ACARE

Advisory Council for Aviation Research and Innovation in Europe

# Aviation
# 15 years of Research and Innovation
# **Success stories**

It has been almost 15 years since ACARE came into being. Over this period significant progress has been made in European Air Transport to both, support society's need for mobility as well as maintain global leadership for Aviation as a sector.

Much has changed since ACARE was formed after the launch of a vision for European aviation 'Vision 2020' in 2001. Successive releases of the Strategic Research Agenda in 2002, 2004 and 2008 served as guidelines for European research.

More challenging goals were established by 'Flightpath 2050' in 2011 and in response ACARE developed a new Strategic Research and Innovation Agenda (SRIA) in 2012 to enable the aims of the new vision to be achieved.

Thanks to the continuous leadership and support by successive EU Commissioners, from Philippe Busquin to Siim Kallas, Aviation in Europe has taken significant steps to not only define a challenging vision but also to put in place the necessary instruments to achieve the results sought.

More than 300 companies as well as research centres, universities, air navigation providers and other stakeholders helped develop the SRIA roadmap to create social and economic value for aviation in Europe.

Fundamentally the aim of our work is to maintain and expand industrial leadership and to meet the ambitious goals on societal and market needs, to protect the environment and secure energy supply, ensuring safety and security levels and improve our research and knowledge Infrastructure.

Our sector is critically dependent on motivated staff from all expert areas, including engineers and pilots, with excellent skills. In addition we need to develop our strategic research and test infrastructure to accelerate innovation for technology and solutions that are novel, efficient and sustainable.

We believe that our strength of collaboration throughout the entire air transport supply chain will help us to achieve the goals that have been set. Horizon 2020, the EU Framework Programme for Research and Innovation is the European instrument along the journey that requires huge R&D investments needed to reach our very challenging goals.

The aviation community is committed to delivering a globally competitive and innovative Europe. We call on EU policy-makers to put in place the necessary policy frameworks and provide long-term support for Aeronautics and Air Transport to achieve the goals set in Flightpath 2050.

**This document presents some of the examples of achievements delivered over the last 15 years. The momentum and investment generated by all of the ACARE stakeholders to deliver such significant innovation needs to continue to enable the vision for European Aviation for 2050 to be achieved.**

**Peter Hartman**
Vice Chairman Air France KLM,
ACARE Chairman

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# 1. Foreword

Aviation is recognised as one of the top five advanced technology sectors and makes a major contribution to European competitiveness. Home to some 450 airlines and 700 airports, it provides close to 9 million skilled jobs directly and indirectly. The sector contributes around 600 billion Euros to European GDP.

European Aeronautics and Air Transport have reached their current position through decades of innovative solutions and strong Research and Technology. This has enabled the sector to command global leadership. European aviation also plays a key role in global safety and security, serving society's needs for air transport.

ACARE brings together representatives from the whole spectrum of stakeholders in the European air transport community: the aeronautics industry, airlines, airports, air traffic control service providers, the European Commission, Member States, research institutes and academia. The top level objectives are to:

- **Meet society's needs for a more efficient, safer and environmentally friendly air transport.**
- **Maintain global leadership for European aeronautics, with a competitive supply chain, including small and medium size enterprises.**

ACARE's primary mission has been to establish and deliver a Strategic Research and Innovation Agenda (SRIA) aimed at influencing all relevant stakeholders in the planning of aeronautics research programmes, at national, EU and even private levels. The SRIA is not a research programme, but rather a roadmap outlining the strategic orientations which should be taken if Europe is to meet society's needs for aviation as a public mode of transport as well as environmental requirements in a sustainable way.

The SRIA provides a strategic approach including policy orientations to improve European capability in Aviation together with proposed solutions to achieve the objectives outlined in Flightpath 2050.

Since ACARE was formed at the turn of the century, the Strategic Research goals that it has formulated have had a clear influence on policy and aeronautical research, including the European Commission's current research framework programme, Horizon 2020. There is strong momentum in programmes of Aeronautics and Air Transport research, which is already delivering important initiatives and benefits for the aviation industry through programmes including: EU collaborative research in Aeronautics and Air Transport (EU Framework Programme for research, technological development and demonstration activities), Clean Sky, SESAR, National programmes in many Member States e.g. Lufo, CORAC, Take-off etc, and research establishment initiatives (EREA Future Sky etc.) as well as private company programmes.

This document details some notable success stories and achievements in Aeronautics and Air Transport over the last 15 years resulting from the orientations on Strategic Research and Innovation provided by ACARE.



# 2. Vision - Flightpath 2050 goals

In 2000, the European Commission developed the first Vision for aviation: "European Aeronautics: A Vision for 2020" with the help of a high-level group including senior stakeholder representatives. ACARE was set up in 2001, to develop a Strategic Research Agenda and bring together relevant stakeholders to deliver the goals set in Vision 2020.

In 2011, the European Commission recognised that a number of key factors had changed including economic, security, climate science and technology which prompted a new vision to be detailed. Once again the Commission brought together a High-Level Group on Aviation Research to develop "**Flightpath 2050**" Europe's revised vision for aviation extending to a longer timescale.

The key Flightpath 2050 goals are detailed below:

**1. Meeting societal and market needs:**

- 90% of travellers within EU able to complete journey door-to-door within 4hrs.
- A coherent ground infrastructure is developed.
- 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.

**2. Maintaining and extending industrial leadership:**

- The whole European aviation industry is strongly competitive, delivers the best products and services worldwide and has a share more than 40% of its global market.
- Europe has retained leading edge design, manufacturing and system integration capability and jobs supported by high profile strategic, flagship projects which cover the whole innovation process from basic research to full-scale demonstrators.
- Streamlined systems of engineering, design, manufacturing, certification and upgrade processes have addressed complexity and significantly decreased development costs.

**3. Protecting the environment and energy supply:**

- $CO_2$ emissions per passenger kilometre have been reduced by 75%, NOx by 90% and perceived noise by 65%, all relative to the year 2000.
- Aircraft movements are emissions-free when taxiing.
- Air vehicles are designed and manufactured to be recyclable.
- Europe is established as a centre of excellence on sustainable alternative fuels.
- Europe is at the forefront of atmospheric research.

**4. Ensuring safety and security:**

- Overall, the European Air Transport System has less than one accident per ten million commercial aircraft flights.
- Weather and other environmental hazards are evaluated and risks mitigated.
- Air Transport operates seamlessly through networked systems allowing manned and unmanned air vehicles to operate safely.
- Efficient boarding and seamless security for global travel.
- The Air Transport System has a fully secured global high-bandwidth data network.

**5. Prioritising research, testing capabilities and education:**

- A network of multi-disciplinary technology clusters.
- Strategic European aerospace test, simulation and development facilities are identified, maintained and further developed.
- Students are attracted to careers in aviation with courses offered by European Universities closely matching the needs of the Aviation Industry.

# 3. Roadmap: SRIA - a phased approach

Since 2001, ACARE has published a number of editions of the Strategic Research Agenda, the first in 2002 and second in 2004. This was followed by an Addendum in 2008 with a new approach in 2012 that led to the publication of the current Strategic Research and Innovation Agenda. The SRIA takes a phased approach reflecting a longer timeframe extending to 2050, consistent with the timeframe covered by Flightpath 2050. The SRIA challenges are:

- **Mobility** - sustainable mobility is essential for Europe's economic development and social well-being by providing connectivity required by business, tourism and leisure. The challenge is to provide a customer-centric intermodal transportation system providing integrated and seamless travel.
- **Competitiveness** - Europe's industry must remain innovative and competitive, developing and delivering high quality products quickly and efficiently meeting time-critical market demands and serving customers' needs. The challenge is to provide leading edge design and manufacturing capability and jobs supported by strategic projects and programmes which cover the whole innovation process from basic research to full-scale demonstration.
- **Environment and Energy** - the challenge is to meet continually rising demand while reducing the environmental impact of manufacturing, operating and maintaining aircraft.
- **Safety and Security** - the challenge is to reassure passengers and society that, even though air traffic will increase, commercial aviation will not only remain extremely safe and secure on a global basis, within a highly diverse and complex system, but the sector will continue to further reduce the risk of accident.
- **Infrastructure and Skills** - ensure that we preserve Europe's research infrastructure requirements and encourage a sustained flow of competent, trained and motivated people

Complementing the SRIA, ACARE has identified a number of policy-related aspects, which are key to the successful implementation of the SRIA. These include:

### Long-term support for Research and Innovation

To ensure the Flightpath 2050 goals for Europe can be achieved successfully, continued long-term investment in Aeronautics and Air Transport through appropriate European and National instruments is a fundamental need. This should include developing the world's leading research infrastructures covering the entire aviation system from wind tunnels through simulation facilities to test aircraft and related technologies.

The stability of multi-year funding instruments such as Public Private Partnerships (PPPs) is also essential and needs to be failsafe to ensure industry can effectively and securely address larger, longer term and higher risk investments in research and infrastructures which are a prerequisite for innovations.

### Roadmap for Cross-modal transport infrastructures

ACARE has identified that infrastructure for co-modality is an area that needs to be picked up as both the preparation of the technology and the preparation of the infrastructure have to be run in parallel to achieve inter-modality between transport modes. Currently, aviation is the only European Technology Platform (ETP) really addressing co-modality issues.

### Support to educational issues

In its SRIA, ACARE has laid down the plan to establish a fully integrated European aviation education system which will deliver the required high-quality workforce, with the skills and the motivation to be able to meet the challenges of the future. This requires a harmonised and balanced approach covering the entire scope from attracting talents over primary and secondary education to apprenticeship, academia and lifelong professional development.

### Certification

The current certification regulations are not the same in Europe and in the USA. EASA does not have equivalent powers as FAA. Harmonisation of such regulation is required together with the need to harmonise or to work on the reciprocal acceptance of rules between various countries.



### REACH and regulations related to materials

The REACH and ROHS regulations respond to a high-level priority related to public health, which we support. Although it has created some administrative constraints to our sector, it also represents a drive for innovation, to find environmentally acceptable substitutes.

Further work is needed to simplify the implementation of REACH, in particular for SMEs who cannot support the additional administrative burden and could decide to stop producing some products, inducing a risk to block supply chains that are critical for European Air Transport.

### Aviation is a Global Market

It is important to stress that the European aviation industry operates in a global market, with competitors from various continents all with their own regulations and priorities. It goes without saying that the European industry could be disadvantaged by laws and regulations solely applicable to European companies.

European Airlines are committed to a robust emissions containment policy which decouples growth from emissions and translates into "Carbon Neutral Growth in 2020" with a strategy based on four-pillars:

1. Improved technology, including the deployment of sustainable low-carbon fuels;
2. More efficient aircraft operations;
3. Infrastructure improvements, including modernised ATM systems;
4. Market-based measures.

