Perspectives for Aeronautical Research in Europe 2019 Report

Conclusion

Final Report

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The 58 Recommendations for Aeronautics Research in Horizon Europe in the chapter 1 as an Introduction to the PARE 2nd Year Report are written in a concise technical language best suited to aviation professionals, summarizing: (i) the assessment of progress towards the 23 ACARE Goals in the chapters 2 to 6 of Part I; (ii) the five major topics in chapters 7 to 11 of Part II relating to the 34 PARE Objectives. The part III consists of five specific studies in chapters 12 to 14, each containing its own sectorial assessments, recommendations and conclusions, that are not summarized neither in the introductory chapter I nor in the concluding chapter 15.

The Conclusion in Chapter 15 has a purpose similar or symmetrical to the Introduction in chapter 1, with a different presentation of the same themes of chapters 2 to 12 for a different audience. Whereas the 58 PARE Recommendations for aeronautics research in Horizon Europe are written as concisely and precisely as possible for aviation professionals, the set of 12 articles in the chapter 15 as conclusion aim to highlight the main points in a form accessible to the motivated non-specialist. Each article consists reports on the "key findings" and the "key actions" they imply. The PARE 2nd Year report includes 5 articles corresponding to the chapters 2 to 6 in Part I, and the remaining will appear in the 3rd Year Report.

Meeting Societal and Market Needs

By 2050, passengers and freight experience must be improved, in order to meet the increasing demand for travel and to handle more easily unforeseeable events. Travel services should be affordable, quick, reliable, efficient, seamless and sustainable, based on a resilient air transport system and capable of automatically reconfigure the journey, including transfer to other transport modes, if necessary.

To guarantee this improvement, the Advisory Council for Aeronautics Research in Europe (ACARE) established the Flightpath 2050 goals. The second chapter of PARE's report, entitled "Meeting Social and Market Needs" addresses Flightpath 2050's goals 1 to 5, which concern air traffic capacity, ground infrastructure, mobility, speed and punctuality, respectively.

Air Traffic Capacity

Currently, the European airline traffic is around 10 million flights per year of all types of vehicles, and is expected to rise to 25 million by 2050, including unmanned and autonomous vehicles. This forecasted growth of air transport puts increasing demand on air traffic capacity with undiminished safety, being this capacity concerned with runway, airways terminal area and en route capacity, and its evolution closely related to air traffic management (ATM). The accommodation of such a growth in flights will be determined by the most restrictive of these three capacity limits, being it the runway capacity.

Key findings:

- In 2007, in Europe, there were about 45 main airports (large and medium hubs) and about 450 country and regional airports (commercial service airports). Three years later, the five major European airports hubs were at saturation – operating at full capacity;

- In 2016, the total numbers of passengers travelling by air in the EU could be established at 973 million, an increase of 5,9% compared to 2015;
- Over a European network of more than 2100 airports, 528 airports account for just 25% of airports, but 98% of the departures. Also, the 25 largest airports in Europe generate 44% of all flights and 90% of all traffic comes from the largest 250 airports;
- There is a geographical concentration of airports in the region London – Amsterdam – Munich – Milan, which creates dense air traffic, with large numbers of climbing and descending aircraft: a significant challenge for terminal area and en route capacity;
- The cities closest to Europe's busiest airports have between 4 and 46 airfields within 100 kilometers (km) from the city centre. For 8 of the 10 cities close to Europe's biggest airports, a single airport handles 80% or more of all the departures within 100 km;
- By 2030, it is expected that no fewer than 19 airports will be operating at full capacity eight hours a day, every day of the year, which means they will be highly congested and 50% of all flights will be affected by delays upon departure or arrival, or both.

During the past years, it has been identified a growing gap between capacity and demand at a number of busy European Union (EU) hubs, being predictable that Europe will not be in position to meet a large part of the expected demand due to a shortage of airport capacity. In concrete terms, in 2050, it is estimated that 36% of flight demand will not be accommodated at European airports.

Key actions: it is recommended that a broad and deep research effort is maintained concerning all aspects of ATM that can contribute to increase airspace capacity, which is the purpose of the 1st Flightpath 2050 goal, with equal or greater safety. Additionally, there are proposed projects and measures that could improve air traffic capacity:

1. Eurocontrol measures to mitigate the capacity challenges;

2. The SESAR project PJ02 (EARTH) - Increased Runway and Airport Throughput;

3. The Airport Collaborative Decision Making (ACDM) concept.

Ground Infrastructure and Multimodal Transport

Nowadays, new airports to serve major cities tend to be built farther requiring transport to reduce access time to the airport, which affect passenger convenience. Vertiports and heliports can be sited much closer to city centres, providing an alternative with faster access than airports, if noise and community issues can be resolved. By 2050, the air transport ground infrastructure should comprise major hubs, secondary airports, vertiports and heliports, all seamlessly connected within a multimodal transport system, and should include interfaces with other modes of transport.

Key findings:

- In the U.S., from the existent 5,664 heliports in 2016, both for private and public use, most of them were essentially unused and have been declared, throughout the years, inactive and for emergency use only. In Europe, unconfirmed reports indicate less than 100 civilian type heliports;
- The most frequent distance between European airport pairs is related to approximately 1000 km, while there are only a few potential links above 3000 km. At smaller airports, departures

most often travel less than 300 km, and at large and very large airports, the 400 km distance bracket Is the most common, even though they have the largest share of 3500 km flights;
- Very high – speed train point to point connections (travelling at 250 km / hour) can be more time efficient than air transport over a distance up to about 600 km, although load factors are lower than in aviation (85% on average);
- Over 50 city-pairs will be connected by new or improved links between 2019 and 2035, such as high – speed trains that can offer comparable transport times for distances up to 800km. Passengers opting for rail will reduce the demand for flights by a little over 0,5% (estimated 0,7%) in 2035.

A network of small, traditional or electric aircraft that take off and land vertically, called Vertical Take – off and Landing (VTOL), would enable rapid, reliable transportation between suburbs and cities and, ultimately, within cities. On a different perspective, shifting short – haul flights to high speed - train would reduce, even slowly, the unaccommodated demand for flights, by reducing the demand for flights.

Key actions: it is recommended that urban and land planning methodologies are developed to optimize, on a regional basis, the location of airports, vertiports and heliports to simultaneously provide convenient links to other transportation nodes and minimize environmental impacts and disturbance of populations. Some of the proposed measures mentioned before could also improve the connectivity of (or the mobility between) airports, which is the aim of the 2nd Flightpath 2050 goal, as well as the new initiative, named ONE Order, proposed by the International Air Transport Association (IATA).

