European Commission

Fly the Green Deal

Europe's Vision for Sustainable Aviation

Report of the
Advisory Council for Aviation
Research and Innovation in Europe
(ACARE)

Research and Innovation

Fly the Green Deal, Europe's Vision for Sustainable Aviation, Report of the Advisory Council for Aviation Research and Innovation in Europe (ACARE)

European Commission
Directorate-General for Research and Innovation
Directorate C — Clean Planet
Unit C.3 — Low Emission Future Industries

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European Commission
B-1049 Brussels

Printed by the Publication Office of the European Union in Luxembourg.

Manuscript completed in June 2022
1st edition.

More information on the European Union is available on the internet (http://europa.eu).

Print	ISBN 978-92-76-43367-5	doi:10.2777/231782	KI-05-21-325-EN-C
PDF	ISBN 978-92-76-43368-2	doi:10.2777/732726	KI-05-21-325-EN-N

Luxembourg: Publications Office of the European Union, 2022

EUROPEAN COMMISSION

Fly the Green Deal

Europe's Vision for Sustainable Aviation

Report of the Advisory Council for Aviation Research and Innovation in Europe (ACARE)

2022 Directorate-General for Research and Innovation

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Foreword by the ACARE Chairteam

Mariya Gabriel
European Commissioner
Innovation, Research,
Culture, Education and Youth

"

Europe is standing united to face the threats to its security and as the world emerges from the COVID-19 pandemic, the European Union is putting forward a new policy on energy, aiming at reinforcing our strategic autonomy. In this context, investments in research, innovation and education are crucial to accelerate the transition to climate neutrality as a priority for the EU.

We are all called to contribute since all aspects of our lives are touched by the need to innovate. From the individual citizen to research organisations and industrial stakeholders, we must engage our efforts to deliver on the necessary transformations - green and digital.

We are celebrating the European Year of Youth and it is important to remind that our efforts are necessary to ensure a sustainable future to young generations. We are determined to achieve the Paris Agreement goal that would greatly reduce the adverse effects of climate change.

While we are committed to ensuring that passengers and freight should enjoy efficient and seamless travel services, based on a resilient air transport system thoroughly integrated with other transport modes and well connected to the rest of the world, this should be delivered with climate neutrality by 2050 as a prerequisite.

In this context, I invited the Advisory Council for the Aviation Research and Innovation in Europe (ACARE) to deliver an updated vision to replace the 2010's report "Flightpath 2050 – Europe's Vision for Aviation".

What you hold in your hands is an ambitious, yet realistic European aviation vision that calls upon all stakeholders to work together cooperatively and coherently.

I make the plea for the community to focus and deliver. This new vision should be complemented by detailed roadmaps on how to achieve the goals in a cost-optimum path, bringing together new technologies, optimised operations, new fuel options, infrastructure investments, market-based measures, and rules.

I take the opportunity to congratulate ACARE and the European aviation ecosystem at large. Your innovative products and operations will make European aviation a powerhouse of global economic growth, employment, trade and tourism.

Underlining the importance of the Versailles Declaration in fostering synergies between civilian, defence and space research and innovation, I would also call upon your attention to a better alignment between the European and National priorities, as well as a fresh look to skills and education.

You have my full support to make this new vision a reality.

"

FOREWORD
by the ACARE Chairteam

ACARE, the Advisory Council for Aviation Research and Innovation in Europe provides strategic, technical and institutional guidance to the European Commission, Member States and its stakeholders, based on an open forum for discussion and a consensus-based decision-making process.

1.
Jean-Brice Dumont
Chair of ACARE,
EVP Airbus

2.
Rolf Henke
ACARE Co-Chair
for DLR

3.
Bart de Vries
ACARE Co-Chair
KLM

“

ACARE stands for more than 20 years of qualified advice and contribution to aviation research and innovation.

In 2021, the ACARE General Assembly with the EC, the Memberstates and the various aviation associations and organisations have tasked the ACARE Chairteam to organize and steer a writing team to come up with a new European vision for aviation in view of the Green Deal of the EC.

This new vision is a result of the work of a writing team composed of almost all European aviation stakeholders and, therefore, it is not only a description of goals but also a commitment of all of us to work towards this vision.

As ACARE Chairteam we are proud to present this document to the public but in particular to the European aviation community.

With this document in your hands, also ACARE is at the dawn of a new era, from growth as in the past to sustainability for the sake of our planet.

”

Top 100 EU Aviation Stakeholders subscribing

An unprecedented alliance of the policy stakeholders as the European Commission, its Member States, aviation research organisations, design and manufacturing industry, airlines, airports, aviation energy and service providers have gathered to synchronise their path lead to a world of exceptionally efficient, accessible and sustainable air mobility.

Logos by category in alphabetic order:

European Commission directorates-general for Climate Action; Defence Industry and Space; Energy; Employment, Social Affairs and Inclusion; Internal Market, Industry, Entrepreneurship and SMEs; Mobility and Transport; Research and Innovation.


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FOREWORD

Europe's evolving view of the future of aviation is set out in a series of vision documents. "European Aeronautics: A Vision for 2020" was written in 2000. "Flightpath 2050 – Europe's Vision for Aviation" was launched in 2010. These documents have provided the universal references for aviation strategy and guided decision-making processes across the globe.

Over the past two decades, European aviation has made significant advances. Aircraft manufacture and operation, air traffic management and customer service are all improving continuously, while maintaining the highest levels of safety.

But since the publication of Flightpath 2050 the world has changed, and continues to change, at an ever-increasing pace. The COVID-19 pandemic caused aviation's biggest challenge ever: an unprecedented and extended global reduction in demand. Full recovery is still some years away and may be constrained by political crises and conflict. Therefore, particular attention must be paid to sector **resilience** and passenger **health**. Escalating and volatile **energy prices** and uncertainties concerning **energy security** are also a concern.

Public perception of air transport is in changing. Challenges arising from the Paris Agreement, specifically on **climate change**, from both CO_2 and non-CO_2 effects, and **local air quality and noise**, are at the forefront of many people's thoughts. Rapid improvements are expected consistent with the European Green Deal and the Fit for 55 package. As well as travellers are now balancing the traditional concerns of journey time, punctuality and price, the fastest, cheapest connection against the ability to tailor their door-to-door journey to their own priorities, including health, and environmental impact. Some people are even choosing not to fly in favour of other transport modes or virtual alternatives. To address climate concerns, elements of the aviation community have produced the Association of European Research Establishments in Aeronautics (EREA) Seven Point Plan (7PP), the World Economic Forum "Clean Skies for tomorrow" initiative, *the Destination 2050 "Route to net-zero European aviation by 2050"* and launched the Toulouse Declaration as a public-private aviation initiative to reach net zero CO_2 emissions by 2050.

Disruptive technologies and operations are emerging that challenge the established norm. Digitalisation is envisaged for all stages of the aviation value chain. Already busy airspace will host a diverse mixture of traditional and new air vehicles with greatly varying performance and flight dynamics. New actors, with novel and disruptive operating and business models, are expecting a seat at the aviation table. The aviation system-of-systems is increasingly being seen as one indispensable, embedded part of a broader system-of- systems providing mobility as a service. While presenting new opportunities,

these developments raise new **safety** and **security** challenges.
Despite shocks and challenges, aviation must continue to transport passengers and freight in an increasingly connected world, delivering societal, economic and environmental benefits. Therefore, under the Advisory Council for Aviation Research and Innovation in Europe (ACARE) umbrella, the European aviation community has come together to develop this **new Vision** with emphasis extending from research and innovation to include market uptake and the regulatory framework. It consolidates the various aviation stakeholders' visions, strategies and roadmaps into a **single, holistic and synchronised view** of the future for European aviation, enabling everyone to work together cooperatively and coherently. Building on the good work already performed, this new Vision replaces Flightpath 2050 to forge the way to the transition from aviation's Era of Growth (1990-2020) to its Era of Transformation (2020-2050). This Vision sets a coherent and comprehensive set of commonly-agreed specific goals, to address the societal and political demands arising from new and emerging challenges with the **urgency** required. This will keep aviation safe and secure, make it climate neutral by 2050 and resilient to energy and health risks while fulfilling society's need and desire to travel. It is anticipated that this Vision will form the basis of Europe's strategy for aviation to 2050 including the position and role of European aviation in World aviation.

INTRODUCTION

By 2050, aviation serves society, connecting people and cultures providing climate neutral, competitive, safe, secure, resilient and affordable air mobility for passengers and freight as a core component of a world-leading sustainable European multimodal mobility service

Climate neutrality for aviation by 2050 is the most challenging and exciting ambition since the beginning of the jet age. All aviation stakeholders must work seamlessly hand-in-hand with other transport modes and sectors, such as energy, for its achievement. Well-aligned policies and incentives must facilitate and prioritise research and innovation as well as maturation and application of new aviation technologies to enable the swift adoption of the cleanest operations.

A group of High-level Experts, comprising the entire European Aviation Sector's ecosystem have gathered together in ACARE. This group has combined reference material, such as Destination 2050, the Fit for 55 package, and outputs from the International Panel for Climate Change (IPCC) and COP26, with their own broad knowledge and expertise to envision the path towards sustainable aviation.

The work has culminated in a set of detailed, quantitative goals to be achieved by 2050 with intermediate milestones in 2030 and 2035. These goals are elaborated in the annexes to this document.

The path to achieving the goals is summarised as:

- **Short-term actions – by 2030:**
  European Union (EU) airlines are enabled and incentivised to deliver immediate impact by offering the cleanest, most climate friendly, passenger centric and competitive on- ground and in the air operations by exploiting the full potential of innovative solutions and upgrades available at that time. EU aviation research replenishes resources rapidly and creates a transformative technology pipeline of solutions, demonstrating their regional applicability. EU regulatory bodies accelerate the new energy and fuel infrastructures at airports as well as working closely with international bodies for new standards.

- **Mid-term milestones - by 2035:**
  Europe has demonstrated, developed and certifies new fully sustainable commercial aircraft and operational solutions, ready and available for deployment in airline fleets. 100 European clean air mobility city hubs have been launched to offer end-to-end connection services that are seamlessly integrated, highly efficient and climate neutral, with increased use of hydrogen and sustainable aviation fuel (SAF) technologies under commercially attractive 'level playing field' conditions already tested and proven thanks to regulatory sandboxes. EU citizens are enthusiastically embarking on the transition to a new era of air mobility.

