



Flightpath 2050 Europe's Vision for Aviation

Report of the High Level Group
on Aviation Research

EUROPEAN COMMISSION

Directorate-General for Research and Innovation
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Flightpath 2050

Europe's Vision for Aviation

Maintaining Global Leadership &
Serving Society's Needs

Report of the High Level Group on Aviation Research

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Foreword

by Siim Kallas, Vice-President of the European Commission and Commissioner for Transport, and
Máire Geoghegan-Quinn, Commissioner for Research, Innovation and Science

Europe is entering a new age where it faces many challenges such as globalisation, a financial system in need of reform, climate change and an increasing scarcity of resources.

This is why the European air transport system is directly concerned by new challenges regarding its competitiveness, performance and sustainability. The European manufacturing and service industry is strongly affected by globalisation, new competitors, new markets and the need for innovation. Sustainable mobility is at stake, as are millions of jobs and billions of Euros of added value. Research and innovation are key to maintaining Europe's capacities and competitiveness and it is time to align efforts towards a new long-term vision for this sector.

We invited key stakeholders of European aviation from the aeronautics industry, air traffic management, airports, airlines, energy providers and the research community to come together in a High Level Group to develop a vision for Europe's aviation system and industry by 2050. The aviation community responded enthusiastically and produced this important document which focuses on two main challenges: meeting the needs of our citizens and the market as well as maintaining global leadership.

The strategy addresses customer orientation and market needs as well as industrial competitiveness and the need to maintain an adequate skills and research infrastructure base in Europe. By 2050, 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 will be necessary in order to meet the growing demand for travel and to cope more easily with unforeseeable events.

It should also help to reduce aviation's impact on citizens and the environment. Aviation has an important role to play in reducing noise as well as greenhouse gas emissions, regardless of traffic growth. Aviation must move towards more sustainable energy sources. It should live up to the highest levels of safety and security to ensure that passengers and freight as well as the air transport system and its infrastructure are protected.

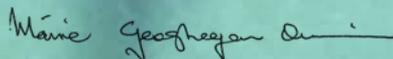
The vision set out in this document stresses the need for an innovation friendly environment relying on strong, sustainable and coherent investment in research and innovation and enhanced governance, funding and financing structures.

Research, technology and innovation are essential catalysts for a competitive and sustainable future and we need to start quickly to be effective. This document setting out a European vision for the future of aviation emphasises where those working in aviation see the priorities for the relevant policy, research and innovation instruments. It is a high-level vision of Europe leading with an aviation industry that is clean, competitive, safe and secure.

Siim Kallas



Máire Geoghegan-Quinn



Aviation - an invaluable asset for Europe

Aviation – an invaluable asset for Europe

Aeronautics and air transport¹ is a vital sector of our society and economy. It is also of sovereign importance for the European Union and its Member States. It is a sector in which European public and private stakeholders provide world leadership and helps to meet society's needs by:

- ensuring suitable and sustainable mobility of passengers and freight
- generating wealth and economic growth
- significantly contributing to the balance of trade and European competitiveness
- providing highly skilled jobs and innovation
- fostering Europe's knowledge economy through substantial R&D investment
- contributing in many ways to global safety, security and self-reliance.

Aviation is a catalyst for growth and skilled employment. As such, it is at the heart of the EUROPE 2020 strategy and its flagship initiatives including: *Innovation Union, An industrial policy for the globalisation era and Resource Efficient Europe.*

Aviation's economic and societal contribution is substantial generating around €220 billion² and providing 4.5 million jobs³. The value of this contribution is illustrated by the economic impact of the disruption to the European air transport system of 2010's volcanic eruption in Iceland which amounted to approximately €2.5 billion in the first week.

Over the past 40 years, the European aeronautic industry has, through collective European efforts encompassing public and private, major companies, thousands of small and medium enterprises (SMEs), academia and research laboratories, successfully raised from a niche sector to a world leading industry. Its products include aircraft, rotorcraft, engines, avionics and systems as well as leading operations and services. Aeronautics therefore continues to be a highlight of an integrated high technology research, development and manufacturing sector. It numbers approximately 82000 aeronautical companies⁴, including a significant share of small and

medium-sized enterprises which in 2009 supported about 500000 sustainable and highly skilled jobs. In the same year, aeronautics generated a turnover in excess of €100 billion, of which approximately 60% is exported outside the European Union.

On average, 12% of aeronautic revenues, representing almost €7 billion per year for civil aeronautics alone, are reinvested in Research and Development (R&D) and support around 20% of aerospace jobs. Every Euro invested in aeronautics R&D creates an equivalent additional value in the economy every year thereafter. Aeronautical technologies are catalysts for innovation and spill-over into other economic and technological sectors, thus contributing to the growth of the European economy as a whole.

Aviation is a vital facilitator of European integration and cohesion by providing essential transport links. It is an important enabler of prosperity and wealth creation for the Member States and their peripheral regions by stimulating development, opening new markets, boosting international trade and encouraging companies to invest.