Choice of Most Efficient Mobility Solutions

The progress in mobile communications and availability of information should ensure that, in 2050, European citizens can make informed mobility choices among several available travel options and have affordable access to one another, taking into account economy, speed and level of service (that can be tailored to the individual customer). Additionally, continuous, secure and robust bandwidth communications should be provided for added value applications.

Key findings:

- In 2009, according to a survey conducted within ModAir project, no airport website provided enough information for the customer to be able to plan the entire trip. Customers needed to visit several websites to do that and still, websites didn't provide information about transit times between different travel modes nor real time information about delays in ground transportation;
- According to ModAir project, a clearly important requirement for passengers is to easily access reliable, impartial and real time information, both for pre – trip planning and to be kept informed of relevant developments during the journey;
- Passengers are mainly willing for better information related to intermodality, comprehensibility of the reservation systems (including better prices when booked air and rail are together), flexibility on their bookings and a secure framework with clear operators 'liability conditions;

- Automation will enable passengers to be informed about the current status of their journey and alternative options, periodically or on demand, using smart phones or interactive panels/screens situated along the intermodal transport network.

In conclusion, nowadays there are many sources of travel information and services with different objectives and priorities making the choice confusing and often non-comparable. Moreover, there is the necessity to develop and/or implement solutions to provide passengers with real time information during their entire journey.

Key actions: to achieve the 3rd Flightpath 2050 goal, it is recommended that a one-shop centralized travel information site is promoted where the EU citizen can readily find the alternative options for connecting any two locations, including costs and timetables, with links to reliable booking.

Overall Ground plus Air Travel Time

By 2050, the interfaces of the airport with other modes of transport must allow 90% of passengers within Europe to be able to complete their journey, door-to-door (D2D) within 4 hours. This D2D time comprises the origin airport access time, the time inside the origin airport to go through airport services, the air travel time, the time inside the destination airport and the time from the destination airport to the final destination place.

Key findings:

- In 2016, the average departure delay per flight ranged from 8 to 16 minutes, with an annual average all – cause departure delay per flight of 11.3 minutes. The aircraft turnaround related processes have been the main factor that have induced delays in the air transport operation over the years;
- For almost 80% of the European cities, the nearest airport is situated at 20 km. Such a short distance reflects that the general accessibility of the European airports is high;
- Passengers spend on average, using Madrid as example, more than thirty minutes to get to the airport. Therefore, researching new ways to get to the airports (for example, the use of VLOTs) from the city centers would be the first key to actually reduce the travel duration;
- The second key to actually reduce travel duration would be the improvement of the current processes carrying at the airports or even the design of a new system regarding both passengers and luggage processes;
- Air travel times can vary significantly in Europe, from one hour in central Europe to four hours between extremities of the continent. Besides depending on flight distance, which can go up to 3000 km within the EU, travel times also depend on the aircraft engine type, being that an aircraft jet powered is faster than one propeller driven.

To sum up, key enablers to reduce overall travel times are a reduction in airport access times, a higher predictability of times accessing the airport and process times inside the terminal. However, as the aviation factor cannot be responsible for what happens outside the aircraft and airports and cannot influence travel time to or from the airport, the 4th Flightpath 2050 goal should only consider travel times and process times inside the terminal.

Key actions: it is recommended that the 4th Flightpath 2050 goal is revised to take into account the distance and duration of flight and cover the time period from arrival at the departure airport to exit from the destination airport. The project DATASET2050 can support this revision process since it addresses the EU passenger mobility in the context of the D2D objectives defined in the Flightpath 2050 vision.

ATM and Weather

In 2050, flights should arrive within 1 minute of the planned arrival time, regardless of weather conditions, thanks to a resilient transport system, capable of automatically and dynamically reconfiguring the journey within the network to meet the needs of the traveler if disruption occurs. Likewise, special mission flights should be able to be completed in the majority of weather, atmospheric conditions and operational environments.

This punctuality of air transport in adverse conditions depends on availability of meteorological data sufficiently in advance for efficient re-routing. Disruptive events and special flights that require reconfiguration of multiple flight paths can be made efficiently if supported by fast and reliable simulation tools.

Key findings:

- A flight is considered to be delayed when it is 15 minutes later than its scheduled time. In 2016, yearly airline arrival punctuality decreased, with 81% of flights arriving within this time, compared to 82% in 2015. Weather delays slightly increased, compared with 2015, to 0.57 minutes per flight;
- The basic issue is overall ATM capacity, not only at airports and in terminal areas, but also en route, with spare capacity to cope with special missions, disruptions and weather hazards (weather conditions such as icing, strong wind, low visibility, snow, etc.);
- A high average weather-related airport arrival delay is usually the result of a notable capacity reduction in bad weather combined with a high level of demand;
- At U.S. airports, the higher frequency of instrument meteorological conditions (IMC) combined with scheduling closer to visual meteorological conditions (VMC) are key elements to reduce winter delays. Weather – dependent delays are more relevant during summer months;
- Both in U.S. and Europe, weather is the predominant element affecting the airport throughput and as consequence of ATM – related departure restrictions. In Europe weather – related constraints represent a smaller share of delays than in U.S., even though weather in Europe is less favorable;
- Runway throughput rates depend on visibility conditions and are reduced significantly when Low Visibility Procedures (LVPs) have to be adopted, since they require an increased spacing between aircraft.

In conclusion, ATM performance depends on a number of factors and is affected by meteorological conditions, such as visibility, wind and convective weather, and can vary significantly in different airports, according to the airport equipment, runway configurations (wind conditions) and approved rules and procedures. Therefore, additional efforts are required to relate weather conditions on airport and ATM performance and to develop a more comprehensive assessment of weather impact.

Key actions: it is recommended that a more comprehensive weather data is made available to ATM and airlines to assist achieving punctuality targets and that a rapid near real time simulation capability is developed for ATM to accommodate special emerging flights and adjust to major disruptive events.

For more information about these topics, you can access the full chapter **here**.

Maintaining and Extending Industrial Leadership

By 2050, the innovative, sustainable and highly competitive European aviation industry must cement its place as the world leader and be recognized globally for its vehicles, engines, services and a large range of very cost effective and energy efficient products. This leading position should be secured though a seamless European research and innovation system that assures continuity through blue sky research, applied research, development, demonstration and innovation in products and services.

To assure that this overall goal is met, the Advisory Council for Aeronautics Research in Europe (ACARE) established the specific Flightpath 2050 goals 6 to 8, which concern the maintenance and extension of Europe's leading position in the aeronautical sector, the mastering of a wide range of technologies and the integration of these in an aircraft design and development program, respectively. The 3rd chapter of PARE's 1st yearly report, entitled "Maintaining and Extending Industrial Leadership" addresses these goals.

