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Accompanying document to the

Proposal for a

Council Regulation

- Setting Up The Clean Sky Joint Undertaking -

Analysis of the effects of a Joint Technology Initiative (JTI) in the area of AERONAUTICS and AIR TRANSPORT

IMPACT ASSESSMENT

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EXECUTIVE SUMMARY

The Seventh Framework Programme (FP7; 2007-2013) introduces the concept of Joint Technology Initiatives (JTI) as a response to the real needs of industry and other stakeholders. JTIs are conceived as public-private partnerships (PPP) and have been identified by the European Commission to support a limited number of European Technology Platforms in reaching their objectives. Clean Sky is the JTI proposed in the Aeronautics sector of the Transport Theme, addressing environmentally friendly technologies for Air Transport.

1) Clean Sky is the preferred option to pursue the stated objective of accelerating the development of clean Air Transport technologies in the EU for earliest possible application. Its overall budget appears to be proportionate to the objectives and the ITDs have clear environmental targets and well defined deliverables and road maps. The base case scenario of FP only EU action will stimulate research, but on a lower level and delayed timescale compared with Clean Sky.

2) Clean Sky mitigates the different types of market failure which discourage private investment in aeronautics research generally and clean Air Transport technologies in particular. It provides integration and demonstration at the full- system level, thus decreasing the risk for private investment in developing new environment-friendly aeronautics products. It applies an innovative integrated multidisciplinary approach, covering the full scope of aeronautics technologies, thus enabling economies of scale and scope in EU aeronautics R&D to be fully exploited. It stimulates private EU R&D investment in environment-friendly technologies thus addressing the existing R&D and environmental externalities.

3) Clean Sky represents a major contribution to the implementation of the goals of the ACARE (Advisory Council for Aeronautics Research in Europe) Strategic Research Agenda on environment. At the aircraft level, it is expected by 2020 to reduce CO_2 aircraft emission by around 20%-40%, NOx by around 60% and noise by 10db to 20db. At the fleet level, over the 2015-2050 period, Clean Sky is expected to lead to an aggregate reduction of 2 to 3 billion tonnes of CO_2 over 35 years, and thus will make a significant step towards achieving the ACARE targets.

4) Clean Sky has an important additionality effect at the Community level, as it will stimulate private and national R&D programmes on clean Air Transport technologies. Clean Sky is expected to stimulate additional private investment of €800 million in R&D for reducing aviation environmental impact, matching the public money provided. In addition, the value of industry funded R&D performed in the EU over the years 2010-2030 is expected to increase considerably, in order to develop new products incorporating Clean Sky technologies. It also has an important impact on economic output in the EU. The present value, at 2006 prices, of the cumulative direct effect over the period 2010-2035 of Clean Sky on economic output in the EU has been estimated to reach approximately ~€100-160 billion reflecting increased operating profits, labour expenditures, capital investment and other direct effects, to be compared to €800 million of public money to be invested into the programme. In addition it is estimated there will be spillover benefits through knowledge transfer to other sectors and regions amounting to €450 billion.

5) Clean Sky governance structure is well balanced, transparent, and efficient. It ensures cross-fertilisation between the different Integrated Technology Demonstrators, and provides mechanisms for openness and transparency that will ensure that public funds are properly and efficiently used, thus considerably reducing the risks associated to investing a large sum of public money in a single programme with a great technological and managerial complexity. Member States will be able to continuously monitor how the important financial

and administrative Clean Sky targets are maintained, thanks to two external advisory bodies: the National States Representatives Group and the Transport Programme Committee. The Commission will have veto rights on all matters impacting on public interest.

6) Clean Sky represents a major opportunity for SMEs. The target for SMEs involvement is 12% of EU funds. In addition Clean Sky will have a major role in integrating the EU industry, offering to SMEs the possibility to work with major players. The internal and external control mechanisms ensuring transparency and openness, will favour the participation of Universities and Research Centres.

7) Clean Sky is a project of common European interest as it contributes in a substantial way to achieving Europe's strategic environmental and social priorities, in combination with sustainable economic growth. It will improve the quality of life of European citizens by its positive impact on public health, mobility, creation of new jobs and contribution to economic prosperity.

Implementation of Clean Sky should take place as soon as possible, for the following reasons:

a) The environmental challenge requires immediate action to promote the development of clean transport technologies for earliest possible deployment1. We have seen that cleaner Air Transport technologies will contribute to improve welfare and living condition in a sustainable way for present and future generations in the EU.

b) Moving fast in launching the JTI is of crucial importance since, by around 2015, approximately 5700 aircrafts of the world present fleet will have reached the end of their targeted lifetime. If Clean Sky breakthrough technologies will be ready for introduction, such fleet replacement will contribute substantially to pollution reduction, and will also contribute to set new international standards. The immediate implementation of the Clean Sky Proposal is crucial as products in the aerospace sector remain in service for a very long time (~25 years). If a technology is not sufficiently mature to be incorporated in new products, it may miss the next market window and fail to influence a whole generation of aircraft development.

c) Launching Clean Sky soon is important to address the challenges from international competition. The US Government has just approved a major Aeronautics Research and Development plan, with the overarching goal to advance US technological leadership in aeronautics. China, India and Russia are becoming very active in the industry. Not launching Clean Sky soon will put the European industry in a position of competitive disadvantage, with negative repercussions not only for the industry itself but also for the EU as a whole.

[1] See COM(2007) 2, p. 8

1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

This document presents the impact analysis of the "Clean Sky" Joint Technology Initiative (further referred to as Clean Sky), which was drawn up in accordance with the Commission's guidelines for ex-ante impact assessments[2].

The Seventh Framework Programme (FP7; 2007-2013)[3] introduces the concept of **Joint Technology Initiatives** (JTI) as a response to the real needs of industry and other stakeholders. JTIs are conceived as public-private partnerships (PPP) and have been identified by the European Commission[4] to support a limited number of European Technology Platforms in reaching their objectives[5]. With the introduction of JTIs, the Community will for the first time offer a legal and organisational framework that allows the effective pooling of resources across all R&D undertakers in a specific area, both from the public and the private sector. JTIs should pursue activities that are of common European interest[6] and their establishment should contribute to the achievement of the Lisbon competitiveness objective and the Barcelona targets for research spending[7].

Clean Sky has been identified by the Commission as one of the potential areas for the establishment of a JTI during the implementation of FP7[8].

The present impact assessment of Clean Sky is based on two documents, and further input has been provided through two hearings organised by the Deputy-DG RTD that took place to review the state of preparedness of the Impact Assessment documentation.

The first document, "Report on the Assessment Exercise on the "Clean Sky" Final Proposal" was drawn up by an independent group of experts, formed of specialists recommended by the Member States, established under a contract of the European Commission. The panel has been involved in a first evaluation that took place in January/February 2006, on which occasion they reviewed an intermediate version of the JTI proposal. Their recommendations have been taken into account, resulting in the March '07 version of the Clean Sky Proposal that has been reviewed for the second report dated February 2007. It is this second report that has served as input, focussing on an analysis of the market situation for European Aeronautics, the objectives targeted within the Clean Sky JTI, the policy options and analysis of the impact on socio-economic level. For their analysis, the panel has used the JTI Proposal document, along with supporting material provided by industry and Commission. The most important economical information is based on studies performed by Oxford Economic Forecasting and PriceWaterhouseCoopers, supplemented by dialogues with industry representatives at a two-days Workshop, end of January 2007.

The second document, entitled "Clean Sky, a Joint Technology Initiative for Aeronautics and Air Transport – Executive Summary", was drawn up by the industrial founding members of Clean Sky in

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2 Impact Assessment Guidelines - SEC(2005) 791, European Commission, 2005.

3 Decision of the European Parliament and of the Council on FP7 No 1982/2006/EC of 18 Dec. 2006.

4 COM(2004) 353 "Science and technology, the key to Europe's future – Guidelines for future European Union policy to support research".

5 SEC(2005) 800, European Commission, 2005Report on European Technology Platforms and Joint Technology Initiatives: Fostering Public-Private R&D Partnerships to Boost Europe's Industrial competitiveness.

6 SEC(88)1882

7 COM(2005) 488 "More Research and Innovation - Investing for Growth and Employment :A Common Approach" Impact Assessment.

8 Council Decision on the Specific Programme "Cooperation" implementing the Seventh Framework Programme (2007-2013) of the European Community for research, technological development and demonstration activities; 2006/971/EC, 19 Dec. 2006.

response to a letter sent out by Dir H (A. Siegler) asking them to demonstrate the readiness of the so-called "Keys to Success" (Market failure, Additionality, Governance and Role of Member States). The document was jointly prepared by Airbus, Rolls-Royce, Alenia Aeronautica, Eurocopter, Thales, Liebherr, Dassault Aviation, AgustaWestland and Safran. As can be deduced from its title, this document also served the as updated executive summary for the final Clean Sky Proposal.

The Clean Sky proposal, and the governance aspects in particular, have taken on board inputs from Member States, collected in the course of a number of workshops (2005-2006) organised by the Commission. The currently proposed governance structure has broad support, both from industrial stakeholders and from Member States.

The Strategic Research Agenda and the Clean Sky Joint Technology Initiative have also been publicly presented and discussed in major events such as the ASD Convention 2006 (Vienna) and the FP7 information days.

In the period June-November 2006, the industrial founding members have organised various workshops and information sessions throughout Europe to generate interest for participation in Clean Sky; this has resulted in more than 120 expressions of interest from industry, SMEs, universities, and research establishments.

In the final stage before going into Inter-Service Consultation, the Clean Sky proposal and the documents related to the impact assessment have undergone evaluation by a panel called together by the Deputy-DG (Z. Stančič), composed of representation from various DGs and SecGen, as well as a number of independent external experts. The additional clarifications provided to this panel have been included in the present version of the documents presented for Inter-Service Consultation.

2. THE PROBLEM

2.1. Critical role of aeronautics R&D for the enlarged EU

The vital role of the Air Transport Sector in the further integration and growth of the enlarged EU and in the life of EU citizens has been clearly illustrated by Vision 2020 and in the Strategic Research Agenda (SRA) of the Aeronautics Technology Platform (ACARE).

Aeronautics is as an industry with a very strong economic and social impact. The Aeronautics sector is characterised by a high R&D intensity (around 14%), a large positive trade balance, and is an important employer of highly skilled personnel. Furthermore it has a critical role in fostering European integration.

2.2. Challenges for the aviation system in the 21st century

The aeronautics sector is confronted with important challenges in the 21^{st} century.

