Clean Sky

Skyline

Innovation takes off

Special edition
Noise reduction

www.cleansky.eu

Contents

Clean Sky concept aircraft	Noise area (take-off)
LSBJ Business Jet (Innovative Empennage)	Up to -68%
TP 90 (Regional Turbo-Prop)	Up to -71%
GTF 130 (Regional Geared Turbo-Fan)	Up to -76%
Short-Medium Range CROR powered[2]	See footnote
Long Range with 3-shaft Advanced Turbo-fan	Up to -81%
Single Engine Light [3]	Up to -47%
Twin Engine Light	Up to -53%

Monitoring and Measuring Progress

From Clean Sky's outset a robust technology and impact evaluation has been an essential ingredient. The JTI represents an unprecedented approach in European aeronautics research: a public-private partnership with a strong programmatic approach and a timeframe now spanning the full FP7 and H2020 duration. The level of co-investment by industry and the European Commission is unprecedented. When the case was made for Clean Sky, the goal was to bring technology to maturity that could deliver a substantial majority of the ACARE SRA[1] Goals for the Environment for 2020. These ACARE goals relate to aircraft technology available by 2020 for absorption into future product developments and are shown below.

Compared to 'Year 2000 aircraft'

CO2 emissions reduced by **50%**

NOX emissions reduced by **80%**

A **halving** of perceived **noise**

Minimized life cycle impact of aircraft on the **environment**

From the very beginning it was recognized that successfully monitoring progress towards the ACARE goals would require a cross-cutting evaluation platform in the Clean Sky Programme. The Technology Evaluator [TE] was born from this need, and its composition reflects the need to pool know-how and simulation / modeling capabilities that exist among industry, the research establishments and academia.

The approach agreed centered on 'inserting' Clean Sky conceptual aircraft into a number of evaluation scenarios. In essence: the technologies developed, matured and demonstrated in Clean Sky are integrated into a conceptual model of a potential future aircraft. These conceptual aircraft are 'flown' (i.e. simulation scenarios are run) and the Clean Sky configurations are compared to the most relevant state-of-the-art of aircraft of similar size and role in the year 2000. The comparisons are performed at a single flight level, or 'mission'; at the level of illustrative airports; and finally across the global air transport system, or 'ATS'. Here below some examples from the most recent TE simulation results on noise. These point unequivocally to major gains now on the horizon. And as we will see in this Skyline Special Edition, with more to look forward to.

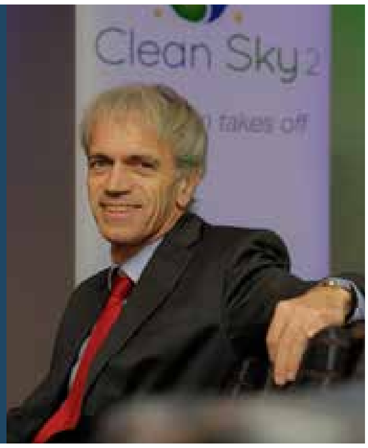
[1] ACARE: Advisory Council for Aeronautics Research in Europe; SRA: Strategic Research Agenda

[2] At time of print a similar comparison was not available for this aircraft concept. However, at the level of an individual aircraft noise impact (EPNdB) evaluations show that these concepts will be compliant with future regulations beyond new Chapter 14, thanks to ongoing reduction in uncertainties and innovative design solutions advanced through Clean Sky

[3] For both rotorcraft concepts these figures relate to the overall full mission level noise footprint and not just take-off

Editorial

Eric Dautriat
Executive Director
of the Clean Sky Joint Undertaking



Our readers are used to finding general information about Clean Sky's progress in Skyline. We always aim to elucidate on both Joint Undertaking policy and the technical content of the research performed by our Members and Partners. This time, we have chosen to focus entirely on one of our environmental objectives and the technical ways to address it: this is a special issue on noise reduction. In the future, we will have further special issues about other transverse areas.

CO2 and noise do not raise the same kind of societal issues. CO2 is global, abstract, and the influence of man-made emissions is complex. The role of aviation is just a small part of it: the impact of any progress is remote and not physically perceivable; it is a collective problem requiring a collective approach. Noise is local, very easy to identify, physical, concrete, and immediate. Decision-makers' sensitivity varies according to their proximity to airports. However, both (CO2 and noise) are environmental issues which would hamper air transport progress if not addressed. Moreover, although both can be measured objectively, they are perceived subjectively by the general public; the role of aircraft in global warming is often exaggerated, as is the actual noise of an aircraft at take-off or landing at some distance when compared to other sources, but this is of course by no means a reason to ignore these issues, particularly given the continued growth of air transport worldwide.

In a society which is often torn between a voluntarily noisy environment (music in some youngsters' clothes shops is close to lethal thresholds!) and an aversion to noise, individual perceptions are key. A lot of research is being performed in order to assess these perceptions, which do not correspond to empirically demonstrable acoustic levels. Indeed, lower-level sources, initially hidden by higher ones, appear to be at least as burdensome once the latter have been eliminated or mitigated through technical progress. Tonal characteristics of aircraft noise sources that are now emerging given the dramatic reduction of jet engine noise are a good example.

Clean Sky is not alone in its endeavour to reduce noise levels. It would simply not exist without national programmes and upstream, EU-funded, collaborative research programmes. The efforts in noise reduction must be addressed globally and transversally monitored. This is why we are reporting here on other projects and other approaches, such as the Open Air project of FP7.

In Clean Sky, our job is to perform the appropriate technological research regarding engines, airframes, and operations in order to speed up the well-observed trend of community noise reduction over the last decades in the relevant areas. Our objectives take the ICAO Committee for Aviation Environmental Protection rulemaking into account; all Clean Sky leaders and research organisations have a strong activity in this area.

