efficiency but also industrial robustness by achieving lower defect rates, reduced rework, faster industrialisation, stronger traceability, lower resource consumption and better scalability across European production and recycling networks. Such capabilities will be essential to preserve sovereignty of the European aviation sector in high-value aerostructures, propulsion systems, equipment and integrated assemblies.

At the same time, to avoid the risk of becoming technologically dependant on non-EU sources and to ensure a competitive and sustainable European aviation sector, the establishment of a European sovereign data space with edge environment technology stacks, from infrastructure to applications and expanding from the initial Gaia-X[67] effort, will be essential. This will enable EU-based data centres as well as scalable and resilient computing capabilities and capacities to be on par with what is available in North America and emerging in China, including towards disruptive digital capabilities via quantum computing. This European sovereign data stack should leverage standardised, cybersecure IT[68] infrastructures to ensure true interoperability. Fully connected to these IT infrastructures, standardised edge environment technology

[67] https://gaia-x.eu/.

[68] Information Technology.

stacks will enable easy operational deployment of a large set of sensors and actuators, next to the real world they need to interact with, while being securely connected to a central European sovereign cloud.

In addition, these assets must always be supported by diversified and reliable energy sources and anchored by a comprehensive and structured data governance defined by the European aviation sector itself. Given the European aviation sector's intrinsic strategic importance, the European sovereign data space should not be made available through aviation-specific initiatives requiring dedicated funding under this position paper, but as a baseline guarantee for the European aviation sector.

Between 2028 and 2034, the ability to swiftly and safely scale operations and establish new EU capabilities, when currently dependent on non-EU sources, including industrial operations at an unprecedented rate, will be a decisive factor in maintaining European competitiveness. This makes it essential to eliminate fragmentation across all dimensions like design, modelling, manufacturing, operations and MRO, recycling, training and certification. The unique characteristics of the global aviation sector, including low production volumes, stringent quality and safety requirements, rigorous certification processes and effectiveness over time, must be addressed with greater speed if the EU is to sustain its competitive edge.

For the European aviation industry, this imperative to do activities faster and better but also differently will require the implementation of AI-supported digital architecture configurations, integrated collaboration frameworks, continuous traceability (i.e. digital threads), industry-specific data models and governance frameworks, and advanced compliance tools and methodologies. These elements will be crucial for maturing the industrialisation processes, enhancing system robustness, and enabling faster and safer production rates in line with aviation's dedicated manufacturing standards, including those standards that are still to be developed and will pave the way to new approaches, such as large part additive manufacturing, and disruptive changes to sustain the competitive edge of the European aviation sector.

The digitalisation of transversal on-board systems

European aviation is entering a new technological era in which aircraft are becoming software-driven platforms built on highly integrated digital architectures. Software increasingly governs aircraft functions and beyond, from propulsion, flight controls and navigation to connectivity and air traffic integration, and enables continuous upgrades across the aircraft lifecycle. Sensors, actuators and control systems are becoming digital, interconnected, software-defined and increasingly AI-enabled.

To deliver this transition, the European aviation sector is becoming increasingly reliant on key digital technologies originating outside of aviation, including computing, connectivity, advanced electronics and AI. These technologies evolve at a much faster pace than aircraft development and service lifecycles, creating major challenges in terms of long-term availability, obsolescence management, secure maintenance, certification and cyber-resilience.

At the same time, although progress in component design and manufacturing helps contain size, weight and power constraints, the development, integration, certification and lifecycle support costs are set to increase significantly. This creates a growing pressure on European system suppliers and reinforces the need for modular, interoperable and cross-platform approaches that can be deployed at scale.

To preserve Europe's technological sovereignty in safety-critical and mission-critical aviation systems, the development, industrialisation and certification of trusted, secure and upgradeable digital aviation platforms will be essential. This includes sustained investment in research and innovation, cyber-resilient and modular architectures, secure connectivity, embedded AI, validation and test capabilities, and frameworks enabling continuous and secure system evolution over decades of operation.

Maintaining Europe's leadership in onboard systems requires a strong and competitive industrial ecosystem across the full value chain, from components and equipment to software, integration and support services. This calls for long-term investment, collaborative European programmes and a policy framework that fosters innovation, accelerates industrial deployment and secures Europe's global competitiveness and technological sovereignty.

Main research and innovation targets (TRL, MRL and CRL 1-6)

Research and innovation efforts in support of the required digital transition need to address three main areas: development and production, maintenance and disposal covering the entire lifecycle, and certification.

Research and innovation efforts will need to be primarily devoted to developing and maturing cutting-edge digital technologies applied to aviation-specific manufacturing tools, including connected, automated production systems and real-time data analytics, enabling operational agility, improved quality assurance, and predictive maintenance capabilities.

Research and innovation efforts will also need to focus on integrating AI into design and modelling. AI-driven approaches can substantially accelerate development cycles, optimise product geometries and simulate performance across a range of AI-generated scenarios, thereby enabling more robust and innovative design and engineering solutions. In addition, fundamental research and innovation efforts need to address digital safety measures and explore new architectures and methods to ensure the safe and secure integration of advanced systems. In this context, certification will involve pioneering end-to-end digital methodologies together with regulators and authorities, and setting new standards for accelerated compliance processes.

Virtual certification in aviation could significantly reduce development time, costs, and reliance on physical testing, but its broad implementation will require major regulatory and technical advances. Authorities such as the EASA and the FAA need to establish clear and harmonised frameworks defining how simulation results can serve as certification evidence. The development of robust verification and validation standards, high-fidelity models with quantified uncertainties, and qualified, interoperable tool chains will be essential in addition to transparent data governance and digital traceability to ensure reproducibility and auditability. Furthermore, emerging technologies such as AI-based systems will require new certification approaches.

Ultimately, a sustained investment in infrastructure, expertise, and international collaboration is necessary to build regulatory trust and enable a gradual transition towards simulation-based certification. During the 2028 to 2034 timeframe, research and innovation efforts will need to focus on prototyping technology demonstrators using pilot manufacturing lines, pilot processes for development, lifecycle management, operation and maintenance, and the creation of digital validation environments requiring aviation dedicated European research and technology infrastructures.

Additionally, research and innovation efforts will have to be allocated to a variety of lighthouse projects[69] implemented in industry-close research and technology infrastructures for pilot lines before full deployment in manufacturing lines, to reduce lead times and optimise resource allocation. These lighthouse projects need to focus on challenges like re-industrialisation including production, as well as MRO, performance optimisation targeting the reduction of assembly and inspection time, the reduction of cognitive load for operators, the transition to full paperless cycles (including digital twins), aviation data models and trusted aviation data governance, adaptive supply chain management through real-time data collection and analytics, etc.

Investment in these research and innovation areas frequently range from hundreds of thousands to several million euros per initiative. Across the European aviation sector, this leads to a total envelope of € 0.5 billion of funding that will be needed.

Summary table

Budget estimates are indicative and derived from sector consultations.