On the one hand this industry is facing the **necessity to reduce its contribution to climate change and emissions and noise around airports**. Air Transport is currently a relatively small source of the greenhouse gas (GHG) emissions contributing to global warming, but its share is rapidly growing. According to data from the European Commission[9], in 2003 the CO_2 emissions from international flights from European airports were about 3% of total EU CO_2 emissions, but the overall impact of these flights was greater than this figure indicates. Apart from emitting CO_2, aircraft contribute to climate change through emission of nitrogen oxides (NOx) which are particularly effective in forming

9 SEC(2005) 1184, annex Impact Assessment p.4. See also SEC(2006) 1684, p. 6; COM(2005) 459 ; the Stern Review (2006) Annex 7.c

ozone (a greenhouse gas) when emitted at cruise altitude. Aircraft emissions also trigger the formation of condensation trails suspected of enhancing the formation of cirrus clouds, which also add to the overall global warming effect.

ACARE identified the reduction of aviation impact on environment as one of its High Level Target Concepts, concluding that step technological changes are needed to reach the goals by 2020 of cutting CO_2 emissions by 50% per seat*kilometre, reduce NOx by 80%, reduce perceived external noise by half, and making substantial progress in reducing the environmental impact of the manufacture, maintenance and disposal of aircraft and related products[10] .

Apart from emission reduction, Clean Sky has also committed itself to **reducing the perceived aircraft noise by half**. The expected growth of air traffic, will impact on the environment also in terms of noise levels, as a problem affecting the community as a whole. One of the many examples of this problem is the issue of aircraft flying over Brussels in approach, landing, and take-off procedures. For the areas surrounding airports, the critical parameter to consider is the so-called "noise footprint" of the aircraft, meaning the area which is exposed to noise levels in excess of 85dB. For an Airbus A300-600, this is 4.17 km², whereas for the upcoming A350 it is anticipated to be in the 1-2 km² area. It is clear that a further reduction of the overall noise level generated by the aircraft will further reduce their noise footprint, with a beneficial effect on the airport neighbourhood.

The situation is different for helicopters, as these have much more flexibility in landing area or the choice of flight trajectory: the usage of helicopters in the Community has until now been concentrated in activities such as medical evacuation, rescue, civil protection, aerial work, and law enforcement. These activities are required to satisfy today's primary needs of the population since the helicopter appears definitely the most efficient or even the unique vehicle able to fulfil these essential functions. As such, the significant noise impact around hospital rooftop platforms, fire fighting and police centres, is generally, although reluctantly accepted. However, these operations are expected to grow sharply in the near future to face the European citizen's demand for a safer and more secure society.

In addition, the citizen's increasing need for mobility in all regions of the Community including peripheral regions is expected to trigger a significant growth (2 to 3--fold increase in the 2015-2030 period) of rotorcraft traffic for passenger transport.

This expected growth of rotorcraft traffic will generate a noise impact, not only near airports but also in many sensitive inhabited areas, to such an extent it would become unacceptable to the society unless a major R & T investment is promptly made to further mature and implement the noise reduction techniques.

On the other hand the EU aeronautics industry is **confronted with strong international competition**. The US industry and government heavily invest in aeronautics R&D. The role of public support is of primary importance. Private investment in civil Aeronautics Research is broadly equivalent in the EU and USA but public investment in Europe is only a quarter of that in the USA[11]. On December 20th 2006, **the US Government issued an Executive Order establishing the US first Aeronautics Research and Development Policy.** The overarching goal of this policy is to advance US technological leadership in aeronautics. A continued strong US Government role in aeronautics R&D is recommended. This will enable the USA to pursue their objectives in aeronautics with considerably greater speed than the EU, due to the different institutional setting. At the same time other competitors

10 SRA-2, p. 17.
11 see ACARE SRA-2, p. 86.

have emerged in recent years such as Brazil. Russia, China, and India are also becoming very active in the industry[12].

Technological capability and innovative potential may play a critical role in reducing aviation impact on the environment and in facing increased international competition. As suggested by ACARE SRA-2, what **this sector requires** is not incremental improvements but major innovations, i.e. **step changes**. However, due to market failure and in absence of public intervention, private companies are not able to mobilise the resources necessary to develop and introduce the major technological advances needed for the greening of Air Transport.

2.3. Market failure justifies Community financial intervention

Public financial intervention is justified by the necessity to address the different sources of market failure discouraging aeronautics research in the reduction of fuel consumption, emission, and noise of future aircraft.

In the case of Aeronautics research, market failure[13] preventing the optimum development of the technological area **assumes a variety of forms[14]**:

1) There is a **higher level of risk,** and a **longer period before project results show a positive return on investment**, than acceptable to industry or to the financial community. Aeronautics programmes are high risk both technically and commercially, with very long programme timescales (returns are often delivered decades after the original investment), and low profitability which discourage private investment. <u>This is the case particularly when R&D for greening aircraft is considered</u>. Thus, it is not possible to rely simply on market mechanisms to achieve major innovations such as those needed for the greening of aircraft.

2) The step changes required to implement the ACARE SRA-2 for greening of Air Transport can only be met effectively if a number of investments are put in place as part of a **co-ordinated approach**. Given the close interdependence between individual systems and parts used in aeronautics, the delivery of the necessary innovation can only be achieved through an innovative integrated **multidisciplinary approach**. Major areas of work have to cover the broad range of R&D work: aircraft (fixed wing and rotorcraft), engines, systems, and eco-design concepts able to deliver more environment-friendly aircraft production and operation.

3) There are significant **externalities**, connected both to aeronautics R&D investment and to aviation impact on climate change.

A **positive externality** is generated by R&D investment in Aeronautics. It is well known in economics that the innovative firm does not fully appropriate the benefits of its R&D investment since there is involuntary knowledge dissemination through various channels, as the social return on R&D investment is higher than the private rate of return. **The gap between the social and the private rate of return on R&D investment is particularly wide in the case of aeronautics** due to the nature of the industry[15]. There are indications that supply chain relationships in the development and manufacture of new products may be a *key channel* through which these large economic benefits are realised. And in the case of Aeronautics the supply chain is particularly articulated, with flows of knowledge both horizontal and vertical. The large social return on R&D in this sector is also due to the

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12 On the rapid rise of R&D in China as compared to EU-25 see Eurostat (2006), Science, Technology and Innovation in Europe, p. 35.

13 For market failure definition, see SEC(2005) 800, p. 11.

14 Note that here the ranking does not indicate priority.

15 Oxford Economic Forecasting, PriceWaterhouseCoopers, Rolls-Royce (October 2004) “The wider economic benefits of R&D – research paper on spillovers”. mimeo

fact that aeronautics technologies also flow into other industrial sectors, generating inter-industry R&D technological spillovers (i.e. design software: automotive; aerodynamics: rail transport; lightweight materials: civil engineering; diagnostics: healthcare).

A **negative externality** is also associated to civil aviation. As with the rest of the transport sector, the full environmental costs to society are not paid by operators or manufacturers, in spite of the EU efforts in ICAO for introducing new economic instruments for reducing international aviation impact[16]. This negative externality represents a market failure that results in sub-optimal investment in, and deployment of, new environmentally beneficial technologies. Technological innovation is a key measure to reduce the extent of this negative externality all over the world.

3. THE OBJECTIVES

3.1. Overall objective

The overall objective is **accelerating in the EU the development of clean Air Transport technologies for earliest possible deployment**[17] which will contribute to achieving Europe's strategic environmental[18] and social priorities, in combination with sustainable economic growth. By accelerating the introduction of green technologies, the Air Transport industry will be stimulated to develop in a sustainable fashion, reducing its environmental impacts, while at the same time satisfying the need of EU citizens for improved quality of life and mobility.

Furthermore, European aeronautical industry will be encouraged to take the lead in the development of clean Air Transport technology at a global level, and at the same time its competitiveness will be strengthened.

3.2. Specific objectives

To achieve this policy target the impact assessment identified a number of specific objectives.

3.2.1 Implementing a large scale **programme** promoting pre-competitive EU **aeronautics R&D** to enable the major technological advances required **to reduce in a significant way by 2020 CO_2 aviation emissions, noise, and NOx** and to reduce the environmental impact of manufacture, maintenance, and disposal of aircraft. The programme should thus allow making significant progress towards the goals set by ACARE in its Strategic Research Agenda with regard to the greening of Air Transport[19].

3.2.2 Such policy should **maximise the efficiency** of EU aeronautics research efforts, by making possible to exploit both economies of scale and scope in R&D. A co-ordinated approach is particularly important in this sector where the necessary innovations can only be achieved through an innovative multidisciplinary approach.

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16 ICAO has endorsed the concept of international open emissions trading.

17 See COM(2007)2, p. 2.

18 The European Parliament and European Council in spring 2005 re-affirmed the EU objective of limiting global temperature increase to a maximum of 2o C (the 2o objective).

19 We are referring to the High Level Target Concept on the Greening of Air Transport in the ACARE 2nd edition of the Strategic Research Agenda (March 2005). Improving Air Traffic Management will also give an important contribution to achieving these goals.

3.2.4 The policy should also **increase industry ability of rapid exploitation** of the potential step changes in clean Air Transport technologies. This is of vital importance to implement ACARE SRA on environment. In many sectors Europe does not currently have sufficient capacity to transform knowledge into commercial products and services[20], however the ability to accelerate market introduction of new technology is particularly critical when confronted with the environmental challenge.

3.3. Consistency with other EU policies

A policy designed to stimulate research and development in the aeronautics sector, leading to environmentally efficient aircraft, is one pillar of the global strategy presented in the communication **COM(2005)459** of September 2005 to reduce the climate impact of aviation, which was endorsed by the Council (2 December 2005) and the Parliament (4 July 2006). Stimulating aeronautics R&D is complementary to measures such as the Commission proposal to include aviation in the EU **Emission Trading Scheme** (ETS)[21].

Furthermore stimulating aeronautics R&D will contribute to the implementation of the European Union Strategic Objectives of "delivering stronger, lasting growth and more and better jobs". These have been identified as the key strategic priorities of the **new start for the Lisbon Strategy launched in 2005** in order to address the challenges facing Europe's society[22]. It will also be consistent with the **Community transport policy** as it encourages sustainable development of Air Transport[23].

Greener aviation technologies will contribute towards mobility within an enlarged EU, which will be particularly important for accession states where traffic is growing rapidly from a low base.

To sum up, a policy aimed to stimulate step changes in clean Air Transport for earlier possible deployment will contribute to improve welfare and living condition in a sustainable way for present and future generations in the EU. The effect of Clean Sky can be reinforced through appropriate, stimulating government incentives.

4. POLICY OPTIONS

4.1. The criteria for screening policy options

The criteria for assessing different policy options were first identified. The Panel concluded that the potential of an action to enable the major technological advances required reducing by 2020 in a substantial way CO_2 aviation emission, noise and NOx is crucially dependent on the joint presence of seven factors. These factors were adopted as criteria and are listed below.