For instance, business jets with shielding empennage, regional aircraft with new wing profiles or landing gear fairings, high bypass ratio engines for large aircraft, flight management functions for noise-optimised trajectories, and rotorcraft with 3D-optimised rotor blades are activities which are currently going through the TRL (technology readiness level) gates and reaching the final demonstration stages in Clean Sky. I emphasise the achievements reached so far regarding the Open Rotor (which have already been reported in a previous Skyline issue), which indicate that this concept, focused on fuel burn reduction, should not be noisier than the new turbofan generation currently entering into service. However, these results need to be confronted, later on, with regard to the perception issues I mentioned before, and by further, integrated tests. Generally speaking, the Technology Evaluator now allows us to determine the noise footprint reduction in the vicinity of airports: an average reduction of more than 60% through Clean Sky and parallel programmes, depending on the aircraft segment, is within reach.

Clean Sky 2 will address more noise-related challenges for all categories of aircraft. The ultra-high bypass ratio engines, which might compete or coexist with the Open Rotor in the future, are part of this effort, as well as disruptive aircraft architectures, or adaptive wings, for regional aircraft. We share, of course, the ACARE final goal of limiting the noise burden within the limits of the airport. This is quite an ambitious goal: exactly what we like.

There is far more to say about Clean Sky and noise – cabin noise issues for example, which will be addressed in Clean Sky 2 – than we can possibly address in this special Skyline. However, making hard choices and keeping it concise is the beauty of such a publication.

Eric Dautriat

Overview of international noise research aimed at technology solutions

Dominique Collin (Snecma)
Technology Focal point for ICAO CAEP/WG1 and Coordinator of X-NOISE EV

The task of monitoring noise technology research programmes has been a particular focus of the International Civil Aviation Organisation (ICAO) since the 6th meeting of its Committee on Aviation Environmental Protection (CAEP/6) in 2004. Over the last ten years, it has been working to develop a broader view of worldwide research activity and place the ambitious goals established for the wider initiatives in perspective.

The first dedicated CAEP Noise Technology Workshop was held in Sao Paulo in December 2001 and information on worldwide noise research efforts has been regularly updated since then. This has included contributions to the Noise Technology Independent Expert Reviews held in 2008 and 2011, as well as the status reports provided to CAEP meetings every 3 years.

The latest report presents an overview of noise research efforts up until the end of 2012, covering known national and regional research initiatives and providing an up-to-date view of on-going and planned efforts with respect to their technical scope as well as their set objectives.

It should be noted that the major initiatives reviewed in 2001 (in the US, EU, and Japan) at the time of the first workshop have been either maintained or expanded, while new significant efforts have been initiated over the years in Canada, the Russian Federation and Brazil, giving us a picture of a truly worldwide effort.

Across the various programmes, general observations can be made concerning research goals. Research programmes set stretch (also called aspirational) goals and as a consequence exhibit steeper progress slopes than supported by historical trends at certification level (which already include several steps of technology breakthrough). From a timeframe perspective, research goals also tend to consider the availability of validated novel technologies at TRL6 (or below), not their successful implementation at industrial level (TRL 8).

Moreover, a general trend is now to consider research aimed at environmental goals as an integral component of global strategic initiatives as observed with ACARE and NextGen, bringing the capability to comprehensively address all elements of a balanced approach as well as environmental interdependency issues. As such, rather than aiming solely at specific technology goals, these initiatives offer a combination of technological and operational solutions that can be effectively associated with the realisation of the global environmental goals.

This overview of the research situation demonstrates a significant commitment of all research stakeholders (manufacturers, research establishments, and funding agencies) to investigate and develop novel technology solutions aimed at reducing noise at source. However, it should be noted that beyond the stated research goals, anticipated progress trends will remain conditioned by several factors such as the capability to ensure viable industrial application for promising technology breakthroughs as well as the commitment to maintaining steady funding over a significant period of time.

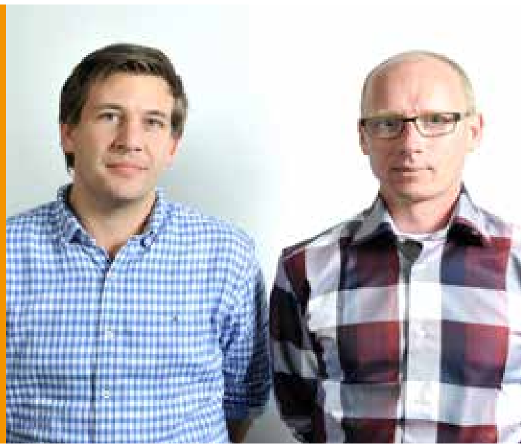
> "A general trend is research aimed at environmental goals as an integral component of global strategic objectives"

This article outlines the information provided in the CAEP/9 Information Paper 14, summarised in a dedicated article as part of the 2013 ICAO Environmental Report, which can be accessed at http://cfapp.icao.int/Environmental-Report-2013/.

Further information on European research projects is also available at www.xnoise.eu

Experience the sound of tomorrow's aircraft today

Michael Arntzen and Michel van Eenige
NLR Virtual Community Noise Simulator



Virtual Community Noise Simulator

NLR has a long track-record and profound knowledge of calculating aircraft noise. This knowledge has been applied in the development of a unique facility: the Virtual Community Noise Simulator (VCNS). Using the VCNS, people are able to experience the sound and visuals of an aircraft flyover in a virtual reality environment. As such, the VCNS can be used to pre-evaluate new air routes and procedures or aircraft types and technologies without the need to conduct a real flight and have staff on site to collect data. The virtual reality environment immerses a person in a visual scenario, thus offering a complete experience that offers more than just audio. Furthermore, the immersion is augmented by the modelling of three-dimensional audio effects that allow localisation of a source by listening.

The audio of the scenario can be based on either recordings or so-called auralisations. A recording determines the authenticity of the simulation and fixes atmospheric conditions and the aircraft trajectory. To circumvent any restrictions, digital signal processing techniques can be applied. It is even possible to transform an aircraft noise prediction into an audio signal that can be listened to in the simulator. This is what is meant by auralisation. Consequently, aircraft that are still in the design stage can be experienced today in the VCNS.

