Report to the European Parliament on the socio-economic impact of Clean Sky

Introduction

The European Union has adopted Horizon 2020, the new framework programme for R&D, in 2014 for 7 years duration. Horizon 2020 has a strong focus on innovation as a basis for societal growth and prosperity.

The European Commission has identified ten areas of priority for action at European level for the period 2014-2020. Among them, a major emphasis is placed on the R&D impact on job creation, societal growth and investment associated with the creation of a strong industrial base and on reducing the environmental impact of technology in line with a forward-looking climate change policy.

President Juncker’s political guidelines emphasise the “need to maintain and reinforce a strong and high-performing industrial base for our internal market” thus ensuring “that Europe maintains its global leadership in strategic sectors with high-value jobs such as the automotive, aeronautics, engineering, space, chemical and pharmaceutical industries”.

1. Programme impact

The European aeronautical industry has been very competitive on the global market and represent today one of two major industries worldwide. This is the result of a careful infrastructural construction, which included pan-European and national interests, the creation of targeted technology poles and the implementation of R&T in all commercial flying segments, through a fine network of cooperation between all stakeholders, both private (industry, research centres, academia, SMEs) and public (EU, national and regional authorities and governmental organisations at large). This setting has contributed to the steady growth of the European civil aeronautics industry, which shows an increase in turnover in 2013 of 8.5 % (compared with 5 % annual air traffic increase) with respect to 2012 to close to € 100 bn, contributing 4 % to the EU GDP. It shows also an equivalent increase in number of jobs in civil aeronautics to 534,000 with a projected impact on the EU job market of 8.1 million. Its competitiveness with respect to main competitors has risen in parallel. As an example, the worldwide share in orders/sales in the short/medium range aircraft has raised from 10% in mid-80's to more than 50% in 2010. Europe should ensure that this trend continues now that new competitors are emerging, presenting a clear challenge to the leadership of the EU and US industrial base in commercial aviation and changing the landscape of competitiveness and product development. The growth of the European aviation industry is reflected in the evolution of its macro- and socio-economic parameters, as shown in table 1. The figures for 2013 show a 10% increase with respect to the previous year.
There is a compelling global case for government intervention through grants to accelerate the market introduction of new technologies beyond the private stakeholders’ investment capabilities. This approach creates a powerful dynamics combining State innovation capabilities through policy and participation of industry and state-owned organisations, with strong fall-out in competitiveness and job creation. Furthermore, the full social value of R&T extends beyond the companies that undertake it. As a result, the level of R&T in general is inevitably below the optimum for society and this is a special problem in relation to the environment where the social impact can be large and trans-national. This demands co-ordination across Europe and hence intervention at EU level.

<table>
<thead>
<tr>
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<th>2013</th>
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<tbody>
<tr>
<td>Turnover (civil aeronautics)</td>
<td>€ 89.2 bn</td>
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<tr>
<td>Turnover (inc. military and space)</td>
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<td>Direct EU employment</td>
<td>534,000</td>
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<td>University 4-5years</td>
<td>40 %</td>
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<tr>
<td>University &lt; 3 years</td>
<td>27 %</td>
</tr>
<tr>
<td>other</td>
<td>33 %</td>
</tr>
<tr>
<td>Total EU employment</td>
<td>8.1 million*</td>
</tr>
<tr>
<td>R&amp;D expenditure</td>
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</table>

*projection

Table 1 - Socio-economic parameters for the aviation industry

2. Framework of the Clean Sky JTI implementation

The European ‘Framework’ research programmes were an important tool for distant-from-market collaborative research. But, in comparison to major competitors where public support for industrial research is far greater, EU (and Member State) support had not placed sufficient emphasis on validating complex systems at large scale and at high technology readiness levels in order to allow for rapid exploitation at acceptable risk.

The Clean Sky JTI sought to overcome such deficiencies by creating a new structure in which European industry collaborates with the European Commission in setting social and market based technological goals while co-funding the programmes to achieve them. This joint leadership role encourages a greater degree of coordination between national, EU and industry based research thus raising the efficiency of innovation within Europe by limiting duplication and by setting coherent targets around which industry leaders and their supply chains can coalesce. There may also be wider benefits to come from taking the lead in signaling clear environmental objectives at a global level.