Scale of investment. Only a **large scale programme** with a well structured and focused research agenda will be able to stimulate the necessary technological breakthroughs.

Continuity of the research programme. **Long-term continuity** is required to achieve the stated objectives.

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20 COM(2005)800 p. 4.

21 See the Impact Assessment conducted for ETS, http://ec.europa.eu/environment/climat/pdf/aviation/sec_2006_1684_en.pdf and section 5 of COM(2005) 35.

22 See COM(2005)459 , p. 22

23 See European Commission (2001), White Paper, European Transport Policy for 2010: time to decide.

Leverage of private and public resources consistent with the objectives of the research programme and with the EU international trade obligations. **High leverage** of private and public resources is a key ingredient for the success of the programme.

Critical mass of participants and **multidisciplinary approach**. The programme should allow for the participation of primes and supply chains members, SMEs, Universities and Research Centres.

Co-ordination and integration between all stakeholders, taking into account the close interdependence between the individual systems and parts used in aeronautics. **Tight co-ordination and integration** is essential for allowing the exploitation of economies of scale and scope in aeronautics R&D. That will partly depend on point f) below.

Efficiency of the governance structure. The governance structure should ensure, for instance, control and flexibility, transparency and monitoring of activities during the programme, accountability. A careful designed governance structure is a key factor to ensure that public funds are efficiently used.

Technology readiness demonstration. The policy should allow for validating complex systems at large scale and **high technology readiness** level. High financial and technological risks are associated with the integration of innovative technologies in new aircraft and rotorcraft. In order to stimulate industry on long term and large multidisciplinary investment, with high risk and low profitability, it is important that the research programme should include the demonstrators needed to validate technologies at Technology Readiness Level [24] 6 (TRL 6), which is the level preceding the system prototype demonstration in an operational environment.

4.2. Alternative policy options

The following policy options were examined:

- No EU action
- EUREKA type of intervention[25]
- FP-only EU action (use of traditional instruments of Collaborative Research)
- Clean Sky JTI

The Panel first assessed the four options on the basis of qualitative analysis, using the criteria identified. The key arguments are briefly summarised below.

No EU action

A *No EU action* approach may take the form of not intervening at any level (national or EU). Such non regulatory option was rejected at an early stage because -as shown in section 2- due to several types of market failure, it is not possible to rely simply on market mechanisms to achieve the major innovations needed for the greening of aircraft.

A *No EU action* approach may take the form of stimulating research only at the national level. However the scale and scope of the research agenda for greening aircraft goes beyond the capacity of individual Member States, both in terms of the financial commitment and of the research capacity involved. National R&D policy may have an important role in complementing an EU programme on

[24] See Technology Readiness Levels elaborated by NASA which are presented in chapter 6 of the report.
[25] See http://www.eureka.net for more information on this type of intervention.

promoting the development of clean Air Transport technologies, but cannot substitute action at the Community level to meet the criteria mentioned above in section 3.1. The option fails criteria a, b, c, d and thus was rejected without further investigation.

EUREKA type approach

The *EUREKA type* approach was considered as not suitable for several reasons. For instance, it will not allow the size of budget required to overcome the high technological and commercial risks which discourage private investment in developing green aircraft technology. In addition, EUREKA funding has a shorter duration than the one required achieving the overall objective in section 2.1. Furthermore, EUREKA is an intergovernmental programme and thus it does not represent an adequate instrument to pursue the objective of accelerating the development and introduction of green air transport technologies, which is of general Community interest. The approach thus failed on the basis of criteria a, b, c, d and thus was rejected at an early stage.

FP-only EU action

Traditional Instruments of Collaborative Research have been designed to stimulate: upstream research and focussed downstream research. The Experts agreed that they represent the most effective instruments to stimulate basic research and validation at the **sub-system level** or at a **system level**.

Traditional Instruments of Collaborative Research were however ranked as **sub-optimal** to pursue the objective **to accelerating the development of clean Air Transport technologies in the EU for earliest possible application,** as it requires full-system technologies demonstration (i.e. integration and demonstration of a combination of systems). It is clear that an individual action of Collaborative Research will not have the scale sufficient to pursue such objective. However, according to the Panel Assessment, even if a large scale budget (a budget comparable to public funds to be potentially invested in Clean Sky JTI) were distributed between different projects of Collaborative Research with the same time horizon, the proposed target to develop technologies to reduce in a significant way by 2020 CO_2 aviation emissions, noise and NOx will not be fulfilled.

An *FP-only EU action* was assessed as not adequate to pursue the stated objective for several reasons: lack of critical mass due to the division of the overall R&D budget in different separate projects (criteria d)); lack of the necessary integration and coordination between participants (criteria e); inability to allow validation at the required level of readiness (TRL 6) (criteria g) and lack of a legal and governance structure able to provide the necessary leadership for achieving the research objectives (criteria f).

Clean Sky Joint Technology Initiative (JTI)

The JTI is a new funding scheme under the Seventh Framework Programme for realising particularly ambitious research and technology agendas, which require high public and private investment at European level[26].

Clean Sky is a JTI aiming to accelerate the development and introduction of major technological changes to substantially improve the impact on the environment of next generation aircraft, rotorcraft, and their associated equipment. It is articulated around 6 **Integrated Technology Demonstrators** (ITDs). There are three vehicle ITDs (SMART fixed-wing Aircraft; Green Regional Aircraft; Green Rotorcraft) and two transverse ITDs (Sustainable and Green Engine; Systems for Green Operations) that will deliver results to the vehicle ITDs. Furthermore an Eco-Design ITD will support the other ITDs in terms of the greening of design, manufacturing, production, maintenance, and disposal. In

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26 see COM (2006) 502 final p. 9

addition a Clean Sky Technology Evaluator will oversee the whole programme. The corporate structure of “Clean Sky” is represented by a **Joint Undertaking** (JU), which will be a legal entity created as a Community organisation under article 171 of the EC treaty.

Clean Sky was assessed by the Panel as **a project of common European interest** as it is expected[27] to reduce by 2020 CO_2 emission per seat of new aircraft by around 20%-40%, NOx by around 60% and noise by 10db to 20db (the reduction depends on the aircraft type as shown in the Proposal, part I, section 2.6). Clear goals are set for each ITD. Clean Sky has been considered by the Panel as an option adequate to make a major step towards the implementation of the Strategic Research Agenda of ACARE on environment. The reasons are briefly explained here (see also section 6). It is a large scale programme on greening Air Transport, with an overall budget of €1.600 million to implement a focused research agenda over a seven years period. The programme will stimulate €800 million additional R&D investment from industry, which represents 50% of the Clean Sky budget (fulfilling criteria a, b, c).

The environmental goals of Clean Sky are so ambitious that they require technological breakthroughs to be validated faster than the usual R&D pace. Thus, Clean Sky, implementing an innovative multidisciplinary approach, will cover the full scope of aeronautics technology and ensure the integration of new component, system and vehicle technologies, their large scale validation, and full-system demonstration. It will thus provide a basis on which innovative green products can be launched at an acceptable risk (criteria g). The **Technology Evaluator** will integrate the technical content across Clean Sky and allow for transparency and monitoring of the R&D activities (fulfilling criteria d, e; see also section 7).

Several flying and full scale ground demonstrators will be manufactured and operated to fully demonstrate the viability of new system technologies and design concepts. They are described in detail in part II of the Proposal, section 5.

It should be noted that the effect of Clean Sky will be leveraged through incorporation of logistics of aircraft and fleet management: the Technology Evaluator will form an all-encompassing model of the Air Transport System at the fleet level, not only taking into account he performance of the various types of aircraft but also of the mode in which they are operated: an aggressive flight envelope with steep climb and descent under high power, as used by low-cost airlines to maximise the turn-around time, has a significant impact on the noise and emissions produced by the aircraft. By including these variations into the ATS model, an additional parameter will be evaluated adding to the accuracy of the predictions. Furthermore, links with the SESAR JU and DG TREN will ensure that up-to-date information is used.

In this context, the "No EU action" described above should be read as "action on national level", as we have established above that action should be taken.

Both the "No EU action" and the "EUREKA-type" approaches have in common that action is required from Member States, either individually or jointly. Apart from the obvious consideration that aeronautics is a transnational issue and that the necessary critical mass needs to be reached in order to obtain the desired scale and speed of innovation, there is the additional issue of dependability on national support. It is often the case that a change in government (in the order of once per decade) also brings a change of priorities along with it, which can seriously impact any initiatives that are taken on a national level.

In order to achieve a large-scale, continuous, and consistent approach to the problem at hand, it is thus preferable to opt for EU-coordinated action.

[27] See Proposal Executive Summary, “Quantifying the value of the Clean Sky programme”.

The final choice is then between FP-only or JTI, and the JTI is the only instrument that at the same time guarantees a tight coordination (ensuring that all efforts are optimally applied to reach the final goals) and a sufficient level of integration and technology readiness to enable quick pick-up and exploitation of the results.

4.3. Implementation choices of Clean Sky JTI

In addition to the general JTI approach described in the previous section, this point will address the reasoning behind the choices that are proposed in the implementation of Clean Sky: why are the 6 Integrated Technology Demonstrators used as a basis, and why is a Community investment of €800 million justified?

The **6 Integrated Technology Demonstrators** represent, on one hand, the three most important types of aircraft in production (large passenger aircraft, regional aircraft and rotorcraft), and on the other hand the two main supporting technologies common to these types (engines and systems). Finally, an overall activity in the form of the Technology Evaluator makes sure that in the entire life cycle of all of these applications, eco-friendly production/operation/maintenance/disposal principles are applied, to secure the final aspect related to green Air Transport System operations.

Although a list of 6 topics is formed by application of the grouping applied above, it should be noted that the actual list of topics is much broader, and at the same time there are points of synergy between the various activities.

To provide a few examples:

- In the Smart Fixed Wing ITD, novel high-lift configurations and adaptive wing structures will be investigated that are to a large extent also applicable to Green Regional Aircraft.

- In Green Regional Aircraft, the emphasis is on low-weight structures, e.g. through application of sensors inside materials to perform continuous health monitoring, that can allow designers to reduce the often conservative safety limits (and associated excess weight) imposed on aircraft structures. It is clear that these technologies are equally applicable to the large passenger aircraft or to rotorcraft, both of which will also benefit from weight reduction.

- In the Engines ITD, general principles will be investigated to reduce emissions and noise. However, the implementation in the three different aircraft types will impose significant differences in design and optimisation, so that this ITD could equally be redistributed across the three airframe ITDs.