Category	Typical Yearly Budget
Large Group/Consortium	€50M – €200M+
Major R&T Department	€2M – €50M
SME or Niche Lab	€200K – €2M
Single R&T Initiative	€100K – €5M

[69] Lighthouse projects are small, well-defined initiatives that serve as models for larger digital transformation efforts within an organization.

Main industrialisation and deployment targets (TRL, MRL and CRL 6+)

The transition to fully digitalised manufacturing and maintenance environments will require comprehensive upgrades to shop floors due to the deployment of industrial Internet of Things (IoT) platforms, advanced indoor positioning systems, advanced robotics, and integrated AI vision quality control systems. The adoption of AI at scale will require the aforementioned robust IT infrastructure and the integration of these IT tools, adapted to aviation constraints, into existing workflows, accompanied by rigorous change management and workforce training programs.

Safety and certification will become critical cost factors for deployment since digital systems must be robustly protected against cyber threats and organisations must continuously update protocols to align with evolving regulatory requirements. Furthermore, the path to digital certification often involves significant investment in both technology and collaboration with certification bodies to ensure that all digital processes and products are transparent, traceable, and auditable.

The necessary investments will depend on the operational footprint, existing technological readiness, and the breadth of adoption. This will include costs related to infrastructure modernisation, digital tool integration, cybersecurity enhancements, regulatory harmonisation, and extensive personnel training including upskilling and reskilling.

In total, the deployment of aviation specific digital solutions for the European aviation sector could represent an envelope of € 4 billion of total funding that will be needed.

Summary table

Budget estimates are indicative and derived from sector consultations

Stakeholder	Project Scale	Estimated Overall Cost Range
Major Manufacturer	Enterprise-wide	€100M - €1B+
Airline Group	Network-wide	€10M - €500M
MRO/Supplier	Targeted area	€1M - €50M
Small Operator	Selective adoption	€500K - €5M

2.4.2. Aviation's Energy Transition : Sustainable Aviation Fuels (SAF), Hydrogen and Electrification

Deployment of Sustainable Aviation Fuels (SAFs) is instrumental for reaching the decarbonisation goals of aviation by 2050. SAFs are particularly key for longer range aircraft, from the regional, business and up to the long range segments for which no alternative sources of energy are foreseen by 2050. These segments also represent the bulk of aviation emissions, particularly the SMR and long range segments which also represents the larger portion of aviation economic value. For shorter-range aircraft, electrification, and possibly hydrogen, may emerge by 2035-2040, but SAF will remain critical to decarbonise current aircraft.

Currently, SAF is qualified up to a 50% blend ratio while research and development activities are performed within the global aviation sector to ensure aircraft are fully compatible with 100% SAF and to develop relevant fuel standards for SAF.

The global challenge is to scale up SAF production and supply, to match required volumes at affordable costs and to retain airlines competitiveness at increasing SAF volumes. Within Europe, ReFuelEU aviation sets the regulatory framework for SAF introduction with increasing targets towards 2050. By 2035, the blending mandate will be 20%, including 5% of e-fuels, which corresponds respectively to 9.2 Mt and 2.4 Mt of fuel according to fuel demand projection. Reaching these targets will require a long-term reliable and application-friendly legal framework that secures bankability for SAF production plants, which is a significant challenge for fuel producers today given economic challenges around SAF adoption at scale. Feedstock availability, logistics and supply, and a framework that delivers affordable fuels will also be required to achieve future targets.

Additionally, it will be necessary to diversify the current production, which consists mostly of Hydroprocessed Esters and Fatty Acids (HEFA) from used cooking oil and fats, and to build first-of-a-kind value chains based on cellulosic feedstock. The same applies for the deployment of e-fuels, especially considering that it is a technology still in industrial infancy with projected production significantly behind ReFuelEU aviation targets. Producing these fuels is a challenge for many regions in Europe since it not only means producing massive quantities of low-carbon hydrogen and creating the corresponding infrastructures, but also ensuring the parallel development of low-cost, low-carbon electricity.

The estimated future energy demand for producing e-fuels for aviation will need to be considered in the mid to long-term plan for electricity production and distribution. Studies have indicated that by 2050, 700-800 Mt of kerosene-type Jet A equivalent fuel will be required globally for the aviation industry across a mix of bio-SAF, eSAF and hydrogen[70]. Hence, the global aviation demand for hydrogen in 2050 is at least in the order of 100 Mt for use as e-fuel or direct use[71]. Noting that current global hydrogen production for all uses is 95 Mt with less than 1% via low-emission production routes[72], the required ramp up is significant. To achieve the 100 Mt mark for hydrogen in 2050 is expected to require 6100 TWh of electricity[73] which represents some 10% of the estimated total world energy needs in 2050[74]. These figures clearly illustrate why SAF production and supply must be considered an integral part of the future global and European energy landscape

Failing to create the conditions for the development of SAF production in Europe will mean relying heavily on imports with impacts on European sovereignty and security of supply. The European deployment of SAF will need to be accompanied by a continued research and development effort aiming at increasing conversion efficiency of processes as well as their selectivity toward kerosene thereby further improving their economic potential.

With the development of electric vehicles in road transportation, the decreasing demand for gasoline and diesel should be anticipated and their production could be adapted accordingly in favour of SAF.

Research and innovation efforts need to cover all TRLs, further maturing already advanced technologies towards industrial application while at the same time addressing new and novel production pathways thereby enabling the efficient utilisation of the entire range of sustainable energies and resources. The focus of these research and innovation efforts should be placed on technologies with considerable potential in terms of scalability.

To guide industry development, availability of feedstock and the production potential of both bio-advanced fuels and e-fuels will need to be clarified. For biofuels, this means clearly assessing biomass availability both at European level and from possible imports, with measures put in place to set up a robust and resilient supply chain. For e-fuels, this means assessing potential CO_2 sources via the development of concentrated biogenic CO_2 routes and furthermore fostering research and development on direct air carbon capture technologies to compensate for potential feedstock limitation for e-fuels.

To ensure balanced and sustainable access to SAF across all sites, either economically viable solutions for widespread SAF distribution are required, or the establishment of robust compensation frameworks at the European level such as book-and-claim systems. Of particular consideration is General Aviation (GA) which is characterised by a very large number of airfields across Europe enabling on the one hand greater territorial connectivity and accessibility, while on the other hand posing an additional challenge when integrating SAF distribution strategies. This extensive network of smaller airfields could have a strategic advantage in terms of territorial access and connectivity, while supporting the sustainability goals as well as the vitality of the existing European ecosystem.

[70, 71, 73, 74] The Mission Possible Partnership (MPP) (2022). *Making Net-Zero Aviation Possible — An industry-backed, 1.5°C-aligned transition strategy.*

[72] IEA (2025). *Global Hydrogen Review 2025.*

[75] Expander's Enhanced Biomass to Liquids.

Hydrogen

Hydrogen will play an important role in the future of aviation, not in the least because it is a key component for biofuels like HEFA and EBTL[75], as well as for eSAF which requires a large development of hydrogen production.

