Clean Sky

Skyline

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Innovation takes off

Best Clean Sky Project Award 2015

This project is funded by the European Union

Contents

EDITORIAL

Eric Dautriat
Executive Director
of the Clean Sky Joint Undertaking

Clean Sky held its annual Forum on March 17th in Brussels. I wish to highlight a pioneering initiative in our programme: the Clean Sky Awards, gold, silver and bronze which were presented to the three winners after a JU selection process involving the ITD coordinators and our Project Officers. The purpose was to distinguish the best projects, completed or almost completed, led by Partners or Associates. A difficult exercise indeed, with some inevitable amount of subjectivity but very rewarding for all those involved. In addition, keynote speeches – including a video recorded address by Commissioner Moedas – round tables and visits to the Exhibit area punctuated this day, as reported by Maria-Fernanda Fau in this Skyline issue.

As a matter of fact, these awards, as well as the story-telling posters presented that day by all the 21 nominees, demonstrate the vitality and the variety of Clean Sky activities. The "golden" Clean Sky Award was won by the STARLET project, which was about investigating cutting-edge fluidic devices for active load control; this project was led by the Institute of Aviation of Warsaw. Because of its technological ambition, this is a relatively low TRL project (TRL 2-3), 3 patents pending, which may give birth to further developments in Clean Sky 2. The future of lower TRL activities in Horizon 2020 in general, and the funding of research organisations and academia in particular, were repeatedly addressed in speeches and round tables, as a potential matter of concern. It is my opinion that these concerns are not entirely justified. Besides the remaining part of "Collaborative Research" under the direct control of the European Commission, mostly dedicated to upstream research, Clean Sky 2 itself should not be considered as exclusively dedicated to integrating mature technologies into full scale demonstrators. Of course, this remains its first remit and the most expensive part, by definition, of its budget.

But there was and will be room for such upstream research in many areas of the Clean Sky programme.

Activities like this STARLET project, in particular through Calls for Proposals, will still be part of the core of an ambitious Clean Sky 2 programme. As regards the participation of Research Organisations and Academia, the statistics from the first Call for Core Partners and the recently closed first Call for Partners, are quite eloquent; for instance, about 70 "higher education" entities applied to the latter, in average to 2 different topics each.

> "There was and will be room for low TRL project research in many areas of the Clean Sky programme."

The second "silver" award was attributed to the HIPEAE440 project, High Compression (Diesel) Engine for a rotorcraft, led by Austro-Engine, Austria. Recently, the engine integration on the helicopter was successfully tested on ground and is scheduled to fly before summer. This is an industrial, high TRL project with full aircraft-level integration, paving the way for a potentially quick technology insertion into product and enabling a high CO_2 reduction – in the range of 40%. A good opportunity to hail the season of demonstrations, which has actually started now, in particular in-flight!

The third award went to Streit-TGA GmbH (coordinator) and two other German SMEs. The project BESTT was about the design and integration of the Thermal Test Bench, now under use for the Eco-Design demonstrations concerning on-board energy management, in particular for business jets. This large facility is typical of an important category of Clean Sky achievements: system-level test facilities, able to test the integration of technologies at full scale, full power, like the Copper Bird for electrical testing, also in Eco-Design, or the PROVEN test rig in SGO as well as others. Improving the accuracy and representativeness of ground tests is the key to simplifying and shortening the development processes. Such facilities will remain available for Clean Sky 2; it will be important to build on these achievements.

Aerodynamics, engines, equipment test facilities; large aircraft, rotorcraft, bizjets or one research organisation and several SMEs: this *tierce gagnant* is not the result of any cautious, political and well-balanced choice, just the outcome of a technical and difficult selection. How could the variety of the innovation chain that Clean Sky is developing be better illustrated?

Next year, we will have another Forum and another presentation of Clean Sky awards. Who will be crowned the winner? At this moment it is near impossible to guess. In the meantime, far more of the Partners' projects will be finalised and a good deal of demonstrations will be completed, meaning undoubtedly, next year's selection will once again be quite hard.

Eric Dautriat

Overview of recent Clean Sky Calls:
Engines firing on all cylinders

Ron van Manen
Clean Sky Technology Evaluator Officer and Programme Manager for CS2 (acting)

When you receive this edition of Skyline we will be approaching the milestone of one year of technical activity in Clean Sky 2. All programmes and projects tend to display what is often referred to as the S-curve: a slow start, followed by a ramp up and steeper climb in effort; a maturing toward a steady state, and then levelling off approaching the effort consumed and results achieved. Clean Sky 2 is no different. Although perhaps its early years of parallel activity with the most intense, and potentially rewarding period of the initial Clean Sky programme nearing the pinnacle of "demo time" (as Eric Dautriat has been quoted) has made a prudent approach to the start-up phase all the more necessary.

Now, with nearly a full year behind us, it is clear that the engines are indeed firing on all cylinders and the operational activity has climbed to a significant level. In particular with respect to the Calls for Core Partners and Calls for Proposals: the cycle of preparing and launching a call, receiving and evaluating proposals, and negotiating and preparing grants is now continuous. Two Calls - one for Core Partners and one for Partners (via the CfP) – have closed and are in their implementation phase. One is open at the time of this publication and at least two will get underway this year. Let's take a look at what has happened so far and is on the horizon for the remainder of the year.

The first Call for Core Partners (launched in July 2014) closed last November, and proposals were submitted to evaluation through December and January. Of 29 topics published, the JU received valid / eligible proposals for 26, and the top-ranked proposals ex-evaluation were launched into the negotiation and grant preparation phase in March. 124 entities participated in one way or another in the proposals received, and in total 59 are among the participants under grant negotiation. Of these over 30 will be new Members of the JU if negotiations are successful. And in total 13 Member States and Associated Countries will be represented. This marks a significant step towards the future complement of CS2 JU Members; but clearly more will come as approximately 60% of the Core Partner related budget is yet to be put into competition via future Calls. The JU expects the first new Members "on board" and operational during the summer, and gearing up quickly in the programme's second year of operations.

The first Call for Proposals (CfP) launched in December of last year and closed in March; the evaluations will have concluded by the end of May and grant preparation / negotiation should start imminently after this Skyline is published; the new Partners are likely to become active in the programme by the 4th quarter of this year. A breath-taking record number of 220 proposals was received for this call, in response to 53 topics (indicative value €48m). This strong appetite for the Partner-level topics tells us we have a keen and fired up "innovation chain" ready to join the Members and co-execute the technical programme.

