Clean Sky 2 Joint Undertaking

DEVELOPMENT PLAN

December 2017

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Clean Sky 2 Table of Contents

1. Scope of this Document

This document defines the Clean Sky 2 Programme's [CS2] main objectives and key performance targets towards environmental impact and energy efficiency, industrial leadership and Europe's need for sustainable and competitive air transport. As such, it provides the direction of technological research and demonstration activities within Clean Sky 2 as set in the context of the European Union's overall aviation strategy[1], and in line with the relevant institutional policy documents and framework (such as Horizon 2020). As the policy goals target the evolution of the air transport system up to 2050, the same time window is considered of relevance for the priorities in, and impact, of the Clean Sky 2 Joint Undertaking's activities.

The primary purpose of this Development Plan is to lay out the high-level structure of the CS2 technical programme, the main activities and their schedule (including milestones), key risks and their mitigation, its forecast budget to completion and the way this will be managed.

In particular, it defines:

- The key technology streams and their maturity to be reached at the end of the Programme.
- The relevant demonstrators and the associated development and cost schedules.
- The benefits projected in terms of mobility, competitiveness and environmental impact.
- Technical interrelationships and interdependencies between Programme elements.

The Clean Sky 2 Development Plan (CS2DP) is linked to the following other documents:

- Council Regulation (EC) No 558/2014 of 6 May 2014, setting up the Clean Sky 2 JU;
- The Clean Sky 2 Joint Technical Proposal (CS-GB-2015-03-16 – v5).

The CS2DP provides the strategic framework for following documents:

- Clean Sky 2 JU (Bi-annual) Work Plan, in particular in this case for 2018 - 2019;
- Annual Budget Plans (ABP);
- Grant Agreements for Members (GAM) for each IADP, ITD and TA;
- Grant Agreements for Partners (GAP).

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[1] https://ec.europa.eu/transport/modes/air/aviation-strategy_en

2. Clean Sky 2 Rationale

Clean Sky 2 is a Public-Private Partnership (PPP) between the European Commission and the EU aviation industry, aiming to reduce aviation environmental impact by accelerating development and deployment of cleaner air transport technologies and in particular the integration, demonstration and validation of these technologies. The initiative builds upon Clean Sky 1 achievements and continues addressing integrated technology demonstrations at large system level, including new configurations and new vehicle demonstrations at the integrated vehicle level. In addition, Clean Sky 2 enlarges the scope of demonstration to a wider set of technologies and introduces further integrated demonstrations and simulations of several aircraft systems at the aircraft platform level.

The environmentally-friendly and resource efficient technologies developed inside the Clean Sky initiative will support the EU aeronautical industry, including the supply chain, to maintain and develop further its global leadership in this sector, which is important for our society.

The environmental impact of aviation

Aviation contributes to climate change predominantly through the release of carbon dioxide (CO_2) and nitrogen oxides (NO_x) through the burning of fuels. Aircraft noise is also an important environmental issue, in particular for the population close to airport areas and under the main arrival and departure tracks. Currently, the aviation sector is responsible for about 12% of transport emissions and 2% of all human-induced CO_2 emissions, with the risk of significantly higher percentages as air transport develops further and other sectors find easier routes to low-emission or emissions-free solutions such as electrification.

Despite all the improvements in reducing the environmental impact of aviation achieved over the last 40 years, the impact is still growing due to the growth of air traffic. According to the EUROCONTROL forecast, the number of flights in Europe in 2035 will be 1.5 times more than in 2012, with an average growth of 1.8% per year in the ‘most-likely’ scenario. This growth will be even stronger outside of Europe with the global expected traffic growth estimated to be 4.3% annually over the next 20 years. As depicted in Figure 1, targeted and timely action is required and crucial to achieve a greener air transport system.

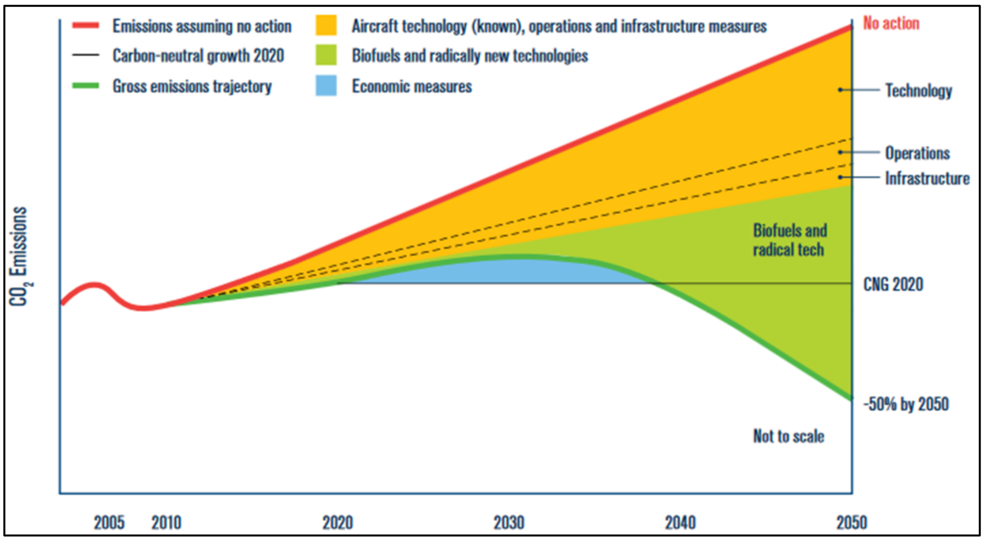

Figure 1: Schematic CO2 emissions reduction roadmap [Source IATA]

The renewed ACARE Strategic Research and Innovation Agenda (SRIA)[1] was completed in 2012 and updated in 2017, with ambitious goals for a sustainable and competitive aviation sector through to 2050. These include a 75% reduction in CO_2 emissions, a 90% reduction in NO_X and 65% reduction in perceived noise by 2050 compared to year 2000 levels, and 4 hour door-to-door journey for 90% of European travellers. These substantial emissions reductions and mobility goals require radically new aircraft technology inserted into new aircraft configurations.

The economic context of aviation

Aviation helps to meet societal needs by ensuring suitable and sustainable mobility of passengers and freight and significantly contributing to the European economy and to the competitiveness of Europe as a region. The sector has strong social impacts as it facilitates the European integration and contributes to sustainable development by providing essential transport links. It also affects the efficiency of business operations by stimulating development, opening new markets, boosting international trade, encouraging investment and allowing effective communication between regions and companies. While a strong effort is being made to address transport inter-modality to increase its servicing capability, there is no alternative to aviation on long and intercontinental routing.

Worldwide, aviation transported nearly 3.6 billion passengers and nearly 51.2 million tonnes of cargo[2] through more than 100 000 flights daily[3] in 2013. The current forecast, in line with the yearly air traffic growth of 4.3%, is for a doubling of these values within the next two decades.

In economic terms, in 2014, the EU aviation sector contributed €707 billion[4] to the EU GDP: a total of 5.0%, including direct, indirect, induced, and tourism catalytic impact. €350 billion of this contribution or ca. 2.5% of the GDP is direct and indirect only impact from aviation. The sector is

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[1] http://www.acare4europe.org

[2] Aviation: Benefits beyond borders – Air Transport Action Group, July 2016

[3] http://www.iata.org/pressroom/pr/Pages/2014-08-12-01.aspx

[4] Aviation: Benefits beyond borders – Air Transport Action Group, July 2016

also a catalyst for growth and skilled employment. The number of jobs created directly by the industry is estimated to have reached 2.5 million in 2014, of which 395 000 are highly skilled and sustainable jobs. In total (direct, indirect and induced impact), aviation supported 6.9 million jobs in EU and represented around 26% of the jobs in the sector worldwide. For comparison, the automotive sector in EU represented approx. 12.6 million jobs[1] directly and indirectly (2015).

Strengthening the competitiveness of the European aviation industry

In the current strategic context and in the face of increasing global competition, the future international competitiveness of the EU aviation sector will depend largely on the environmental and energy efficiency performance of its product portfolio. In particular, results on fuel efficiency (and/or carbon footprint) and noise reduction directly drive the expansion capability, or “license to grow” of air transport. Capacity increases positively the impact on jobs at roughly twice the rate of GDP growth. Achieving reduced impacts on the environment, in particular of CO_2, NO_x and noise, contribute strongly to an improved societal impact of the sector.

To ensure the development and deployment of new and radical technologies, the relevant industrial players need to collaborate at an early stage, and a sizeable and stable multi-annual R&D budget is required to reduce the risks related to this research. For these reasons, public intervention at EU level through traditional collaborative research is not enough and a Joint Technology Initiative (JTI) with a Joint Undertaking is needed (large scale demonstration, validation, potentially faster market access, etc.). Collaboration within a JTI is an effective means to provide the necessary framework for the European industry to develop and demonstrate new and efficient (breakthrough) technologies, and to address the different sources of market failures discouraging aeronautics research.

Setting up the Clean Sky 2 programme

In July 2013, the European Commission launched an Innovation Investment package[2] that paved the way for the continuation of the Clean Sky JTI within the EU Horizon 2020 Framework Programme. In May 2014, the Council of the European Union agreed to extend the Clean Sky JTI within the EU Horizon 2020 Framework Programme, followed by the entry into force of the Clean Sky 2 Regulation in June 2014.

Clean Sky 2 follows the 10 priorities of the Juncker Commission, the Transport White Paper, and Flightpath 2050 and is fully in line with the Horizon 2020 objectives. It helps to overcome the so-called "market failure" by using public support to reduce the development risk of non-conventional technologies to a level that is considered to be financially viable by the aviation industry.

The spill-over effects of the aeronautical industry

Aeronautical technologies are a proven catalyst for innovation and spill over into many other sectors. The main reasons are the strict performance, environmental, weight, and safety

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[1] http://www.acea.be/statistics/tag/category/employment-trends

[2] http://ec.europa.eu/programmes/horizon2020/en/area/partnerships-industry-and-member-states

requirements any aeronautical products must comply with, as well as the necessity of a “system” vision and the management of complexity. As a consequence, an aeronautical technology is often extended to another field allowing it to achieve a competitive advantage and stay on the technological leading edge. Aeronautics has been one of the first-users and promoter of many new technologies or processes such as carbon-fibre reinforced composites, Computer-Aided-Design, Computational-Fluid-Dynamics, automation, satellite-based navigation or turbine technology, which later spread over many other application fields.

3. The EU and Global Policy Context – Aviation and Environment

Governments and international bodies are increasingly raising awareness and advocating policy measures to mitigate climate change and environmental impacts of aviation. Reaching an effective political consensus at the EU and global level in qualitative and quantitative terms is a difficult process. However, the relevance of R&D including strong and long-term investments in environmental technologies is acknowledged by all parties. Notwithstanding the recent signs of retrograde action from the US government, increasingly global industrial sectors are themselves considering providing contributions to sustainable development, and aviation is no exception.

Aviation has delivered strong gains in fuel efficiency and noise emissions in the past decades, but overall growth in air transport dwarfs these improvements per RPK, and total emissions from the aviation industry will continue to rise over the next decades unless trend-breaking action is taken to introduce game-changing technologies. The past two years have seen important actions taken and agreements reached that will have a bearing on the aviation sector’s future perspective:

- the signature of the COP21 Paris climate change agreement in 2015;
- the adoption of the European Commission’s new Aviation Strategy in December 2015;
- the agreement on the ICAO CO_2 standard for new aircraft in February 2016;
- the adoption of the European Commission’s European Strategy for low-emission mobility in July 2016;
- the ICAO agreement on global market-based measures for control of CO_2 emissions from international aviation in October 2016, often referred to as CORSIA;
- the ratification of the Paris agreement in November 2016;
- the European Commission’s adoption of the Accelerating Clean Energy Innovation Communication as part of the Energy Union initiative in November 2016.

The European Union has shown leadership in the global context in terms of setting clear and effective policy objectives toward the mitigation of environmental and climate related impacts. The European aviation community has developed its environmental industrial strategy often in parallel with the developing policies of the Union, often preceding directives and their implementation, as the development cycles for new engines and aircraft often span decades, and involve a rigorous validation and certification process.

Aviation and its supporting aeronautics sector must accelerate the development and introduction of environmentally-friendly products and services. While the push for action is clear, this state of matters confirms the objectives and goals set up:

- already by the European Commission and stakeholders through the Vision 2020 and Flightpath 2050 documents and through the Strategic Research and Innovation Agenda (SRIA) of the Advisory Council for Aeronautics Research in Europe (ACARE);
- the subsequent setting up of the first ever European Public-Private Partnership (PPP) in aeronautics - Clean Sky - in 2008 under FP7;
- the decision to continue this undertaking with an even higher commitment in 2014 under Horizon 2020.

These have been steps in the right direction and are more important today than ever before.

This focusing of efforts on the political and strategic side has been matched by the achievements of the Clean Sky and Clean Sky 2 technical programmes to date. The independent internal Technology Evaluator assessment confirmed that the technologies developed since 2008 through Clean Sky match the initial objectives set and have high potential to reduce emissions significantly once on the market. Even if the economic and production viability of many of these technologies still needs assessing beyond the research perimeter, it has been crucial to demonstrate that 600 organisations across Europe are pooling knowledge and resources together in a partnership and have been able to successfully carry out a complex joint technology development programme.

This progress is continuing. Its effectiveness is contributed to by the central role that Clean Sky 2 has developed in Europe with regard to coordination with regional efforts in aeronautics. Clean Sky 2 continued in 2016 to engage actively with European regions seeking and building synergies with their investments through the regional funds, in particular through the European Structural and Investment Fund. Please refer to chapter 12.1.

Aviation is the result of the confluence of four main areas: aeronautics, airports, air traffic management and airlines, each with its specificities in terms of economy, time scales and societal impacts. These sectors are strongly bound together as technology deployment, economic and societal fall-outs depend critically on their convergence. Furthermore, Clean Sky has continued to engage with other European organisations involved or linked with aeronautics research.

While cooperation with SESAR and Fuel Cells and Hydrogen JUs was already established, the possibility of synergies with the ECSEL JU started in 2016. Even more importantly, a strong and effective cooperation was set up and a MoU signed with the European Aviation Safety Agency (EASA), which is responsible for the future certification of Clean Sky technologies. Clean Sky contributed to the first European Aviation Environmental Report released by EASA in January 2016. More details are given in chapters 12.2 and 12.3.