The Clean Sky JU was created as an act of the European Council in 2007 in the first wave of Joint Technology Initiatives with the mandate of implementing an ambitious programme of environmentally friendly technology development, an area of ever increasing political and socio-economic relevance, in line with the Union priorities for 2014-2020, endorsed recently by the European Parliament. Clean Sky (referred to as Clean Sky 1 from now on) will complete its technical
programme by end 2016 and has already proven to be an efficient tool for boosting the market introduction of new technologies, with expected fall-out on jobs, growth and investment.

The sequel Clean Sky 2, which capitalises on its predecessor and pushes technology development further in R&T intensity and product span, has now been set up. The Regulation governing the Clean Sky 2 JU was adopted by the European Council in May 2014 with duration until 2024 and with the responsibility for both technical programmes. The Clean Sky 1 and Clean Sky 2 programmes will run in parallel until completion of the former in 2017.

The Clean Sky set-up is leading to greater industrial and inter-national integration within the Union. It has started to correct the distortions that exist as a result of the provision of public support outside Europe whilst focusing the stimulus on socially desirable environmental improvements.

3. Programme objectives and results to date

In past years, the European aeronautical industry has established successfully its role in the international market. In the current policy and strategic context and in the face of increasing competition with the emergence of new integrators, the future international competitiveness of the EU aviation sector will depend largely on the environmental performance of its technologies.

Clean Sky 1 addresses the development of environmentally friendly technologies in all flying segments of commercial aviation. This is equivalent to say that innovation is tackled across the board, over the whole range of products that are at the basis of the aviation sector.

The objectives of the Clean Sky 1 programme are to advance and improve the way the European aeronautical industry acquires technology whilst providing a specific stimulus to accelerate improvements in the environmental performance of air transport. Huge technological and industrial progress has been made and further development will depend upon greater integration of technical and industrial contributions from across the European industry.

Clean Sky 1 targets the reduction of the main noxious gas emission (CO₂, NOx) and noise, the latter with two main objectives: (1) halving perceived noise per operation and (2) maintaining noise levels outside airport boundaries below annoyance levels. Table 2 shows the impact forecast at global fleet level as foreseen at the start of Clean Sky 1 and as achieved to date per flying segment, according to the assessment carried out by the Clean Sky Technology Evaluator in 2015, two years before programme end. The noise reduction value relates to the expansion capability of an airport with regard to traffic without increasing noise levels from current figures. Capacity increase impacts positively on jobs. Results achieved, in particular on CO₂ and noise, represent a major leap forward to meet the overall environmental targets and contributing strongly to improve societal impact.
### Clean Sky 1 achievements two years before programme end show the potential for a CO₂ reduction which cumulates in -25% at global fleet level, very close to the original forecast. Similarly NOx is at -40% and noise reduction is well inside forecast brackets. Actual implementation will depend on industrial strategies regarding market deployment. Figures quoted represent the impact of the Clean Sky 1 technologies at the maturity level they have reached so far and will evolve further when attached to a concrete new product.

*Reduction percentages are compared to emissions and noise produced by an aircraft manufactured with year 2000 technology.

**The percentage value shows the reduction of the noise footprint in areas surrounding airports for same noise levels produced by currently operating fleets.

**Table 2 - Summary table of the Clean Sky 1 objectives and results to date per flying segment.**

The organisation of the technical work is shown schematically in fig. 1. It is divided into 6 technical areas named Integrated Technology Demonstrators (ITDs), three of which target commercial flying segments (“vehicle ITDs”), while the remaining three tackle supporting technologies to the former (“transversal ITDs”) and include a number of individual projects. The technical activities comprise an internal self-assessment carried out on individual systems through a Technology Evaluator, which allows an ITD-independent forecasting of the environmental impact of Clean Sky technologies in view of deployment.