In addition, when it comes to hydrogen or other cryogenic fuels, the main pursuit will be to move towards climate-neutral aviation while significantly reducing fuel production costs compared to SAF. Building on foundations laid in Clean Aviation, this result could be achieved in two ways: from a sophisticated synergy of batteries and fuel cells, or from an advanced fuel system and scalable gas turbine. In other words, to leverage the full potential for larger aircraft such as SMR, pure-hydrogen and cryogenic fuel systems will be crucial.

Hydrogen-powered flight therefore represents a transformative convergence of electrification and hydrogen technologies in which propulsion power can be delivered through combinations of batteries, fuel cells and hydrogen-fuelled gas turbines. To reach commercially viable hydrogen aircraft, Europe must continue to support the scaling of both hydrogen-electric (fuel-cell-based) combustion systems and direct hydrogen-combustion systems to meet the stringent size, weight and performance requirements of modern aviation.

Hydrogen enables in-flight zero CO_2 emissions when used either in fuel cells or combustion engines and can deliver near-zero life-cycle CO_2 when produced from low-carbon or zero-carbon electricity. Hydrogen fuel-cell powertrains are particularly attractive for regional, commuter and smaller short-range aircraft where they can offer very high energy efficiency and zero in-flight NOX and particulate emissions. On the other hand, direct hydrogen combustion engines are better suited to higher-thrust applications, notably SMR and long range aircraft, where they can deliver the required thrust levels with drastically reduced NOX and particulate emissions compared to conventional kerosene engines. Additionally, studies have shown that when using direct hydrogen combustion engines for the SMR segment a similar level of decarbonisation could be achieved across Europe as with SAF, however at a significantly lower energy intensity cost and with an additional gross profit margin for airlines[76].

These types of analysis and insights confirm the need to continue studying the application of hydrogen at scale especially when considering how hydrogen fuel and technologies could be economically disruptive to the European aviation sector should suitable infrastructure, logistics, fuel conveyancing and storage technologies be developed[77]. Furthermore, using hydrogen as the primary fuel of aircraft could also compensate for the possible limitation in concentrated biogenic CO_2 availability in case direct air capture does not materialise and will be devoted to carbon sequestration.

Rather than prioritising one approach at the expense of the other, Europe must mature a diverse technological portfolio that includes both fuel-cell-based and direct-combustion hydrogen propulsion concepts, as well as hybrid combinations of the two. This will preserve technological optionality, allow different aircraft segments to adopt the configurations best suited to their mission profiles, and help ensure that the most efficient solutions can be deployed as hydrogen technologies move toward commercial viability. Within this context, the fuel and energy system becomes a central enabler for both fuel-cell and combustion-based configurations.

Assuming a longer-term future in which hydrogen is used as a direct fuel, similar quantities of hydrogen will be required in comparison to SAF with similar timescales; in other words, for example in the order of 100 Mt by 2050 as mentioned earlier. Beyond the development of hydrogen production, this will require new infrastructure towards hydrogen logistics and distribution to airports, liquefaction, storage, and fuelling of aircraft. The technologies and deployment impacts of all these infrastructures will need to be further researched and considered when considering the deployment of hydrogen as a primary aviation fuel.

The effort to meet such an objective is huge and hydrogen research and innovation is a long-term road that must be paved progressively, starting with the most appropriate platforms. The consistency of activities is key, ensuring an alignment between production capacity and distribution infrastructure.

Electrictrification

In the coming years, electric energy is to have an increasing role in most segments of aviation while for some new aviation segments it will become the primary energy means. Increased electrification and hybridisation of aircraft will require fast-charging capabilities during ground service, by far exceeding today's ground power unit connections on existing airports, that need to be developed specifically. Additionally, the integration of future aircraft charging needs in operations, including energy management, need to be considered as part of the electric network planning together with the development of the electrification and hybridisation of aircraft.

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[76] See e.g.: Hydrogen in aviation offers potential for growth and deeper emissions reductions, new study shows. https://www.rolls-royce.com/media/press-releases/2025/09-12-2025-hydrogen-in-aviation-offers-potential-growth-and-deeper-emissions-reductions-study-shows.aspx (retrieved 21 March 2026).

[77] UK Department for Transport (2026). *Jet Zero Taskforce 2025 Annual Report.*

2.4.3. Core aviation sciences and technologies

A critical need for European competitiveness

Several disruptive technologies, such as for example the unducted propulsion concept for SMR or propulsion hybridisation, are envisaged on the next generation of aircraft that will enter into service during the next decade.

Nonetheless, beyond these visible disruptive innovations, the design, production and operation of new aircraft also rely on incremental improvements resulting from long-term and continuous research and innovation efforts involving technological bricks (e.g. materials and systems), understanding and modelling of physical phenomena (e.g. aerodynamics and high voltage effects at high altitude), as well as prediction tools (e.g. computational fluid dynamics). These incremental improvements are the required investment to keep the European aviation sector ahead of global competitors and new entrants in those aviation segments that make-up the bulk of existing and future European economic value.

The increase of engine bypass ratio and aircraft aspect ratio are typical examples of incremental improvements that have brought the majority of efficiency improvements on the current generation of aircraft and that are still considered for next generations. Moreover, the extreme optimisation that is today required to improve an already very efficient system and introduce new complex innovations, requires continuously improved physical understanding and numerical means in domains as diverse as noise, icing, combustion, material behaviour in the real environment, and electric system resilience to radiations.

This need for continuous incremental improvement is also applicable for methodological developments in data assimilation, as well as the need for always more efficient computation capabilities on specific aviation related phenomena that also have to be prepared for future computer technologies. Progressing towards a more numerical certification will also require improved and validated, via appropriate physical testing, modelling and simulation capabilities in a large scope of domains and disciplines.

Besides traditional research and innovation topics for aviation, new challenges have also recently emerged and constitute important crosscutting research streams for the coming years. For instance, the question of increasing SAF incorporation towards 100% blending ratio thereby removing the requirement for a fossil-derived blend component, raises additional questions around requirements for both drop-in and non-drop-in SAF solutions as well as questions around compatibility considerations to enable qualification and safe adoption of a variety of pathways.

While hydrogen is a possible future option for some aviation segments, the introduction of the first hydrogen-powered commercial aviation aircraft is no longer envisaged for 2035[78]. Yet valid arguments in favour of hydrogen remain, such as a higher energy efficiency for its production compared to e-fuels and potential major system-level synergies like enabling high-power density cryocooled superconducting drivetrains. Considering hydrogen as a potential aviation fuel has led to long-running scientific and technological challenges, for example for materials, which need short-term research even for an entry-into-service after 2035.

Non-CO_2 effects including contrails have emerged as key contributors to aviation climate impacts yet have significant remaining uncertainties and questions relating to their mitigation. Scientific research remains required to consolidate climate impact estimates relating to aviation non-CO_2 emissions and to develop technologies which assist with the measurement of atmospheric conditions. Additionally, technologies

[78] ATAG (2026). *Waypoint 2050 Third Edition.*

and operational methodologies mitigating non-CO_2 emissions and their impacts will need to be developed, as well as technologies and operational methodologies that deliver the means to monitor aviation non-CO_2 effects and verify positive outcomes from such mitigations.