The inclusion of international flights into the EU Emissions Trading Scheme (ETS) led to international controversy. However, the scope of the directive was restricted until 2016 to enable the EU to successfully reduce the potential for retaliatory measures. ICAO is in the process to develop a global market-based measure (MBM) which could prevent any potential distortion of competition as well as provide genuine mitigation of emissions. As the global MBM will be applicable to all international flights, it should replace the aviation ETS for intra-EEA flights.

European States should collectively opt to include domestic flights in the global MBM to ensure a level playing field, limit administrative burden, and avoid any potential double counting of emissions in two different systems (the aviation ETS and the global MBM).

# 4. Success stories: Significant progress to date

## This section provides examples of research projects and achievements that have been completed since the formation of ACARE.

In recognition that there is **complementary research at a European and National level** that ultimately brings together a complete picture of this effort, examples are drawn both from European Framework Programmes as well as national research programmes from Member States.

The examples, categorized in support of the key challenges, include the following:





# 4.1 Mobility

## 4.1.1 "Total Airport Management Suite" (TAMS) optimises airport operational decision making.

Scientific coordination by DLR, a joint 32M€ project with five partners, co-financed by the German Federal Ministry of Economics and Technology (BMWi).

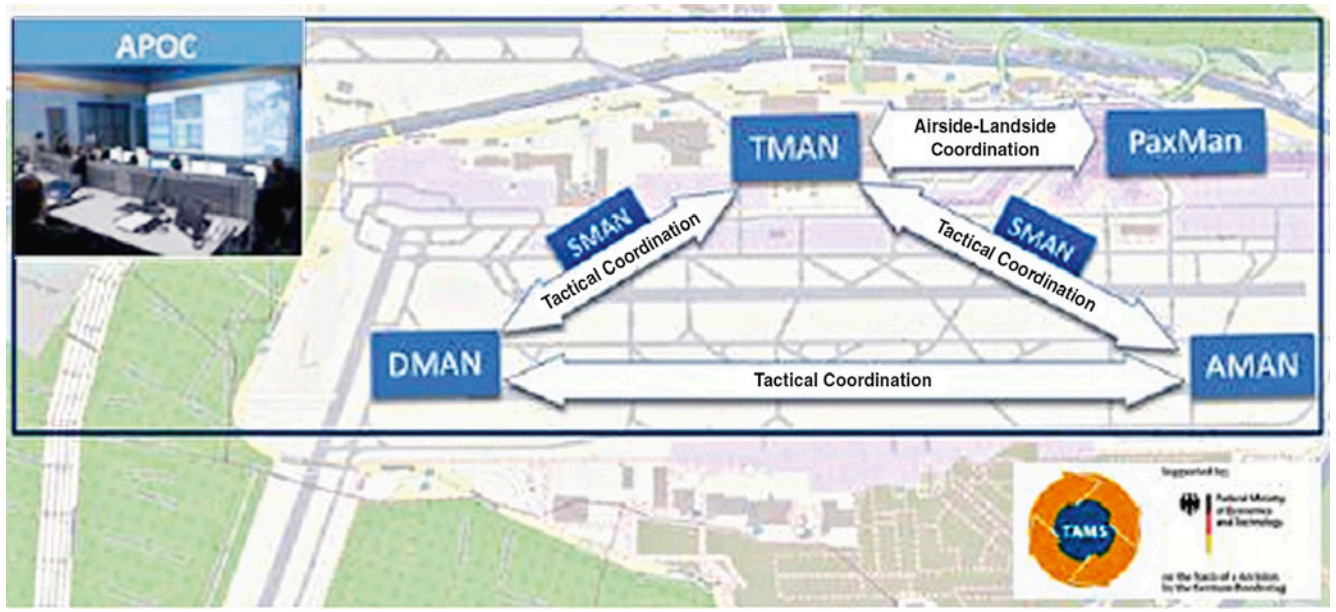
The goal of the project was to integrate various airport operations related planning and optimisation subsystems into an AirPort Operations Center (APOC) on the basis of a holistic operational concept to make airports more competitive and attractive without the need for cost-intensive infrastructure enhancements. As a result, the comprehensive, intelligent and profitable use of existing resources is set to become an increasingly important factor for airports wishing to remain competitive.

The integration of various air- and landside airport sub-processes into the APOC not only boosts the efficiency and cost-effectiveness of airport operations, but also helps to reduce their impact on the environment. The TAMS validation demonstrated the added value available for air traffic systems - enhanced process predictability reduces delays, fuel consumption and the resulting $CO_2$ emissions, as well as simultaneously increasing passenger convenience.

TAMS enable stakeholders to make well-informed decisions in a pro-active coordinated way, based on a joint picture of the operational situation and its anticipated development.

TAMS goes beyond Airport Collaborative Decision Making (A-CDM) in three respects: first, it takes a balanced approach to both landside and airside processes; second, it is more pro-active than reactive and extends the time horizon of A-CDM planning to a pre-tactical range of several hours; and thirdly it has also introduced new concept elements such as an Airport Operations Plan (AOP) and an Airport Operations Center.

TAMS uses a range of visualisation technologies to display the information required by airport operators, local air traffic managers, airline operators, ground handling companies and security companies, generates forecasts, provides optimisation suggestions and supports the various airport process owners. Employees can use smart phones, desktop computers and large video walls to obtain up-to-date information on operations, general conditions, such as the closure of terminal areas, expected weather conditions or predictions regarding future operations.



# 4.1 Mobility

## 4.1.2 Extended Arrival Management (E-AMAN)

Today, arriving airport traffic is managed and sequenced in the airspace close to the airport. Faced with increasing traffic, airports are looking for ways to overcome congestion and reduce the need for holding.

The SESAR Solution Extended Arrival Management (E-AMAN) allows for the sequencing of arrival traffic much earlier than is currently the case, by extending the AMAN horizon from the airspace around the airport to further upstream.

Controllers in the upstream and cross-border sectors including those in neighbouring functional air blocks (FABs) can instruct pilots to adjust the aircraft speed before beginning descent, thereby reducing the need for holding. The results from SESAR flight trials show that this solution offer valuable reductions in fuel consumption and $CO_2$ emissions.

Validation exercises in Italy have highlighted the efficiency gains and environmental benefits that can be achieved with Extended AMAN. Concretely, up to 84 kg of fuel per flight and a related reduction of 268 kg of $CO_2$ can be saved. Meanwhile, exercises in Heathrow have shown that a reduction of up to a minute in holding times can be achieved, saving airlines around €1.25 million in fuel and 5,000 tonnes of $CO_2$, as well as reducing noise for communities.

E-AMAN is planned for synchronised deployment at 24 European airports in accordance with Commission Implementing Regulation (EU) No 716/2014 on the establishment of the Pilot Common Project (PCP).


## 4.1.3 Aeronautic Study on SEamless Transport (ASSET)

This project, led by DLR involved 12 participants with a total budget of 3.6M€.

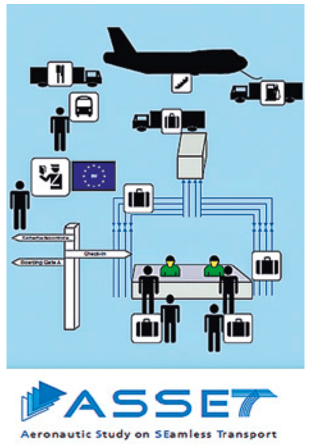
ASSET was one of the first EU projects to deal with airport landside improvements and to tackle the ACARE punctuality goal.

Aim of ASSET was to develop and assess solutions for airport process improvements in terms of time efficiency regarding both, passenger transfer and aircraft turnaround in an integrated approach. Therefore, representatives of nearly all directly or indirectly involved stakeholders (airports, airlines, aircraft manufacturers, technological suppliers, security service providers etc.) gathered to work conjoined on this project.

Elaboration of potential solutions comprised compilation of currently discussed solution approaches (e.g. Collaborative Decision Making, Total Airport Management etc.) as well as development of new opportunities focussing on three main process chains:

- Passenger processes
- Baggage processes
- Aircraft turnaround processes

Achievement was a ranking list specifying promising solutions as basis for future development, reference airport models as well as a systematic scheme for future airport assessments.






## 4.1.4 Initial four-Dimensional Trajectory Management (i4D)

Initial four dimensional trajectory management (i4D) makes use of the flight management system and communication capabilities of the aircraft and ground systems in order to share and integrate data, and optimise the aircraft trajectory in all four dimensions. This enables more efficient and predictable handling of flights.

Thanks to i4D, controller workload can be optimised since conflicts between trajectories in the en route phase can be resolved automatically. During arrival planning, i4D provides greater predictability to ATC since, once they receive their allotted arrival time, aircraft can manage their arrivals to great precision. This also allows the aircraft to better manage their speed profile, which leads to fuel savings and fewer emissions.

Flight trials have demonstrated the maturity and robustness of i4D in real traffic conditions, confirming the important efficiency and environmental gains as well as increased flight predictability. I4D is planned for synchronised deployment in accordance with Commission Implementing Regulation (EU) No 716/2014.

## 4.1.5 Remote Tower Services

Small or local airports are life-lines to local and regional economies, generating mobility of goods, services and people. But keeping these airports open with air traffic services is a challenge given the costs involved in running them compared to the number of flights they handle.

SESAR's Remote Tower Services offers new possibilities for places where it is too expensive to build, maintain and staff conventional tower facilities and services, or at airports where such services are currently unavailable.

Using high-definition video cameras together with supporting zoom and infrared cameras, panoramic high resolution screens give traffic controllers a 360-degree view of an airport, allowing them to remotely provide air traffic and aeronautical flight information services in real time. Like at onsite manned control towers, controllers at their remote workstations have access to information from supplementary sensors and controller tools to ensure that flights take off and land safely and smoothly.

Validation exercises in Norway, Sweden and Germany have shown that Remote Tower Air Traffic Services are safe and cost-effective, enabling smaller airports to ensure a continuity of operations and provide services on-demand at single airports. In 2014, the world's first RTS in Sundsvall opened for business, serving Örnsköldsvik airport over 150 km away.

# 4.1 Mobility

## 4.1.6 Airport Operations Centre (APOC)

SESAR is developing a number of solutions within the Airport-Collaborative Decision-making framework to improve information sharing at airports, thereby improving efficiency and predictability of flights. One such solution is the Airport Operations Centre (APOC), which brings together the main airport stakeholders to become a platform for stakeholder communication and coordination, based on shared knowledge.

Instead of islands of potentially conflicting decision-making, the APOC provides a coordinated capability, supported by technology and processes, which balances the business priorities and strategies of all airport stakeholders. APOC keeps the airport flowing by matching resources and facilities to changes in demand or schedule.