A second Call for Core Partners opened on April 16th and will run until July 30th. Expect the evaluations to take over October / November and rankings / results to be available by year-end. This Call is somewhat smaller than the first one at roughly €92m (indicative) over 17 topics; and this leaves scope for in all likelihood two further Calls for Core Partners, of which one will take place in the autumn of this year. Separately, a second Call for Proposals will be launched in the summer; its preparation now nearing completion. Our planning for the 2016 Calls: not just further Calls for Core Partners and the current Calls for Proposals, but potentially also some further evolutions in terms of the type of Calls, will get underway after the summer. An area we will be looking at closely is getting the balance right with regard to the scope of topics best suited to longer-term and lower-TRL activity; and ensuring we access and utilize the "full innovation chain" and make Clean Sky 2 as welcoming as we can for SME and academic participation - in line with the Joint Technical Programme: our roadmap for the decade of CS2 target areas, objectives and content.

Clean Sky 2: MTU Aero Engines takes on the role of lead partner

Martina Vollmuth
Press Officer Technology, MTU Aero Engines

It is true to say that ambitions continue to grow; the European Clean Sky 2 Joint Technology Initiative is substantially broader in scope than its predecessor Clean Sky 1, and MTU Aero Engines is also stepping up its activities under the program. "With Clean Sky 2, the European Commission sends out a strong political signal recognising the need to support the European aviation industry and secure its international competitiveness," explains Dr. Rainer Martens, MTU Chief Operating Officer. Germany's leading engine manufacturer is one of the 16 Clean Sky 2 lead partners from the aeronautical industry in Europe, which means that it will now take on a larger role than it previously played in Clean Sky 1.

Under the most ambitious aeronautical research program ever launched in Europe, MTU will concentrate its efforts on the low-pressure turbine and high-pressure compressor -two technology areas in which the company excels. Under Clean Sky 2, its main objective is to further develop these two modules, paying special attention to the interactions of the components sitting on the low-pressure and high-pressure shafts. Thus, investigations into the low-pressure turbine will also take the inlet and exit case designs into consideration, and the optimisation of the high-pressure compressor will also involve making improvements to the low-pressure compressor and inter compressor duct. These efforts aim to further enhance the aerodynamics and to develop new, lighter-weight and more temperature-resistant materials for the second generation of geared turbofan engines. Among the materials that hold the greatest promise for low-pressure turbine applications are ceramic matrix composites or CMCs for short. Martens explains: "To validate the new technologies, MTU uses demonstrators, which will be tested between 2017 and 2020."

The engine demonstrator built under SAGE 4 (Sustainable and Green Engines), a Clean Sky 1 sub-project led by MTU, will be tested this year. MTU will soon begin making the final preparations for the test runs. The tests serve to demonstrate the maturity of technologies for new, lower-weight constructions and materials when subjected to further increased mechanical and thermal loads and to verify the suitability of advanced aerodynamic airfoil designs. The ultimate goal is to jointly validate improved geared turbofan technologies, especially for the low-pressure section, with other European partners.

"All of the technologies we planned to have validated in October 2012 are incorporated in our module," according to Dr. Joachim Wulf, Chief Engineer, Technology Demonstrators at MTU. "The SAGE 4 demonstrator is based on the PW1500G from the PurePower family of engines and permits the validation of numerous new technologies for an upgraded generation of GTF engines." MTU in Munich assembled a super-module, which consists of a low-pressure turbine made by MTU, a turbine exit case (TEC) from GKN Aerospace and a bearing chamber from Pratt & Whitney.

Once fully assembled, the demonstrator engine will be put through its paces on the test bed for several weeks at MTU in Munich. The first results are expected to be available before the year is out. Shortly after Clean Sky 1 ends, at the end of 2016, the new technologies will already "be available to support the next step in the evolution of the current GTF," assures Wulf.

MTU is gearing up for Clean Sky 2 while the work on the SAGE 4 demonstrator is still underway. Martens informs that "the call for core partners has already been closed, whereas the call to cover activities to meet other partners' technology requirements is still open." For Clean Sky there are two major approaches and another central task of the European technology program – above and beyond the development of break-through technological solutions – is to create a network of core partners, small and medium-sized enterprises (SMEs) and academia and research establishments.

Aerodynamic and aero-acoustic identification test of the Low-Speed Business Jet configuration

Olivier Colin
Topic Manager, Dassault Aviation

An important milestone of SFWA was reached in 2014 with a wind tunnel test in the Large Lowspeed Facility (LLF) of the German Dutch Windtunnels DNW in Marknesse, the Netherlands. The test was performed using a model of a business jet configuration incorporating a natural laminar flow wing and a U-shaped empennage. The design and manufacturing of the model and the completion of the wind-tunnel test are the results of a broad European cooperation, coordinated by Dassault Aviation.

A 1.3-ton 5-meter span model was manufactured to fit the needs of this test. Two turbo-fan simulators (TPS) are integrated into the model in order to obtain representative exhaust jets at the rear fuselage nacelles. The model was manufactured through the LOSPA CfP (Low-SPeed Aero-acoustic Aerodynamic model) by ARA (Aircraft Research Association) and FAM (Future Advanced Manufacture), who collaborated with DASSAULT AVIATION, ONERA (The French Aerospace Lab) and INCAS (National Institute for Aerospace Research Elie Carafoli, Romania) on the design and manufacturing of the model. A wide range of instrumentation is integrated into the model to allow for a complete analysis of the flow physics phenomena taking place during the wind-tunnel test: a six-component balance, 350 static pressure taps, 110 unsteady pressure transducers and several strain gauges. In order to increase test productivity, the model is equipped with motorized control surfaces such as ailerons, HTP trim and elevator. These motorizations were provided, installed and calibrated by DNW .