Europe is home to approximately 150 scheduled passenger airlines and 450 airports, which in 2009 supported 751 million passengers⁵. World wide, traffic is predicted to grow at a rate of close at 4-5% per year with even higher growth rates⁶ in the Middle East and Asia.



The aviation sector is also fully aware of its responsibilities towards Europe's citizens: protection of the environment, security and safety. It is meeting these challenges successfully and so enabling its continued contribution to European economic and societal well-being.

Challenges

However, the industrial competition is becoming ever fiercer from established, traditional rivals such as the US and even more so from new and strong challengers, notably Brazil, Canada, China, India and Russia. Regions such as the Middle East and Asia at large have emerged as strong competitors for air services and infrastructure. Authorities in these countries have understood the strategic nature of aviation and support their industries accordingly, enhancing competition at all levels.

Europe must succeed despite this increased competition. For that to happen, Europe must address three key challenges: increase the level of technology investment, enhance its competitiveness in world air transport markets and accelerate the pace of policy integration.

Technological leadership, the root of Europe's current success, will continue to be the major competitive differentiator. Break-through technology will be required to secure future competitive advantage, most notably in terms of energy, management of complexity and environmental performance. Substantial and sustained investment in the technologies of today and tomorrow is needed to guarantee the future, as well as readiness to spin-in advances arising from defence investment where appropriate.

This is not only a matter of success but also of survival. Aviation will be as valuable for future European generations as it is for ours.

Opportunity

Europe must seize the opportunity of the expanding aviation market, and preserve its pre-eminent position to ensure the continued success and economic contribution of its aviation industry in European and export markets.

With its leading knowledge and manufacturing capability, the European aviation industry is in a position to define and shape a sustainable future.



Remaining competitive is also about the timely delivery of competitive products and services. It is linked to a common level playing field of government support, which requires policy action to redress distortions and facilitate a favourable environment for innovation.

Building on the vision⁷ for 2020, and the ensuing ACARE initiative, this document lays out our vision for European aviation to 2050. Today and even more so tomorrow, a safe and efficient Air Transport System, led by innovative technology, will be a vital vector for our economy, our society and the cohesion of Europe and the world

Our Vision

The European aviation community leads the world in sustainable aviation products and services, meeting the needs of EU citizens and society.

¹Aeronautics and air transport comprises both: air vehicle and system technology, design and manufacture; and also the constituent parts of the overall air travel system (aircraft, airlines, general aviation, airports, air traffic management, and maintenance, repair and overhaul) as well as many non-transport applications of aircraft, such as search and rescue. For convenience this is collectively called Aviation in this document

²The economic and social benefits of air transport 2008, Air Transport Action Group (ATAG)

³Delivering a bright future for European Aviation and Passengers. 5 year Strategic Plan 2010-2014. Association of European Airlines

⁴Source: ASD Facts and Figures, 2009

⁵Source: Eurostat

⁶Source: Airbus Global market forecast 2010-2029

⁷European Aeronautics: A Vision for 2020. Meeting society's needs and winning global leadership. Report Of The Group Of Personalities, January 2001

The European Aviation Vision 2050

Highly ambitious goals

Aviation serves the citizen, brings people together and delivers goods through seamless, safe and secure, cost effective transport chains, adding value through speed, reliability and resilience in a global network, over any distance, without negative effects on the environment. Aviation also contributes to society in other critical, non-transport areas such as emergency services, search and rescue, disaster relief and climate monitoring.

Our Vision for the European aviation is extensive, holistic, highly ambitious and built on the parallel objectives of:

Maintaining global leadership:

- **Providing the best products and associated services in aeronautics and air transport**
- **Ensuring the competitiveness of European industry, supported by a strong research network and balanced regulatory framework, in the face of fierce competition from both established and emerging rivals**
- **Maximising the aviation sector's economic contribution and creating value:**
 - directly from aviation manufacturing, equipment, systems and services;
 - indirectly by creating demand up the supply chain, involving SMEs and based on cutting-edge research and education;
 - catalytically by providing the connectivity needed by other globalised industries and trade.
- **Attracting the best people and talents**
 - celebrating and publicising the success of the sector to create and sustain excitement around the European Aviation Vision.

Serving society's needs

- **Meeting societal and market needs for affordable, sustainable, reliable and seamless connectivity for passengers and freight with sufficient capacity**

European Aviation Vision 2050

- **Supporting the integration and cohesion of the European Union, its neighbours and partners**
- **Addressing societal needs with non-transport aerial applications enabled by new flight control technologies**
- **Protecting the environment and enabling the use of sustainable energy and alternative energy sources**
- **Ensuring complete and non-intrusive security**
- **Ensuring safety**
- **Providing opportunities for highly qualified and skilled jobs in Europe.**

The following pages describe our Vision, in terms of how the world will be, for European aviation in 2050.