Both in the case of Clean Sky 1 and of Clean Sky 2, the technical programme is the result of an initial proposal from the main stakeholders, which underwent (in 2008 for Clean Sky 1 and in 2014 for Clean Sky 2) an impact assessment carried out by the Commission and an evaluation by external experts, who were charged both with assessing the proposed programme against the Strategic Research and Innovation Agenda established by the Aviation Technology Platform (named ACARE) and with assessing the intrinsic technical merits of the proposed approach. The Commission is part of the assessment process, thus ensuring that no direct overlap occurs between Clean Sky and Commission funded...
programmes. The Clean Sky approach with respect to in-kind contributions and intellectual property rights follows the Commission approach in full. In the case of Clean Sky 2, quantified complementary activities were introduced in the Regulation to be carried out by non-Commission members leading to a stakeholders' investment amounting to 125% of the public funding.

Fig. 1 - Schematic of the Clean Sky 1 technical work organization.

4. The effectiveness of the global approach – Main achievements to date

The activities of Clean Sky 1 are managed by the JU executive team and are carried out by a consortium including 83 private full members of the JU, who engage for the full programme duration, and 530 partners over the life of the programme, selected through open competition across the European Research Area, for a total of 613 beneficiaries. This approach serves both the purpose of selecting and relying on the best organizations in Europe and of widening the participation to organisations not yet involved in the Aeronautics innovation chain or included in the traditional industrial supply chain, while setting a modus operandi that is mirroring the product development one.

A number of successful projects have been carried to completion in the different ITDs by members and partners, both demonstrators which have been completed or entering now the testing phase and projects leading already to marketable products. Some examples are listed below; in order to show the broad range of innovations performed in Clean Sky 1, they are selected either at a high level of integration (full demonstrators) or, to the contrary, at the level of individual, smaller-size projects often lead by SMEs. Despite the long cycle from technology to product which is a key feature of aeronautics, these few examples show cases of Clean Sky technologies having already been used for a commercial application,
or having a clear perspective of such a concrete application in the near future. Other cases are maturing also.

### 4.1 Tech 800 demonstration engine

**Main coordinating organisations:** Turbomeca, *Electronique Industrielle de l'Ouest - TRONICO SAS; FUNDACION TECNALIA RESEARCH & INNOVATION; Oxsensis Limited (Ceramic Optical Temperature Sensor for Turbine Engine Measurements); GE AVIATION SYSTEMS LTD; SENER INGENIERIA Y SISTEMAS S.A.; INTRENIA SL; AKIRA TECHNOLOGIES SARL; FUNDACIO PRIVADA ASCAMM; UNIVERSITE DE TECHNOLOGIE DE COMPIEGNE Actividades Aeroespaciales S.A.*

**Purpose:** demonstrating technology advances which could be readily applied to develop small/medium size helicopter engines of significantly improved environmental and economic characteristics. To this purpose, involved organisations developed several technologies up to a full scale ground demonstrator.

**Project content:** to provide a platform to test new designs exploiting gains coming from a combination of increases in compressor and turbine efficiencies, improved architecture and materials, a higher pressure ratio, more efficient thermodynamic cycle, and intake and exhaust acoustic treatments. In parallel to this project, demonstration of a low-NOx combustion chamber took place in a related national programme.

**Market opportunity:** The successful technologies were integrated in the product development of the new Turbomeca ARRANO engine, which has recently been selected by Airbus Helicopters for the new Airbus H160 helicopter.

### 4.2 High Compression piston engine for Rotorcraft

**Main organisations:** Airbus Helicopter; *partners: TEOS, AustroEngine.*

**Purpose:** demonstrating in flight the drastic CO₂ emission reduction which can be obtained on small helicopters using high compression piston engines in place of turboshaft engines.

**Project content:** the demonstration is carried with a specifically developed 8 cylinder turbocharged piston engine burning standard Kerosene (Jet A) fuel at equivalent usable power for the helicopter drive system but providing better performance at altitude. The fuel saving and CO₂ emission reduction reaches 40-50%. The engine demonstrator developed by partners selected through a Call for Proposals represents one of the highest value projects funded by Clean Sky 1.

