An Ambitious Vision for Clean Aviation

Courtesy of DLR

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The aviation industry's contribution to economic growth, societal development and cohesion is well recognised. While already subject to intense and increasing global competition, there is now an **unprecedented urgency** to act on climate change. Aviation's climate and environmental impact needs to be addressed without delay in order not to jeopardise its role and benefits to citizens in the developing climate emergency[1]. As such, the sector has a **duty to act**. Together with the European Union, and in line with the **European Green Deal**, European aviation has the **power to lead**.

An **inclusive, ambitious and institutionalised European Partnership for Clean Aviation** under Horizon Europe is the most effective and impactful means through which the aeronautics and air transport sectors can bring a decisive contribution towards a climate-neutral Europe. Only such a partnership can pull together the resources and commitment to develop and enable the introduction of safe, reliable, efficient and affordable **climate-neutral air transport**. It can simultaneously build Europe's leadership in innovation and technology, and deliver jobs and economic growth throughout the transition to a climate-neutral Europe by 2050. It can offer future generations the promise of continued, affordable and equal access to air travel, and its social and economic benefits, and contribute to the UN's Sustainable Development Goals.

The European aeronautics community is ready and committed to act now.

The challenge of transforming the aviation paradigm

Aviation's resource and capital intensity, technical complexity, highly regulated and global nature make this **a massive and systemic challenge**. Transforming aviation towards climate neutrality will require an integrated approach spanning technology providers and innovators, manufacturers and operators, public sector authorities and travellers. It will involve re-inventing innovation, product development and fleet replacement cycles needed to introduce a new breed of aircraft with decisive steps in aircraft technology. It will require infrastructure to make new fuels and energy sources available, climate-optimised networks and operations, and innovative public policy and regulation. The partnership can support the implementation of the right public policies needed to deliver the necessary impact in the aviation system and within the timeframes required.

Despite the level of complexity and interdependency, the European aeronautics community is convinced that climate-neutral aviation is achievable, provided it can develop and execute a **trajectory** within the setting and spirit of a true public private partnership, with **fair and balanced investments and commitments**. This will be contingent on:

- An **exceptional research and technology effort** to reduce energy needs and fuel consumption, while ensuring safety and competitiveness;
- Fast-tracked research, development and deployment of **sustainable aviation fuels** by the relevant actors for wide-scale and economically viable use within the next decade;
- **Optimised green air operations and networks** to fully exploit new aircraft and systems capability;
- A suitable **global aviation regulatory framework** creating the conditions for a transition.