SESAR validations have shown how APOC can improve efficiency at both regional and large airports and, in 2014, initial APOCs were opened by SESAR European Airports Commission (SEAC) members at Heathrow and Charles de Gaulle airport.



# 4.2 Competitiveness

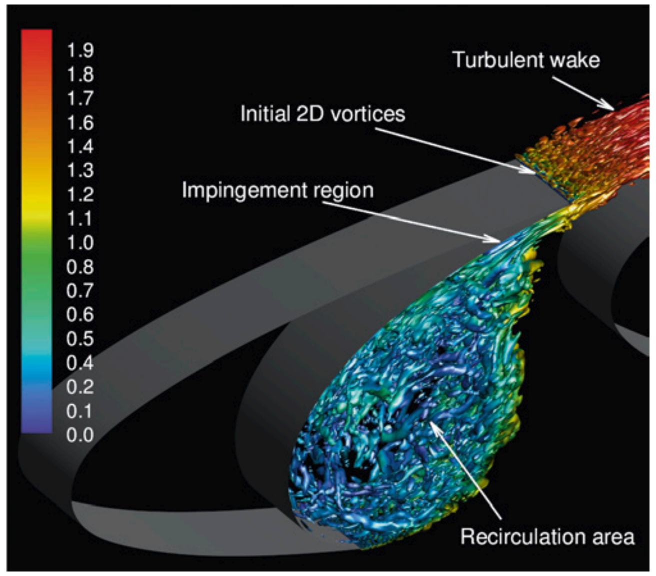
## 4.2.1 High-Lift Aerodynamics: A GARTEUR success story

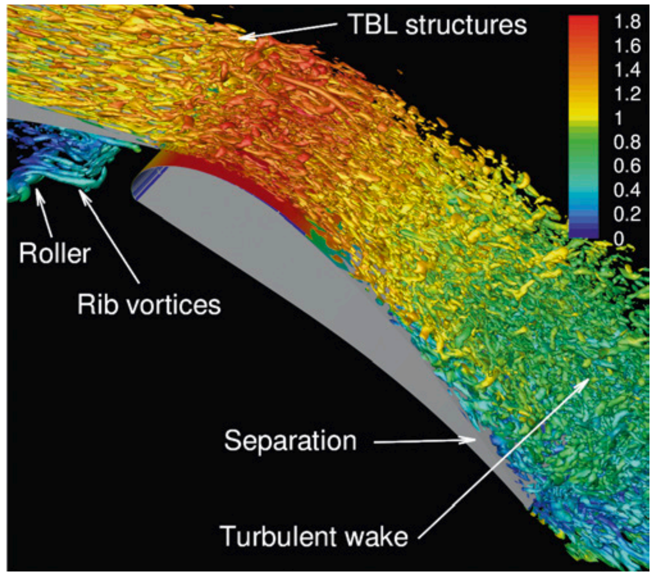
This project, led by GARTEUR involves 7 partners with a budget of circa 2.1M€ (from year 2000)

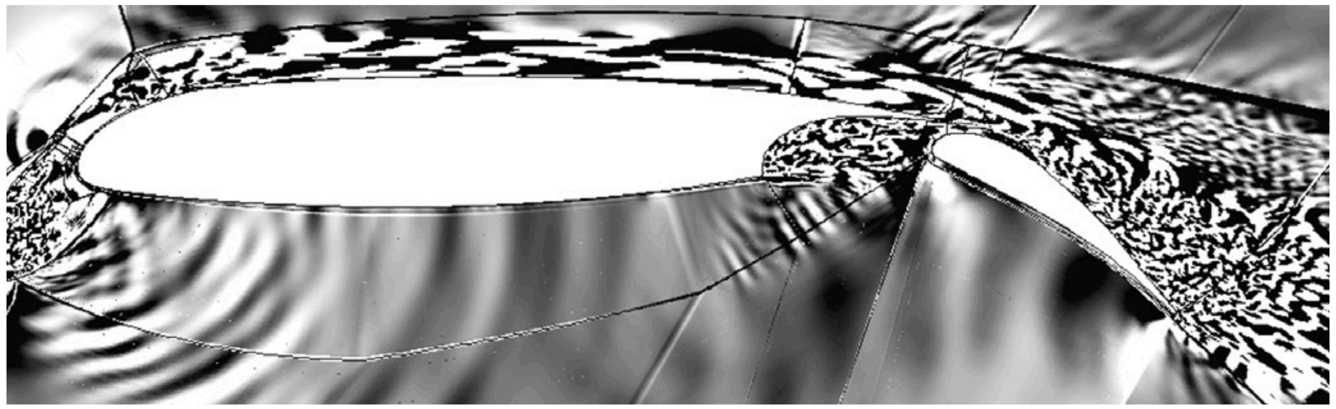
GARTEUR is an independent organisation for **Research Collaboration in Europe** in the field of aeronautics and involves seven nations with major research and test capabilities in aeronautics (France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom).

A number of EU-projects are quoted as important contributors to the wing design on modern European aircraft types such as Airbus A380 and Dassault Falcon 7X. GARTEUR activities on High Lift Aerodynamics were carried out within six Action Groups from 1981 to 2014 with participation of Research Establishments and industries.

The joint European knowledge in High Lift Aerodynamics, applied on modern European aircraft types, has been built up over the past decades through national efforts coordinated via GARTEUR Action Groups and continued in European projects funded via Framework Programmes (EUROLIFT, DESIREH, SADE, ATAAC and GO4HYBRID projects). This illustrates coordinated efforts between GARTEUR nations, strong connections between GARTEUR and EU activities, long time scales from basic research to application and the impact of lower TRL research on future projects.



Advanced simulation of the flow dynamics around a three-element airfoil thanks to the ZDES technique developed by ONERA (adapted from Deck & Laraufie, Journal of Fluid Mechanics, vol 723, pp 401-444, 2013)

# 4.2 Competitiveness

## 4.2.2 TANGO-ALCAS-SARISTU-MAAXIMUS

The introduction of advanced composites in primary civil aerostructures has a long history in Europe that goes back more than 30 years. The experience gained, allowed their gradual increase as a percentage of the structural weight from 5% to 53% (cf. Fig. 1 and 2).

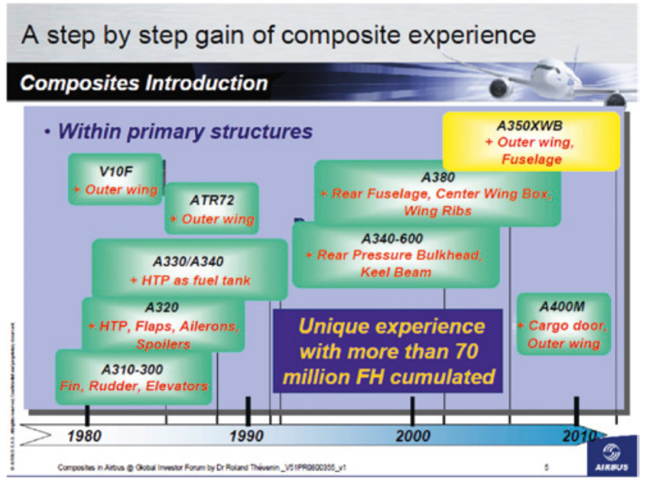



Fig. 1

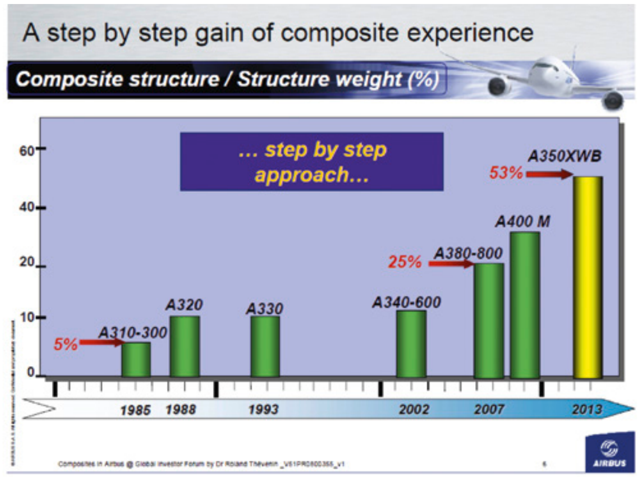



Fig. 2

Composites offer higher stiffness to weight ratio and integration advantages, compared to metals. A string of successful research projects - industrial, national as well as European collaborative ones - contributed to this success story. In this brochure, a cluster of four European integrated research projects (FP5-TANGO, FP6-ALCAS, FP7-SARISTU and FP7-MAAXIMUS) is presented. They all aimed towards maintaining and enhancing the competitive position of the European Aerospace industry, in the face of significant challenges from strong global competition.
**They contributed to reducing further the operating costs**, through the cost effective **application of carbon fibre composites to aircraft primary structures**, taking into account **systems integration**.

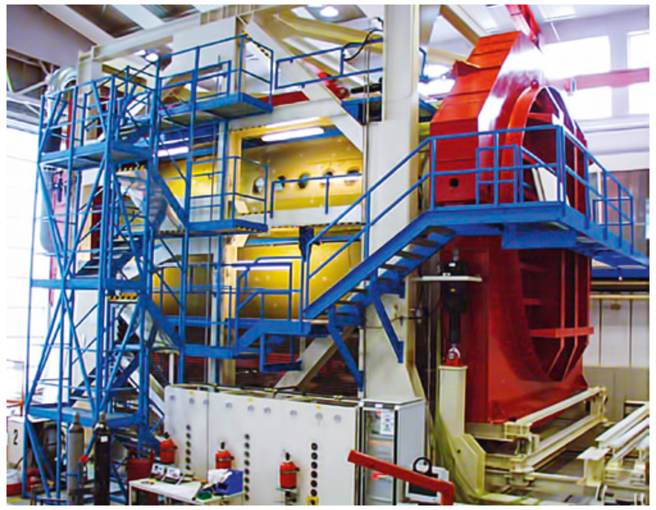
**FP5-TANGO** - a 32 strong European partnership commenced in 2000 and finished in 2006 with a total budget of 84M€ and EU contribution of 42M€. FP5-TANGO delivered four structurally tested platforms (lateral wing-box, centre wing-box, metallic fuselage and composite fuselage), including a full suite of design, manufacture and test reports including recommendations for future technology applications.