This illustrates that the structure proposed in the Clean Sky technological description is not a "hard" separation into discrete projects. Rather, it is a grouping driven by management and exploitation principles, allowing each of the topics to be led by a core team of organisations that are directly involved in their development. As will be addressed in section 6.4, this approach also increases the robustness of Clean Sky.

The **overall JTI operating budget of 1.6 billion €** was established in a bottom-up approach where the budgetary requirements of individual ITDs were mapped against their technical objectives as summarised in the table below.

Table 4.1

ITD Budget	Smart Fixed Wing	Green Regional Aircraft	Green Rotorcraft	Green Engine	Systems	Eco-design	Tech. Eval.	TOTAL
€ million	388	175	159	424	306	117	31	1,600
%	24	11	10	27	19	7	2	100

Commission and industry have, in the preparation phase of the Clean Sky proposal, worked together to identify the targets and topics to be addressed by this JTI. The ambition is to address all relevant modes of air transport (with freight being implicitly covered, as freighters are typically derived from passenger aircraft) as a response also of the scenario developed by ACARE on the future Air Transport System.

Industry has made calculations of the budgets involved in reaching these targets using an interactive process; the evaluation panel in 2006 asked for a budget estimate per ITD (see also the response to Q10, listing their recommendations) and has accepted the estimates in the course of the 2007 evaluation.

Part of the justification for the € 1.6 billion overall budget (with €800 million Community funding) is that actual demonstrators will be built, in order to ensure not only feasibility but also compatibility with industrial concepts and approaches. JTIs, being the top level of FP7 instruments in terms of integration but also of technology readiness level, are thus also required to demonstrate the maturity of the technological developments resulting from them.

A budget reduction could be applied equally across all ITDs by reducing or removing the scope of the demonstrators, but as outlined in the previous paragraph, this lack of validation would increase the time to market. As a result, the beneficial effect on European competitiveness would be postponed or possibly nullified by the loss of competitive/technological advantage within the long time scale cyclic nature of the aeronautical sector.

An alternative approach to budget reduction would be to remove one ITD from the package of 6. However, as explained higher, this would severely undermine the impact of Clean Sky as not all major aspects of air transport would be covered: either one of the 3 aircraft types (large passenger planes, regional aircraft or rotorcraft) would need to be eliminated, or one of the cross-cutting activities (engines, systems or eco-design).

Neither option makes sense: Europe cannot afford to lose its current level of competitiveness in any of the three types, nor is it possible to disregard the development of the horizontal activities as this would hamper the "greening" target of Clean Sky.

Finally, the currently proposed membership of Clean Sky includes all major integrators in Europe and the overall participation has been selected through an open process based on technological excellence as a main requirement. An FP7 collaborative research approach could not possibly create a similar know-how and R&D base. Furthermore, achieving the overarching goals for Clean Sky would not be possible through a pure FP7 collaborative research approach, due to the lack of alignment between the projects and the absence of overall coordination.

4.4. Options short-listed and preliminary ranking

The conclusion of this phase of the assessment was that Clean Sky is more adequate to achieve the objectives stated in 3.1, 3.2 as compared to an FP-only EU action. Briefly, Clean Sky was assessed as the **preferred option** since it represents a **large scale project** which will promote a **large additional R&D investment** by aeronautical firms to pursue ambitious environmental goals, and has the capability to fully **exploit** the economies of scale and scope created by the innovative **multidisciplinary** approach adopted.

It was decided however, given the large scale of the programme and thus the risks associated to it, to shortlist both Clean Sky and Collaborative Research Instruments for a more in-depth comparative investigation. The results of such analysis are discussed in section 5 and 6. The added value of intervening by implementing the Clean Sky JTI will be discussed in section 6.

5. ANALYSIS OF IMPACTS

5.1. Analysis of Impacts of a FP – only EU action

5.1.1. General Impact

The Framework Programme is a key enabler to foster research at a European level and it enables many industrial sectors to maintain their position in the global competition. Collaborative Research in FP7 will bring similarly good results in many areas including aeronautics as in the previous framework programmes. However **in the current situation, the traditional instruments of the Framework Programme by themselves are no longer adequate to answer the global challenges posed to the aeronautics industry in a timely fashion**.

The question is to what extent Collaborative Research can be an effective tool for developing and demonstrating new greener technologies. It is very probable that with the use of the traditional instruments a good progress can be achieved in developing new and greener technologies. However there are special cases when a set of smaller projects cannot bring the critical mass for success. The aeronautics industry is now one of the few cases where the level of progress with an FP-only EU action would not be sufficient to secure that the market failure discouraging new product development would be properly addressed. This is due to the need for a very quick action, requiring an integrated approach towards full-scale demonstration.

Without answering these needs properly, the FP-only EU action option would delay the launching of new products, releasing them too late to exploit market opportunities. The European aeronautical industry is faced with heavy global competition, thus delay in launching new product in comparison with competitors will have a natural distorting effect on the business results of the European industry. In addition there are certain life cycles in product development and the aeronautical industry is not an exemption. So there is the risk that the results which are not used for the next generation of aircraft and rotorcraft will be obviously outdated by the time there is a product launch again.

In addition there would probably be **less focus on environment, if the FP-only action would be adopted.**

5.1.2. Environmental Impacts of an FP-only EU action

As described in section 4.1.1. it is not easy to reach very ambitious objectives on one target area in a relatively short period of time through a number of individual projects. If there is a delay in delivering the research results, the less polluting, less noisy new aircraft, rotorcraft, or engine cannot help to decrease the overall impact of aviation on environment. On top of that, ambitious goals cannot be achieved using such a fragmented approach and the contribution to the ACARE targets would be limited.

There is a very high level of uncertainty on how much the results of stand-alone projects will be deployed in product development. Timing is a key issue for the industry. If the research results are not properly evaluated, tested, demonstrated, there is a chance that they would not be incorporated into the next phase of the product development cycle, or there might be a **delay in their implementation as a follow up action is needed to validate the results**. On account of the uncertainties, it is impossible to forecast to what extent such a set of projects would have an impact on environment (e.g. on air quality, climate, water quality) and when this impact is realised.

5.1.3. Economic Impacts of an FP-only EU action

It was described above why it is difficult to forecast in advance whether the results of FP-only EU option have a direct positive impact on environment. It is even more difficult to address the indirect economic benefits of a project targeted on environment. These projects will surely strengthen the innovation and research potential of Europe, but the impact on the industry through commercially available aircraft is not substantial. A smaller project or a set of smaller projects (Level 1 and Level 2), can have some positive impacts on issues like competitiveness, macroeconomic environment, but in a short-term these impacts would not be substantial at the European level.

If the research results are implemented with a delay and the shortfall in public funding between Europe and the United States continues, there is a **risk of loss of competitiveness** for the European aeronautical industry. It has been estimated that addressing the problem stated in section 1 with a set of smaller projects instead of with one solid programme may cause at least three to four years delay in launching new products. This delay can decrease the competitiveness of the companies concerned and thus makes a negative economic impact at the European level as well.

If there is no delay, but the industry launches a new product without using the benefits of the Framework Programme, then there is a danger that it will be done without a thorough research basis and the new products would be **less efficient and thus less competitive** than they could have been. The end result is the same as in case of the delay: the economic impact of an FP-only EU action would not be positive enough at the European level.

5.1.4. Social Impacts of an FP-only EU action

Social impacts are usually additional benefits of an industrial research project. Research achievements generate social benefits through a complex chain of impacts. Research results are usually not directly utilised in implementation, but they are integrated with several other technologies. Therefore the proportional impact of one smaller research project is hard to measure. Another issue is the uncertainty of implementation, as described in the previous sections.

If there is a delay in implementation of the research results due to the fragmented approach, the social benefits would be delivered later as well. This would mean that emissions and noise generated by aviation would grow at a higher rate for 3-4 years more than in case of using a single programme. An additional social disadvantage is due to loss of competitiveness for the European aeronautics industry. Because of the impact of a delay on the business performance of the aeronautical companies, jobs may be lost and the standard of living would decrease in the affected regions.

Following an FP-only EU action, the aircraft developed in the next decades would pollute more than those developed within Clean Sky, resulting in a **detrimental effect on health**, both on European and global scale. Additionally, aircraft developed without the benefit of the Framework Programme would be less efficient. The higher fares resulting from this will **limit mobility** and will therefore cause a negative social repercussion.

Quantitative social benefits of this option cannot be forecasted as the research project should be large enough to provide a basis for such a measurement. The uncertainty on the extent to which research results of a FP-only EU action could effect the social environment is very high.

5.2. Analysis of Impacts of Clean Sky

5.2.1. General Impact

One of the key findings of the ACARE SRA–2 is that European research needs to be more efficient. It has to be achieved by better coordination of work and less duplication. The European Commission has also realised the need for more efficient instruments for well focused larger research projects and introduced the **Level 3 project** in FP7. **Aeronautics is one of those areas where such a tool can be and should be used**. The industry is mature enough to work together within such a large project and on the other hand there is a need for an integrated approach as a response to similar initiatives in the United States. The JTI is the type of instrument that can make the necessary positive impact on the aeronautics and Air Transport industry.

Clean Sky will have a significant positive impact in many areas. It will decrease the environmental impact of aviation not only in Europe but on a global level as well. Another effect will be the increased efficiency of new aircraft which will increase the efficiency of the aviation community. **Increase in efficiency within environmental constraints enhances market development and translates in increase of air traffic and manufacturing and servicing provisions by the sector**. There will be a demand for more employees and that is a very important economic benefit for the EU. An indirect effect of the increased efficiency of aviation will result in increased passenger satisfaction and higher rate of mobility. Prospect of **step change improvements** in technology and environmental performance offer the potential for addressing environmental concerns and simultaneously maintain and boost the competitiveness of the European aeronautical and aviation industry.

5.2.2. Environmental Impacts of Clean Sky

Sustainable development is one of the key issues the world is facing nowadays. Without the necessary actions to decrease the environmental impact, the present industrial growth is made at the expense of the quality of life of future generations. Clean Sky plans to contribute to efforts trying to make industrial development more sustainable.

Clean Sky will certainly have a positive impact on the environment. One of the success factors is the critical mass of contribution from the industry and from the European Commission. **Industry commitment is very high in terms of resources invested and this will guarantee the utilisation of the research results.** New generations of wide and narrow body aircraft, regional aircraft, and rotorcraft are planned to be developed soon and these products can benefit from the technological advances delivered by Clean Sky. Most of the environmental benefits (decrease in emissions) are achieved by lower fuel burn and so environmental and efficiency benefits are combined. As airlines seek for more efficient aircraft, the chance that a more efficient one in terms of fuel consumption will be successful is very high.

