Decision of the Governing Board adopting the updated Clean Sky 2 Development Plan

THE GOVERNING BOARD OF THE CLEAN SKY 2 JOINT UNDERTAKING,

Having regard to the Council Regulation (EU) No 558/2014 of 6 May 2014 establishing the Clean Sky 2 Joint Undertaking[1] ('Clean Sky 2 JU');

Having regard to the Statutes of the Clean Sky 2 JU as annexed to Council Regulation (EU) No 558/2014 of 6 May 2014, and in particular Article 8(2)(t);

Having regard to the consultation with the Scientific Committee and States Representatives Group dated 11 of October 2019, and their positive outcome;

WHEREAS:

1) The Statutes of the Clean Sky 2 JU confer on the Governing Board the overall responsibility for the strategic orientation and the operations of the Clean Sky 2 JU;

2) In the light of the status of implementation of the Clean Sky 2 Programme, it is deemed appropriate to update the Clean Sky 2 Development Plan;

3) The updated Clean Sky 2 Development Plan should replace the Clean Sky 2 Development Plan adopted by the Clean Sky 2 JU Governing Board decision of 15 December 2017;

4) The scope of the updated Clean Sky 2 Development Plan is mainly to lay out the high-level structure of the Clean Sky 2 technical programme, the main activities and their schedule (including milestones), the key risks and their mitigation, its forecast budget to completion and the way this will be managed;

5) The updated Clean Sky 2 Development Plan includes presents different scope modifications implemented and needed for the execution of the programme until the completion; it includes a revision of the master plan, of the risks and it depicts the financial evolutions which took place, it provides a summary of the progress to date and the forecast until end 2023 based on the technical progress to date on the different ITDs/ IADPs/TAs;

[1] OJ L 169/77, 7.6.2014

HAS DECIDED:

Article 1

The Clean Sky 2 JU Governing Board decision of 15 December 2017 adopting the Clean Sky 2 Development Plan is repealed.

The updated Clean Sky 2 Development Plan set out in the Annex is adopted.

Article 2

The Executive Director shall make the updated Clean Sky 2 Development Plan publicly available on the Clean Sky 2 JU website.

Article 3

This decision shall enter into force on the date following its adoption.

Brussels, 21 November 2019

Stephane Cueille

Chairman of the Governing Board

Annex:

- Updated Clean Sky 2 Development Plan *(ref. CS-GB-2019-11-21 CS2DP)*

Clean Sky 2 Joint Undertaking

DEVELOPMENT PLAN

October 2019

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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.
It aggregates the detailed plan prepared in the different technical areas (e.g IADPs/ITDs/TAs) and it provides a high-level summary and a consolidated view across the Clean Sky 2 Programme.

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 (JTP V5).

The CS2DP provides the strategic framework for following documents:

- Clean Sky 2 JU (Bi-annual) Work Plan, in particular in this case for 2020-2021;
- Annual Budget Plans (ABP);
- Grant Agreements for Members (GAM) for each IADP, ITD and TA;
- Grant Agreements for Partners (GAP).

[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's 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 the Clean Sky Programme (FP7) 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 in the Clean Sky initiative will support the EU aeronautical industry, including the supply chain, to maintain and further develop 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 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 crucial to achieve a greener air transport system.

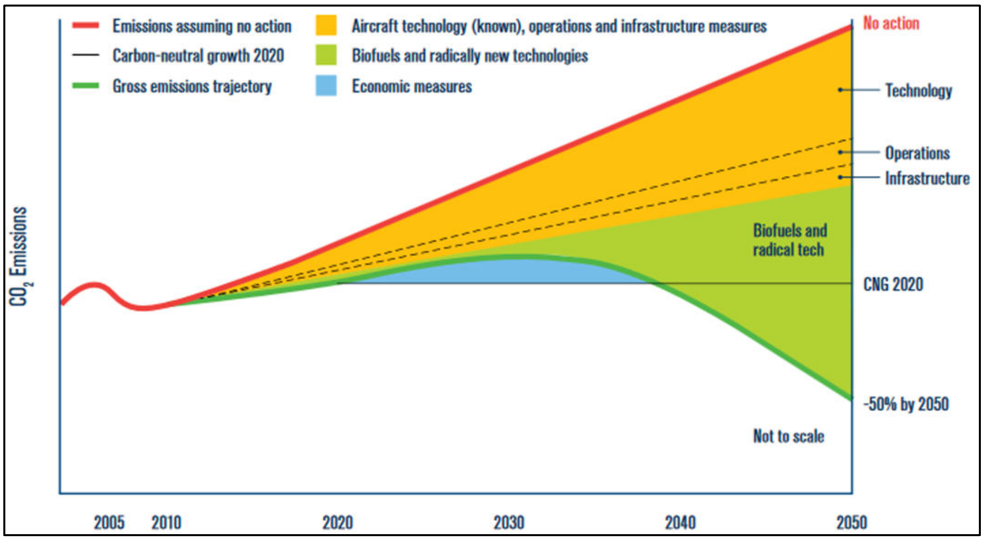


Figure 1: Schematic CO_2 emissions reduction roadmap [Source IATA]

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 a 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 a strong social impact as it facilitates 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 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[5] 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 positively increases 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

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

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[1] 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 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 promoters 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.