While the impact of aviation on climate change is driving significant research, innovation and reduction efforts, the question of the local and operational impact of climate change on aviation, and of how to best adapt, has been much less researched. Impacts of climate change are for instance already touching on flight conditions (e.g. increased turbulence), operational life of the aircraft (e.g. consequences of extreme temperature on materials), air traffic management (e.g. more frequent disruptions linked to extreme weather events) and airport operations (e.g. increased risks of flood, and consequences of high temperature on operations).

Therefore, in parallel with shorter-term developments for the entry-into-service of key new products, the European research and innovation strategy needs to support and maintain a continuous and more fundamental research stream, supported by a dynamic and skilled research network and working with up-to-date experimental facilities. This fundamental research stream will be key for maintaining the competitiveness of the European aviation sector at the time when new entrants such as China claim high ambitions and can mobilise huge resources. Such effort needs to be more adequately tackled in the context of collaborative research that has been a key component of successive European framework programs. Furthermore, these efforts need to be complemented by appropriate support for the necessary research and technology infrastructure to allow their scientific sound success.

The particular case of materials

Strategic significance and economic security.

The aviation sector maintains a structural reliance on a complex matrix of metals, advanced composites, and high-performance materials. As critical building blocks for the European Union's resilience and open strategic autonomy, these advanced materials have been designated as one of the ten critical technology areas essential for the EU's economic security[79]. In the current global climate, aviation supply chains are increasingly exposed to geopolitical volatility, necessitating a decisive shift towards materials independence.

Lightweight, high-strength materials remain the cornerstone of aerodynamic performance and fuel efficiency and are vital for driving innovations in clean energy technologies as also outlined in the European Net Zero Industry Act[80]. Continued research on materials could offer significant potential to substitute certain critical raw materials, thereby directly supporting the objectives of the European Critical Raw Materials Act[81].

Sustainable industrial sovereignty.

To be able to secure its industrial sovereignty while reinforcing its global technological leadership, the European aviation sector needs to pioneer the next generation of materials, in particular for power generation and for extreme propulsive environments, and revolutionise manufacturing with a focus on sustainability and repairability. The digitally enabled development and qualification of a new generation of multi-functional materials, the application of advanced technology concepts, and the improvement of product performances will be essential to optimise resource use, resource reuse, and resource waste disposal through the complete product lifecycle.

The comprehensive material lifecycle, from production and systemic reuse, to recycling and end-of-life management, represents a critical lever for reinforcing European sovereignty and strategic autonomy. By securing a circular value chain, the EU could mitigate its structural reliance on external suppliers and protect its economic security against geopolitical volatility and supply chain disruptions. To realise this vision, the European aviation industry must prioritise advanced material processes such as the adoption of non-toxic substances and sophisticated additive manufacturing techniques. Coupled with high levels of automation, these processes and techniques will not only improve structural quality but could also deliver the essential benefit of "buy to fly" ratio, further cementing Europe's global industrial leadership and sovereign capability.

Improved sustainability assessment methods and new production processes developed to reduce the industrial footprint, like for instance energy and consumables needed for operations, together with the aforementioned required digitalisation should also enhance and accelerate the application of more sustainable materials and product circularity, including the re-use and recycling of scarce materials to address the full lifecycle.

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[79] Clean Aviation Joint Undertaking; SESAR Joint Undertaking (2025). *Aviation Research & Innovation Strategy (ARIS) — A pathway to competitive and sustainable aviation supporting Europe's sovereignty.*

[80] European Commission. *Regulation on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (Net Zero Industry Act).* COM(2023) 161 final, 16 March 2023.

[71] European Commission. *Regulation 2024/1252 establishing a framework for ensuring a secure and sustainable supply of critical raw materials.* 11 April 2024.

Research and technology infrastructures

Any new European aircraft generation needs to exceed its predecessor's performance at a competitive price to support both sustainability goals and European competitiveness. Performance increases may come with disruptive technology changes but are more likely to come due to incremental improvements. The need for performance increases is amplified by the prospect of new aeronautical energy carriers like hydrogen or SAF that may come at a significantly higher price.

With already highly optimised aircraft, further performance increases quite often require the different disciplines to drive their designs securely towards physical boundaries. Furthermore, the application of disruptive technologies will need to be verified whereby their design tools will need to be validated first. Before being applied on a new aircraft, incremental and disruptive technology changes must rely on achieving sound physical understanding and modelling. This requires well designed and highly documented experiments to validate the underlying physical understanding and furthermore to develop accurate models.

For such physical experiments and such digital modelling, appropriate means need to be operated and be available to the European aviation community. Therefore, care must be taken to monitor the European research and technology infrastructure landscape to be able to adapt and modify to current and coming needs to contribute to high Certification Readiness Levels (CRL).

Accelerating the maturity of breakthrough technologies requires for instance accessible infrastructures for rapid prototyping, ground testing and flight testing. These facilities need to be able to integrate streamlined regulatory authorisations, such as experimental permits and conformity pathways, to enable efficient progression from concept to flight.

Furthermore, the capabilities offered by the European research and technology infrastructures need to cover all types of current and future aircraft and are critical to support the development of the entire European aviation ecosystem. Ensuring the availability, reliability and appropriate capability of European research and technology infrastructures therefore needs to be considered a high-priority and challenging objective. Large-scale testing infrastructures need to be readily available, fully operational and properly staffed, and equipped with the appropriate testing capabilities (e.g. measurement systems, test set-ups and advanced instrumentation) to meet testing demands on-time, thereby securing key programme development gates and milestones that depend on validated test data.