Table 5.1 summarises the most important environmental benefits the Clean Sky will generate:

Table 5.1

Impact	**Quantitative**[28]	**Qualitative**
Aircraft emission reduction of new aircraft put on the market	CO_2 by 20 – 40 % per seat-kilometre NOx by 40 – 60% per seat-kilometre	Positive impact on air quality and the global climate
Aircraft noise reduction of new aircraft put on the market	20 dB	Positive impact on millions of European citizens living in the vicinity of airports

Probably the most important environmental benefit of Clean Sky is to decrease the emissions of new aircraft launched around 2020. The project will thus make a significant step towards the achievement of ACARE CO_2 and NOx targets. The realisation of the targets on NOx and CO_2 emission reduction will cause a significant positive impact on the global climate and air quality. Effects will be positive not only in Europe but also at a global level. The reason is first of all that local emissions contribute to the global environment, but it is also due to the nature of aviation: more environment-friendly aircraft produced by the European industry will fly everywhere.

Local air quality around airport will also change for the better as more and more aircraft flying to European airports will utilise the technologies demonstrated in Clean Sky. Another benefit in the vicinity of airports will be the noise reduction achieved similarly to the decrease in emissions. With noise reduction, fewer family homes will be negatively impacted.

Due to the full scale recycling programme of the Eco-design ITD there are certain additional benefits in the quality of water and soil. Clean Sky will have a positive impact on water quality not only at a global level (cleaner rains) but also locally at the airport level because of the elimination of fluid-based actuators. Recycling concepts will be embedded in future aircraft design, production, maintenance, and end-of-life disposal. If such methods are employed less waste is generated and the use of natural resources is limited.

As presented above, Clean Sky will make a major contribution to the ACARE goals on reducing the environmental impact of aviation. There are quantified forecasts on the impact in terms of the most important target fields. The following table is the summary of the environmental benefits to be achieved by each Technology Demonstrator of Clean Sky:

[28] On the basis of industry estimations.

Table 5.2

Impact	Smart Fixed Wing	Green Regional	Green Rotorcraft	Sustainable and Green Engines	Systems for Green Operations	Eco Design
Aircraft CO2 reduction	12 – 20%	10 – 20%	26 – 40%	15 – 20%	10 – 15%	10%
Aircraft NOX reduction			53 – 65%	15 – 40%		
Aircraft noise reduction	10 dB	10 dB	10 dB	15 dB	17 dB	10 dB

NOTE: the Smart Fixed Wing and Green Regional columns only cover airframe contribution; the Rotorcraft column includes both engine and airframe contributions.

Thanks to the integration of the results of the platform, some of the positive impacts mentioned above will be additive to each other. For example a new wide body aircraft designed by utilising the research results of Clean Sky will probably incorporate the new smart fixed wing and the new sustainable and green engine. Therefore the benefits achieved in terms of CO_2 emissions will be an approximate sum of the targets of the two Integrated Technology Demonstrators concerned.

5.2.3. *Economic Impacts of Clean Sky*

Although accurate quantification of the financial benefits of a research project is impossible, it can be stated that the economic benefit Clean Sky will generate for the European economy is substantial. Clean Sky is a green programme but **the economic benefits alone can justify the significant investment of public money**. One of the advantages of Clean Sky in economic terms is the provision of tools for the European aeronautical industry in the global competition. The reason behind that is the need for developing new and efficient products. The life cycle of an aircraft fleet is around 20-25 years. By 2010 about one third of the aircraft will reach the targeted lifetime of 20 years so there will be an urgent need for replacement. Narrow body aircraft (capacity of 110 – 220 seats) has the largest share in the aircraft segment (around 60%). Consequently, it is crucial that a new narrow-body product taking advantage of new technology development enabling step changes in environment protection must be ready for this important fleet renewal process. It is very likely that without Clean Sky the European industry cannot offer competitive new products when the fleet renewal of several airlines will be at stake.

The other very important economic advantage is the **generation of new jobs** through the better performance of the industry with more successful products.

More efficient aircraft fleets will obviously help airlines to **decrease their operational costs**. This is especially important in Europe where several airlines are loss-making and thousand of jobs are in danger because of possible bankruptcies.

On a macroeconomic scale Clean Sky will contribute to the economic growth of Europe. The ACARE SRA-2 states that the European Air Transport industry generates 2,6% of the European GDP directly. In addition as the growth in the air transport industry is larger than in many other sectors, the contribution is growing. The contribution is also substantial in terms of employment: 3 million European citizens are working in this industry. On the basis of these estimates Clean Sky will impact not only the air transport industry, but it will have a positive effect on the whole European economy.

An important side-effect will be achieved through the stimulation of **SME involvement** into the supply chain of aeronautics industry, taking into account that SMEs involved in research represent around 3 million EU-15 enterprises.

Cleaner and quieter aircraft will alleviate constraints as in air traffic growth, through opposition to new infrastructure and environmental changes. The project will bring positive effects to the enlarged Europe through **lower transport** costs and consequently more trade and tourism. On the other hand without proper actions, such as the Clean Sky, to help the European industry to maintain its competitiveness, the growth in transport may be slower and thus the growth rate of the European GDP will be lower as well.

Innovation and research potential of Europe will be strengthened as a large project like the Clean Sky would bring all key and leading edge players of an industry together and this would generate a spill-over effect on other initiatives as well. A large aeronautical research project will mean benefits to other industries as well due to the resulting technological spillovers. For instance, lightweight materials and eco-friendly processes developed within Clean Sky may be applicable in the automotive industry, where this knowledge can be turned into a commercial advantage (higher mileage for cars, novel electric actuation systems…). This research and development spillover effect will be one of the major economic benefits at the European level as described in the following table:

Table 5.3

Economic Benefits to Europe (2010-2035)[29]	**Quantitative[30]**	**Qualitative**
R&D spillover	€450 billion	Positive spillover impact through knowledge transfer to other sectors and geographical regions with limited aeronautical industry
Added value for prime contractors	€160 billion	Helping all the European aeronautical industry to maintain a competitive position on a global level
Added value in supply chain	€190 billion	Providing benefits to a broad range of industries, including SMEs.

Estimates on added value and economic additionality in Europe have been derived from both high-level market forecasts and from data provided by individual companies on the investment required to develop and exploit the first generation of products that will be able to benefit from the results of Clean Sky. In many cases this required access to commercially sensitive information at company level, such as R&D spending levels to be committed to new programmes and expected market share. Data from individual companies was cross-checked by Oxford Economic Forecasting, clarifying possible anomalies. Overall figures are quoted which are turnover-weighted averages to provide an industry level view. Figures are integrated over **20 years** (2010-2030) for R&D, and another 20-year period offset by 5 years (2015-2035) for market impact, as representative of a development programme for and the lifetime of an aeronautical product.

29 R&D spillover benefits are expected from 2010 even if new products will enter into service only from 2015.

30 Amount in billion euro on the basis of industry estimations.

The initial base for further considerations is the total aerospace industry market opportunity that includes original equipment market (OEM) and aftermarket sales. This figure is derived from industry agreed sales forecast based on factors such as expected traffic growth and age and profile of the existing fleet. It is estimated, for the period from 2015-2035, at 1500 € Billion and includes the potential business opportunity with respect to airframes, engines and systems. It is to be noted that this figure is gross, and "bought out costs" (costs for goods or services bought outside the company such as investments for production lines or labour) of about 30% are included.

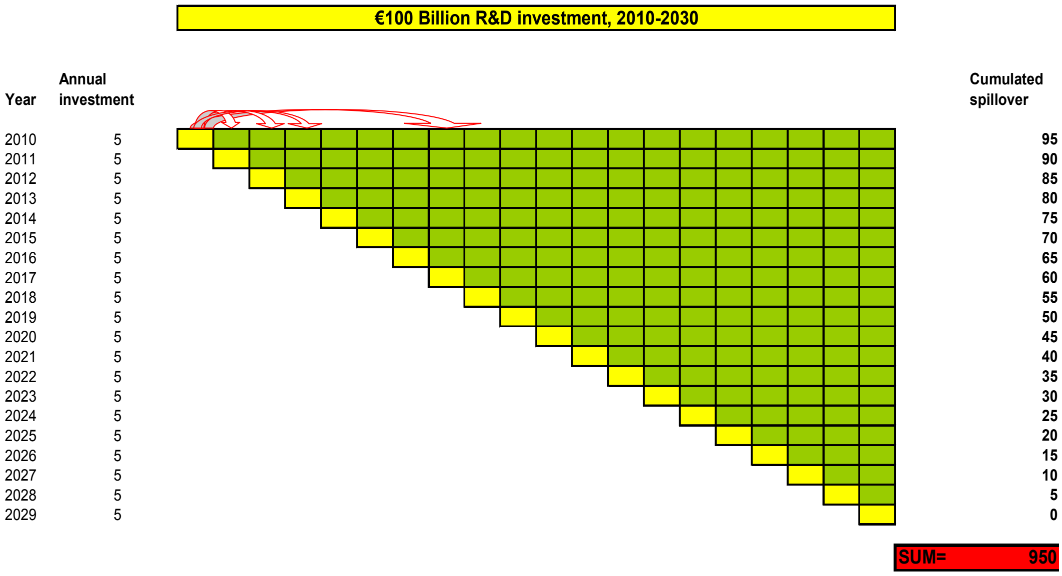
Considering the present time frame and based on expected launch dates of new programmes, it is estimated that 2/3 of this market opportunity would be influenced by technology developed in Clean Sky. At this point in time, a number of new aircraft types are already too far ahead in their development phase (e.g. 787, A380) to benefit from Clean Sky technologies. In addition, one of the effects of the global market for aeronautics is that European companies participating in Clean Sky also contribute to aircraft built outside Europe. Thus, the market opportunity developing from Clean Sky is about 1,000 € Billion for the projected time window.

The next step is the estimate of the R&D budget which could be accounted for as a percentage of the expected turnover. Again, the figure quoted is an average of individual companies forecast, and runs to about 10%, corresponding to 100 € Billion for the same period 2010-2030.

In parallel to the R&D expenditure, additional economic output (that is, turnover minus bought out costs) in Europe is estimated and the turnover-weighted average indicates that about half of the net world market opportunity related to Clean Sky will impact on EU economy, corresponding to about 350 € Billion, divided roughly 40/60 between primes (direct additional output of 160 € Billion) and supply chain (indirect additional output of 190 € Billion).