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

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 the environmental impact 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 Revenue Passenger Kilometres (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 years have seen important actions taken and agreements reached that will have a bearing on the aviation sector's future perspective, among others:

- 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 in parallel with the developing policies of the Union, often preceding directives and their implementation, as the development cycles for new engines and aircraft 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 affairs confirms:

- the objectives and goals set out 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 are 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 national and regional efforts in aeronautics. Clean Sky 2 continued in 2019 to actively engage with Member States and European regions seeking and building synergies with their investments through the national/regional funds, in particular through the European Structural and Investment Fund. Please refer to chapter 11.1.
Aviation is the result of the confluence of four main areas: aeronautics, airports, air traffic management and airlines, each with its own 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 setup 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 11.2 and 11.3.

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.

Figure 1: 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-€400billion and the associated spill-over is of the order of €400billion. 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 Clean Sky with the CS2 Programme is even more compelling. CS2 technologies will bring a potential saving of 4 billion tonnes of CO_2 from roughly 2025 through to 2050 in addition to approximately 3 billion tonnes achievable as a consequence of Clean Sky.

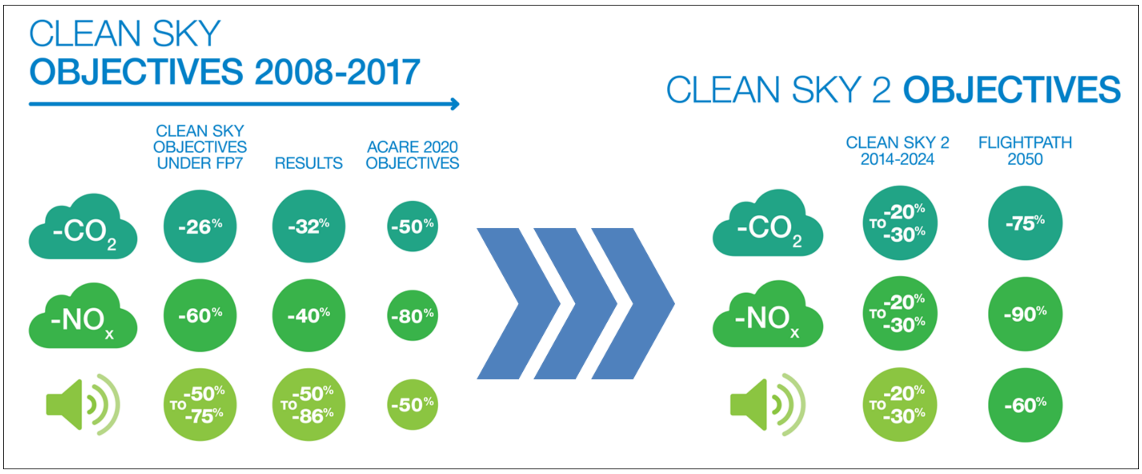


Figure 2: Transition from Clean Sky (FP7) to Clean Sky 2 (Horizon 2020)

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

Clean Sky 2 focuses and allows the coordination of aviation stakeholders' initiatives and investments at a European scale. It gives 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 reduces 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 attracts 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 involved 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 to meet 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.

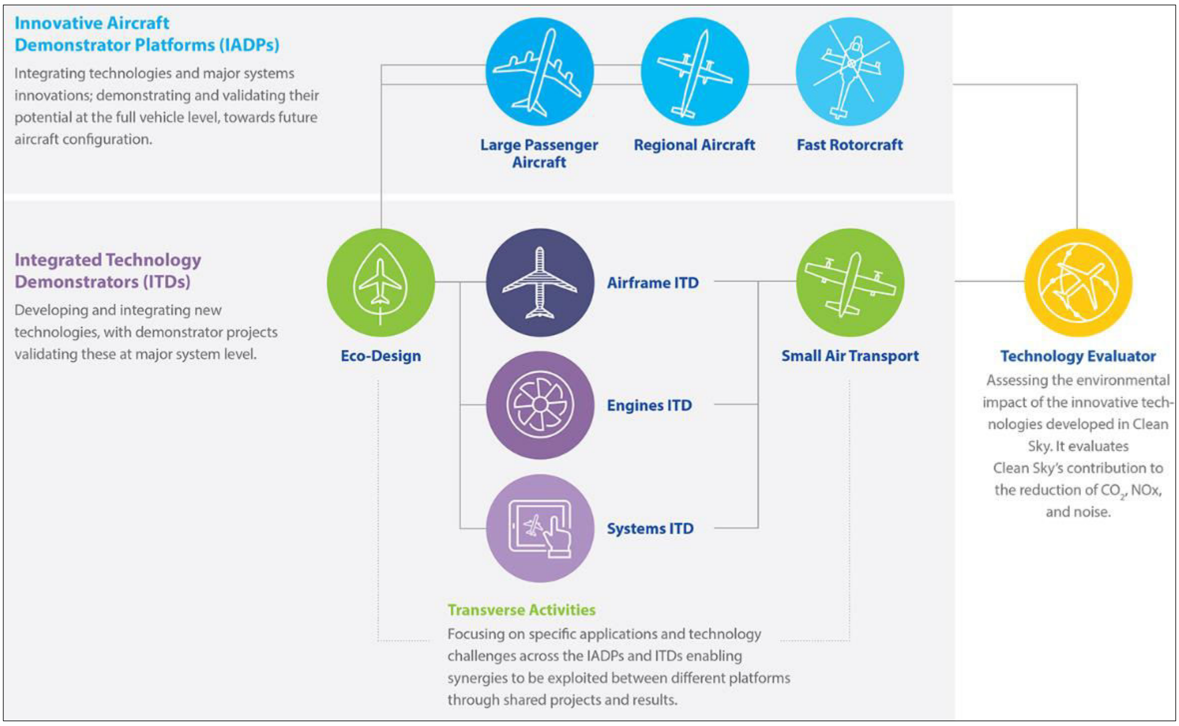


Figure 3: Clean Sky 2 Programme Logic and Set-up

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 Calls 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 maturation 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 coordination 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. 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 [TE]** 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 were 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 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 may also 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 which set out 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.