Opportunities for Clean Sky 2

Within Clean Sky 2, several research initiatives are directed towards obtaining quieter aircraft flyovers. This is made possible by adapting innovative noise reduction technology to the aircraft or by implementing noise abatement procedures. By altering aircraft engines or the airframe, there is potential to reduce the source noise of an aircraft. Results of such an approach are not always best assessed on paper, especially when communicating with stakeholders. In NLR's experience, adding a small simulation based on the VCNS adds to the impact of a result. In the Netherlands, NLR has recently executed a study where, after a long study on aircraft route/noise mitigation, the end results were presented to the general public using the VCNS.

For Clean Sky 2, where novel aircraft or low noise technology emerges, it would be a good exercise to assess the actual audible impact compared to today's (reference) aircraft. The impact of a new engine on an aircraft, e.g. an ultra-high by pass, contra-rotating open rotor or geared turbofan, could be assessed in a scenario near a large airport. This also offers an opportunity to help select the most promising noise reduction technologies and to demonstrate them to industry, the European Commission, communities in the vicinity of airports (or the public in general) and other interested stakeholders.

Conclusions

NLR's Virtual Community Noise Simulator offers new ways to actually listen to and experience future aircraft scenarios in a virtual reality environment, rather than studying deduced aircraft noise contours. As such, it provides clear opportunities to evaluate Clean Sky 2 technologies (including effects of atmospheric conditions), to support the selection of the most promising aircraft designs, and to inform communities on the expected noise benefits of these new technologies.

The National Aerospace Laboratory (NLR) is the independent knowledge enterprise on aerospace in the Netherlands. The overall mission is to make air transport and space exploration safer, more sustainable, and more efficient.

Interviewing the European Commission

Rudolf Strohmeier

Deputy-Director General,
DG Research and Innovation

Mr. Strohmeier, you are the new representative of the European Commission on the Clean Sky 2 Governing Board. How do you see the challenges in front of you for the new programme?

The Public Private Partnerships (PPPs), including Clean Sky 2, are an important instrument for the European Commission to address specific societal challenges in cooperation with industry. These partnerships cover the entire value chain, helping to structure the sector and facilitate standardisation in the sector. And of course they mobilise public and private funds which leverage additional private investments to develop new technologies, products and services addressing the concerns of citizens and society. By that, they keep the European industry competitive in world markets and contribute to growth and jobs in Europe.

> "Clean Sky 2 will succeed in bringing innovative technologies for the greener and quieter aircraft of the future"

That is why it is important for me to represent the public interest on the Clean Sky 2 Governing Board. There are a lot of challenges in front of us. Clean Sky 2 has more ambitious objectives and higher investment compared with the previous programme. It will therefore require stronger commitment from both public and private partners in order to achieve the goals. At the same time, we should exploit the political and financial complementarity between the Clean Sky 2 programme and EU Structural Funds, allowing the leveraging of national and regional activities.

How do you see the impact of Clean Sky 2, which is strongly focused on innovation, in the global development cycle of new technology and products in aeronautics?

World air traffic is expected to double during the next twenty-thirty years, supported by increasing levels of air travel demand and improved air traffic management operability. If we want to mitigate its environmental impact, energy efficiency and environmental sustainability should continue to be the main drivers for future technology development.

Clean Sky 2, which brings together more than € 4bn of research activity jointly funded by European tax payers and aeronautical stakeholders, is targeting those innovations which can bring the biggest advances in the next generation of aircraft, in order to have maximum environmental impact and provide breakthrough innovations. Clean Sky 2 is the core European programme for this purpose and it will be complemented by further activities funded at national, regional and private levels. That is why I am confident that with its ambitious objectives, high investment and strong industrial commitment, Clean Sky 2 will succeed in bringing innovative technologies for the greener and quieter aircraft of the future, meeting environmental and competitiveness challenges in the near and long term perspective.

The European Commission is keen on improving the quality of life of Europeans. Aircraft noise is an important issue. What priority should it get among the Clean Sky 2 objectives?

The development of less polluting air transport has important social and economic impacts. Exposure to aircraft noise, in particular, has an adverse effect on quality of life and public health. In addition, noise pollution also has an important impact on future extensions of airports which, in Europe, are reaching their capacity limits and are often close to cities. Reducing noise pollution is one of the key objectives of the European Union's transport policy, and it remains high on the agenda of public concern. It has therefore been chosen as one of the main objectives of the Clean Sky 2 programme, along with the CO2 and NOx emissions reduction.

I know that reducing noise levels is a complex task which requires a broad approach, including various operational and technological aspects. Nevertheless, I am convinced that Clean Sky 2, due to its true collaborative spirit and large support, will be a very appropriate tool for addressing aircraft noise reduction at the source, through innovative low noise technologies and novel engine architectures.

The SME perspective

Simplified rotorcraft noise models

Nico van Oosten
CEO of Anotec Engineering (Spain)

One of the objectives of the GRC5 project within the Clean Sky Green Rotorcraft ITD is to implement a tool to minimise noise impact on the ground that is capable of being executed on-board "on-the-fly", providing flight directives to the Flight Management System of the helicopter. The semi-empirical model to be used for this purpose requires information to be derived from experimental data. For this purpose, noise measurements have to be made simultaneously on the outside of the helicopter (i.e. close to the noise source) and on the ground.

The main objective of the ANCORA project was to develop and validate the measurement systems and methodologies required to derive the transfer functions between on-board and ground-based microphones.

anotec engineering

Installation of surface microphones on helicopter fuselage

Until now, microphones on the outside of helicopters have mainly been used to measure the influence of e.g. the boundary layer noise on interior cabin noise or as error signal sensors in active rotor noise control systems. In these applications, the requirements regarding the microphone type and its location are not particularly stringent. The application in the ANCORA, however, requires the accurate measurement of the absolute noise levels on-board, which requires the appropriate selection of the microphone location on the helicopter exterior.

As a first step, the feasibility of the application of surface microphones on the helicopter fuselage was demonstrated with specific flight tests on the AW139 prototype, during which the best position for the surface microphones on the helicopter was selected and their use for the purpose of the project was validated.