**Market opportunity:** this new power plant could be further developed and serialised in several versions and ratings to open new market opportunities not only for a whole range of light helicopters but also for general aviation propulsion and auxiliary power functions with significant advantages in terms of acquisition and maintenance costs.
4.3 Regional turboprop flight test

Main organisations: Alenia-Aermacchi, ATR, Fraunhofer Gesellschaft

Objective: maturing design and manufacturing of advanced composite panels, to prove the CFRP material feasibility and its benefits by insertion on future regional aircraft products.

Project content: in this in-flight demonstrator, an entire section of the aluminum upper fuselage ("crown panel") has been replaced with an innovative composite multi-layer panel containing optical fibres and piezo electric sensors/actuators for in-flight measurements. The first flight took place on 8 July 2015, following the assessment of clearance for flight of the modified aircraft. This activity has been complemented by ground demonstrators.

The new fuselage of next Regional Turboprop is planned to be based on the most advanced composite technologies developed in Clean Sky 1.

Market opportunity: it is estimated that the European aeronautic industry can increase by a factor two the market share in the regional aircraft segment. The workforce employed in the European regional turboprop aircraft for scheduled passenger service is expected to grow from the current 3000 units to about 8000-9000 units in the next 20 years, taking into account about 9500 new aircraft deliveries (3000 turbo prop and 6500 regional jet). In the next 20 years the market share of a new European regional turboprop programme will account for 30-40%, twice the current value.

4.4 ALPS engine demonstrator

Main organisations: Rolls-Royce, ITP, GKN; partners: FACC AG, Austria, University of applied sciences (UAS) Rapperswil, Switzerland.

Objective: introducing a composite fan structure in large 3-shaft engines, used on long range aircraft, with reference to the TRENT engine family of Rolls Royce.

Project content: the composite fan is one of the 14 key technologies at Rolls-Royce and dedicated performance testing was completed in October 2014. Design, manufacture, assembly and test of advance dressings provided down-selection of sub-component designs for application.

The test programme included flight test on the Rolls-Royce dedicated Flight Test Bed, with an engine demonstrator incorporating all major modifications and new technologies; complementary testing will be performed on ground in cold weather/icing trials.

Part of the composite fan system involved an AT-CH consortium selected in 2010 through the 3° Call for Proposals (project ORCA). The new engine incorporates technologies carried out by IPT (Spain) for the low pressure turbine (LPT) and an intermediate compressor case manufactured by GKN (Sweden) with involvement of partners selected via Calls.
Market opportunity: the achievements of this Clean Sky 1 project will become standard in the TRENTEngine family. Individual technologies at sub-system level will progressively enter production starting in 2017.

4.5 Helicopter eco-flight procedures

Main organisations: AgustaWestland, Airbus Helicopters

Objective: developing low emissions, low noise flying procedures for rotorcraft.

Project content: the activities have consisted of developing VFR (Visual Flight Rules) procedures for both helicopters and tilt rotors, using a test bed AW139 helicopter, with pilot evaluation and flight trials, plus correlation with numerical acoustic database updated and validated against flight data. The IFR (Instrumental Flight Rules) procedures are ready for piloted simulation experiments, with low noise trajectories defined. Final demonstration on a H155 of the SNI (Simultaneous Non Interfering) procedures was achieved on May 5-6 2015, as well as the Demonstration of Low Noise Helicopter-Specific IFR SNI procedures at airport.

Market opportunity: in both cases (VFR and IFR), the procedures can be implemented in helicopter operation as from 2016. This activity contributes to the validation and implementation of new rotorcraft operational procedures in the Framework of the SESAR Joint Undertaking.

4.6 BME Clean Sky 27

Main organisation: Budapest University of Technology and Economics.

Purpose: accelerating the application of renewable organic bio-based epoxy resin composites to aeronautical components in alternative to mineral oil based plastics.

Project content: novel interdisciplinary process tailored to aeronautics to develop high tech composite materials through advanced chemistry working on simple products like sugars, largely available as glucose and polysaccharides. Different solutions were investigated to obtain the base epoxy elements from sugar in order to replicate conventional petroleum based resin structures. A demonstrator, simulating an aircraft sandwich interior floor, has been produced and tested with positive results in terms of mechanical properties, process energy efficiency and technology readiness and finally proven also at industrial level.