Retaining and Strengthening Market Share

Nowadays, the European aeronautical industry sustains a near peer position with its worldwide competitors in almost all aerospace applications: large civil jet aircraft, regional aircraft, helicopters, military aircraft, missiles, satellites and launchers, engines and equipment. In 2050, it must be equally competitive, deliver the best products and services worldwide and have a share of more than 40% of the world market.

Key Findings:

- Airbus has a share of 50% of world market for jet airliners with more than 100 seats and the Airbus – Boeing 'duopoly' dominates the market for jet airlines of more than 120 seats, with a full range of narrow and wide body aircraft;
- ATR is the leading supplier in the regional aircraft market;
- Airbus Helicopters (formerly Eurocopter) and Augusta – Westland are market leaders in helicopters;
- Dual use and specific technologies ensure an equally strong position in the world market for military aircraft, missiles, space launchers and satellites;
- Safran and Rolls – Royce rival Pratt & Whitney and General Electric in aero – engines and in the equipment sector, Liebherr, Safran, GKN and others are major suppliers of European and non- European aircraft.

These impressive achievements across a full range of aeronautical products depend on: leading – edge technologies in all the sectors contributing to the design of aeronautical vehicles and the integration of all these cutting – edge technologies in efficient aircraft production, certification and service support programmes.

Key Actions: it is recommended that a broad – based application – oriented research and development activity is maintained covering all sectors relevant to the global competitiveness of the European aircraft industry, which is part of the 6th Flightpath 2050 goal.

Cutting-edge at the Full Range of Technologies

Modern Europe is facing several challenges, among which is the introduction of innovative technological solutions to the European aviation market. To be concrete, the competitiveness of the aerospace industry depends on mastering cutting - edge technologies over a wide range of 11 technological areas. Therefore, for Europe to remain competitive, it must retain 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 flight demonstrators by 2050.

Key Findings:

- The necessity to introduce new technological solutions results from the needs of society, new technologies that have appeared and new types of transport means and air transport systems;
- There are many challenges for aviation industry especially from the environmental side, being that the amount of greenhouse gases generated by the aviation industry accounts for about 13% of the total generated amount in the world;
- There are currently two aviation programs being implemented in Europe that give answer to Europe's challenges, which are Clean Sky 2 and SESAR 2020. Other smaller programs that contribute to the development of innovative cutting edge solutions are: EPATS (continued in the frame of SAT-Rdmp), FUSETRA, GABRIEL and ERA;
- Patents in the mentioned technological areas are an indicator of innovation in aviation. Since 1969, the peak in the number of patents in aviation per year was reached in 2016, with approximately 3500 patents in aviation.

Although the European aerospace industry is currently quite competitive, there are a number of emerging technologies that could be used by current and new competitors to change the balance, which need to be monitored and supported to ensure Europe remains a leader in the aeronautical sector.

Key Actions: to achieve the 7th Flightpath Goal, it is recommended that a stable independent observatory of citizen needs, global trends in aviation and technological advances that could meet them, is supported to ensure that major breakthroughs occur first in Europe or are matched without delay in reaching the market.

Efficient Development and Life-Cycle Management

The growing capability (related with certification) and complexity (frequently supported by new technologies) of the modern aircraft increases the relevance of life – cycle analysis that needs to be considered also at component level, such as batteries. Taking this into account, by 2050, streamlined systems engineering, design, manufacturing, certification and upgrade processes should have addressed complexity and significantly decreased development costs (including a 50% reduction in the cost of certification). Also, a leading new generation of standards should have been created.

Key Findings:

- Rise in the cost of development (including certification) is correlated with the increased complexity of the machine;
- Two measures of aeronautical development efficacy are: specific development cost (SDC) and specific development period (SDP), both per number of model's passenger seats;
- Significant reductions on the measures mentioned before can be achieved by:
    - Intensive use of modelling and simulation instead of physical test and experiment;
    - More specific, flexible and adaptive regulatory requirements (standards) for certification, including the involvement of airworthiness authority in virtual design; and
    - A fully integrated multi – physics and multi – scale model of the complete aircraft should be coupled with aerodynamic and thermal models, eliminating ground test rigs completely;

To reduce CO2 emissions considerably, which is a challenge for the aviation industry, the interest in hybrid and/or electric aircrafts is increasing worldwide. This would require an efficient power source for the electric engine and, in view of its high energy density, long life, and rate capability, the lithium-ion battery is an ideal candidate for this purpose. However, batteries also introduce new safety concerns to aircraft that would have to be managed.

Key Actions: it is recommended that the architecture of industrial aviation programmes in analysed in order to identify best practices in matching design, development, certification, production, operations and maintenance in the most cost – effective and time – efficient manner. Also, the introduction of new technologies and stricter safety requirements should be accompanied by more efficient testing and validation to minimize time and cost.

For more information about these topics, you can access the full chapter **here**.

Protecting the Environment and the Energy Supply

In 2050, the effect of aviation on the atmosphere must be fully understood by the general public and must convince it that the aviation sector has made the utmost progress in mitigating environmental impacts and therefore air travel is environmentally sustainable. For this, a combination of measures, including technology development, operational procedures and market - based incentives should be taken into account to mitigate environmental impacts at a rate outweighing the effects of increasing traffic levels.

To ensure that this overall goal is met, ACARE established the specific Flightpath 2050 goals 9 to 13, concerning the reduction of noise and emissions, emissions – free taxying, recycling enabled by design, alternative fuels and atmospheric research, respectively. The 4th chapter of PARE's 1st year report, entitled "Protecting the Environment and the Energy Supply" addresses this set of 5 goals.

Reductions of Noise and Emissions

The growth of air transport at a rate of 3 to 7% per year leads to flights increased to the double by 2030, and triple by 2050. In order to avoid increased noise exposure near airports and emissions in cruise, the corresponding reductions must be made per flight. To be concrete, in 2050, technologies and procedures available must allow a 75% reduction in Carbon Dioxide (CO2) emissions per passenger kilometre (km), a 90% reduction in Nitrogen Oxides (NOx) emissions and a 65% reduction in the perceived noise of flying aircraft. These reductions are relative to the capabilities of typical new aircraft in 2000.