Taking into account that there are roughly 600 participants in the original Clean Sky Programme, we expect 800-1000 for Clean Sky 2. 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[4]	2025+	35 to 40%	> 50%	60 to 70%	5
Regional Multi-mission 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	2030	20%	20%	20%	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

[4]ATR 72 airplane, latest SOA Regional A/C in-service in 2014 (technological standard of years 2000), scaled to 90 Pax

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	Funding
		LPA	REG	FRC	AIR	ENG	SYS	E	M	C	RoM	RoM m€
Breakthroughs in Propulsion Efficiency (incl. Propulsion-Airframe Integration)	Advanced Engine/Airframe Architectures	✈			✈			✈		✈	532.3	93.9
	Ultra-high Bypass and High Propulsive Efficiency Geared Turbofans	✈			✈	✈		✈		✈		354.0
	Hybrid Electric Propulsion	✈						✈	✈	✈		27.9
	Boundary Layer Ingestion	✈						✈		✈		14.2
	Small Aircraft, Regional and Business Aviation Turboprop					✈		✈	✈	✈		42.3
Advances in Wings, Aerodynamics and Flight Dynamics	Advanced Laminar Flow Technologies	✈			✈			✈		✈	180.0	98.2
	Regional Aircraft Wing Optimization		✈		✈			✈	✈	✈		81.7
Innovative Structural / Functional Design - and Production System	Advanced Manufacturing		✈		✈			✈		✈	178.183	29.2
	Cabin & Fuselage	✈	✈		✈			✈	✈	✈		136.3
	Innovative Solutions for Business Jets				✈				✈	✈		12.7
Next Generation Cockpit Systems and Aircraft Operations	Cockpit & Avionics	✈	✈				✈	✈	✈	✈	158.578	146.6
	Advanced MRO	✈							✈	✈		12.0
Novel Aircraft Configurations and Capabilities	Next-Generation Civil Tiltrotor			✈	✈				✈	✈	222.563	109.5
	RACER Compound Helicopter			✈	✈				✈	✈		110.1
	Regional Innovative Configuration		✈					✈	✈	✈		2.9
Aircraft Non-Propulsive Energy and Control Systems	Electrical Systems		✈		✈		✈	✈		✈	157.985	109.3
	Landing Systems		✈				✈	✈		✈		32.2
	Non-Propulsive Energy Optimization for Large Aircraft	✈						✈		✈		14.5
	Low Power WIPS		✈					✈		✈		2.1
Optimal Cabin and Passenger Environment	Environmental Control System		✈				✈	✈	✈		58.9929	20.8
	Innovative Cabin Passenger/Payload Systems	✈	✈		✈		✈	✈	✈	✈		38.2
Eco-Design		✈	✈	✈	✈	✈	✈	✈		✈	39.1	39.1
Enabling & Long-Term Technologies		✈	✈	✈	✈	✈	✈	✈	✈	✈	136.5	136.5

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

Notes:

(1) Enabling Technologies are aligned with the major thematic research and technology development areas as shown but are considered as standalone; they are contributing to enhance the environmental performance of future A/C without resulting on a demonstrator onto an ITD/IADP.

(2) The total funding of these different demonstration areas is of 1664M€. The difference with the CS2 funding Programme of 1716M€ corresponds to the effort required to manage the different activities and to run the Technology Evaluator.

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 key goals of the Clean Sky 2 Regulation 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 novel open rotor (CROR) engine architecture to advanced Ultra-High Bypass Ratio (UHBR) turbofan to hybrid [and/or distributed] propulsion concepts, exploring the potential configurations that exploit the potential of Boundary Layer Ingestion (BLI). In parallel with these 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 principal aircraft systems. 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[1]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 integrating and testing 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 6, for a certain number of technologies.

- **Platform 3 "Next Generation Aircraft Systems, Cockpit and Avionics"** has a clear focus to develop and demonstrate a next generation cockpit and navigation suite, addressing large aircraft, regional aircraft and business jets. Based on the results of a number of projects which are currently on-going or to be started, Platform 3 should allow functions and enabling technologies which are emerging from individual developments, aimed to aircraft safety enhancement and robust operations, to be integrated and validated into enhanced cockpits and new disruptive cockpit concepts in several demonstrators.
  The Regional Aircraft and Business Jet aircraft enhanced cockpit demonstrators will integrate functions targeting flight crew workload reduction, mainly through advanced pilot's interfaces such as innovative pilot's displays and multimodal devices, Pilot monitoring system, as well as enhanced navigation means and support to aircraft status management, enabled by appropriate optimized avionics technology.
  The Large Aircraft disruptive cockpit operations concept demonstrator will implement a "Human Centric" approach to operate the aircraft and integrate innovative functions and Human-Machine interface technologies to reduce crew workload, improve situational awareness and support increased navigation functions availability, robustness and autonomy, in line with relevant SESAR enabling functions and technologies.
  Corresponding functions to be integrated in the demonstrators will be developed in LPA Platform 3 with leaders and Core Partners and as well in ITD Systems and in other national R&T framework. With the core of Platform 3 demonstrators being ground-based demonstrators, selected functions and technologies will be brought to flight test demonstration when justified, either on Large Aircraft or on business jet.