4. Clean Sky 2 Programme: Overview, Structure and Contributors

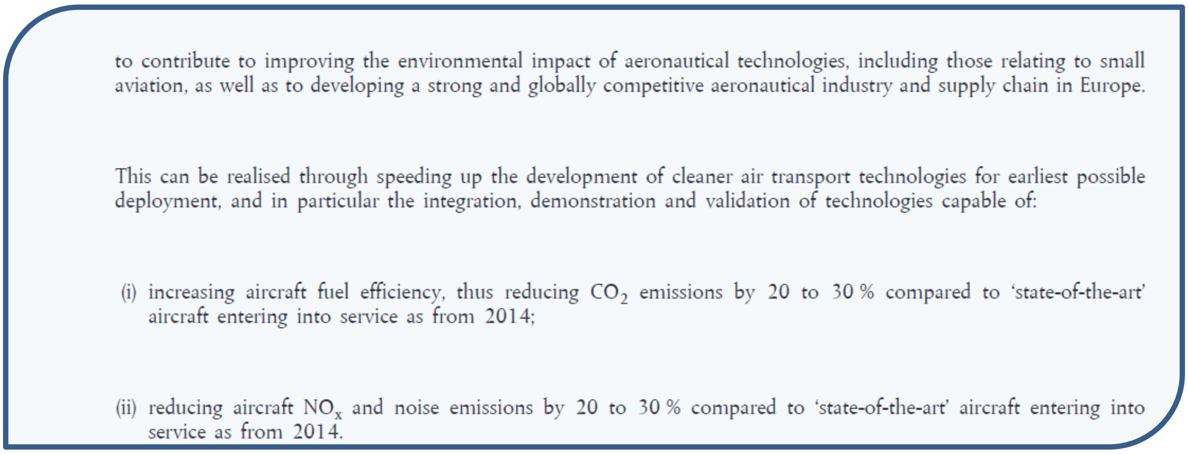
4.1. Clean Sky 2 overview

Clean Sky 2 builds on the work of Clean Sky. Close alignment between the two ensures a seamless transition and anchors the gains that can be reached in impacts and societal benefit. Based on the technology readiness level (TRL) demonstrated at the end of Clean Sky, several technologies will be ready for potential development and deployment. Others will need to be matured further within a research environment, and will require a higher level of system integration and further validation under Clean Sky 2. More importantly, given the extremely long development and product life-cycles in aeronautics, and the levels of investment and financial risk going well beyond the private sector's autonomous capability, the long-term stability in research agenda and funding through an instrument such as CS2 is essential in addressing long-term goals as set out in the renewed SRIA where it has been patently stated that evolutionary technology development and incremental performance improvements will no longer suffice. The PPP approach creates the best conditions to give the required confidence to market players to invest in breakthrough innovation. The inclusive approach coupled with the active pursuit of synergies will also allow the CS2 Programme to exploit synergies between its technologies and those matured outside with potential complementarity. Innovations from CS2 will drive major advances in the next generation of aircraft by mastering the technologies and the risks, in time to meet the market window to replace the current fleet.

High Level Objectives for Clean Sky 2

The Clean Sky 2 Programme builds on its predecessor, but will also drive towards more ambitious objectives and extend its reach [including longer-term and lower-TRL actions] in order to:

- Accelerate the progress towards the ACARE SRIA goals for 2020-2050;
- Enable a technological leap in the face of emerging competitors;
- Justify the early replacement of aircraft that have yet to enter service and accelerate the adoption of new technology into the global fleet.



to contribute to improving the environmental impact of aeronautical technologies, including those relating to small aviation, as well as to developing a strong and globally competitive aeronautical industry and supply chain in Europe.

This can be realised through speeding up the development of cleaner air transport technologies for earliest possible deployment, and in particular the integration, demonstration and validation of technologies capable of:

(i) increasing aircraft fuel efficiency, thus reducing CO_2 emissions by 20 to 30 % compared to 'state-of-the-art' aircraft entering into service as from 2014;

(ii) reducing aircraft NO_x and noise emissions by 20 to 30 % compared to 'state-of-the-art' aircraft entering into service as from 2014.

High Level Objectives for Clean Sky 2 as set out in the Regulation [see also Figure 2]

The Programme aims to accelerate the introduction of new technology in the 2025-2035 timeframe. By 2050, 75% of the world's fleet now in service (or on order) will be replaced by aircraft that can deploy Clean Sky 2 technologies. Based on the same methodology as applied in the Clean Sky economic case in 2007 the market opportunity related to these programmes is estimated at ~€2000 billion. The direct economic benefit is estimated at ~€350-€400 billion and the associated spill-over is of the order of €400 billion. These figures are additive with respect to the Economic Value Added expected from Clean Sky. As a result of the higher growth now forecast, the environmental case for continuing the Clean Sky with the CS2 Programme is even more compelling. CS2 technologies will bring a potential saving of 4 billion tonnes of CO_2 through Clean Sky 2 from roughly 2025 through to 2050 in addition to approximately 3 billion tonnes achievable as a consequence of Clean Sky.

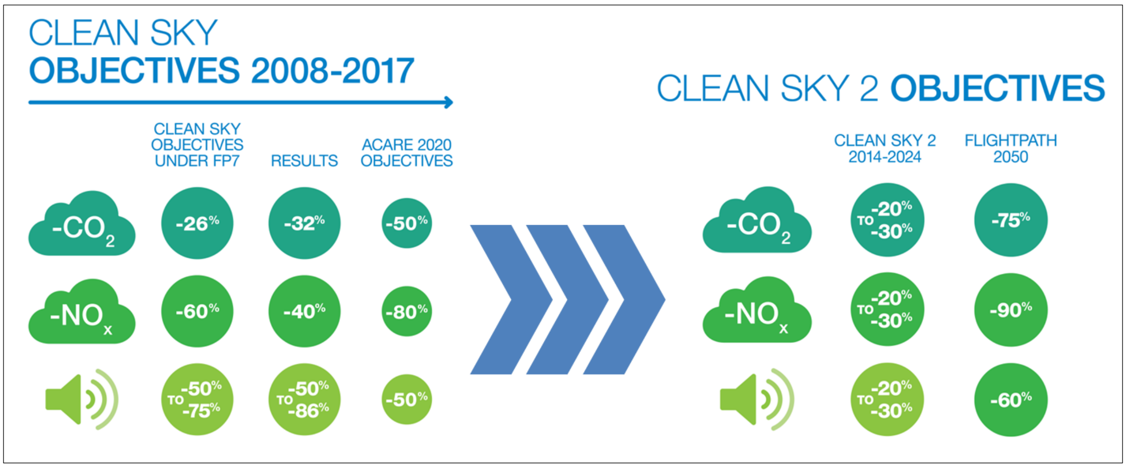


Figure 2: Transition from Clean Sky 1 to Clean Sky 2

The importance of the Clean Sky 2 JU Public-Private Partnership

Clean Sky 2 will focus and allow the coordination of aviation stakeholders' initiatives and investments at a European scale. It will give the necessary stability and stimulus to the aviation sector stakeholders to introduce game-changing innovations at a scale and in a timeframe otherwise unachievable. Clean Sky 2 will reduce the high commercial risk that is associated with research activity in the aeronautics sector and which is beyond the capacity of private industry. As a Public-Private Partnership it will attract strong private investment on the pre-requisite that this is complemented with a comparable "seed" amount of public funding.

The Clean Sky and Clean Sky 2 set-ups are leading to greater industrial and international integration within the Union. It has started to correct the distortions that exist as a result of the provision of public support outside Europe whilst focusing the stimulus on socially desirable environmental improvements.

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

The results of Clean Sky and Clean Sky 2 to date show clearly that the formula is successful, with realistic perspectives of competitiveness and growth of the industry across the Union leading to strong socio-economic benefits through the development of advanced technologies meeting the set environmental targets.

The technological advances made and demonstrated in Clean Sky under the FP7 Programme, complemented with progress to be made in the Clean Sky 2 Programme and under parallel and complementary research and technology development, in part resulting in the Clean Sky 2 JU Regulation's *Additional Activities* undertaken by the Members, only "crystallize" into tangible benefits in the aviation [air transport] system when absorbed in complete aircraft configurations and new aircraft designs and programmes. Clean Sky 2 aims to lay the groundwork for such new innovations to be prepared for the aviation system by systematically selecting successful technologies and integrating these into major system level and ultimately full aircraft level demonstration and de-risking efforts. This will render the next generation of air vehicles more efficient and reduce emissions and noise more than an evolutionary trajectory in terms of aircraft development would allow, and thus – importantly – accelerate the route to market for new solutions by de-risking and maturing the new approaches. New vehicle configurations incorporating advances that will help the sector fundamentally shift gears in terms of performance gains will have to be evaluated with flight demonstrators as they will be essential to fulfil the ambitious objectives of the renewed ACARE SRIA. Put simply, the goal of a large-scale Public-Private Partnership approach at the scale of Clean Sky 2 will be to pull forward adoption and ultimately market readiness of technologies that enable a doubling of the "evolutionary" rate of performance improvement, and set a trend-breaking development that will lead to aircraft "skipping a generation" in comparative terms to the business-as-usual development trend.

Evidence is mounting that conventional aircraft configurations are approaching intrinsic performance limits, as the integration of the most recent technologies are showing diminishing returns. Therefore, the need today is even greater for industry to develop materially different, substantially more environmentally-friendly vehicles to meet market needs, and ensure their efficient integration at the air transport system level.

4.2. Clean Sky 2 overall programme structure

The set-up of the Clean Sky 2 Programme is based on the notion of building on and extending the successful formula trialled in the Clean Sky Programme under FP7. As such Clean Sky 2 continues to use the Integrated Technology Demonstrators (ITDs) mechanism. The ITD instrument's objective-driven agenda to support real market requirements providing the necessary flexibility is well-suited to the needs of the major integrator companies. The new Programme also focuses on reinforcing interactions between demonstrations of improved systems for a better integration into viable full vehicle architectures. The Clean Sky 2 structure involves demonstrations and simulations of several systems jointly at the full vehicle level through Innovative Aircraft Demonstrator Platforms (IADPs).

A number of key areas are coordinated across the ITDs and IADPs through Transverse Activities where additional benefit can be brought to the Programme through increased coherence, common tools and methods, and shared know-how in areas of common interest.
As in Clean Sky, a dedicated monitoring function - the Technology Evaluator (TE) - is incorporated in Clean Sky 2.

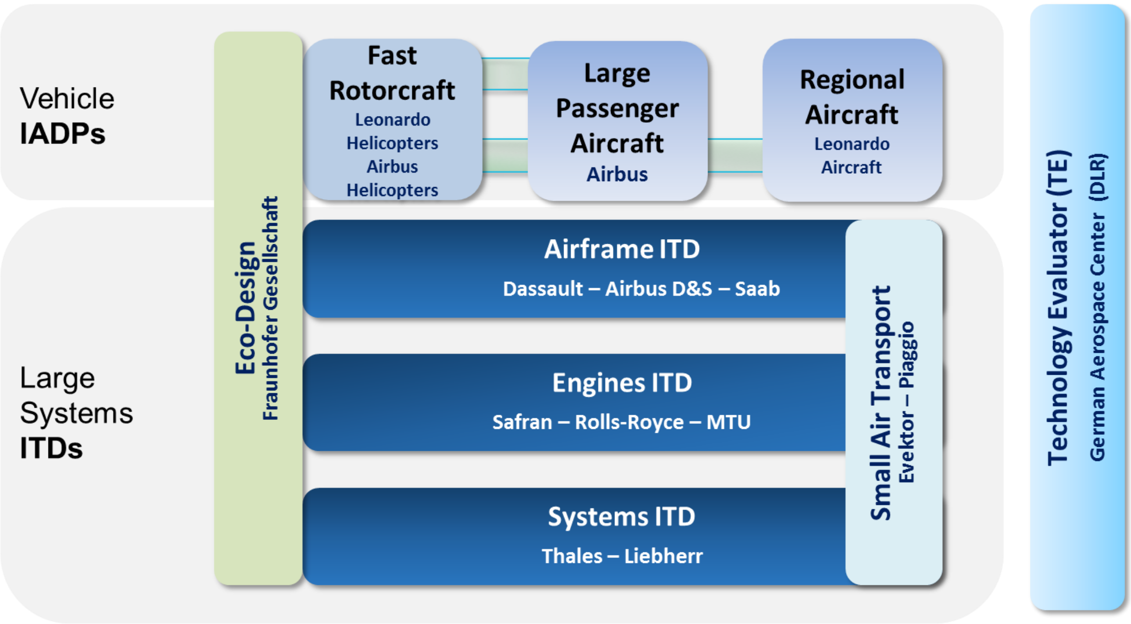


Figure 3: Clean Sky 2 Programme Logic and Set-up

Innovative Aircraft Demonstrator Platforms [IADPs] aim to carry out proof of aircraft systems, design and functions on fully representative innovative aircraft configurations in an integrated environment and close to real operational conditions. To simulate and test the interaction and impact of the various systems in the different aircraft types, vehicle demonstration platforms are covering passenger aircraft, regional aircraft and rotorcraft. The choice of demonstration platforms is geared to the most promising and appropriate market opportunities to ensure the best and most rapid exploitation of the results of Clean Sky 2. The IADP approach can uniquely provide:

- Focused, long-term commitment of project partners;
- An “integrated” approach to R&T activities and interactions among the partners;
- Stable, long-term funding and budget allocation;
- Flexibility to address topics through open Call for Proposals;
- Feedback to ITDs on experiences, challenges and barriers to be resolved longer term;
- A long-term view to innovation and appropriate solutions for a wide range of issues.

Three IADPs are defined in the CS2 Programme:

- **Large Passenger Aircraft [LPA]** covering large commercial aircraft applications for short/medium and long range air transport needs;
- **Regional Aircraft [REG]** focusing on the next generation of approx. 90-seat capacity regional turboprop powered aircraft enabling high efficiency/reliability regional connections;
- **Fast Rotorcraft [FRC]** aiming at new configurations bridging the gap between conventional helicopters and utility / commuter fixed wing aircraft: both in speed and range/productivity.

In addition to the complex vehicle configurations, Integrated Technology Demonstrators (ITDs) will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels. Each of the three ITDs orientates a set of technology developments that will be brought from component level maturity up to the demonstration of overall performance at systems level to support the innovative flight vehicle configurations:

- **Airframe ITD [AIR]** comprising topics affecting the global vehicle-level design;
- **Engines ITD [ENG]** for all propulsion and power plant solutions;
- **Systems ITD [SYS]** comprising on-board systems, equipment and flight management.

The Transverse Activities [TAs] enable important synergies to be realised where common challenges exist across IADPs and/or ITDs; or where co-ordination across the IADPs and ITDs allows a cogent and coherent approach to common technical challenges. TAs do not form a separate IADP or ITD in themselves, but coordinate and synergise technical activity that resides as an integral part of the other IADPs and ITDs. A dedicated budget, mainly addressed to technology development, and driven by excellence toward the TA objectives, while simultaneously supporting the industrial, competitiveness and societal leadership of the Programme Participants in the actions of the SPDs, is reserved for these activities to be performed inside the concerned IADPs and ITDs. Transverse Leaders are nominated and coordinate each TA. Currently three Transverse Activities are agreed for Clean Sky 2 and are specified in the Statutes for the JTI:

- **Eco-Design TA [ECO]:** Addressing materials, processes and resources impact considering the life cycle optimisation of technologies, components and vehicles - their design, manufacturing, operation, maintenance and disposal; and addressing the ever-increasing pressure to reduce harmful impacts on the Earth's resources and the impact related to scarce elements and resources;
- **Small Air Transport TA [SAT]:** airframe, engines and systems technologies for small aircraft, extracting synergies where feasible with the other segments;

- The **Technology Evaluator** will enable an independent Technology and Socio-Economic Impact Evaluation which is an essential task within the CS2JU. Environmental Impact Assessments currently focused on noise and emissions will be continued and expanded where relevant for the evaluation of the Programme's progress. Other impacts, such as on Mobility or on Industrial Leadership of Clean Sky 2 concepts will be assessed. The TE may also perform evaluations on innovative *long-term* [low TRL] aircraft configurations where beneficial to the Programme's content.