Key Findings:

- Overall noise reduction at airports requires consideration of two classes of noise sources: engine noise sources and aerodynamic noise sources. Noise is dominated by the engine at high thrust at take - off and by aerodynamics at approach with the engine at idle;
- The major contributor to the reduction of engine noise has been the increase in the by - pass ratio of turbofan engines, which also decreases fuel consumption, leading both to lower emissions and more favourable economics;
- The overall noise exposure of near airport residents can be reduced by land planning and by operational measures, such as noise abatement procedures (NAP), which can be broken down into three broad categories: noise abatement flight procedures, spatial management and ground management;
- Aviation emissions of CO_2 and NOx are produced by aircraft, support vehicles and ground transportation dominantly. The emissions from these sources fall into two categories: emissions that cause deterioration in local air quality (LAQ) and emissions that cause climate change;
- In 2012, aviation represented 13% of all European Union (EU) transport CO_2 emissions and 3% of the total EU CO_2 emissions. European aviation specifically represented 22% of global aviation's CO_2 emissions. Similarly, aviation now comprises 14% of all EU transport NOx emissions, and 7% of the total EU NOx emissions;
- As a result of technological improvements, the noise footprint (85 decibels dB (A) maximum sound pressure level contour) of new aircraft is at least 15% (up to 50%) smaller than that of the aircraft they replace. Further design improvements offer the potential to reduce perceived noise from aircraft by 65% by 2050;
- ACARE runs the research projects Aviation Noise Research Network and Coordination (X - Noise EV) and Forum on Aviation and Emissions (Forum AE), related to aviation noise research and emissions research, respectively.

Key Actions: it is recommended that:

1. A broad research effort is supported to reduce aircraft noise at the source through operating procedures and taking into account psychoacoustic effects;
2. A modest effort is made towards a long-term definitive solution: aircraft inaudible outside airport boundaries and hydrogen propulsion that emits only water vapour, besides struggling with short-term solutions to an increasingly pressing noise problem;
3. A set of trade-offs is formulated between different types of emissions (CO_2, NOx, particles and water vapor) in local airports and global cruise flights.

Emissions - free Taxying at Airports

The taxying of aircraft on engine power and the use of auxiliary power units (APU) on the ground can be significant contributors to emissions at airports and also generate noise. By 2050, aircraft movements must be emissions – free when taxying, which can be achieved with electric towing vehicles and power supplies, especially batteries. Therefore, the feasibility and economic of emissions - free taxying critically depends on the available battery technology.

Key Findings:

- The current preferred battery technologies for ground movements at the airport or on the airfield and in the aircraft itself are the lead – acid and the nickel – cadmium (Ni - Cd) batteries. However, since these batteries are technically exhausted, no significant improvement in terms of energy density, cycle life, calendar life, etc. is expected;
- There is a shift to lithium – ion (li - ion) technology in the aviation industry, being that li - ion chemistry offers a large variety of materials and cell architectures, which enables the possibility to design high - power as well as high - energy systems;
- In general, regarding li – ion batteries, an increase in the energy density, with state-of-the-art chemistry, could be mainly achieved by optimizing the form factor and the cell production process. Nevertheless, even if the current chemistry has proven itself, efforts are still to be made to increase the energy density as well as other key performance parameters to meet future requirements;
- There are several deficiencies of actual day li – ion batteries that, if remedied with suitable ease and cost parameters, would enable superior li – ion batteries that could open new applications and expand the market for present ones;
- Although electric towing and power supplies are feasible, the investment in vehicles and support infrastructure must be assessed as well as how costs are covered.

Key Actions: it is recommended that a methodology to comprehensively assess the implications of electric taxying and electrical energy supply is developed in terms of requirements, costs, land and environmental impact for a variety of airport configurations.

Design and Manufacture bearing in mind recycling

Competition in the aircraft industry market and global warming has driven the industry to think along economic and environmental lines. For instance, in 2050, air vehicles must be designed and manufactured to be recyclable, preventing depletion of limited resources and making better and repeated use of materials already available. This goal has resulted in the emergence of a more electric aircraft (MEA) concept, providing the utilization of electric power for all non – propulsive systems.

Key Findings:

- Recycling of aircraft parts depends mostly on the materials used and also on the fabrication process. The choice of materials for an aircraft is subject to a considerable set of constraints related to performance, weight, availability, cost, ease of manufacture and maintenance, durability and resistance to hostile environments. Adding the recycling ability is an additional constraint which can bring benefits in several of other areas;
- Recent technological advances in the field of power electronics, fault-tolerant architecture, electro-hydrostatic actuators, flight control systems, high density electric motors, power generation and conversion systems have ushered the era of the MEA;

- A small size, high energy density (more than 100 watt-hour per kilogram (Wh/kg)) battery is the need of the aircraft industry as a 10kg decrease in the weight of aircraft will result in the savings of 17,000 tons of fuel and 54,000 tons of carbon dioxide emission per year for all air traffic worldwide. The reduction in battery weight is also profitable in terms of cost;

- The life duration of an aircraft battery depends on various factors such as number of operating hours, ambient temperature, start frequency and on-board charge. It is therefore difficult to determine in advance how long the expected life of a battery will be in the real situation;
- Though most of the civil aircraft have used Ni - Cd batteries, the trend is shifting towards li - ion batteries with its tremendous opportunities to be employed in MEA. However, li - ion cells comprise a sensitive electrochemistry which needs a detailed knowledge of its characteristics to allow its benefits to be exploited fully while ensuring maximum safety;
- In general, the same processes used to recycle automotive batteries are used to recycle aircraft batteries. Examples of battery recycling plants operating in Europe are: *Batrec* in Switzerland, *Umicore* in Belgium, and *SNAM* and *Recupyl* in France.

Key Actions: it is recommended that a comprehensive assessment of materials used in aircraft production is made and that recyclable alternatives and related issues of availability, ease of use, certification, maintenance and cost are assessed.

Sustainable Alternative Fuels Sources

Nowadays, there is a strong need to reduce the dependence on fossil fuels which affects all modes of transport. Even though aviation is not the largest user, it should try to improve its position and contribution to the whole by finding sustainable alternative less polluting fuels and possibly also safer handling with undiminished energy density per unit weight and volume. European aviation specifically must guarantee that, in 2050, Europe is established as a centre of excellence for sustainable alternative fuels, including those for aviation, based on a strong European energy policy.

Key Findings:

- The European Commission (EC), Airbus, and high-level representatives of the Aviation and Biofuel producer's industries launched in 2011 the European Advanced Biofuels Flightpath. This action is scheduled to achieve 2 million tons of sustainable biofuels used in the EU civil aviation sector by the year 2020;
- By now, several alternative biofuels are under scrutiny or are already approved: synthetic Fischer – Tropsch (FT); hydrogenated esters and fatty acids (HEFA); pyrolysis oils (HPO); and alcohol to jet (ATJ). Although there are already potential alternatives, it is not easy to match the energy density, usability and cost of kerosene/paraffin in large quantities;
- The use of alternative biofuels has been explored by the Initiative Towards sustAinable Kerosene for Aviation (ITAKA) project. ACARE also runs the research project entitled Coordinating research and innovation of Jet and other sustainable aviation Fuel (Core – JetFuel);
- Although airlines have been willing to test new fuels, a coordinated effort must be done far upstream to: consider a variety of sources of fuel, that do not interfere with food production

and whose environmental impact is neutral or positive (waste disposal); establish the technical feasibility to meet all applicable quality and safety standards and certification requirements; and assess the economic and environmental feasibility of large-scale sustained production, distribution and use.