**FP6-ALCAS** - a 32 strong European partnership commenced in 2005 and finished in 2012 with a total budget of 101M€ and EU contribution of 53M€. It was organized into four technical platforms:

- **Airliner Wing** - design, manufacture and test of an inner wing and centre box of a large civil airliner
- **Airliner Fuselage** - key fuselage challenges and complex design features, including large cut-outs and large damages in curved panels, keel beam and landing gear load introduction, tyre impact damage, post-buckling and elementary crash analysis
- **Business Jet Wing** - cost reduction by combining parts into an integrated wing structure
- **Business Jet Fuselage** - double curved rear fuselage with sandwich shell concept and VTP/HTP and engine integration

**FP7-SARISTU** - a 64 strong European partnership commenced in 2011 and finished on-time in 2015 with a total budget of 51M€ and EU contribution of 32M€. FP7-SARISTU focused on smart intelligent aircraft structure concepts. SARISTU has ten application scenarios and investigated:

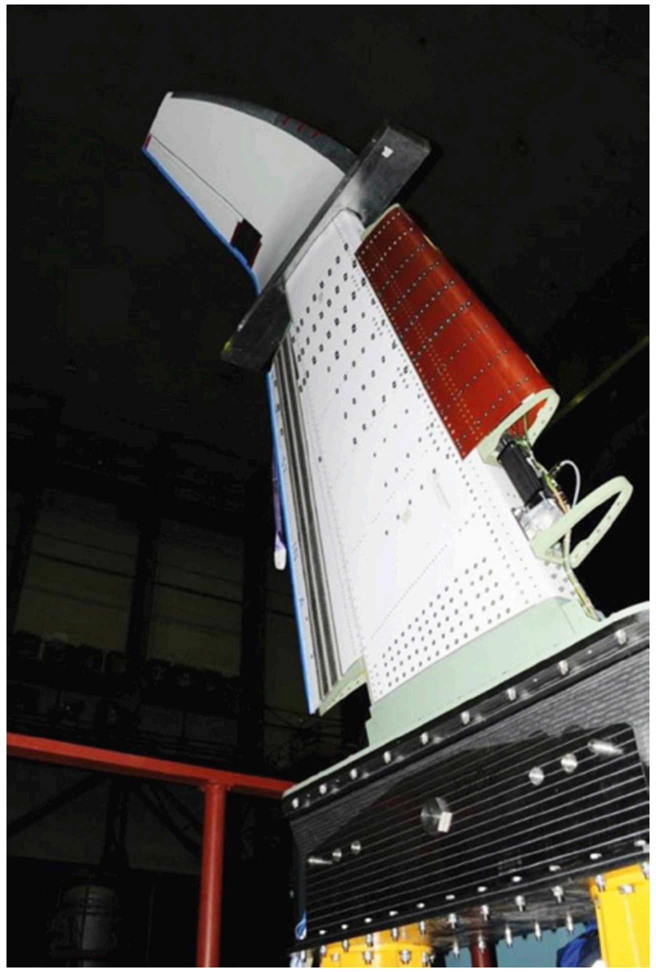
- Conformal morphing leading-edge device, including the integration of lightning strike protection;
- The integration of trailing-edge devices for cruise optimisation
- Wingtip active trailing-edge devices for load alleviation, integration and minimized maintenance;
- The structural integration of fibre-optic monitoring devices for a multitude of applications
- The integration of guided wave ultrasonic monitoring for rapid damage detection and assessment;
- Pitch-catch ultrasonic monitoring for the same purpose on typical fuselage structures;
- Ultrasonic and fibre-optic techniques to enable the full monitoring for multi-site damage detection;
- Passive SHM techniques focusing on damage-indicating coatings;
- The manufacturing challenges associated with nanoparticle-reinforced structures;
- The use of nanoparticles in CFRP towards enhanced electrical capabilities;



SARISTU - IS12 - Wind tunnel demonstrator

**FP7-MAAXIMUS** - a 57 strong European partnership commenced in 2008 and is still ongoing with a total budget of 67M€ and EU contribution of 40M€. The aim is to demonstrate the fast development and 'right first time' validation of a highly optimised composite airframe. This will be achieved through a physical platform as well as a virtual development one. FP7-MAAXIMUS delivers:

- A set of physical tests at coupon, structural detail and panel level;
- A generic composite barrel section manufactured and tested under quasi-static load;
- A set of advanced optimisation and analysis methods integrated in a demonstrator framework.



TANGO - AMF test in Hamburg

# 4.2 Competitiveness

## 4.2.3 Light Helicopter Demonstrator with High Compression Engine (HCE)

Helicopters. The engine underwent already successfully ground testing on Iron Bird and a H120 helicopter. Flight testing is planned for the second half of 2015.

The advantages of the High Compression Engine compared to turbo shaft are:

- Lower $CO_2$ emission and fuel consumption between 30% and 50% depending on mission,
- Lower operating costs for operators by 30%,
- Improved performances in hot and high conditions,
- Increased range with same amount of fuel (roughly double in certain missions).

The helicopter used for the Demonstrator is a serial H120 modified to accommodate with this new engine, as shown on the picture below.

The successful completion of the project will pave the way towards competitive single engine light helicopters in Europe.


H120 HCE Demonstrator during Ground run

## 4.2.4 ODICIS - One display for a cockpit interactive solution

Scientists initiated the EU-funded project 'One display for a cockpit interactive solution' (ODICIS) to develop a single-display cockpit and test its functionality. The focus was on flexibility of the system architecture, optimisation of useful surface area and continuity of information. Taken together, achievement of these objectives was proposed to increase operational safety and efficiency while reducing development cost.

The ODICIS consortium, led by Thales, successfully developed the single display mock-up consisting of a seamless interface with a curved surface that was presented for the first time at the 2011 Paris Air Show. From an original 351 user-defined requirements, scientists came up with a suitable graphics generator and image management algorithms integrated into the projection solution. They employed a human-machine interface (HMI) with a tactile system and a display suited to the requirements for each fundamental format (flight display, navigation display, system pages, etc.). Technical and operational evaluations addressed aspects related to the ability of the projection system to maintain image integrity at wide viewing angles.

The ODICIS cockpit display is expected to set the standards for a new generation of cockpit design rules. The curved, touch-screen projection display affords an optimal combination of space used and information displayed to enhance the efficiency and safety of aircraft operation.



# 4.3 Environment and Energy

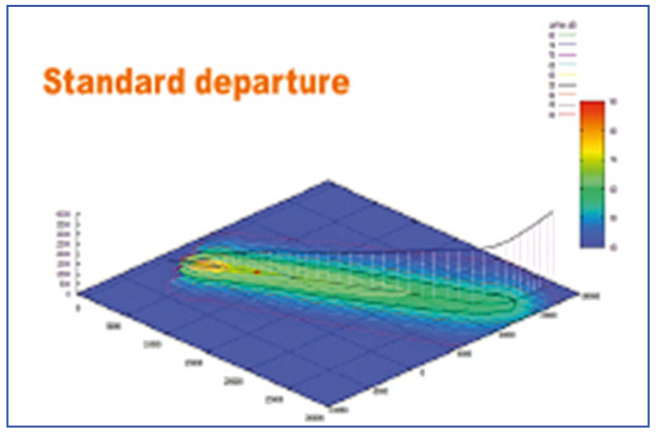
## 4.3.1 Advanced Flight Management Systems enabling environmentally optimised flight paths

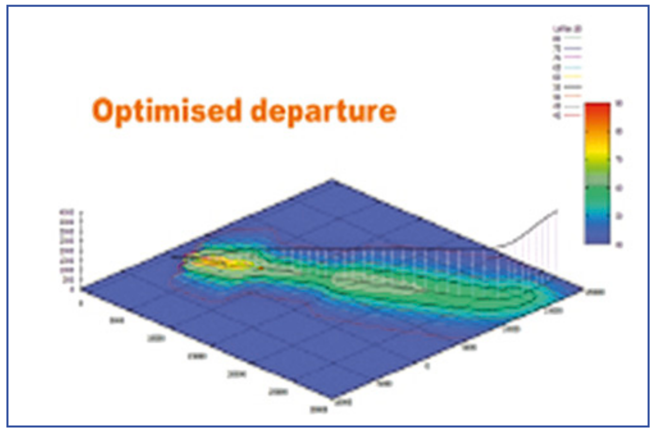
This Clean Sky project, led by Thales involves 30 participants including leaders and partners with a budget of 35M€ (17.5M€ EC funding)

Flight Management Systems - used on commercial aircraft to automatically execute the flight plan - have been enhanced to contribute to aircraft trajectories optimisation in all mission phases. Automatic adjustments of speed, altitude, thrust, lead to gains in perceived noise, fuel consumption and $CO_2$ emissions. The FMS, supported by open-world tools, performs real-time multi-parameter optimisation and proposes the best trade-off to the crew.

These new capabilities will drive the performance of the next generations of aircraft. Importantly: they can also be implemented on the existing fleet for an immediate and global effect on the environment.

As an example, the Multi Criteria Departure Procedure (MCDP) takes into account individual aircraft parameters (type, take-off weight, thrust mode) and weather conditions (temperature, humidity) to compute in real time an optimal take-off profile reducing noise, fuel consumption, as well as $CO_2$ and other emissions. These parameters are inserted in the Flight Management System and flown automatically, thereby giving a benefit in crew workload and optimising the noise and emissions for the local situation.



# 4.3 Environment and Energy

## 4.3.2 Advanced Low-Pressure System (ALPS)

This project, led by Rolls-Royce involves some 50 participants including Clean Sky leaders with a budget of 86M€ (45M€ EC funding)

The Advanced Low Pressure System engine, which is funded through the SAGE 3 ITD of Clean Sky, has demonstrated the CTi (Carbon and titanium) fan blade and associated composite engine casings– to deliver a weight saving of over 680kg on a twin engine aircraft, the equivalent of seven or eight passengers travelling "weight free". Composite panels containing electrical harnesses and pipework fit around the fancase, and will further reduce weight and simplify maintenance. The focus is on delivering a reduction in $CO_2$ emissions and some reduction in noise through the composite fan system.

It is just one technology that will help future Rolls-Royce engines such as the Advance engine design deliver a 20% fuel efficiency improvement. This will be stretched to 25% improvement for UltraFan™, compared to the first generation of Trent engines. Both Advance and UltraFan™ are being funded by the EU as part of the Clean Sky 2 programme.

The ALPS programme has already delivered 3 full scale ground demonstrators and 1 flight demonstration campaign that involved a total of six flights that took place in October 2014. Rolls-Royce plans two further ground demonstrations in 2015, including testing of a modified low pressure turbine, at this point the ALPS programme will finish its journey with Clean Sky.

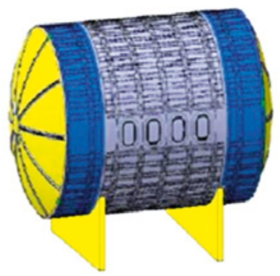
The results to date have shown that the environmental targets set within Clean Sky will be achieved. The programme will make it possible to design and build better aircraft and achieve sustainable mobility and connectivity and will also contribute to the improvement of the entire sector. With innovative, tangible results such as ALPS, Clean Sky places Europe at the forefront of the greening of aviation.