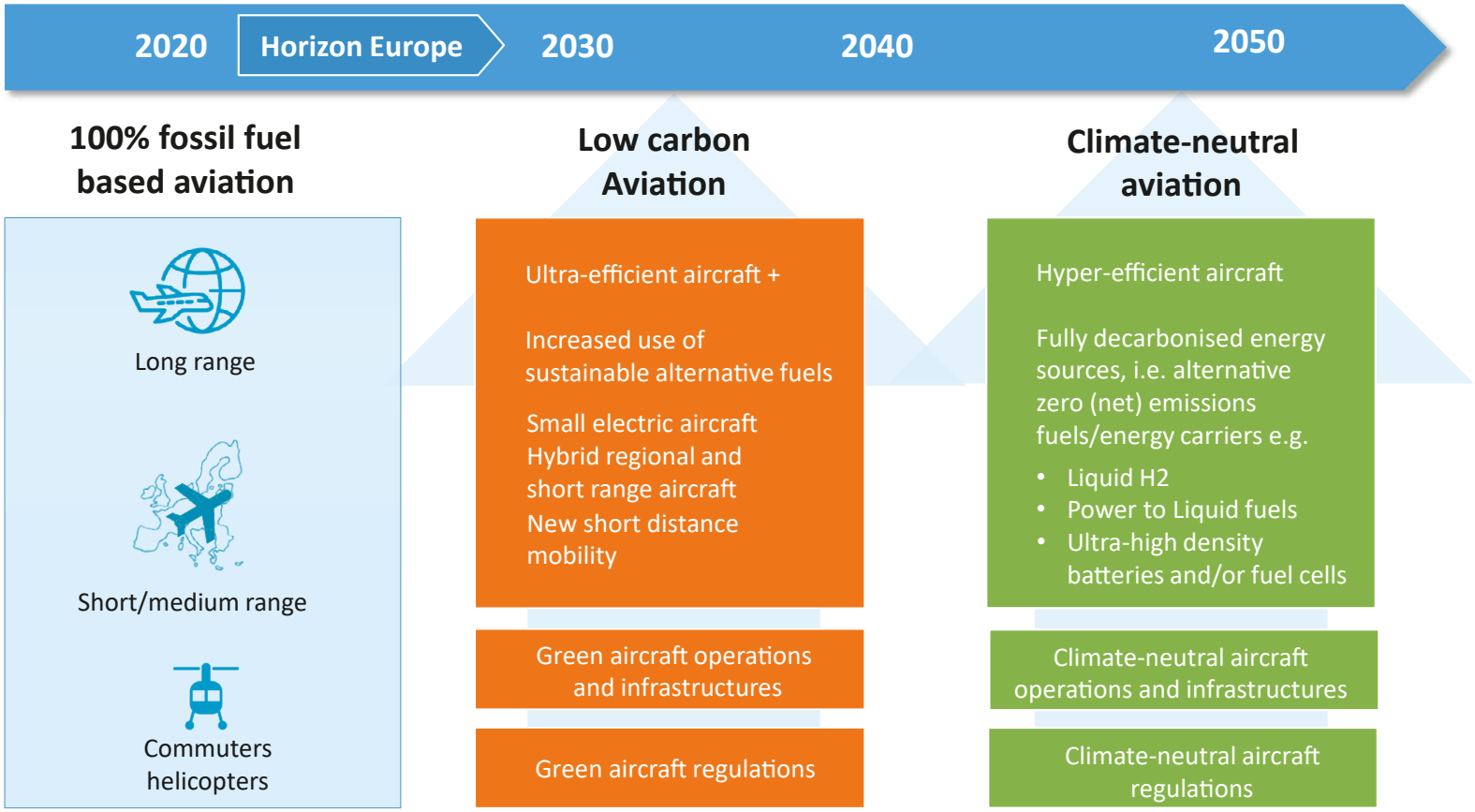
The EU institutions' and European Member States' support will be essential in creating the conditions for impact, and ensuring the trajectory is successful. The research needed to meet this challenge within the Horizon Europe timeframe is likely to exceed ~ €12 billion in effort, with several times this amount in private sector investment thereafter. Based on ~ €4 billion of EU funding for the Partnership, ~ €6 billion of effort will be undertaken directly in the Partnership's activities. A further ~ €6 billion in research activity will need to be actively connected to the Partnership. Through an **Innovation Architecture**, the Partnership will harness **the combined resources and innovative power** in the wider European research arena to meet the challenge of climate-neutral aviation. Other mechanisms in Horizon Europe will be enlisted to contribute to the trajectory. **Synergies** with national and regional research and innovation actions will be pursued.


Courtesy of DLR

1. European Parliament Declaration 25 November 2019.

An ambitious trajectory to address climate-neutral aviation

The European aeronautics sector is committed to work towards climate-neutral aviation by 2050. The journey towards greening air transport has made important technological progress under the Clean Sky and Clean Sky 2 programmes. Clean Aviation can build on the technologies developed, and accelerate the drive towards a climate-neutral system by taking a holistic approach to the challenge. Achieving an early and meaningful impact is critical in light of the 'climate emergency' as seen by Europe's citizens, recognised by the European Parliament and highlighted in the Commission's agenda for the Green Deal. Impact results when technologies developed through research actions lead to competitive product innovations and subsequently renewed airline fleets. Developing new processes and technologies to accelerate product introductions and in parallel provide the potential to upgrade existing aircraft will be key. Accelerating this requires the development of relevant regulations and infrastructures that can ensure new vehicles are safe, operable and affordable.



The Clean Aviation trajectory defines **two clear horizons** towards climate neutrality by 2050:

- **2035**: low-emissions aircraft exploiting the research results of Clean Aviation, making accelerated use of sustainable fuels and optimised 'green' operations;
- **2050**: climate-neutral aviation, by exploiting future technologies matured beyond the Clean Aviation phase coupled with full deployment of sustainable aviation fuels.

The Clean Aviation Partnership will aim for **decisive steps in new aircraft performance** by 2035. Ultra-efficient aircraft coupled with the progressive use of sustainable alternative fuels, electric commuter size aircraft and hybrid electrical regional / short-range aircraft will represent the first major steps, together with optimised green trajectories and air traffic management. Clean Aviation will also develop the technologies that will deliver climate neutrality by 2050. These will require further effort beyond the Horizon Europe timeframe. Aircraft deploying these technologies will operate on **fully decarbonised energy sources** (such as liquid hydrogen for combustion or fuel cell applications, power to liquid synthetic fuels; or ultra-high density batteries).

A shared, dynamic, and impact-driven roadmap

The Clean Aviation Partnership's strategic research and innovation agenda sets out the way to achieve the overall vision, in terms of timescales and magnitude of impact. It identifies the key building blocks of research and innovation needed. Beyond specific aeronautical research and innovation, a roadmap highlights technological needs that are cross-sectoral or that are emerging from other sectors with the potential for adoption in the aviation environment. Developing these technologies will require **collaboration with other sectors** and synergies across Horizon Europe and other European instruments, as well as national and regional research and innovation actions.