The main challenge for the development of the ground-based measurement system was to provide a robust and reliable noise measuring system, comprised of 31 microphones, quickly deployable in the field over a wide area at a reasonable cost. After investigating a variety of options, a solution was found based on the latest generation of sound level meters, adapted by the manufacturer (Svantek) for the specific use of ANCORA.

An advanced methodology to determine the transfer function between the noise measured on-board the helicopter and the noise measured on the ground was developed.

During a flight test campaign with a small turboprop in Trebujena (Spain), simultaneous noise measurements were made on-board and on the ground with the systems developed earlier to obtain a comprehensive database for a variety of operating conditions and flight procedures. The data obtained was used to test and validate the algorithms developed.

Based on the research performed in ANCORA, it can be concluded that it is feasible to derive transfer functions between the noise measured on-board the helicopter and the noise measured on the ground.

The developed systems will now be applied during a new flight test campaign with the AW139 prototype to derive the transfer functions for this helicopter for its further use in GRC5.

A spin-off of ANCORA is the availability to the EU aircraft industry of a robust and reliable mobile noise measurement system, easily scalable and optimised for minimum deployment time, at a cost substantially lower than that of systems currently used. Having such a system readily available for flight tests anywhere greatly enhances the possibility of its use in research projects with a relatively limited budget, thus allowing for a significantly increased knowledge of rotorcraft (and also fixed wing aircraft) noise, one of the main objectives of Clean Sky.

Tackling noise of highly fuel efficient engine concepts for future narrow-body airliners

Damien Prat, Pierre Spiegel and Jens Koenig
Airbus

The air transport sector has an important contribution to make to the continuously increasing demand for fast and convenient transportation. Intensive research is required to develop technologies which meet these needs and which also contribute to the ACARE CO2 and noise emissions goals.

Airbus, a leading partner in the Clean Sky programme, is addressing this challenge in several ways: A fast route, in which incremental product improvements are introduced into products through upgrades whenever they become available as mature technologies, and a strategic route, in which technologies with even higher improvement potentials are developed and matured in collaborative research programmes in close cooperation with the contributing industries and with the involvement of research establishments, SMEs and Universities.

While the Airbus A320neo and Airbus A330neo are best-practice examples of the fast application of technology, Clean Sky is one of the most significant programmes for the strategic route. Europe´s Clean Sky is a flagship programme hosting important projects to mature technologies with the potential for application in future short and medium haul airliners in the 2030+ timeframe.

Joint design studies by Airbus and different engine manufacturers show that the best candidates for future aircraft propulsion systems are the Ultra High Bypass Ratio engine (UHBR) and the Contra Rotating Open Rotor (CROR). Each engine is competing to provide another double-digit fuel burn improvement beyond the latest state of the art large turbofan engines. Mainly due to its even higher effective by-pass ratio compared to the UHBR, the CROR has an even higher potential for a lower fuel burn. However, key challenges of the CROR engine are the optimisation of the integration of the aircraft-propulsion system in terms of weight and noise emission.

In close cooperation with engine manufacturers Snecma (Safran) and Rolls Royce, a major focus of research and development activities in Clean Sky is placed on tackling the noise of the CROR propulsion system installed on a single aisle type of large passenger transport aircraft. The CROR noise signature is mainly due to the aero-acoustic effect of the rotor blades in the absence of the shielding of a surrounding nacelle. Compared to a single propeller the interaction between the front and rear rotor generates additional noise.

Airbus's design studies under Clean Sky have included large wind-tunnel test campaigns, involving isolated, semi-installed and powered full aircraft models of open-rotor configurations at 1/5th and 1/7th -scale at low and high speed. As outlined in more detail in the accompanying article by Giuseppe Pagnano, Coordinating Project Officer at the CSJU, the low speed tests pursued in the large low-speed facility (LLF) at DNW in the Netherlands involved three blade designs from Snecma, Rolls-Royce and Airbus which emerged from a subsequent development in three generations of rotor blade geometries mainly in research projects involving Snecma-HERA and Clean Sky. Some of these configurations were replicated at 1/5th scale for complementary experimental high-speed

1/7th scale aero-acoustic wind tunnel test model of a CROR powered single aisle airliner with the Airbus CROR blade geometry in the DNW wind tunnel in early 2013. This configuration has also been used for numerical tool development and validation in Clean Sky.

characterisation in the ONERA S1 test facility. All three designs featured a low CROR isolated acoustic signature and high propulsion efficiency at cruise speed, indicating very good fuel efficiency for real aircraft application.

Tests conducted with different configurations in pusher and puller configuration and with different engine locations demonstrated that for the noise emission with CROR engines installed into the aircraft, a strong potential with respect to overall noise performance, fuel efficiency and aircraft operation can be expected with a pusher configuration with engines mounted on the rear of the fuselage.

The transposition of the various experimental results to real size engines and aircraft with the latest CROR blade geometries and with the best tested aircraft configuration indicate that the noise level could satisfy the strict "ICAO Chapter 14" regulation, which is expected to replace the current "Chapter 4" noise regulation in 2017.

However, as the fuel, noise, and operational performance of an aircraft with such a radically new engine concept is so critical for the success of a potential future Airbus aircraft, the results achieved in research so far should be validated through full scale demonstrations of the engine in both ground and flight conditions.

The test of a full scale ground test engine developed under the lead of Snecma is scheduled to take place in the Clean Sky SAGE2 in 2016. A flight test demonstration of the most promising engine is planned in Clean Sky 2 within the Large Passenger Aircraft (LPA) programme.

For further information - see also the Snecma article in our last issue - Skyline 13, June 2014.

Smart Fixed Wings: successful large scale contra-rotating open rotor tests

Giuseppe Pagnano
Coordinating Project Officer, Clean Sky JU

In the framework of the Clean Sky project for Smart Fixed Wing Aircraft (SFWA), low-speed aerodynamic and aeroacoustic wind tunnel tests have been carried out on a large scale Contra-Rotating Open Rotor aircraft model. Two test entries have been performed in both the closed (performance & handling qualities) and open (noise) test section of the Large Low Speed Facility LLF of the German Dutch Wind Tunnels (DNW-LLF). The model was supported by a ventral (for the aerodynamic tests) and dorsal sting set-up (acoustic tests), which were mounted to the LLF torpedo system.