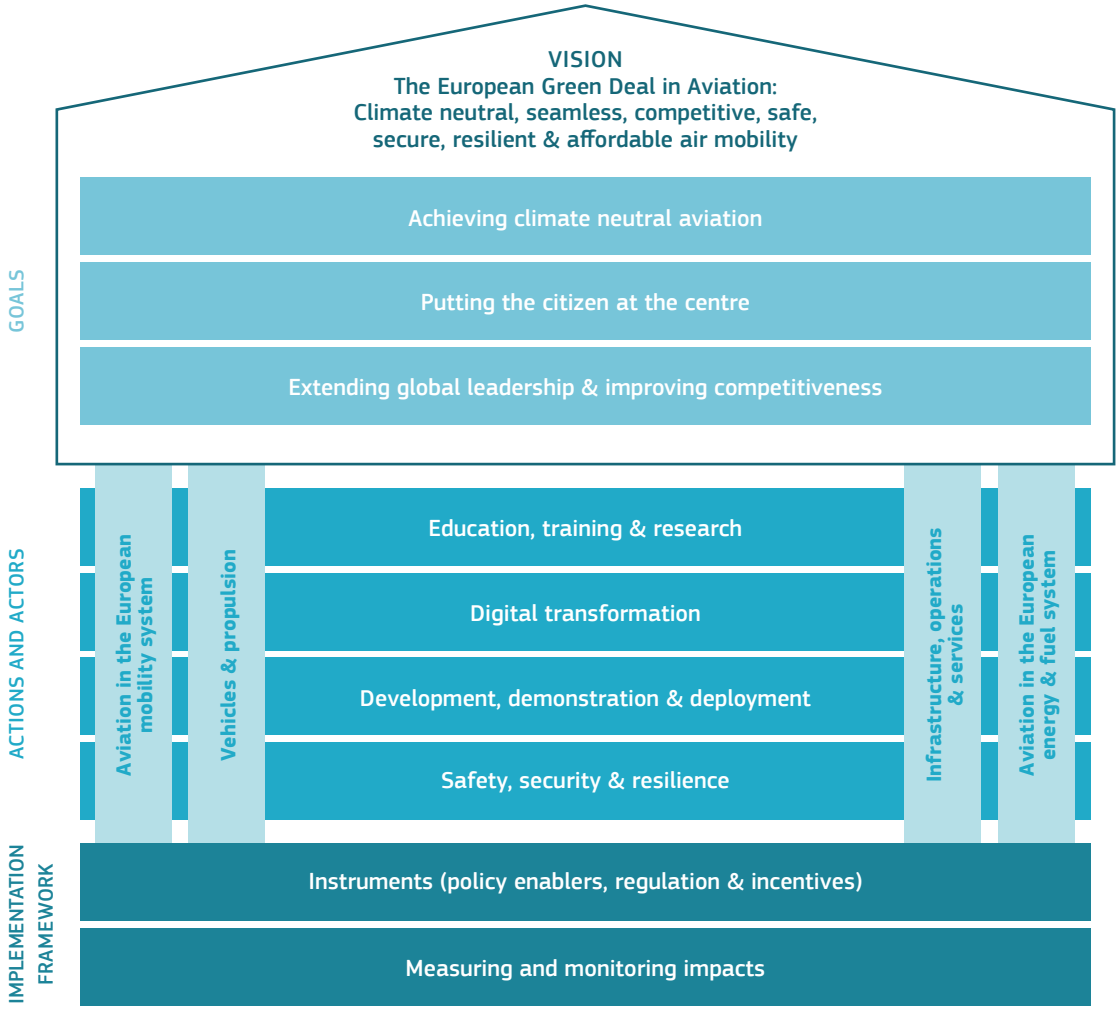
- **Long-term objectives - from 2035 to 2050:**
  Airports, airlines and all aviation operators enable an unprecedented roll-out of disruptive sustainable fleets and services to achieve the 2050 goals. European passengers and citizens enjoy affordable, clean, silent and seamless mobility.

Global demand for European air mobility science, products and services is high. Long lasting benefits are delivered due to excellence in ecological and economic performance. The accelerated transformation to a new dawn in aviation history has been secured by a comprehensive set of smart and agile regulations and carefully crafted strategic incentives.

The overall Vision is only possible with the proactive support and facilitation of the **European Commission (EC) and EU Member States that support the implementation through synchronised** instruments tailored to the stakeholders' position in the value chain and phased to accelerate the evolutions of solutions through the development life-cycle.

Throughout the process, ACARE will continue to play the key role of aligning all stakeholders and advising the EC, in a balanced, cohesive and unbiased manner.

This approach to creating the Vision and its goals was structured as shown in the "Temple" depicted below and is described step-by-step in this Vision document.



The specific, overarching goals of the Vision are to:

- By 2050, achieve **climate neutral**[1] aviation based on validated and globally accepted tools and models, in the full sustainability context (environmental, economic and societal) in line with United Nations (UN) Sustainable Development Goals (SDGs), integrating the circular economy concept to be an equitable contributor, with other transport modes, to fully climate neutral mobility;
- Ensure the sustainability and other **needs of citizens** not only as travellers and as customers but also as recipients of aviation's external impacts, such as noise and other disturbances. This goal also includes meeting the needs of the education system and skilled workforce;
- Design and apply the necessary **instruments** to maintain the European aviation industry's **global leadership and competitiveness** all along the supply chain, including researchers, manufacturers, infrastructure and aircraft operators, and service providers, by providing the highest quality, cost efficient, innovative products and services and developing and sustaining the required human capital, knowledge and skills.

To meet these goals, work must **start immediately** with priorities on sustainability, putting the citizen at the centre and developing the instruments needed to enable and incentivise the realisation of the Vision. Development must be complete by 2040 to enable deployment by 2050. These overarching goals cascade into a more specific, second set of cross-disciplinary goals for the **actions and actors** across aviation's themes and domains.

The vertical pillars are the key, specific components for the aviation sector:

- Aviation in the European mobility system: integrate aviation services with the complete range of other multimodal services to create and provide European Mobility as a Service (MaaS);
- Vehicles and propulsion: improve and optimise the environmental, noise and other impacts of existing vehicles; develop, deploy and operate new vehicles, not only to achieve climate neutrality through the full lifecycle but also to meet the needs of customers; ensure that European products are attractive and competitive in the global market; minimise the impacts on non-customers;
- Infrastructure, operations and services: adapt, develop and intelligently operate infrastructure, such as airspace, airports including energy hub concepts, air traffic management, providing the services needed to optimise aviation and to enable new concepts, such as climate-optimised routing, within the overall European mobility system;
- Aviation in the European energy and fuel system: ensure that security and sustainability are an integral part in accelerating the global transition to clean energy; make sure that aviation has affordable and secure access to fully sustainable energy and fuel sources; and enable commonalities and economies of scale with other sectors.

[1] As defined in Article 2 of EU REGULATION (EU) 2021/1119 - https://ec.europa.eu/clima/eu-action/european- green-deal/european-climate-law_en

The horizontal enablers are the key transversal components common to all aviation's vertical pillars as well as other sectors. These are:

- Education, training and research: build the human capital, knowledge and concepts that underpin aviation's development and continuous improvement;
- Development, demonstration and deployment: to ensure that research ideas can be progressed as rapidly, safely, securely and efficiently as possible from concept through to operation;
- Digital transformation: ensure that aviation reaps the benefits delivered by, for example, artificial intelligence (AI) and big data;
- Safety, security and resilience: ensure that aviation is robust against ever-evolving risks, threats and disruptive events in the physical and cyber worlds.

The Vision is underpinned by policy instruments and tools for measuring and monitoring progress:

- **Instruments:** such as regulatory and institutional frameworks, rules, regulations and standards that enable, incentivise, synchronise and support advancements towards the goals. Unlike in the past these instruments will not only be focused on research and development but also include deployment, operation, maintenance, upgrade, re-use, recycling and disposal;

- **Measuring and monitoring impacts:** novel aeronautical-specific methods that use metrics and performance indicators to assess progress towards the goals at all levels from policy to operational, to quantify aviation's environmental, economic and social impacts, to provide operational data, e.g. for climate optimised routing, and as an entry-point to global discussions.

- **ACARE** is the single, open, independent and non-partisan focal point for all aspects of European aviation, representing all stakeholders, associations and organisations, to develop and implement a common vision and coordinated strategy providing advice to support aviation policy development at national and European level extended from research and innovation through to deployment and operations.

AVIATION'S CONTRIBUTION TO SOCIETY

European aviation[2] is a vital sector. It's prime goals of climate neutrality, citizen centricity and global competitiveness are fully in line with and contributing to the three Pillars of the UN SDGs: environment, society and economy. It is a sector in which European public and private stakeholders provide world leadership to meet society's needs.

Aviation provides the essential transport links vital for European integration and cohesion. Millions of Europeans rely on aviation for education, training, goods and services. It is an important enabler of prosperity and wealth, stimulating development, opening new markets, boosting international trade and encouraging investment. Aviation also supports many "official" tasks such as climate monitoring, law enforcement, emergency medical services, disaster relief, and search and rescue.

Prior to the COVID-19 crisis, aviation's economic and societal contribution was substantial[3]. In 2018, aviation directly employed approximately 2.7 million people in Europe; every aviation job supported 4.1 more jobs amounting to 13.5 million European jobs in total (3.6% of all employment). Aviation contributed €210 billion to European gross domestic product (GDP), extending to approximately €850 billion (4.4% of all Europe's GDP) when downstream indirect

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and induced effects and tourism are taken into account. Beyond this economic impact, aviation is of sovereign importance and is intimately linked European and National Security, the common research base in Aerospace and Defence as well as spin-offs and contributions to many other sectors, for example being a civil component in dual- use systems-of-systems, such as the European Future Combat Air System (FCAS. The benefits of aviation have also recently been demonstrated in UN SDGs 1 to 6.

In the ten years prior to the pandemic European air traffic grew continuously. Almost overnight in March 2020, the pandemic reduced European air traffic by approximately 70%. However, aviation continued to play a vital societal role, initially in rapidly repatriating citizens and then providing freight services not least for vaccines distribution. The decline of aviation due to the pandemic and recent geopolitical instabilities have had adverse impacts on trade, commerce and tourism, on which many developing countries depend upon. This has exacerbated poverty, hunger and civil unrest[4].

Recovery is gradual but traffic is not expected to return to 2019 levels until 2024 or beyond. Aviation currently accounts for around 2- 3% of CO_2 emissions globally, and 4% in Europe. When non-CO_2 emissions are taken into account for all sectors then this proportion might increase significantly[5].

With demand to fly in Europe set to grow, plus other emitting sectors decarbonising in line with their own commitments, the proportion of emissions attributable to aviation in Europe will increase if no action is taken. Through various initiatives, stakeholders across Europe's aviation sector are working together to achieve net zero CO_2 emissions and a 90% reduction of non-CO_2 effects by 2050 consistent with the EU's long-term climate goals and the Paris Agreement[6]. The aviation sector is fully aware of its responsibilities and the associated challenges, across all three UN sustainability Pillars. This Vision provides the basis for meeting these challenges successfully and so enabling aviation's continued contribution to European economic and societal well-being.

[2] As in Flightpath 2050, "aviation" means aeronautics and air transport as well as non- transport applications of aircraft,

[3] Aviation: Benefits Beyond Borders, Air Transport Action Group (ATAG), September 2020

[4] https://www.reuters.com/world/pandemics- protests-unrest-grips-developing-countries- 2021-07-28/

[5] Lee et al, The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018, Atmospheric Environment, Elsevier, 2020

[6] Grewe, et al, Evaluating the climate impact of aviation emission scenarios towards the Paris agreement including COVID-19 effects. Nat. Commun. 12, 3841, https://doi.org/10.1038/s41467-021-24091-y, 2021.

THE VISION : VIEW OF AVIATION 2050

By 2050, Europe's world-leading research and innovation has delivered advancements in zero emission and clean energy sources that means all European journeys are climate neutral. Local air quality is assured. Noise and other nuisance impacts are minimal.

Specifically for aviation, technological and operational advances and, crucially, the secure supply of energy and green aviation fuels have enabled climate neutrality. All of mobility's other external costs, such as land use, infrastructure investment, maintenance, decommissioning and recycling costs, and noise, are internalised and passed on to the end- user. This focuses consumer choice, creating a true level playing field for the optimisation of mobility services to the benefit of the passenger, customer and society as a whole. The overall mobility system is resilient to changing circumstances.

The increasingly diverse elements of air transport – advanced air mobility (AAM), regional and short- to medium-flights, and, possibly, sub-orbital transport – are fully-integrated, indivisible components of the continental-scale, sustainable, socially inclusive and customer- centric European MaaS system. This system is a truly intermodal mobility system-of- systems, including high speed and conventional rail, buses, autonomous cars and other emerging concepts. MaaS takes travellers and their baggage, and freight and cargo, **from door-to-door, sustainably, safely, securely, affordably, quickly, smoothly, seamlessly, predictably, without interruption and on-time.** In case of disruption, journeys are automatically reconfigured to minimise impact to the traveller. Seamless door-to-door travel is the norm with one digital ticket covering the entire trip. Customised choices for passengers and freight are offered based on individual preferences including, for example, **environmental impact, modal mix, facility levels, quality of service, on-board comfort, journey time, special needs, optional rescheduling, price and journey monitoring.**

Since all external costs of all modes of transport are taken into account, the traveller and the freight forwarder can make an informed selection of their preferred option based on the context of their mobility need.