Market opportunity: renewable organic epoxy resins made from natural materials are a good alternative to petroleum derived chemicals with a clear ecological impact. The technology could be applied within the next 5 years to a variety of composite aircraft interior applications in combination with carbon or even more ecological fibers also able to contribute to mass savings. The sugar
used is a non-fossil based raw material and does not interfere and compete with food production due to its large availability.

**4.7 Green polyurethane resin seating Cushion**

**Main organisation:** Axyal – FR (SME)

**Purpose:** Applying renewable bio-based polyurethane resin to seating cushions for large passenger aircraft in alternative to pure mineral oil based seating cushions.

**Project content:** novel natural oil based polyols has been used for aircraft seating cushions. Different polyols have been investigated to replicate conventional petroleum based seating cushions. Several green polyols showed promising properties leading to the selection of a soy bean oil based polyol. Additionally to replacing of petroleum based polyols, the natural polyol allowed leaving flame retardants out of the new formulation, keeping the strict aeronautical requirements concerning fire, smoke and toxicity. A demonstrator simulating an aircraft seating cushion has been produced and tested with positive results in terms of mechanical properties and technology readiness.

**Market opportunity:** renewable organic polyols made from natural materials are a good alternative to avoid harmful substances through the technology of halogen-free flame retardants. This means that the flame retardancy becomes a property of the foam itself instead of something that is added afterwards. This technology, which has a high potential for applying different materials to aircraft interior, replaces petroleum derived chemicals contributing to CO₂ emission reduction.

**5. The socio-economic impact of Clean Sky 1**

**5.1 The Clean Sky supply chain eco-system**

The setting of Clean Sky 1 mirrors the business model of the aeronautical sector production supply chain, which keeps the major integrators in charge of the development of the final product (e.g. an aircraft, an engine, a flight system). In the case of Clean Sky 1, an EU innovation/know-how chain was set within the R&T perimeter and involving all actors capable of contributing at different levels to the successful assembly and testing of final demonstrators. The concentration under a single coordinated Clean Sky 1 programme of the activities aiming at meeting clear environmental objectives speeds up the pace of technology progress and consequently the market introduction of new products providing a competitive boost to the EU manufacturing industry. This acceleration is shown schematically in fig. 2.

A major winning factor has been the methodology applied when widening the participation to include further organisations. While selection and identification of full-time members of the Clean Sky 1 Joint Undertaking was performed as a condition for finalising the Regulations, further participants have been selected
through a total of 16 open Calls launched between 2009 and 2013, leading to the participation of 533 organisations scattered throughout 24 countries (fig. 3).

With regard to the SME participation in particular, a questionnaire was launched recently among all entities that applied to the Clean Sky 1 Calls, including those who were not selected eventually. Up to 93 % point at the Clean Sky route to EU funding as equally or better suited for their needs than collaborative Calls and 57 % could use Clean Sky 1 soon after project completion as a springboard for business expansion.

Fig. 2 – Schematics of the acceleration mechanism provided by Clean Sky 1 and Clean Sky 2 for the introduction of new technologies (the specific case of CO₂ emission reduction is shown) – the objectives of the JU will be met within the allotted timescale (2017 for Clean Sky 1 and 2024 for Clean Sky 2), shortening the time necessary to reach the same objectives through the standard approach shown by the hyperbolic curve (in red).

Fig. 3 – Participation in numbers of different organisation types to Clean Sky 1 Calls for Proposals.
5.2 Long term impacts of Clean Sky

The gross impact estimates at the beginning of the Clean Sky 1 programme were as follows:

- In order to quantify the economic effect of Clean Sky 1, the potential impact of its absence can be considered on either a single uncompetitive aircraft product, or a delay in launching a major programme, or a shift in work share away from Europe in the absence of Clean Sky 1. This suggested that between 12% and 20% (€100 bn to €160 bn) of the total value added generated by the European aeronautics industry between 2010 and 2035 would be dependent on the technical capability to be delivered by Clean Sky 1 (table 3).