4.3. Clean Sky 2 members and contributors

The Clean Sky 2 Joint Undertaking is built on a membership, complemented by activities performed by Partners. The membership of the Clean Sky 2 JU is comprised of:

- The European Commission representing the Union and ensuring EU public policy;
- Leaders and their Affiliates as defined in the Statutes and committed to achieving the full research and demonstrator activity of the Programme;
- Core Partners (and their Affiliates) as selected through the Calls for Core Partners and duly accepted by the Governing Board of the CS2JU upon successful selection and negotiation, who bring a further substantial long-term commitment towards the Programme.

The different roles and tasks are defined as follows:

As ***Members****,* *Leaders* and *Core Partners* are jointly responsible for the execution of the overall Programme, meeting the High-Level Objectives, and providing the in-kind contributions in order to meet the minimum level to be brought to the Programme by the Members as set in the Regulation.

Core Partners are selected through open and competitive calls planned over the first years of the Programme, guaranteeing a transparent selection of the best membership and strategic participation. As Members of the JU in the meaning of the Clean Sky 2 Regulation, Core Partners are expected to make long-term commitments and contribute to the implementation of the Programme over its lifetime: bringing key competences and technical contributions, and significant in-kind resources and investment.
Core Partners contribute to the global management of the technology streams and demonstrators and as such also may manage activities of Partners selected via Calls for Proposals.
Core Partners join the ITD/IADP Steering Committees in which they are active, contributing to its governance. Core Partners are also represented at Governing Board level via a process of co-opting and rotation at ITD/IADP level.
Leaders' and Core Partners' participation and contributions are governed through the Grant Agreements for Members [GAMs] managed by the JU and setting out the actions over the full period of the Programme, via extendable and renewable multi-annual GAMs that closely align with the CS2JU's Work Plans.

Partners participate in the Programme in specific projects with a well-defined and limited scope and commitment defined in topics launched in Calls for Proposals [CfP]. Partners are selected through these calls which are launched in a regular and phased approach over the Horizon 2020 funding period [2014 – 2020]. Partners' participation is governed through dedicated Grant Agreements for Partners [GAPs]: complementary grants structured to complement the Members' contributions and activities and jointly managed by the JU and *Topic Managers* appointed by the Members. Partners' activities are monitored and managed by the JU in close collaboration with the Topic Manager in order to ensure the alignment of actions and the convergence of technical activity towards the Programme's goals.

The funding repartition of the CS2 Programme is set out in the Regulation and is as follows:

- Up to 40% of the Union's available funding of €1 716 million [net of administrative costs] is ring-fenced for its 16 leaders and their Affiliates;
- Up to 30% of the Union's funding is available for Core Partners; and
- At least 30% will be awarded via Calls for Proposals and Calls for Tenders.

The 60% to be awarded via the Calls for Core Partners and Calls for Proposals represents over €1 billion, making it alone over 25% greater than the total budget of the first Clean Sky Programme and just over five times the call funding volume of Clean Sky. With this substantial amount of funding open to competition, Clean Sky 2 will foster wide participation where SMEs, research organisations and academia interact directly with key industry stakeholders. The different call mechanisms and the related breadth of the call topics and technical scope of the CS2 programme will provide opportunity for the vast bulk of the aeronautics industry in the European Research Area to participate, and also allow for space for newcomers, including important opportunities for "cross-over" participants from outside the sector. Getting capable new firms involved in the aeronautics sector can make an important contribution to the competitiveness of the sector and to the European economy.

Noting there are roughly 600 participants in the original Clean Sky Programme, for Clean Sky 2 we expect 800 - 1000. That is ample evidence of a dynamic and open system operating in the JU and with all stakeholders.

5. Programme Key Environmental Objectives

The translation of the Programme's high-level environmental objectives into targeted vehicle performance levels is shown below. These are in line with the approach to be taken in the CS2 TE impact and technology evaluation cycles. Each conceptual aircraft summarises the key enabling technologies, including engines, developed in Clean Sky 2, contributing to the achievement of the Programme objectives. The target TRL for key technologies at closure of the Programme indicates the level of maturity and the level of challenge in maturing towards potential uptake into marketable innovations:

Conceptual aircraft / air transport type	**Reference a/c***	**Window**[1]	**ΔCO_2**	**ΔNO_x**	**Δ Noise**	**Target**[2] **TRL @ CS2 close**
Advanced Long-range (LR)	LR 2014 ref	2030	20%	20%	20%	4
Ultra advanced LR	LR 2014 ref	2035+	30%	30%	30%	3
Advanced Short/Medium-range (SMR)	SMR 2014 ref	2030	20%	20%	20%	5
Ultra-advanced SMR	SMR 2014 ref	2035+	30%	30%	30%	4
Innovative Turboprop [TP], 130 pax	2014 130 pax ref	2035+	19 to 25%	19 to 25%	20 to 30%	4
Advanced TP, 90 pax	2014 TP ref	2025+	35 to 40%	> 50%	60 to 70%	5
Regional Multimission TP, 70 pax	2014 Multi-mission	2025+	20 to 30%	20 to 30%	20 to 30%	6
19-pax Commuter	2014 19 pax a/c	2025	20%	20%	20%	4-5
Low Sweep Business Jet	2014 SoA Business a/c	2035	> 30%	> 30%	> 30%	≥ 4
Compound helicopter[3]	N/A	2025	TBD	TBD	TBD	6
Next-Generation Tiltrotor	AW139	2025	50%	14%	30%	5

**The reference aircraft will be further specified and confirmed through the Technology Evaluator assessment work.*

[1] All key enabling technologies at TRL 6 with a potential entry into service five years later

[2] Key enabling technologies at major system level

[3] There are no direct comparisons yet; The most relevant traditional helicopter reference will be selected and then the target levels will be determined in an updated plan

6. Clean Sky 2 Key Technology and Demonstration Areas

The CS2 technology and demonstration activity is structured in nine key (technology) themes further subdivided in a number of demonstration areas, as depicted below. Inside each area, the aim is to integrate, demonstrate and validate the most promising technologies capable of contributing to the CS2 high-level and programme specific objectives. A demonstration area may contribute to one or more objectives and also may involve more than one ITD/IADP. The funding values in the table are all indicative.

Theme	Demonstration area	Demonstrator / Technology stream in Programme Area						Contribution*			Funding
		LPA	REG	FRC	AIR	ENG	SYS	E	M	C	RoM m€
Breakthroughs in Propulsion Efficiency (incl. Propulsion-Airframe Integration)	**Advanced Engine/Airframe Architectures**	✈			✈			✈		✈	**474.8**
	Ultra-high Bypass and High Propulsive Efficiency Geared Turbofans	✈				✈		✈		✈	
	Hybrid Electric Propulsion	✈						✈	✈	✈	
	Boundary Layer Ingestion	✈						✈		✈	
	Small Aircraft, Regional and Business Aviation Turboprop					✈		✈	✈	✈	
Advances in Wings, Aerodynamics and Flight Dynamics	**Advanced Laminar Flow Technologies**	✈			✈			✈		✈	**212.6**
	Regional Aircraft Wing Optimization		✈		✈			✈	✈	✈	
Innovative Structural / Functional Design - and Production System	**Advanced Manufacturing**		✈		✈			✈		✈	**243.6**
	Cabin & Fuselage	✈	✈		✈			✈	✈	✈	
	Innovative Solutions for Business Jets				✈				✈	✈	
Next Generation Cockpit Systems and Aircraft Operations	**Cockpit & Avionics**	✈	✈				✈	✈	✈	✈	**175.8**
	Advanced MRO	✈							✈	✈	
Novel Aircraft Configurations and Capabilities	**Next-Generation Civil Tiltrotor**			✈	✈				✈	✈	**222.5**
	RACER Compound Helicopter			✈	✈				✈	✈	
Aircraft Non-Propulsive Energy and Control Systems	**Electrical Systems**		✈		✈		✈	✈		✈	**150.2**
	Landing Systems		✈				✈	✈		✈	
	Non-Propulsive Energy Optimization for Large Aircraft	✈						✈		✈	
Optimal Cabin and Passenger Environment	**Environmental Control System**		✈				✈	✈	✈		**39.7**
	Innovative Cabin Passenger/Payload Systems	✈	✈		✈		✈	✈	✈	✈	
Eco-Design		✈	✈	✈	✈	✈	✈	✈		✈	**39.1**
Enabling Technologies		✈	✈	✈	✈	✈	✈	✈	✈	✈	**120.5**
Technology Evaluator											**17.2**

** E = Environment, M = Mobility, C = Competitiveness*

Note 1: Enabling Technologies are themselves aligned with the major thematic research and technology development areas as shown; nonetheless they are shown as a separate line item in order to indicate their RoM value and share of activity in the Programme.

Note 2: the balance between indicated figures and the overall expected Programme value of €1716 million is comprised of a number of ancillary activities, the main contributor being management cost.

7. Outline of the Clean Sky 2 IADPs, ITDs and TAs

7.1. Large Passenger Aircraft IADP [LPA]

The large commercial aircraft market [generally seen as civil aircraft with a capacity exceeding 100 seats and covering short/medium and long range mission] remains highly competitive, with several new entrants having the means to reach a technology level comparable to legacy US and European manufacturers. Their ambition is often coupled with strong government support, expectations for a captive “home” market and low costs and pricing. To stay ahead, the LPA programme objectives are to further mature technologies tackled in Clean Sky, e.g. the integration of innovative propulsion systems; to validate other key enabling technologies like hybrid laminar flow control strategies for the wing, horizontal and vertical tail plane as well as an all-new next generation fuselage/cabin and cockpit-navigation.

The Large Passenger Aircraft goal is development and demonstration of the best technologies to accomplish the Clean Sky 2 Regulation’s key goals with respect to energy efficiency and impact on the environment, thereby fulfilling future market needs and improving the competitiveness of future products. The set-up allows to push the value of technologies tackled in Clean Sky, and to add the validation of additional key technologies at integrated level with large scale demonstrators in operational conditions.

Three distinct ‘Platforms’ will be managed in parallel and develop the abovementioned technologies and demonstrators:

- **Platform 1 “Advanced Engine and Aircraft Configurations”**

  One major part of the scope of the Platform 1 “Advanced Engine and Aircraft Configurations” is to provide the development environment for the integration of the most fuel-efficient propulsion concepts into compatible airframe configurations and concepts targeting next generation short and medium range aircraft. The considered propulsion concepts range from the counter-rotating open rotor [CROR] engine architecture over advanced Ultra-High Bypass Ratio (UHBR) turbofan to hybrid [and/or distributed] propulsion concepts, and exploring the potential of configurations that exploit the potential of boundary layer ingestion. In context with new engine and system architectures, studies for Non-Propulsive Energy (NPE) generation will be performed.

  Another major part of the scope of Platform 1 is the development of integrated flow control techniques for advanced aircraft performance for the whole operational envelope. The major technologies with respect to this are the Hybrid Laminar Flow Control technology (HLFC) for skin-friction drag reduction and fluidic actuators for high-lift performance improvement. Finally the opportunities and the limits of scaled flight-testing will be investigated. The overall set-up of Platform 1 aims to ensure that all technologies being developed and demonstrated are following consistent target aircraft configurations and concepts, which means that the compatibility between airframe and propulsion technologies is assured.

  The validation will be performed through the most appropriate means (e.g. flight test, ground test, wind tunnel test or simulation) depending on the maturity level and TRL targeted after integration of a given technology at A/C level.

- **Platform 2 “Innovative Physical Integration Cabin – System – Structure”** aims to develop, mature, and demonstrate an entirely new, advanced fuselage structural concept in full alignment towards next-generation cabin-cargo architectures, including all relevant principle aircraft systems. In order to account for the substantially different test requirements, the large scale demonstration will be based on three individual major demonstrators. A lower centre section fuselage and one “typical” fuselage will be developed, manufactured and tested with focus on industrial manufacturing including pre-installation and modularisation. Within the “new” Fuselage, Cabin/Cargo and System demonstrator modules/ components will be integrated to validate Multi ATA technologies and their industrial processes (e.g. joining). It is essential to have two 180° demonstrator shells which are “pre-equipped” to validate the reduction of Final Assembly Line (FAL) effort. A Cabin and Cargo demonstrator will be dedicated to integrate and test a next generation of large passenger aircraft cabin and cargo. A number of smaller test rigs and component demonstrators will also be part of the programme in the preparatory phase. The target is to accomplish technology readiness level 5+.
- **Platform 3 “Next Generation Aircraft Systems, Cockpit and Avionics”** has a clear focus to develop and demonstrate a next generation cockpit and navigation suite. Based on the results of a number of research programmes which are currently on-going or soon to be started, Platform 3 should allow functions and features which are emerging from individual developments to be integrated and validated into a disruptive new concept in a major demonstrator suite. With the core of Platform 3 being a major ground based demonstrator, selected features and functions will be brought to flight test demonstration when justified. The scope of Platform 3 will cover the development of a disruptive cockpit operations concept, towards a “Human Centric” approach to operate the aircraft, including innovative functions and Human-Machine interface technologies required to reduce crew workload, improve situational awareness and support disruptive cockpit operations.
  In addition the development of value-driven end-to-end maintenance service architectures will be investigated, enabling the replacement of scheduled maintenance by efficient on-condition maintenance.

7.2. Regional Aircraft IADP [REG]

Regional aircraft provides essential building blocks towards an air transport system that respects the environment, ensures safe and seamless mobility, and builds industrial leadership in Europe. The Regional Aircraft IADP will bring technologies to a further level of integration and maturity than pursued to date. The goal is to integrate and validate, at aircraft level, advanced technologies for regional aircraft so as to meet the CS2 Regulation’s objectives and simultaneously drastically de-risk their integration on future products.

Full-scale demonstrations, with acceptable risk and complexity but still providing the requested integration, are essential to enable the insertion of breakthrough technologies on regional aircraft entering into service beyond 2025. The Technology Development will be arranged along 8 “Waves” and will be developed through roadmaps defined to satisfy the high-level requirements of the future Highly-Efficient Next Generation Regional Aircraft, the configuration of which will be developed at conceptual level in a dedicated work package. To increase synergies and cross-fertilisation across the different ITDs and IADPs some of the above technological roadmaps will be shared with the “streams” of the Airframe ITD and with the developments of sub-systems and systems planned inside Systems and Engines ITD. The Demonstration Programme will be divided into technologically compatible and “scope close” demonstrations, including two flying test-beds [FTBs] and several ground demonstrators, some of which will be managed in and performed through the Airframe ITD:

- **Flying Test Bed 1 - Innovative Wing and Flight Controls (Regional IADP):** Integration and flight testing of technologies suitable for regional aircraft applications for a new generation wing and advanced flight control systems. Innovative wing related systems and wing structural solutions will also be incorporated where feasible. Aerodynamic enhancements and LC&A features will be considered to complement FTB2, such as: high A/R by means of adaptive/innovative winglets.
- **Flying Test Bed 2 - Flight Demonstration of a high efficient and low noise Wing with Integrated Structural and related Systems solution, including power plant aspects (Regional IADP):** A new wing will be designed, manufactured and equipped with new structural solutions strongly integrated with advanced low power and high efficient systems such as ice protection, fuel, flight control, engine systems, LE and winglets morphing.
- **Full-scale innovative fuselage and passenger cabin (Regional IADP):** Integration and on-ground testing of a full scale innovative fuselage and passenger cabin including all the on-board systems and advanced solutions for increasing passenger comfort and safety. The fuselage will be a full scale demonstration of technologies for composite material, structures and manufacturing aimed at weight and cost reduction and to minimize the environmental impact through eco-design and energy consumption optimization all along the life-cycle (towards a zero-impact).
- **Iron Bird (Regional IADP):** Virtual and Physical “Iron Birds” will also be an important part of the Regional A/C Ground Demonstration Programme. These will also be used to integrate, optimise and validate the systems modification of the Flying Test Bed and the results of their simulations and ground testing will be essential to achieve the permit-to-fly.
- **Ground Demonstration of the wing (Airframe ITD),** including the airframe and related systems.
- **Ground Demonstration of the Cockpit (Airframe ITD),** including the structure and related system.
- **Nacelle ground demonstration (Airframe ITD).**

7.3. Fast Rotorcraft IADP [FRC]

The Fast Rotorcraft IADP consists of two concurrent demonstrators - the Tiltrotor demonstrator and the Compound Rotorcraft demonstrator - along with transversal activities relevant for both fast rotorcraft concepts.