The integrated research roadmap will include the required upstream 'exploratory' research that is essential to finding tomorrow's pathways to mature technologies, ready to be incorporated into further new and disruptive innovations. Continuous and close research collaboration between the wide European stakeholder community of academia, research centres, small and medium companies and tier one and aircraft manufacturers is essential. The Partnership will pursue the concurrent maturation of upstream and key enabling technologies along **one shared and integrated roadmap**. This will enable their earliest integration and application on board of future vehicle generations and be a vital contribution to the overall targets.

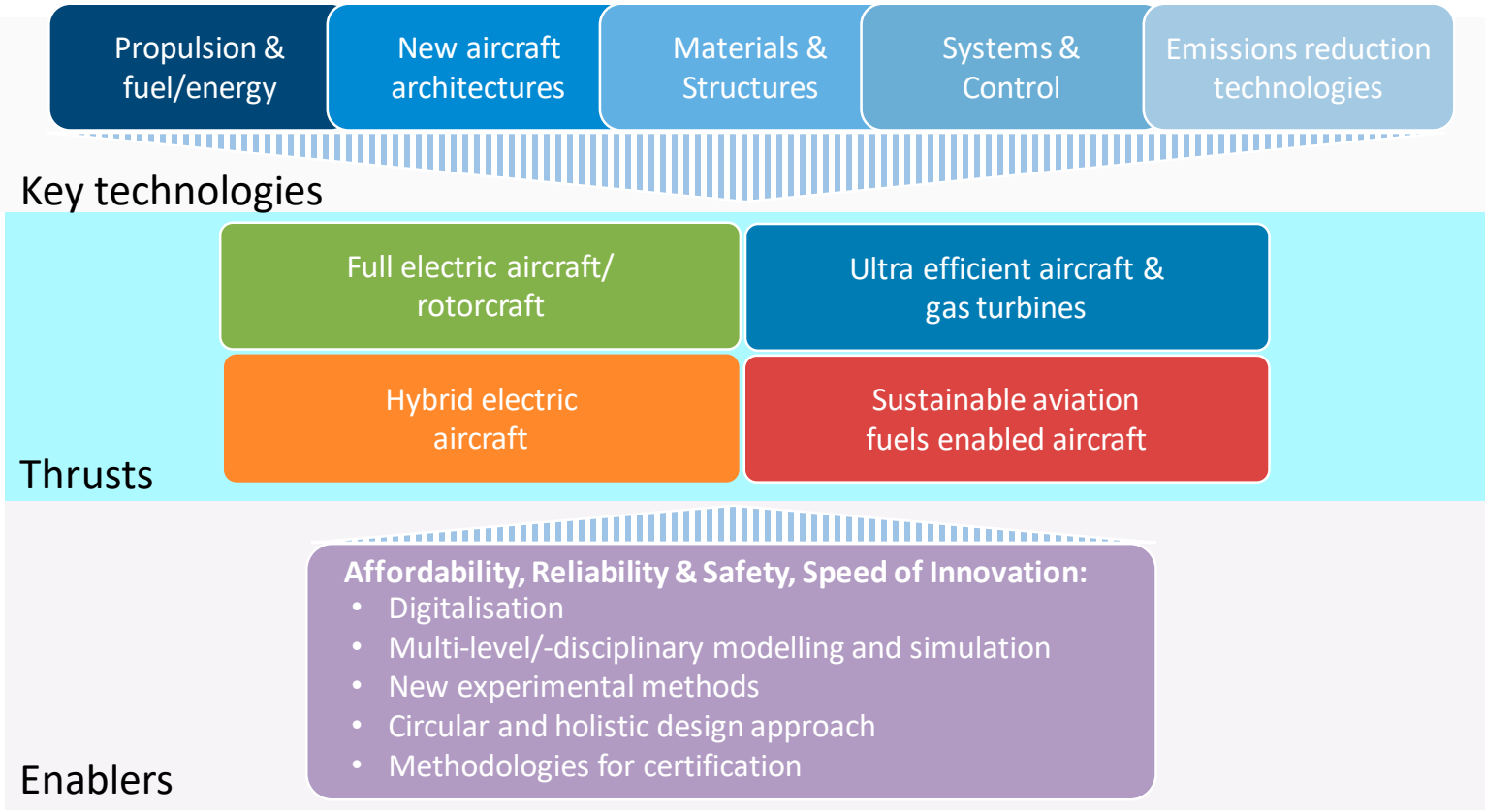
Achieving the desired impact will require **agility and flexibility in planning and prioritising** research actions. Regular reviews and dynamic (re-)allocation of effort and resources will ensure the effective use of resources and the maximisation of impact within the timescales set out for the trajectory.