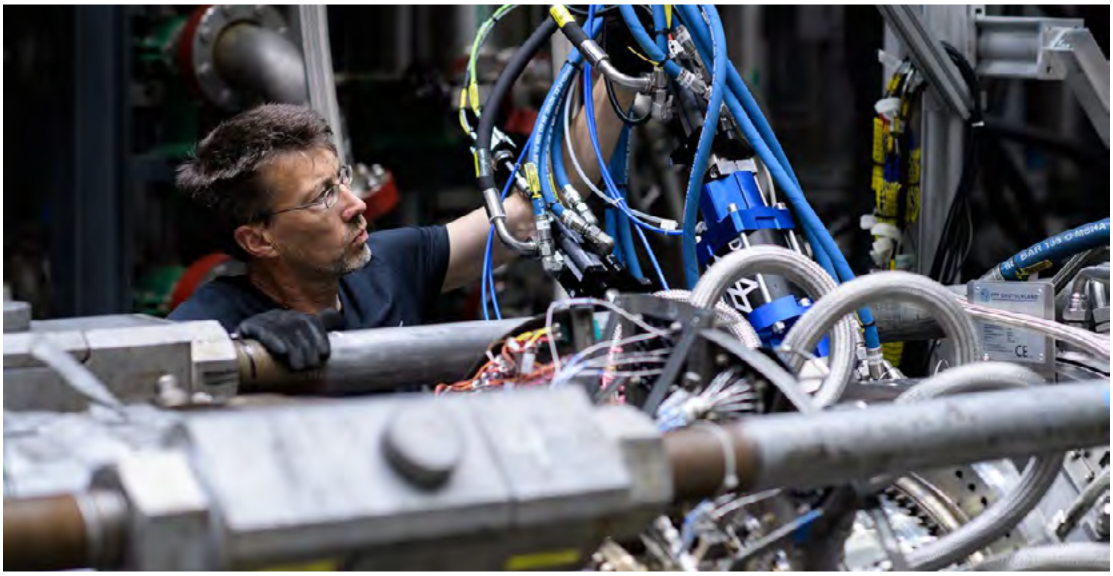
In parallel, these European research and technology infrastructures also play a crucial role in the business development of innovators working with smaller aircraft, including General Aviation and drones, which may serve as early-stage incubators for many technologies later scaled to larger aviation segments. Most of these innovators, often start-ups and small and medium enterprises (SMEs), cannot themselves justify the necessary investment in advanced structural, propulsion or flight-test facilities.

Europe therefore needs shared and cost-effective test centres that support both civil and dual-use developments and are supported through processes coordinated between EASA and military airworthiness authorities. Enabling broad access to high-TRL test environments is essential to ensure that promising technologies can be validated quickly and scaled efficiently across the wider European aviation ecosystem.

2.5. Education and workforce

Education and workforce development, especially upskilling and reskilling of the workforce due to digitalisation and AI, is essential in preparing the current and future workforce generations for rapidly evolving professional demands, notably in sectors such as aviation that are shaped by climate change, sustainability challenges, and increasing technological complexity.

Modern education in aviation must go beyond teaching static tasks and instead promote continuous learning, adaptability, and upskilling. It must promote awareness of Safety, Security and System Resilience (S3R) at all stages of the student course. This is fundamental because aviation professionals must master fundamental technical knowledge, interdisciplinary skills, and address new challenges like sustainability and digital transformation to serve European aviation competitiveness and sovereignty goals.



In Europe, meeting the growing demand for skilled Science, Technology, Engineering, and Mathematics (STEM) talent is a major challenge, with insufficient graduation rates compared to industry needs particularly when facing global competition. Strategic programs like ERASMUS and industry-supported initiatives, along with collaboration across continents, are vital for maintaining European competitiveness in aviation and other critical sectors. A second path to increase the European aviation workforce is to address gender imbalance which is still high in the European aviation sector. Attracting more women to the European aviation sector could also fill the gap in the increasing demand for a skilled workforce as 50% of the European population is still not addressed properly to create vocational careers. Research and innovation funding could be devoted to deep dive into the blockages and carry out aviation sector specific analysis.

Education must blend theoretical and practical learning, instilling competencies such as digital skills, ethics, teamwork, and the responsible use of AI. Additionally, humanities could be integrated or adapted to STEM educational paths in aviation. Efforts must also focus on keeping European aviation careers attractive, combating misconceptions about the environmental impact of the aviation sector, and encouraging young talent to join the aviation journey.

Lifelong learning is indispensable, highlighting the importance of strong partnerships between academia, industry, and government. This starts with internships and apprenticeships, continues through industry-linked thesis projects, and evolves via ongoing, flexible learning opportunities. To remain competitive, Europe's education framework must adapt, modernise, and emphasise sustainability, sovereignty, and competitiveness as cornerstones for future development. To remain skilled and competitive, continuous training for the European aviation workforce is required.

2.6. Safety, Security and System Resilience (S3R) needs as enabler of innovation

Safety, Security and System Resilience (S3R) together with certification are not peripheral constraints on innovation; instead, they are core conditions for Europe's competitiveness in aviation. In a safety-critical sector such as aviation, a technology has no strategic value if it cannot be validated, certified and deployed in a timely and predictable manner. Europe must therefore preserve and strengthen its capability to certify novel architectures, new fuels, digital systems, AI-enabled functions, advanced manufacturing processes and more-electric and hydrogen-based aircraft systems. This requires early regulatory engagement, enhanced test and validation capability, fit-for-purpose certification methods and sufficient regulatory capacity.

A central principle in advancing aviation safety is the migration towards a predictive and proactive safety system. This system leverages the full potential of data exploitation, risk monitoring, early warning mechanisms, and adaptive safety networks, augmented by AI. By 2028, such capabilities are expected to enable stakeholders throughout the aviation value chain to anticipate and pre-emptively mitigate risks before they materialise. In parallel, the evolution of safety is anchored in improved human-system integration and the development of organisational safety-performance frameworks. The latter must function reliably under both normal and unforeseen operational conditions, supported increasingly by AI-powered digital assistants which facilitate decision-making and enhance operator performance.

The security landscape contends with the dual challenge of physical and cyber threats. It is therefore imperative to establish a robust European aviation security framework, underpinned by system-wide risk assessment and harmonised incident management. Security governance must evolve rapidly, adopting real-time intelligence gathering and analytics, especially those enhanced by AI, to identify, forecast, and neutralise emerging threats across the aviation network. Institutional preparedness must encompass continuous training, standardisation of response protocols, and a seamless information exchange to ensure resilient and coordinated incident response across Europe.

System resilience functions as a critical attribute in mitigating the impact of disruptions. This necessitates the integration of resilience by-design early in the lifecycle of air transport systems thereby equipping aviation networks with the means to deal with resource and energy constraints, supply chain interruptions, and sudden failures or hazards. Demonstrations of operational resilience coupled with adaptive response mechanisms must be pursued systematically through the incorporation of recovery and continuity planning into the daily fabric of aviation operations.

The effective implementation of future aviation S3R hinges on the coordinated advancement of research and institutional oversight. European initiatives such as Future Sky Safety[82] exemplify the collaborative approach needed to unify metrics, facilitate risk observatories, and support annual progress reporting. Beyond research and innovation coordination, regulatory and institutional integration is vital, and it is key that regulations and legal frameworks be modernised at the same pace as the innovation. Embedding resilience and security considerations into certification processes and operational governance will minimise fragmentation and enable Europe-wide harmonisation in crisis response and preparation.

Public preparedness is not only a matter of incident response but also crucial for fostering trust in the deployment of innovative technologies. Societal engagement should be a strategic priority, ensuring that citizens are both capable of handling incidents and are receptive to cutting-edge advancements in aviation. Furthermore, enhancing interoperability with other transport modes will facilitate coordinated multimodal operations, providing critical continuity of mobility during system stress events such as energy shortages or resource constraints.

[82] https://www.futuresky-safety.eu/.