- **Joint activities:**

  These activities cover the methodology for technology evaluation of fast rotorcraft demonstrations and the Eco-Design concept implementation, along with the programme management activities for the Fast Rotorcraft IADP.
  Concerning the methodology for technology evaluation, the activities will allow for the defining of SMART objectives and criteria adapted to the fast rotorcraft missions in line with the general TE approach for Clean Sky 2.
  Concerning Eco-Design concept implementation, the activities will allow coordinating approaches and work plans in the two demonstration projects regarding the greening of rotorcraft production processes and ensuring complementarity of case studies. The general Life Cycle Assessment approach will be coordinated with the participants of the Eco-Design TA.

- **The Next-Generation Civil Tiltrotor demonstrator (NGCTR):**

  The aim of NGCTR is to design, install and demonstrate in flight innovative Civil Tiltrotor technologies enabling future prototype development, and show significant improvement with respect to the current state-of-the-art Tiltrotors. The project will also allow the development of R&T activities which will increase the know-how needed for future Tiltrotor aircraft and their operation through a volume of research and innovation activities not available today within the EU, and equivalent to that of conventional helicopter platforms.

  The primary objectives are to demonstrate the potential to reduce the CO_2 and noise footprint, reduce the cost of ownership, and achieve high speed, high efficiency, and high productivity. The technology demonstrator will utilise an existing platform into which innovative technologies will be incorporated, which are scalable to different sizes of aircraft in the future as market requirements demand. The primary focus will be on:

  - Advanced wing architecture;
  - Tail structure and configuration;
  - Non-tilting engine installation with efficient nacelle architecture and split gearbox drivetrain;
  - Advanced Flight Control with a modular, distributed and scalable flight control system.

  This approach allows the project to capitalise on existing assets for those elements necessary for flight but not intrinsic to the technologies being matured and demonstrated. However, in addition to these key technologies to be flown on the demonstrator, advancement of other technologies that will support a highly efficient state-of-the-art product in the future will be developed in parallel and subject to ground based demonstration. If opportunity arises they may be incorporated into the technology demonstrator later in the validation programme.

  NGCTR will further develop technologies initiated in Clean Sky, and launch new activities specific to Clean Sky 2 and the NGCTR project. In the area of CO_2 emissions reduction, NGCTR will continue/develop engine installation and flight trajectories optimisation (this is now done by analytical models and with scaled model tests, whereas Clean Sky 2 will validate it at full scale), while specific new Clean Sky 2 activities on drag reduction will be necessary due to modified fuselage-wing architecture. This specific Clean Sky 2 topic will also be related to operating cost reduction, in order to address competitiveness of the architecture and solutions adopted. A new prop-rotor blade (developed outside of Clean Sky 2) will support reduced noise emissions. In Clean Sky noise reduction was mainly addressed through trajectory optimisation. This will continue in Clean Sky 2 and will be linked to SESAR concepts where necessary. Clean Sky 2 transversal subjects will cover new material (e.g. thermoplastics, surface treatments, less hydraulics and more electrical systems), validating them at full scale and in real operational conditions where possible.

  In close collaboration with the Technology Evaluator, key parameters will be defined to show Clean Sky 2's achieved progress according to a specific Tiltrotor roadmap (a direct comparison with conventional helicopter architecture is not adequate as the two configurations must be regarded as substantially different types of rotary wing platforms). Today, certified Tiltrotors are not available in the civil sector although this should be the case during the lifetime of Clean Sky 2 (while only one product is available in the military); hence, a database from which baseline information can be extracted for the current state-of-the-art is not available. Therefore, 'key performance parameters' (KPP) will be introduced to show NGCTR's progress with respect to reference data taken as baseline (mainly referring to technologies which have been tested or conceptually designed in the period 2005-2012). Objectives will be defined considering Tiltrotor specificities and in line with the main pillars of Clean Sky 2, as well as Horizon 2020, towards a Smart, Green and Integrated Transport and addressing environmental compatibility (Greening Objectives), competitiveness (Industrial Leadership) and mobility. Considerable attention will be paid to the project's impact on EU economy and jobs creation, to confirm and further sustain a steady growth of the sector with regard to revenues, workforce productivity, high rate of new employment (in particular of higher educated personnel) and R&D expenditure.

- **The Compound Rotorcraft demonstrator:**

With the unveiling at Paris Air Show 2017, the Compound Rotorcraft demonstrator has been renamed as the RACER demonstrator. The RACER high speed research helicopter aims at demonstrating in flight that the compound rotorcraft configuration, implementing and combining cutting-edge technologies from the current Clean Sky 2 Programme, can open up new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a way sustainable for both the operators and the industry. The project will ultimately demonstrate the capability to combine the following capabilities: payload capacity, high manoeuvrability, agility in vertical flight including capability to land on unprepared surfaces near obstacles and to load/unload rescue personnel and victims while hovering; long range, high cruise speed, low fuel consumption and emissions, low community noise impact, and high productivity for operators.
A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested. With a First Flight planned for the end of 2020, this demonstrator will allow Technology Readiness Level 6 to be reached at whole aircraft level in a basic configuration in 2021, with a potential of adding other innovative technologies during following flight test campaign and based on a significant flight demonstration, exploring a substantial part of the flight envelope. The project is based on:

- identified mobility requirements and environmental protection objectives;
- lessons learnt from earlier experimentation with the low scale exploratory aircraft X^3;
- technology progress achieved for rotorcraft subsystems on one side through participation in Clean Sky projects and other research activities at EU, national or local level.

The individual technologies from the first Clean Sky Programme (Green Rotorcraft ITD, Smart Green Operations ITD, Eco-Design ITD) that will be further matured and integrated in this RACER demonstration concern:

- New rotor blade concepts aiming at improved high speed efficiency and minimizing noise. Airframe drag reduction through shape modifications and interference suppression;
- Engine intake loss reduction and muffling;
- Innovative electrical systems e.g. brushless generators, high voltage network, efficient energy storage and conversion, electrical actuation;
- Eco-Design approach, substituting harmful materials and green production techniques;
- *Fly-neighbourly* demonstration of new flight guidance functions and approach.

The RACER project essentially consists of the following main activities and deliveries:

- **Airframe structure and landing system**: Advanced composite or hybrid metallic/composite construction, featuring low weight and aerodynamic efficiency;
- **Lifting rotor and propellers**: Low drag hub, pylon and nacelles, flight test of 3D-optimised blade design;
- **Drive train and power plant**: New drive-train architecture and engine installation optimised for the RACER configuration;

- **On board energy, cabin and mission systems**: Implementation of the more electrical rotorcraft concept to minimise power off-takes from the engines and drive system;
- **Flight control, guidance and navigation**: Smart flight control exploiting additional control degrees of freedom inherent to RACER configuration for best fuel economy and quieter flight;
- **RACER Demonstrator overall design, integration and testing**: All coordination and cross-cutting activities relevant to the whole vehicle delivering a full range of ground & flight test results and final conclusion.

On the basis of progress to date and forward looking planning in Q1/2018 the precise scoping of technology down-selected for inclusion in the flight demonstrator will take place and be implemented for the period after 2018.

7.4. Airframe ITD [AIR]

Aircraft level objectives on energy and environmental efficiency, industrial leadership and enhanced mobility, and the fulfilment of future market requirements and contribution to growth cannot be met without strong progress on the airframe. Strong progress towards the 2020 targets has been obtained through Clean Sky (estimated at 75% of the relevant part of the initial ACARE goals, for 2020). However, further progress is required on the most complex and challenging requirement on new vehicle integration to achieve the high-level goals set in the CS2 Regulation, to fully meet the 2020 objective, and to progress towards the ACARE SRIA’s 2050 goals. This progress will be enabled through the foreseen execution of 9 major Technology Streams:

- **Innovative Aircraft Architecture**, to investigate radical transformations of the aircraft architecture. The aim of this Technology Stream is to demonstrate the viability of some most-promising advanced aircraft concepts (identifying the key potential showstoppers & exploring relevant solutions, elaborating candidate concepts) and assessing their potentialities.
- **Advanced Laminar Flow** as a key technological path to further progress on drag reduction, to be applied to major drag contributors: nacelle and wing; This Technology Stream aims to increase the nacelle and wing efficiencies by the mean of Extended Laminar Flow technologies. Fuselage related laminar flow is also targeted.
- **High Speed Airframe**, to focus on step changes in the fuselage and wing, enabling better aircraft performance, with reduced fuel consumption and no compromise on overall aircraft capabilities (such as low speed abilities & versatility).
- **Novel Control**, to introduce innovative control systems and strategies to improve overall aircraft efficiency. The new challenges that could bring step change gains do not lie in the optimisation of the flight control system component performing its duty of controlling the flight, but in opening the perspective of the flight control system as a system contributing to the global architecture optimisation. It could contribute to sizing requirements alleviations thanks to a smart control of the flight dynamics.
- **Novel Travel Experience**, to investigate new cabins including layout and passenger-oriented equipment and systems as a key enabler of product differentiation, having an immediate and direct physical impact on the traveller, and with a great potential in terms of weight saving and eco-compliance.
- **Next Generation Optimised Wing**, to progress the aerodynamic and structural efficiency, including ground testing of innovative wing structures. The challenge is to develop and demonstrate new wing concepts (including architecture) that will bring significant performance improvements (in drag and weight) while improving affordability and enforcing stringent environmental constraints. New concepts of wing must be explored for the efficient application on future medium/small regional aircraft and rotorcraft.

- **Optimised High Lift Configurations**, to progress on the aerodynamic efficiency of wing, engine mounting and nacelle integration for aircraft serving small, local airports by enabling excellent field performance, and increasing aircraft versatility.
- **Advanced Integrated Structures**, to optimize the integration of systems in the airframe along with the validation of important structural advances and to make progress on the eco-production efficiency and manufacturing of structures.
- **Advanced Fuselage** to introduce innovation in fuselage shapes and structures, including cockpit and cabins. New concepts for the fuselage are to be introduced to support future aircraft and rotorcraft designs. More global structural optimisation will provide further improvements in drag and weight, in the context of a growing cost and environmental pressure, including emergence of new competitors.

Due to the large scope of technologies undertaken by the Airframe ITD, addressing the full range of aeronautical portfolio (Large passenger Aircraft, Regional Aircraft, Rotorcraft, Business Jet and Small Air Transport) and the diversity of technology paths and application objectives, the above technological developments and demonstrations are structured around 3 major Activity Lines, allowing for better focus on the synergies of the integrated demonstrations in a technically consistent core set of user requirements, and, when appropriate, better serve the respective IADPs:

- **Activity Line 1**: Demonstration of airframe technologies focused on **High Performance & Energy Efficiency (HPE);** devoted to technology demonstrations on reference aircraft operating at high speed and high altitude flight conditions with longer range, and turbofan power plant.
- **Activity Line 2**: Demonstration of airframe technologies focused toward **High Versatility and Cost Efficiency (HVE)** devoted to technology demonstrations on reference aircraft operating at lower speed and lower altitude flight conditions, with shorter range, and turbo-propeller power plant**.**
- **Activity Line 3** covering common transversal enabling technologies, in particular eco-design.

7.5. Engines ITD [ENG]

In Clean Sky, industry leaders committed to build and test seven engine ground demonstrators covering the full civil market. The goals were to validate to TRL 6 a 15% reduction in CO_2 compared to 2000 baseline, a 60% reduction in NO_X and a 6dB noise reduction. This represents roughly 75% of the ACARE 2020 objectives. These targets have been largely achieved.

For Clean Sky 2, the Engines ITD will build on the success of Clean Sky [SAGE] to validate more radical engine architectures to a point where their market acceptability is not determined by technology readiness. The platforms or demonstrators of these engines architectures are summarised below:

- **Ultra High Propulsive Efficiency (UHPE) demonstrator addressing Short / Medium Range aircraft market, 2016-2021:** Design, development and ground test of a propulsion system demonstrator to validate the low pressure modules and nacelle technology bricks necessary to enable an Ultra High By-pass Ratio engine (e.g. advanced low pressure fan, innovative nacelle modules, gearbox, pitch change mechanism if any, high speed power turbine). This ground demonstrator will be built around an existing high pressure core.

- **Business aviation / Short range regional Turboprop Demonstrator, 2015-2020:** Design, development and ground testing of a new turboprop engine demonstrator. The turboprop demonstration will be built on the existing ARDIDEN3 core engine. The enabling technologies such as the Power & Accessory Gear Box, the Propeller, the Controls System, the Air Intake &

Nacelle will be developed to deliver on ground a full advanced Integrated Power Plant System (IPPS). The enabling technologies for the core gas turbine engine will address the compressor, the combustion chamber and the turbine.

- **Advanced Geared Engine Configuration (HPC and LPT technology demonstration), 2015-2020:** Design, development and ground testing of a new demonstrator to validate key enablers to reduce CO_2 emissions and noise as well as engine weight. Key elements are: improvement of efficiencies, reduction of parasitic energy flows, innovative lightweight and temperature resistant materials, low pressure turbine and exhaust noises reduction. On the compressor side compression system rigs will be built, in which the planned compressor technologies - in particular those relevant for interactions between low pressure, high pressure and static structure - can be tested and achieve TRL5.

- **Very High Bypass Ratio (VHBR) Turbofan technology, 2014-2021:** Development and demonstration of technologies in each area to deliver validated power plant systems matured for implementation in full engine systems. Research and demonstration will require the following: behaviour of fans at low speeds and fan pressure ratios and structural technology, aerodynamic and structural design of low pressure turbines for high speed operation, systems integration of novel accessory and power gearboxes, optimised power plant integration, compressor efficiency, and control & electrical power system technology developments.

- **Very High Bypass Ratio (VHBR) Large Turbofan demonstrator, 2014-2021:** Design, development, building, ground testing and flight testing (in LPA Platform 1) of an UltraFan® engine to demonstrate key technologies on a scale suitable for large engines. The Advance3 core demonstrator (stemming from earlier research including Clean Sky) will be used as the gas generator for this UltraFan® demonstrator. Key technologies included in this demonstrator will be: integrated low pressure system for a high power very-high bypass ratio engine (fan, compressor, power gearbox, intermediate pressure turbine, variable area nozzle), engine core optimisation and integration, and optimised control systems.

