Joint Technology Initiative Clean Sky – The European Program Towards Ecologically Compatible Air Transportation

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ABSTRACT

The Clean Sky Joint Technology Initiative (JTI) [1] is an innovative 7 years program that will radically improve the impact of air transport on the environment while strengthening and securing aeronautics industry's competitiveness. Purpose of this one of the largest European research projects ever is to achieve, to demonstrate, and to validate technological breakthroughs to reach the main environmental goals of 50% less CO_2, 80% less NO_X, and 50% less noise emission by 2020. Clean Sky is expected to lead the early introduction of new, radically green air transport products that will encourage the aviation world to make greener products to be brought into service sooner. The paper introduces to Clean Sky JTI, which combines the efforts of 86 organizations in 16 countries. The comprehensive set of Clean Sky demonstrators comprise smart structures and integrated advanced low-noise solutions, innovative concepts for active flow and load control as well as green design, manufacture, maintenance and recycling for airframe and systems. Clean Sky will offer the innovations developed under this program to all commercial aircraft industries.

Keywords: noise reduction, lower emissions, reduced fuel consumption, greener design, strategic aeronautical research

1 SCOPE OF CLEAN SKY

Worldwide, air transport is a keystone to further economic growth. At the same time, air transport is facing all the global economic and ecological challenges. The oil resources vanish. Hence, the price will continue to be highly volatile and generally rising. In addition, global warming is a world-wide recognized issue. Therefore, carbon trading and ecologically motivated taxes are likely to increase. Thus, environ-mental friendliness of air traffic is of significant importance. Cumulatively, the aeronautic sector employs 3.1 million people and generates € 220 billion of direct added value for the economy in the European Union (EU) counting for some 2.6% of Europe's GDP.

Clean Sky will assess, design, build, and test many technological validation vehicles that will give the industry greener, more innovative aviation products. It is expected to yield green aircraft components, which generate less noise, lower the emissions, reduce the fuel consumption, and apply the environment protection principles at all levels of use: design, production, maintenance, overhaul, repair, and disposal.

The program will be of enormous socio-economic impact while implying aircraft industry and opening access to SMEs and to new member states. A significant part of the Clean Sky program will be performed by partners still to be selected through Calls for Proposals (CfP) and subcontractors selected through Calls for Tender (CfT) [1]. In addition, a large multiplier effect is expected by complementary national programs. With more environmentally friendly products and the creation of highly qualified jobs, a major contribution to sustainable growth in air transport related industries is aimed at.

Clean Sky was set up to meet the goals of the strategic research agenda (SRA) of the Advisory Council for Aircraft Research in Europe (ACARE). These goals are expressed as

i) 50% cut in CO_2 emissions per passenger kilometer (which means a 50% cut in fuel consumption in the new aircraft of 2020),
ii) an 80% cut in nitrogen oxide emissions, and
iii) a reduction in perceived noise to one half of current average levels.

Noise nuisance outside the airport boundary by day and night shall be eliminated by quieter aircraft, better land planning and use around airports, and by the systematic implementation of noise reduction procedures [2].

A maximum engagement by the industry in the task of studying and minimizing the industry's impact on the global environment is stimulated by the Clean Sky JTI. The total amount of € 800 million of public funding has been made available via European Commission (EC) to be allocated into Clean Sky. This amount has been considered the minimum contribution needed for making Clean Sky a success. Private partners will contribute € 800 million out of their budgets and it is doubtable that without a dedicated program like Clean Sky they could have been persuaded to spend such an amount on environmental research additionally.

Clean Sky is enabling a quantum leap in innovation by drastically accelerating time to market of substantial technological improvements. Progress would have been much slower without such technology demonstration effort undertaken within the next years. By 2020, so the vision, aircrafts are cleaner and quieter and the positive contribution of the aeronautics sector to sustainment and improvement of our environmental conditions is widely understood and appreciated [2].

2 STRUCTURE OF CLEAN SKY

A JTI is a type of project organization created by the European Commission for funding research in Europe that allows the implementation of ambitious and complex activities, including the validation of technologies at a high level of readiness. Size and scale of JTIs require the mobilization and the management of very substantial public and private investments and of large human resources [1]. In the particular case of JTI Clean Sky, all major European aeronautics companies are involved replacing competition by European cooperation. The members of the consortium and the EC have established a Joint Undertaking (JU), which is a legally self standing holding type enterprise. Fraunhofer is a member of the Clean Sky JTI Governing Board and one of the platform leaders. The other leading partners are Agusta Westland, Airbus, Alenia Aeronautica, Dassault Aviation, EADS-CASA, Eurocopter, Liebherr-Aerospace, Rolls-Royce, Saab AB, Safran and Thales.