Advisory Council for Aviation Research and Innovation in Europe

From vision to plan

ACARE

3. From Vision to Plan

3.1. Instruments, flexibility and risk management

The forthcoming MFF, the new Horizon Europe programme (FP10) and the European Competitiveness Fund (ECF) will be critical for maintaining a highly competitive and sustainable European civil aviation ecosystem, particularly in an international landscape where traditional and new entrants are committing significant resources to strengthen or gain their positions.

The European aviation sector requires long term vision predictability and in particular funding stability given the long development lead times in aviation. It is therefore crucial that no diversion of attributed aviation-dedicated funding occurs and that the reallocation of funds to short term priorities or new European Partnerships is avoided.

Consequently, a clear and transparent governance framework will be essential to ensure that FP10 and the ECF operate in a coherent, complementary and predictable manner, and all stakeholders need to be fairly represented according to their role.

The link between FP10 and the ECF must be clearly defined and transparently governed. The respective roles of collaborative research funding (TRL, MRL and CRL 1 to 6) and industrial deployment instruments (TRL, MRL and CRL 6 to 9) should be structurally coordinated to avoid fragmentation, duplication and funding gaps.

It will be essential to formalise:

- How future work programmes across FP10 and the ECF will be co-created, designed and approved;
- How strategic priorities will be aligned across instruments; and
- How transition pathways between European Partnerships and deployment funding will be operationalised.

Existing co-creation mechanisms, including European Technology Platforms (ETPs), industrial alliances, Joint Undertakings, research associations and other public-private partnerships, must be maintained and strengthened as structured dialogue channels. These mechanisms have proven their effectiveness in aligning EU institutions, Member States, industry, research organisations (RTOs), start-ups, small and medium enterprises (SMEs) and academia around common European priorities. The "Smart and Clean Aviation Moonshot" provides an opportunity to strengthen the strategic focus and integration of these mechanisms.

A transparent and inclusive governance will be essential to ensure that European research and innovation programmes remain co-created, effective and aligned with the needs of Member States and the full research and industrial ecosystem.

Over-reliance on delegated acts in the implementation of the new research and innovation framework risks limiting comitology procedures and reducing structured stakeholder involvement. This would weaken the co-creation model that has been central to the success of Horizon Europe and its public-private partnerships.

ACARE therefore calls for:

- Strong Member State involvement through established programme committees, notably to support ATM initiatives and coordination between national and EU programs.
- Structured and institutionalised stakeholder consultation in strategic planning and work programme design.
- Clear visibility of decision-making processes across FP10 and the ECF.
- Safeguards to prevent excessive centralisation of strategic priority-setting.

Maintaining a robust, participatory governance framework will ensure policy continuity, increase programme legitimacy, and strengthen Europe's capacity to deliver on long-term strategic aviation objectives.

3.2. Impact assessment

Recognising the risks and opportunities of international competition and complex global challenges like climate change, energy issues and geopolitical instability, it is key to assess the contribution and impact of the different segments of the European aviation sector to the main challenges of the forthcoming MFF. The following "impact matrix" is proposed to this effect together with the aviation air vehicle platforms and CO_2 emissions share diagrams.

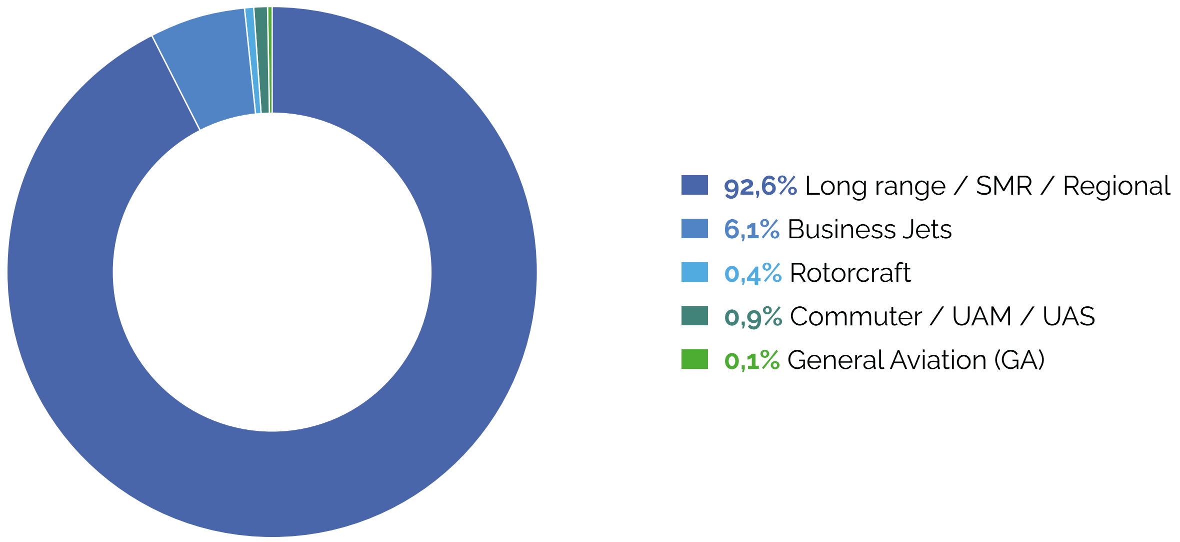


Figure 3 Estimated share of air vehicle platforms towards the aviation contribution to Europe's GDP in 2030[83], excluding military aviation.

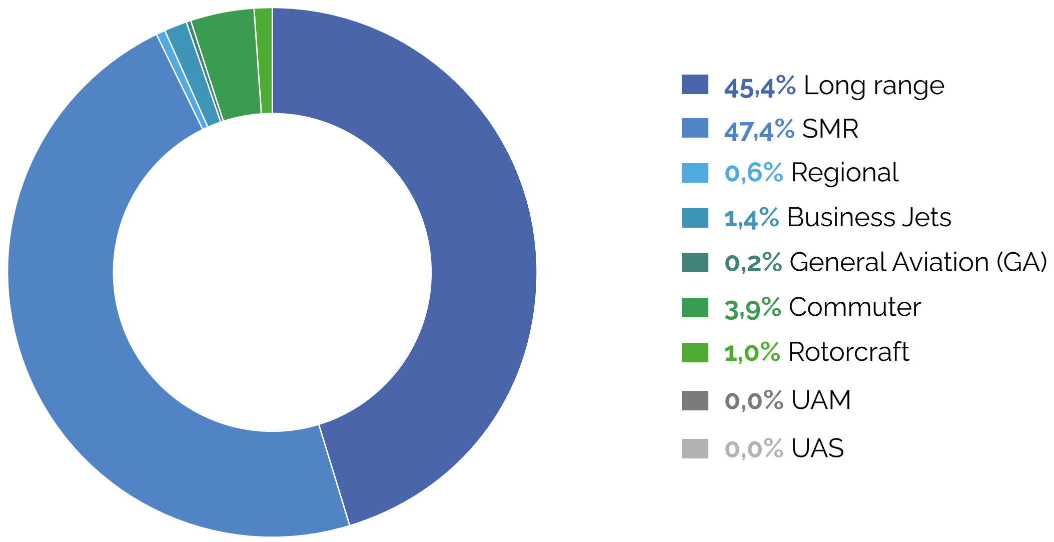


Figure 4 CO_2 emissions share per air vehicle platform[84], excluding military aviation.