The R&D spill-over benefits are estimated using the assumption that the average rate of social return across the G7 economies is close to 100% in the civil aerospace sector (the rate of social return in defence related activities sets at 30% due to security and national interest factors). This assessment was carried out for industry by Oxford Economic Forecasting and confirmed by PriceWaterhouseCoopers[31]. The forecasting assumes for simplicity that the R&D expenditure related to Clean Sky is spread evenly across 20 years between 2010 and 2030. A 100% social rate of return means that every yearly R&D investment will generate the same amount for the following years in the relevant period. A 100 € Billion R&D corresponds to 5 € Billion/year in the period 2010-2030 and will generate 5 € Billion/year <u>every following year</u> in the period 2010-2030 leading to a cumulated value of about 450 € Billion, taking into account a reduction factor (about 50%) for spill-over within the European economy. This scheme is illustrated in the graph below.

[31] Oxford Economic Forecasting, PriceWaterhouseCoopers, Rolls-Royce (October 2004) "The wider economic benefits of R&D – research paper on spillovers". mimeo



As an end result, the total additional economic output to the EU in the period 2010-2035 which can be associated to Clean Sky is the sum of direct and indirect industry outputs and spill-over, corresponding to **€ 800 Billion**.

The average European citizen will also profit from the project in several ways. Households around airports and heliports should spend less on protection from noise due to the less noisy aircraft and rotorcraft. This would be also beneficial for local authorities involved in compensation schemes to households around major airports with noisy operations. The increase in mobility will contribute to the economic development of peripheral regions, which are hardly accessible with other means of transport. Finally, there will be global economic benefits as well as airlines operating in five continents will buy and use the more efficient aircraft, regional aircraft, rotorcraft and engines.

5.2.4. Social Impacts of Clean Sky

Any positive impact on environment has a direct positive effect on public health. Considering this, the largest social advantage of decreasing emission and noise generated by new aircraft and rotorcraft is the positive impact on public health. As one of the priorities of the European Commission is to maintain or even increase the quality of life of European citizens, this impact on **public health** is another justification of the public contribution to the project.

Although the increase in airline operational efficiency is an additional benefit of the project, it will have a huge social impact through the **increase in mobility**. The more efficient aircraft fleet of airlines can result in lower fares and most probably will cause higher passenger comfort (less noise, more efficient operations).

The positive effect on **employment** by generating new jobs will also contribute to the increase of standard of living and quality of life in the regions where the aeronautics industry is present. Moreover there is a positive effect not only for a limited number of people but for all the European citizens. Investment into research has a high social return through spillover to other industries and generates an increase in the quality of life of the European citizens.

Additionally, the commitment to care of environment through the lifecycle of the aircraft – from production till recycling – will affect workers positively, e.g. more attention will be paid to hazardous material used in production, maintenance, operation and dismantling.

A quantitative social benefit is calculated by the decrease of the **social cost of emissions**. The environment benefit can be measured by the economic value of avoiding the emission of a certain amount of gases. In terms of CO_2 emissions Clean Sky can improve emission of new aircraft by 1% per year over 20 years[32] resulting in 30% overall improvement compared to emissions by the current aircraft generation. Estimations show that with the help of the Clean Sky the aggregated quantity of carbon avoided can be between 2 and 3 billion tonnes over 35 years. The social cost spared by not emitting this volume into the air is several hundred billion euros[33].

Table 5.4

Social impact (2015 – 2050)	**Quantitative[34]**	**Qualitative**
Decreasing the social cost of carbon	€700 billion	Positive impact on public health, quality of life and standard of living

6. COMPARING THE OPTIONS

6.1. Ranking the options in terms of the criteria

The reasons why Clean Sky is the preferred option in terms of the criteria set in section 4.1 are summarised in Table 6.1 and discussed below[35]:

Table 6.1

	FP-only EU action	**Clean Sky JTI**
a) Scale of investment	+	++
b) Continuity of the research programme	+	++
c) Leverage of private and public funds	+	++
d) Critical mass of participants and multidisciplinary approach		++
e) Co-ordination and integration between participants	+	++
f) Efficiency of the governance structure		++

32 20 years after the new more environment friendly aircraft will be on the market, probably there will be a step change by introducing a newer aircraft.

33 The Social Costs of Carbon Review – Methodological Approaches for Using SCC Estimates in Policy Assessment", AEA Technology Report for DEFRA (UK Govt), December 2005. The median value resulting from this study was used to quantify the social benefit.

34 In billion €.

35 Note that the assessment is made in relation to the objectives in 3.1, thus regarding projects that require full-system demonstration. The ranking –as indicated in section 3.2 p. 8- would be different if projects on basic research or requiring validation at the subsystem or system level were in question.

g) Technology readiness demonstration		++

Note: the sign + indicates a positive assessment of the instrument on the base of that criteria. The marking ++ indicates a higher score.

a) Clean Sky JTI has a **budget** (€1.600 million) focused on R&D for greening aircraft (fixed wing and rotorcraft) which is much larger than feasible with traditional instruments of Collaborative Research.

b) Clean Sky JTI has a **long-term research agenda** lasting seven years. Even in FP7 a Collaborative Research project generally has a shorter duration.

c) Clean Sky JTI has considerably more powerful effect in terms of **leverage of private and public funds** (see section 5.2).

d) Clean Sky JTI has the necessary **critical mass and multidisciplinary approach**, covering the full scope of aeronautics technologies, required to accelerate the development and introduction of major technological advance for greening Air Transport (see section 3.2 for the articulation of Clean Sky in Integrated Technology Demonstrators (ITDs)). On the other hand a Collaborative Research instrument, due to the fact that the R&D effort is undertaken in different separate projects, will not allow achieving the objective of the action (see section 4.1).

e) Clean Sky structure and governance ensure a **tight integration and co-ordination** between the different ITDs, which is required to exploit economies of scale and scope in aeronautics R&D. Such integration will allow avoiding duplication, exploiting potential synergies and achieving cross fertilisation between participants. The role of integrating and coordinating participants is assigned to three elements: the Technology Evaluator, specific elements of the governance structure, such as cross-participation in the steering committees or the Clean Sky Director activities (see section 6), and finally external monitoring mechanisms. An *FP-only EU action* on the other hand, will not provide similar integration and coordination between participants.

f) Clean Sky will have the legal and governance structure able to provide the necessary **leadership for achieving the research objectives** (see section 6). A similar structure is not feasible with an *FP-only EU action*. As the majority of the Executive Board members will be from industry, the modus operandi will be quite pragmatic and business-oriented in nature, responding quickly to changing market conditions as these arise.

g) Clean Sky ITDs will manufacture and operate several flying and full scale ground demonstrators[36] to validate technologies at a high technology readiness level (TRL 6)[37], sufficient to provide the basis on which innovative greener products can be launched at an acceptable risk. Due to that, Clean **Sky will accelerate the timing of new product development**. Traditional Instruments of Collaborative Research would not be adequate for the large demonstrators required for the step changes proposed in the Clean Sky programme, each one combining several new technologies.

Thus **Clean Sky has a greater potential to deliver major innovations and to bring early to market** the new technologies. By including the demonstrators needed to validate technologies at a high

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36 The demonstrators' objectives and required characteristics can be found in part 2 of the Proposal.

37 See 3.1. Technology Readiness Levels elaborated by NASA which are presented in chapter 6 of the report.

technology readiness level (TRL 6), Clean Sky will address a major source of market failure discouraging R&D investment in greening the aeronautics sector. Accelerating the introduction of technological advances for new green aircraft is crucial as products in the aerospace sector remain in service for a very long time (~25 years). If a technology is not sufficiently mature to be incorporated in new products, it may miss a market window and fail to influence a generation of aircraft development. **Moving fast in launching the JTI is of crucial importance** since around 2015 approximately 5700 aircrafts of the world present fleet will reach the targeted lifetime. If Clean Sky breakthrough technologies will be ready for introduction, such fleet replacement will contribute substantially to pollution reduction.

The assessment performed by the panel concluded that **Clean Sky has a high probability of success**, due to its integrated approach which allows to fully exploit synergies and to generate technological spillovers between different ITDs; thanks to the role of the Technology Evaluator which will integrate the technical content across Clean Sky and evaluate the merit of ITDs R&D activities in relation to ACARE targets; and also due to the flexible and carefully crafted governance structure which is adequate to the technological and managerial complexity of the programme. The risks inevitably associated to investing a large sum of public money in a single programme with a great technological and managerial complexity are considerably reduced in the Clean Sky case.

Clean Sky represents a major opportunity for SMEs. To start with, there is a target to place a percentage of 12 % of the EU funds attributed to Clean Sky to SMEs[38]. In addition, Clean Sky will offer the possibility to work with major players in the industry. It will have a major role in integrating the EU industry, enabling new areas of excellence in the EU (new both from a geographical and sector point of view) to become part of the supply chain of major integrators. The internal and external control mechanisms present in the Clean Sky governance[39] will ensure the transparency and openness favouring the participation of areas of excellence amongst Universities and Research Centres. The role of academia will be particularly important in defining the simulation models to be applied by the Technology Evaluator.

It is worth noting that Clean Sky structure is structured in a particular way, with a core team of members identified at the start of the programme, and partners to be added later. In spite of the impression created by the fact that a large core team is already known, Clean Sky is an open structure. In an Annex, the openness of Clean Sky is elaborated, but the following points summarise the overall approach:

The membership and partnership of Clean Sky reflects best practices within the aeronautical sector for participation in R&D projects, with the additional requirement of widening the know-how and technology base to as many Member States and Associated States as possible, compatible with maintaining the level of technical excellence required to ensure meeting the overall objectives.

ITD Leaders currently include all major European aeronautical integrators which have the means and infrastructure necessary to carry out the strategic development and system of systems integration. They also carry the majority of the risks through their commitments in Clean Sky. The team of ITD leaders will nevertheless be broadened throughout the course of Clean Sky to also include the Technology Evaluator activity.

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38 It should be noted that this is a TARGET, in the sense that excellence will still be the primary driver to accept participants into Clean Sky.

39 See for instance the mechanisms for ensuring openness and fairness in Clean Sky as to the Call for Proposal and Call for Tender. A 1st instance reviewing process and arbitration Board of contested partner selection decision is chaired by the Clean Sky Director. Second instance review and re-opening of contested partners' selection decisions is competence of the Executive Board. And the Commission can veto decisions on the 2nd instance arbitration of contested partners' selection decisions.

Potential associates have been gathered through an open process carried out at European level, and a first selection of applicants has been made openly and transparently based on an objective set of criteria. The criteria were centred on technical excellence focused on Clean Sky needs. Out of 98 candidates, 74 organisations have been invited to enter into Clean Sky; the remaining 24 have been invited to join in a later stage as Associates or Partners, together with any organisations that may show an interest capability at a later stage.

The initial team of Clean Sky members will detail the programme of work thus allowing the identification of more specific technical areas where further participation will be sought, either through further association of members or through partners selected via calls for proposals.