Key Actions: it is recommended that a comparative study of potential alternative fuels, their availability in the required large quantities and the feasibility and cost of large - scale production, distribution and use is performed.

Atmospheric Research, Weather and the Environment

Aviation is one of the most climate/weather sensitive industries: it is affected by changes to visibility, storminess, temperature, icing events, etc. Therefore, one of the most important activities is to assess the atmosphere and the environment state in order to predict the future climate issues and develop mitigation strategies, which would help to reduce possible disturbances in the airspace and allow an increase in airports capacity. Taking this into account, in 2050, Europe should be at the forefront of atmospheric research and take the lead in the formulation of a prioritized environmental action plan and establishment of global environmental standards.

Key Findings:

- The monitoring of the atmosphere is performed by a vast array of earth and satellite sensors, plus specialized weather aircraft used to fly through tropical storms and collect *in-situ* (non-space) atmospheric data. It is possible to obtain much more comprehensive weather data both in time and locations aboard aircraft in regular flights;
- There are several methods to monitor the atmosphere, such as: routine ground – based measurements (made by ground – based sensors – land based and buoys); systematic aircraft measurements (made by aircraft and balloons); and satellite measurements (made by space – borne sensors);
- Changes to temperature, precipitation, and storm patterns are all expected in the near-term, certainly by 2030. The impacts of sea level rise are more gradual and not expected until later in the century. However, more frequent and intense storm surges will have an earlier impact on European aviation, reducing capacity and increasing delay;
- Currently, there are several European initiatives and projects that have as main objective monitoring the atmosphere through satellite and airborne instrumentation, which are:
    - Copernicus project, previously known as the Global Monitoring for Environment and Security (GMES);
    - Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) project;
    - Advanced Satellite Aviation Weather Products (ASAP) initiative;
    - European Organisation for the Exploitation of Meteorological Satellites (EUMESAT);
    - In – service Aircraft for a Global Observing System (IAGOS) project.

Key Actions: it is recommended that regular airliner flights are used to collect *in-situ* atmospheric data, which should further be processed to have near real - time knowledge of conditions along flight routes. This data could be supplemented by drones – unmanned aircraft systems (UAS) - specifically designed to fly in more remote regions of the atmosphere.

For more information about these topics, you can access the full chapter **here**.

Ensuring Safety and Security

In 2050, European aviation must have achieved unprecedented levels of safety and security and continue to improve. The accident rate in commercial flight must be less than one per million flights and all types of aircraft and rotorcraft must safely operate in the same airspace and in most weather conditions. On the other hand, security processes for passengers and cargo must allow seamless and non-intrusive security, air vehicles must be resilient to internal and external threats, and air transport data networks must be hardened against and resilient to cyberattacks.

To ensure that all of these goals are met, the Advisory Council for Aeronautics Research in Europe (ACARE) established the specific Flightpath 2050 goals 14 to 19, which are addressed in the 5th chapter of PARE's 1st year report, entitled "Ensuring Safety and Security".

Ultra – Low Accident Rate in Commercial Flight

The aviation accident rate has been declining throughout the years, nevertheless, the rate of decline has slowed markedly since 2004 and, at the same time, we are seeing a continued growth in the number of flights, which are set almost to the triple by 2050. In 2015, the accident rate of the European Union Aviation Safety Agency (EASA) Member States (MS) operators of Commercial Air Transport (CAT) aeroplanes was approximately 3 accidents per million flights. By 2050, the European air transport system must have reduced this rate to less than one accident per million commercial aircraft flights.

Key Findings:

- From 2010 to 2015, on EU's territory and with EU–registered aircraft, there were 188 fatalities (155 fatalities in 2015 from the 3 accidents) in CAT aeroplanes and, in 2016, there was only one fatal accident involving any EASA MS operator of CAT aeroplanes;
- The Key Risk Areas identified by EASA MS operators for accidents and serious incidents are: (a) system/technical failure, (b) airborne collision/conflict – collision of two aircraft in the air, (c) movement area collision or ground collision/handling, (d) fire, (e) runway excursion or abnormal runway contact, (f) runway collision, (g) aircraft upset – full range of loss of control situations, (h) terrain collision/conflict – aircraft collision with terrain, and (i) obstacle collision;
- Comparing the average number of CAT EASA MS accidents and serious incidents by Key Risk Area for the period 2007 – 2015 with that of 2016, the Key Risk Areas (a), (b) and (e) show a negative change in 2016 (from stable trend to increasing or from decreasing to increasing) in contribution to fatal accidents in these 10 years, accounting for 18% of those accidents. Aircraft upset represents only 3% of the accidents and serious incidents involving an EASA MS operator in 2016, but continues to be the most fatal Risk Key Area for EASA MS operators;
- With 45% of fatal accidents involving technical failures in some way during the 2007 to 2016 period, this is both a major accident outcome and a precursor to other types of accident. Over these 10 years, 27% of fatal accidents involved ground collision and other associated ground events;

- The origins of the causal and contributory factors behind the accidents and serious incidents involving EASA MS operators between 2007 and 2016 are: flight operators (56.64%), technical (21.30%), human factors (8.53%), Air Traffic Management (ATM) (5.87%), aerodrome operations (4.49%), organisational (2.40%) and maintenance (0.77%).

Key Actions: the safest mode of transport can only benefit from being made even safer, which requires investigating accident classes, finding preventive and corrective actions and proving that they can be implemented. It is recommended that accident causes are considered by order of statistical occurrence and that appropriate safeguards for each class are identified and implemented.

Weather-Hazards and Risk Mitigation

The aviation system is highly sensitive against disturbing weather effects that can become hazardous for the aircraft operation by producing setbacks such as delays and accidents/incidents. Moreover, due to the expected growth in aviation, an increasing number of airports will operate near their capacity limit and hence will be more sensitive to disturbances by weather phenomena. To ensure safety, by 2050, weather and other hazards from the environment must have been precisely evaluated and risks properly mitigated.