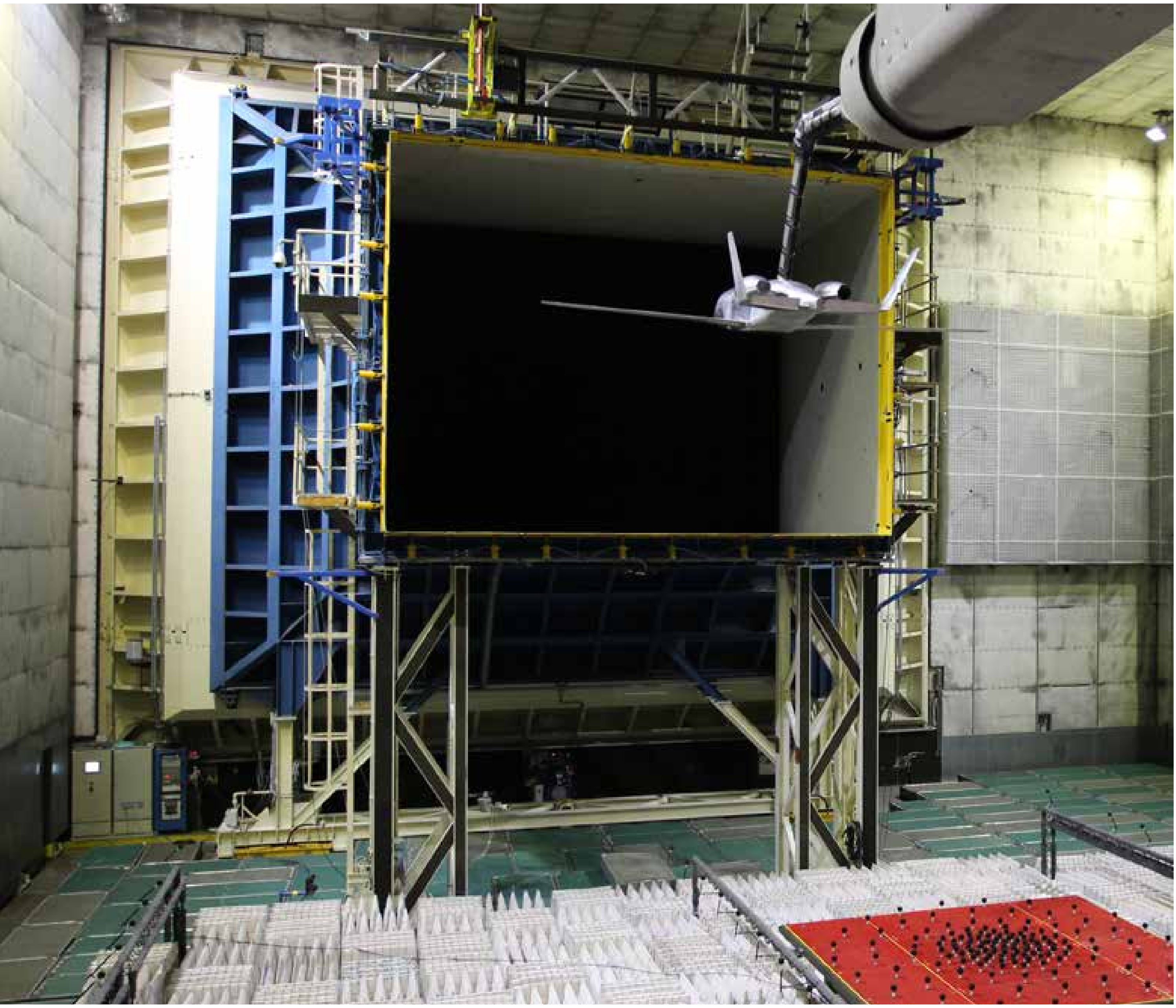
The model delivery took place in October 2014, and was followed by an event meeting held in Markeness (DNW facilities) on December 3rd with all the project partners (see picture).

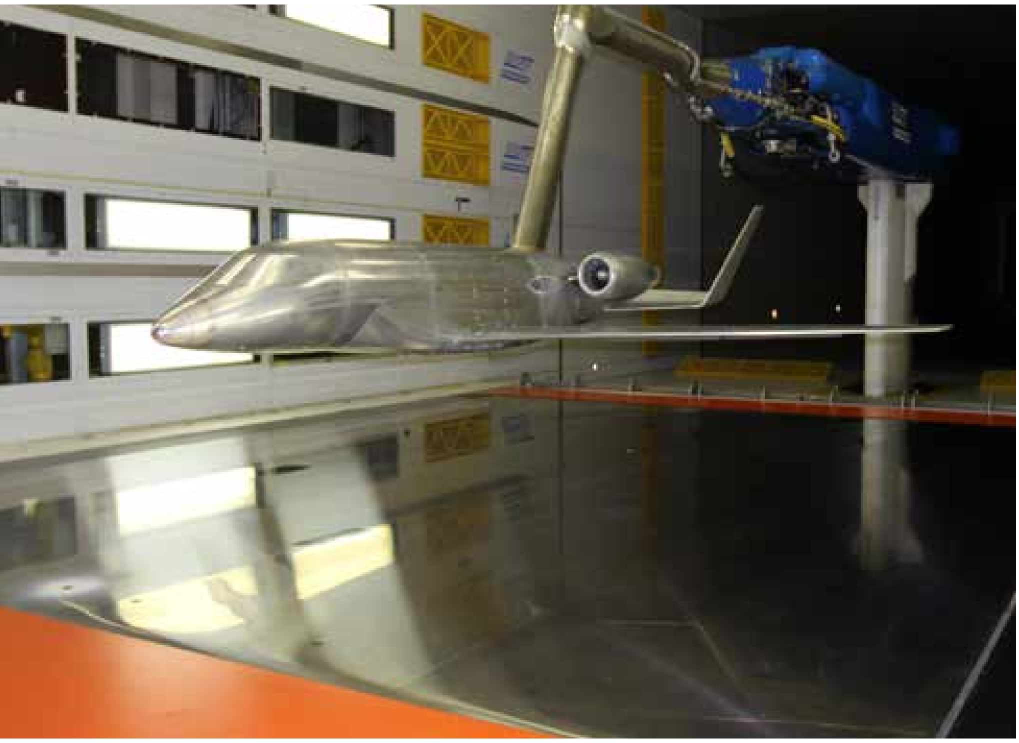
The test preparation, including model assembly and nacelle and sensor calibration, was performed during a five week period by the DNW and DASSAULT AVIATION teams. Through PLAAT (Powered Low-speed Aero-acoustic Aerodynamic Testing) Project the wind-tunnel test was performed in the Large Low speed Facility (LLF) of German-Dutch Wind Tunnels (DNW) in Marknesse, the Netherlands. This test was split into aerodynamics and acoustics parts.

The part of the test dedicated to aerodynamics was performed in December 2014 in the closed test section of the DNW-LLF wind tunnel, with the objective of validating the low speed aerodynamics of the innovative afterbody and wing. In that respect, the simulated engine was essential to analyse the engine afterbody integration. Promising results were obtained and are under analysis.

The acoustics part of the test was performed in April 2015 in the open test section of the DNW-LLF wind tunnel. It involved noise shielding evaluation of the U-shaped tail using the TPS installed on the model and airframe noise measurements. The objective of this test was to validate the noise shielding efficiency of the innovative afterbody.

These aerodynamic and acoustic wind tunnel tests were very successful and all the objectives and measurements were accomplished within the budget. The results highlighted the differences between anticipated and measured characteristics of the innovative tail and supported the convergence of the design of the Low-Speed Business Jet configuration.