The skies are populated by a wide, diverse mix of vehicles operating safely, securely, resiliently and efficiently in and across common blocks of airspace, airports and vertiports. These vehicles include:

- next-generation small, regional and short-medium aircraft (comprising 75% of the fleet);
- large transport aircraft in configurations best-suited to the task;
- executive and business aircraft;
- advanced vertical air vehicles of all types;
- recreational flying vehicles;
- high altitude platform systems (HAPS); and
- unmanned aerial systems (UAS) including remotely controlled, highly automated and autonomous aircraft.

In the urban environment. In addition to HAPS and UAS, a proportion of the other vehicles are pilotless and some are highly automated, demanding new forms of traffic management. Despite the wide spectrum of vehicles, the vast majority of passengers are still carried on commercial air transport services.

These vehicles are powered by a range of fully sustainable fuels and energy sources. During the transition, sustainable aviation fuels (SAFs) were the alternative to kerosene for long flights while electricity and hydrogen were developed as longer-term solutions. Electric aircraft were used earlier for short flights. Ultra-quiet aircraft enable operations throughout the night and also eliminate nuisance during the day.

Air vehicles are operated by a mix of operators, evolved from those in business in 2022, including those from general aviation and non-aviation sectors. The operators' business models have evolved to enable seamless, coordinated journeys and some operators provide complete end-to-end mobility solutions. Supporting markets, such as insurance and financial services, have evolved to enable the operation of new air vehicles and facilitate new entrant operators.

All air vehicles have access to optimised ground infrastructure, comprising an integrated network of sustainable and highly efficient airports of all sizes, vertiports and heliports. Collectively these are called ground nodes. They connect seamlessly and securely with each other and with other transport modes. These ground nodes enable **simple, convenient, coordinated, safe and secure intermodal connections** optimised for passenger experience. They have been designed for and provide services that support all forms of aerial mobility, types of vehicle and energy requirements. They are expandable and reconfigurable to accommodate new concepts as they emerge. Traditional hub airports remain and operate at high utilisation levels. Urban ground nodes are integrated into the built environment, which has been re-designed to include and exploit the third dimension.

Smaller, regional and secondary ground nodes serve remote and rural areas.

Aviation is fully integrated into the broader energy sector ensuring affordability and availability of fuels and energy security. The ground nodes provide the energy infrastructure to support all types of propulsion systems used by aircraft and land vehicles. This includes recharging stations and battery exchange for all electric vehicles and support for other new types of vehicle propulsion, such as refuelling or tank exchange for hydrogen. Secure networks of online sensors monitor and collect data on the air transport system and the environment, including pollution, contrails, noise, weather, vehicle status, congestion, health, including the emergence of pandemics. There is also a global safety and security system to predict safety and security threats, manage risks as they emerge and recover from disruption caused by, for example, factors such as **disease, climate change, volcanic eruptions and solar storms** that affect electronic equipment. Highly resilient networks also provide global communications, navigation and surveillance services. These are built of systems-of-systems, spanning ground, air and space.
The Single European Sky (SES) has been fully implemented by 2030. SESAR and its successor programmes have ensured global air traffic management (ATM) has delivered safety, capacity and flexibility to meet increasing, volatile and diverse demand in the air and on the ground.

The overall air transport infrastructure, coupled with new ATM processes, the sensor network and aircraft concepts allow climate-optimised routing. Ultra-efficient airspace and airport operations maximise capacity utilisation. On the rare occasions that they occur, delays are mitigated by system-wide situational awareness.

Europe drives ATM – technology, procedures, charging mechanisms – on the global scale resulting in a highly efficient global system. Automation has changed the roles of both the pilot and the air traffic controller (ATCO) from active operational control to strategic management and hands-off supervision.

Research and innovation (R&I) is well-funded, highly efficient and effective. It is built on enabling instruments that incentivise collaboration and partnerships, including public and private sectors, industry and universities. R&I is supported by state-of-the-art facilities, test- beds, demonstrators and processes

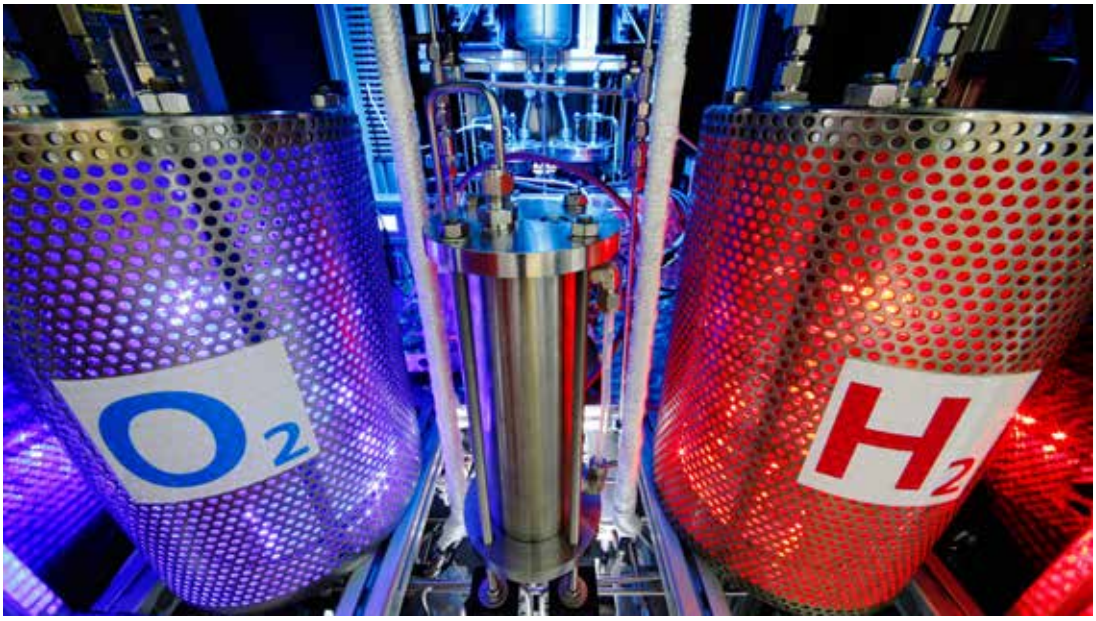
OVERARCHING GOALS

Achieving climate neutral aviation

Protecting the environment is of the utmost importance for all sectors. Particular focus is on aviation due to the likely future traffic growth and its uniquely high visibility compared to most other sectors. A fundamental objective for ACARE is to deliver, by 2050, a fully **climate neutral** air mobility system, meaning that from 2050, emissions do not add to climate change.
The route to achieving a climate neutral air mobility system is built on the starting principle of **net-zero**[7] emissions. A net-zero emissions balance will be achieved when the amount of greenhouse gas released into the atmosphere is neutralised[8]. Continued action now on all emissions is essential to assist in accelerating the reduction of long-lived CO_2 but also the consequences of removing the warming impact of non-CO_2 impacts that can have benefit in much shorter timescales e.g. within a given year.
Since the publication of FlightPath 2050 there have been considerable strides in understanding both carbon and non-carbon emissions and how, through atmospheric processes, they cause effects on global warming over different time periods.

The precautionary principle calls for rapid action to reduce those emissions, taking into account the remaining uncertainties, specifically in non-CO_2 impacts, as part of a risk-based impact assessment ensuring confidence in robust mitigation gains.
Concerning CO_2 emissions, earlier work by the Destination 2050[9] team in Europe and the international Air Transport Action Group[10] (ATAG) have both laid out routes to net-zero CO_2 emissions by 2050. Both rely on a combination of mechanisms that change in impact over time.
ACARE recognises that the flow of objectives from climate neutral to net-zero greenhouse gas emissions to net-zero CO_2 needs to be coherently expressed, assessed and confirmed. This new Vision is a mechanism to support this journey to this crucial understanding, providing intermediate detailed and quantitative goals in 2030 and 2035 to define the path to the end-goal in 2050.

[7] Net Zero: resulting in neith11 pter a surplus nor a deficit of something specified when gains and losses are added together3. https://www.merriam- webster.com/dictionary/net-zero
[8] https://www.consilium.europa.eu/en/5-facts-eu- climate-neutrality/
[9] https://www.destination2050.eu/
[10] https://aviationbenefits.org/environmental- efficiency/climate-action/waypoint-2050/



Complementary to other areas, such as the impact on citizens, fuel and energy, and research and innovation, this goal focuses on the harmful effects arising from emissions:

- contributing to climate change, such as CO_2, NOx, water vapour and particulate matter (which enhance water condensation into contrail-cirrus);
- affecting local air quality, such as unburned hydrocarbons, NOx, SOx and particulate emissions.

Starting immediately, the vectors enabling climate improvements will be based on, e.g. continued implementation of mechanisms putting price on pollution (e.g. EU ETS, taxation initiatives, etc.) covering the whole climate impact of aviation, increasing technologies for more efficient aircraft, replacement of fossil fuels with SAFs monitoring, reporting and verification of the contents of aromatic and sulphur concentrations in fossil fuel, as well as their reduction, and introduction and increasing utilisation of alternative fuels and propulsion, such as electricity and hydrogen. This is supported by environmentally optimised operations and routing to ensure that energy consumed by whatever means is minimised. Importantly, the air transport system is fully circular and the use of energy and resources is efficient.

By 2035

European aviation has prepared the opening of the first 100 highly efficient clean air city hubs, using hydrogen and SAF under commercially attractive conditions thanks to regulatory sandboxes, providing a level playing field.

Putting the citizen at the centre

The full transparency and internalisation of external costs across transport modes will enable citizens to select the best travel options, particularly relating to avoiding emissions and modal choice.

Complementary to mitigating its effects on climate change, in 2050, the needs of citizens will be one of the driving forces for the aviation system. The objectives are:
Achieving the highest levels of customer satisfaction, for passengers and freight;

- Minimising the negative social impact of transport, including, for example, local air-quality, noise, and the induced health risks;

- Ensuring full engagement of citizens, in a socially-inclusive way, in decisions on the development of the air transport system and its integration with other transport modes.

For all transport customers, both passengers and freight, the focus is on improving convenience through informed choice, balancing factors such as quality of service, journey time and price, as well as other special needs. Passengers are offered choices on comfort, entertainment and uninterrupted access to global high- speed personal communication and internet services. Passenger rights, covering service levels, privacy and data protection, are protected through a uniform legal framework that is applied consistently across all transport modes.

The aviation workplace is highly safe and secure. In addition to normal health, safety and environmental safeguarding, specific measures are in place to protect workers from aviation-specific risks and hazards, including air quality and noise.
Aviation's external impact on citizens will be understood, measured and quantified using widely accepted, commonly-applied, science-based metrics and techniques.
The development of aviation and the broader transport system and its components will use the impact metrics to monitor and reduce external impacts continuously. These external impacts will be quantified as costs that are fully internalised in a transparent and unbiased way across all transport modes. The rights of citizens will be protected in a uniform legal framework that ensures that the transport system is developed in a balanced way to the benefit of all.

Aviation will continue to contribute, proportionately, to overarching societal goals. Aerial applications enabled by new flight technologies include, for example: climate monitoring; emergency medical services; search and rescue (SAR); high altitude platform systems (HAPS) for multiple applications; inspection, surveying; communications and many others. Aviation will make increasing contributions to economic development, prosperity and social well-being, specifically within the EU but also globally. As today, it will support the integration and cohesion of the EU, its neighbours and partners. The European aviation industry will be non-discriminatory and continue to develop, taking into account the climate prerogative, to be truly representative of European society and demographics.

The safety and security of the European air transport system will increase enabling deployment and operation of new and disruptive technologies, operations and business models. The aviation system and supply chain will be resilient against internal and external threats, including health, natural disasters, terrorism and criminal activity.

By 2035

European passengers are enjoying the most efficient and convenient worldwide air mobility service network comprising the 100 most seamlessly interconnected end-to-end destinations. They are enthusiastically embracing the transformation to a new era of silent and clean integrated air mobility.

Improving global leadership and competitiveness

By 2050, the innovative, sustainable and highly competitive European aviation sector will have confirmed its place as the world leader. It will be recognised globally for its vehicles; propulsion; services of all kinds, including ATM, maintenance, repair and overhaul (MRO) and ground handling; and a large range of highly competitive, very cost effective and fully sustainable products. The European aviation industry will be self-sufficient without any strategic external dependencies and has a secure, market-driven and competitive supply- chain.