Key Findings:

- Weather is responsible for: 13% of all aircraft losses between 1995 and 2004, 33% of all accidents/incidents from 2004 to 2007 and 40-50% of delays at European airports;
- The severe weather-related accidents and incidents can be attributed to the following weather–hazards: wind, wind shear and turbulence; in-flight icing; low visibility due to lithometers, fog or precipitation; lee waves; hail damage; thunderstorms; and volcanic ash;
- During the flight in en-route area, aviation is only disrupted marginally by weather phenomena. However, during start and landing, it is very sensitive to those effects, especially fog, snow and wind, which can disrupt the operations with even a low intensity;
- The severe weather impact can be associated with two different, yet interdependent, risks, notably Flight Safety Risk and Flight Efficiency Risk (likelihood and potential extent of incurred flight delays or even cancellations made due to severe weather risk management). The Flight Safety Risk can have different sources and manifestations: In-flight Safety Risk (impact on flight crew), which is divided into Hazard Encounter Risk and Knock-on Flight Safety Risk, and ATCO Excessive Overload Risk. In particular, the Hazard Encounter Risk is described using two generic risk management functions: risk prevention and risk mitigation.

Key Actions: besides collecting higher-quality and more comprehensive weather data with higher spatial and temporal resolution (see ACARE goals 5 – Article Chapter 2 - and 13 – Article Chapter 4), its effects on aircraft dynamics must be modelled to identify effective prevention and corrective actions that must be simulated and further validated. Therefore, it is recommended that a low–cost basic research on flights in adverse weather conditions (*e.g.* wind, rain, ash clouds, lightning, icing, storms and weather fronts) is promoted and promising advances are selected for demonstration.

Integrating Drones in Manned Airspace

The record of aviation as the safest mode of transportation is based on the highest engineering standards and professional qualifications as regards aircraft and cannot be compromised for Unmanned Aerial Vehicles (UAVs) operating in the same airspace. These UAVs constitute a new threat to the European airspace as demonstrated by the occurrence of several incidents involving conventional aircraft and UAVs. However, in 2050, the European air transport system must operate seamlessly through interoperable and networked systems allowing manned and UAVs to safely operate simultaneously in the same airspace.

Key Findings:

- Unmanned aerial system (UAS), of which the UAV is the airborne component, comprises two fundamental types: Remotely-Piloted Aircraft Systems (RPAS), a class of UAS that has a "pilot" operating the Remotely-Piloted Aircraft (RPA) from a Ground-Control Station (GCS); and UAS with no remote pilot, or autonomous air vehicles (AAVs). The term "drone" although possibly inaccurate or inappropriate, refers to all types of UAS;
- There are two types of UAS operations: 1) the professional use of drones for various security, safety, survey and other tasks; and 2) the recreational use where the general public are using drones for fun and private activities. The Key Risk Areas identified in UAS operations are: (a) airborne conflict/collision – the collision of UAs with aircraft in the air, (b) aircraft upset, (c) system failure and (d) third party conflict – the collision of UAS with people or property;
- There is an increasing trend in the number of reported UAS occurrences (both incidents and accidents) per year from 2010 to May 2016 inclusive (which may be due to the increasing number of drones within the EU), from which 63% are related to Airborne Conflict, which is the main Key Risk Area. This means that airspace infringements and proximity of drones to other aircraft if causing a significant number of occurrences;
- Within the previous time period, the highest number of occurrences took place in D and G airspace classes and during approach and en-route phases of the flight. Regarding the altitude, when the drones are spotted the manned aircraft is most often in the area from 0-6000 feet (≈ 0-1829 meters) above the ground and the distance from the aircraft to the drone is from 0-1000 feet (≈ 0–305 meters);
- Conventional ATM cannot be applied to unmanned aircraft and therefore the EU needs to develop a UAS Traffic Management (UTM) system that allows UAVs to fly jointly manned aircraft and implement the regulatory framework regarding the integration of UAS into busy airspace as it is European airspace. Also, the use of partially unused airspace could provide testing area and additional capacity for UAVs to prove to be at least equal to manned aircraft in terms of safety.

Key Actions: it is recommended that:

1. The evolution of air traffic capacity in Europe compared with the growth of air transport is assessed to identify the spare capacity available to other users like UAVs;
2. The qualifications required of operators of UAVs and other aircraft compared with airline pilots and air traffic controllers are established to ensure that aviation remains the safest means of transport;
3. The design, production, certification and maintenance procedures for UAVs and other aircraft are defined to preserve or improve on the safety levels of current airliners that operate in the same airspace;
4. The increased use of partially underused airspace is explored to enable the expansion of operations by new types of aircraft.

Comprehensive and Unobtrusive Security Measures

The recent societal threat of terrorist acts at airports or during flight implies the reinforcement of security measures to prevent those acts to happen, resulting in delays and queues, which are the most frequent sources of traveller dissatisfaction. While the patience and understanding of passengers are essential, there should be a minimum of delay, intrusion and disruption in the implementation of safety measures, through the use of the most appropriate equipment and airport architectures. In 2050, efficient boarding and security measures must allow seamless and non-intrusive security for global travel, with minimum passenger and cargo impact.

Key Findings:

- The main types of scanning and detection devices currently deployed by European airports are based on the following existing technologies: Advanced Imaging Technology (AIT), Advanced Technology (AT) X-Ray, Boarding Pass Scanners, Bottled Liquids Scanners (BLS), Chemical Analysis Devices (CAD), Enhanced Metal Detector (EMD) and Explosives Detection Dogs (EDD) and Explosives Trace Detector (ETD);
- Passengers spend on average 20 minutes waiting in line to get to the security screening checkpoint. New technologies and procedures could significantly reduce these waiting times, allowing to process about 360 passengers per hour instead of the approximately 150 passengers per hour that are processed nowadays;
- Examples of emerging trends in technology for threat detection that could improve airport security and efficiency while reducing the burden for passengers are biometrics screening, computed tomography (CT) scanning, facial scanning and behavioural analytics. Nevertheless, all of these new technologies are in the first level of maturity, *i.e.*, in the concept phase;
- Until now, most risk-based decisions regarding the checkpoint have focused on assessing the risk of a particular item but considering all passengers as equals. A new risk-based differentiation concept is introduced, which focuses its attention on "the person" in the assessment of threats, instead of focusing on the risk of the item. As a result, based on a reasoned process of selection, different people would be screened in different ways;
- The project Smart Security, a joint initiative of the International Air Transport Association (IATA) and Airports Council International (ACI), defines a future where passengers proceed through security checkpoints with minimal inconvenience, where security resources are allocated based on risk and where airport facilities are optimized, through the implementation of new technologies and processes.

Key Actions: it is recommended that non-intrusive passenger screening methods and foolproof luggage checking that allow fast flow through registration, border and boarding procedures are developed.