These Calls will be public and transparent, and will be implementing the principle of excellence by following an open and competitive process guided by the quality of the contribution and the value for money offered. Commission will oversee the correct implementation of the Calls for Proposal.

The budget distribution of activities carried out by ITD leaders, Associates and Partners is in line with risk sharing management of long time scale industrial projects, and guarantees that the challenging targets will be met in full and in time.

It is appropriate to conclude that, within the specificities of the aeronautical sector, the breakdown of financial engagement and definition of technical responsibilities is the result of an open assignment of tasks within the aeronautical community at European level, constrained by the specific requirements of environmentally friendly technologies as envisaged by Clean Sky.

6.2. Expected incremental impact of Clean Sky JTI

The Experts appreciated the major efforts undertaken by industry in order to quantify the environmental and economic effect of Clean Sky. The quantification effort was undertaken to comply with one of the key recommendations provided by the intermediate assessment[40]. In the Q&A session with industry representatives, many questions were raised regarding the assumptions on which the quantification exercise was based and clarifications were required as to the scenarios considered. Such requests of clarifications were satisfactorily answered by the industry representatives. Although the difficulty of a precise quantification of the environmental and economic benefits from Clean Sky is evident, the analysis provided by industry was considered as a very useful exercise.

The expected **incremental environmental benefit** from JTI was calculated by Industry by comparing a Clean Sky JTI scenario with an *FP-only EU action* scenario. In the Clean Sky scenario it is assumed that a 1st generation of new aircraft incorporating the Clean Sky R&D output will enter into service starting in 2015, and the **new products will allow substantial reduction of CO_2 emissions, NOx and noise.** At the aircraft level, it is expected to reduce by 2020 CO_2 emission per seat-kilometre of new aircraft by around 20%-40%, NOx by around 60% and noise by 10db to 20db (see 4.1). In the *FP-only EU action* scenario, emissions reduction in new aircrafts will be lower, as technology will arrive later to the market for the reasons discussed in section 5.1.2.

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[40] An intermediate assessment was undertaken in January 2006. All recommendations issued in the resulting report were fully taken into account in the final Clean Sky Proposal from industry.

The estimates of emission savings at the fleet level over the 2015-2050[41] period on the assumption of 50% market absorption of Clean Sky technologies by the running fleet (in the order of 10,000 aircraft) and average CO_2 production per passenger*km, due to new products incorporating Clean Sky technologies, are indicated in the Table below. Industry has estimated that over the period 2015-2050 Clean Sky will lead to a cumulative reduction of 2 to 3 billion tonnes of CO_2, suggesting that, although it takes some time for the new cleaner aircraft to replace the existing fleet, Clean Sky makes a significant step towards reducing the environmental impact of Air Transport.

Table 6.2

Expected incremental environmental effect of Clean Sky (as compared to *FP-only EU action*) Estimated CO_2 saving of fleet incorporating Clean Sky R&D output (2015-2050)
2 to 3 billion tonnes CO_2 (cumulative, 2015-2050)

The expected **incremental economic benefits** from JTI were calculated by Oxford Economic Forecasting (OEF), working closely with the European aeronautics industry. The starting assumption is that Clean Sky, by bringing innovative technologies to a maturity level where they can be incorporated into new products, will act as the catalyst for substantial investment in new generations of green aircraft, engines, and systems entering into service between 2015 and 2035.

The additional economic output created by the Primes and Supply Chain and spillover benefits arising from the new generations of products exploiting JTI-supported technologies were assessed. Total World Market Value 2015-2035 was estimated using Industry forecast which considers factors such as: traffic growth expectations, the age of the existing fleet, predicted new programme launch dates. Next, the proportion of the new product market value that could utilise Clean Sky technology between 2015-2035 was assessed.

Each industrial participant involved in the drafting of the Clean Sky Proposal used this database to estimate the potential business opportunity related to Clean Sky in respect of Airframes, Engines, and Systems. Each participant was asked to estimate the Direct additional economic output associated to their activities within the EU[42]. Each participant was also asked to estimate the proportion of their supply base they expected to source within the European Union in order to calculate indirect additional economic output and to provide an estimate of the proportion of their turnover spent on R&D in the European Union[43]. Using a turnover-weighted average, industry level data were obtained. Considering the period 2010-2035, the economic output created in the EU from the development and exploitation of JTI supported technologies, according to the OEF analysis, should reach approximately €800 billion (see section 2.7 of the Proposal). It includes a) additional economic output created in the EU by Primes and b) additional economic output created in the EU by the supply chain and c) R&D spillovers benefits to the EU.

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41 The relevant table in the Clean Sky Proposal refers to the 2005-2050 period. The starting date was set to 2005, as that was the start year of the market forecast database used in the econometric exercise. However the additional reduction in environmental impact of Clean Sky will began after 2015 as only platforms launched in/after 2015 are considered. The end date of 2050 was chosen to reflect that, due to the service life of aircraft, the environmental performance of products developed from Clean Sky will continue to be significant for a much longer period after 2035 (date at which the 1st generation of products developed from Clean Sky are expected to be no longer competitive in the market).

42 This figure included Labour costs, Profit, Capital expenditure incurred in (or in the case of profits repatriated back to) the European Union.

43 Industry clarified that the estimates provided by individual companies were cross-checked and any anomalies investigated.

An attempt was then made to estimate the **direct contribution from Clean Sky**. The potential ability of the Clean Sky JTI to influence the additional economic output created by the aerospace industry was explored by considering different potential scenarios. From such analysis emerged that the direct contribution from Clean Sky could be estimated to reach around 12 to 20 % of the total additional economic output in the period 2010-2035, and thus **would amount to around €100 to €160 billion**.

Table 6.3

Expected additional economic effect of Clean Sky (as compared to FP-only EU action)	
Estimated direct contribution from Clean Sky to total "additional economic output" to the EU (2010-2035)[44] (12-20% of total "additional economic output")	**~€100-160 billion**

To sum up, although the difficulties associated to estimating market development over a rather long time horizon (2010-2035) and to assessing the spillovers effect, makes the individual figures only indicative, the exercise from OEF represents sufficiently convincing evidence that Clean Sky will generate considerable economic benefits for the Community as a whole.

6.3. Additionality of Clean Sky

Clean Sky is expected to have a major impact in terms of "additionality" at the Community level. To start with, the European Aeronautics Industry will invest an additional €800 million in R&D for reducing aviation environmental impact. Although this short term effect is quite impressive, the long term repercussions are also of considerable importance. A large scale long term EU programme delivering demonstrators needed to validate technologies at a high technology readiness level will act as a catalyst to influence the magnitude of private R&D investments in product development programmes. The value of industry funded R&D performed in the EU over 2010-2030 in developing new products incorporating Clean Sky technologies is expected to be around €100 billion.

Clean Sky will also **stimulate national governments programmes** on aeronautics research addressing environmental problems. Research and Development remains a key driver of the aeronautical industry. However, the cyclical nature of the sector implies that the baseline for assessing the impact of Clean Sky, varies substantially from year to year, while an R&D programme focussing on innovation technology has an intrinsically more stable character.

The overall R&D expenditure in civil aeronautics in 2005 was 5.5 € Billion, representing 6.8 % of the consolidated turnover but dropping by 4.5 % with respect to the previous year in relative terms. Private industrial investment accounted for 70 % of the whole R&D at 3.8 € Billion.

The leverage effect of Clean Sky is expected to produce a higher degree of stability in the industrial investment and to promote further national funding. Germany has already increased the funding of its national Aeronautics R&D LUFO programme by 40 € Million earmarked for complementary activities to Clean Sky at national Level. Spain is considering a similar approach at the level of 100 € million. It is expected that the large participation of organisations and National States to Clean Sky will carry sufficient critical mass to increase the leverage further.

44 R&D spillover benefits are expected from 2010 even if new products will enter into service only from 2015.

Apart from this direct leverage process, the alignment of national programmes with the JTI programme (the coherence effect) creates an implicit level of additionality. National research in aeronautics is likely to be more focused towards environmental research due to Clean Sky. The National State Representative Group (one of Clean Sky external advisory bodies) will act as interface to relevant national research programmes and provide inputs to Clean Sky on identification of potential areas of cooperation.

Finally the additionality can also be measured in terms of the direct contribution to total "" to the EU from the development and exploitation of Clean Sky supported technologies[45]. As seen in table 6.3 the direct contribution from Clean Sky is estimated to reach around €100-160 billion, compared to the €800 million of public money to be invested in the programme.

Setting the baseline to assess industrial added value is not so straightforward: a meaningful numerate assessment of the impact of Clean Sky on the level of **industry R&T expenditure** would have to differentiate between Programme R&D and Research and Technology investment and then to distinguish between environmentally-related and non-environmental R&T. This type of data is not available from published industry data.

The JTI proposal sets out the broader market failure arguments that underpin the case for public intervention both to increase general levels of R&D and R&T and in particular to increase investment in environmental technologies. There is good evidence that social returns to RTD in civil aerospace substantially exceed the average in Europe. Furthermore, in the case of environmental technologies a dual market failure (due to the impact on environment of aviation) arises suggesting that the impact of public intervention will be especially strong.

Evaluating the extent to which JTI activities represent an increase over that which would have happened in the absence of Clean Sky will always be very difficult especially as, over the economic cycle, industry RTD expenditure will go up and down. However, one of the envisaged outputs of the Technology Evaluator could be a better evidence base, allowing for tracking of the added value of Clean Sky in the course of the JTI activities.

6.4. Risks associated with Clean Sky

As a start, quantification is required of the statement "JTI not being successful".

Various scenarios are possible:

- Individual ITDs not reaching in full their targets
- Failure of total JTI to reach its targets
- Failure of JTI consortium (e.g. by withdrawal of key partners)

Individual ITDs not reaching in full their targets

Probability: low to medium – Impact: Low

As we are dealing with pre-competitive research, we must understand that there is a lot of uncertainty on the targets that were set forward for Clean Sky: quite probably, the targets will be met. Nevertheless, there is a possibility that they may not be achieved in full, as is there an equal possibility that Clean Sky will exceed expectations.

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[45] This is the present value, in terms of 2006 euro, of the flow of future expected additional economic output over the 2010-2035 period.

Nevertheless, the impact on the overall JTI of an ITD not reaching all of its targets in full will be low: as the Technology Evaluator will be used to monitor, assess and optimise the impact of the various innovations across the ITDs, the possibility exists at Executive Board level to redistribute budget and resources between ITDs in case one of them is facing inescapable complications that prevent it from realising its goals. In other words, no money or resources will go to waste, and the overall impact is therefore quite low.