Clean Sky Forum:
Breaking new ground in technologies, partnerships and innovation chains

Maria-Fernanda Fau
Communications officer, Clean Sky JU

The **Clean Sky Forum** took place on March 17th 2015 in Brussels. Bringing together some 230 stakeholders in the aeronautics and aviation industries, the panel discussions looked at the aircraft of the future, its journey from the testbench to the market and explored different and innovative partnership opportunities. Furthermore, opportunities and challenges for global sustainable aviation were addressed. The Clean Sky Forum also hosted the award ceremony for the three 2015 Best Clean Sky Projects. More details on winners and their projects can be found in a dedicated article in this Skyline issue.

See the programme, presentations and pictures on **www.cleansky.eu**

The event kicked off with a video message from Carlos Moedas, Commissioner for Research, Science and Innovation. And distinguished speakers from EU institutions, industry, academia, SMEs, and research bodies across Europe: **Richard Parker** - Clean Sky Governing Board Chairman, Rolls-Royce Chief Technology Officer, **Rudolf Strohmeier** - Deputy Director General, Research, Science and Innovation, European Commission, **Eric Dautriat** - Executive Director, Clean Sky Joint Undertaking, **Manuela Soares** - Director for Transport, DG Research and Innovation, European Commission, **Eric Bachelet** - Executive Vice President for Research & Technology, Safran, **Dimitri Bofilios** - Managing Director, INASCO, **Hester Bijl** - Dean, Faculty of Aerospace Engineering, University of Delft, **Axel Flaig -** Head of Airbus Research and Technology, Airbus, **Peter Hecker -** Chairman of the Clean Sky Scientific Committee, **Marco Protti** - Head of Advanced Research, Alenia Aermacchi, **Josef Kaspar** - Chairman of EREA, **Fred Abbink** - CEAS Chairman - Retired NLR General Director, **Florian Guillermet** - Executive Director, SESAR, **Thomas Roetger** - Assistant Director, Aviation Environment- Technology, IATA, **Johann-Dietrich Wörner** - Chairman of the Executive Board DLR, Vice-Chair of ACARE, **Maurizio Castelletti** - Head of Unit, Single European Sky, European Commission and **Gerben Klein Lebbink** - Chair, Clean Sky State Representatives Group.

Close up of the Best Clean Sky Project Awards

Clean Sky Forum Plenary

Best Clean Sky Project Award exhibit area

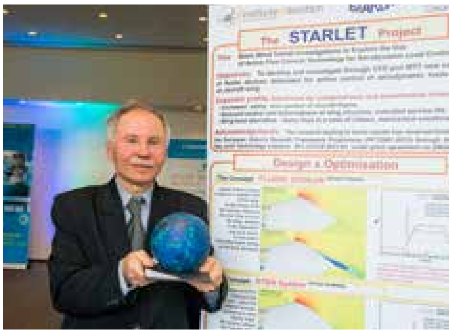
Ric Parker, Chair of Clean Sky Governing Board

Panel discussion

Exhibit area

STARLET project:
Best Clean Sky Project 2015

Janusz Sznajder, Wienczyslaw Stalewski and Andrzej Krzysiak
Senior Researchers, Institute of Aviation, Warsaw, Poland



The main objective of the STARLET project was to develop and investigate, through CFD Simulations and Wind Tunnel Tests, new concepts of fluidic devices dedicated to active control of aerodynamic loads on aircraft wing. The investigation was focused on the alleviation of excessive aerodynamic loads in off-design conditions, which occur in gusts or rapid manoeuvres, by flow control techniques. Proposed fluidic devices could be an alternative to usage of conventional mechanical solutions such as symmetrical deflections of ailerons or deflections of spoilers.

As a result of studies, taking into account the use for this purpose the different concepts of the fluidic devices, as the most promising the following three solutions were chosen.

The "FLUIDIC SPOILER" concept

This concept consists of the matrix of mini nozzles located on an upper wing surface in the tip. Air jets blown from these nozzles influence the main flow around the wing, leading to its separation and as a result, to the alleviation of bending moments acting on the wing structure, Fig.1. Experimental investigation showed that using these devices 10%-30% alleviation of the maximum wing-root bending moment in sudden-gust conditions can be achieved.

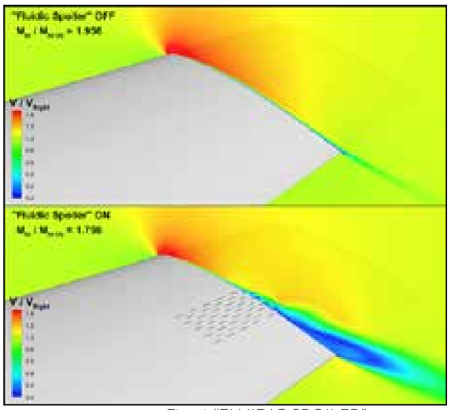


Fig. 1 "FLUIDIC SPOILER" concept.

The "DUAL TRAILING-EDGE NOZZLES" (DTEN) concept

This concept consists of the specially shaped nozzles, located at wing trailing edge. The system utilises the Coanda effect to change the flow circulation around the wing, leading to span-wise redistribution of aerodynamic loads, Fig. 2. Experimental investigation showed, that using these devices 30% alleviation of the maximum wing-root bending moment in sudden-gust conditions can be achieved.

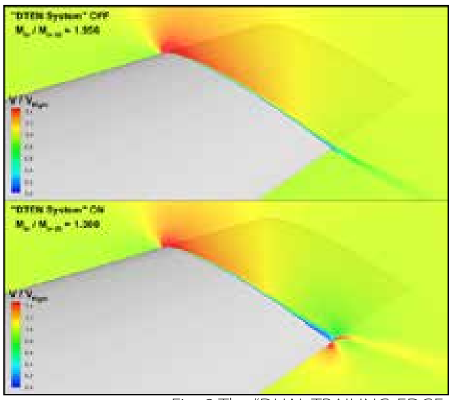


Fig. 2 The "DUAL TRAILING-EDGE NOZZLES" (DTEN) concept.

The "LEAKY WING" concept

The concept consists of a system of ducts connecting upper and lower wing surfaces (nominally closed). When the ducts are opened, natural flow through them and influences a flow on the upper wing surface leading to its separation and, as a result, to the alleviation of wing loads. Fig. 3. Investigation showed that using these devices 17% alleviation of the maximum wing-root bending moment in sudden-gust conditions can be achieved.