## 4.3.3 One Piece Barrel (OPB) Demonstrator

This project, led by Alenia involves 5 participants including Clean Sky leaders and partners with a total budget of 10.5M€

Alenia Aermacchi's composite fuselage One Piece Barrel Demonstrator is a source of pride for the Clean Sky Joint Technology Initiative. The 'barrel' is a wholly integrated structure, representative of the section of the fuselage of a regional turboprop aircraft. Such a technology makes the construction process cheaper and quicker, and furthermore the aircraft considerably lighter.

Pre-Production Manufacturing



One Piece Barrel (OPB)

The barrel integrates multiple technologies into a single unit:

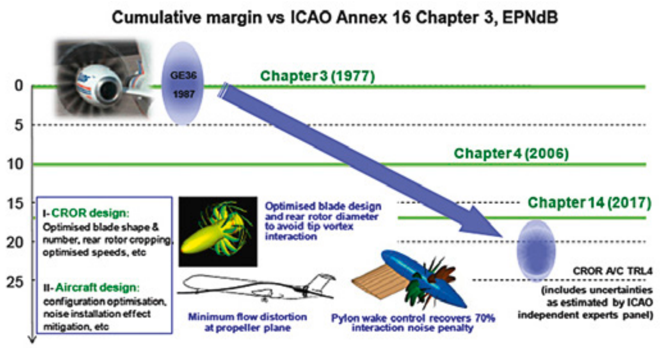
- Innovative multi-functional layer and multi-layer architectures, ensuring electric conductivity and lightning resistance;
- Embedded damping veil for vibrations and related acoustics;
- Hail impact performance technologies;
- Sensor technologies to monitor the status of the structure and accurately report any degradation of its mechanical properties.

The One Piece Barrel Demonstrator will allow the relevant Green Regional Aircraft ITD Demonstration to be performed starting in November 2015 and ending by March 2016.

## 4.3.4 Counter-Rotative Open Rotor (CROR)

This project, led by Safran involves some 50 participants including Clean Sky leaders and partners with a budget of 127M€ (67M€ EC funding)

One flagship of Clean Sky is the Counter-Rotative Open Rotor: This new propulsion concept is expected to enable reductions of over 35% in fuel burn and $CO_2$ emissions per passenger-km compared to the relevant Year 2000 reference aircraft. This is the most far-reaching step towards the overall ACARE 2020 Goal of -50% $CO_2$ to date, and involves highly complex technological development underway, and full-scale demonstrations to be performed in Clean Sky, both on the engine and on the installation. Several critical issues have been successfully addressed so far. In particular, aero-acoustic wind-tunnel tests performed in 2012 have shown very encouraging results: CROR powered aircraft can be expected to produce noise levels similar to those of most recent turbofans currently under development. This is already an outstanding achievement made possible only through the concerted efforts made under Clean Sky. Safran plans a ground demonstration of a full Open Rotor at the beginning of 2016.



# 4.3 Environment and Energy

## 4.3.5 From TECH800 demonstrator to Arrano engine

This project, led by Turbomeca involves 33 participants including Clean Sky leaders and partners with a total industry and EC funding budget of 40M€.

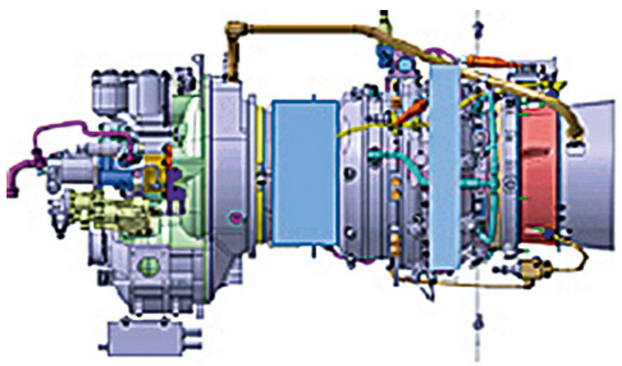
Turbomeca in the scope of Clean Sky designed a whole new demonstrator aiming at reducing fuel consumption by 15% with respect to Year 2000 baseline.

This was made possible thanks to results of several European and National research projects launched in the past years such as Newac, Dream, Crescendo enabling to improve modelling tools and focus on promising technology up to TRL3 to 4.

First target for the Clean sky demonstrator called Tech800 was to push thermodynamic cycles by increasing pressure ratio and temperature and design an innovative mechanical architecture in order to minimising overall weight with respect to maintenance and reliability needs. A large partnership across 10 countries has been set up thanks to various calls for proposals.

The first run was performed in first quarter 2012 in an intermediate configuration allowing testing most components such as compressor, combustor, HP and LP turbine. The final configuration at high Turbine Entry Temperature was successfully tested in mid-2013 and is going on for a completion at the end of 2015.

The Arrano engine program (1100 to 1300 shp engine) was launched in 2012. The more mature technology concepts developed in Cleansky have been introduced in the design of this new turboshaft engine. Thanks to these technology insertions, ARRANO proposes a double digit benefit on fuel consumption compared to the previous generation of engines. ARRANO has recently been selected by Airbus Helicopter as the sole source for the newly unveiled H160. This concretisation is the results of the huge effort performed in years of Research projects that lead to breakthrough performance and competitiveness.



TECH800 3D Mock up

TECH800 demonstrator after test



## 4.3.6 European collaborative efforts on Renewable Jet Fuel

Renewable jet fuel is foreseen to significantly contribute to the operators' ambition to reduce their $CO_2$ footprint. Since the first non-fossil jet fuel was certified for use in commercial aviation in 2009, collaborative R&D efforts and industrial initiatives have diversified the landscape of feedstocks and conversion technologies, started to increase volumes produced and support the certification of new production pathways.

ACARE's focus on renewable fuels contributed to the launch of six EU-funded projects as well as national initiatives, ranging from initial proofs of concept for novel technologies, e.g. the solar-thermochemical fuel production from $CO_2$ and water in SOLAR-JET, to demonstration of production technologies at pre-commercial scale, e.g. the recently initiated project BioReFly. Motivated by the lesson learned that successful commercial deployment requires more than technological developments, the EU supports the collaborative project ITAKA, involving all value chain stakeholders, from feedstock supplier via refinery operator to end users. This concept is also applied in the Air France "Lab-Line for the Future" initiative, the German burnFAIR project or in the Dutch initiative BioPort Holland, which aims at the establishment of continuous production and logistics integrated into the European pipeline system.

# 4.4 Safety and Security

## 4.4.1 Tools for Flight Crews of the Future - The Man4Gen and SUPRA Projects

**Man4Gen** (Manual Flying Skills for 4th Generation Airliners): This project involves 9 partners with a total budget of 4.7M€.

**SUPRA** (Simulation of Upset Recovery in Aviation): This project involves 9 partners with a total budget of 4.9M€.

Man4Gen (2012 - 2015) is developing procedural, training and flight deck features that enable the flight crews of highly automated and complex airliners of the future and today to stay on top of things when it matters most: in unexpected and challenging situations.

As a continuation of the highly successful project SUPRA (2009 - 2012, targeting prevention of Loss of Control In-flight events) which developed simulation technologies for flight simulation outside the normal aerodynamic envelope for flight training and research, the Man4Gen project is going further up the chain of events by developing technology and methods to support flight crew Situation Awareness. The goal is to avoid having to recover the airplane from an unusual or undesired state. An important result for the industry are the developed training tools allowing for quantification of core flight crew competencies as well as design of customised training focusing on the right competencies.


Man4Gen Simulator experiment in DLR AVES simulator



## 4.4.2 High Altitude Ice Crystals/High Ice Water Content International Field Campaign

Led by Airbus: "Icing Phenomena & Protection Systems" **High Altitude Ice Crystals (HAIC)** is a 4-year large-scale integrated project with 34 partners from 11 European countries and 5 International partners from Australia, Canada and the USA with a budget of 22.8M€.

Commercial aircraft have been experiencing in-service events while flying in the vicinity of deep convective clouds since at least the early 1990s. Heated probes and engines are the areas of aircraft most prone to mixed phase and glaciated icing threat.

In anticipation of regulation changes according to glaciated and mixed phase icing conditions, the HAIC project will characterise the high ice water content environment and will provide the necessary Acceptable Means of Compliance (numerical tools and test capabilities) and appropriate ice particle detection and awareness technologies to the European Aeronautics industry for use on-board commercial aircraft. HAIC will also develop international cooperation and collaboration.

The first HAIC and **High Ice Water Content (HIWC)** International field campaign took place in Darwin, Australia, in early 2014. The aim was to provide the first modern extensive data set of the core areas of deep convection in order to characterise the 99$^{th}$ percentile of total water content statistics as a function of distance scale. The field campaign was the result of an international collaboration between the HAIC, EASA-HIWC and US-led projects, with EC funding support which brought together expertise in a wide range of skills including: airframers, engine manufacturers, equipment & systems suppliers, research institutes and academics, meteorological services and SME's able to provide knowledge, service, or support in specific areas, with the main stakeholders based in Europe, North America, Australia and Japan.

During the field campaign, the SAFIRE Falcon 20 research aircraft carried out 23 flights representing a total of 76 flight hours on-site. The collected dataset will be a unique resource for fundamental research, new industrial developments of detection and/or awareness technologies and for the regulation makers to assess the glaciated and mixed phase icing conditions envelope as defined in the regulation.