Resilience to External and internal threats

The EU is facing one of the greatest security challenges in its history. Threats are increasingly taking non-conventional forms, some physical such as new forms of terrorism, some using the digital space with complex cyberattacks. Nevertheless, by 2050, air vehicles must be resilient by design to current and predicted on-board and on the ground security threat evolution, internally and externally to the aircraft.

Key Findings:

- Current and emerging threats to aviation security have been clustered into the following eight threat categories: 1) Improvised Explosive Devices (IED), firearms and close range destructive threats; 2) Chemical, Biological, Radioactive, Nuclear and Explosive (CBRNE) threats; 3) Ground-to-air threats; 4) Ground-to-ground threats; 5) Cyber threats; 6) Electromagnetic threats; 7) Sabotage, seizure and hijacking; and 8) Bluff threats and threats from social media;
- Currently, aviation security is primarily based on the preventive phase and is inflexible to new threats. This is also mirrored in the research landscape for aviation security once most projects concentrate on preventive measures such as the detection of CBRNE-substances. However, the aviation security system should be resilient to the evolving threat situation, thus be based on the complete resilience cycle which has the following phases: prepare (take into account), prevent (repel or thwart), protect against (absorb or mitigate), respond to (cope with) and recover from (and adapt to).

Key Actions: it is recommended that:

1. Aircraft are designed and procedures are established to (a) prevent unauthorised entry into the cockpit, (b) allow remote take-over up to safe landing in the case of an identified flight anomaly while (c) designing the system to be immune to the most sophisticated hacking;
2. An independent observatory of external risks to aircraft overflights is set up to advise airlines, or failing that, warn passengers;
3. A worldwide airliner flight monitoring system and accident data recorders are designed to ensure that accident/incident data is available regardless of time and location of occurrence.

High–Handwidth Data Resilient to Cyber Attacks

The use of digital data and the level of interconnection of IT systems are strongly increasing in civil aviation. Consequently, stakeholders of the air transport system like airlines, airport and air traffic control (ATC) are more and more interlinked and, thus, depend on secure means of data exchange. In the future, it is expected an increase in this inter-connectivity, which means the air transport system will be even more vulnerable and exposed to multiple points of attacks. Taking this into account, in 2050, the air transport system must have a fully secured global high-bandwidth data network, hardened and resilient by design to cyberattacks.

Key Findings:

- More than a dozen wireless technologies are currently used by air traffic communication systems during different flight phases. From a conceptual perspective, all of them are insecure as security was never part of their design. On the other hand, the L-band Digital Aeronautical Communications System (L-DACS) and Aeronautical Mobile Airport Communications System (Aero-MACS) that are supposed to replace the current Very High Frequency (VHS) system, have begun to at least consider the issue of wireless security and some corresponding designs are already included by the specifications or will be in the future;
- The assessment of cyber risk involves: 1) identification and inventory of key assets – data, systems and infrastructure – that are essential to operations; 2) revision of internal controls

and digital profile to identify internal vulnerabilities and external threats; 3) valuation of the cyber assets at risk using modelling and other data and technology tools;
- The vulnerabilities that need to be taken into account are: (a) in a large, complex interconnected system there are many entry points for cyber intrusion and many links to spread the cyber-attack; (b) the weakest node may be the preferred entry point, for example small suppliers of equipment or codes well protected by large industries or government bodies;
- In order to face the future cyberattacks, firstly, it would be necessary to identify the multiple threats that could compromise aviation security (*e.g.* phishing threats, jamming threats, remote hijacking, distributed-denial-of-service (DDoS) attacks and Wi-Fi-based attacks) as well as to identify the systems which could be vulnerable to attacks. Then, it would be required to develop strategies in order to mitigate the threats identified;
- Blockchain is one of the favourites current technologies focused on cyber-security. However, Blockchain has also some technical challenges and limitations (throughput, latency, size and bandwidth, security – the current blockchain has a possibility of a 51% attack, wasted resources, usability, etc.) that made its application in aviation, air transport and ATM uncertain, and that will require further research in the future.

Key Actions: it is recommended that:

1. The evolution of bandwidth requirements required to cope with increasing telecommunication needs associated with improved navigation, on-board systems monitoring, passenger connection and other services, is assessed;
2. Evolving standards for protection against cyberattacks are established, with different levels, the highest for flight systems and the lowest but non-trivial for ticketing, bearing on mind the risk of intrusion from lower levels.

For more information about these topics, you can access the full chapter **here**.

Prioritizing Research, Testing Capabilities and Education

In 2050, Europe's aviation industry must be underpinned by world-class capabilities and facilities in research, test and validation and in education. Europe must have the world's leading research infrastructures covering the entire aviation system from wind tunnels through simulation facilities to test aircraft. At the same time, Europe's students in aviation-related university courses, which should be academically challenging and support the evolving needs of industry and research, must perform highly.

To ensure that all of these goals are met, the Advisory Council for Aeronautics Research and innovation in Europe (ACARE) established the specific Flightpath 2050 goals 20 to 23, which are addressed in the 6th chapter of PARE's 1st-year report, entitled "Prioritizing Research, Testing Capabilities and Education".

European Research and Innovation Agenda

There is a large gap between the high-quality scientific research sponsored by the European Research Council (ERC) and the market-oriented near term developments of the Joint Undertaking (JUs), *e.g.* "Clean Sky" and "SESAR", that needs to be filled by fundamental applied research with an aeronautical focus, to ensure that Europe remains a source of new ideas that are the basis of innovation and long-term competitiveness. Taking this into account, by 2050, European research and innovation strategies should be jointly defined by all stakeholders, public and private, and implemented in a coordinated way covering the entire innovation chain.

Key Findings:

- European research is defined and funded in a coherent and agile way, to avoid duplication and inefficiencies, prioritising initiatives resulting from strategic roadmaps defined and agreed by European stakeholders, satisfying actual needs (industry pull) and potential future demands (technology push);
- The European Union (EU) aeronautics programme has started with a budget of 36 M€ in the 2nd Framework Programme (FP) for Research and Technological Development (FP2) and had a steady growth to 3.6 B€ in the 7th Framework Programme (FP7), which testifies its success and the growing importance of this initiative;
- The growth of the aeronautics programme has seen a shift from (i) basic research (less than 1 M€), to (ii) industrial cooperation (4-10 M€), to (iii) large-scale demonstration (20-120 M€) to (iv) integration activities or JUs (more than 1 B€). This growth should be considered as an efficient element of integral European transport system growth that "provides completely safe, secure and sustainable mobility for people and goods;
- Technological innovation can achieve a faster and cheaper transition to a more efficient and sustainable European transport system by acting on three main factors: vehicles' efficiency through new engines, materials and design; cleaner energy use through new fuels and propulsion systems; better use of network and safer and more secure operations through information and communication systems;
- The ERC has sponsored high-quality research in basic science, including mathematics and physics, with some underrepresentation of engineering;
- Research facilities, used for different disciplines and specialities, differ greatly in size and range of application but are often linked to one another through a complex immaterial network that transforms basic scientific knowledge into competitive products while integrating environmental, safety and security requirements.