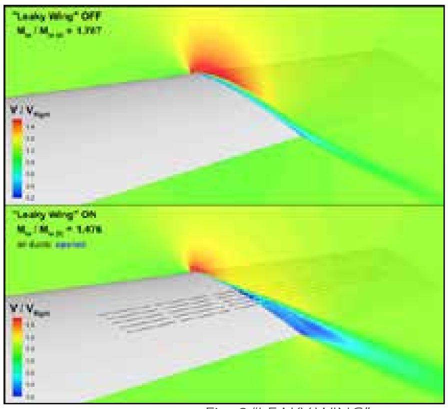


Fig. 3 "LEAKY WING" concept

Conducted as part of the STARLET project, research has shown that using the proposed fluidic devices can effectively reduce the wing bending moment in sudden-gust conditions. The main advantage of these devices is their high speed of operation, incomparable with conventional mechanical devices.

Expected benefits from the use of the proposed fluidic devices:

- Increased safety and comfort of aircraft flights.
- Reduced strain and deformation of wing structure meaning extended service life.
- Reduction of wing weight, therefore the reduction of Direct Operating Costs.
- Wing-load alleviation - faster than the classic, mechanical solutions.

HIPE AE 440 POWERPACK project:

Reduced fuel consumption and emissions for High Compression Engines

Best Clean Sky Project 2015

Sabine Kunstmueller
Austro Engine GmbH

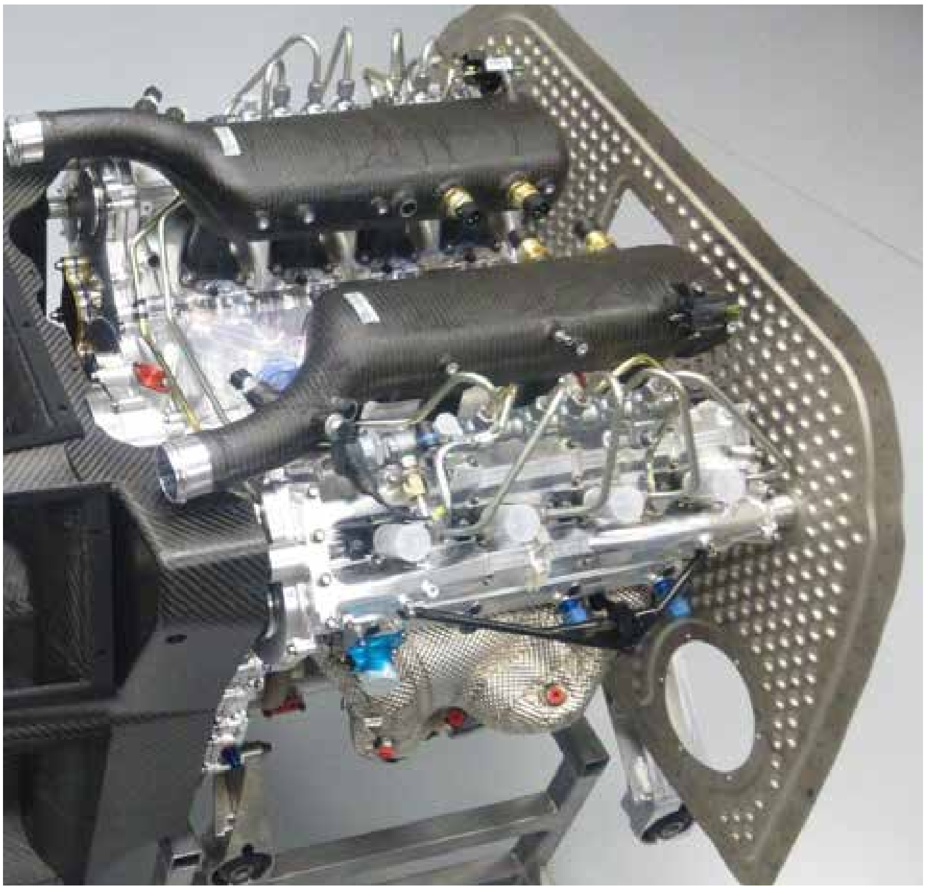
Outstanding technical breakthroughs implemented on high compression engines over the last 20 years were adapted to be used in this technology for the light helicopter demonstrator EC 120. The HIPE AE 440 engine is a liquid-cooled, V8 four-stroke engine with 4.6L displacement. The high pressure direct fuel injection is realized by common rail technique (1800bar) and the engine is fuelled with kerosene (Jet-A). The engine is controlled by dual channel FADEC and is supercharged via 1 turbo per cylinder bank.

The advantages of the HIPE AE 440 project are:

- the reduction of fuel consumption compared to turbine engines (minimum 30% up to 50% depending on mission);
- the reduction of emissions up to 40%;
- lower operating costs (fuel maintenance and overhaul);
- performance in hot temperature and high altitude conditions.

The HIPE AE 440 Partner Consortium (TEOS, AUSTRO ENGINE) was tasked with the design, prototyping and testing of the engine meeting the technological targets (lower fuel consumption, power, reduced emission, reliability etc.). This development was made possible thanks to their respective experience with general aviation (Austro Engine) and racing car engines (TEOS).

Project key dates:	
Kick off meeting	June 2011
First engine tests	March 2013
Iron Bird tests	Nov 2013 – Feb 2014
First successful ground tests	Feb 2015



BESTT project:

Thermal management on the way for more electric aircraft

Best Clean Sky Project 2015

Alexander Streit
General Manager, Streit-TGA GmbH

The increasing operation of electrical systems assigns the engineers new challenges with regard to the thermal management of modern aircraft systems.

Within BESTT, a unique test bench was developed to shorten development cycles on ground.

One of the six "Integrated Technology Demonstrators" distributed all over Europe was built on the premises of the Fraunhofer Institute for Building Physics IBP in Holzkirchen, south of Munich in Germany.

Under the project "BESTT- Development, Construction and Integration of Bench Systems for Ground Thermal testing", created under the direction of the plant engineering and construction company Streit-TGA, a worldwide unique test facility was designed and integrated . For the BESTT project, with a financial volume of €2m, the companies Streit-TGA (engineering and plant construction of test benches), Temes Engineering GmbH (manufacturing of electric and electronic systems) and Modelon GmbH (system modelling and control design) have joined forces to develop and implement the test facility.

Within the 38 month-long research project, which ended in December 2014, several innovative developments have been put into action. One is the so called Air Treatment Unit (ATU), developed by Streit-TGA, a powerful and highly accurate air conditioning unit for cabin air supply. By using the ATU, the climatic conditions in the cabin demonstrators can be simulated to mimic real aircraft conditions, a task that could not be realised to a satisfactory level with conventional ventilation and air conditioning systems on ground so far. Besides the cabin demonstrators and the conditioning of their interior spaces, plant equipment was developed to simulate the outer conditions of a real flight scenario.