- **Light weight and efficient jet-fuel reciprocating engine**
  The Small Aero-Engine Demonstration projects related to SAT [Small Air Transport] will focus on small fixed-wing aircraft in the general aviation domain, and their power-plant solutions spanning from piston/diesel engines to small turboprop engines. The Engines ITD Work Package 7 focuses on piston engines burning jet fuels, in the power range suitable for general aviation, from 5 to 19 seats. These technologies will bring new solutions to replace old gasoline leaded fuel pistons or small turbines for single and twin engine aircraft. The scope includes the core engine in order to improve the power density, but also the equipment such as the turbocharger, the propeller integration and the aircraft installation optimisation

- **Reliable and more efficient operation of small turbine engines**
  This area in the Engines ITD will focus on the reliability and efficiency gains in small turbine engines demonstration project for the business and general aviation such as reference 19 seat aircraft linked to Small Air Transport [SAT], developing leading edge technologies, design tools and manufacturing technologies for application in both, spiral development programmes as well as new engine architectures.

- **Transverse enabling technologies for engines including Eco-Design**

  In addition to advanced concepts such as ultra-high bypass ratio, geared turbofan, advanced turboprop or high power density piston engines, significant performance increases may also be obtained by the further optimisation of specific engine sub-systems, such as:
  - Light weighting through the use of advanced light-weight materials e.g. carbon fibre reinforced plastics.
  - The application of advanced metallic alloys or ceramic matrix composites, to enable the increase of thermal and mechanical loads.
  - The use of advanced manufacturing technologies e.g. additive manufacturing, to open up the design space to deliver disruptive engine designs e.g. more integral designs, improved airflow optimisation, more complex geometries.

  The link between these technologies and Eco-Design in a dedicated Work Package 9 will provide the ability to fully quantify the actual eco-benefit (or eco-penalties) of such technologies throughout the life cycle of the product. Materials, processes and resources employed for aero-engines are generally of very high ecological and economic values, so the industry must assess and understand the full *ecolonomic* (i.e. ecological and economic) impact of introducing such technologies to ensure that they are environmentally and economically sustainable throughout the entire life cycle of the product.

  As in Clean Sky, ENG ITD will contribute to Technology Evaluator activities by providing relevant information to LPA IADP and AIR ITD. By working on improving engine thermal efficiency, ENG ITD partners contribute strongly to the reduction of CO_2, NO_x and noise.

7.6. Systems ITD [SYS]

While systems and equipment account for a small part of the aircraft weight they play a central role in aircraft operation, flight optimisation, and air transport safety, cost and environmental performance at different levels:

- Direct contributions to environmental objectives: optimised green trajectories, electrical taxiing, more electrical aircraft architectures, which have a direct impact on CO_2 emissions, fuel consumption, perceived noise, air quality, weight.
- Enablers for other innovations: for example, “bleedless” power generation and, actuators, are necessary steps for the implementation of innovative engines or new aircraft configurations.
- Enablers for air transport system optimisation: many of the major improvements identified in SESAR, NextGen and Clean Sky for greening, improved mobility or ATS efficiency can only be reached through the development and the integration of on-board systems such as data link, advanced weather systems, trajectory negotiation, and flight management predictive capabilities.
- Smart answers to market demands: systems and equipment have to increase their intrinsic performance to meet new aircraft needs without a corresponding increase in weight and volume: kW/kg, flux/dm3 are key indicators of systems innovation.

In Clean Sky, the Systems for Green Operations ITD developed solutions for more efficient aircraft operation. Further maturation and demonstration as well as new developments are needed to accommodate the needs of the next generations of aircraft. In addition, the systemic improvements initiated by SESAR and NextGen will call for new functions and capabilities for environmental or performance objectives, but also for flight optimisation in all conditions, flight safety, crew awareness and efficiency, better maintenance, reduced cost of operations and higher efficiency. Finally, framework improvements will be needed to allow for more efficient, faster and easier-to-certify development and implementation of features and functions.

The Systems ITD in Clean Sky 2 will address these challenges through the following actions:

- Work on specific topics and technologies to design and develop individual equipment and systems and demonstrate them in local test benches and integrated demonstrators (up to TRL 5). The main technological domains to be addressed are [1] cockpit environment and mission management, [2] aircraft communication platform and networks, [3] innovative wing systems (WIPS, sensors, and actuators), [4] landing gears and [5] the full chain of electrical power generation, distribution and usage. The outcomes will be demonstrated system architectures ready to be customized and integrated in larger settings. An important part of this work will be to identify potential synergies between future aircraft at an early stage to reduce duplication.
- Hand-over of individual technologies or systems to the IADPs for customisation, integration and maturation in large scale [flying] demonstrators. This will enable fully integrated demonstrations in IADPs and the assessment of benefits in representative conditions, including the progress towards the Clean Sky 2 high-level goals to be monitored through the Technology Evaluator.
- Transverse actions will also be defined to mature processes and technologies with potential impact on all systems, either during development or operational use. Examples of these transverse actions can be development framework and tools, simulation, incremental certification, integrated maintenance, eco-design etc.

7.7. Small Air Transport Transverse Activity [SAT]

The SAT TA in Clean Sky 2 brings together the R&T interests of European manufacturers of small aircraft used for passenger transport (up to 19 passengers) and for cargo transport, belonging to EASA´s CS-23 regulatory base. This includes more than 40 industrial companies (many of which are SMEs) accompanied by dozens of research centres and universities. The new Member States industries feature strongly in this market sector. The community covers the full supply chain, i.e. aircraft integrators, engine and systems manufacturers and research organisations.

The approach builds on accomplished or running FP6/FP7 projects. Key areas of societal benefit that will be addressed are:

- Multimodality and passenger choice
- Safer and more efficient small aircraft operation
- Lower environmental impact (noise, fuel, energy and emissions)
- Revitalisation of the European small aircraft industry

To date, most key technologies for the future small aircraft have reached an intermediate level of maturity (TRL3-4). They need further research and experimental demonstration to reach a maturity level of TRL5 or TRL6. The aircraft and systems manufacturers involved in SAT propose to develop, validate and integrate key technologies on dedicated ground demonstrators and flying aircraft demonstrators at an ITD level up to TRL6. The activity will be performed within the Clean Sky 2 ITDs for Airframe, Engines and Systems; with strong co-ordinating and transversally integrating leadership from within a major WP in Airframe ITD.

Electric/hybrid propulsion appears to be more and more an efficient solution for SAT. It is envisaged to launch studies and (thematic) topics on non-competitive technologies, configuration, and infrastructures. Tighter propulsion-airframe integration, made possible with electric power, will deliver improved efficiency and safety, as well as environmental and economic benefits. Therefore operations close to the cities would lead to an even more attractive transportation means.

7.8. Eco-Design Transverse Activity [ECO]

The Eco-Design Transverse Activity (TA) aims to coordinate and support valuable projects in ITDs/IADPs contributing to a significantly reduced ecological impact of future air vehicles over their product life cycle.

Several demonstrators at different TRL were assessed in CS1 through Eco-Statements implementing Life Cycle Assessment. In CS2 Eco-Design TA aims to broaden the assessment methodology to include more environmental indicators providing a framework for technology guidance including future social impacts to enhance the competitiveness of the European aviation sector.

Eco-Design TA will mainly focus on materials, processes and resources sustainability, efficient manufacturing and production, lifetime service, and end-of-life, and shall also consider emerging aspects coming from future requirements to be met.

Eco-Design TA will be coordinated by a Leader in cooperation with ITDs/IADPs with the core of technology development and demonstration residing in the ITDs/IADPs. Eco-Design activity, including the launch of call topics, will be screened and assessed through the *Vehicle Ecological Economic Synergy* (VEES) sub-project determining the relevance, benefit and impact for the transversal action. Selected projects will be implemented with the TA supporting members and partners in monitoring and measuring their progress toward the *ecolonomic* goals. Workshops on specific themes of interest (i.e. chrome VI free processes, composites recycling, additive manufacturing) will aim to foster joint collaborative approaches and to ensure synergies.

Eco-Design AnalySis (EDAS) will then support the assessment of the Eco-Design technologies. The principles of an extended aeronautical database and novel life-cycle assessment [LCA] methodologies will be developed with a design for environment vision to help quantify the environmental benefits of the most promising technologies and orientate the research in the Eco-Design theme.

The Eco Hybrid Platform virtual demonstrator offers an integrated visualisation of “ecolonomic” improvements of aircraft products and production. This allows the representation of all Eco-Design activities in CS2 and a single point of access to the Eco-Design toolbox for eco-statements and socio-economic assessment. Dissemination of Eco-Design results represents crucial support to the European aircraft industry and will be implemented accordingly.

Data base management principles and interfaces also have to be discussed and agreed for a proper cooperation.

The Eco-Design Coordination Committee will steer the Eco-Design activities performed in the different SPDs toward the action objectives ensuring the proper level of interaction between the involved parties.

A first set of Eco-Design relevant projects have been identified via independent expert evaluation in line with the objectives of Eco-Design TA.

7.9. Technology Evaluator [TE]

The Technology Evaluator (TE) will be monitoring and assessing the environmental and socio-economic impact of the technological results arising from all CS2 activities across all the CS2 instruments. The TE will specifically quantify the expected improvements of the aviation sector in future scenarios in comparison to baseline scenarios.

The TE will provide feedback to the CS2 instruments to enable the optimisation of their performance.

Technology impact assessments as part of CS2 cover environmental as well as socio-economic impacts with a particular focus on reducing aircraft CO_2, NO_x and noise emissions by 20-30% compared to 'state-of-the-art' aircraft entering into service as from 2014. Where applicable, benefits of CS2 demonstrators and technologies will be monitored against well-defined environmental targets and socio-economic targets of the ACARE Flightpath 2050 and the corresponding goals outlined in the Strategic Research and Innovation Agenda (SRIA).

CS2 results will be considered in the form of 'concept aircraft models' where related impacts will be assessed on three levels: mission level, airport level, and air transport system (ATS) level. All three levels are strongly interconnected and build on one another. Technology assessments will be performed on all IADP, ITD, and SAT TA results, including mainliners, regional aircraft, business jets, small air transport vehicles, fast rotorcraft, as well as on TE concept aircraft models. All the assessments will be based on comparisons between newly-developed and 2014 reference technologies covering the 2025, 2035, and 2050 time horizon.

To ensure sufficient flexibility and to reduce the need for coordination between the instruments and the TE, mission level assessments are mainly conducted by the IADPs, ITDs, and the SAT TA. As one of the lessons learned from CS, assessments of individual technologies at vehicle level can be expedited by assigning mission level assessments to the CS2 instruments doing the synthesis of a concept model. On the mission level, the instruments' results will be complemented by a limited number of TE concept models both for those parts of the global fleet not under consideration in or going beyond the scope of CS2 and for CS2 technologies without dedication for one of the instruments' concept models.

With regard to the mission level, the TE ensures harmonisation of methods, metrics, and reporting. The TE will conduct airport and air transport system level assessments with the CS2 instruments' concept models as input. The TE will also conduct the socio-economic assessments on micro- and macroscopic level and it will establish a link to the ECO TA for life-cycle analysis types of evaluation.

The monitoring and information capacities are established by an efficient and effective interfacing between TE and the CS2 instruments.

The TE is constantly refining metrics and methods. The TE will elaborate possible extensions of its scope, in particular with regard to global warming and local air quality assessments. Furthermore, the TE will look into opportunities for collaboration with SESAR 2020 and EASA. TE methods and models, especially for airport and ATS level assessments, are ready to include concepts and procedures developed in SESAR 2020 such as sector-less and climate-optimised operations. With regard to EASA, an exchange on methods, metrics, and certification aspects might be mutually beneficial.

8. Master Plan

State of play as of December 2017

◆ CDR
◇ PDR
◈ CoR
▲ FT
△ Testing/GT
ET = Enabling Technology

Demonstrator /Technology Streams Maturing Over Time

Theme	Demonstration Area	Demonstrator /Technology Streams	Number of ETs	TRL at End	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Breakthroughs in Propulsion Efficiency (incl. Propulsion-Airframe Integration)	Advanced Engine/Airframe Architectures	UHPE Integration	tbd	tbd										
				TRL Maturity										
		LPA-01-D2: Advanced engine integration driven fuselage ground demo	3	6				◇		◆		△		
				TRL Maturity				TRL3		TRL4		TRL5	TRL6	
		ENG - Demonstrator 1 WP A-1.2 UHBR configuration	1	6		◈		◇		◆				
				TRL Maturity					TRL4		TRL5	TRL6		
		ENG - Demonstrator 1 WP A-1.2 CROR configuration	1	5				△						
				TRL Maturity	TRL4				TRL5					
	Ultra-high Bypass and High Propulsive Geared Fans	ENG - Demonstrator 5 - VHBR – Middle of Market Technology	5	6			◇	◆						
				TRL Maturity					TRL3		TRL4		TRL5	TRL6
		ENG - Demonstrator 6 - VHBR – Large Turbofan Demonstrator UltraFan™	5	6				◇	◆	△			▲	
				TRL Maturity					TRL3		TRL4		TRL5	TRL6
		ENG - Demonstrator 2 - UHPE	5	5			◈	◈ ◇		◆		△		
				TRL Maturity						TRL3			TRL4	TRL5
		ENG - Demonstrator 4 - Adv. Geared Engine Configuration (HPC-LPT)	5	5					◇	◆	△			
				TRL Maturity						TRL3		TRL4	TRL5	
		LPA-01-D8: Radical Configuration Flight Test Demonstrator	1	6							◇	◆		△
				TRL Maturity					TRL4		TRL5	TRL6		
		LPA-01-D10: UltraFan Flight Test Demonstration	4	6					◇		◆	▲		
				TRL Maturity					TRL4		TRL5	TRL6		
		LPA-01-D3: Validation of scaled flight testing	1	4										
				TRL Maturity						TRL3	TRL4			
	Hybrid Electric Propulsion	LPA-01-D9: Hybrid Electric Ground Test Bench	4	6										
				TRL Maturity				TRL3		TRL4			TRL5	TRL6
	Boundary Layer Ingestion	Boundary Layer Ingestion	tbd	tbd										
				TRL Maturity										
	Small Aircraft, Regional and Business Aviation Turboprop	ENG - Demonstrator 3 - Business aviation / short range Regional TP Demonstrator	5	5		◈	◇	◆		△				
				TRL Maturity						TRL3		TRL4	TRL5	
		ENG - Demonstrator 7 - Small Aircraft Engine Demonstrator	5	6				◇ ◆	△	▲				
				TRL Maturity			TRL3	TRL4	TRL5	TRL6				
		ENG - Demonstrator 8 - Reliable and more efficient operation of small turbine engines	5	4			◈ ◇	◆	△					
				TRL Maturity		TRL3			TRL5					
Advances in Wings, Aerodynamics and Flight Dynamics	Advanced Laminar Flow Technologies	Advanced Laminarity [WP A-2]	1	6					◆				△	
				TRL Maturity			TRL 3/4	TRL4			TRL5		TRL6	
		Demonstrator 2 WP A-2.2 NLF smart integrated wing	1	6					◆				△	
				TRL Maturity			TRL 3/4	TRL4			TRL5		TRL6	
		Demonstrator 3 WP A-2.3 Extended laminarity	1	5										
				TRL Maturity		TRL 3/4		TRL4	TRL5					
		LPA-01-D11: Active flow control flight test demonstrator	2	6					◇	◆	▲			
				TRL Maturity			TRL3	TRL4		TRL5	TRL6			
		LPA-01-D4: HLFC on tails large scale ground-based demonstrator	5	5						◇		◆	△	
				TRL Maturity					TRL3		TRL4	TRL5		
		LPA-01-D5: Natural Laminar Flow demonstrator for HTP bizjets	tbd	tbd										
				TRL Maturity										
		LPA-01-D6: Ground-based demonstrator HLFC wing	tbd	tbd										
				TRL Maturity										
		LPA-01-D7: HLFC on tails flight test operation	tbd	tbd										
				TRL Maturity										
		WP A-2.1 - BJ Laminar Nacelle	1	5					△					
				TRL Maturity		TRL 3/4		TRL4	TRL5					
		WP A-2.2.1 - NLF LE/Wingbox GBD (new demonstrator introduced by DLR/NACOR)	1	6									△	
				TRL Maturity			TRL 3/4	TRL4			TRL5		TRL6	
		WP-A-2.2 - NLF	1	6									△	
				TRL Maturity			TRL 3/4	TRL4			TRL5		TRL6	
	Regional Aircraft Wing Optimization	Component manufacturing and testing [WP B-1.2]	5	6							△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		REG D1 - Air Vehicle Technologies – Flying Test Bed#1 (FTB1)	6	6					◇		◆		▲	
				TRL Maturity						TRL3	TRL4	TRL5	TRL6	
		REG D2 - High Lift Advanced Turboprop – Flying Test Bed#2 (FTB2)	5	6				◇	◆		▲			
				TRL Maturity				TRL3	TRL4	TRL5	TRL6			
		Demonstrator Code validation demonstration [WP A-4.1.1.3]	1	5/6										
				TRL Maturity		TRL 3/4	TRL5/6							
		Demonstrator 5 WP A-4 Smart control surfaces	1	6										
				TRL Maturity			TRL3	TRL4				TRL6		
		Demonstrator Fixed Leading Edge [WP A-4.1.1.1-3]	2	5/6										
				TRL Maturity		TRL 3/4	TRL5/6							
		Demonstrator Power Controller [WP A-4.1.1.4]	1	5/6										
				TRL Maturity		TRL 3/4		TRL5/6						
		Full Manufacturing & Test [WP B-1.2]	4	6							△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		High lift wing [WP B-2.2]	1	6							△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		Morphing Leading Edge Demonstrator	3	6							△			
				TRL Maturity						TRL4	TRL5	TRL6		
		Novel Control [A-4]	1	6										
				TRL Maturity			TRL3	TRL4				TRL6		
		ON-GROUND ACTUATION RIG FTB#2 WING [WP B1.4, B3.2]	7	6							△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		ON-GROUND STRUCTURAL COCKPIT FTB#2 [WP B-3.3]	4	6							△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		ON-GROUND STRUCTURAL RIG FTB#2 WING [WP B-1.3, B2.2]	13	6							△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		Virtual high lift demonstrator [WP B-2.2]	1	6							△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		WP-A-4.1 Moveables	1	6										
				TRL Maturity		TRL 3/4		TRL4				TRL6		