A National States Representative Group (NSRG) has been formed for reviewing all information and for commenting on program progress and compliance with the targets. The close involvement of Member States effectively stimulates the alignment of national research with Clean Sky. ACARE is the advisor to the Commission on JTI alignment with the SRA. It is responsible for updating the strategic orientation and for assuring consistency with the regulations of collaborative research in Europe's 7th Framework program [3].

The target of 12% SME participation in Clean Sky is challenging as it is 20% higher than the rate achieved in previous aeronautical collaborative research. Hence, Clean Sky stimulates many companies to participate in EU research for the first time. Because Clean Sky activities are closer to the market, they are more attractive to companies having a shorter time horizon and a strong interest in fast return of invest (ROI). Even at a funding level of 50%, SMEs are very interested in participating in Clean Sky because the project qualifies them as a supplier to the aeronautics industry and makes them a part of the standard supply chain of the airframers [3].

Research institutions and universities are involved in

Fig. 1: Technology domains of the Clean Sky JTI [1]

Clean Sky right from the beginning. They seamlessly feed latest technology into the project based on best engineering knowledge available in Europe. This helps meeting the challenging goals.

More than € 200 million of the EU contribution are allocated to CfPs open to all European organizations.

Within the Clean Sky JTI, the work is organized in six Integrated Technology Domains (ITD) (see Fig 1). Smart Fixed-Wing Aircraft (SFWA) ITD aims to develop an all new wing design that makes use of passive and active flow and load control technologies and will help to reduce the drag of the wing in cruise as a means for reducing fuel burn and emissions by up to 20% and noise by 5 to 10dB. The objective of the Green regional aircraft (GRA) ITD is to validate and demonstrate technologies best fitting the environmental goals set for the regional aircraft entering the market in the following years. The ECO Design ITD is taking the three distinctive phases of the total aircraft life cycle into consideration: aircraft design & production, aircraft use & maintenance, aircraft withdrawal. The Systems for green operation (SGO) ITD will improve aircraft operation through the management of aircraft energy and the management of mission and trajectory. Full engines or core ground demonstrators will be the output of the Sustainable and Green Engines (SAGE) ITD while modified existing rotorcraft will be that of the Green Rotorcraft (GRC) ITD. Finally, the technological innovations of all ITDs undergo will be assessed regarding their economic and environmental effects. This will be done by the Technology Evaluator group.

2.1 The Smart Fixed Wing ITD (SFWA)

The SFWA will work towards the goal of reducing the medium- and long-range aircraft fuel burn and noise emissions by developing an all new »smart wing« design. Passive and active flow and load control technologies will be employed to reduce the in cruise drag of the wing. Hydrocarbon-based fuel is still the main source of energy, thus the impact of damaging emissions has to be reduced substantially. The main focus of SFWA is on advanced wing design and aircraft configurations to save fuel with the largest aerodynamic potential provided by laminar flow technology. Innovative technological concepts still have to drastically reduce its complexity to be used economically. More fuel-efficient missions are envisaged with adaptive airframe structures, allowing the aircraft to be consistently operated at modes of higher fuel-efficiency. Additional control surfaces may be obviated by adaptive structures, thereby reducing system complexity and weight substantially [4]. Installing novel engine types as geared turbofan or the open rotor are requiring significant changes to aircraft architecture and solutions to be found to technology issues raised therewith [1]. Functionalization of the surface, general bonding and application of control strategies basing on durability driven loads as introduced by Fraunhofer, Germany, are novel concepts for the support of smart wing adaptabilities.

New high-lift systems designed for high climb rates at take-off and quiet drag generation at approach enable aircraft to perform steep take-off and approach without effecting cruise drag. Blown flaps enhance high-lift performance additionally. SFWA will include all disciplines traditionally involved in aircraft design: flight physics, structure and systems [1].

2.2 The Green Regional Aircraft ITD (GRA)

The platform concentrates on low weight (LWC) and low noise (LNC) for regional aircraft up to 50 tons, including all-electric technologies. SHM concepts based on FOBG, Acoustic Emission and Ultrasonics, Wireless Communication, thermoset and nano-reinforced composite materials as well as laser beam welding represent the core of Fraunhofer involvement in LWC. Technologies that shield or lower the noise produced by conventional aircraft or engines, such as low noise component design, landing gear fairing, and advanced acoustic panels are being developed. Advanced leading edge design, landing gear geometry and kinematic will be developed and tested in the wind tunnel for low noise purposes in LNC. Simulation capabilities will include those for computational fluid dynamics (CFD) and computational aero acoustics (CAA) as prediction tools for noise. Furthermore, the new technologies imply the need for appropriate and advanced measuring techniques and equipment for use in boundary layer and acoustic measurement even under cryogenic conditions. In the longer term, active noise control techniques benefiting from new knowledge on micro and nano-technologies will allow aircraft noise to be reduced further.