Therefore several aircraft fuselage parts were integrated into the FTF, the Flight Test Facility, at Fraunhofer IBP. In this unique test bench, a 30m long low pressure tube with a diameter of 10 m and low pressure capabilities down to 150 mbar absolute, the fuselage parts can be exposed to outer skin conditions from -55 ° C up to + 80 ° C. Combining realistic outdoor conditions with precise interior climate control, high accuracy tests for thermal management of future generations of aircraft can be carried out on the ground. Another major component, the so-called "ACC - Aircraft Calorimeter" was developed and installed. A low-pressure chamber with a volume of 50 m^3, which enables operational pressures from atmosphere to nearly 0 mbar absolute at temperatures from -60 ° C to + 120 ° C.

ATU – Air Treamtment Unit, high accuracy air conditioning system for flight condition simulations

ACC – Aircraft Calorimeter, insulated low pressure steel vessel, internal minimum absolute pressure 0 mbar, internal temperatures -65°C to +120°C

ONERA: A major contributor to the success of Clean Sky

Bruno Sainjon
CEO ONERA

ONERA, the French Aerospace Lab has played a major role in the European scene for more than 20 years, bringing its science and technology experience through numerous European projects.

Involved since the beginning of the Clean Sky JTI, ONERA is an Associate of three platforms (ITDs), Smart Fixed Wing Aircraft (SFWA), Green Regional Aircraft (GRA), Green RotorCraft (GRC) and is also participating in the Technology Evaluator (TE).

2014 marked an important milestone with the launch of Clean Sky 2's first call for Core Partners on July 9th. For ONERA it was a strategic move to continue and emphasize its participation in the Clean Sky 2 adventure, leading to higher TRL (up to 6), while preserving some research on lower TRL activities.

ONERA will bring to Clean Sky 2 unique capabilities: multidisciplinary expertise, powerful numerical simulation tools, wind tunnels for design and research in the open calls to come, both in the vehicles domain and in the engines and systems domains.

Amongst the ONERA proposals within Clean Sky 2 programme there are:

- two projects with German counterpart DLR:
  - 1) for the Large Passenger Aircraft IADP, the project on Advanced Engine and Aircraft Configurations (ADEC), and
  - 2) for the Airframe ITD, the project on New Innovative Aircraft Configurations and related issues (NACOR)
- a project proposed by a consortium led by CIRA on an advanced wing for the Regional Aircraft IADP.

Clean Sky - ONERA's highlights

Smart Fixed Wing Aircraft (SFWA)

ONERA is centrally involved in technologies such as: natural and hybrid laminar flow control, buffet, flutter, loads and vibration control, innovative power plant integration and new after body shapes. In 2014, an experimental investigation was performed at the ONERA S3Ch transonic wind tunnel. Complementary numerical simulations plus real time feedback control led to demonstrate, for the first time, active gust load alleviation in transonic flow conditions.

Green Regional Aircraft (GRA)

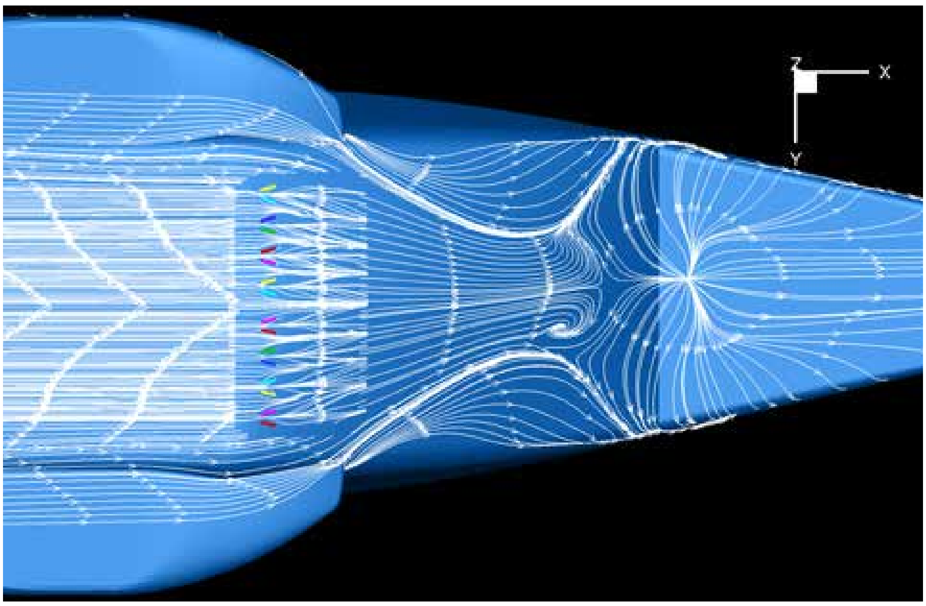
ONERA activities are devoted to aerodynamics, acoustics, aeroelasticity and materials. The most recent significant activities have been the execution of lightning tests on composite materials, computations of the aeroelastic behavior of a regional aircraft under gust and the comparison calculations/test results of the acoustic installation effects of an Open Rotor.

Green RotorCraft (GRC)

The Clean Sky Green Rotorcraft gathers a large part of the EU funding for rotorcraft research. The activities are mainly in the fields of innovative blades to reduce noise and vibrations, drag reduction to optimize the flow on the helicopter fuselage, environmentally friendly flight paths and preparing the specific helicopter noise and pollution calculation tools for the Technology Evaluator. For the fuselage drag reduction, ONERA's work was focused on the reduction of the drag generated by the rotor hub with the investigation of a full fairing (3,5% reduction) and the fuselage backdoor separation with the use of vortex generators (5% reduction expected). The definition of a VFR low noise procedure for the single engine helicopter leads to a gain of 37,5% reduction of the 75dBA footprint.

Technology Evaluator (TE)

The main ONERA role in the Technology Evaluator is to assess each year the progress made in the environmental benefits of Clean Sky fixed wing aircraft at mission level, in close collaboration with our partners and vehicles ITDs, showing noise and emission reductions obtained by Clean Sky. ONERA is also responsible for the specification, development and maintenance of a critical tool called the TE Information system. It provides to all TE members through a secured web service, full traceability and access to all the results as well as year by year progress. This Information system is the gateway for the Clean Sky programme to the TE project.