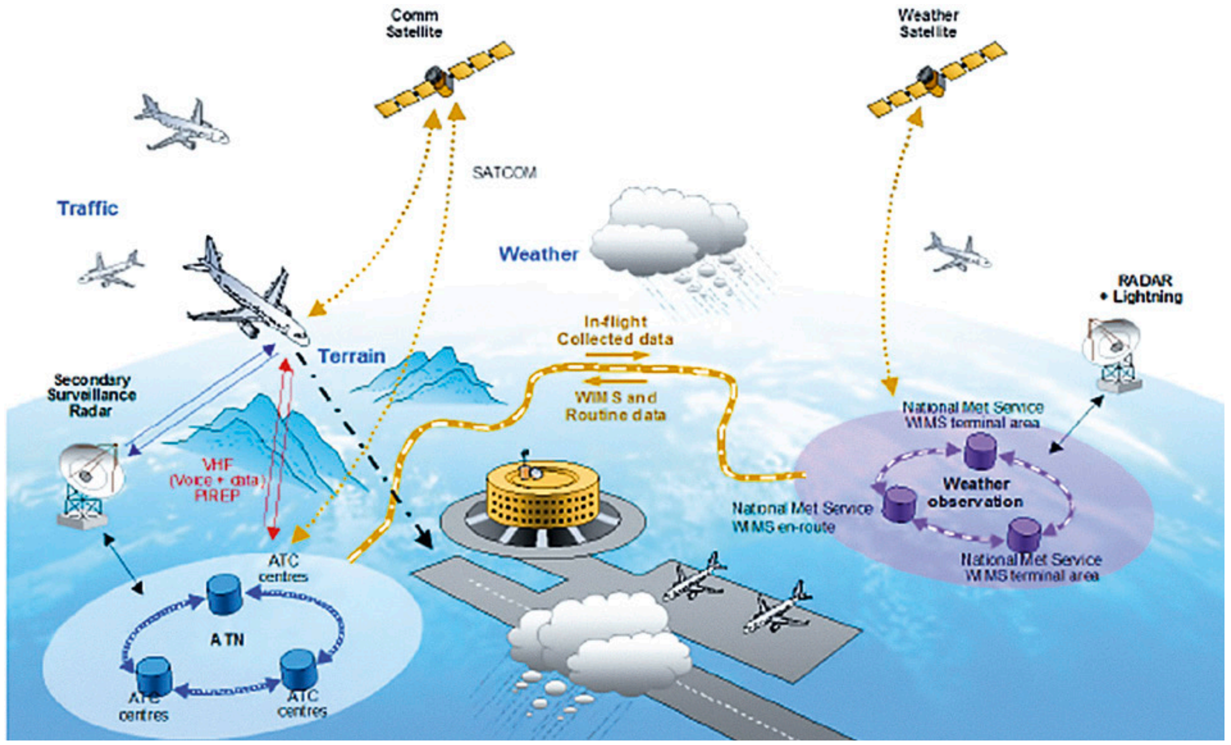
# 4.4 Safety and Security

## 4.4.3 FLYSAFE - Airborne Integrated Systems for Safety Improvement, Flight Hazard Protection and All Weather Operations

Led by Thales and involved 36 partners.

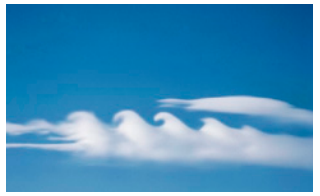
The project 'Airborne integrated systems for safety improvement, flight hazard protection and all weather operations' (FLYSAFE) focused particularly on the areas identified as the main types of accidents around the world: loss of control, controlled flight into terrain, and approach and landing accidents. It has addressed three types of threats including adverse weather conditions, traffic hazards and terrain hazards. For each of them it has developed new systems and functions, notably: improved situation awareness, advance warning, alert prioritisation, and enhanced human-machine interface.

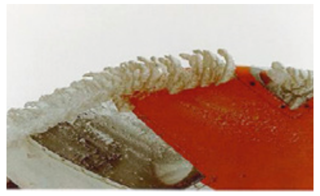
FLYSAFE has also developed solutions to enable aircraft to retrieve timely, dedicated, improved weather information, by means of a set of 'Weather information management systems' (WIMS). These WIMS are able to gather, format and send to the aircraft all essential atmospheric data, as relevant for the safety and efficiency of their flight. This uplinked data has been presented in an innovative and consistent way to the crew. Innovative prediction capabilities have been deployed, both on board of the aircraft and on the ground, to provide warnings which are optimised with respect to the simultaneous constraints of safety and airspace capacity.

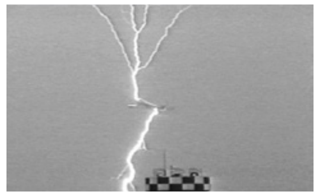



**Weather Information Management Systems**


Wake Vortex


Clear Air Turbulence


Icing


Thunderstorm



## 4.4.4 Safe reduction of wake turbulence separation minima

Wake turbulence is the turbulence observed behind an aircraft as a natural consequence of the lift generated by wing surfaces. This phenomenon (also called wake vortex) poses a significant safety hazard for aviation in the takeoff or landing phases as the spacing between consecutive aircraft is reduced. With the sustained growth of air traffic observed at a number of international airports, the current wake turbulence standard separation minima applied by Air Traffic Control defined in the 1970's need to be revisited. Since the 1990's significant research efforts in US and Europe have been dedicated to gain a sufficient understanding so as to improve the evaluation of the safety risks associated to wake turbulence and to identify optimum aircraft separation in the context of airport operations. Under FP5, FP6 and FP7 the main following directions for research were as follows:

- Characterisation of wake vortex behaviour, its monitoring and development of prediction model
- Alleviation of wake through aircraft design
- Safety assessment for reduction of aircraft separations
- Improving airport operations - new operational concepts to improve runway capacity

As key result from these projects the deployment of 2 new aircraft separation schemes has been initiated at 2 major European airports (London Heathrow and Paris CDG) for entry in service in 2015. The main related benefits from these deployments are the reduction of flight delays (up to 50% of delays generated by adverse weather) or the increase of runway throughput (in the order of 5%) without compromising on the safety levels for these operations.

## 4.4.5 High Intensity Radiated Field Synthetic Environment (HIRF SE)

HIRF SE was an FP7 European project, started on the 1/12/2008 and finished on the 31/05/2013, with a total budget of about 26.5M€ (17.8M€ EC funding).

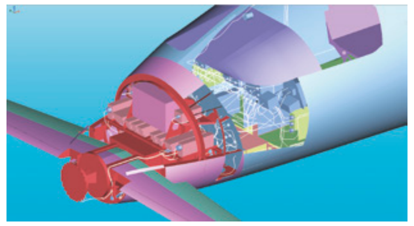
The HIRF SE consortium led by Alenia Aermacchi, consisted of 43 partners with a strong background in computational EMC, electromagnetic modelling, EMC aircraft testing/ certification and software development.

The HIRF Synthetic Environment research project had the goal to provide the aeronautic industry with a numerical modelling computer framework which could be used during both the development phase, in order to ensure adequate electromagnetic performance, and during the certification/qualification testing phase on air vehicle.

Novel air vehicles concepts, like fly by wire technology, had led to a high increase of the electromagnetic testing time, in order to ensure compatibility of new technologies with existing and future regulations. In this view, availability of new HIRF Synthetic Environment framework become more and more significant to cope with competing requirements of new designs, with the related increase of tests in number and complexity, and of costs and time reductions.

The correct operating of the numerical framework was verified and validated by comparison with data from real testing on small and medium air vehicles and pre-existing data for large air vehicles. The validation process demonstrated on several real aircraft that the Framework is able to predict electromagnetic response of complex test objects in various test configurations.


EMC testing campaign on rotorcraft (Agusta Westland, AW139)


Electromagnetic Testing and Simulation on fixed wing aircraft (Piaggio P180)

# 4.4 Safety and Security

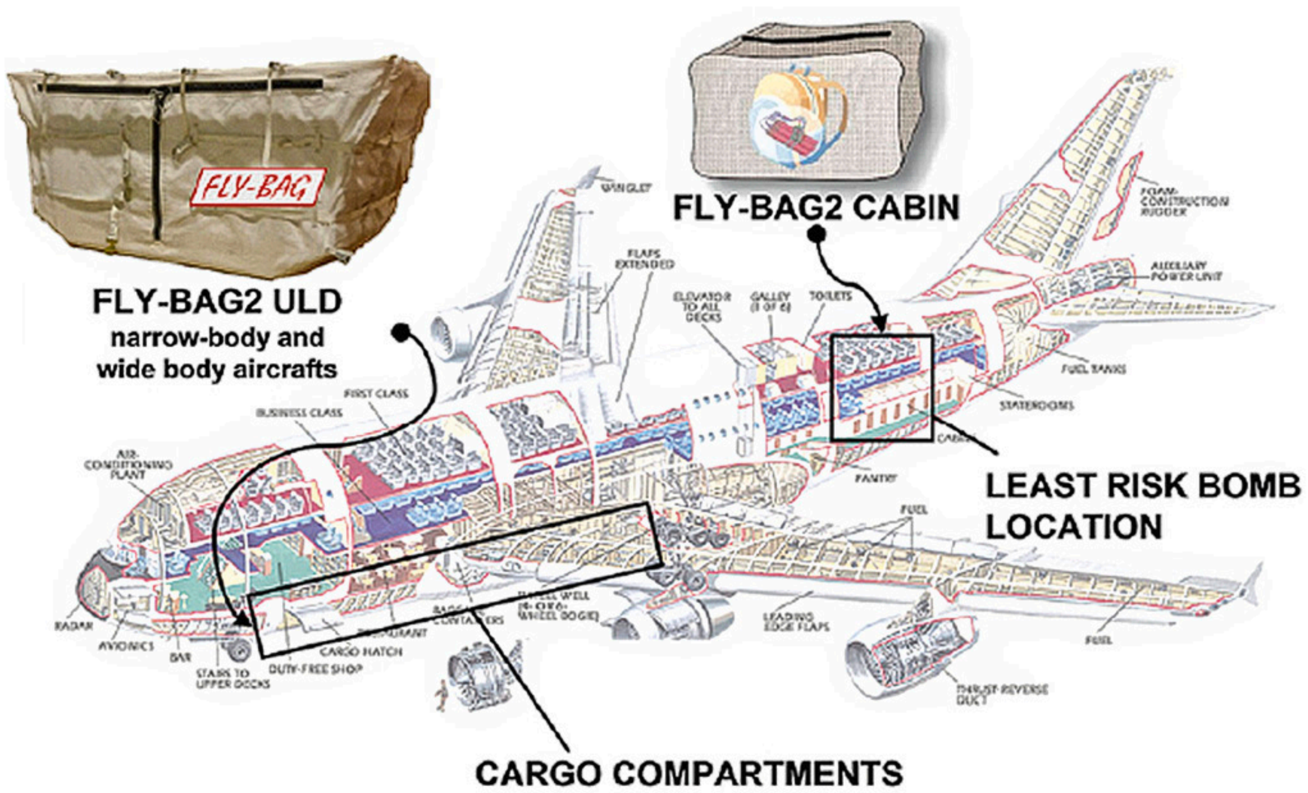
## 4.4.6 FLY-BAG Blast-resistant textile-based luggage container

**FLY-BAG** Blast-resistant textile-based luggage container for narrow-body passenger airplanes, and **FLY-BAG2** - Advanced technologies for bomb-proof cargo containers and blast containment units for the retrofitting of passenger airplanes.

FLY-BAG was an FP7 Project running between 2008 and 2010, with a total budget of 3.057M€ (2.18M€ EC funding) and 7 partners, and was followed by FLY-BAG2, running between 2012 and 2015, with a total budget of 5.68M€ (44.4M€ funded by EC), and 13 partners.

The threat of attacks to passenger airplanes with explosives hidden in luggage loaded in the cargo holds or taken on board is dramatically evident from terrorist events in the past years. Currently available security scans are necessary, but cannot guarantee a 100% detection rate: complementary passive countermeasures are needed in order to protect aircrafts, crew and passengers in case an explosive device is smuggled on board.