European air transport in 2050

Global Position

In 2050, the European air transport system is integrated in a complete logistical transport chain and part of a fully interconnected, global aviation system that is based on a multilateral regime rather than on a series of bilateral agreements. Interoperability between Europe and the other regional components of the global network is complete. Commercial air transport services are provided mainly by airlines organised as a few global alliances. Thanks to tight links between technological and regulatory approach, Europe has a global lead in the implementation of international standards covering all aviation issues, including interoperability, the environment, energy, security and safety. This leadership ensures that the global regulatory system enables market access and free, fair and open competition.

Outside Europe, the currently emerging economies have developed and become established. Europe, along with the United States, is now one of several economic powerhouses alongside Brazil, Russia, India and China. Population and economic growth has increased the global volume of traffic markedly, to around 16 billion passengers annually (compared to the 2.5 billion passengers in 2011). The exploitation of the best air mobility options - diverse routes, locations and flight levels - for passenger and freight transport avoids airspace congestion and bottlenecks.

In 2050, the diversity of air vehicles operating in common blocks of airspace is many-fold, including: a range of

next generation wide and narrow body commercial aircraft, executive aircraft, advanced rotorcraft of all types including tilt-rotors, specialised aircraft (quiet short-take-off and landing (QSTOL), regional, business) and remotely controlled unmanned aircraft systems (UASs). A proportion of these vehicles are pilotless and some are autonomous. Non-transport aviation missions have increased significantly and are undertaken by remotely controlled and autonomous vehicles, particularly where missions are simple and repetitive, dangerous or require long endurance.

Within Europe

The European aviation market will be larger than in 2011. Within Europe the number of commercial flights⁸ is up to 25 million in 2050 compared to 9.4 million in 2011. Even with the advent of high-speed rail, the distance involved means that air transport remains the only viable direct way of connecting Europe's regions. Even for shorter distances in some geographical areas, aviation sometimes offers the most efficient means of transport. Air transport is the principal way of conveniently satisfying the growing demand for diffused, flexible point-to-point connections. The number and quality of aviation market services has increased significantly mainly because of passengers demand to plan and predict their journeys in real time whilst at the same time staying connected to work, relatives and friends.

Innovation

Environmental protection has been and remains a prime driver in the development of air vehicles and new transport infrastructure. In addition to continuously improving fuel efficiency, the continued availability of liquid fuels, their cost impact on the aviation sector and their impacts on the environment, has been addressed as part of an overall fuel strategy for all sectors. Aviation continues to exploit liquid fuels, prioritised by operational and technology considerations. Producing liquid fuels and energy from sustainable biomass has become an important part of the energy supply. A coordinated approach to fuel development is taken across the sectors that are highly dependent on liquid hydro-carbon fuels: aviation; marine and heavy duty transport and is a key part of managing carbon dioxide emissions from the transport sector as a whole.

Disruptive, step-change technologies have played an integral part of the development process. European

industry has introduced to the world market a complete set of new products and services including a real new generation of air vehicles and ever-more efficient, environmentally friendly and quiet engines. These are leading edge and recognised as reference products by the whole aeronautics community. As a result of these efforts society in 2050 considers that travel by air is environmentally friendly.

Europe is recognised globally for the innovative concepts realised in its products and services driven by a vibrant and successful industry and enabled by efficient policies. Strong, coherent research networks and partnerships between private and public actors drive European innovation and are enabled by strong public funding and a range of globally-recognised, efficient instruments.

Infrastructure

The ground infrastructure is in place for all types of aviation, transport and non-transport, commercial and non-commercial. It comprises major hubs, secondary airports, vertiports and heliports, all of which are seamlessly connected within a multimodal transport system. Access to airports is facilitated by specialist vehicles. Traditional hub airports operate at high utilisation levels. Delays are mitigated by highly efficient operations and through night operations enabled by ultra-quiet aircraft. Congested airports are no longer a bottleneck due to action taken by the Single European Sky, SESAR, successor programmes, connections to other ATM systems worldwide and new aircraft concepts.

Access to airports is quick, comfortable and simple for all people in Europe. Intermodal connections, especially air-rail provide a win-win situation in terms of passenger convenience and sustainability. Airport design, processes and services are based on new concepts and are highly efficient. Airport operations are resilient against weather and other disruption. Flight planning, aircraft sizes and infrastructure are optimised and where necessary increased. New operators have evolved from the general aviation market segment. Seamless door-to-door travel of passengers and freight is the norm.

The Single European Sky is fully implemented and the successor programmes of SESAR and similar interoperable programmes globally have ensured that capacity meets expanding demand in the air and at airports. These developments have optimised the access and trajectories of air vehicles, ensured equity of access and safe and efficient vehicle operations with the most

efficient possible fuel consumption and emissions at the lowest possible cost.

Infrastructure and services, operators, aircraft, airports, ground handlers and the military are integrated into these global, interoperable networks provided by a small number of organisations. These networks are seamlessly connected to other modal networks, most notably rail, sea carriers and local and regional transport. Shared information platforms and new IT tools and services facilitate data exchange and decision making. They 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.