Airbus, responsible for the design and production of the 1:7 scale model of a future A320-like aircraft, provided a model (designated Z08) equipped with 2 CROR engines, developed by NLR. The model, equipped with hundreds of static pressure ports on the fuselage, wings, and tailplanes, also contained a large amount of unsteady pressure sensors on the air-motor driven CROR blades, powered by the DNW air supply system. An innovative NLR Rotating Shaft Balance RSB and telemetry system facilitated a step-change in data stream acquisition; approximately 50 terabytes of data were collected (equivalent to an MP3 playlist that would take 48 years to get through!).

A second test entry in December 2012 – January 2013 was one of the most lengthy (35 production days, only interrupted by 11 calendar days during Christmas) and successful test campaigns conducted at DNW, with an unprecedented level of productivity, consuming more than 1000MWh of energy and 2500 tons of compressed air. This could only be achieved thanks to the dedication of the highly skilled integrated test team of Airbus, DNW, and NLR all of whom were responsible for the daily operation of the model and facility, as well as the acquisition and online analysis of the data that allowed efficient supervision of the test programme.

Progress on aviation noise research in Europe

Eric Lecomte
European Commission, DG Research and Innovation, Aviation

Eugène Kors
SAFRAN Snecma - Research & Technology

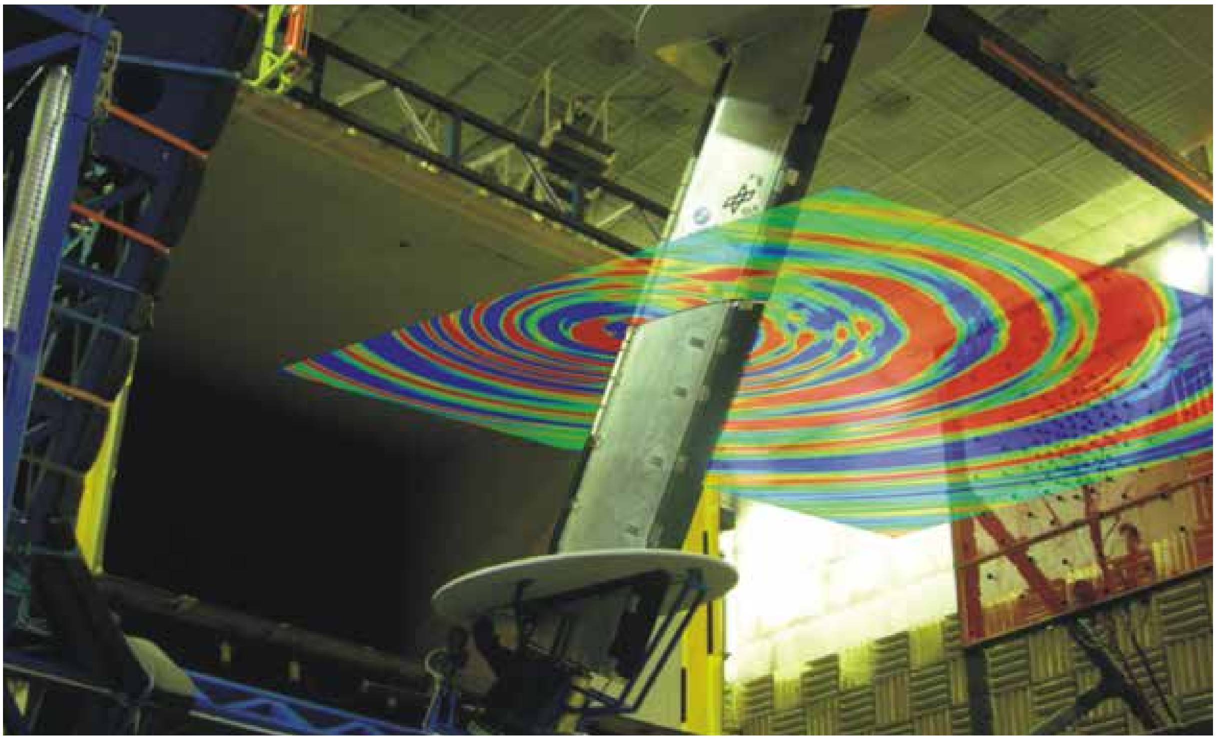
World air traffic is expected to more than double by 2050. Main airports are already under constant pressure already today to sustain current capacity levels and face strong resistance from the public regarding their expansion to meet expected traffic growth. The health and nuisance effects from aircraft emissions, especially noise emissions, figure as one of the key hindering factors. It is therefore necessary to mitigate the noise impacts of air traffic to ensure that air transport continues to support European economic growth.

In 2010, the European Commission invited a group of high level personalities to define Europe's Vision for Aviation 'Flightpath 2050', setting the ambitious goal of reducing perceived noise by 65% compared to levels in the year 2000. In technical terms, this target translates into the ACARE goal of reducing perceived noise by 15dB per operation by 2050.

The Research Framework Programmes have contributed significantly to this objective. The FP5 projects SILENCE(R), SOURDINE, and FP6's VITAL reduced noise by 5dB using first generation noise reduction technologies and noise abatement flight procedures. The noise research effort continues in eleven FP7 projects with a total budget of around €75m. Research initially focussed on the engine, but as this was significantly reduced, other sources, like airframe high lift devices and landing gears, became relatively significant and were also tackled.

In September 2014, the FP7 project OPENAIR (OPtimisation for low Environmental Noise impact AIRcraft) was completed. Even at proposal level it aimed to include the most promising technologies by organising a competitive call for ideas. Once started, it developed and down selected the best performing technologies to be demonstrated in large scale wind-tunnel tests. Engine and airframe technologies were eventually matured to TRL4-5, and contributed to reducing noise around airports by 2.3 dB.