Europe's leading position in aviation needs to be supported by an optimised and harmonised policy framework, incentivising instruments and funding mechanisms.
The European aviation sector will be organised to ensure aligned thinking and full cooperation between all actors including European and Member State governments and regulators; researchers, innovators and educators; manufacturers; and operators and service providers. The seamless European innovation process will assure rapid and continuous progression from initial concept from research, development, and demonstration, through to deployment and operation for all products and services.

This process will be supported by enabling instruments and governance structures and processes, from today's Important Projects of Common European Interest (IPCEI) through to large-scale living labs, demonstrators and prototypes.

Capabilities and jobs will be supported by high profile, strategic flagship programmes and projects that span the entire innovation process through to production and operation.
European aviation, directly and through spin-offs, will continue to make a significant contribution to and support the economic success of other, related sectors including space, automotive, maritime, emergency response, defence, security and tourism.

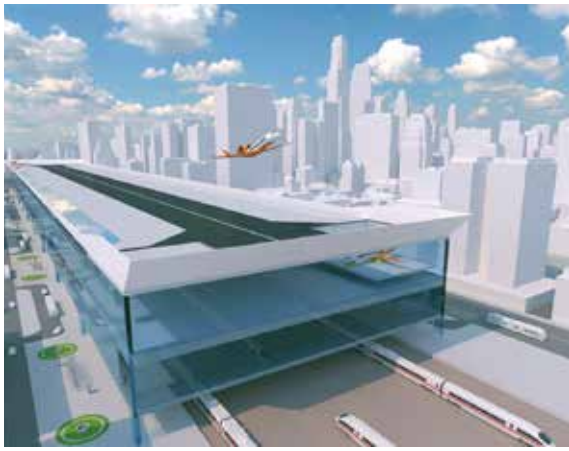
By 2035

Europe will be recognised as leading the world rankings across the top 100 most advanced, best performing and competitive organisations of the whole aviation sector and its value chain.
European citizens will benefit from the doubling of highly valuable new jobs in aviation research, product development, and manufacturing and operational services.

ACTORS AND ACTIONS : AVIATION PILLARS

Aviation in the European mobility system

In 2050, the transport system has evolved from a mode-centric system to full customer- centricity for both passengers and freight. Air transport is integrated into a secure, socially inclusive and customer-centric European MaaS system. This enables passengers and freight to transfer seamlessly between transport modes to reach the final destination quickly, smoothly, predictably, on time and without interruption. Processes for passengers and freight, such as safety and security, are non-intrusive and do not disrupt the smooth flow of the journey. Aviation plays a major role in the MaaS systems as a highly sustainable mode of transport. While the speed of flight might even decrease for environmental reasons, there is a significant reduction of process times and increase in predictability across all modes, resulting in only a very low risk of disruption for door-to-door journeys. Consistent door-to-door oriented passenger rights are applied with guaranteed journey reconfiguration if contracted services cannot be met irrespective of mode.
The friction points for transferring between different modes of transport have been removed. Connectivity benefits from advanced urban and regional air mobility concepts, which are fully integrated into the European transport system.



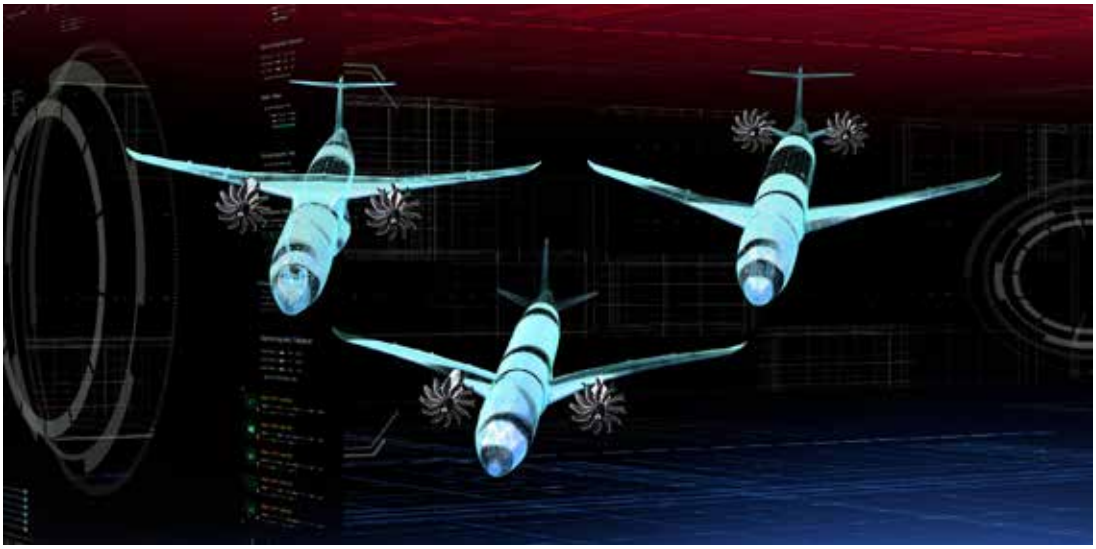
The relationship between the system and the passenger has evolved. The guiding principle is total passenger satisfaction without impact on or nuisance to non-travellers. Customised mobility choices are offered based on individual preferences - e.g. regarding travel context, facility levels, quality of service, on-board comfort, journey time, special needs, optional rescheduling, price - and journey monitoring.
Since all external costs of all modes of transport are internalised and information is available covering all aspects of the journey, an unbiased selection of mobility options is possible.

Vehicles and propulsion

2050 the Europe fleet contains the highest proportion of sustainable air vehicles in the world. These vehicles are highly efficient aerodynamically, with very low drag, for reduced energy consumption and lower noise impact compared to 2020. They are designed and built to withstand more extreme weather conditions and are enabled by advanced materials and structures, are lighter weight, and can adapt to different conditions, for example to enable climate-optimised routing.

The ambition is to base propulsion on the use of 100% pure SAFs following the principles of ReFuelEU Aviation, and hydrogen, using advanced novel gas-turbine concepts. Propulsion is also provided by electricity supplied by batteries and fuel cells, where possible, as standalone or hybrid-electric systems.

Aircraft architectures have become more complex, due to integration of propulsion units into the airframe, although maintenance and upgrade are simplified using new concepts, products and processes. Energy sources and the associated control systems are also integrated into the vehicle. Compared to 2020, there will be various and diverse vehicles depending on transport requirements, propulsion system and energy. This will affect not only the architecture of the vehicles but the architecture of the whole aviation system including ground infrastructure and ATM.



Within the vehicle, the enhanced and personalised comfort of the passenger is assured. The cabin environment is controlled and optimised intelligent systems – vibration, motion and noise cancelling, and temperature, air quality and humidity control systems. These systems. along with optimised ergonomic design, also monitor and ensure the health and well-being of passengers and flight crews. The passenger is also provided with continuous and reliable high-speed connectivity and automated cabin service. Inflight entertainment uses virtual and augmented reality and immersive technologies.

Through-life sustainability is the universally applied design principle, based on eco-design, and circularity design principles. Vehicles are designed bearing the entire environmental impact (in terms of CO_2eq or other more comprehensive metrics) of the lifecycle in mind, using approaches optimised for continuously improving sustainability, considering structure and component reuse, remanufacture, repair and eventual end-of-life aspects. To reduce costs, optimise efficiency and eliminate waste, design and manufacturing processes are integrated, optimised and fully automated, end-to-end. Vehicles come with a digital product passport, and a digital twin that catalogues full-life history and predicts future performance. New advanced aeronautical specific models, methods and data inventories have been developed and established to quantify the environmental impact of products and services built on international standards.
Like design and production, maintenance, repair and overhaul (MRO) is predictive, is supported by real-time system and structural health monitoring using sensors integrated within the vehicle and is globally standardised.

Modelling and quantification of the environmental impacts of the materials and energy, emissions, and waste streams associated with a product throughout its life cycle is enabled by integrating pre-design, design, development, production, operations, and maintenance using a digital data flow starting from extraction of raw materials until their reuse following a fully circular approach.

In addition to conventional type-approval and airworthiness certification, European aircraft have the least possible environmental impact over the whole life cycle. Performance-based certification using virtual qualification and certification techniques is widely applied, delivering higher efficiency and reliability than physical testing. The certification process is based almost exclusively on digital product passports and digital twins. The underlying data and derived digital tools used are freely available but secure, with data systems in place to minimise the risk of fraud.

Infrastructure, operations and services

In 2050, redesigned and new infrastructure, operations and services support aviation's achievement of carbon-neutrality and meeting societal goals.

Airports are no longer only places that aircraft take-off and land but are ground nodes for seamless interchange between transport modes. Ground nodes range in size from large multimodal hubs to smaller local facilities and vertiports and heliports. There are sufficient and suitable ground nodes to support all types of aviation, transport and non-transport, commercial and non-commercial. Ground nodes cater for seamless transfer between air and other transport modes, such as high speed and conventional rail, buses, and autonomous cars. They are sustainable and able to provide the energy sources required for the propulsion systems of the day (e.g. SAF, hydrogen, electricity) for air vehicles and other modes of transport. Measures have been implemented to adapt to the impacts of climate change.

There is a global weather and environment monitoring network based on the secure integration of multiple sensors, on the ground, on air, sea and land vehicles themselves, in the stratosphere and space-based. These sensors monitor and collect data on the transport network and the environment, including pollution, contrails, noise, weather, vehicle status, congestion, health, and other safety and security threats, such as volcanic eruptions, earthquakes, Tsunamis, extreme weather events and conflicts. The data collected are fed into processing centres that analyse and synthesise the inputs to produce and publish status reports (nowcasts) and short-, medium- and long-term forecasts that are used in the planning and optimisation of the entire mobility system.

All flights are planned, to climate optimised 4D trajectories, using predictive algorithms to minimise or eliminate adverse environmental and social impact, such as CO_2 and non-CO_2 climate impacts (e.g. contrails) and noise. When en-route, flights are re-planned dynamically, using continuously updated data, to maintain climate optimised trajectories and to avoid threats, such as adverse weather.
Airspace is integrated at global level and is managed to cater for the extremely high levels of complex and heterogeneous traffic and the increasing variability of traffic patterns, e.g. to avoid contrail generating areas. Building on SESAR, the outcomes of which are fully operational, traditional ATM has evolved to encompass and support all types of airspace user, from U-space management through conventional civil and military operations to the very edge of space. U-space management optimises strategic and tactical plans as well as dynamically managing operations to ensure safety, security and efficiency. It caters for the complex, asymmetrical and heterogeneous mix of vehicles. The ATM role into a highly- optimised function resulting from a partnership between humans and high levels of automation.

Aircraft on-board systems cater for applications such as 4D navigation, situational awareness, self-separation of traffic, traffic prediction, collision alerting and avoidance, all weather approach and landing, and automatic flight control. These systems collect, integrate and fuse data collected by the vehicle's own sensors as well as satellite-based and terrestrial navigation (exploiting multi-constellation GNSS), surveillance and weather systems.

Aviation in the European energy and fuels system

The EU's energy transition – eliminating the use of fossil fuels is a complex challenge related to almost all aspects of society. Aviation represents only a part of the EU energy demand and this has to be placed in the bigger picture carefully weighing effects of measures within all sectors to get the swiftest transition possible. ACARE represents aviation and ensures that aviation needs are reflected in the larger energy transition that is only possible through a concerted effort by all fuel users. By 2050, choices and priorities have been set and this transition has been completed.

Aviation is fully integrated in the European energy and fuels system to assure the energy supply, both in terms of capacity and energy security, and benefit from the economies that come from large-scale, climate neutral electricity generation, fuel and battery production. The generation of all electricity used directly or indirectly for aircraft propulsion is renewable, and the processes used to manufacture synthetic fuels and hydrogen are climate neutral.
The raw materials used to manufacture batteries and fuel cells are extracted sustainably and ethically and are 100% re-used or recycled at the end-of-life. Bio-fuels are produced ethically, meeting the relevant sustainability criteria defined, for example by the International Civil Aviation Organization (ICAO) and the Roundtable on Sustainable Biomaterials (RSB).