<table>
<thead>
<tr>
<th>Aeronautics Industry Value</th>
<th>EU Benefit</th>
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<tbody>
<tr>
<td>Market Opportunity</td>
<td>R&amp;D spill-over</td>
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<tr>
<td>Industry Value Added</td>
<td>“Clean Sky” Value Added</td>
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<td>~€1500Bn</td>
<td>~€450Bn</td>
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<tr>
<td>~€100Bn</td>
<td>~€160Bn</td>
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<td>~€350Bn</td>
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Source: “Clean Sky” proposal to the European Commission, March 2007
Note: All numbers shown in 2006 prices using a risk free discount rate of 3.5%

Table 3 - Estimates of the economic value opportunity related to Clean Sky 1

- In addition to the large direct economic benefits described above, Clean Sky 1 will reduce the environmental footprint. There is a substantial economic benefit directly attributable to reduced CO₂ emissions. Based on projections of aircraft emissions growth from the IPCC and using values of the social cost of carbon from a study carried out on behalf of the UK Government, estimates put the total amount of carbon reduction attributable directly to Clean Sky 1 up to 3 billion tons, which implies up to 1 billion tons fuel saving, up to 2050. According to preliminary estimates, Clean Sky 2 will add 4 further billion tons of CO₂ savings, meaning that cumulative Clean Sky technologies will allow more than 2 bn tons of fuel savings up to 2050.

<table>
<thead>
<tr>
<th>Aircraft Level</th>
<th>Fleet Level</th>
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<tr>
<td>CO₂ Reduction</td>
<td>CO₂ savings</td>
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<tr>
<td>20 to 40%</td>
<td>3 to 6 bn tons</td>
</tr>
<tr>
<td>NOx Reduction</td>
<td>Fuel savings value*</td>
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<tr>
<td>~40%</td>
<td>1 to 2 bn tons</td>
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<tr>
<td>Noise Reduction</td>
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<tr>
<td>~75%</td>
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*Fuel savings is typically 1/3 of CO₂ savings in weight.

Table 4 - estimate of the environmental value opportunity related to Clean Sky.

1 The study (“Assessing the economic impact of aerospace R&D”) was performed by Oxford Economic Forecasting in 2006, when the Clean Sky 1 programme was proposed. The Joint Undertaking intends to have a full re-evaluation of these long term impacts in 2016, which will contribute to the final assessment of Clean Sky 1, due in 2017.
Table 2 compares Technology Evaluator performance predictions upfront with the assessment on the same technologies in 2015, when demonstrators are either running or entering their testing phase, just over one year from programme completion. Current Clean Sky 1 results are in line with original forecast of emission reduction in particular, thus confirming the validity of the ex-ante analysis on CO₂ savings shown in table 4.

5.3 Size and impact of R&T job creation

The complexity of the global network of organisations involved in supply chains makes it extremely difficult to quantify the correlation between R&T jobs and development and production jobs, but trends can be identified with some assumptions from previous experience. In particular, the presence of highly competitive European integrators ensures a favourable transition from R&T to production in term of jobs. The implementation of the Clean Sky programme is relying currently on about 4000 full-time equivalent jobs for its 7 years duration. It is assumed currently that, in the aerospace sector, jobs in R&T translate into jobs in production to the ratio of 1:100. However, another important element necessary for proper forecasting is the time delay between the successful testing of a technology at Technology Readiness Level 6 (up to full-scale integrated testing) and its full deployment in the production chain and, of course, it is hardly conceivable that a technology enters production without a quantifiable R&T phase. Clean Sky 1 and Clean Sky 2 will contribute substantially to the build-up of R&T resources and their effectiveness both by increasing the number of activities and by streamlining complementary activities at European, national, regional and private level.

The impact of R&T resourcing is very important when considering technology production. For instance, in one of the project examples given in section 4, the Arrano engine developed under the responsibility of Turbomeca and supported by a Clean Sky 1 demonstrator with €18.2 million European public investment, it is expected that production will entail between 1000 and 1500 jobs for the next 20 years. To be noted that, conversely, production maintaining competitiveness levels will foster further technology demands, which translate in RT&D jobs.