The air transport network is able to cater for much greater traffic densities through new services based on ever higher degrees of automated flight management and control for all air vehicles. In addition to the benefits delivered to commercial air transport, precise navigation and on-board systems give all-weather, 24/7 capacity to rotorcraft and aircraft capable of door-to-door operation with limited infrastructure. All types of rotorcraft are capable of simultaneous, non-interfering approach to airports as part of regional networks including city vertiports and secondary, remote infrastructure, complying with local noise regulations. Automation has changed the roles of both the pilot and the air traffic controller. Their roles are now as strategic managers and hands-off supervisors, only intervening when necessary.



⁸Source: Eurocontrol

Meeting societal & market needs



In 2050, the passenger experience is paramount. Air transport is at the heart of an integrated seamless, energy efficient, diffused intermodal system taking travellers and their baggage from door-to-door, safely, affordably, quickly, smoothly, seamlessly, predictably and without interruption. Choices are offered between customised products and services offering levels of facilities, quality of service, on-board comfort, journey time, optional rescheduling and price.

Passage through the airport is streamlined and rapid. All checks: for security and immigration; are conducted smoothly and in a non-intrusive manner.

Passengers are able to access global high speed personal communication and internet services for work or leisure continuously throughout the entire journey. These services are also used to facilitate speed and convenience by providing dynamic information to the passenger at all stages of the journey. Executive passengers have access to a truly flexible and rapid air transport service providing a seamless flying office.

Freight shippers have similar choices regarding price, service level, and journey time. Cargo remains an important component of the payload on passenger aircraft and unmanned aircraft systems (UAS) are playing an increasing role as freighters.

UASs (fixed and/or rotary wing) are also active in non-transport aviation activities. These include new applications, for example providing part of society's information infrastructure, a variety of monitoring functions, disaster relief, etc. Rotorcraft play a significant role in public services, including search and rescue, and also in (regional) transport.

The transport system is resilient against disruptive events and is capable of automatically and dynamically reconfiguring the journey, including transfer to other modes, to meet the needs of the traveller if disruption occurs.

Goals:

1. European citizens are able to make informed mobility choices and have affordable access to one another, taking into account: economy, speed, and tailored level of service. Travellers can use continuous, secure and robust high-speed communications for added-value applications.
2. 90% of travellers within Europe are able to complete their journey, door-to-door within 4 hours. Passengers and freight are able to transfer seamlessly between transport modes to reach the final destination smoothly, predictably and on-time.
3. Flights arrive within 1 minute of the planned arrival time regardless of weather conditions. The transport system is resilient against disruptive events and is capable of automatically and dynamically reconfiguring the journey within the network to meet the needs of the traveller if disruption occurs. Special mission flights can be completed in the majority of weather, atmospheric conditions and operational environments
4. An air traffic management system is in place that provides a range of services to handle at least 25 million flights a year of all types of vehicles, (fixed-wing, rotorcraft) and systems (manned, unmanned, autonomous) that are integrated into and interoperable with the overall air transport system with 24-hour efficient operation of airports.
5. A coherent ground infrastructure is developed including: airports, vertiports and heliports with the relevant servicing and connecting facilities, also to other modes.





Maintaining and extending industrial leadership

In 2050, the innovative, sustainable and highly competitive European aviation industry has cemented its place as the world leader. It is recognised globally for its vehicles, engines, services and a large range of very cost effective and energy efficient products. This position has been secured through a seamless European research and innovation system that assures continuity through blue sky research, applied research, development, demonstration and innovation in products and services.

Europe's industry maintains and improves its critical mass, leading edge capabilities and competitiveness through continuous and focused investment funded by strategic industrial and public-private partnerships, supported by cutting edge research organisations and education, organised in geographic clusters and networks.

Multi-disciplinary design and development tools are used routinely and co-operatively to support a high level of integrated system design. Final product performance is achieved to within a very fine tolerance (0.5%) of design prediction based on balanced design techniques and simulations ensuring right-first-time manufacture. This, with seamless integration of design and manufacturing, and the successful management of complex supply chains, means that development timescales and costs have been dramatically reduced.

Close-to-operations, full-scale technology validation, demonstration and in-flight testing is used to manage risk and to test technology. This enables the relentless pursuit of breakthrough and step-change innovations in products and services. New concepts, methods and tools are used to manage increasing complexity. The physical limits inherent in current micro-processing have been overcome by new technologies to produce reliable and resilient, embedded and certified equipment that provides the extensive computing power needed within the vehicle.

Goals

The regulatory environment enables, where appropriate, the emergence of global operators (air and rail, ports and other transport) and facilitates fair, balanced and reciprocal international cooperation. Europe has led the harmonisation of standardisation and certification processes globally. The European certification process, based on virtual simulation tools is widely applied at both component and product level and is streamlined, efficient and low cost. Europe continues to drive global standardisation covering all elements of the industry through the entire life cycle from design through to disposal.

System complexity and automation require highly-skilled staff and the best researchers, engineers and managers are attracted by the European aviation sector, which has the reputation for being a most highly desirable, attractive, challenging and rewarding career choice.