In addition, as mentioned in section 4.3, there is a strong degree of interlinking between the various ITDs, which creates a degree of "robustness" as well as increased confidence, in the sense that contributions from various factors add up to achieve the desired result. For instance, in the case of regional aircraft, the targets for emission reduction will be achieved through a combination of weight and drag reduction (leading to lower fuel consumption and thus proportionally lowered emissions), as well as engine optimisations to reduce emissions of CO2 and NOx. These engine optimisations, in turn, rely on a trade-off between NOx emission and the production of noise: cleaner engines use different operating parameters that make them noisier and vice versa. Finally, an increase in noise can partly be compensated by adapting a novel aircraft configuration where the engines are e.g. mounted at the tail or above the wings, to shield noise radiation to the ground.

This interdependency helps in decreasing the vulnerability to individual factors, as there is in most cases a possibility to compensate through other factors.

Failure of total JTI to reach its targets

<u>*Probability: very low – Impact: high*</u>

As explained above, the multitude of contributing factors to each of the JTI targets (the robustness of the strategy) makes it highly unlikely for the entire JTI not to reach its goals. Even if only one ITD achieves in full what it set out to do, its application across the other areas will already create a significant benefit. E.g. if the engine ITD succeeds in developing the new types of optimised turbojets, then the various aircraft types will all reap the benefits of that success. Equally, if the Green Regional Aircraft succeeds in developing its low-weight "smart" structures with embedded sensors, these can equally be applied to the Smart Fixed wing and Rotorcraft ITDs, partly contributing to their success.

Failure of JTI consortium – withdrawal of partners

<u>*Probability: low to medium – Impact: medium*</u>

The most critical players inside the JTI are the ITD Leaders, who will all together be accounting for about 35-40% of the efforts within the project, and who have taken up the responsibility to exploit its results afterwards. Also, the risks are carried mainly by the ITD Leaders.

The probability of one of these main players pulling out is on one hand rather low, as each of the companies has already agreed to a Memorandum of Understanding signed at the CEO level. The level of commitment is therefore very high – also because a lot is at stake for each of them. In addition, the risk of ITD Leaders withdrawing will diminish as the project develops, because the pressure to get return on investment increases.

Nevertheless, even though it is in principle possible that one or more resign from Clean Sky, the effect will be serious but not disastrous as each of the ITDs is co-led by two members. This implies that there is always a back-up (albeit not necessarily of the same scale or scope), and that no ITD shall become decapitated should one of its leaders decide to leave the project.

Clean Sky is much less vulnerable to departure of any of the other parties (apart from ITD Leaders) involved, as the scale of their contribution is an order of magnitude smaller, and alternatives can be found for as good as all of them within Europe. The only foreseeable impact could be that a delay in the ITD work programme would result from the withdrawal of one of its participants. Nevertheless, as withdrawals are usually announced via internal frictions within the JU or alarming reports regarding the condition of the organisation in question, it should be possible for the JU's governing bodies to anticipate on potential trouble and develop pre-emptive backup solutions.

While accepting that it is impossible to eliminate all risks in a 7-year long R&D activity as complex as Clean Sky is, it is felt that the governance and internal and external control mechanisms that are part of the overall infrastructure of the Clean Sky Joint Undertaking will provide enough guarantee that recovery actions could be implemented quickly if and when necessary.

7. MONITORING AND EVALUATION

7.1. Preparation of the Governance structure

Since the preparation of the Clean Sky JTI has started, monitoring and evaluation was one of the key issues considered. The European Commission, representatives of aeronautical industry, Member States and research organisations have been working together in the last two years to achieve a good governance structure for the project. The outcome of the work of different stakeholders is a well balanced, transparent, efficient governance structure.

Regulators will be naturally involved in Clean Sky: this is a well-established practice in aeronautics industry, which will also be applicable here. In the most direct form, regulators will certify all developments of Clean Sky for future application, but they will also be able to prepare legislation to ensure a swift take-up and exploitation of the innovations resulting from Clean Sky – which can provide EU companies with an additional strategic benefit.

7.2. Monitoring and evaluation

The monitoring and evaluation of the progress within the Clean Sky Joint Undertaking is carried out both by ***external*** **and** ***internal*** **bodies**.

The internal evaluation is first of all executed through the management structure of Clean Sky. The first step is the ITD Steering Committee that manages, monitors, evaluates the work of the participants in the Integrated Technology Demonstrator. This Committee reports to the Clean Sky Directorate where the work of the ITDs are evaluated at first hand and then there is a strategic evaluation at the level of the Executive Board, which is composed of the European Commission, the ITD leaders and one representative of Associate Members from each ITD (rotation based). Another important tool in the evaluation is the Technology Evaluator which is a separate entity within the project, similar to the Integrated Technology Demonstrators.

Although Clean Sky has an efficient management structure that ensures that the right decisions are made at the right time, when public money is to be spent there is a need for external monitoring and evaluation as well. There are different steps in the external evaluation according to the phase of the project: evaluation before Clean Sky starts *(ex ante)*, continuous monitoring of progress during the project and evaluation after Clean Sky finished *(ex post)*.

Assessment studies like the present one show the effort made in order to prepare the project to satisfy all the expectation and criteria. The special meetings with the representatives of Member States and Associated States, the deep involvement of the aeronautical technology platform - comprising industry, Member States and research establishments – in the preparation process ensures that the Proposal is satisfactory to all stakeholders.

When the project starts, the two main external reviewing bodies will be the Transport Programme Committee and a new organisation, the National States Representatives Group. The main task of the group is to monitor the progress of the project against the original targets. The interface among the Group and Clean Sky will be the European Commission but direct contact with the Clean Sky Director is also foreseen. In addition to the two organisations mentioned above, ACARE will maintain the role it had during the preparation of the JTI: it will specially focus on the progress considering the Strategic Research Agenda which the objectives of Clean Sky are in line with.

In addition, it is foreseen that an **Advisory Board** will support the JU (mainly through the Director and the Commission) in all scientific, technical, managerial and administrative issues. This Advisory Board will be formed of independent experts, not necessarily restricted to the aeronautics field or Europe. A representation of the airlines may also be a member, to represent the vision of the end users; to avoid market distortion, individual airlines will in principle not be directly consulted.

7.3. Measurement of progress

7.3.1. Evaluation levels

It is always difficult to set clear quantitative indicators for a research project. Some results of the project can be realised only if there is a proper implementation afterwards and this is usually out of the scope of the research projects. In addition the external environment changes during the lifetime of the project and accurate forecasts are not always easy to make. Despite these difficulties Clean Sky can be a positive example for progress measurement when comparing to other FP7 instruments.

There are three different kinds of measurement to be maintained during the life time of the project:

- evaluation and forecast on whether the project produces the required results in terms of the benefit for the environment and for the competitive position of the industry;
- continuously checking that public money invested is well spent by sufficiently following the project plan and production of the deliverables;
- monitoring that the selection process for Associate Members and additional partners is transparent and fair.

The evaluation of the progress of the project against the criteria above will be executed at the following levels:

- technical;
- managerial;
- financial.

7.3.2. Technical evaluation

The measurement of the technical progress implies evaluating to what extent the project has reached the technical objectives indicated in the Proposal and later in the project plans of each Integrated Technology Demonstrators. Clean Sky has well defined quantitative and qualitative objectives defined for each ITD. These objectives mostly target CO_2, NOx and noise reduction by indicating a target range for the ITD. As Clean Sky will have full scale demonstrators, the evaluation of the work of each ITD against the original objectives will be much easier than in case of most of the research projects.

Within the project, the most important instrument for progress measurement is the Technology Evaluator. By using a holistic approach, the Technology Evaluator ensures the technical cooperation coherence among the ITDs. It is the Technology Evaluator where most of the internal evaluation during the lifetime of the project is done. It will measure the work of all the six Integrated Technology Demonstrators against the relevant technical project plan and the ACARE target. The Evaluator will ensure the consistency between the Integrated Technology Demonstrators' activities and will help to utilise the research results of one Demonstrator in another one without duplicating research activities. The Technology Evaluator will allow a detailed assessment of the environmental benefits associated with the new technologies. The Technology Evaluator will also use the help of research centres to measure the work in progress towards the objectives and will suggest necessary corrections to the ITDs.

The management structure of the project will obviously take part in the technical measurement as well by using a bottom up approach. Detailed technical sub-objectives will be measured at the level of ITD Steering Committees and in the JTI Directorate where there is a Responsible Officer for each of the six Integrated Technology Demonstrators. Results of higher level analysis of progress will be evaluated at the Executive Board level and the results of this analysis will be shared with the external evaluating bodies through the involvement of the European Commission.

7.3.3. Managerial monitoring

The managerial monitoring is executed by the governing bodies of Clean Sky: the Steering Committees of the Integrated Technology Demonstrators, the Directorate and the Executive Board. A clear management and communication structure ensures the day-to-day management of the project and helps in the strategic planning process. These bodies are also responsible for the administrative, managerial monitoring of the project by analysing the reports from lower management levels and measuring the progress against the detailed project plan.

The Director will be the legal representative of the project. The Director and the supporting staff in the Directorate will collect all the relevant information from the ITDs and will prepare most of the reports on the basis of the information received. The Director will report directly to the Executive Board. The personalised responsibility for the management activities will help the monitoring work of the European Commission and the external monitoring bodies.

7.3.4. Financial monitoring

Besides the technical and managerial aspects, the financial management will probably attract more attention for the external evaluators of the project: the National States Representatives Group and the Advisory Board can continuously monitor how the important financial and administrative Clean Sky targets are maintained. The guarantee that funding received from the Commission is spent according to public interest is also due to the veto right of the European Commission in issues of strategic importance.

With the proper use of the management structure, fair representation will be ensured. The selection process is clear and indicates that the actual selection will be transparent and satisfactory for all stakeholders. Target for SME involvement (12%) is a major contribution to the overall goals of the European Commission in the Framework Programme. A well established selection process can guarantee that companies not yet part of the supply chain will have equal possibilities if they have useful capabilities for the project. There is clear indication for the plan to incorporate universities and research centres, especially in the work of the Technology Evaluator.

The present governance structure ensures that each important stakeholder group is informed on progress. In addition the structure ensures interactivity partly indirectly through the European

Commission and partly directly through the management of Clean Sky at forums like the General Forum and different kind of information events.

The issue of valuing the in-kind contributions will be handled using the following principles:

The overall approach shall be based on FP7 modus operandi, where in-kind contributions in projects are assessed at review level.

The Implementing Rules of the Financial Regulations shall be used as guideline.

Additional items will be covered by International Accounting Standards.

Assessment of contributions will take place in accordance with the usual practice of the founding industrial partners.

Verification will take place via an independent auditor.