Beyond the reduction of noise at source and noise abatement procedures, the balanced ICAO approach towards noise management around airports also includes operations restriction, land use planning, and more recently local community outreach. On this subject, the FP7



OPENAIR Large scale acoustic wind tunnel test – © OPENAIR

COSMA project investigated the sources of annoyance and revealed that acoustic factors account for only part of the annoyance. It highlighted that more transparent communication with surrounding communities also contributes to better acceptance of air transport noise.

Noise issues are actively discussed in the EU-funded support action X-NOISE and in the ACARE working group on Energy and Environment in which the European Commission also participates. In addition to this, several open workshops have been organised by X-NOISE and the working group. The latest workshop took place in October in Brussels to discuss future trends in aviation noise research. The progress of noise research was presented, including work performed in EU collaborative research, by the Clean Sky and SESAR Joint Undertakings, as well as at national and international levels. Future research perspectives were discussed: further maturation of passive noise source reduction technologies and abatement procedures, development of new generation active noise technologies, investigations into breakthrough propulsion systems and novel aircraft configurations, and improvement of annoyance measurement and communication tools. A number of potential synergies were identified between the activities of the joint undertakings and those of national and collaborative research programmes, depending on the technological maturity level and focus - vehicle or operations - of the research activity.

The Coordinator's insight into OPENAIR

OPENAIR started on 1st April 2009 as a programme on aircraft noise reduction with a total budget of €30 million, 60% of which was provided by the European Commission. The project objective was to deliver a 2.5 dB noise reduction at TRL5 for both engine and airframe noise sources beyond the SILENCE(R) achievements. To do so, OPENAIR focused on validation of so-called "Generation 2 technologies", such as electronically assisted solutions, designs exploiting improved computational aero-acoustics, and new affordable absorbing materials. Incorporated in the work were trade-off studies on engine cycles, turbomachinery and nacelle aerodynamics, and acoustic liner design. Solutions included active/flow control techniques with parallel studies on mechanical integration and manufacturing.

- The engine noise technologies focused on both the turbomachinery design by creating a low noise signature at the source as well as by optimising the attenuation/re-direction of the sound through innovative nacelle configurations. Among the technologies validated by OPENAIR are MDO Outlet Guide Vanes (OGVs) and acoustically lined OGVs as well as an active noise control OGV system with loudspeakers in the stator vanes that are capable of both forward and rearward radiated fan noise control. A "Folded Cavity inlet liner" performed well thanks to a large space that is folded behind the conventional liner. The highly curved bypass duct technology proved beneficial through improved noise attenuation characteristics thanks to the adapted duct shape. Many configurations of supplementary liner areas in the bypass duct were tested, both "splitters", which fully cover the duct height, as well as so-called "fins", which protrude halfway into the duct. To change the directivity of the rearward radiated fan noise, the scarfed nozzle technology proved successful, and the "Microjet" technology reduced jet noise by blowing air at the nozzle exit.
- Under the Airframe Noise sub-project, technologies were developed that focused on the main landing gear and on wing slats and flaps: A low noise landing gear design grouped all efforts to design landing gear components to a low noise configuration. Among these, the aft placed deceleration plate worked well in reducing the upstream velocity in the gear structure and in thereby reducing noise. In the adaptive slat concept, a morphing trailing edge of the slat that could fully close the gap between the wing and the slat enabled quiet operation. On the flaps, porous flap side edges performed well during large scale wind tunnel testing.

Following OPENAIR, now that these technologies are at TRL4/5, a final validation phase will be needed at full scale to prove the technical feasibility and economic viability.

At the final OPENAIR project meeting in September 2014 the 47-strong partner consortium under the leadership of SAFRAN/Snecma celebrated their successes after 5 and a half years of fruitful collaboration. Working on noise reduction technologies for both engine and airframe related noise sources, a total of 15 technologies were validated to TRL4/5 through large scale testing on fan rigs, jet noise facilities and wind tunnels. The technology evaluation of OPENAIR showed through an airport impact study that the combined benefits of these technologies could bring an average reduction of 2.3 dBs per operation.

The way ahead for Green Regional Aircraft

Andrzej Podsadowski
Green Regional Aircraft Project Officer, Clean Sky JU

Regional aircraft typically operate over airports with a high frequency of take-offs and landings located near densely populated areas. As such, they contribute significantly to community noise and gas emissions. These issues currently limit the further growth of air traffic operated by regional airliners across the world, which will have to face even more stringent environmental rules in the near future.

In accordance with ACARE's *European Aeronautics: A Vision for 2020*, which aims to drastically reduce the environmental impact of air transport over the coming decades, the following three breakthrough technologies are being investigated as part of the Clean Sky GRA ITD – Low Noise Configuration (LNC) domain (see Figure 1):

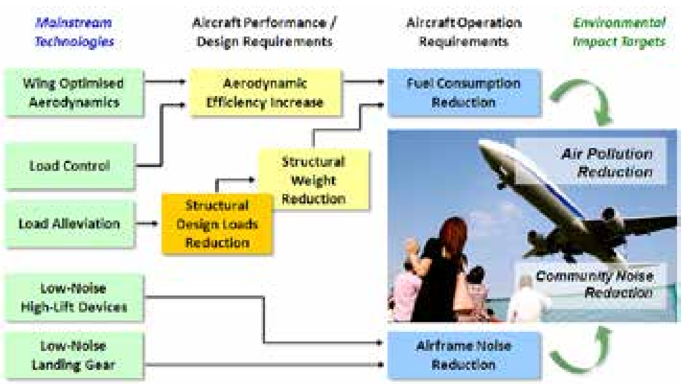


Fig. 1 – GRA ITD LNC domain: project logic

1. **advanced aerodynamics and load control** (LC) to enhance the lift-to-drag (LoD) ratio over the whole flight envelope, thus reducing fuel consumption and air pollutant emissions while also allowing steeper noise-abatement climb paths;
2. **load alleviation (LA) to prevent loads from exceeding given limits at critical conditions** (gust encounters or high-speed manoeuvres), thus optimising wing structural design for weight saving;
3. **low airframe noise to reduce acoustic impact in the flight approach phase.**

Research looking into relevant concepts and technical solutions, tailored to different configurations of future regional aircraft, namely 130-seat rear-engine geared turbofans (Figure 2) and 90-seat wing-mounted engine turboprops, (Figure 3) has been carried out.