5.4 Dissemination and exploitation

The involvement of stakeholders from as wide a technology and country base as possible is one of the key priorities of the Clean Sky 2 JU. Awareness campaigns are set through information days scattered throughout the whole of Europe dealing with state of progress and participation opportunities. Clean Sky aims also at the full dissemination of projects and technological results developed within the programme. Dissemination activities are addressed particularly towards the European scientific and academic communities. They play a pivotal role within Clean Sky 1 and represent a basin of growth in terms of creating technical competences ensuring the continuity of the programme. The main dissemination tools are newsletters, workshops and technical conferences.
shows the spectrum of dissemination/information events the Clean Sky 2 JU has been involved in to date.

Exploitation of results obtained in Clean Sky 1 at Technology Readiness Level 6 (pre-market limit) for market deployment is the culmination and concretisation follow-up stage. The aeronautics community approaches development and production mostly through sharing of fore- and back-ground knowledge within supply chains, while patenting is not the main tool for know-how protection. This is very much aligned with the Commission approach and the Clean Sky 2 JU Intellectual Property Rights strategy is fully in line with Horizon 2020 policy. Clean Sky 1 activities have given rise to spill-overs. While quantification is difficult at this stage, it is a fact that Clean Sky 1 technologies, in particular key ones such as materials, engines and control systems, are benefitting areas like weather forecasting, automotive and others.

<table>
<thead>
<tr>
<th></th>
<th>Clean Sky 1</th>
<th>Clean Sky 2</th>
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<tr>
<td>A Information days</td>
<td>13</td>
<td>25</td>
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<tr>
<td>Conferences/Exhibitions</td>
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<tr>
<td>Patents applications</td>
<td>151</td>
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</table>

Since the Clean Sky 1 programme onset and up to September 2015, 151 patent applications have been filed and 499 technical publications have been produced.

Table 5 – (A) Number of dissemination events and material related to Clean Sky 1 and Clean Sky 2 since January 2012. (B) Number of patent applications and technical publications since programme onset.

5.5 Job creation in production

In 2013, the aviation sector employed 0.78 million people directly, with an increase of 3.5 % with respect to 2012 and an average increase of 13 % in the previous 5 years. The number of direct jobs is the catalyst for all indirect and induced employment spring-boarding from aviation, which stood at 7.8 million in 2012 with a projection of 8.1 million in 2013.

The effectiveness provided by Clean Sky will accelerate and amplify the creation of jobs in production through increased EU competitiveness. It is estimated that 12-20% more jobs can be set about 10 years in advance with respect to the normal pace of progress.
6. Clean Sky 2 – Objectives and lessons learnt from Clean Sky 1

The technical programme in Clean Sky 2 will address the most promising new aircraft technologies capable of improving the environmental performance and the competitiveness of the EU aeronautical industry and will build on technologies and demonstrators developed under Clean Sky 1.

The Clean Sky 2 innovation chain will provide the momentum and focus for a strong acceleration in the introduction of new technologies with respect to the traditional piecemeal approach, thus advancing the socio-economic impacts and the deployment of the new technologies at product level with a positive fall-out on environmental impact and job creation. As shown in fig. 2, this acceleration process is all the more important as it is shifted to more advanced technology, where performance increments are more difficult to achieve.

Clean Sky 2 will tackle reduction of emissions and noise further with respect to the Clean Sky 1 specific objectives and will build on the successful features of Clean Sky 1, such as the project-like character with a small number of well-focused demonstrators and clearly set deadlines. In line with the Technology Evaluator predictions for Clean Sky 1, CO₂ savings from Clean Sky 2 will amount to 4 bn tons in the period 2025-2050, on top of savings associated with Clean Sky 1, provided that market deployment follows the Clean Sky 2 timeline.

Transition from Clean Sky 1 to Clean Sky 2 is progressive and technical and managerial continuity is ensured. The Technology Evaluator ensures continuous monitoring of scientific and technological developments through detailed assessment of the environmental benefits associated with new technologies and will measure the impact of different technology advances against their specific targets. This capability is an important asset to move swiftly from research and technology into production and to build a socio-economic context where to measure the whole range of societal benefits associated with the increased global competitiveness of the EU aeronautical industry at all levels of the supply chain.