  In addition the development of value-driven end-to-end maintenance service architectures and applications suite will be defined and demonstrated, enabling the replacement of scheduled maintenance by efficient value driven 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 achieved in CS1 GRA. 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 is arranged along "Waves" and developed through roadmaps defined to satisfy the high-level requirements of the future Highly-Efficient Next Generation Regional Aircraft, the configuration of which are developed at conceptual

[1]Air Transport Association (ATA)

level in a dedicated work package. Such work package includes also preliminary conceptual studies and experimental activities aimed to explore hybrid-electrical regional aircraft configurations.

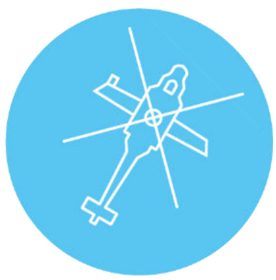
To increase synergies and cross-fertilisation across the different ITDs and IADPs, some of the above technological roadmaps will be shared with the "streams" of the Airframe ITD and with the developments of sub-systems and systems planned inside the Systems and Engines ITDs. The Demonstration Programme 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 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.
- **Outer Wing Box** On-ground demonstrator dedicated to validation of design and of innovative low cost and low weight structural technologies integration at full scale/full size through structural static and fatigue tests.
- **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 minimise the environmental impact through eco-design and energy consumption optimisation 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.

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 the 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 the EU's economy and job 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 to demonstrate 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 flight-worthy 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 campaigns 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 to improve high speed efficiency and minimise 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.

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 made through Clean Sky (estimated at 75% of the relevant part of the initial ACARE goals for 2020).[redacted] 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 potential.
- **Advanced Laminar Flow** as a key technological path to further progress on drag reduction, to be applied to major drag contributors (nacelle and wings); this Technology Stream aims to increase 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 optimise 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.

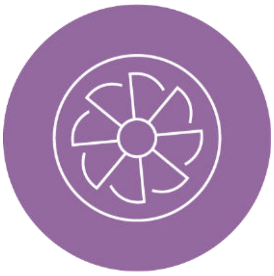
In addition to these technology streams, the **Eco-Design** branch of the Airframe ITD WBS was established in 2018 by merging former WP A-3.4 Eco-Design for Airframe and WP B-3.6 New

Materials and Manufacturing. The ECO TA link was added to ensure the communication to ECO TA and the internal coordination of activities linked to ECO TA.

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 A**: Demonstration of airframe technologies focused on **High Performance & Energy Efficiency (HPE);** this Activity Line is 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 B**: Demonstration of airframe technologies focused on **High Versatility and Cost Efficiency (HVC);** this Activity Line is 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 C: Demonstration of airframe technologies focused on Eco-Design (ECO); this** Activity Line is devoted to the development and maturation of technologies to reduce the environmental impact for the non-operational phases of the aircraft lifecycle. Technologies will be developed to TRL 4/5 and ground demonstrators incorporating the most promising ones will then be manufactured and tested, thus allowing a maturation of technologies to TRL 5-6.

7.5. Engines ITD [ENG]



The European engine sector currently has about 40% of the global market and H2020/Clean Sky 2 will allow it to at least maintain that share. At this scope, Safran, MTU and Rolls-Royce have secured corporate commitment to build on the success of SAGE to validate more radical engine architectures to a position where their market acceptability is not determined by technology readiness. The platforms or demonstrators of these engines architectures are summarized below:

- **Ultra-High Propulsive Efficiency (UHPE) demonstrator addressing Short / Medium Range aircraft market, 2014-2023:** Design, development and ground test of a propulsion system demonstrator to validate, Low Pressure Modules & Systems and Nacelle Technologies.
- **Business aviation / Short range regional Turboprop Demonstrator, 2015-2022:** Design, development and ground testing of a new turboprop engine demonstrator.
- **Advanced Geared Engine Configuration (HPC and LPT technology demonstration), 2015-2023:** Design, development and ground testing of a new demonstrator to reduce CO_2 emissions and noise as well as engine weight.
- **VHBR Large Turbofan demonstrator, 2014-2023:** The trend to very high Bypass Ratio engines requires technology development across a broad range of complex gas turbine systems, from fan inlet through the complete compression, combustion and turbine to exhaust. Rolls-Royce will lead the development and demonstration of technologies in low-speed low pressure-ratio fan, aerodynamic and structural design of high efficiency multi-stage Intermediate Pressure turbines, integration of novel accessory and power gearbox.
- **Very High Bypass Ratio (VHBR) Middle of Market Turbofan technology, 2014-2023:** Design, development, build, ground test and flight test of an engine to demonstrate key technologies at a scale suitable for large engines. The Rolls-Royce Advance 3 engine core will be demonstrated and provide the core gas generator used for the demonstrator.
- **Light weight and efficient jet-fuel reciprocating engine:**

For the small aero-engine demonstration projects related to SAT [Small Air Transport]: Development of an alternative 6-cylinder engine architecture, integration and optimization of aircraft installation for such an engine and technologies improvements on core engine (power density), turbocharger, propeller and engine control system. Ground test of engine demonstrator up to permit-to-fly.