Innovative Structural / Functional Design - and Production System	Advanced Manufacturing	Aileron, fuselage panel jigless assembly [WP B-3.4]	1	6			◇	◆			△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		Cockpit segment, engine nacelle demonstrators [WP B-3.4]	1	6			◇	◆			△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		Joints metal - composite [WP B-3.4]	1	6			◇	◆			△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		Thermoplastic secondary structures [WP B-1.2]	1	6			◇	◆			△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		Demonstrator z [WP B-3.1 Nacelle Systems Demonstrator (TBC)]	1	5							△			
				TRL Maturity					TRL3	TRL4		TRL5		
		WP-A-3.1 Aileron Demonstrator	1	6				◇	◆			△		
				TRL Maturity			TRL3			TRL4		TRL5	TRL6	
		Coupons and subscale components [WP B-1.2]	4	6			◇	◆			△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
	Cabin & Fuselage	REG D3 - Full scale innovative Fuselage & Pax Cabin demonstrator (Structural demonstration)	6	6				◇		◆		△		
				TRL Maturity						TRL5			TRL6	
		REG D3 - Full scale innovative Fuselage & Pax Cabin demonstrator (Comfort/Thermal demonstrations)	6	6					◇		◆		△	
				TRL Maturity						TRL5			TRL6	
		WP-A-3.3 WP A-3.4 Door Demonstrator	1	6			◇		◆		△			
				TRL Maturity			TRL3			TRL4		TRL5	TRL6	
		WP B-3 Advanced integrated Structures	1	6			◇	◆			△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		Demonstrator x [WP B-4.3] - Regional Aircraft Fuselage Major Components Demonstrator	4	6			◇		◆			△		
				TRL Maturity					TRL3		TRL4	TRL5	TRL6	
		LPA-02-D1:Next Generation Fuselage, Cabin and Systems Integration	7	6			◈				◆		△	
				TRL Maturity					TRL3	TRL4	TRL5	TRL6		
		LPA-02-D2: Next Generation Cabin & Cargo Functions	12	6										
				TRL Maturity						TRL3		TRL4	TRL5	TRL6
		LPA-02-D3: Next Generation Lower Center Fuselage	8	5			◈		◆			△		
				TRL Maturity				TRL3				TRL4	TRL5	
	Innovative Solutions for Business Jets	WP A-3.1 - BJ Compostie Wing Root Box	1	4/5							△			
				TRL Maturity				TRL3			TRL4/5			
		WP A-3.3 - BJ Central Wing Box Panel	1	6							△			
				TRL Maturity		TRL4/5			TRL6					
		WP A-3.3 - BJ Half Central Wing Box	1	6							△			
				TRL Maturity		TRL4/5			TRL6					
		WP A-4.1 - EWIPS Integration on a BJ Flap	1	5/6					△					
				TRL Maturity		TRL 3/4			TRL5/6					
		WP A-5.2 - BJ Low Weight Seat Demonstrator	1	6							△			
				TRL Maturity		TRL 3/4				TRL5		TRL6		
Next Generation Cockpit Systems and Aircraft Operations	Cockpit & Avionics	D23. Integrated Cockpit	1	tbd										
				TRL Maturity										
		D18. Fly by Wire	3	5					◇	◆	△			
				TRL Maturity				TRL3		TRL4	TRL5			
		LPA-03-D4 Regional Active Cockpit	5	5					◆		△			
				TRL Maturity					TRL3	TRL4	TRL5			
		D1 Extended Cockpit Demonstrations	10	3			◇		◆		△			
				TRL Maturity			TRL3			TRL4	TRL5			
	Advanced MRO	LPA-03-D6 Maintenance service operations enhancement demonstrator	14	4										
				TRL Maturity			TRL2		TRL3	TRL4				
Novel Aircraft Configurations and Capabilities	Next-Generation Civil TILTROTOR	Next-Generation Civil TILTROTOR	11	6				◇	◆		△		▲	
				TRL Maturity						TRL3		TRL4	TRL5	TRL6
	RACER Compound Helicopter	RACER Compound Helicopter	14	6			◇	◆	△		▲			
				TRL Maturity					TRL3		TRL4	TRL5	TRL6	
Aircraft Non-Propulsive Energy and Control Systems	Electrical Systems	REG D4 - Iron Bird	6	5				◇		◆		△		
				TRL Maturity						TRL3	TRL4	TRL5		
		Demonstrator Mixed Thermal Ice Protection [WP A-4.1.1.1-1]	1	5/6										
				TRL Maturity		TRL 3/4		TRL5/6						
		D20. De-Ice	1	5					◇	◆	△			
				TRL Maturity				TRL3		TRL4	TRL5			
		D15. Primary In-Flight Ice Detection Systems	2	6					△	▲		▲		
				TRL Maturity				TRL3	TRL4		TRL5	TRL6		
		D14. Advanced Electrothermal Wing Ice Protection Demonstrator	3	6						◆	△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		D3. Smart Integrated Wing Demonstrator	1	5*							△			
				TRL Maturity				TRL3		TRL4*		TRL5*		
		D4. Innovative Electrical Wing	1	6							△			
				TRL Maturity				TRL4		TRL5	TRL6			
		D10. HVDC Power Management Centre Demonstrator for large A/C	1	5*										
				TRL Maturity							TRL4	TRL5+		
		D9. Innovative Electrical Network (IEN) - demo on Copper Bird	2	5			◇	◆	△					
				TRL Maturity							TRL5			
		D19. EPGD	1	5					◇	◆	△			
				TRL Maturity					TRL3	TRL4	TRL5			
		D13. Next Generation Cooling system Demonstator	3	5			◆		△		▲			
				TRL Maturity			TRL3			TRL4	TRL5			
		D16. Thermal Management demonstration (Avant Test Rig)	5	6								△		
				TRL Maturity							TRL3	TRL4	TRL5	TRL6
		Demonstrator Ultra low power [WP A-4.1.1.6]	1	5/6										
				TRL Maturity		TRL 3/4		TRL5/6						
		D8. Power Generation	4	5				◇	◆			△		
				TRL Maturity				TRL3		TRL4	TRL5			
		Non-Propulsive Energy Optimization for Large Aircraft	tbd	tbd										
				TRL Maturity										

	Landing Systems	**D17. Advanced Landing Gear Sensing & Monitoring System Demonstration (ALGeSMo)**	**1**	**6**										
				TRL Maturity					TRL4	TRL5	TRL6			
		D21. EMA and brake LG	**1**	**5**				◇	◆		△			
				TRL Maturity						TRL3	TRL4	TRL5		
		D5. Advanced Landing Gear Systems	**5**	**4**			◇	◆ △	▲					
				TRL Maturity				TRL4						
		D6. Electrical Nose Landing Gear System Demonstrators	**5**	**5**				◇		△				
				TRL Maturity					TRL3	TRL4	TRL5			
Optimal Cabin and Passenger Environment	**Environmental Control System**	**D11. Next Generation EECS Demonstrator for large A/C**	**4**	**6**						△	▲			
				TRL Maturity				TRL3	TRL4	TRL5	TRL6			
		D12. Next Generation EECS Demonstrator for Regional A/C	**tbd**	**tbd**										
				TRL Maturity				TRL3				TRL5		
	Innovative Cabin Passenger/Payload systems	**Demonstrator 6 WP 5.1 Ergonomic flexible cabin**	**1**	**6**					◆		△			
				TRL Maturity					TRL4		TRL5	TRL6		
		Novel travel experience [A-5]	**1**	**6**					◆		△			
				TRL Maturity					TRL4		TRL5	TRL6		
		LPA-01-D12: Flight test demonstration of active vibration control technologies/noise prediction methods for rear-mounted engines	**2**	**6**				◇	◆	▲				
				TRL Maturity				TRL4		TRL5	TRL6			
		D2. Innovative Cabin and Cargo technologies	**tbd**	**tbd**										
				TRL Maturity										
		D22. Comfortable & Safe Cabin for SAT	**3**	**4**				◇	◆	△				
				TRL Maturity					TRL3	TRL4				

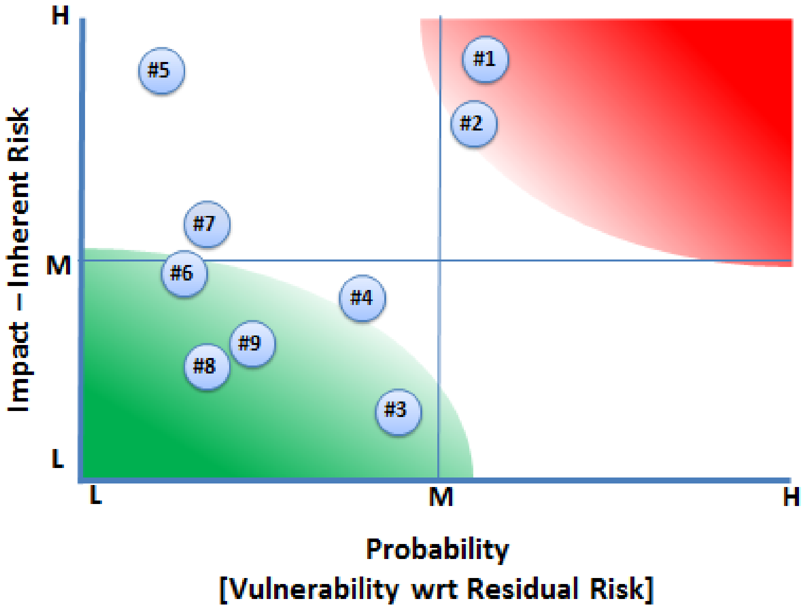
9. Overview of Major Risks

#	Risk Description	Likelihood (H/M/L)	Impact (H/M/L)	Impact Category†	Mitigation Plan
1	Execution of the technical activities in Clean Sky 2 may not result in the achievement of the High-Level Goals [HLGs] as stated in the Regulation	M	H	R/T	Build and maintain a robust “flow-down” of targets from the Regulation’s quantitative HLGs into objectives of each IADP/ITD and 1st level Work Packages and Major Demonstrator elements. Integrate monitoring into the TE work plan and support with Annual [periodic] Reviews with external experts and Scientific Committee, adjusting programme content where necessary. Define “SMART” objectives for the IADPs/ITDs in all areas of qualitative goals of the Regulation [e.g. competitiveness and mobility] and monitor progress towards these goals through periodic assessments with the TE and by the JU directly via supporting studies and Coordination & Support actions, where necessary. Propose and implement adjustments to the technical content of the programme where justified in order to safeguard the achievement of the HLGs, both within the membership and through [revised] calls for proposal topics, including “thematic topics” where external stakeholder input can widen the portfolio of technologies with a high potential for contributing to the HLGs.
2	Strategic or technical priorities within industrial companies may result in a lack of resources available for Clean Sky 2, delays in the completion of the activities and/or a need to revise programme content.	M	H	R/T/S	Maintain an early warning capability through quarterly reports, the Annual and Intermediate Progress Reviews and ,where necessary, alert the Governing Board. Propose re-orientations when needed and ensure these are reflected in the CS2DP and WP. Use GAM Amendment process to officiate. Implement ad-hoc ex-ante technical evaluations of revised programme content to ensure their congruence with the Programme’s HLGs.
3	Technical setbacks in one or several IADPs/ITDs/TAs may result in under achievement of milestones and deliverables, and/or a significant under-spending of annual budget.	M	L	T/S/C	Review each quarter and advise GB where issues arise. Re-balance the budget across ITDs/IADPs and with partners if necessary. Propose re-orientations when needed and ensure these are reflected in the CS2DP and WP. Use GAM Amendment process to officiate. Re-balance the overall budget towards increased Calls for Proposals, in particular “thematic topics” allowing for input of proposed programme content from external stakeholders, on the basis of a prior validation of this thematic content delivering demonstrable progress towards the Programme’s HLGs.
4	The provision of timely and correctly formatted data from the IADP/ITDs to the TE may be late, incomplete ir erroneous	M	M	R/T	Regular reviews in the TE Coordination Committee allow for an “early warning” which can be escalated to the Coordinators and ultimately, if needed to the GB. Ensuring the TE related outputs are described in the GAMs for the IADPs/ITDs concerned, and monitoring their delivery should enable timely corrective action. Further support through TE calls or JU Calls for Tender could be put in place to acquire relevant data and metrics.
5	Planning for cost and effort for complex and/or large ground and flight demonstrators (10 year programme)	L	H	T/S/C	Each IADP / ITD to deploy a detailed risk management and “through to completion” plan with critical path management. CS2DP process to highlight “through to completion” plans, budgets and risks, allowing due assessment and revision opportunities.