The findings are: 1) Natural Laminar Flow (NLF) wings for highly-efficient aerodynamics; 2) active control of wing movables and aeroelastic tailoring for LC/LA functions; 3) HLD innovative architectures (droop noses, morphing flaps) as well as more conventional ones (Kruegers, standard flaps); 4) low-noise solutions for HLD (liners, fences) and for landing gears (bay acoustic treatments, fairings, wheel hub caps, etc.).

The technology maturation road map aims to develop, assess and, ultimately demonstrate the relevant technologies in an experimental environment (TRL 5)

Fig. 2 – GTF 130-seat green regional A/C

Fig. 3 – TP 90-seat green regional A/C

that replicates actual in-flight operational conditions. So far these have been developed on a multidisciplinary basis (aerodynamics, aero-structures, aeroacoustics, systems, etc) through high-fidelity numerical Computational Fluid Dynamics (CFD)/Computational Strucutral Mechanics (CSM)/Computational Aeroaviation Analysis (CAA) methods and virtual modelling CAD/CAE tools and, when applicable, validated by preliminary WT tests and laboratory experiments on mechanical prototypes.

To-date the main achievements are as follows.

- Transonic NLF wing CFD design;
- Load Control (through differential deflections of small T/E tabs combined with split ailerons);
- Load Alleviation (based on feedforward/feedback control of ailerons (symmetrically deflected and elevator);
- High-Lift Devices: a) 3D CFD/CAA analyses and 2D WT tests to assess aerodynamic/aero-acoustic performances of various architectures; b) mechanical design and functionality tests on a small morphing flap prototype based on a smart actuated compliant mechanism; c) mechanical design of an innovative droop nose, based on a rotational drive lever mechanism assisted by SMA patches to deform skin.
- Landing Gear: CFD/CAA based development of low-noise solutions.

Ongoing activities concerning preparation of technology demonstrations, either through WT tests or ground tests:

- Wind Tunnel (WT) demo of NLF wing design and of high-speed LC device performances on a half-wing innovative elastic model (Figure 4) reproducing the wing static deformation (bending and torsion);
- WT demo of a gust load alleviation strategy on an aero-servo-elastic A/C half-model, reproducing a wing structural dynamic response;
- WT demo of landing gears low-noise configurations on a full-scale mock-up of nose landing gear (NLG) (Figure 5) and main landing gear (MLG);
- Ground demo of droop nose mechanical prototype (Figure 6);
- Ground demo of morphing flap on a full-scale mechanical prototype, sized to the inner half outboard flap;
- Ground demo of LC & LA system architecture on a test rig integrating a real/partially simulated HW/SW environment.

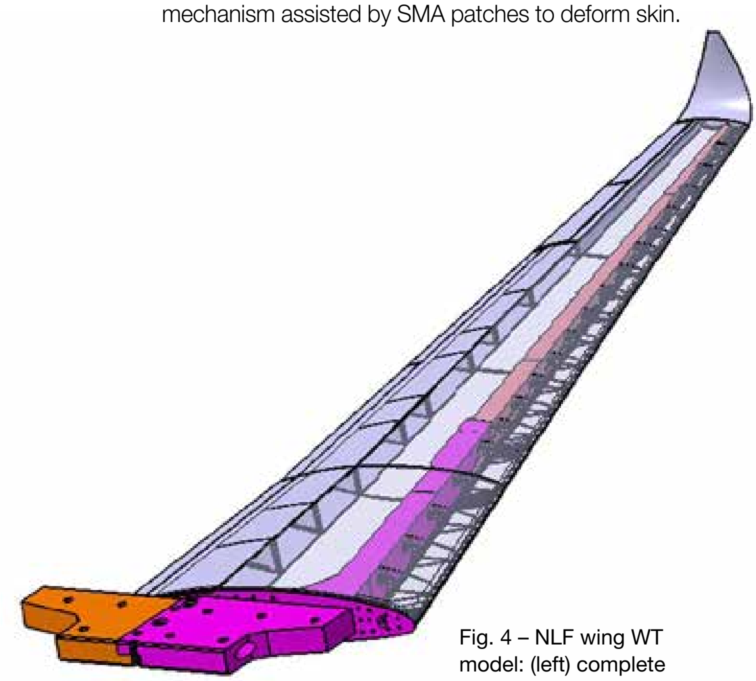


Fig. 4 – NLF wing WT model: (left) complete model CAD geometry; (right) steel outboard spar HW

Fig. 5 – NLG WT model HW (partial assembly) with ramp-type spoiler (low-noise solution)

Fig. 6 - Droop Nose mechanical prototype HW

Farnborough International AIRSHOW

14-20 JULY 2014

Clean Sky at Farnborough Air Show

Clean Sky was present at one of the highlights of the European aeronautics calendar, the Farnborough International Airshow from 14 – 18 July 2014.

The 'Innovation Zone' hosted the Clean Sky Demonstration Stand, which displayed 13 items of hardware from the different technology platforms of the programme. The stand offered a wide range of additional activities including live demonstrations of the hardware, audiovisual material, and documentation offering further technical explanations. Part of the stand was devoted to the recently launched Clean Sky 2 programme and detailed information regarding the current and forthcoming Calls for Proposals.