- **Reliable and more efficient operation of small turbine engines**: for the small aero-engine demonstration projects related to SAT [Small Air Transport]: Development and demonstration of technologies in each area to deliver validated compression, combustion and power turbine systems for small turboprop engines, as well as optimized propeller.
- **ECO design:** Life Cycle inventories for several engine manufacturing technologies will be provided to Eco TA for Life Cycle Analysis allowing to fully quantify and potentially optimize the actual eco-benefit and Life Cycle Impact of these technologies.

Engines ITD has the objective to deliver substantial improvements in engine technology; in particular the following challenges will be addressed:

- Development of system level technologies that are a step change from current state-of-the-art engine architectures and capable of delivering substantial reductions in emissions.
- An incremental approach to TRL progression, utilizing design studies and rig tests to explore and understand the technologies under development, their system interactions and the risks associated with their implementation. The ultimate goal of the project is to achieve TRL6 on some of the architectures.
- The leadership will be provided by Rolls-Royce, Safran and MTU but participation in the programme being extended to encompass both large tier 1 suppliers and more specialized companies as well as academia and research organizations.

7.6. Systems ITD [SYS]

While systems and equipment account for only 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, and weight.
- Enablers for other innovations, for example “bleedless” power generation and actuators, which 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,[5] the full chain of electrical power generation, distribution and usage, and [6] Cabin and Cargo systems technologies. The outcomes will be demonstrated system architectures ready to be customised and integrated into 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 are also defined to mature processes and technologies with potential impact on all systems, either during development or operational use. Examples of these transverse actions are development tools and simulation, eco-design etc.

A link with LPA Platform 3 and SAT is established to ensure the alignment do respective demonstrators.

7.7. Small Air Transport Transverse Activity [SAT]

The Small Air Transport (SAT) is a Transversal Activity (TA) in the frame of Clean Sky 2 research project. SAT deals with small general aviation and commuter/feeder aircraft and their technology needs: ‘fixed wing’ aircraft between 4 and 19 seats.
The SAT Initiative proposed in Clean Sky 2 represents the R&D (Research & Development) interests of European manufacturers of small aircraft used for passenger transport and for cargo transport, belonging to EASA´s CS-23 (European Aviation Safety Agency Certification Specifications-23) regulatory base. This will include dozens of industrial companies (many of which are SMEs, i.e. Small or Medium size Enterprises), research centres and universities. The community covers the full supply chain, i.e. aircraft integrators, engine and systems manufacturers and research organizations.
SAT main goal is to meet the Flightpath 2050 target whereby "90% of travellers within Europe are able to complete their journey, door-to-door within 4 hours", improving overall European air mobility.
Mobility, in fact, is a key to answer many societal needs, being essential to connect people, to provide additional business opportunities, to increase society’s health and to ease trans-national employment.
Focusing on small aircraft, SAT will be able to guarantee a smarter use of the available ground infrastructures, making the operation of small aircraft economically viable.
A reduction of operating cost of Small Aircraft transport will open the market, contributing to improve mobility in Europe, connecting small cities and helping to reduce flight time, offloading surface transport, thus increasing the overall mobility of European society.
SAT focuses on market innovations to reduce operational cost and environmental impact, ensuring good operational safety levels as well, to unlock the potential offered by small regional airports, which are closer and more accessible to the travelling society.

Since the operation of small aircraft need only little or no additional infrastructural investments, it opens many opportunities for regional growth and employment, especially in remote areas far from big airports or with limited or absent road and railway connections to bigger cities.
To reach its main goals, two different platforms have been designed inside SAT TA: a Reference and a Green aircraft.
The Reference aircraft is a virtual aircraft designed considering 2014 technologies with an existing engine assuring the requested take-off power.
To enhance convergence towards an optimal and consistent Green aircraft, three different design loops will be performed by integrating key technologies developed in the frame of Clean Sky 2 Integrated Technology Demonstrators (ITDs):

- AIRFRAME ITD - Low cost composite wing box and engine nacelle using Out of Autoclave (OoA) technology, Liquid Resin Infusion (LRI) and advanced automation process.
- AIRFRAME ITD - Innovative high lift devices, allowing aircraft operations from short airfields (<800m).
- AIRFRAME ITD - Affordable small aircraft manufacturing of metallic fuselage by means of Friction Stir Welding (FSW) and Laser Metal Deposition (LMD).
- SYSTEM ITD - Affordable fly-by-wire architecture for small aircraft (CS23 certification rules).
- SYSTEM ITD - More electric systems replacing pneumatic and hydraulic aircraft systems (high voltage Electrical Power Generation and Distribution System, low power de-ice system, landing gear and brakes).
- SYSTEM ITD - Advanced avionics for small aircraft, to reduce pilot workload, paving the way for single pilot operations for 19 seats.
- SYSTEM ITD - Advanced cabin comfort with new interiors materials and more comfortable seats.
- ENGINE ITD - New generation of turboprop engine with reduced fuel consumption, emissions, noise and maintenance costs for 19 seats aircraft.
- ENGINE ITD - Alternative diesel engine option for small 9 seats commuter aircraft.