- 1. The whole European aviation industry is strongly competitive, delivers the best products and services worldwide and has a share of more than 40% of its global market.**
- 2. Europe will maintain leading edge design, manufacturing and system integration capabilities and jobs supported by high profile, strategic, flagship projects and programmes which cover the whole innovation process from basic research to full-scale demonstrators.**
- 3. Streamlined systems engineering, design, manufacturing, certification and upgrade processes have addressed complexity and significantly decreased development costs (including a 50% reduction in the cost of certification). A leading new generation of standards is created.**





Protecting the environment and the energy supply

In 2050, the effect of aviation on the atmosphere is fully understood. A combination of measures, including technology development, operational procedures and market-based incentives mean that its environmental impacts have been mitigated at a rate outweighing the effects of increasing traffic levels. The public is informed, understands and is convinced that the aviation sector has made the utmost progress in mitigating environmental impacts and therefore considers that air travel is environmentally sustainable.

Dependence on crude oil is reduced by drop-in liquid fuels from other sources at a competitive cost. This has been facilitated by a coherent research strategy, regulatory enablers and streamlined certification and approval processes and the establishment of sustainable supply chains. The progressive introduction of fuel cells and battery powered vehicles for ground operations at airports has made an important contribution to reducing the carbon footprint of the aviation sector. Electrical and hybrid-electrical engines have entered the aviation market. Alternative energy is used for ancillary systems. These advances in hybrid propulsion and energy storage techniques ensure the competitiveness and sustainability of light rotorcraft, manned and unmanned.

A coherent approach has been applied across a wide range of high leverage disciplines including materials; the manufacturing process; systems optimisation; aerodynamics; vehicle and engine design and integration; infrastructure; fuel and operational procedures. Fuel specifications are included as an integral design component for future airframe and engine designs and fuels are designed with the engine in mind. The whole life cycle impact of vehicles, equipment and systems has been addressed.

Substantial developments in vehicle and engine have combined and built upon each other to yield a truly new generation of European air vehicles and equipment with significantly improved and continuously improving

fuel and noise efficiency. In parallel the air traffic control system is optimised to provide the best trajectories for fuel and time efficiency and associated atmospheric emissions and also to address noise. Noise projection on the ground is also reduced. Noise generated by rotorcraft at heliports continues to be in compliance with the local operational rules.

Revenues from the Emissions Trading Scheme (ETS⁹) have been used to supplement funding for research, technologies, products and fuel innovations providing Europe with a sustainable aviation.

Goals

- 1. In 2050 technologies and procedures available allow a 75% reduction in CO2 emissions per passenger kilometre to support the ATAG target¹⁰ and a 90% reduction in NOx emissions. The perceived noise emission of flying aircraft is reduced by 65%. These are relative to the capabilities of typical new aircraft in 2000.**
- 2. Aircraft movements are emission-free when taxiing.**
- 3. Air vehicles are designed and manufactured to be recyclable.**
- 4. Europe is established as a centre of excellence on sustainable alternative fuels, including those for aviation, based on a strong European energy policy.**
- 5. Europe is at the forefront of atmospheric research and takes the lead in the formulation of a prioritised environmental action plan and establishment of global environmental standards.**



⁹see article 3d) of Directive 2003/87/EC on the greenhouse gas emission allowance trading scheme of the Community as amended by Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008

¹⁰Carbon-neutral growth starting 2020 and a 50% overall CO2 emission reduction by 2050



Ensuring safety and security

Safety

In 2050, European aviation has achieved unprecedented levels of safety and continues to improve. Manned, unmanned, legacy and next generation, autonomous aircraft and all types of rotorcraft operate simultaneously in the same airspace and in most weather conditions. A holistic, total system approach to aviation safety is integrated across all components and stakeholders. This is supported by new safety management, safety assurance and certification techniques that account for all system developments.

The occurrence and impact of human error is significantly reduced through new designs and training processes and through technologies that support decision-making. *Just culture*¹¹ has been adopted uniformly across Europe as an essential element of the safety process.

Advanced on-board monitoring systems allow the aircraft and air transport system to predict and mitigate technical and operational issues, including weather, before they arise.