The FLY-BAG project developed and demonstrated a blast-resistant textile-based luggage container for narrow-body passenger airplanes. The aim of FLY-BAG2 was to develop new devices for both cabin (addressing the Least Risk Bomb Location requirements) and cargo environments, and to enlarge the experimental validation of the new concepts including full scale tests on retired aircraft. The technology developed has been shown to be effective in neutralising certain sizes of bomb material threat. The devices can be used for low-cost carriers as well as flagship airlines.




# 4.5 Infrastructure and Skills

## 4.5.1 MOOC Introduction to Aeronautical Engineering

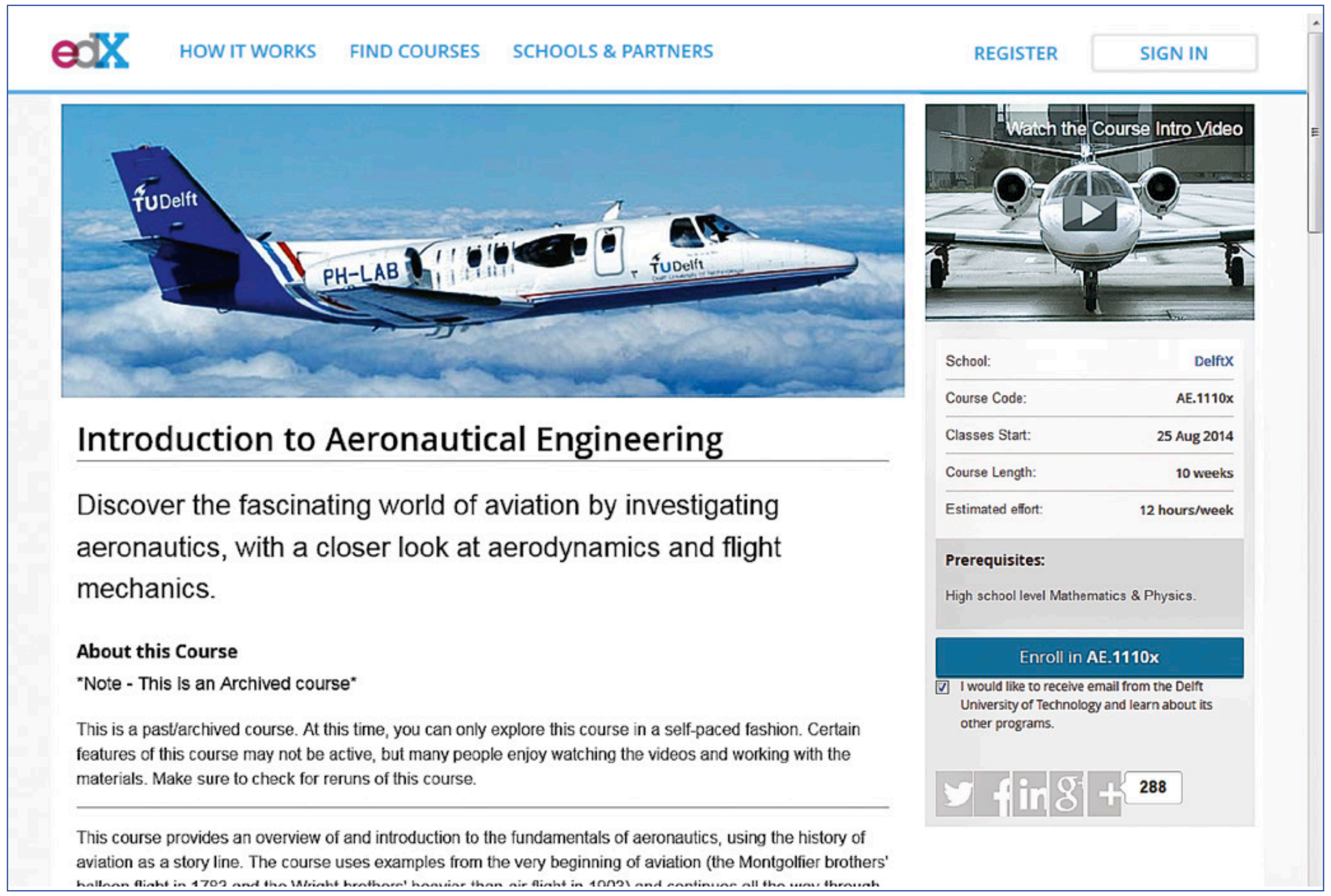
In 2014 the faculty of Aerospace Engineering at TU Delft launched the MOOC (Massive Open Online Course) Introduction to Aeronautical Engineering. This free online course provided an overview of and introduction to basic knowledge of aeronautics. More than 20.000 participants worldwide learnt to make all the essential calculations for every aircraft.

The history of aviation is the leitmotiv for the online course, with examples from the very early days (the Montgolfier brothers' balloon in 1783 and the first aeroplane flown by the Wright brothers in 1903) through to today's Airbus A380 and aircraft of the future. The course is intended for future aeronautics students, professionals in the aviation sector who do not have an engineering background, and anyone with an interest in aviation. TU Delft offers this course as one of the first MOOCs.

TU Delft organised the first two MOOCs in autumn 2014. The number of students who successfully passed these MOOCs was many times more than the annual number of on-campus students.

In two runs the MOOC Aeronautical Engineering attracted over 22,000 students in 2014.

Wherever a person is in the world, the MOOCs give them free access to TU Delft's knowledge. Those taking part view video material, read, carry out assignments, hold discussions on the forum, and can conclude the course with a participation certificate.




A MOOC on the EdX platform

# 4.5 Infrastructure and Skills

## 4.5.2 Design Synthesis Exercise: an engine for innovation

TU Delft has a unique educational programme on new designs in aeronautics and astronautics: the Design Synthesis Exercise (DSE). The DSE regularly leads to spin-off companies and is therefore a true engine of innovation. ATMOS UAV is such a spin-off company which designs and manufactures high quality, highly safe and reliable drones that inspect infrastructures: coastlines, pipelines, harbour quays etc. In a trial to start in spring 2015 the ATMOS drone will be used by the Dutch Ministry of Infrastructure and the Environment to inspect river overflow areas.

The DSE programme forms the closing piece of the third year of the Bachelor degree course in aerospace engineering at TU Delft. In this exercise students work in groups of ten, for a period of ten weeks full time on the design of a (part of an) aircraft, spacecraft, space mission of wind turbine. Of course a major goal is also to improve the students' design and soft skills while working in teams with their fellow students. All teams present their designs to a jury consisting of aerospace professionals from the industry.

ATMOS UAV inspecting a flood area, courtesy of ATMOS UAV

## 4.5.3 DLR School Labs - Best Practice for Attracting Young People to Research and Science

DLR_School_Lab

This project, led by DLR involves 3 partners with a total budget of 11M€.

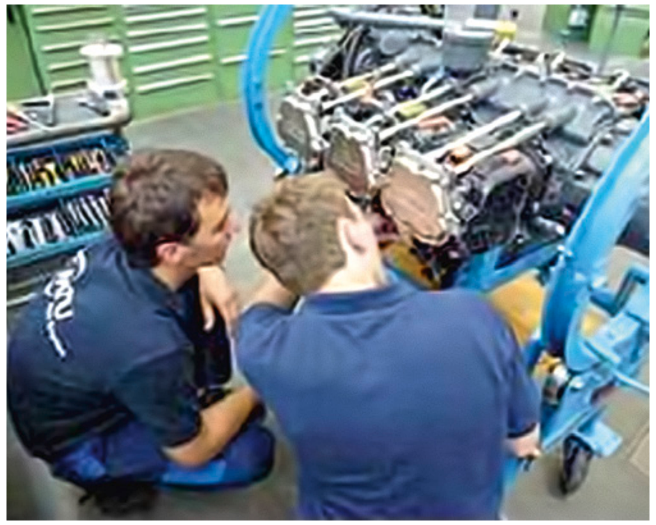
In order to attract young people's interest to the Aeronautics and Air Transport sector, several activities have been successfully implemented on the basis of Vision 2020/ Flightpath 2050. Initially DLR developed and implemented the concept of school_labs, offering hands-on experiments where pupils perform research projects on small scale similar to the actual research projects in the DLR labs. This close to reality research work has proven to convince young boys and girls to start a career in natural sciences and/or engineering. On the basis of the very positive experiences at DLR the EU Project RESTARTS (Raising European Student's Awareness in Aeronautical Research Through School-Labs) fostered the development of school labs in Europe by developing demonstration and experiment materials for schools and allowing European school teams to experience a visit at one of the DLR School_Labs providing direct contact between pupils and DLR researchers.



## 4.5.4 Mobility project for apprentices in the aviation industry led by MTU Aero Engines GmbH

Between 2011 and 2013, MTU Aero Engines, organised a mobility project for apprentices funded by the European Commission. To gain new know-how, intercultural and further key-competences, 12 learners in the technical and commercial vocational field were sent on internships at Rolls-Royce and BAe Systems Operations in Great Britain.

All project goals were met. The apprentices gained relevant expertise as well as foreign language and cross-cultural competences. In a global labour market, such qualifications are extremely valuable for the apprentices themselves and for MTU requiring highly qualified employees. The cooperation between all project partners, including Cassidian Air Systems as a regional partner of MTU, was likewise successful. It led to a long-term and productive collaboration for more mobility activities for apprentices in the aviation industry.



## 4.5.5 Composites FielLab

A public-private partnership between NLR and Fokker Landing Gear where a national research centre shares its research infrastructure with industry in order to, together, achieve new innovations in lightweight materials.

This unique research facility within the Dutch aerospace sector focuses on the industrialisation and follow-on development of automated manufacturing technologies for composite components.

This joint endeavor has led to a remarkable achievement: a Pilot Plant for composite components, or so called Automated Composite Manufacturing (ACM) Field Lab.

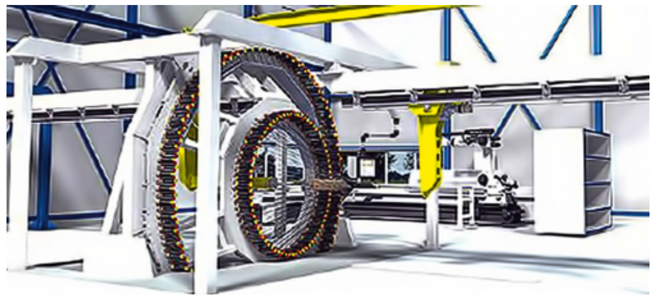
The entire focus is on the further development of automated manufacturing processes for composites, manufactured by means of resin transfer molding (RTM) injections. The project also seeks to optimise the production process, to increase quality and affordability of the products.