7.8. Eco-Design Transverse Activity [ECO]

The Eco Design (ECO) is a Transversal Activity (TA) in the frame of Clean Sky 2 project.

The Eco Design approach consists of integrating environmental criteria over the different phases of a product's lifecycle. Environmental protection is and will be more and more a key driver for the aviation industry as a whole. The challenge with respect to the environment is to reduce continuously the environmental impact in the face of continuing expansion in demand for aviation.
ECO is the only contributor to meet the Flightpath 2050 target whereby "Air vehicles are designed and manufactured to be recyclable", improving overall European aircraft industry environmental compliance. Environmental compliance, in fact, is key to answer also societal needs, being people more conscious of environmental aspects, to provide additional business opportunities, to increase society's health and to ease the compliance to emerging regulations.

Figure: Closed Life Cycle Approach provided through the Clean Sky Programme circular economy model

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 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.

7.9. Technology Evaluator [TE]

The Technology Evaluator (TE) will monitor and assess 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, the benefits brought about by 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, and 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 instrument's 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. The TE will also look into strengthening collaboration with EUROCONTROL and a peer-review of TE's environmental assessment methodology by EUROCONTROL and/or CAEP (ICAO Committee on Aviation Environmental Protection) will be established.

8. Master Plan

Since 2017 (date of the last revision of the plan), the plan has remained stable in term of number of demonstrators as their overall number remained roughly unchanged (102 instead of 101). The effort devoted to different themes was reshuffled in order to maximise benefits arising from the different areas of demonstration against the environmental objectives, to increase the effort towards key technologies considered promising for future Aircraft generation (such as electric propulsion) , and to keep investing in long-term technologies. These adaptations correspond to roughly 8% of the overall CS2 operational funding.

The main areas where the effort was increased are the following:

- Breakthrough in propulsion efficiency
- Aircraft non propulsive energy and control systems
- Optimal Cabin and passenger environment
- Long term enabling technologies addressing future challenges (f. instance full and hybrid distributed electrical propulsion systems)

The effort in other themes was reduced to keep the overall funding variations neutral. Over the last 2 years, several technical gates (TRL3, PDR, CoDR) have been passed across the different themes, providing a better understanding of technical challenges ahead of us until completion of the programme.

In addition, some Members strategic decisions took place from 2017, leading to adapt the programme content in some areas (for instance, the propulsion efficiency domain with the re-orientation of open rotor activities). Therefore, the master was adapted to this new context, with extension of the duration of certain activities until 2023 and with revision of the maturity of the work at completion.

The maturity plan of the 102 demonstrators broken down in 7 majors themes is now as follows:

- 9 demos are planned at TRL3 at programme completion
- 11 demos are planned at TRL4 at programme completion
- 46 demos are planned at TRL5 at programme completion
- 36 demos are planned at TRL6 at programme completion

Overall, the CS2 Programme schedule is delayed by a year when compared to 2017. Indeed, many activities suffered from a good understanding of key technical challenges at the beginning of the Programme and targeted too ambitious objectives (time wise). Indeed, the level of understanding was not deep enough at that time in absence of reviews yet passed or completed (such as PDR or CDR or certain TRL gates). Therefore, the estimate of the effort needed to carry out the activities lacked credibility in 2017 and this situation led to underestimate the effort required to meet Programme objectives. A complete review of the resource planning and assessment of planning objectives took place in the course of 2019. The proposed master plan as it stands at mid-term of the Clean Sky 2 Programme is deemed more robust with a higher level of confidence.

CS2 Programme results will start being delivered from 2020 with a significant ramp-up in 2021. One fifth of the demonstrators will be completed in 2024, the final year of the CS2 Programme and they will deserve a specific attention to remain on track. The costs of demonstrators will be carefully monitored in order to get Members' commitments fulfilled with potentially additional support from national programmes/regional or self-investment. Discussions will take place on case by case when problems arise to assess the situation and the proposed recovery scenario.

State of play as of September 2019

CDR · PDR · CoR · FT · Testing/GT · ET = Enabling Technology

Theme	Demonstration Area	Demonstrator /Technology Streams	Number of ETs	TRL at End	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
					Demonstrator /Technology Streams Maturing Over Time									
Breakthroughs in Propulsion Efficiency (incl. Propulsion-Airframe Integration)	Advanced Engine/Airframe Arichitectures	LPA-01-D13: UHBR Short Range Integration	4	5										
				TRL Maturity				TRL2		TRL3	TRL4		TRL5	
		LPA-01-D1: Enabler for Integrated Open Rotor Design	2	4										
				TRL Maturity								TRL3		TRL4
		LPA-01-D2: Advanced Rear-end	7	6										
				TRL Maturity				TRL2			TRL3	TRL4	TRL5	
		LPA-01-D16: Common Technology Bricks for Future Engines	5	5										
				TRL Maturity							TRL3	TRL4		TRL5
		AIR-D3-3 UHBR integration [WP A-1.2]	1	6										
				TRL Maturity					TRL3	TRL4		TRL5		TRL6
	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	5										
				TRL Maturity								TRL4		TRL5
		LPA-01-D10: UltraFan Flight Test Demonstration	4	6										
				TRL Maturity					TRL3		TRL4		TRL5	TRL6
		LPA-01-D3: Validation of scaled flight testing	1	5										
				TRL Maturity				TRL3		TRL4		TRL5		
	Hybrid Electric Propulsion	LPA-01-D9: Hybrid Electric Ground Test Bench	4	6										
				TRL Maturity				TRL3	TRL4		TRL5			TRL6
		REG WP1 - Hybrid/Electrical Regional Aircraft Configuration	3											
				TRL Maturity						TRL2			TRL3	
	Boundary Layer Ingestion	LPA-01-D14: Boundary Layer Ingestion	1	3										
				TRL Maturity									TRL3	
	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			
		REG WP2.3 - WTT Demonstrator for the Innovative Propeller	8											
				TRL Maturity							TRL3	TRL4	TRL5	