Fuselage drag reduction using vortex generators in the backdoor region

Technology Evaluation in Clean Sky

Michel Goulain
Technology Evaluator Project Officer, Clean Sky JU

A specificity of Clean Sky is to have put in place two complementary means for evaluating the aircraft and rotorcraft technologies which are developed in the programme.

The first, as usual, is to evaluate the new technology stand alone, in comparison to older models, using specific criteria such as weight saving, fuel saving, maintenance or production improvement, overall aircraft system simplification, noise reduction capacities amongst others. These technology specific evaluations are performed inside Clean Sky's ITDs (Integrated Technology Demonstrators) and depending on the Technology Readiness Level (TRL) that is achieved, these technologies can go from simulations only to ground or flight tests.

The second evaluation method is a global evaluation of the environmental benefits (emissions and noise reduction) of the Clean Sky programme. To achieve this aim, key technologies are clustered into aircraft or rotorcraft simulation models in order to figure out what would be the performance level of these Clean Sky aircraft/rotorcraft when equipped with Clean Sky technologies.

This second kind of evaluation is done through a specific Clean Sky project: the Clean Sky Technology Evaluator, which we have reported on several times in Skyline – but we deemed it appropriate to remind our readers of its principles, before addressing the last results obtained.

Methodology of the Technology Evaluator

In order to forecast the environmental improvement when Clean Sky aircraft/rotorcraft are flying, the Clean Sky aircraft/rotorcraft models simulate flights in specific scenarios. It is then possible to compare the noise and emissions of these Clean Sky aircraft/rotorcraft with their reference counterparts of aircraft/rotorcraft which include technologies from the year 2000.

These scenarios have been designed at 4 levels: A single aircraft/rotorcraft flight or "aircraft level"; all aircraft/rotorcraft movements at and nearby an airport-the "airport level"; the fleet of aircraft and rotorcraft all around the world or "global level", and "life-cycle level" where the entire life-cycle of an aircraft/rotorcraft, from design, to manufacturing and to dismantling, is evaluated. These four levels are described hereafter.

The evaluation results of these levels are generated by dedicated simulation platforms and capitalised in the Technology Evaluator Information System based on a web-service platform which is available for all Technology Evaluator members.

ACARE objectives

The four evaluation or assessment levels were defined in order to be able to assess as much as possible the Clean Sky contribution towards the ACARE environmental objectives.

Aircraft level assessments

Scenarios at this level compare Clean Sky and reference aircraft and rotorcraft alone on a single trajectory.

Emissions measured are CO_2 and NO_x reduction in percentage for a complete flown aircraft mission and per available passenger seat.

A number of noise measurements have also been defined. In the table shown the average noise reduction for fixed-wing aircraft at take-off is given. These emissions and noise results can be directly compared to the ACARE objectives, bearing in mind, for example, that a 10dB noise reduction means halving the perceived noise.

Airport level assessments

At this level, a number of representative airports are considered for which the environmental impact of a traffic scenario with Clean Sky aircraft for a representative day is compared with the environmental impact of the same traffic scenario but with reference aircraft.

Firstly, based on the year 2000 status, assumptions are made with respect to the increase of the traffic on these airports in the year 2020. Then according to the hypothesis of replacing reference aircraft with Clean Sky aircraft, emissions, noise maps and the population impacted by noise levels can be derived.

Bizjet aircraft	
Low Sweep Bizjet (LSBJ) aircraft	Composite natural laminar wing, U Tail for noise optimisation 2020 Entry in Service technology engines
High Sweep Bizjet (HSBJ) aircraft	Natural Laminar Flow Wing Innovative 3-engines afterbody (2020 EIS technology engine)
Regional aircraft	
Turbo Prop (TB) 90 aircraft	Advanced Composite Materials and SHM Low Noise Landing Gears and High Efficiency High Lift Devices Electrical Environmental Control System
Geared Turbofan (GTF) 130 aircraft	Advanced Composite Materials and SHM Natural Laminar Flow Wing Advanced Gearded Turbofan
Air Transport Aircraft	
Short and Medium Range (SMR) aircraft	Natural Laminar Flow Wing Contra Rotative Open Rotor (CROR) engine
Long Range (LR) aircraft	Advanced three shafts Turbo Fan engine
Helicopters	
Single Engine Light	SEL specific low drag, low noise and more electrical technologies Advanced engine
Twin Engine Light	TEL specific low drag, low noise and more electrical technologies Advanced engine
Twin Engine Heavy	TEH specific low drag, low noise and more electrical technologies Advanced engine

Clean Sky aircraft and rotorcraft with their main advanced technologies.
Some other categories of helicopter will be studied later on.

Global level assessments

It was considered meaningful to provide global environmental results. At a worldwide level, assumptions are made about the global traffic increase from 2000 to 2020. Then it is possible to compute emission savings at global level when making assumptions about Clean Sky technologies insertion and replacement rates of various kinds of aircraft.

It is also foreseen to provide the overall reduction of people exposed to noise in Europe when Clean Sky technologies will be implemented, taking the results of all major airports in Europe.

Life Cycle level assessments

The aim of the assessments at this level is to compare over the whole life cycle of an aircraft/rotorcraft the environmental impact in terms of emissions and materials between reference and Clean Sky aircraft/rotorcraft. Because of the complexity and novelty of the approach only 3 kinds of aircraft/rotorcraft were compared: a short-medium range transport aircraft, a business jet aircraft and a rotorcraft.

The methodology is the following:

First, data is collected for individual parts and developed into an eco-statement for a limited number of representative parts. Then, an upscaling method, based on a breakdown of the aircraft into modules such as fuselage or systems is used to derive from these limited parts the life-cycle analysis of the whole aircraft using the "GaBi" life-cycle analysis software. The same process is applied to reference and Clean Sky aircraft. Then the difference between the computations provides an estimation of the environmental benefit over the whole life cycle.

TE 2014 main results

At aircraft level:

Below the main aircraft level results from the 2014 assessment are shown.

As the Clean Sky program is not completed, some technologies have not yet been fully integrated in the Clean Sky aircraft models, and some results are still under validation; however, as reported in a previous Skyline issue, we already know that the preliminary noise results obtained through wind tunnel testing for the Open Rotor configuration are very encouraging, showing a certification level forecasted as better than the newly developed generation of turbofans. For the "Twin Engine Heavy" rotorcraft noise results are not applicable as the simulated missions were flown over the sea in order to transport people to a set of North Sea oil platforms.

At airport level:

In the 2014 assessment for regional and mainliner aircraft traffic at airport level, five airports were considered to determine potential Clean Sky benefits when comparing a year 2020 airport fleet scenario with Clean Sky aircraft and a year 2020 airport fleet scenario with reference 2000 aircraft. These airports were two primary hub airports with a complex geometry, one primary hub airport with a simple geometry, one secondary hub airport, and one regional airport.