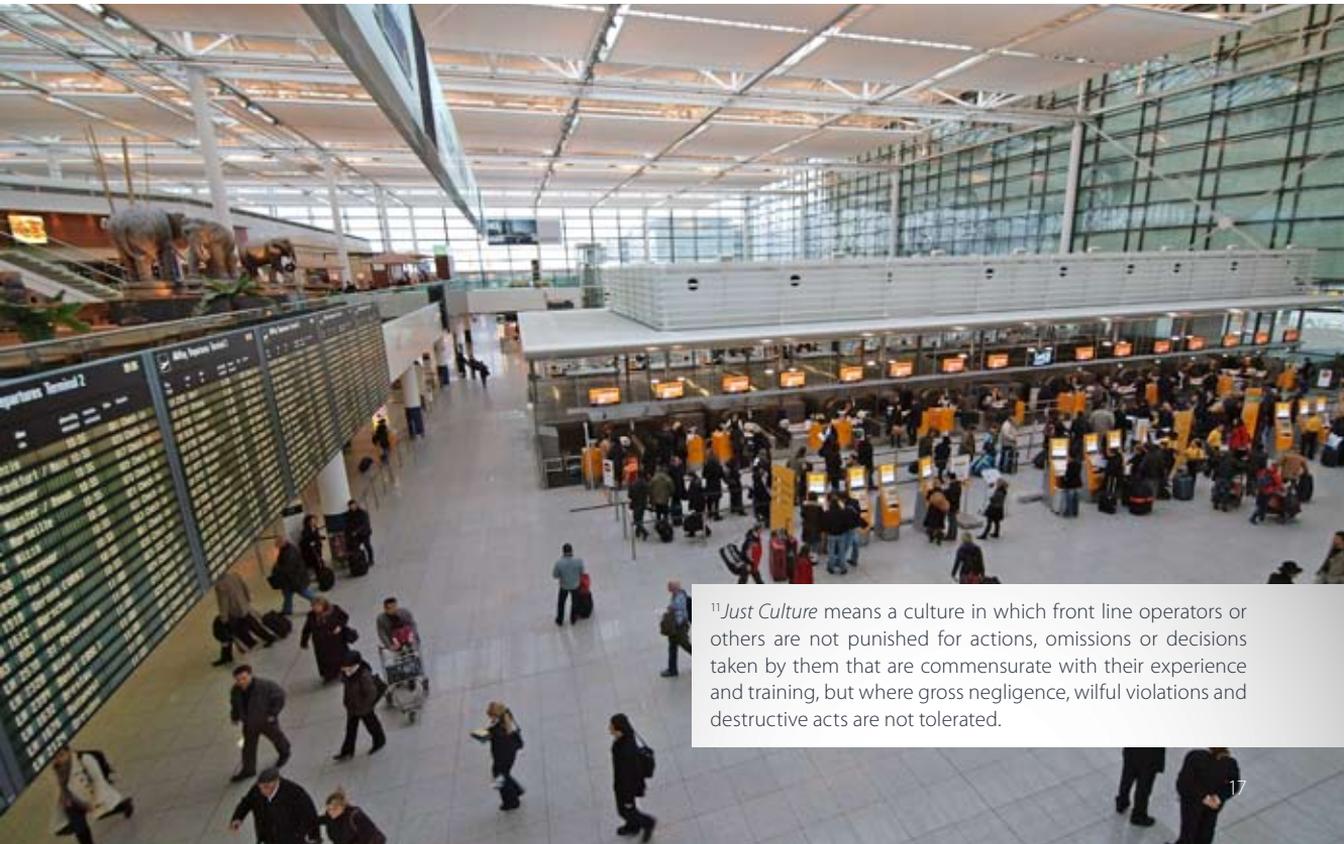
Security

In 2050, security processes for air travellers are non-intrusive, preserve privacy and personal dignity and are free of interruption and delay. The majority of passengers pass through security screening without intervention or disruption. The security chain for freight has been significantly improved. Aviation security is part of an integrated security strategy for all modes of transport and is based on the three principles of: resilience and effectiveness; passenger experience; and fast, integrated and seamless processes. Risk assessment is integrated into the security screening process for passengers and cargo, based on a range of inputs such as intelligence information and behavioural recognition to ensure that resources are focused appropriately and effectively.

Air transport data networks, including navigation, air-ground communications and all key on-board processing elements, are fully secure and hardened against and resilient to cyber attacks enabling the operation of all aircraft types.

Goals:

- 1. Overall, the European air transport system has less than one accident per ten million commercial aircraft flights. For specific operations, such as search and rescue, the aim is to reduce the number of accidents by 80% compared to 2000 taking into account increasing traffic.**
- 2. Weather and other hazards from the environment are precisely evaluated and risks are properly mitigated.**
- 3. The European air transport system operates seamlessly through fully interoperable and networked systems allowing manned and unmanned air vehicles to safely operate in the same airspace.**
- 4. Efficient boarding and security checks allow seamless security for global travel, with minimum passenger and cargo impact. Passengers and cargo pass through security screening without intrusion and unnecessary intervention or disruption.**
- 5. Air vehicles are resilient by design to current and predicted on-board and on-the-ground security threat evolution, internally and externally to the aircraft.**
- 6. The air transport system has a fully secured global high bandwidth data network, hardened and resilient by design to cyber attacks.**



¹¹*Just Culture* means a culture in which front line operators or others are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but where gross negligence, wilful violations and destructive acts are not tolerated.



Prioritising research, testing capabilities & education

In 2050, Europe's aviation industry is underpinned by world-class capabilities and facilities in research, test and validation and in education.

Europe has the world's leading research infrastructures covering the entire aviation system from wind tunnels through simulation facilities to test aircraft. The infrastructure capabilities have been defined collaboratively by all stakeholders. Facilities are organised as research clusters networked across Europe to facilitate and secure the local collaboration of industry, universities and national research organisations.