Key Actions: it is recommended that the long-term competitiveness of European aviation is safeguarded by supporting a Basic Research Programme (BRP) with a wide variety of low-cost applied basic research up to the 3rd Technology Readiness Level (TRL3), entitled "Experimental proof of concept", to bridge the gap between the fundamental research of ERC and near-market driven focus of Jus. This broad programme will ensure that Europe does not miss out the promising new ideas that could be exploited first by others to their advantage.

Industry-Research-Academia Clusters

As seen before, the EU FP have shifted from one end to the other and should be rebalanced. For this, by 2050, a network of multi-disciplinary technology clusters should be created based on collaboration between Aerospace Industry (AI), Universities and Academia (UA), and Research Centres (RC).

Key Findings:

- The creation of these technology clusters could be the result of 3 initiatives, two ongoing and one to be restored from the past: (iii) demonstration and (iv) integration activities existing in the JUs Clean Sky and SESAR; the fundamental research in mathematics, physics and engineering existing in the ERC; and restoring the (i) basic and (ii) industrial research that existed in the aeronautics programme since the beginning and lapsed with increasing scale;
- The following existing networks should be considered: Association of European Research Establishments in Aeronautics (EREA); Aerospace Engineering Universities (PEGASUS); Aviation Noise Research Network and Coordination (X-NOISE EV); and FORUM on Aviation and Emissions (FORUM-AE) project;
- From FP2 to FP7, the involvement of EU countries in FP projects suffered an evolution from a more uniform distribution towards a more concentrated one. Such change may be reasonably associated to the evolution of the relative importance of the different thematic categories (used to classify EU funded projects related to the aeronautic sector) and to the identification of a less fragmented and more specialized cooperation network;
- Considering all FPs, on average, an industrial actor participated in a mean number of 3.2 EU funded projects, with a standard deviation of 14.6, a research organization in 3.0 (11.1) projects, and a university in 2.6 (6.1) projects.

Key Actions: it is recommend to create multidisciplinary technology clusters, which require a balanced and proportionate support of 4 levels of projects:

1. basic research (3-5%): having 50-100 UA up to 1M€ each exploring up to TRL3 all sorts of novel promising ideas;
2. collaborative industrial (15-17%): 20-40 industrial research projects (4-10M€) joining AI, RC and UA develop further the more prospects;
3. large-scale demonstrators (20-30%): 5-10 large scale demonstrators (20-100M€) to reach a practical scale on the best results at a lower level;
4. JUs (50-60%): 1-2 JUs lead by industrial shorter-term applications (1-2B€).

Test, Simulation and Development Facilities

The large simulation and test facilities are essential institutional support to the aeronautical industry, representing large investments of the Member States that have been coordinated in some occasions (e.g. the joint Dutch-German aero-acoustic wind tunnel - DNW and the joint British-French-German cryogenic pressurized wind tunnel or European Transonic Wind tunnel - ETW). By 2050, strategic European aerospace test, simulation and development facilities should be identified, maintained and continuously developed, and the ground and airborne validation and certification processes should be integrated where appropriate.

Key Findings:

- Strategic aviation infrastructure is of the highest quality and efficiency, providing the basis for world-class research and competitive product development while supporting education. It ranges from wind tunnels via iron and copper birds up to experimental aircraft and simulation capabilities for in-flight and airport operations;
- The data quality and operational efficiency of European aviation infrastructure helps the industry to minimise risks and development costs and helps society to determine the impact

of aviation in benefits such as fast transport as well as in penalties such as the impact on the atmosphere;
- The main topics of these facilities are:
  - Improved and validated fluid dynamics, aerodynamic control, combustion, noise and thermal modelling based on high-performance computation, covering all needs for the aircraft and its engines, external and internal;
  - Methods and tools facilitating the evaluation of aircraft and engine configurations;
  - Results from the demonstration, allowing to assess not only improvements in vehicle development but also to verify and validate new modelling techniques.

Key Actions: it is recommended that (a) a list of simulation, testing and certification needs and (b) an inventory of existing facilities in Europe are compared in order to identify the needs (i) already met, (ii) those requiring upgrades to be met or (iii) those requiring new facilities.

Young Talent and Women in Aviation

Aeronautics requires mostly but not only hard skills in STEM (Science, Technology, Engineering and Mathematics), that are becoming less abundant and eagerly sought by other sectors. Moreover, the aviation sector is already and will face a shortage of skilled aviation professionals in the future. Thus, the aviation industry must engage promising young talent of both genders as early as possible and sustain their interest. In 2050, students should be attracted to careers in aviation and courses offered by European Universities must closely match the needs of the AI, its research establishments and administrations and evolve continuously as those needs develop. Additionally, lifelong and continuous education in aviation should be the norm.

Key Findings:

- The major demographic trend in Europe is characterised by an ageing population and declining younger age cohorts. In 2010, the industry employment was already assisting to a concentration of age structures in the middle age range (35-50 years) and experiencing lower recruitment rates of youngsters – in part due to longer education and training periods – but also due to broad use of early retirement schemes. This demographic tendency, in addiction with lower proportions of qualified young people who were (and are) choosing for STEM-related careers was (is) a concern for the aerospace industry;
- Initiatives to mitigate the threat of skills shortages were already put in place in Europe:
  - national clusters units and the new European Aerospace Cluster Partnership (EACP) established opportunities to develop and expand transnational education and training programmes;
  - the Hamburg Qualification Initiative (HQI) established an exchange in the field of training between the aviation clusters of Hamburg and the French aerospace valley of the regions Midi-Pyrénées (Toulouse) and Aquitaine (Bordeaux);
  - PEGASUS alliance was created with the purpose to optimise the higher education services offered in the best interest of Europe both in terms of continuing to attract the best students and also to offer highly relevant educational and research programmes;
- To attract more young talent and women to aviation, the following measures are highlighted: (i) promotion of diversity in types of education and training; (ii) implementation of awareness

programmes regarding careers in aviation; (iii) organisation and promotion of scholarships, grants and prizes; (iv) improving knowledge transfer from experienced to young employees by e.g. mentoring programmes (v) improvement of recruiting processes as well as of the working environment.

Key Actions: it is recommended that a comprehensive programme of attraction of talent to aeronautics to all education levels is fostered, complemented by job satisfaction measures at professional level, with special measures to promote gender equality and increase the participation of women.

For more information about these topics, you can access the full chapter **here**.