The 2014 airport level results indicate that Clean Sky technologies could bring very significant environmental benefits: reductions in NO_x emissions between 20-40%.

However noise results are not yet available because of some incomplete aircraft noise modelling (see short and medium range aircraft results in the table below)

At global fleet level:

At global level a 2020 global fleet traffic scenario with Clean Sky aircraft inserted is compared to the same 2020 scenario but this time with reference 2000 aircraft. This allows us to determine the Clean Sky benefit or "delta" at global fleet level in terms of CO_2 and NO_x reduction.

Some assumptions are made for the insertion of Clean Sky aircraft in the fleet. In order to show the full potential of the Clean Sky technologies a theoretical 100% insertion rate is assumed. Figure 1 shows the example of a 2020 fleet scenario with Clean Sky short and medium range aircraft equipped with Open rotor engine and natural laminar wing technologies and the associated CO_2 reduction effect.

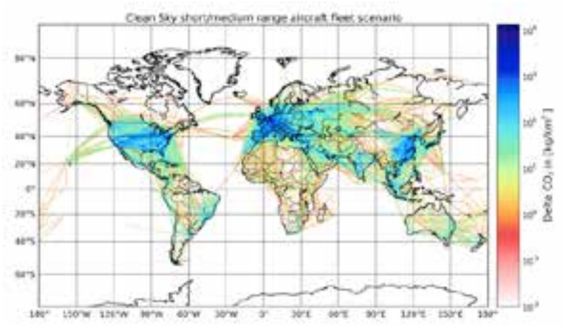


Figure 1: A Clean Sky short/medium range aircraft fleet scenario and its associated CO_2 delta

The 2014 assessment result shows that the overall effect of Clean Sky aircraft emission reductions including short, medium, long range and regional aircraft in the fleet - leads to about 20% of CO_2 savings over one month. The Clean Sky short and medium range aircraft represent about 55% -the largest contribution to this overall CO_2 reduction. This is linked to the high weight of this segment in the global fleet, and also to the fact that Clean Sky 1 put less emphasis on the long range, wide body aircraft, in a period when Airbus was launching a new commercial aircraft, the A350.

At Life Cycle Analysis (LCA) level:

Besides the continuation of upscaling activities from parts to full aircraft, a first comparative LCA analysis of a reference part and a Clean Sky demonstrator part was undertaken.

More results will be presented in a future Skyline article.

These environmental benefits of the demonstrator part are mainly related to the weight reduction and its reparability.

Conclusion

The evaluation of Clean Sky's progress towards the ACARE environmental objectives at all four assessment levels (aircraft, airport, global, and life cycle) was successfully performed in 2014, and its results are extremely encouraging, with regard to both the evaluation process and the environmental improvement potential.

The first life-cycle comparison of a reference part to a Clean Sky part was undertaken.

Concerning emissions and noise evaluations at aircraft, airport and global levels, these are more complete than in previous years, particularly considering noise and NO_x metrics, which were evaluated for the first time for some Clean Sky aircraft in this assessment.

Finally, the level of confidence in the output of the simulations increased with both the Technology Readiness Level of the technology developed in the ITDs, and with the level of accuracy of the Clean Sky aircraft/rotorcraft models which have been developed by ITDs, and which integrate these technologies.

Clean Sky concept aircraft	Noise reduction at take-off (dB)	CO_2 reduction per available passenger seat	NO_x reduction per available passenger seat
Low Sweep Bizjet (LSBJ) aircraft	-5	-33%	-34%
High Sweep Bizjet (HSBJ) aircraft	-1	-19%	-26%
Turbo Prop (TB) 90 aircraft	-13	-30%	-34%
Geared Turbofan (GTF) 130 aircraft	-14	-21%	-34%
Short and Medium Range (SMR) aircraft	not yet av.	-38%	-33%
Long Range (LR) aircraft	-6	-18%	-46%
Clean Sky concept rotorcraft	**Noise area reduction for total mission**	**CO_2 reduction**	**NO_x reduction**
Single Engine Light	-47%	-30%	-76%
Twin Engine Light	-53%	-27%	-75%
Twin Engine Heavy	not applicable	-22%	-47%

2014 results for Clean Sky aircraft /rotorcraft at aircraft level

Clean Sky on your agenda for Le Bourget 2015

51st INTERNATIONAL
PARIS AIR SHOW
LE BOURGET
FROM 15 TO 21 JUNE 2015
WHERE AEROSPACE LEADERS
GET DOWN TO BUSINESS

The 51st edition of the Paris Air Show will open its doors to aeronautics professionals and the public at large between the 15th – 21st of June next and Clean Sky will be participating in what is the greatest international air show.

Clean Sky will highlight its contribution to cutting–edge technology developed with the aim of reducing CO_2 emissions and noise levels created by aircraft by 2020. Fourteen innovative pieces of hardware developed within our aeronautics research programme will be on show. They will be accompanied by audio-visual and interactive materials demonstrating the progress achieved since the start of the programme in 2008. They have been tested and evaluated and will be part of the performing aircraft of tomorrow.

Visitors will have the chance to see a wide array of hardware at our stand such as an open rotor mockup and its composite lade, the laminar wing demonstrator mockup, a helicopter diesel engine, as well as a performing power electronic model, an ice detector sensor and an air intake, all related to the more electric aircraft concept. We will display brand new samples for regional aircraft and will offer a community noise simulation to experience the reduction of noise in the vicinity of airports. Not least, visitors will be able to find out about Clean Sky 2, its new features and planned calls for proposals.

We expect to receive many visitors at our stand and conferences including our Members, professionals, policy makers and the public at large. We are confident you will enjoy the visit.

You will find all the information about Clean Sky at Paris le Bourget 2015 including our exact location and the programme for our stand and conference activities on www.cleansky.eu.

Innovative Hardware on show:	Open rotor	Open rotor blade	Nozzle Burner	Airbus A340-300 BLADE (Breakthrough Laminar Aircraft Demonstrator)
Innovative composite (RTM technology) load introduction rib for the smart flap	Nose Landing Gear	Droop Nose Mechanical Prototype	Main Landing Gear Electro-Mechanical Actuator	Helicopters High Compression Engine (HCE) model
Scoop Intake with integrated electro-thermal ice protection and acoustic attenuation	PRIMARY In-flight Icing detection system	HEMAS actuator	Virtual Community Noise Simulator (VCNS)	H1 Part 6: titanium fan wheel

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