#	Risk Description	Likelihood (H/M/L)	Impact (H/M/L)	Impact Category†	Mitigation Plan
	may lack maturity and/or accuracy, leading to delayed completion of technical activities or reduced scope of activities.				Implement a robust "Gate" process for major demonstrators [in particular flight demonstrations], diverting resources if necessary to alternative programme content that demonstrates clear progress towards the HLGs at lower and more manageable risk. Re-balance budget between 1st Level Work Packages and/or between IADPs/ ITDs to divert funding and resource available towards alternative actions that will reduce the risk of not achieving the programme's HLGs.
6	Competences and resources to successfully enable the completion and test of flight demonstrators may be underestimated or insufficient.	L	M	T/S/C	Clearly identify the required competences and resources and closely monitor through PDR/CDR and milestone management. Enforce consistent and robust risk management; implement early-warning system to avoid late discovery of critical path related risks. Have clear descriptions of work in call texts for such activities directly related to flightworthy hardware, including requested skills and agreements.
7	Some costs may be overrun, and some participants may be unable to carry on until completion. Competences and resources to successfully enable completion of the technical work programme may be insufficient.	L	M	T/S/C	Manage priorities: abandon non-crucial technology development and integrate only the crucial ones in the demonstration area of the programme. Implement a contingency margin. Identify the required competences and resources and closely monitor through PDR/CDR and milestone management. Enforce consistent and robust risk management; implement early-warning system to avoid late discovery of critical path related risks. Propose re-orientations when needed and ensure these are reflected in the CS2DP and work plan. Use GAM Amendment process to officiate.
8	The strong interdependencies between IADPs (as provider of requirements and as Integrator) and ITDs (as provider of a/c components, equipment, systems, and solutions) can cause delays in the overall programme in case of (technical / schedule) problems.	M	L	T/S/C	Improve coordination and create well-defined interfaces between IADPs and ITDs. Introduce programme management tools and techniques in parallel with the Grant Management systems supporting the individual grants in financial/legal aspects.
9	Partners' contribution to GAMs for activities on the critical path.	M	L	T/S/C	a) Preparation phase: assess the appropriateness of proposing a Call for Proposals instead of Sub-contracts b) Negotiation phase: Involve well trained people from the beginning for both technical and legal aspects and deeply liaise with the JU for specific and difficult cases to find out the best feasible solution c) Implementation phase: Implement specific monitoring and management measures from the start of the project (to be defined with the CS2JU on case-by-case basis)

†Impact category: R (Reputational for JU); T (Technical Targets), S (Schedule Targets) or C (Cost Targets)

Marci chart


H
M
L
Impact – Inherent Risk
#5
#1
#2
#7
#6
#4
#9
#8
#3
L
M
H
Probability
[Vulnerability wrt Residual Risk]

10. Funding Resources Estimates

The maximum funding available as defined in the Regulation is €1 755 million, of which a maximum of €39 million corresponds to the contribution towards the Joint Undertaking administrative costs. This leads to an estimated net funding available for the Clean Sky 2 R&I operations of €1 716 million.

In accordance with the Statues of Clean Sky 2, Annex I Art. 16 which define indicative funding shares, the Union contribution dedicated to operational costs (€1 716 million) is quantified in € amounts as set out below in the following tables.

In Table 1 the net indicative allocation to IADPs, ITDs and TAs is shown. Column 1 in the table shows the original indicative IADP and ITD funding estimates from which 1%, 2% and 4% for the TE, ECO and SAT TAs respectively are subtracted (see columns (2), (3) and (4)). Column (5) represents the indicative funding for the IADPs/ITDs and TAs up to programme completion as set at the start of the programme.

		(1)	**(2)**	**(3)**	**(4)**	**(5)** = (1) - (2) - (3)- (4)
IADPs / ITDs	Indicative Allocation Regulation - % (Annex III Clean Sky JU Council Regulation)	Indicative Allocation Regulation - M€	**TE** 1% IADPs/ITDs values - M€	**ECO** 2% IADPs/ITDs values - M€	**SAT** 4% IADPs/ITDs values - M€	Resulting Indicative Allocation - M€
				Transverse activities		
			[1% = 17.16]	[2% = 34.32]	[4% = 68.64]	
LPA	32%	548.17	5.48	12.48	21.71	**508.50**
REG	6%	109.63	1.10	2.50	4.34	**101.70**
FRC	12%	200.20	2.00	4.56	7.93	**185.71**
AIR	19%	333.67	3.34	7.60	13.21	**309.52**
ENG	17%	286.00	2.86	6.51	11.33	**265.30**
SYS	14%	238.33	2.38	5.43	9.44	**221.09**
TE						**17.16**
ECO						**39.06**
SAT						**67.95**
TOTAL*	**100%**	**1,716.00**	**17.16**	**39.06**	**67.95**	**1,716.00**
				124.18		

*Total Values for Transverse Activities as agreed in the June 2016 CS2DP and approved by the GB

Table 1 - Original distribution of Funding in € million: operational budget to completion per CS2 Programme.

Table 2 [overleaf] shows the indicative allocation of funding per IADP/ITD or TA, taking into account the TA re-allocations where these are known/agreed, and applied and incorporated into the IADP/ITD amounts. The following evolutions in programme content and related funding estimates have also been introduced:

- Transfer of technical activities for a total of €7,7 million from AIR to SYS (agreed in 2015/16).
- Transfer of technical activities for a total of €7,5 million from AIR to SYS (agreed in 2017).
- Transfer of technical activities for a total of €2,0 million from AIR to REG (agreed in 2017).
- Transfer of technical activities for a total of €0,9 million from REG to SYS (agreed in 2017).

State of play as of December 2017

	(1)	**(2)**	**(3)**	**(4)** = (1) + (2) + (3)
IADPs / ITDs / TAs	Allocation - M€	Reapplication ECO	Reapplication SAT	Allocation incl. TA Redistribution - M€
LPA	**508.50**	**2.55**		**511.05**
REG	**102.80**	**0.23**		**103.03**
FRC	**185.71**			**185.71**
AIR	**292.35**	**0.60**	**24.15**	**317.10**
ENG	**265.30**	**3.40**	**16.50**	**285.20**
SYS	**237.16**	**1.02**	**24.30**	**262.48**
TE	**17.16**	**-**	**-**	**17.16**
ECO GAM	**-**	**6.06**	**-**	**6.06**
ECO funding for re-distribution		**25.20**		**25.20**
SAT	**-**	**-**	**3.00**	**3.00**
TOTAL	**1,608.99**	**39.06**	**67.95**	**1,716.00**

Table 2 - Indicative Distribution of Funding in € million: operational budget to completion per IADP/ITD/TA.

(1) TE: activities are performed within the TE and not within the IADPs/ITDs.

(2) ECO: €6,06 million estimated funding for the ECO TA coordination and monitoring through its GAM. The remaining ECO TA funding will fund technical activities in the IADPs / ITDs. The related (re-)distribution of the remaining funding is partially completed and remains in progress, based on the evaluation of project proposals.

(3) SAT: €3 million estimated funding for coordinating and monitoring within the TA through its GAM. The estimated balance (€64,95 million) is redistributed to the AIR/ENG/SYS ITDs in accordance with the information received from SAT Leaders and confirmed by Leaders in May 2017).

The JU envisages launching CfPs to a total indicative topic value well in excess of the minimum of 30% of the programme funding value, to ensure a full execution of the €1 716 million available funding and ensure the minimum value of 30% of the programme funding is met, as set out in the Regulation for Calls for Proposals and Calls for Tenders. This increase in the CfP share will also allow the JU to introduce “Thematic Topics” in the upcoming CfPs. These topics will help widen the participation in the CS2 programme and allow for innovative solutions to be proposed by applicants outside a strict “pull” from the Members’ technology development and demonstration activities. Currently, approx. €60 million in total is earmarked for Thematic Topics over the remaining Calls (2018-2020).

State of play as of December 2017

Funding envelope to completion	**Allocation according to Regulation**		**2017 CS2DP**	
Leaders	**<40%**	**<686.4**	**39.3%**	**675.2**
Core-Partners	**<30%**	**<514.8**	**28.2%**	**483.6**
Calls for Proposals / Tender	**>30%**	**>514.8**	**32.5%**	**557.2**
TOTAL	**1,716.0**		**1,716.0**	
Of which Thematic Topics in CfPs			approx. 60m€	

Table 3 - Distribution of estimated funding between Leaders, Core Partners and for Calls for Proposals/Tenders

(1) Leader and Core Partner shares may evolve over the programme lifetime.

(2) Figure for Calls for Proposals/Tenders shows the balancing figure to €1 716 million and is subject to change.

11. Clean Sky 2 Programme Implementation to date

Summary of Call results to date – Calls for Core Partners

With Clean Sky 2 now operating for over three years, all four Core Partner Calls that were foreseen for the Programme were successfully launched and closed. The conclusion of the negotiations for the fourth and final Call for Core Partners is expected by end of 2017. This will complete the selection process for the Clean Sky 2 Core Partners and for the membership, on time with respect to the planning made at the Programme's start.

On the basis of the four calls launched, and the successful grant implementation with the candidate Core Partners resulting from these calls and still under grant preparation, the JU expects to have established a preliminary planned allocation over the programme's life of approximately 94% of the foreseen Core Partner funding [which is up to €514.8 million according to the Regulation]. The remaining "unallocated" Core Partner funding provides a healthy contingency margin, and will allow for flexibility in the downstream management of the Programme in bi- or multi-annual work plans and GAMs.

When disregarding multiple winning applications leading to participation as Core Partner via more than one call and/or in more than one IADP/ITD, the net number of Core Partners incl. their affiliates and linked third parties acceding to the programme on the basis of Calls for Core Partners is expected to be 184 with over 50 SMEs participating [both numbers are subject to the GB approval of the accession of top-ranked applicants and the approval of the Core Partner Wave 4 ranking lists and subsequent accession to the membership].

The Members originate from 20 different countries: 18 Member States and two countries associated to Horizon 2020 [Turkey and Israel].

A detailed list with the Members participating in the CS2 programme is available on the CS2 website[1] and will be updated on a regular basis.

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[1] http://cleansky.eu/members-0

Summary of Call results to date – Calls for Proposals

In the three years since the Programme's start seven Calls for Proposals (CfPs) were successfully launched and five closed, with the grant preparation completed.

With the sixth CfP to be fully implemented by early 2018, Clean Sky 2 will engage close to 400 Partners from 24 different countries with a strong SME involvement in terms of participation and grants awarded: approx. 38% of the Partners selected, requesting 27% of the over €246 million EU funding launched via CfPs so far. It is expected that the outcome of the seventh Call will continue this track record.

Four more CfPs are currently foreseen over the period to completion with a total funding of over €230 million and an increasing share for Thematic Topics:

- 2018: 2 CfPs per year
- 2019: 1 CfP per year
- 2020: 1 CfP per year

As Thematic Topics will contribute to the progress towards the high-level objectives of the CS2 regulations and are not [necessarily] linked to one IADP/ITD [demonstration activities/strategy], meaning they are not "inside" one of the current IADPs/ITDs, the JU expects a significant increase in the participation in the programme with the envisaged launch of these Topics in 2018.

Starting with a pilot in one of the upcoming calls, the JU will slowly ramp up call by call the total indicative funding value for Thematic Topics in order to reach the target of roughly €60 million in total at the end of the CS2 programme.

12. CS2 Links to Other Programmes

12.1. Synergies with other European, national and regional programmes

Via regular interaction with the Commission in the Work Plan preparation and its alignment with the Commission's Work Programme, the JU will ensure that activities conducted within the ITDs/IADPs and launched via Calls do not present redundancies with respect to earlier or current Framework funded projects (e.g. FP7 projects), and upcoming Horizon 2020 actions.

The coherence and complementarity with National Programmes in the Member States will be checked via the States Representatives Group and, when appropriate, directly with Agencies in charge of any programme which may provide inputs for the execution of the Clean Sky activities.

The increase of the innovation and competitiveness-related budgets under EU cohesion policy over the past decade is of the utmost importance to ensure optimal synergies between the funds as a result of the increasing competitive pressure from global markets and to maximise the impact and efficiency of public funding.

In this context, Article 20 of the Horizon 2020 Regulation and Article 37 of the Horizon 2020 rules for participation encourage synergies between Horizon 2020 and other European Union funds, such as ESIF. To achieve this, it is crucial to align strategies and implementation modalities and complement existing and future roadmaps.

The CS2JU is called by its founding Council Regulation no. 558/2014 of 6 May 2014 to develop closer interaction with European Structural Investment Funds (ESIF) and to underpin smart specialisation efforts in the field of activities covered by the CS2JU.

Thus, Clean Sky 2 encourages synergies with ESIF[1] by allowing complementary activities to be proposed by applicants to the calls launched by Clean Sky 2. Synergies with the Clean Sky 2 Programme and its technology roadmap can be achieved by broadening the scope, adding parallel activities or continuing Clean Sky co-funded projects/ activities through ESIF support. Clean Sky 2 also encourages the use of ESIF to build and enhance local capabilities and skills in fields related to the programme, in order to boost the level of European competitiveness of stakeholders in this area.

- Occitanie (FR) in February 2015
- Andalucía (ES) in July 2015
- Cataluña (ES) in August 2015
- Romania (at national level) in July 2015
- Campania (IT) in October 2015
- Flevoland (NL) in November 2015
- Östergötland (SE) in November 2015
- Västra Götaland (SE) in November 2015

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[1] Article 37 of the H2020 Rules for Participation providing that, in case of cumulative funding, the grants may not cover the same cost items.

- Czech Republic (at national level) in March 2016
- Castilla La Mancha (ES) in April 2016
- Zuid-Holland (NL) in June 2016
- Portugal (at national level) in October 2016
- Castilla Y Leon (ES) in June 2017
- Podkarpackie (PL) in November 2017
- Greece (at national level) in November 2017
- Sterea Ellada (GR) in November 2017

To facilitate synergies with ESIF, the MoU is an important and effective instrument. It provides a strategic approach and the opportunity to discuss in advance with MS and regional authorities ways to stimulate synergies. The MoU follows the regional strategy/RIS3 and the applicable ESIF regional funding instruments which can identify thematic objectives or align the regional funding instruments to support possible pilot projects.

At a strategic level, Clean Sky 2 has developed a coherent and comprehensive policy strategy and an action plan on synergies for Member States and Regions which are interested in investing ESIF within the aeronautics R&I area and other related technologies. In this regard, Clean Sky 2 is developing closer interaction with interested Member States (MS) and Regions in Europe by discussing strategies and possible cooperation via a tailor-made approach as well as designing modalities of cooperation - depending on the level of interest, the regional stakeholders' base, and the commitment which a Member State/Region may decide to engage with.

In this regard, **five scenarios** have been identified which outline the appropriate and possible mechanisms for cooperation. These scenarios should be considered and adapted according to the regional funding schemes envisaged under the operational programmes, rules and processes while keeping the CS2 Programme/calls in line with its own rules. Additionally, a quality label may be given to the complementary activities proposed by either a successful applicant in a Clean Sky call or proposed by a Clean Sky beneficiary, over the course of implementation, via an independent evaluation process. The "**Clean Sky Synergy Label**" can provide an incentive effect and a guarantee of success for Member States/Regions to invest in the projects, support actions, local capabilities and infrastructures of national and/or regional importance.

Further bilateral institutional contacts with a number of MS and Regions should enable approximately 20 MoU to be in place by end of 2018. Furthermore, the CS2JU will continue implementing the pilot-phase across 2017-2018 with these Member States and Regions in view of launching more pilot projects and monitoring the synergies achieved.