Selection of energy sources and fuels are optimised to the type of aircraft and its operations at the design stage. The technologies and fuels that are used will include but might not be limited to:

- Bio and power-to-liquid (PtL) SAF, blended or 100% pure, using novel gas-turbine concepts;
- Sustainable hydrogen, also using novel gas-turbine concepts;
- Full electric, using hydrogen fuel cells and/or advanced batteries;
- Hybrid-electric, either SAF or hydrogen.

The detailed quantitative goals for the aviation pillars are listed in annex B.

ACTORS AND ACTIONS : ENABLERS

Education, training and research

Excellent, world-leading research is critical to realising the Vision. In 2050, Europe's aviation industry continues to be underpinned by world-class capabilities and facilities in education, training and research. There are strong links to, extensive cooperation and knowledge sharing with other related sectors, particularly relating to energy and digitalisation.
Europe's students in aviation subjects perform highly. University courses are academically challenging and support the evolving needs of industry and research. Courses are both theoretical and practical, making use of complementary research facilities, such as living labs and digital twins. The aviation community engages actively with European students from the earliest age and is committed to lifelong learning and continuous education thus promoting interest in the sector and stimulating innovation. Educational policies across the EU motivate students to pursue further studies in science, technology and mathematics to ensure a steady supply of talent for a first class work force.

European universities work actively together, integrated in a well-structured network, offering harmonised, up-to-date and relevant curricula, facilitating frequent and fluent mobility of students and staff, sharing best practices in education and supporting the consolidation of a European aviation workforce. Currently aeronautical engineering, and in general aviation- related educational programmes include transverse elements relevant to the European aviation research policy and regulatory framework (e.g. climate neutrality, circular economy, clean energy options, digitalisation). Where this is not yet the case, aviation-related educational programmes should fully integrate education on sustainability, and specifically on the impacts of the sector on climate change, on equal footing with classic core subjects studied in aeronautics as materials sciences, fluid dynamics, structural analysis, propulsion, aircraft performance and structures, etc. Universities contribute by means of their educational programmes and dissemination activities to the communication of the benefits of European aviation. Lifelong and continuous education is the norm for all workers, facilitated by partnerships between industry, universities and training organisations.

Aviation research is well-funded and is multisectoral and multidisciplinary. There are strong links between research and industry with seamless handover of concepts as they pass along the research-development-demonstration-prototype-commercialisation process. There are new, novel, efficient and effective ways of funding the progression of technologies along the maturation process that ensure that beneficial technologies are deployed as quickly as possible.
Europe has the world's leading aviation research organisations and infrastructure covering the entire aviation system from ground or component test facilities through simulations to test aircraft. All stakeholders have collaboratively defined the infrastructure capabilities.
Facilities are organised as research clusters networked across Europe to facilitate and secure the regional and EU-wide collaboration of industry, universities and national research organisations.
The key research enablers of high-performance computing and communication networks are available at low cost, allowing an extensive use of automation and real time computing, and the fusion of huge volumes of data.

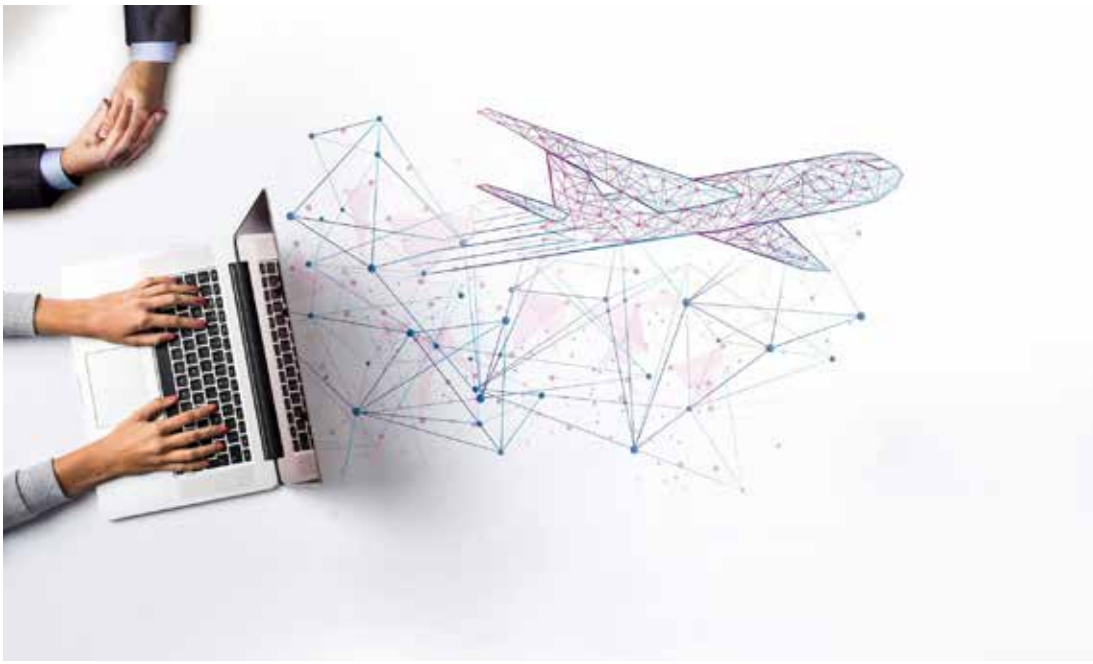
Research and innovation are characterised by pan-European coordination, supported by collaboration platforms and methodologies based on the cornerstone of a universally applied and high-performance innovation framework. Full digitalisation and common agreements on the handling of intellectual property enables free sharing of research methods, the associated data and models, and outcomes underpinned by an open science framework.

Digital transformation

Digital transformation is a key enabler for the future of aviation, its sustainability and its integration in the European MaaS system. This requires issues such as data structure, data rights and data protection to be addressed. Shared-information platforms and new IT tools and services will facilitate data exchange and decision making at all stages of the lifecycle, from research using open science frameworks, through to tactical and operational optimisation. They will support optimised and interconnected services, providing real-time information to professionals and the travelling public, and enhancing system resilience in the event of disruption and crisis. AI-based tools will enable optimised mobility offerings and travel options, especially in cases of disruption, allowing the system to remain operational at acceptably high-performance levels.

Examples of applications where digital and smart tools applied are too numerous to list comprehensively but include:

- globally accepted tools for modelling the atmosphere and its impact on mobility, supported by reliable data;
- new ways of smart testing and certification, linking numerical and experimental high- fidelity methods to access the full design space for the various vehicles and propulsion systems;
- integrated design, development, manufacturing, test, certification and MRO (including digital design, manufacturing, predictive maintenance and services), which are all highly automated, based on AI and robotics. Wide use of digital twins and augmented reality helps engineers to conceive and design cutting edge solutions quickly. Collaborative tools help in sharing experience and solutions;



- planning, managing and operating the fully integrated, global, multimodal transport infrastructure, including system wide information management (SWIM) based on system wide big data and allowing for GDPR-compliant exchange of journey and customer-mobility context data;

- planning and managing concurrent global door-to-door journeys, utilising intelligence available from historical, real-time and forecast system-wide (big) data and the outputs from highly accurate and reliable weather models and individually climate-optimised 4D trajectories;

- weather prediction and alerting tools at micro, meso and macro scales ranging from prediction of wind flows around buildings for safe AAM, through windshear, thunder, fog and sandstorm events, to jet stream and high-altitude winds;

- aircraft on-board systems for applications such as 4D navigation (applied to all types of flight from low altitude to sub-orbital), situational awareness, self-separation of traffic, traffic prediction, collision alerting and avoidance, all weather approach and landing, and automatic flight control. For crewed aircraft, systems monitor crew workload and provide decision support whereas they are fully in control of autonomous air vehicles;

- safety risk-based assessment and mitigation at strategic and operational levels, including, for example, new operations such as VTOL and suborbital flight, and in highly complex and congested traffic areas;

- digital twins and associated digital threads as key enablers for design, validation, certification, manufacturing and maintenance, repair and overhaul (MRO) for the air transport system-of-systems in its entirety, its component systems, vehicles, products and components.

Development, demonstration and deployment

Achievement of the Vision depends on developing, demonstrating and deploying the outputs of research as quickly and efficiently as possible to fulfil the needs of passengers, operators and society as a whole. Comprehensive and consolidated test, demonstration and validation infrastructures speed up the development process and increase the success rate from research to full operation. The supporting infrastructures are harmonised, interoperable, available and coordinated for collaborative use across Europe. For aeronautics, they include modelling, fast- and real-time simulations, test rigs of all kinds, flight-trial systems and platforms for demonstration used to test and evaluate new technologies and concept demonstration planes (D-planes). Similar capabilities are available for the other components of the air transport system, including air traffic management, ground nodes and their integration into the overall mobility system. Large scale tools, such as living labs, are applied across the aviation system.
Supported by substantive plans, addressing regulation and incentivisation, development and demonstration, and investment, aviation has secured an accelerated and highly effective path to deployment at industrial scale.

Supporting capabilities include:

- high performance computing platforms and very high-speed digital networks, supporting multi-disciplinary design tools, optimisation methods, simulations and test-beds for all different vehicle and propulsion technologies, their integration and optimisation;

- test facilities for propulsion systems and propulsion system integration;
- gaseous and liquid hydrogen combustion chambers and combustors;
- tools for the standardisation and measurement of SAF composition, e.g. relating to aromatics;
- ground test rigs, e.g. for hydrogen engines and safety testing of new batteries;
- flight demonstrators, for aircraft, engines, power systems and integration;
- physical and digital wind tunnels, system and structure test rigs;
- full-size virtual or simulated urban environment settings to assess the impact of air vehicles in urban settings;

- modelling and simulation tools for the impact of aviation nuisances on the population.

These capabilities are supported and enabled by the creation of the appropriate pan- European body to coordinate and sponsor aviation research, development and demonstration to ensure the technologies can be developed rapidly from initial concept through to full operation, overcoming the barriers that traditionally occur in the research-development-deployment path.

Safety, security and resilience

Safety remains as the foundation stone of aviation and, in the integrated mobility system, the other transport modes now achieve the same safety standards, based on a single, transport- wide vision for safety. In addition to the traditional concerns of safety, such as accidents and incidents, the scope has increased to encompass health. The safety and ethical challenges associated with autonomy; increased automation; artificial intelligence (AI) and AI-human partnerships; distributed systems-of-systems; the human-machine interface; and the changing role of the human – pilots and air traffic controllers – in the system have been solved. Other research priorities have been addressed, including multi-factor risk-modelling, the future aviation workforce, new ways of organising air traffic services (ATS), climate effects and the survivability of aircraft. Virtual techniques, based on digital twins, replace physical tests enabling virtual certification to improved levels of safety and security.

Security also remains a priority and has broadened in scope from mainly physical security to include cyber and supply chain (physical, software and hardware) security. The evolution of vehicles, new technologies, highly interconnected complex systems and services and new supply chains potentially creates new security vulnerabilities, increasing the attack surface available to malicious actors (internal and external). These vulnerabilities have been addressed using a holistic approach addressing physical infrastructure, people, processes and technology including cyber security). Security is designed into the system-of-systems from early in the development life-cycle and an embedded security culture ensures that security is maintained through deployment, operations and decommissioning. Other issues have also been solved, including personal and data privacy and associated legal issues; and biological threats.

As with safety, security standards and processes have been harmonised across the individual transport modes to achieve an even higher level of security across the integrated transport system, facilitated by data exchange. To remain ahead of ever-evolving threats, there is continued investment in physical (person and property) security as well as cyber and data security. Standards are continuously updated.

The quantitative goals for enablers are listed in annex C

The European transport safety and security systems remain underpinned by strong, equitable and globally harmonised regulation, further optimised accounting for and making use of disruptive digital technologies. In cooperation with international partners within the global ICAO framework, Europe has led the way to the development of this regulatory system.