The first work undertaken in the ACM Pilot Plant will involve research into automated manufacturing technologies according to the Robot Based Composite Manufacturing' concept, which Fokker Landing Gear and NLR jointly developed in recent years.

The ACM Field Lab also allows other companies to conduct research at high Technology Readiness Levels (TRL).

This is unique in the (Dutch) aerospace sector and also of interest for high tech - high spec companies outside of the aerospace sector.

Ultra-modern equipment has been purchased for this new facility, including a braiding machine for composites, which is one of the largest in Europe. NLR already possessed some of the required equipment in its ACM Technology Centre, where the focus is on TRLs 3 to 6. The ACM Pilot Plant will focus on TRLs 7 and 8.



# 5. Advanced technology innovation spill-over effects

Air Transport has important "multiplier" effects meaning that its overall contribution to employment and GDP is much larger than its direct impact alone.

Indirect benefits of Air Transport include employment and activities of suppliers e.g. fuel suppliers, infrastructure construction companies, suppliers of sub-components as well as a wide variety of business service activities such as IT. There were close to 9 million direct and indirect skilled jobs from Air Transport in Europe and the sector contributed around 600 billion Euro to European GDP in 2010.

**Wider spin-off benefits** from aviation affect industries across a whole spectrum of economic activity including:

- Air Transport is indispensable for tourism, a major engine of economic growth globally.
- Air Transport facilitates world trade, helping countries participate in international markets and allowing globalisation of production.
- Increasing countries connectivity and helping to raise productivity by encouraging investment in innovation as well as improving business operations and efficiency and allowing companies to attract high-quality employees.
- A focus on Research and Innovation helping to enhance research capacity at Universities and research institutes. Every Euro 90 million of investment in research eventually generates an additional around Euro 65 million in GDP year-after-year.

**Aviation technologies are catalysts for innovation**, enabling the fertilisation of developments in many other fields, sectors and domains. Some examples of the numerous spill-over effects that aviation's high technologies and innovation has had on other domains are listed below:

- Complex systems and information technologies including Computer Aided Design, Computational Fluid Dynamics, virtual reality, critical software and systems, micro-computers and vocal command systems.
- Health and medicine, applications of new Titanium alloys prosthesis, ultra-sound scanners, new laser types, digital imagery and related data-processing.
- Automation, robotics and advanced materials including manufacturing technologies and processes (e.g. Additive Layer Manufacturing), precision tools, manufacturing robots, advanced welding techniques, innovative materials and composites.
- Measurement methods and sensing technologies developed for aviation benefit to various domains (advanced sensors and probes, temperature, pressure measurements, non-destructive testing processes, etc.)
- Sports, home and leisure have also benefited from technology eminating from aeronautics with applications including composites sport equipments and gears, break-proof and scratch-proof lenses for optics,

Aviation's unique safety and certification standards warrant complex methodologies and processes to introduce aero-innovations to the market. Applications of such techniques including the modelling of risk management and mitigation, fault-proofing for complex systems can be read across to other sectors.

Beyond the direct catalytic effect for technology, aviation also has indirect benefits to other sectors allowing fast and safe mobility and exchanges in Europe thus contributing to the growth of the European economy as a whole.

The Daurade submarine - @DGA

An example of spill over is "Embedded intelligence in underwater drones" developed by ONERA so that the device can get its bearings and manage its exploration independently, with limited communication in the absence of GPS. In 2010, this work enabled the testing of the mission planning system for the Daurade submarine, performing missions at sea along the French coast. Its scientists are already working on the cooperation between aerial, marine and subsea drones and an operator on the surface.

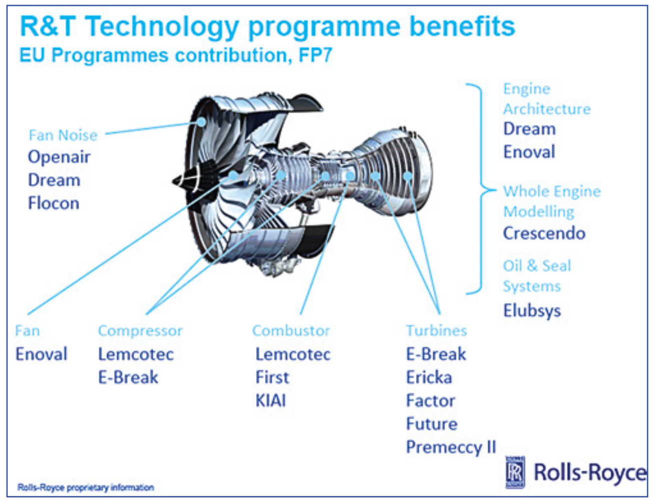
Another example is a Railway Collision Avoidance System (RCAS) developed by DLR based on concepts developed in Aerospace applications. RCAS is a safety overlay system which can be deployed on top of any existing safety infrastructure in train networks. It implements a two-stage Traffic Alert and Braking Command concept: In the first step a Traffic Alert signal shall warn the train driver in case of another RCAS unit on an imminent collision course. Thus, the train driver is prepared to receive a Braking Command in a second step, when the distance to the potential collision point is about to become smaller than the braking distance with some safety margin.

**Today, the aeronautics R&D spending in Europe is close to 12% of turnover (ASD). Spill-over effects of this investment contribute solutions in wider industrial sectors that can be applied or adapted beyond Aerospace.**


Railway Collision Avoidance System, developed by DLR.

# 6. Technology Integration and Application

The results of key research programmes, shown in the attached illustrations, have been applied to the launch of products demonstrating that both EU and National research programmes are necessary in an integrated complex system requiring the participation of entire supply chains.


The aim of Research and Innovation is to provide seamless technology progression.

In the case of propulsion systems this includes:

1. Initial technology concepts and development through the Level programmes.
2. Rig testing on viable technologies within Level 2 programmes; before
3. Final system validation in the Level 3 Clean Sky programmes

As technology reaches a higher level of maturity (Technology Readiness Level- TRL) it can be exploited within the latest integrated systems and sub-systems with the aim of moving closer to the ACARE goals.

Within the Level 1 technology programmes there is a higher involvement and influence by Universities. As the technology moves into the validation phases (Levels 2 and 3) then the larger industrial businesses tend to drive the programmes, supported by Research Institutions and SMEs.

Such an approach to research is applied to other vehicles in aviation. The attached illustration shows programmes applied to the launch of the Falcon 7X.




## Focus on new technologies for cleaner, more efficient and higher-performance rotorcraft

The fruit of several years of National and EU research is the H160 which started the flight test campaign in June 2015. This clean sheet design of a 5.5-6 ton class helicopter will help to keep the European helicopter industry at the helm within its branch while setting new benchmarks in low noise VTOL operations.

The most visible H160 technology breakthrough is Airbus Helicopters' initial production use of its Blue Edge® main rotor blades - result of nationally funded research on ERATO blades jointly designed with ONERA and DLR, which reduce exterior noise levels by 50 percent (3 dB) and also allow a payload increase of up to 100 kg when compared to traditional rotor blades, depending on flight conditions.

The H160 is the first-ever, fully-composite civil helicopter, resulting in an airframe that is lighter in weight, more robust, resistant to corrosion and fatigue, while requiring less maintenance. Airbus Helicopters' proven Spheriflex main rotor hub is further enhanced with the application of innovative composite thermoplastic technology - which reduces weight and increases damage tolerance. A multitude of regional, national and EU-funded research programmes on materials, manufacturing technologies and design techniques contributed heavily to this outstanding structural design.

**The above examples typify the enormous effort that goes into integrating technology resulting from early investment in Research and Innovation to ultimately develop efficient, reliable and safe products to support the growing needs of Air Transport in Europe.**

**To continually reduce the duration of the innovation cycle, aviation requires significant and long term effort in R&D as well as management of system complexity executed in programmes that span over multiple years.**


©Airbus Helicopters Thierry Rostang 2015

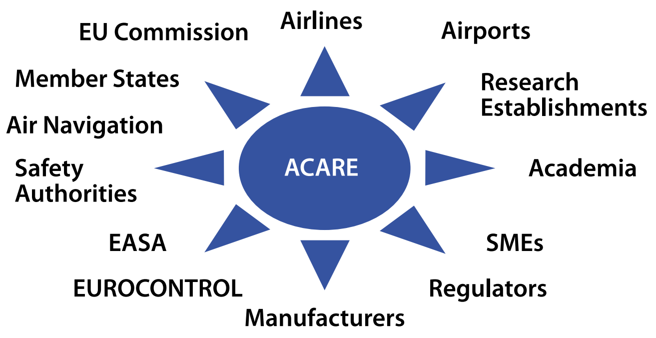
# 7. ACARE - looking forward to the next 15 years

ACARE plays a key role in providing strategic advice on European aviation research and innovation to policy makers and other stakeholders.

Today **Europe is a world leader in aviation**: The SRIA represents a vital contribution to maintaining and expanding this excellence through European, National and regional Public and Private programmes that provide the pathway to research, development and innovation and policies needed to deliver the Flightpath 2050 vision.

ACARE has demonstrated the strength of working closely together across the whole aviation community including air transport, the manufacturing industry, research establishments, universities, regulatory authorities, Member States and the European Commission.

**ACARE brings together hundreds of stakeholders**




Substantial results have been achieved since the launch of ACARE. Projects conducted in Aeronautics and Air Transport across the European community have been wide ranging.

At a European level there are significant programmes underway as part of Horizon 2020 including Clean Sky and SESAR that will deliver much needed solutions that can be integrated into future aircraft and the broader Air Transport system.

ACARE and its stakeholders will continue to play a pivotal role in providing strategic advice to Europe which will include actions in the following areas:

- Strengthening the competitiveness of the European aviation sector consistent with European priorities
- Accelerating the Single European Sky
- Determining the planning priorities for future Air Transport policy initiatives
- Monitoring progress and identifying gaps in research areas and proposing steps to accommodate these in future programmes
- Establishing close links to other transport modes to achieve Flightpath 2050 goals on mobility
- Supporting international initiatives to address global issues for aviation through the work of ICAO

This successful track record for Air Transport in Europe can progress further provided the level of momentum applied to Research and Innovation is such that the much needed innovation continues to be undertaken.

This collaborative framework is essential in developing an even more successful Air Transport System in Europe and long term commitment will be required to achieve the challenging goals set by Flightpath 2050 and the Roadmap set by the ACARE Strategic Research and Innovation Agenda.

It is profoundly important to maintain, strengthen and widen this collaborative framework for aviation to enable the air transport system in Europe to remain competitive at a global level. The challenges which the sector is facing have been and remain huge and long term support and commitment is required from all stakeholders to work together so that Europe stays at the helm of global aviation.

Advisory Council for Aviation Research and Innovation in Europe

www.acare4europe.org

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