2.3 The Green Rotorcraft ITD (GRC)

To allow operation in populated areas for passengers and freight delivery as well as for civil operations (police, medical aid, ...) without disturbing the public, rotorcrafts have to be dramatically optimized regarding their emissions. The noise reduction has been addressed in low level cruise flight, as well as landing and take-off, through innovative and adaptive rotor aerodynamics. Rotor blades are modified by passive optimisation as well as active control techniques and new turbo-shaft engine architecture will also reduce CO_2 and NO_x emission. The approach is focusing on noise, efficient power use and optimal flight operations [3,4].

2.4 The Sustainable and Green Engine ITD (SAGE)

For engines a series of difficult trade-offs have been identified. Increase in by-pass ratio to further decrease the fan and jet noise increases drag and weight. Increasing the overall pressure ratio and the turbine inlet temperature improves the engine thermal efficiency and hence reduces CO_2 but, without improved NO_x control technology, increases NO_x emissions. New technology concepts have been needed to compensate for this effect. Major decisions may be necessary in the next years of the platform in case the market dictates a re-direction of work, as for availability of alternative fuels (e.g. liquid H_2, bio fuels, synthetic fuels, LNG) or power sources (e.g. fuel cells). Novel engine technologies (Ultra High By Pass Ratio, geared fan, contra-fan, etc.) are under development [3]. However any further increase in By-Pass Ratio as well as most noise shielding technologies increase drag and weight. For this reason, noise reduction is at it's limit without more radical changes in aircraft designs and configurations.

2.5 The Systems for Green Operations ITD (SGO)

The Systems platform deals with the energy systems for large aircraft whilst for business jets, rotorcraft and regional aircraft, the airframers' requirements are performed in the Eco-Design platform. The SGO ITD will improve aircraft operation through the management of aircraft energy and the management of mission and trajectory. Technologies from this ITD are enablers for further improvements in environmental impacts at the vehicle level. The development of appropriate tools able to handle design tradeoffs on a multidisciplinary optimization basis has been an important element of the research.

As aircraft noise should no longer be a political and social issue, the development of trajectory management plays an important role in this platform. Trajectory and mission management is highly related to new engine characteristics and noise reduction. There will be concerted effort to optimise operational procedures beside developing quieter engines. Models to optimize take-off profiles as well as models of noise annoyance and models integrating the effects of emissions generation, species evolution and global decisions support will be generated.

Fraunhofer will address sensorics within A/C main and auxiliary energy generation and will contribute in SGO environmental testing campaigns.

2.6 The ECO Design ITD (ECO)

ECO design is important for the greening of air transport. More and more aircraft products are made of recyclable materials to have minimal environmental impact. The project also addresses the consequences of the EU REACH initiative to replace toxic materials. The ITD Eco Design (ED) focuses on environmentally sound aircraft production, as well as on aircraft recycling technologies. Clean and resource efficient technologies both for aircraft structures and equipment are created and matured, along with a quantification of environmental improvements using a focused life cycle assessment approach. As results, „green“ pre- and post-use-phase technologies along with ecologically effective aircraft design guidelines will be presented.

A second pillar of ED is the systems domain which tackles the generics and validation of eco-friendly aircraft systems. Following an “all electric” philosophy, hydraulic fluids shall be obviated in future aircraft. Volatile organic compounds (VOC) are avoided in advanced systems architectures which will be pioneered on the business, regional and rotorcraft scale flight vehicles.

2.7 The Technology Evaluator (TE)

The Technology Evaluator acts as an essential element of the Clean Sky as it independently verifies the achievements against the targets identified. TE monitors ITDs progress along Clean Sky duration for JU stakeholders, internal and external entities. TE consistently assesses the merit of complementary R&D activities performed in ITDs with regards to ACARE environmental objectives, bringing global air traffic system view. TE helps identifying interdependencies of impacts and provides elements of guidance and justification for decision making within Clean Sky, to maximize JTI synergy effects.

The Technology Evaluator is linked to the ACARE observation platform and will therefore also be a valuable tool to monitor the relevant research performed outside the Clean Sky project. Furthermore the Technology Evaluator will track important related developments in national, multinational and European RTD programs in an independent way. Fraunhofer Society leads the global assessment of ecolonomic impacts in Clean Sky.

3 SUMMARY

The European air transport sector - comprising more than 130 airlines, operating across a network of over 450 airports with some 60 air navigation service providers (ANSP) and the manufacturing industry – is expressing an urgent need for environmentally compatible air traffic. The JTI Clean Sky is consequently the answer to the challenges of ACARE’s vision 2020. The combined effort of the private and public partnership of Clean sky will culminate in the advanced technology demonstrators of the six ITDs, bringing the future aircraft to environmental friendliness.

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