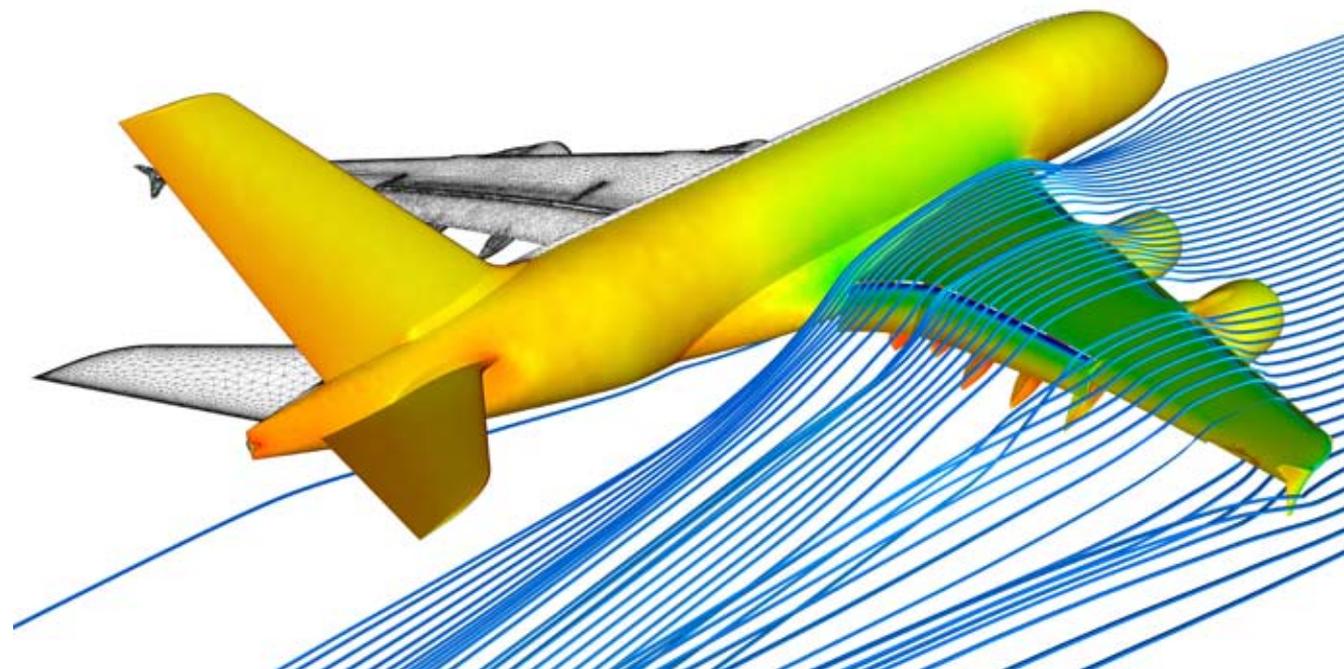
Comprehensive and consolidated test, demonstration and validation infrastructures are harmonised, interoperable and available across Europe to support the transition to automated, autonomous and integrated systems and beyond. They include modelling, fast- and real-time simulation and flight-trial systems. These capabilities integrate the ground and airborne validation and certification processes. Education and training for controllers, pilots and engineers are incorporated into the system supported by training and simulation tools.

European aeronautics research is defined, organised and funded in a coherent and coordinated way with minimum administrative burden. Transparency and accountability in publicly funded programmes is well-balanced with timeliness and efficiency and the appropriate protection of intellectual capital. Programmes are focussed on common objectives and roadmaps shared by all stakeholders. The full innovation chain is applied consistently from ideas through fundamental and applied research; technology development and demonstration; commercialisation and market development to market entry. Research is undertaken by the relevant partnerships, including industry, research institutes, universities and government. Appropriate levels of funding, not least the European Framework Programme for Research & Innovation, have been made available. Public-private-partnerships have been established as necessary.

Europe's students in aviation subjects perform highly. University courses are academically challenging and support the evolving needs of industry and research. The aviation community engages actively with European students from the earliest age and is committed to life-long 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.

Goals:

- 1. European research and innovation strategies are jointly defined by all stakeholders, public and private, and implemented in a coordinated way covering the entire innovation chain.**
- 2. A network of multi-disciplinary technology clusters are created based on collaboration between industry, universities and research institutes.**
- 3. Strategic European aerospace test, simulation and development facilities are identified, maintained and continuously developed. The ground and airborne validation and certification processes are integrated where appropriate.**
- 4. Students are attracted to careers in aviation. Courses offered by European Universities closely match the needs of the Aviation Industry, its research establishments and administrations and evolve continuously as those needs develop. Lifelong and continuous education in aviation is the norm.**