Resilience is the capability to anticipate, mitigate and recover from disruptive events, including:operational resilience,

- which is achieved by the transport system being capable of automatically and dynamically reconfiguring a journey, including transfers to other modes, to continue meeting the needs of the traveller
- industrial or supply chain resilience;
- business resilience;
- societal resilience.

POLICY FRAMEWORK

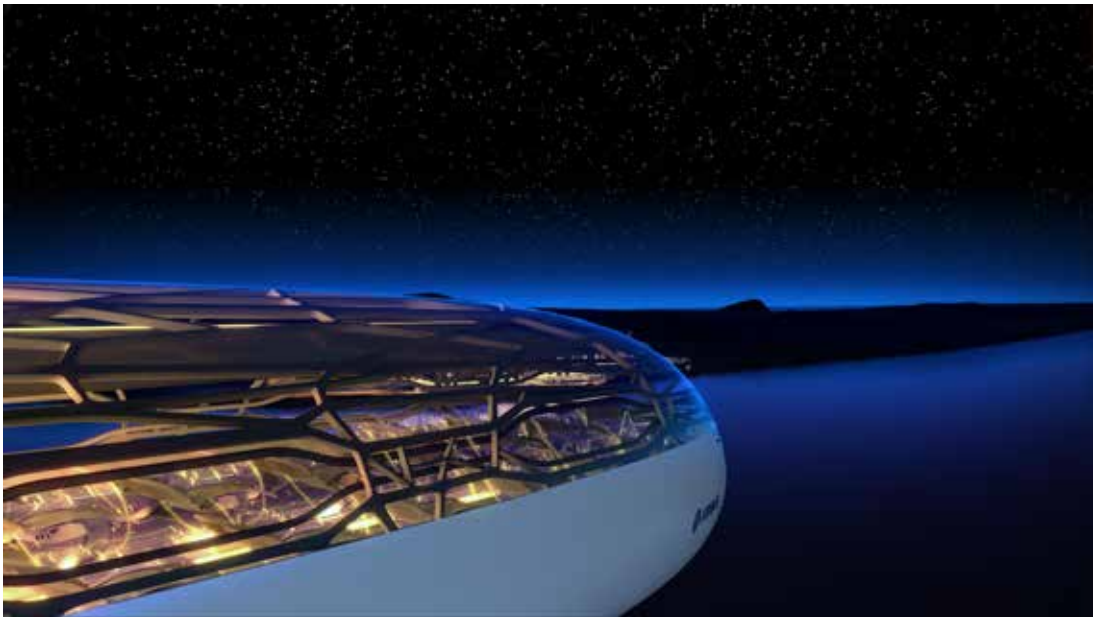
Instruments

In 2050 the aviation policy framework has developed to support the transformation from the Era of Growth via the Era of Transformation to the era of seamless integrated agile accelerator of policy, research and innovation. A range of different interacting and complementary instruments – regulations, standards and incentives – have been developed and applied to enable, support and accelerate the changes needed to realise the Vision.

The European aviation policy framework has a sharp focus on mobility and strongly supports the associated research and innovation. It promotes and enables coherence, alignment and integration with other related and critical areas, such as energy. Green Deal legislative and non-legislative acts and Fit for 55 cover and lead to further exploring clean energy options, sustainable aviation fuels, fuel quality optimisation, taxation, climate neutrality, circular economy, revision of the EU ETS and associated implementation of the Carbon and Offsetting and Reduction Scheme for International Aviation (CORSIA), digital transformation, intellectual property rights (IPR), personal data and privacy rights, foreign direct investment, green bonds and taxonomy. The EU has built strong links with international partners and plays a leading role in international organisations, such as ICAO, to ensure that the global aviation system is fully sustainable and that its governance creates a truly level playing field. This policy framework is implemented through a comprehensive set of phased, synchronised and dedicated instruments providing guidance and enabling the stakeholders to work together with the EC, Member States and third-country partners to realise this aviation Vision.

- By 2025 based on this Vision, the European aviation sector has established a single, independent, open-access, non-partisan organisation to represent all stakeholders, to develop and implement a common, coordinated strategy and support aviation policy development encompassing research, development, demonstration, deployment and operations. This organisation has legal personality and is appropriately funded and staffed to provide a single point of advice and guidance to the entire EC, covering all Directorates, on all aviation matters, including research and innovation and beyond;

- An appropriate and proportionate European governance and institutional structure is in place established using the instruments available to the EC. This structure steers, guides and coordinates aviation research, innovation, development, demonstration and ensures accelerated deployment to secure societal, ecological and economic impact. It evolves in line with developments affecting the aviation sector both from within and externally, e.g. facilitating integration with other transport modes and with the energy sector. It is a platform to coordinate, activities across the EU, Member States, third countries, stakeholder associations of all types, universities and research centres, manufacturers, operators and service providers. It is also the custodian of the roadmap for the realisation of this Vision and the customer for, major pan-European projects and works closely with existing Agencies, such as the EU Aviation Safety Agency (EASA) and Eurocontrol, to enable the timely evolution to the future aviation system;



- Coordination mechanisms are applied to deliver efficiency, economies of scale and synergies between EU aviation research and innovation, national-regional aviation initiative, research and innovation in other related sectors and other EU level programmes;
- A framework is established comprising regulations, rules and guidance, specifying targets. This framework includes an overarching Strategic Research and Innovation Agenda (SRIA), taking input from individual SRIAs from European partnership. This overarching SRIA includes a detailed and phased roadmap for the realisation of this Vision and the means for measuring progress towards its goals;
- To support progress along the roadmap, tools are set up, e.g. the Alliance for Zero- Emissions Aviation, IPCEI are defined, other lighthouse projects are identified and funded, D-plane demonstrators are provided and living labs are established;
- Cross-border regulatory sand-boxes are used for the assessment and validation and acceleration of innovative solutions that are outside the scope of existing regulation;
- Incentives and enablers are applied, ensuring the development, demonstration, deployment and exploitation of the concepts developed through research;
- Funding and financing mechanisms, compliant with competition rules, facilitate the product cycle from research through development to deployment.
- Between 2022 and 2050 Europe has developed and applied the most efficient policy, regulation, and incentivisation framework that has enabled and driven the most effective transition towards climate neutral aviation as well as aviation's integration into the European MaaS system.

Policy actions and incentives are listed in annex D.

Measuring and monitoring impacts

By 2025, taking advantage of synergies with existing mechanisms, such as the EASA European Aviation Environmental Report (EAER), a comprehensive and uniform set of quantitative, widely agreed measures, comprising metrics and key performance indicators based on agreed models and available sensor data, has been established to assess, through a standard single score, progress towards meeting aviation's goals. These metrics cover the three main areas highlighted in this Vision: achieving climate neutral mobility, putting the citizen at the centre, and improving global leadership and competitiveness. The measures are initially adopted in Europe and, more gradually, accepted world-wide. A similar approach is applied in the other components of the mobility system, including rail, maritime and other land transport, enabling a common approach across the MaaS system.

In parallel, also by 2025, an impact assessment process is established including data collection, analysis methods, reporting and feedback. This process is based on good scientific understanding and impact assessment models, particularly of climate, atmosphere, local air quality and noise, which have developed sufficiently to enable common understanding and consensus on the greenhouse gas effects, and robust impact assessments to be made. Models for the assessment have been developed in ways that any new knowledge can be included in a straightforward way, allowing re-evaluation of measures and previous analysis in a transparent way. Impact assessment if supported by a monitoring network is in place across Europe to capture the real-world data needed to calculate the measures and metrics.

The measuring and monitoring process gives a holistic picture of progress towards realisation of the Vision and the Destination 2050 Roadmap. Progress is monitored regularly by comparing the value of each metric with pre-agreed targets defined as waypoints in aviation's roadmap and specific milestones at the intermediate points in 2030 and 2035 where this Vision has specific goals.

An evaluation of the status in the year 2022 is performed for all goals on the agreed metrics. The results of the impact monitoring process are used as feedback, quantified through the single score the contribution of the new vehicles joining the fleet, to refine and prioritise activities in a continuous improvement process.

Responsibility for and ownership of the measuring and monitoring process, its data and results are defined by the EC in an appropriate legal instrument. Operational responsibility is allocated to an appropriate body, either an existing organisation such as EASA or Eurocontrol, or a new construct with responsibility for the complete mobility system.

An initial list of metrics for measuring and monitoring is provided in annex E.

The role of ACARE

For more than 20 years ACARE addresses strategic, policy, regulatory, technical and institutional issues, providing an open forum for discussion and a consensus based decision-making process. As well as individual stakeholders spanning the entire aviation sector (e.g. from aircraft integrators and suppliers of all tiers, airlines, airports and ATM providers, other service providers, research establishments and universities), it counts European aviation associations as its members. ACARE's reach extends beyond research and innovation and also beyond the purely civil sector into the dual use civil-military domain.

Up to now, the role of ACARE was to:

- develop visions and strategies;
- turn those strategies into reality;
- provide strategic advice on research and innovation;
- facilitate mutually beneficial international cooperation;
- communicate the benefits of European Aviation.

ACARE always did all this in a balanced, unbiased and multi-directional manner and delivers huge value to the EC and its stakeholders.

However, ACARE recognises that huge challenges lay ahead and that these can only be overcome by a new approach. To make the required rapid, significant scientific and technological progress, even deeper collaboration is needed between many actors, extending well beyond the aviation sector to encompass, for example, energy and all other transport modes. This collaboration must span and integrate all aspects of aviation from research and innovation to operations.

Working closely together with the EC, EASA, Eurocontrol, representatives of Member States and the European aviation associations of all types, ACARE is best positioned to act as the single, concerted voice across its rich European representation that is needed to future proof European aviation by turning this Vision into the European Aviation Strategy.In addition ACARE will be able to coordinate the realisation of the Vision and Strategy as it well positioned to oversee and secure coherence between individual initiatives needed to deliver impact.

To achieve this, also the ACARE structure and organisation needs to be aligned with the new vision. The issues to be addressed in defining the future ACARE are the terms of reference, the legal status of the organisation, governance, budget and the tasks to be undertaken. During this process, also the annex of this vision will be reviewed in order to match goals, stakeholders, timescales and expectations ensuring continuous alignment with the Green Deal in the most efficient way.

CONCLUDING REMARKS

The European aviation sector is a vital contributor to the continent's economic and societal well-being. It provides global connectivity for travellers and freight, makes a massive contribution to wealth generation, directly and indirectly and facilitates economic activity, for example by supporting tourism and inward investment.

However, aviation is facing serious and dynamic challenges. Society expects ever improved aviation services, increased economic contribution, decreasing environmental impact and the highest levels of safety and security. Technological capabilities and business models generally evolve gradually but are occasionally disrupted by major step changes. Other infrequent disruptive events have major impacts on the aviation sector.

It is essential to have a comprehensive and highly efficient and coherent response to these challenges across the whole aviation value chain and other contributing sectors with aligned political support. This Vision provides the first step in meeting these challenges by painting a picture of the desired future European aviation system and defining detailed, quantitative goals that need to be met for the Vision to be realised. The numerous and extensive goals defined in the annexes to this document for 2050 with intermediate steps in 2030 and 2035. World-class, efficient, timely research and innovation must be appropriately funded and organised at European-scale to deliver the scientific and technological advances that aviation needs to meet its challenges. This research and innovation must be based on a coherent programme, coordinated across the EU, Member States and industry. It must also extend coherently across transport modes and other related sectors, such as energy.

Achieving the intermediate and, ultimately, the 2050 goals described in this Vision, requires consistent and urgent attention to the highly interdependent investment chains of aviation stakeholders. For example, policy and regulation must stimulate research and innovation and enable operators to integrate high performance products into their operations.
To be successful, European aviation must transform itself. For this transformation to succeed, political support, the right administrative instruments and targeted, focused funding is needed.