[83] Based on figures taken from Oxford Economics (https://www.oxfordeconomics.com/), EBAA (https://www.aerotime.aero/articles/the-impact-of-business-aviation-on-the-economy-facts-and-figures), Mordor Intelligence (https://www.mordorintelligence.com), GAMA (https://gama.aero/), and the European Drone Strategy 2.0.

[84] Based on figures taken from the EASA European Aviation Environmental Report 2025, the ICCT (https://theicct.org/), and the Airbus website (retrieved 21 March 2026).

Impact matrix

	GDP and Employment	Economical Sovereignty	Decarbonisa-tion	Mobility in EU	Research & Innovation	Member States Com-petitiveness
Contribution to…	*Ensure GDP growth and employment*	*Ensure supply chain sovereignty and economical development*	*Ensure the net zero emissions and net neutral climate ambitions*	*Connecting people and insuring interoperability*	*The excellence of EU research and innovation*	*EU-National synergies, in-dustrialisation and national employment*
Platform 1 – Long range	√√√	√√√	√√√	√	√√√	√√√
Platform 2 – Short and Medium Range (SMR)	√√√	√√√	√√√	√√√	√√√	√√√
Platform 3 – Regional	√√	√√	√	√√	√√	√√
Platform 4 – Commuter	√	√√	√	√	√	√
Platform 5 – Business Jets	√√	√√	√	√	√√	√
Platform 6 – General Aviation (GA)	√	√√	√	√	√	√
Platform 7 – Rotorcraft	√	√√	√	√	√√	√
Platform 8 – Urban Air Mobility (UAM)	√	√	√	√	√	√
Platform 9 – Unmanned Aircraft Systems (UAS)	√	√	√	√	√	√
Air Traffic Management (ATM)	√√	√√√	√√	√√	√√	√√
Airport Operations	√√	√√	√	√√	√	√√
Digitalisation, design, advanced manufacturing, and integration capabilities	√√	√√	√√	√√	√√	√√
Sustainable Aviation Fuels (SAF)	√	√√	√√√	√	√	√
Core aviation sciences and technologies	√√	√√√	√√	√	√√√	√√

√ *Least contribution* | √√√ *Most contribution*

3.3. Towards a sector-specific research, innovation and implementation plan: Budget assessment

The ACARE community recommends a total investment of €66 billion over the 2028–2034 timeframe as the working hypothesis for the European aviation sector, including research and market update, in line with previously published estimations[85].

Reaching research and innovation (i.e. covering TRL1 to TRL6) targets, as described in this position paper, is estimated at requiring €18 billion (i.e. roughly 25% of the overall investment), while reaching the industrialisation and deployment targets (i.e. covering from TRL6+ upwards) is estimated at requiring €48 billion (i.e. roughly 75% of the overall investment).

Subject to conditions to be further detailed, including but not limited to the recommendations shared in this position paper and the governance of the dedicated instrument(s), the needed support is estimated at €22 billion of EU funding.

The following table illustrates how the required total investment is spread across the different segments and maturity levels (TRLs, MRLs, CRLs). The funding mix will need to be further refined when clearer information on future instruments will become available especially as far as governance and EU funding are concerned.

[85] Clean Aviation Joint Undertaking; SESAR Joint Undertaking (2025). *Aviation Research & Innovation Strategy (ARIS) — A pathway to competitive andsustainable aviation supporting Europe's sovereignty.*

Indicative Budget Assessment for whole period 2028-2034 (part 1)

Figures for the whole period 2028–2034	**Research and innovation (TRL, MRL, CRL 1-6)**	
	Flagships	Figures
Platform 1 – Long range	New efficiency barriers broken in aerodynamics and propulsion, with key integrated systems; lighter-weight materials and manufacturing in all areas; new architectures at airframe and propulsion anticipating further generations of aircraft with new fuels.	**[15-20]%**
Platform 2 – Short and Medium Range (SMR)	Focus on ultra-efficient SMR architectures, novel wings architectures, and technologies for hybrid-electric and CO_2 free (like hydrogen) propulsion.	**[25-30]%**
Platform 3 – Regional	Development of technologies of electric, hybrid-electric and hydrogen architectures powered by some combination of fuel cell-battery hybrid powertrains; electric engine with battery packs and gas turbines.	**[5-8]%**
Platform 4 – Commuter	New airframe concepts due to advanced materials and lower-cost manufacturing; optionality and exploration of novel propulsion and energy carriers; enhanced system safety standards, and system functionality to smaller airports.	**[2-3]%**
Platform 5 – Business Jets	New generation of Business Jets with new architectures, ultra-efficient airframe, engines and systems.	**[2-3]%**
Platform 6 – General Aviation (GA)	Research into electric main engines and high-level pilot assistance automation for aircraft up to eight seats.	**[2-3]%**
Platform 7 –Rotorcraft	Preparing the development of future rotorcraft, making them more sustainable, safer, more interconnected, self-protected and with neutralisation capacities, while being designed to cost and designed to manufacture.	**3%**
Platform 8 – Urban Air Mobility (UAM)	Next generation eVTOL aircraft with distributed electric propulsion power source with improved battery specific energy, improved battery performance through-life, and electric machine specific power.	**1%**
Platform 9 – Unmanned Aircraft Systems (UAS)	Increased robustness to adverse conditions; new maintainability concepts; improved electrical battery, system, and motor performance; increased autonomy functionality to enable seamless airspace integration.	**1%**

Support to market uptake including product development & industrialisation (TRL, MRL, CRL 6+)	
Flagships	Figures
Industrialising fuel-burn reduction technologies and ensuring 100% SAF compatibility to de-risk intercontinental routes.	**[5-8]%**
Industrialising fuel-burn reduction technologies, ultra-efficient SMR architectures including novel wing architectures and high production rates.	**[25-30]%**
Support for entry-into-service flagships and modular payload optimisation for regional connectivity.	**[5-8]%**
Demonstration and certification of new aircraft with hybrid propulsion; battery certification and production at scale within Europe; creation of electrical charging infrastructure creation to enable deployment.	**[2-3]%**
Digital transformation to impact value chain industrial processes and resources for aircraft design, production and maintenance.	**[2-3]%**
Scaling standardised modular components to reduce total acquisition, maintenance, and support costs.	**[2-3]%**
Preparation of a high-rate and low-cost production that reconsiders manufacturing by focusing on highly automated tools and production-oriented design for large and complex composite and metallic structures while adopting new materials and developing the associated processes.	**3%**
Supporting new market deployment in "first adopter" scenarios with certification of the next generation of UAM, investment in the necessary UAM infrastructure, and fully integrated UAM in the airspace.	**3%**
European supply chain capability for scale and cost including batteries; increased specific certification process methodologies; deployment of new services for U-space to ensure conflict detection and resolution enabling UAS and crewed traffic operation in a single integrated airspace.	**3%**