In Clean Sky 1, the focus on innovation was spread across all level of technology and system integration. Industry, Academia, Research Centres and SMEs have been targeting new technologies, processes and integration methodologies, with a preset distribution of funding to high and low tier members and project-linked participation of partners selected via Calls of 50%:25%:25% respectively, not differing much from the financial engagement typical of production supply chains.

Results and degree of participation have shown that these values can be shifted more towards lower tiers and Clean Sky 2 is setting funding windows of 40%:30%:30%, respectively to Leaders, Core-partners and Partners, while at the same time more than doubling the overall funding. In particular, the participation of both Academia and SMEs is set to maintain at least similar percentage levels of participation while increasing Call funding from € 200 million to € 540 million.
The selection mechanism for members has also evolved. While 16 major organisations (founding members: 14 integrators and 2 research centres) have elaborated the Clean Sky 2 technical programme (Joint Technical Programme) and are named in the Regulations, all other members (core-partners) are selected via dedicated open Calls. The process will be completed in the first half of 2016 through 4 Calls (one completed), with the selection of about 100 new members (table 6).

A further feature of Clean Sky 2, as set in its Regulation, is the leveraging effect on the financial commitment of members: while the Clean Sky budget was the result of a 50:50 split in the contribution by public and private members, it is expected that members other than the Union will contribute at least 25% more than the European Commission funding.

### Table 6 – Participation by numbers and organisation type to Clean Sky 1 and Clean Sky 2.

<table>
<thead>
<tr>
<th>Founding members (major integrators)</th>
<th>Clean Sky 1</th>
<th>Clean Sky 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associates/Core partners (mid-tiers)</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Industry</td>
<td>117</td>
<td>23</td>
</tr>
<tr>
<td>SMEs</td>
<td>226</td>
<td>25</td>
</tr>
<tr>
<td>Academia</td>
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</tr>
<tr>
<td>Research Centres</td>
<td>80</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>613</td>
<td>166</td>
</tr>
</tbody>
</table>

*after the 1st Call for Core-partners (3-4 planned in total) and the 1st Call for Proposals.

**This figure refers to the start of the Clean Sky 1 programme under Regulation 71/2008. The total number of Clean Sky Associates was 66 at the moment of the adoption of the Clean Sky 2 Regulation n° 558/2014 which lists under Annex II.2 the current Clean Sky Associates.

Finally, Clean Sky 2 is expected to encourage complementary activities at regional level, which will steer private investments onto the programme and will increase the effectiveness of its implementation, by reducing redundancies and duplications to a level in line with failure risks associated with research. This activity is pursued by triggering synergies between Horizon 2020 and the Structural Funds programme. Several Memoranda of Understanding have been signed already with aeronautical relevant regions in Western and Eastern Europe and the process is continuing.

### 7. Conclusions

The European aeronautical industry has grown over the last decades to a major competitiveness position worldwide and should maintain it in the face of the current change in the competition landscape, with new performers and integrators entering the market.

The Clean Sky Joint Undertaking has been created with the purpose of meeting air transport targets set for minimising its environmental impact with ambitious
quantitative milestones and in line with the EU priorities. It was set up as a public-private partnership where public funding provides the trigger for more than equal investment from the private sector on a commonly agreed programme which encompasses the whole of the supply chain and at the same time providing newcomers with opportunities for enlarging their technical and business base.

The results of Clean Sky 1 to date show clearly that the formula is successful, with realistic perspectives of competitiveness and growth of the industry across the Union leading to strong socio-economic benefits through the development of advanced technologies meeting the environmental targets which were set.

This brief document highlights the performance of the Joint Undertaking with respect to the socio-economic challenges it was set to meet. It is intended to provide an update to early findings towards the conclusion of the programme set for 2017 and in time for the full assessment foreseen in the Clean Sky Regulations.

Clean Sky 2 benefits from the set of relationships built and cemented in Clean Sky 1 both among stakeholders and between stakeholders and the JU executive team. This consolidation has strong added value and is making the JU more and more efficient as the number of participants grows. Clean Sky 2 has started operations and launched the first Call for Proposals. It is finalising in parallel its membership and can count at this early stage on more than 160 participants. It capitalises on the results achieved by Clean Sky 1, with ambitious technology reduction targets of emissions and noise and potential fuel savings of up to 4 billion tons.