This Vision represents the view of the future at one point in time in early 2022. The Vision's goals are ambitious and based on current knowledge and understanding. As time passes, aviation's challenges will undoubtedly evolve, as will the capabilities for addressing those challenges. To account for this dynamic landscape, updates of the Vision will be needed from time-to-tim.

ANNEX A - OVERARCHING GOALS

ACHIEVING CLIMATE NEUTRAL AIR MOBILITY

Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• By 2030, net CO_2 emissions from all intra-EU flights and those departing the EU are reduced by 55% compared to the 1990 baseline[11]; • By 2030, non-CO_2 climate effects are fully understood, managed, monitored and reduction targets are set in-line with the latest scientific understanding and available mitigation solutions.	• By 2035 new technologies, fuels and operational procedures in service result in a 30% reduction in non-CO_2 climate effects of all intra-EU flights and those departing the EU relative to the 1990 baseline.	• By 2050, net-zero CO_2 emissions has been achieved for all intra-EU flights and those departing the EU; • By 2050 new technologies and operational procedures in service result in a 90% reduction in NOx emissions from all intra-EU flights and those departing the EU relative to the year 2000[12]; • By 2050 new technologies and operational procedures in service result in a 90% reduction in non-volatile particulate matter (nvPM) emissions from all intra-EU flights and those departing the EU relative to the year 2000; • By 2050 new technologies and operational procedures in service result in a 90% reduction in warming contrail cirrus relative to the 2000 baseline; • By 2050 new technologies, fuels and operational procedures reduce the climate impact of CO_2 and non-CO_2 effects of all intra-EU flights and those departing the EU by 90% relative to the year 2000.

[11] Derived from European "Fit for 55"
[12] Derived from FlightPath2050

PUTTING THE CITIZEN AT THE CENTRE

Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• A single framework is in place to protect travellers' rights in a consistent way across all transport modes; • By 2030, European citizens are able to make informed mobility choices and have affordable access to sustainable, reliable, resilient, equitable, flexible, customer-centric and seamless connectivity both as passengers and for freight. Mobility choices are contextualised and personalised taking into account environmental impact and customers' individual preferences and requirements; • Operational noise abatement procedures are applied such that for Continues Descent Operations (CDO), relative to 2019 baseline, there is a 50% of reduction of average time in level flight by 2030 in Europe during night-time; • By 2030, all airports have carried out an assessment of the best trade-off between noise exposure and emissions reductions in order to implement the most efficient Noise Abatement Departure Procedure(s); • Aviation is a desirable sector to work in meaning that all posts are filled quickly and that there is low turnover of employees.	• A policy framework is established and applied, comprising metrics and calculation techniques for predicting, measuring and setting standards for the health, social, environmental, climate and other impacts of air transport, such as noise and local air quality, and enforcing compliance; • By 2035 land use management principles are applied for each airport region in Europe such that, relative to 2019 baseline, there is no population increase within Lnight=50 dB contour, and no existing population within Lnight=50 dB contour without noise insulation measures and no population increase within Lden=65 dB contour, and no existing population within Lden=65 dB contour without noise insulation measures in place.	• 90% of travellers within Europe are able to complete their journey in less than four hours; • 90% of freight within Europe is able to complete the journey, seamlessly, in less than four hours; • Air transport is an integrated component of the overall mobility system that is resilient to and automatically reconfigurable against disruptive events so that the traveller or cargo has a 95% probability of completing the journey on-time; • By 2050 technologies, operational improvements and noise abatement procedures reduce the perceived noise emission of flying aircraft by 65%[13] per operation relative to the 2000 baseline; • Land use management principles are applied for each airport region in Europe such that, relative to 2019 baseline, there is no population increase within the Lden=45dB contour by 2050; • Operational noise abatement procedures are applied so that for Continues Descent Operations (CDO), relative to 2019 baseline, there is a 90% of reduction in average time in level flight by 2050 in Europe; • All external mobility costs are internalised consistently, equitably and transparently across all transport modes when designing, developing, constructing, operating and maintaining the integrated, intermodal transport system.

[13] A reduction of 65% equals minus 15 dB/operation

IMPROVING GLOBAL LEADERSHIP AND COMPETITIVENESS

Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• By 2030 technological solutions for sustainable Zero-Emission vehicles have been demonstrated, and suitable certification methods and regulatory frameworks have been developed to support accelerated development and deployment.	• By 2035 Zero Emission air vehicles are starting to be deployed across Europe.	• By 2050, the high degree of competitiveness and strong reputation for quality and sustainability means that European aviation products and services have secured a 60% of their respective world markets; • By 2050, compared to 2022 there is a 30% increase in cost competitiveness of "Made in Europe" aviation technology, products and services throughout the supply chain achieved by streamlining systems engineering, design, manufacturing and upgrade, enhancing technology and people capabilities, and improving process efficiency; • By 2050, there is a 50% reduction in the cost of certification, enabled by enhanced digital capabilities and new standards.

ANNEX B - GOALS FOR AVIATION PILLARS

AVIATION IN THE EUROPEAN MOBILITY SYSTEM

Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• By 2030 within the EU and its partners, external costs are completely understood across all transport modes; • By 2030, aviation fully enables citizens and freight forwarders to make informed mobility choices on the aviation segment of journeys and have affordable access to sustainable, reliable, resilient, equitable, flexible, customer-centric and seamless air connectivity both as passengers and for freight. Mobility choices and services are contextualised and personalised taking into account customers' individual preferences and requirements.	• By 2035 Europe will be first to demonstrate seamless air mobility operation with other transport modes including integrated tickets, GDPR-compliant exchange of journey information and automatic reconfiguration in case of disruption in greater than 50% of journeys; • By 2035 within the EU and its partners, external costs are completely internalised across all transport modes.	• By 2050 the EU has integrated air mobility services seamlessly with other transport modes across 90% of its major airports; • There is a significant reduction of process times and increase in predictability across all modes, consistent door-to-door oriented passenger rights irrespective of mode, as well as the removal of friction points for transferring between different modes of transport; • The transport system is resilient to disruptive events and has implemented measures to adapt to the impacts of climate change. It is capable of automatically and dynamically reconfiguring individual journeys within the network to meet the needs of the traveller if disruption occurs helping the system to remain operational at (acceptably) high performance levels. Actions have been taken to adapt the sector's infrastructure and operations to impacts of climate change such as sea level rise and higher average temperatures. Airspace users have full situational awareness of the transport system as a whole as well as its customers' itineraries. Flights arrive within one minute of the planned arrival time regardless of weather conditions.

VEHICLES AND PROPULSION

Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• By 2030 Europe will demonstrate the "first-of- kind" hydrogen and hybrid electric, regional and short- and medium-range (SMR) solutions; • By 2030, European fleet efficiency improvement and emission reductions are enabled by retrofitting and forward fitting of technologies matured under European research programmes, ACARE driven initiatives, matching national programmes and industrial research. Together with fleet replacement, this reduces overall emissions more than countering the effects of any traffic growth; • All aircraft[14] and engines entering service after 2030 will be certified for 100% non-blended SAF or other low/ zero carbon fuels (e.g. [liquid] hydrogen); • By 2030, new regional and short-medium range aircraft will be defined and product developments launched. These aircraft will start entering service by 2035.	• By 2035, all aircraft have 100% capability and over 10% make significant regular use (around. 50% of the time) of SAF in Europe; • By 2035, overall European fleet fuel efficiency potential improves by at least 10% over 2018 levels with a stretch target of 15% improvement. This is enabled by the ramp up of new solutions with lower fuel burn aircraft to comprise between 30% and 50% of the overall fleet; • By 2035 Europe has introduced the world's first certified commercial hybrid-electrics and hydrogen solutions.	• By 2050, 75% of the European regional and short- medium range fleet will comprise the new aircraft that started entering service from 2035; • By 2050, overall European fleet fuel efficiency will have improved by between 30% and 50% compared to 2018 levels; • By 2050, air vehicles, their propulsion systems and the energy sources they utilise will be designed using circularity principles, facilitated by eco-design, with transparency and traceability from production, operation to end-of-life; • By 2050, the European aeronautical supply chain and manufacturing sector will have achieved net- zero greenhouse gas emissions across all of Scope 1, Scope 2 and Scope 3. The cycle time through design to certification is reduced by 50% in order to meet aggressive time schedules.

[14] Due to propulsion systems and fuels used General Aviation may have different timescales

INFRASTRUCTURE, OPERATIONS AND SERVICES

Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• By 2030 air transport operations throughout Europe use the most efficient generation of vehicles supported by best-in-class air traffic management (ATM) and ground operations; • All air vehicles have access to optimised ground infrastructure; • By 2030, 30% airports and other aviation infrastructure operate climate-neutral; • By 2030 operational fuel efficiency has improved by at least 5% compared to 2018 due to optimised flight trajectories and flight operations. This includes the benefit of minimised aircraft movements on-ground and reduced engine/electric taxi; • By 2030, airports have plans in place to adapt their infrastructure to allow operations of hydrogen aircraft once they enter the market; • All flights are planned with the ability to re-plan dynamically en-route, to climate optimised routes eliminating adverse environmental and minimising social impact, such as emissions and noise	• All air vehicles have access to ground infrastructure optimised for their operation, multimodality and passenger experience. Coherent ground infrastructure has been developed including airports, vertiports and heliports with the relevant servicing and connecting facilities to other modes (incl. baggage handling and integrated security); • An ATM system is in place that provides the required capacity and flexibility to cater for demand. It delivers a range of services to handle all types of vehicles (fixed-wing, rotorcraft) and systems (manned, unmanned, highly automated) that co-exist in shared airspace and are integrated into and interoperable with the overall air transport system with 24-hour efficient operations of airports; • European airports, ATC and energy production such as green electricity, SAF and Hydrogen operations will evolve to support new aircraft and fuels/energy systems; • The availability at all major airports with sustainable fuels increases progressively. By 2035, SAF is available for flights departing an EU airport with a minimum share of 20% SAF; • By 2035, at least 100 EU airports have become hydrogen hubs, initially for emission free ground transport while preparing the infrastructure for hydrogen-fuelled aircraft.	• By 2050, hydrogen fuelling will have become standard with high availability to meet demand; • By 2050, airports and other aviation infrastructure operate with zero emissions.

AVIATION IN THE EUROPEAN ENERGY AND FUELS SYSTEM

Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• Aviation is fully integrated with the European energy and fuels sector to ensure availability, affordability and security of supply; • By 2030, SAFs make up 10% of all of the aviation fuel consumed in Europe for intra-EU and departing flights; • By 2030, sustainably produced hydrogen will be available in key EU airports for ground operations and aircraft demonstration; • By 2030, aromatics and sulphur maximum contents in jet fuel uplifted in the EU are reduced, minimising non-CO_2 impacts; • By 2030, standards for the composition of SAFs are available and the means of ensuring compliance are in place; • All types of refuelling – battery charging, fuel cell exchange, hydrogen – is available at EU airports for ground vehicles providing access to the airport.	• In Europe, by 2035, 20% of conventional jet fuel is replaced by sustainable aviation fuel.	• By 2050, over 80% of conventional fuel will be replaced by SAF; • By 2050, sustainable hydrogen is available as an aviation fuel at all European airports; • The energy and transport chains are integrated within the mobility as a service system, e.g. the passenger can ride on a hydrogen powered bus to an hydrogen powered airport to board an hydrogen powered flight.