Achieving the Vision

Achieving the Vision

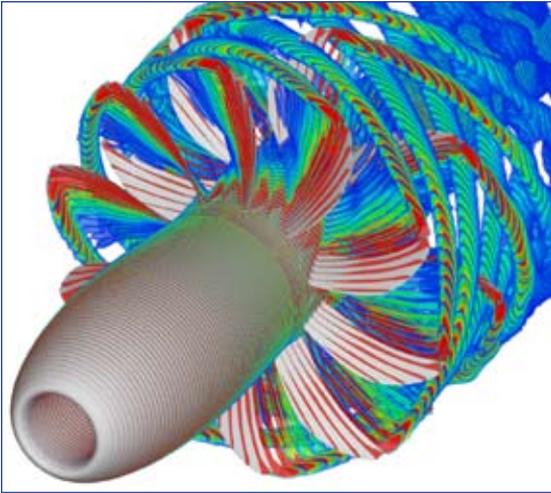
A research and innovation friendly environment for Europe

Aviation is marked by the high complexity of its components, products, vehicles, systems and systems-of-systems, all of which are both technology and capital intensive. Air vehicles are subject to very long R&D cycles (up to 20 years). Research efforts need to be based on a long-term programming approach that provides continuity across R&T efforts over many years. Infrastructure development is dependent on the availability of excellent research, testing and validation capabilities and, vehicles additionally require platform integration and full-scale demonstration.

The scale of the risks associated with massive investments in technological research and innovation, which only bear fruit on a long-term basis, can easily lead to a situation of market failure and/or distortion. Companies will continue to need funding which cannot be obtained on the financial markets. Therefore public sector incentive support is essential, both at European and national levels.



To ensure success the governance, funding and financing framework must:



The European aviation world will need to be underpinned by an efficient and effective policy and regulatory framework that also addresses funding and financing issues as a pre-requisite for the Vision 2050 to be realised.

It is clear that overcoming the challenges and achieving our Vision requires a supreme effort. Most importantly public funding support is required, in partnership with private funding, and must continue at an increased level to meet the objectives of global leadership and to serve the needs of society. The total combined public and private funding required by the sector over the next 40 years could be greater than €250 billion¹².

- **Ensure that simple and effective mechanisms accepted by all stakeholders are put in place to enable co-ordination of shared and common objectives for R&T projects at private, European, national and regional levels.**
- **Establish innovative European funding and financing instruments and means that provide excellent governance, well-founded roadmaps, long-term goals and improved administration.**
- **Enable and incentivise a much shorter time to market from initial research to commercialisation assisted by an integrated, research and innovation friendly environment.**
- **Create a global level playing field to allow European industry to compete fairly under market conditions.**
- **Provide the means for coordinated oversight of a comprehensive research programme including aeronautics, traffic management, and alternative fuels related research.**



¹²Airbus estimate. Vision 2020 estimated the research funding need as ca 100bn over 20 years.

From Vision to the Research Agenda

The leadership of Europe in the field of aviation is underpinned by a commonly shared vision and a globally acknowledged research agenda. Ten years ago the Advisory Council for Aeronautics Research in Europe (ACARE) was established to provide dedicated and independent advice on strategic issues affecting the sector. The preparation of the Strategic Research Agenda in 2001, following the publication of Vision 2020, is a prime example of the work this body has performed.

ACARE comprises representatives from all stakeholders in the aviation sector including the European Commission, Member States, Research Centres, Airports, Airlines, Air Navigation Service Providers, Industry, and Universities. It addresses strategic, technical and institutional issues, providing an open forum for discussion and a consensus based decision-making process. It is a unique body with a ten-year experience of providing value to the European Commission and its stakeholders.

To reach the goals set out in this vision for 2050, it is urgent to act today. Therefore, along a model similar to ACARE, it is proposed to establish a strategic advisory body for research and innovation that encompasses both aeronautics and air transport and associates regulatory and institutional enablers. The strategic advisory body should:

- **Achieve full participation of representatives of airline, airport and other operational aviation areas.**
- **Provide recommendations to guide the way towards achieving the Vision.**
- **Bring together authoritative, senior figures from all aeronautics and air transport stakeholders, Member States and the European Commission to build consensus in favour of strategic actions.**
- **Create the appropriate mechanisms to connect to the equivalent platforms of other transport modes and relevant technology sectors (e.g. energy) in order to achieve the objectives of the Vision.**
- **Urgently develop a new strategic road map for aviation research, development and innovation, which will account for both the evolution of technology and technology shocks or step changes. This road map is needed to guide and support future actions in public and private funding programmes towards the Vision including future Framework Programmes.**

The appropriate level of funding and risk sharing, distributed between the public and private bodies, must underpin this strategic roadmap.

The roadmap must be used actively drive research and innovation in Europe, and consequently reinforce leadership on a global basis.



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Europe is entering a new age where it faces many challenges such as globalisation, a financial system in need of reform, climate change and an increasing scarcity of resources.

This is why the European air transport system is directly concerned by new challenges regarding its competitiveness, performance and sustainability. The European manufacturing and service industry is strongly affected by globalisation, new competitors, new markets and the need for innovation. Sustainable mobility is at stake, as are millions of jobs and billions of Euros of added value. Research and innovation are key to maintaining Europe's capacities and competitiveness and it is time to align efforts towards a new long-term vision for this sector.