The integrated roadmap comprises four key thrusts aiming at the selection of best approaches and solutions for maturation:

1. **Full Electric Aircraft and Rotorcraft** – maturing technologies towards demonstration of novel configurations, on-board energy concepts and flight control in the small / commuter segment.
2. **Hybrid Electric Aircraft** – driving research into ultra-efficient aircraft structures, configurations, novel power sources and management, and their integration; aiming predominantly at regional and short-range applications.
3. **Ultra-efficient Aircraft and Gas Turbines** – to address the short, medium and long-range needs with highly integrated, ultra-efficient gas turbines.
4. **Sustainable Aviation Fuels enabled Aircraft** – driving the capability of aircraft and engines to fully exploit the potential of both drop-in and non-drop-in alternative low and zero carbon fuels.


Courtesy of TU Delft, NLR, KLM

Key technologies will build essential knowledge and capability, identifying research areas where further exploration is required to maximise impact by 2050. These include new airframe technologies and aircraft configurations, new propulsion solutions, and new systems functions and their capabilities such as autonomous operations. Enablers such as digitalisation, competitive advanced manufacturing, advanced validation techniques and new certification methods will also be included, to ensure that development cycles can accelerate. The Partnership will select the best solutions with the **highest potential impact** for development for air vehicles and their operations. A life cycle assessment will support the selection, and regular technology / impact assessments will ensure close monitoring of progress and potential benefits. Maturation goals including a demonstration strategy will be set for each of these.



The critical success factors

The Clean Aviation Partnership aims at building an effective European innovation eco-system for aviation. It will actively seek and develop synergies with other European Partnerships, EU research programmes, national research and innovation programmes, as well as with European structural investment funds and financial instruments. With suitable incentives, this can produce a substantial leverage effect and help reach the challenging ultimate objective of climate-neutral aviation.

Large scale and operationally relevant **demonstration and validation** of technology are the prerequisite for the necessary confidence for **long-term investments** needed for product development, and to build confidence among airlines and operators who will purchase and integrate aircraft into their fleets. By concurrently maturating, integrating and demonstrating viable solutions, the programme will provide the required evidence and confidence for all stakeholders. Aligning this process with the public policy elements and new infrastructure provisions required for early market acceptance and uptake is key to delivering impact.

To secure the most effective allocation and use of resources and secure timely impact, the execution of the Clean Aviation Partnership and parallel collaboration projects will need to adopt the most effective, lean and focused professional project management standards, driving speed, agility, openness and impact.

Essential to achieving real impact will be satisfying each of the following conditions:

1. Strong pro-active European Union support on global regulation, standards for and certification of future products, supported through a strong and strategic alignment with EASA;
2. Close alignment with EU policy enabling a faster market uptake of green aircraft;
3. Decisive and rapid acceleration in the production and deployment of sustainable aviation fuels under favourable economic conditions for all operators.

Courtesy of ONERA

The aeronautics community commitment

With an ambitious programme of development and deployment (under suitable economic and regulatory conditions), new aircraft can bring a reduction in emissions in the operational fleet of between one third and one half compared to today's best available aircraft. Combined with fully exploiting the potential of new sustainable fuels, such as power-to-liquid synthetic fuels, methane and/or hydrogen, the fleet in operation in 2050 can deliver approximately a **90% reduction in net emissions** compared to current technology aircraft, and fuels. Validating the technical concepts mentioned through aggressive research and technology demonstration will be key to making decisive progress. The Partnership will **identify and down select** the solutions with the highest chance for evolving into sustainable products and service innovations and this will enable a fast take-up in the global aviation markets and deliver the expected benefits for citizens and society.

The commitment from the aeronautics community is to **deliver a set of integrated technologies,** sufficiently matured within Clean Aviation and its timeframes, for subsequent commercial development and market adoption by 2035; and in parallel set out the pathway towards climate neutrality by 2050. Clean Aviation can provide the focus, the vision and the backbone for delivering this trajectory, pulling together the sector's resources and corralling the combined technological capability and research efforts at European, national, regional and private enterprise levels.

The Clean Aviation partnership will bring together all European policy, research and industry actors. The initiative will allow Europe to seize the opportunity, and will lead the way towards climate-neutral aviation through **transformative change.** This can create a clean aviation system of unrivalled competitiveness, efficiency and environmental friendliness. This is the best and surest way to offer future generations the promise of sustainable economic growth and freedom of mobility.

Courtesy of Bauhaus Luftfahrt

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