ANNEX C –GOALS FOR ENABLERS

EDUCATION, TRAINING AND RESEARCH

Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• From 2022 onwards, as identified in the EREA 7PP, links to other transport modalities and industrial sectors and links between national programmes and EC activities are established. These links generate and secure benefits from knowledge sharing, synergies and spin-offs in both directions; • From 2025, Europe leads the world's accelerated innovation path for sustainable aviation; • From 2025, EU aviation is attractive to start-ups and venture capital as disruptors/accelerators of innovation; • By 2025, compared to 2020 there is 30% more effort on readying climate neutral aviation solutions for industrial use in science, technology and education; • By 2030, education initiatives attract and educate 30% more people in aviation sector skills compared to 2020, creating new, high-value skills for the future European workforce, accelerating development of know-how for new, key technologies and differentiators; • By 2030, research programmes and public-private partnerships have increased the research and innovation pipeline in climate neutral aviation technologies by 50% compared to 2020; • By 2030, Europe is the world-leading aviation centre for academic and applied science in hydrogen and SAF, passenger centricity and noise reduction; • By 2030 Europe is the most attractive place for aviation research, demonstration, deployment, conferences, and developing international policy and implementation; • By 2030, Europe is at the forefront of climate impact and atmospheric research, developing a full system understanding of CO_2 and non-CO_2 effects, minimising uncertainties, assessing the impact and risks resulting from those uncertainties and taking the lead in the formulation of a prioritised environmental action plan and establishment of global environmental standards.	• European research is supported by appropriate infrastructure, living labs and high fidelity digital tools that are also used for training. As identified in the EREA 7PP, oversight is provided by a European Aviation Research Union; • Specialised training in the design and certification of new, innovative concepts is provided through collaborative organisations for education and training, perhaps established a Joint Undertakings; • By 2050, Europe is recognised as leader is sustainable aviation education, in technical and non-technical areas of study and research.	• Between 2035 and 2040, the research focus includes large and ultra-efficient hydrogen powered aircraft.

DIGITAL TRANSFORMATION

Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• The challenges of digital transformation have been solved by 2030, including: - European standards for data handling, sharing and access and cyber security are in place so that all actors can share the same sets of data for certification, performance, maintenance and end-of-life purposes; - the development of digital European aviation standards as a prerequisite for efficient research collaboration and to virtually integrate and leverage the results of numerous disciplines and stakeholders on compatible European Zero Emission aircraft platforms; - understanding the relationship between the human and the machine and the associated safety implications; - test, validation and certification of complex systems that show non-deterministic, emergent and learning behaviours; - dissemination and sharing of requirements, new rules and best practices, contributing to standardising a digital approach to leverage innovation across European research; - making European results and IP recognisable and protectable; - GDPR compliant exchange of personal data; - a holistic approach to security, addressing physical infrastructure, people, processes, and technology, through the system life-cycle from design through manufacture and certification to operations, maintenance, and decommissioning, including all aspects of the supply chain. • There are no successful cyber-attacks on aircraft and critical aviation infrastructure.	• European aviation is using the new EU digital back-bone and design standards, enabling researchers, the supply chain and the OEMs to validate via digital twins the end-to-end viability and impact of European Aircraft; • The first major aircraft components have been flight-certified with the help of digital certification; • Short- and medium-term weather forecasts make use of a worldwide network of ground based and airborne sensors; • Fully GDPR-compliant passenger support before, during and after a journey is integrated so much that the average travel can be considered seamless; • Each aircraft and its components can be tracked and monitored from design and production throughout their operational lives.	• All major aircraft parts are certified largely by means of digital certification; • All routing is based on fully digitised 4D navigation where the system has been proven to be very resilient in case of minor and major disruptions; • In research computing capacity is no longer a limiting issue. Real time simulations including CFD- and FEM-analyses are possible to a level such that both design and off-design performance are being predicted accurately; • Digitalisation has proven to bring an important contribution to the safety of aircraft.

DEVELOPMENT, DEMONSTRATION AND DEPLOYMENT

Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• By 2030, the first-of-its-kind hybrid-electric, short/medium range solution have been demonstrated; • By 2025, efficient upgrades to 100% non-blended SAF potential have been developed and certified; • By 2025, deliver climate friendly air traffic routing solutions; • Deliver latest generation aircraft with greater than 20% improved efficiency compared to 2020; • Accelerate the delivery of the latest generation of components and vehicles by 2030; • Demonstrate passenger-centric aircraft, including easy access, cabin comfort and baggage handling • Societal acceptance of new technologies (e.g. AI), vehicles (e.g. air taxis), systems, services and operations (e.g. supersonic flight) is assessed and understood.	• Facilities and infrastructure, such as large-scale demonstrators, D-planes and living labs are in place and widely available; • Demonstrate cost competitive circular- and eco- design, manufacture and assembly as the future of EU aircraft production for further implementation and impact; • Deliver a comprehensive EU deployment plan for hydrogen including assuring its availability, certified standards for products, handling and services including maintenance, repair and overhaul (MRO); • Establish EU Flag carrying pilot projects supported by pre-commercial public procurement for demonstration and deployment, enabled by cross border/ EU regulatory sand boxes to experiment and validate impact across Europe.	• Deliver the first pan-European, full scale climate neutral solutions and develop more efficient, larger and longer-range solutions; • Deliver next generation, high efficiency 100% non- blended SAF vehicles; • Deliver the first hydrogen-hybrid-electric solutions.

SAFETY, SECURITY AND RESILIENCE

Timeframe		
Short-term (<2030)	**Medium-term (<2035)**	**Long-term (<2050)**
• By 2030 the Safety Management System (SMS) encompasses risks from diseases, security threats and climate change; • By 2030 the SMS takes full benefit of operational data collected daily for all segments of the air transport, though validated processes, tools, solutions and training for end-users; • By 2030, a close link has been established between aviation and international health organisations (EMA, WHO) and, through this, systems have been developed to help prevent future pandemics. Based on scientific modelling, the aviation industry (with other transport modes) can adapt operations and networks at short notice in to prevent illnesses from spreading • By 2030, apply disruptive technologies such as AI, digital twins, interconnected systems to develop enhanced manned-unmanned teaming for air transport security management; • By 2030, develop dedicated training devices such as hybrid simulation tools in order to qualify and/or certify the air transport security devices; • By 2030, air transport resilience has been demonstrated against cyber/physical threats by addressing the following situations: - Threat management: Detection of threats and engagement of mitigation actions; - Attack management: reduce damages by protecting persons and neuralgic systems during the attack (cyber / physical); - Crisis management: Engage actions to rescue persons and reconfigure the air transport system. • By 2030 Europe is the first to demonstrate seamless air mobility operation with other transport modes including integrated tickets, GDPR-compliant exchange of journey information and automatic reconfiguration in case of disruption in greater than 30% of journeys.	• Levels of safety have increased by a factor of two compared to 2020; • Safety, security and resilience are assured seamlessly and to the same standards along the entire journey irrespective of the modes used.	• Levels of safety have increased by a factor of five compared to 2020; • By 2050, implement intelligence solutions in the Safety Management System (SMS) to infer prevailing risks in real-time and support their mitigations with the concerned actors collaboratively; • By 2050, apply a cross-sector risk management system to support the detection, characterisation and mitigation of common threats, cascading failure cases from interconnected systems and systematic risks; • By 2050, demonstrate the autonomous management of air transport security (in all situations) by an interconnected resilient system, while maintaining human in the loop; • By 2050, develop standards and periodic exercises to check and adapt the air transport system security management to new threats; • By 2050, demonstrate the interconnect ability of air transport resilient Security system to outside systems (city, national, etc.) for a global Security management at the level of cities, countries or Europe; • By 2050, the transport system is resilient to disruptive events; it is capable of automatically and dynamically reconfiguring individual journeys within the network to meet the needs of the traveller if disruption occurs helping the system to remain operational at (acceptably) high performance levels. Airspace users have full situational awareness of the transport system as a whole as well as its customers' itineraries. Flights arrive within one minute of the planned arrival time in normal conditions.

ANNEX D - POLICY ENABLERS

POLICY ENABLERS

Policy actions	Incentives
• By 2025 a dedicated EU Mission supported by the appropriate governance and organisational structures, linking EU and national programmes, is in place and leading the path towards climate neutral aviation. Well phased and synchronised demonstrator Programmes, IPCEI & alliances are accelerating the time to market; • By 2025, ACARE is reformed and is supporting the EC where appropriate in input for policies including international coordination and in extracting benefits for Europe; • By 2030 Europe is recognised as the world-leading place for aviation product development and product innovations, thanks to the continuous implementation of the most efficient funding frameworks and the timely classification of sustainable aviation as an IPCEI; • By 2030 a legal framework for seamless door-to-door journeys is in place addressing passenger rights in a multimodal transport environment as well as enabling personalised travel and reconfiguration of journeys by exchange of contextual journey information in a GDPR-compliant way; • • By 2030 and continued throughout 2050 Europe's collaborative research programmes and Public Private Partnerships are proven catalysts that have accelerated science, technology maturation, innovation and new product demonstrations; • By 2035 Europe's lighthouse projects and regulatory cross-border sand-boxes have proved, validated and certified new products, services and value chains across sectors and countries; • Regulation encourages and permits new sustainable business models for innovative aircraft technology for future aircraft and fleet retrofits and exploiting next generation digitalisation/automation technologies; • By 2025 regulation encourages and permits the use of Sustainable Aviation Fuels and Hydrogen by rewarding airlines that uptake these sustainable fuels; • Regulation encourages climate optimised routing; • Direct Air Carbon Capture technologies are recognised and incentivised as part of the compliance mechanism inside market based measures; • Spin-off opportunities are enabled to benefit European citizens by exploitation of aviation in critical areas such as climate, emergency response, space and security; • Strategic partnerships with non-aviation sectors are established to make use of emerging technologies (e.g. drop-in and non-drop-in fuels, fuel cells, artificial intelligence, electronics, materials); • The EU has established world-wide recognised SAF and hydrogen standards and certification processes for aviation.	• Accelerate SAF production and deployment; • Develop and deploy liquid hydrogen infrastructure at airports; • Increase the delivery, diffusion and market adoption of solutions that will reduce the environmental impact of aviation (emissions, air, water and land quality, other pollution and noise) and increase the quality of life, in particular around airports; • Increase the delivery, diffusion and market adoption of solutions that will increase aviation safety and security levels in particular by improved cooperation with the EASA and deep transformation of operations with the help of innovation; • Improve aviation industry image and perception in society by fulfilling customer and general public expectations of a globally competitive and sustainable European aviation industry; • Increase the delivery, diffusion and market adoption of solutions that will improve the mobility and connectivity of European citizens with safe, reliable, affordable and resilient air travel options; • Increase the delivery, diffusion and market adoption of solutions that will develop a strong circular economy dimension for aviation by utilising lifecycle 'eco-design', 'biomimicry' and 'circularity' approaches; • Apply penalty and incentive schemes to encourage environmentally friendly measures, such as climate optimised routing.

ANNEX E - EXAMPLE METRICS

METRICS FOR MEASURING IMPACT

Theme		
Achieving climate neutral air mobility	**Putting the citizen at the centre**	**Improving global leadership and competitiveness**
• Greenhouse gases and other non-CO_2 emissions that cause climate impact; • Climate impact assessed on a cradle-to-cradle basis, considering the entire impact of the vehicle, its systems and energy source, including energy production and storage mechanisms, not only direct emissions from the aircraft; • The individual components of the cradle-to-cradle impact enabling each to be assessed individually in in combination; • Local air quality impact; • Impact on biodiversity.	• Societal perception of aviation; • Access to unbiased mobility information; • Connectivity and level of integration of transport; • Customer satisfaction, including affordability, punctuality, comfort, choice, flexibility and equity; • Welfare factors including jobs, wealth creation and societal well-being; • Workforce facilitation, compensation and satisfaction (e.g. training, compensation, working conditions and interesting jobs); • Noise and other nuisance impacts; • Safety performance; • Security performance; • Resilience; • Interoperability; • Predictability.	• Market share of European aviation companies; • Cost competitiveness of European aviation; • Time to market for products from initial concept to certification; • Time to impact - from scientific to technical mature technologies to deployed products and services generating impact; • Metrics quantifying research and innovation; • Metrics quantifying education & training specific for aeronautics (number of students, number of graduates, number of faculties specific for aeronautical studies, percentage of students from other domains moving towards aerospace jobs and training, number of PhD theses and ratio of implementation of that research into products), percentage of unemployed workforce that enters aeronautical jobs at all levels, retention rate of aerospace industry, quality and quantity of training; • Aviation's contribution to economic and societal development.

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KI-05-21-325-EN-C

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of the European Union

doi: 10.2777/231782
ISBN 978-92-76-43367-5