Clean Sky team at Farnborough Air Show


High Compression Engine for helicopters part of GRC ITD

Clean Sky Demonstration Stand at the Innovation Zone


Contra-rotating open rotor project part of SAGE ITD
of Clean Sky Programme


Carbon Titanium (CTi) Fan Blade part of SAGE ITD

Clean Sky 2: quietly climbing out beyond the threshold

Ron van Manen
Clean Sky 2 Programme Manager
and Clean Sky Technology Evaluator Officer

When our previous Skyline edition was published the Clean Sky 2 Regulation had been adopted and was poised to enter into force. I drew the analogy of an aircraft reaching its rotation speed on the runway before lifting off. Now, with this Special dedicated to noise, let's see what we can expect to hear from the CS2 in the near future as the Programme climbs out beyond the runway threshold.

To start: CS2 will *build on and extend* efforts underway in Clean Sky. Thus progress currently being made will culminate in a number of large-scale demonstrator projects in CS2: among them, several with significant efforts focused on noise reduction. The CROR concept will be demonstrated in-flight. This should allow us to confirm the recent game-changing results with respect to this technology's viability in aviation's future, compared to results of the earlier 'unducted fan' of the 1980s.

In parallel new CS2 projects will commence on mid- to large thrust engines based on "ultra-high bypass ratio" or "ultra-high propulsive efficiency" architectures; deploying step-changes in the engine's bypass ratio and pressure ratios, and often using geared fans. The technological challenges are equally daunting, with subtle but important differences. Limiting the mass ["weight"] and wetted area impact of higher bypass ratios and highly loaded gearboxes; finding innovative solutions to the airframe-engine integration, where the increased fan size poses aerodynamic, structural, stability and aero-elastic issues not yet addressed. Implications for airport and airline infrastructure may need to be understood and mitigated. But the potential for strong gains in aircraft noise is clear. Together with the CROR concept: tomorrow's aircraft designers will be equipped with a range of propulsive options that will address the needs for energy efficiency and minimal community impacts.

Looking further afield, we'll see exciting new efforts getting underway towards distributed and hybrid propulsion architectures. These potential drivers of a "configuration revolution", will enable CS2 to make important first strides towards the new and far more challenging SRIA goals for 2035 and ultimately 2050. They can enable performance leaps in noise shielding and containment, and shift the needle in aircraft performance in the longer term future.

> "We expect a steep performance curve coming out of CS2 projects"

Continued efforts in regional aircraft and business aviation will deliver gains in noise performance; plus, new to CS2: small air transport. The drive towards a regional 90-seat turboprop will see the next stage of research and demonstration planned for CS2 looking at airframe noise (for instance through advanced high-lift systems) and importantly: the propulsion via next-generation turboprop engines and propellers. As this is a field with relatively modest gains and research efforts in the past decades, we expect a steep performance curve coming out of CS2 projects. Likewise in small, utility or commuter aircraft represented in the SAT projects: calls underway or being prepared in the upcoming year will bring together participants and projects that can bring a major innovative impulse to the overall propulsion architecture, improving noise to levels enabling new mobility options from small community airfields to become viable both economically and environmentally. Continued efforts in business aviation will solidify the European sector's already admirable performance and keep the drive going towards quieter and more efficient business jets able to operate from local airfields.

And finally in CS2: two new rotorcraft concepts aim to bridge the performance gap between traditional helicopter configurations [and payload/range capability] and regional turboprops. With vertical take-off and landing coupled to "aircraft type cruise performance", new modes of operation will come within reach, and could bring new air connections. Noise performance will again be an area of focus, especially in terms of operations and flight trajectories that minimize community impacts.

So, as you can see there is symphony of noise related activity that will help address some of the key challenges in aviation's future.

Call 16
Closing date: 03/04/2014

30 topics were published with a total value of **€23,655,000** and a **maximum funding level** of **€17,700,000.**

72 proposals were submitted, **5 of which were ineligible**.

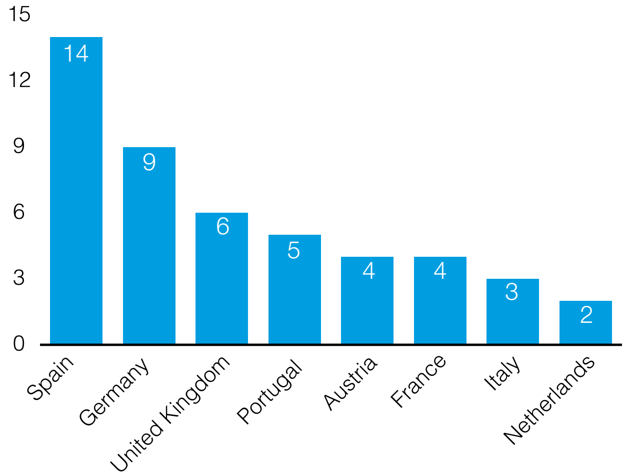
The proposals were evaluated by **72 independent technical experts** (29 external and 43 internal).

The total value of the winning projects is approximately **€17,165,000**, with **requests for funding** totaling **€11,430,000.**

About **€3,600,000** was requested by **winning SMEs**, which is **34% of the funding** for winners.

8 countries are represented among the winning participants.

Number of beneficiaries per country



Coming events

Clean Sky 2 Info Day on 3 February 2015 in Paris

Clean Sky is organising a Info day on the First Call for Proposals (Call for Partners) wihtin Clean Sky 2 Programme, part of Horizon 2020.

SAVE THE DATE: Clean Sky Forum on 17 March 2015 in Brussels

The Clean Sky Forum will take place on Tuesday 17 March 2015 in Brussels, Belgium. The event is a successor to the Clean Sky General Forum of previous years. More information is coming soon on www.cleansky.eu

SAVE THE DATE: Clean Sky Demonstration Stand at Paris Le Bourget

Clean Sky will be part The 51th Paris Air Show taking place from 15 to 21 June 2015.

SAVE THE DATE: 5th CEAS Air & Space conference on 11-17 September 2015 in Delft

The 2015 CEAS Air and Space Conference will be held from 7- 11 September in Delft (NL).

SAVE THE DATE: Aerodays on 20 -23 October 2015 in London

Aerodays is the European Commission flagship event in aviation research and innovation that takes place only once as part of each EU Research Framework Programme. The goal is to share the achievements of collaborative research and innovation in aeronautics and air transport within Europe.

November 2014

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