State of play as of September 2019

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

Theme	Demonstration Area	Demonstrator /Technology Streams	Number of ETs	TRL at End	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
					Demonstrator /Technology Streams Maturing Over Time									
Advances in Wings Aerodynamics and Flight Dynamics	Advanced Laminar Flow Technologies	AIR-D3-7 NLF smart integrated wing [WP A-2.2]	1	6					◇				△	
				TRL Maturity			TRL 3/4	TRL4			TRL5		TRL6	
		AIR-D3-10/11/12 Extended laminarity [WP A-2.3]	1	4										
				TRL Maturity			TRL3						TRL4	
		LPA-01-D11: Active flow control flight test demonstrator	2	5				◇	◇		△			
				TRL Maturity						TRL3	TRL4	TRL5		
		LPA-01-D4: HLFC on tails large scale ground-based demonstrator	5	5					◇		◇	△		
				TRL Maturity						TRL4		TRL5		
		LPA-01-D5: Natural Laminar Flow demonstrator for HTP bizjets	4	4					◇ ◇	△				
				TRL Maturity					TRL3		TRL4			
		LPA-01-D6: Ground-based demonstrator HLFC wing	7	4								◇	◇	△
				TRL Maturity						TRL2		TRL3		TRL4
		AIR-D3-6/8 BJ Laminar Nacelle / NLF BJ HTP [WP A-2.1/A-2.2]	1	5					◇ ◇	△				
				TRL Maturity			TRL3		TRL4	TRL5				
		AIR-D3-9 NLF Leading Edge GBD [WP A-2.2]	1	5					◇	◇△				
				TRL Maturity		TRL3	TRL 3/4	TRL4		TRL5				
	Regional Aircraft Wing Optimization	AIR - Component manufacturing and testing [WP B-1.2]	5	6							△			
				TRL Maturity				TRL3		TRL4		TRL5	TRL6	
		REG WP2.1 - WTTs demonstrators for Innovative AirVehicle Technologies (DN, Morphing Flap, NLF, …)	5					◇	◇	◇	△			
				TRL Maturity			TRL3			TRL4	TRL5			
		REG D1 - Adaptive Wing Integrated Demonstrator – Flying Test Bed#1 (FTB1)	6	6					◇		◇	△△		
				TRL Maturity						TRL3	TRL4	TRL5	TRL6	
		REG D1 - Adaptive Wing Integrated Demonstrator – Outer Wing Box Ground Test	2	5					◇	◇			△	
				TRL Maturity		TRL3				TRL4			TRL5	
		REG D2 - Integrated Technologies Demonstrator – Flying Test Bed#2 (FTB2)	5	6				◇	◇		△	△	△	△
				TRL Maturity				TRL3	TRL4	TRL5	TRL6			TRL6
		AIR-D3-15 Icing code for de-icing [WP A-4.1.1.3]	1	5										
				TRL Maturity						TRL3	TRL4		TRL5	
		AIR-D2-7 Innovative movables [WP A-4.1.2]	1	5										
				TRL Maturity							TRL3		TRL4	TRL5
		AIR Composite Fixed Leading Edge [WP A-4.1.1.1-3]	2	4										
				TRL Maturity			TRL3				TRL4			
		AIR Electronic Power controler for Copper Bird Rig [WP A-4.1.1.4]	1	5										
				TRL Maturity					TRL3		TRL4	TRL5		
		AIR - Full Manufacuring & Test [WP B-1.2]	4	6							△			
				TRL Maturity				TRL3			TRL5	TRL6		
		AIR - High lift wing [WP B-2.2]	1	6							△			
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		AIR - Morphing Leading Edge Demonstrator	3	6							△			
				TRL Maturity						TRL4	TRL5	TRL6		
		AIR-D3-17/18/19 Novel Control [A-4.2]	1	6										
				TRL Maturity			TRL3	TRL4				TRL6		
		AIR - ON-GROUND ACTUATION RIG FTB#2 WING [WP B1.4, B3.2]	7	6							△			
				TRL Maturity				TRL3		TRL4	TRL5		TRL6	
		AIR - ON-GROUND STRUCTURAL COCKPIT FTB#2 [WP B-3.3]	4	5							△			
				TRL Maturity				TRL3		TRL4	TRL5			
		AIR - ON-GROUND STRUCTURAL RIG FTB#2 WING [WP B-1.3, B2.2]	13	6							△			
				TRL Maturity				TRL3		TRL4	TRL5		TRL6	
		AIR - Virtual high lift demonstrator [WP B-2.2]	1	6							△			
				TRL Maturity						TRL3		TRL4		