12.2. Clean Sky 2 – SESAR & SESAR 2020 coordination

Clean Sky 2 is focused on aircraft-based and aircraft performance-driving technology development culminating in demonstration-based validation. Yet it is obvious that the full benefit of these technologies will only be achieved if they are compliant with and can be fully integrated in overall future air transport system defined by SESAR/SESAR 2020, NextGen and similar initiatives. The compatibility of Clean Sky 2's work with the overall principles and concepts of operations of SESAR/SESAR 2020 [and through these European initiatives with the overall global air transport system] is a key objective to be met in CS2. Cooperation, compatibility and consistency between activities and developments in Clean Sky 2 (especially for flight procedures and Extended Cockpit where direct implementation of SESAR/SESAR2020 regulations will be performed) and the objectives of SESAR/SESAR 2020 (in terms of Concepts of Operation and ATM rules) is crucial for the success of both programmes.

Clean Sky 2 has implemented an effective interface with SESAR 2020 at executive, programme and technical levels with regular meetings and involving the Systems ITD and the Regional and Large Passenger Aircraft IADPs. A Memorandum of Cooperation [MoC] was signed between the two Joint Undertakings in December 2015.

The purpose of this MoC is to establish a cooperative framework between the Parties that contributes to the sustainable development of the European air transport system through an effective implementation and integration of some areas of their respective Programmes. The scope of this framework includes the following objectives:

- Sharing (where feasible) the respective scope of activities and coordination in relevant aviation domains within each JU's development, validation and demonstration activities, while mitigating gaps or overlaps between the work programmes;
- Exchanging information about the calls to be launched by each Party and topics related to avionics/ATM/environmental aspects;
- Pursuing consistency between work programmes with regard to the definition of the performance targets, in particular regarding environmental targets;
- Exchanging periodically on the progress achieved in their respective work programmes;
- Coordinating and implementing relevant activities at the aviation, aeronautics and air transport level and agreeing joint communication actions where relevant and feasible.

The two JUs have implemented this MoC through a CS2JU/SESAR JU Steering Committee co-chaired by the Parties' Executive Directors. Ad-hoc Working Groups may be formed to fulfil the purpose of the MoC and enable interfacing between relevant SESAR JU projects and CS2 projects in areas such as, but not limited to:

- Avionics and ATM/CNS infrastructure and services;
- Mission and Business Trajectory Management (''MBTM'');
- Assessing the Single European Sky performance targets and the complementarity between JUs' activities.

Upon the request of either Party, the Parties may jointly implement dedicated common reviews and organise common meetings with the participation of respective industries. The Parties may also establish coordination on possible cooperation with other EU bodies.

12.3. Clean Sky 2 – EASA coordination

Starting from a revised policy on research by EASA leading to intensified contacts, several technical meetings and workshops have taken place and are planned to further enhance the interactions between EASA and Clean Sky JU.

The foreseen scope is to understand the potential impact on the evolution of standards and the certification of components and systems for the application in future aircraft or equipment. The starting point will be:

- the outcome of the CS activities in FP7 and related demonstrators and achievements;
- the status of technologies developed and their TRL;
- the results of other EC collaborative and coordination programmes; and
- the content of the CS2DP and the list of technologies to be developed during the [CS2] work programme.

Contributions by EASA need to be defined in order to be consistent and compatible with the Horizon 2020 rules as well as with the EC criteria for the funding of agencies and use of public money. The approach already achieved in Horizon 2020 Aviation Safety projects is an option for the engagement of EASA in projects.

For the JU members, the possibility to use the TAC approach (Technical Advisory Contract) is considered still applicable, allowing the CS member to directly contract EASA for supporting activities and be covered as eligible costs. With the new EASA regulations, a higher level of involvement than TAC is expected to be possible, if justified by the need. The formal involvement of EASA as subcontractor following tenders is being explored.

Based on the specific MoC signed on 23 November 2016, periodic meetings between Directors are held, while Technical Coordination meetings and dedicated workshops on different areas are planned on a bimonthly basis.

The areas for joint thematic workshops and involvement of representatives of each Party to other initiatives are the following:

- Environmental impact and noise;
- More electric aircraft and hybrid propulsion;
- Icing;
- Composites and Structural Health Monitoring;
- Modelling for Certification;
- Additive Manufacturing;
- Rotorcraft Operations;
- Safety-related items, like Cabin Air Quality.

Also with EASA, as with SESAR: the exchange of information about the Calls for Proposals and topics of potential interests and synergy will be activated by both Parties, as well as the cross participation and information related to activities of common relevance, like CAEP working groups at ICAO level.

Annexes

A. Abbreviations

A/C:	Aircraft
ACARE:	Advisory Council for Aviation Research and Innovation in Europe
AIR:	Airframe (ITD)
ATA:	Air Transport Association of America
ATM:	Air Traffic Management
CAEP:	Committee on Aviation Environmental Protection
CS:	Clean Sky Programme
CS2:	Clean Sky 2 Programme
CS2DP:	Clean Sky 2 Development Plan
CSMM:	Clean Sky Management Manual
CDR:	Critical Design Review
CfP:	Call for Proposal
CfT:	Call for Tender
CNS:	Communication, Navigation and Surveillance
CoR:	Concept Design Review
CROR:	Counter Rotating Open Rotor
CS2JU (JU):	Clean Sky 2 Joint Undertaking
ECO:	Eco-Design TA
ENG:	Engines (ITD)
ESIF:	European Structural and Investment Funds
FRC:	Fast Rotorcraft (IADP)
FT:	Flight Test/Testing
GAM:	Grant Agreement for Members
GAP:	Grant Agreement for Partners
GRA:	Green Regional Aircraft (ITD)
GRC:	Green RotorCraft (ITD)
GT:	Ground Test/Testing
ITD:	Integrated Technology Demonstrator
IADP:	Innovative Aircraft Demonstrator Platform
JTI:	Joint Technology Initiative
JTP:	Joint Technical Programme
LPA:	Large Passenger Aircraft (IADP)
PDR:	Preliminary Design Review
PPP:	Public-Private Partnership
RIS3:	Regional Research and Innovation Strategies for Smart Specialisation
SAGE:	Sustainable And Green Engines (ITD)
SAT:	Small Air Transport Transverse Activity
SESAR:	Single European Sky Air Traffic Management Research
SFWA:	Smart Fixed Wing Aircraft (ITD)
SGO:	Systems for Green Operations (ITD)
SPD:	Systems & Platform Demonstrators
SYS:	Systems (ITD)
TA:	Transversal Activity
TE:	Technology Evaluator
TP:	Turboprop

B. Detailed Overview of Clean Sky 2 Technology and Demonstration Areas

Detailed overview with the Demonstrator / Technology Streams (state of play December 2017 and all figures are indicative):

Theme	Demonstration area	Programme Area [IADP/ITD/TA]						Demonstrator / Technology Stream	Contribution			Funding
		LPA	REG	FRC	AIR	ENG	SYS		E	M	C	RoM m€
Breakthroughs in Propulsion Efficiency (incl. Propulsion-Airframe Integration)	**Advanced Engine/Airframe Architectures**	✈			✈			UHBR Configuration	✈		✈	**474.8**
								CROR Configuration	✈		✈	
								UHPE integration	✈		✈	
								Advanced engine integration driven fuselage ground demonstrator	✈		✈	
	Ultra-high Bypass and High Propulsive Geared Fans	✈				✈		Ultra High By-pass Ratio engine	✈		✈	
								VHBR – Middle of Market Technology	✈		✈	
								VHBR – Large Turbofan Demonstrator UltraFan™	✈		✈	
								UltraFan Flight Test Demonstration	✈		✈	
								Validation of scaled flight testing	✈		✈	
								Radical Configuration Flight Test Demonstrator	✈		✈	
								Advanced Geared Engine Configuration	✈		✈	
	Hybrid Electric Propulsion	✈						Hybrid Electric Ground Test Bench	✈	✈	✈	
	Boundary Layer Ingestion	✈						Boundary Layer Ingestion	✈		✈	
	Small Aircraft, Regional and Business Aviation Turboprop					✈		Business aviation / short range Regional Turboprop Demonstrator	✈	✈	✈	
								Small Aircraft Engine Demonstrator	✈	✈	✈	
								Small Aircraft Turbine Engine	✈	✈	✈	
Advances in Wings, Aerodynamics and Flight Dynamics	**Advanced Laminar Flow Technologies**	✈			✈			Applications for business jets / regional aircraft: Natural Laminar Flow (NLF) smart integrated wing Laminar Nacelle for Business Jets Leading edge/Wingbox Advanced Laminarity Natural Laminar Flow demonstrator for HTP bizjets NLF LE/Wingbox GBD	✈			**212.6**
								Applications for large passenger aircraft: HLFC on tails large scale ground-based demonstrator Ground-based demonstrator HLFC wing HLFC on tails flight test operation Active flow control flight test demonstrator	✈			

Advances in Wings, Aerodynamics and Flight Dynamics	**Regional Aircraft Wing Optimization**		✈		✈			Full Manufacturing & Test			✈	
								Component manufacturing and testing			✈	
								Innovative Flight Control System with EMAs for Aileron and for Winglet/Wingtip		✈	✈	
								Load Control/Load Alleviation System			✈	
								Demonstrator Power Controller			✈	
								Flying Test Bed#1 (FTB1): Innovative Wing Innovative Flight Control System including EMA for Winglet/Wing	✈	✈	✈	
								Flying Test Bed#2 (FTB2): High Lift Advanced Turboprop On-ground Structural Rig FTB#2 Wing On-ground Actuation Rig FTB#2 Wing On-ground Structural Cockpit FTB#2		✈	✈	
								Code validation demonstration			✈	
								Smart control surfaces			✈	
								Demonstrator Fixed Leading Edge			✈	
								High lift wing			✈	
								Morphing Leading Edge Demonstrator			✈	
								Novel Control			✈	
								Virtual high lift demonstrator			✈	
								Moveables			✈	
Innovative Structural / Functional Design - and Production System	**Advanced Manufacturing**		✈		✈			Advanced multifuntional CFRP for regional aircraft fuselage	✈		✈	**243.6**
								Nacelle Systems Demonstrator	✈		✈	
								Aileron Demonstrator		✈	✈	
								Aileron, fuselage panel jigless assembly	✈		✈	
								Cockpit segment, engine nacelle demonstrators			✈	
								Coupons and subscale components	✈		✈	
								Joints metal - composite	✈		✈	
								Thermoplastic secondary structures	✈		✈	
	Cabin & Fuselage	✈	✈		✈			Advanced integrated Structures		✈	✈	
								Regional Aircraft Fuselage Major Components Demonstrator			✈	
								Regional Aircraft Pax Cabin Major Components Demonstrator		✈	✈	
								Low cost material, process, manufacturing, assembling technologies for regional aircraft fuselage			✈	
								Affordable and low weight regional aircraft pax cabin	✈		✈	
								Door Demonstrator		✈	✈	
								Next Generation Fuselage, Cabin and Systems Integration	✈	✈	✈	
								Next Generation Cabin & Cargo Functions	✈	✈	✈	
								Next Generation Lower Center Fuselage	✈		✈	

	Innovative Solutions for Business Jets				✈			Half Central Wing Box		✈	✈	
								Central Wing Box Panel		✈	✈	
								EWIPS Integration on a business jet flap		✈	✈	
								Low Weight Seat Demonstrator		✈	✈	
								Composite Wing Root Box		✈	✈	
Next Generation Cockpit Systems and Aircraft Operations	**Cockpit & Avionics**	✈	✈				✈	Flight Test Demonstration on LPA Aircraft		✈	✈	**175.8**
								Enhanced Cockpit Large Aircraft		✈	✈	
								Disruptive Cockpit Large Aircraft		✈	✈	
								Extended Cockpit Demonstrations		✈	✈	
								Enhanced functions and technologies ground and flight tests on Business jet		✈	✈	
								Integrated Cockpit for Small Air Transport		✈	✈	
								For regional aircraft: Fly by Wire Regional Active Cockpit Performance/Health Monitoring linked to SHM and to EMA		✈	✈	
	Advanced MRO	✈						Maintenance Service Operations Enhancement Demonstrator		✈	✈	
Novel Aircraft Configurations and Capabilities	**Next-Generation Civil Tiltrotor**			✈	✈			TiltRotor Nose / Cockpit Section		✈	✈	**222.5**
								TiltRotor Cabin Section		✈	✈	
								TiltRotor Tail Section		✈	✈	
								Wind Tunnel Model Test		✈	✈	
								NextGenCTR's Tie Down / Flight Demonstrator (Ground & Flight)		✈	✈	
								NextGenCTR's drive system components and assembly – demonstrator		✈	✈	
								NextGenCTR's wing assembly - demonstrator		✈	✈	
								Engine-nacelle integration - demonstrator		✈	✈	
								Fuel system components - demonstrator		✈	✈	
								Flight control & actuation systems and components - demonstrator		✈	✈	
	RACER Compound Helicopter			✈	✈			Wing for incremental lift & transmission shaft integration		✈	✈	
								Rotorless Tail		✈	✈	
								LifeRCraft doors		✈	✈	
								RACER Flight Demonstrator Integration		✈	✈	
								RACER Airframe Integration		✈	✈	
								RACER Dynamic Assembly Integration		✈	✈	
								RACER On-board Systems Integration		✈	✈	
	Electrical Systems		✈		✈		✈	Smart Integrated Wing Demonstrator (incl. Structure Integrated System)			✈	**150.2**
								Innovative Electrical Wing			✈	
								Power Generation	✈		✈	
								EPGD - Electric-Power Generation and Distribution	✈		✈	

Aircraft Non-Propulsive Energy and Control Systems								Innovative Electrical Network (IEN) - demo on Copper Bird	✈		✈	
								HVDC Power Management Centre Demonstrator for large A/C			✈	
								Advanced Electrothermal Wing Ice Protection Demonstrator			✈	
								Primary In-Flight Ice Detection Systems			✈	
								De-Ice			✈	
								Next Generation Cooling System Demonstrator	✈		✈	
								Thermal Management Demonstration (Avant Test Rig)			✈	
								Advanced Electrical Power Distribution System			✈	
								Mixed Thermal Ice Protection Demonstrator			✈	
								Ultra Low Power Demonstrator			✈	
								Non-Propulsive Energy Optimization for Large Aircraft	✈		✈	
	Landing Systems		✈				✈	Advanced Landing Gear Systems	✈		✈	
								Electrical Nose Landing Gear System Demonstrators	✈		✈	
								Electrical Rotor Landing Gear System Demonstrator	✈		✈	
								Advanced Landing Gear Sensing & Monitoring System Demonstration	✈		✈	
								EMA and brake LG	✈		✈	
								Electrical Landing Gear Systems	✈		✈	
Optimal Cabin and Passenger Environment	**Environmental Control System**		✈				✈	Next Generation EECS Demonstrator for large A/C	✈	✈		**39.7**
								Next Generation EECS Demonstrator for Regional A/C	✈	✈		
								Advanced Systems integration, E-ECS and Thermal Management	✈	✈		
	Innovative Cabin Passenger/Payload systems	✈	✈		✈		✈	Ergonomic flexible cabin		✈	✈	
								Flight test demonstration of active vibration control technologies/noise prediction methods for rear-mounted engines	✈	✈	✈	
								Innovative Cabin and Cargo technologies		✈	✈	
								Human centered cabin design for regional aircraft		✈	✈	
								Comfortable & Safe Cabin for Small Aircraft		✈	✈	
								Novel travel experience		✈	✈	