Indicative Budget Assessment for whole period 2028-2034 (part 2)

Figures for the whole period 2028–2034	**Research and innovation (TRL, MRL, CRL 1-6)**	
	Flagships	Figures
Air Traffic Management (ATM)	Connected and integrated flight management system (FMS), electronic flight bag (EFB) and flight operations centre (FOC) functionalities for trajectory optimisation.	**11%**
	Next generation core ATM platforms for high levels of automation for most routine tasks and automated conflict detection and resolution algorithms.	
	IRIS2 is used for safety critical applications in ATM with capabilities to increase ATM system robustness (e.g. satellite-based multilateration (MLAT), GBAS dual frequency/ multi-constellation leveraging Galileo and providing robust protection against jamming and spoofing).	
	Wake energy retrieval maturation.	
Airport Operations	Align local airport planning with coordinated European network and energy strategies. Development and adoption of digital twin technology and AI to simulate and optimise real-time processes. Development and validation of automated ground operations alongside robust "security-by-design" architectures.	**1%**
Digitalisation, design, advanced manufacturing, and integration capabilities	Developing and maturing cutting-edge digital technologies applied to aviation-specific manufacturing tools. Prototyping technology demonstrators in pilot manufacturing lines, and pilot processes for design, development, lifecycle, operation and maintenance domains, and the creation of digital validation environments.	**[8-10]%**
Sustainable Aviation Fuels (SAF)	Continued research on conversion pathways for improved efficiency and higher selectivity towards kerosene and reduced cost, as well as enabling technologies for eSAF (such as carbon source technologies). Enabling future specification development for 100% SAFs including testing of aircraft manufacturers equipment.	**1%**
Core aviation sciences and technologies	Long-term and continuous research and innovation efforts regarding technological bricks (e.g. materials and systems), understanding and modelling of physical phenomena (e.g. aerodynamics), as well as prediction tools (e.g. CFD). Continuously improved physical understanding and numerical means of non-CO_2 effects and impact of climate change on aviation.	**15%**
Total		**€18bn - 100%**

Support to market uptake including product development & industrialisation (TRL, MRL, CRL 6+)	
Flagships	Figures
Strategic deployment of Trajectory-Based-Operations (TBO) Phase 2 and moving towards a multilink environment until 2035.	**7%**
Rollout of a new service delivery model for ATM in Europe.	
Moving towards a multilink environment and new communication sub-networks (e.g. LDACS, HYCON).	
Operational non-CO_2 mitigation measures in place.	
Target carbon-neutrality and economic efficiency in ground operations by utilising renewable energy, electric and autonomous ground vehicles, and smart building retrofits. Additionally, contribute to aircraft emissions reduction in the taxi and turnaround phases.	**1%**
Large scale and fully digitalised design, manufacturing and maintenance environments. Transforming the next generation of aircraft, ATM and operations systems into a connected, software-defined and smartly automated platform, driving operations and new services in a European sovereign digital ecosystem.	**25%**
Demonstration facility development and techno economic assessments to demonstrate viability of large scale SAF production.	**2%**
Deployment of new numerical means, and new research and technology infrastructures.	**[6-8]%**
	€48bn - 100%

List of acronyms

Acronym	**Full term**
3D	3 Dimensions
4D	4 Dimensions
ACARE	Advisory Council for Aviation Research and Innovation in Europe
AI	Artificial Intelligence
ALE	Automatic Launched Effector
ANSP	Air Navigation Service Provider
APU	Auxiliary Power Unit
ARIS	Aviation Research & Innovation Strategy
ASD	Aerospace, Security and Defence Industries Association of Europe
ATAG	Air Transport Action Group
ATM	Air Traffic Management
ATR	Avions de Transport Régional/Aerei da Trasporto Regionale
AZEA	Alliance for Zero-Emission Aviation
CFD	Computational Fluid Dynamics
CO_2	Carbon Dioxide
COMAC	Commercial Aircraft Corporation of China, Ltd.
CRL	Certification Readiness Level
CS	Certification Specification
CTOL	Conventional Take-Off and Landing
DAA	Detect And Avoid
DES	Digital European Sky
DOC	Direct Operating Cost
EASA	European Union Aviation Safety Agency
EBAA	European Business Aviation Association
EBTL	Expander's Enhanced Biomass to Liquids
EC	European Commission
ECF	European Competitiveness Fund
EEP	European Export Platform
EFB	Electronic Flight Bag
EMC	ElectroMagnetic Compatibility
eSAF	electro-Sustainable Aviation Fuel

Acronym	**Full term**
ETP	European Technology Platform
EU	European Union
eVTOL	electric Vertical Take-Off and Landing
FAA	Federal Aviation Administration
FMS	Flight Management System
FOC	Flight Operations Centre
FP10	Framework Programme 10
GA	General Aviation
GAMA	General Aviation Manufacturers Association
GBAS	Ground Based Augmentation System
GDP	Gross Domestic Product
GLS	GBAS Landing System
GNSS	Global Navigation Satellite System
HEFA	Hydroprocessed Esters and Fatty Acids
HIL	Human-In-the-Loop
HIRF	High-Intensity Radiated Field
HMI	Human-Machine Interface
HYCON	Hyper Connectivity
ICCT	International Council on Clean Transportation
IEA	International Energy Agency
IoT	Internet of Things
IRIS2	Infrastructure for Resilience, Interconnectivity and Security by Satellite
IT	Information Technology
kW	Kilowatt
LDACS	L-band Digital Aeronautical Communication System
LPV	Localiser Performance with Vertical Guidance
MFF	Multiannual Financial Framework
ML	Machine Learning
MLAT	Multilateration surveillance
MPP	Mission Possible Partnership
MRL	Manufacturing Readiness Level

Acronym	**Full term**
MRO	Maintenance, Repair, and Operations
Mt	Megaton
MTOW	Maximum Takeoff Weight
MW	Megawatt
NOx	Nitric oxide and nitrogen dioxide
PDU	Power Distribution Unit
R&T	Research & Technology
RAM	Regional Air Mobility
RNP	Required Navigation Performance
RTO	Research organisation
S3R	Safety, Security and System Resilience
SAF	Sustainable Aviation Fuels
SAR	Search And Rescue
SDO	Strategic Deployment Objective
SESAR	Single European Sky ATM Research
SME	Small and Medium Enterprise
SMR	Short and Medium Range
SRL	Societal Readiness Level
STEM	Science, Technology, Engineering and Mathematics
STOL	Short Take-Off and Landing
TBO	Time Between Overhaul
	Trajectory-Based-Operations
TRL	Technology Readiness Level
TWh	Terawatt-hour
UAM	Urban Air Mobility
UAS	Unmanned Aircraft Systems (UAS)
UK	United Kingdom
US	United States
UTM	Unmanned air Traffic Management
VTOL	Vertical Take-Off and Landing
WB	Wide-Body

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