State of play as of September 2019

CDR / PDR / CoR — FT / Testing/GT — ET = Enabling Technology

Theme	Demonstration Area	Demonstrator /Technology Streams	Number of ETs	TRL at End	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Innovative Structural / Functional Design - and Production System	Advanced Manufacturing	AIR - Aileron, fuselage panel jigless assembly [WP B-3.4]	1	6										
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		AIR - Cockpit segment, engine nacelle demonstrators [WP B-3.4]	1	6										
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		AIR - Joints metal - composite [WP B-3.4]	1	6										
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		AIR - Demonstrator z [WP B-3.1 Nacelle Systems Demonstrator]	1	5										
				TRL Maturity					TRL3	TRL4		TRL5		
		AIR - Coupon and subscale components [WP B-1.2]	4	6										
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		AIR-D2-3 Flaperon [WP-A-3.1]	1	6										
				TRL Maturity					TRL3	TRL4	TRL5		TRL6	
	Cabin & Fuselage	REG D3 - Full scale innovative Fuselage & Pax Cabin demonstrator (Structural demonstration)	3	6										
				TRL Maturity		TRL3			TRL4	TRL5		TRL6		
		REG D3 - Full scale innovative Fuselage & Pax Cabin demonstrator (Comfort/Thermal demonstrations)	1	6										
				TRL Maturity		TRL3				TRL4	TRL5		TRL6	
		AIR-D1-1 Door Demonstrator [WP-A-3.3]	1	6										
				TRL Maturity			TRL3			TRL4		TRL5	TRL6	
		AIR - WP B-3 Advanced integrated Structures	1	6										
				TRL Maturity				TRL3		TRL4	TRL5	TRL6		
		AIR - 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	5										
				TRL Maturity							TRL3	TRL4		TRL5
		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	4										
				TRL Maturity								TRL2	TRL3	TRL4
	Innovative Solutions for Business Jets	AIR-D2-1 BJ Composite Wing Root Box [WP-A-3.1]	1	5										
				TRL Maturity					TRL3	TRL4	TRL5			
		AIR-D2-6 BJ Composite Central Wing Box Panel [WP-A-3.3]	1	3										
				TRL Maturity			TRL3							
		AIR-D2-5 BJ Composite Half Central Wing Box [WP-A-3.3]	1	3										
				TRL Maturity			TRL3							
		AIR-D3-13 EWIPS Integration on a BJ Flap [WP A-4.1]	1	5/6										
				TRL Maturity			TRL3			TRL4	TRL6			
		AIR-D2-12 Full scale mock-up of the BJ office centered cabin [WP A-5.2]	1	4/5										
				TRL Maturity					TRL3	TRL4		TRL4/5		

Demonstrator /Technology Streams Maturing Over Time

		State of play as of September 2019			◆ 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**
Next Generation Cockpit Systems and Aircraft Operations	Cockpit & Avionics	SYS - D23. Affordable future avionic solution for SAT	1	5			◇		◆				△	
				TRL Maturity			TRL3			TRL4		TRL5		
		SYS - D24 Enhanced vision & awareness	1	5			◇			◆	△			
				TRL Maturity			TRL3				TRL4	TRL5		
		SYS - D25 Integrated modular communications	1	5				◇			◆		△	
				TRL Maturity		TRL2		TRL3			TRL4		TRL5	
		LPA-03-D1: Disruptive Cockpit Large Aircraft	10	4/5						◇		◆	△	
				TRL Maturity								TRL 3		TRL4/5
		LPA-03-D2: Regional Active Cockpit	7	5				◇	◆	△				
				TRL Maturity					TRL3		TRL4	TRL5		
		LPA-03-D3: Enhanced functions and technologies ground and flight tests on business jet	7	6							△			
				TRL Maturity					TRL3		TRL4	TRL5		
		SYS - D1 Extended Cockpit Demonstrations	9	5				◇		◆	△			
				TRL Maturity		TRL2		TRL3		TRL4	TRL5			
	Advanced MRO	LPA-03-D4: Maintenance service operations enhancement demonstrator	14	4				◇	◆	△				
				TRL Maturity			TRL2		TRL3	TRL4				
Novel Aircraft Configurations and Capabilities	Next-Generation Civil TILTROTOR	FRC - Next-Generation Civil TILTROTOR	11	6					◇		◆		△	▲
				TRL Maturity						TRL3	TRL4		TRL5	TRL6
	RACER Compound Helicopter	FRC - RACER Compound Helicopter	14	6			◇			◆	△ ▲			
				TRL Maturity					TRL3	TRL4	TRL5		TRL6	
	Regional A/C Advanced Config.	REG WP1 - TP90 Pax Configuration	All REG Ets for TP90									◇		
				TRL Maturity				TRL3		TRL4		TRL5		
	Regional A/C Innovative Config.	REG - Long Term (TP130 pax Configuration)	All REG Ets for 130 pax							◇				
				TRL Maturity				TRL2		TRL3				

State of play as of September 2019

CDR FT
PDR Testing/GT
CoR ET = Enabling Technology

Theme	Demonstration Area	Demonstrator /Technology Streams	Number of ETs	TRL at End	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
					Demonstrator /Technology Streams Maturing Over Time									
Aircraft Non-Propulsive Energy and Control Systems	Electrical Systems	REG D4 - Iron Bird	3	5										
				TRL Maturity						TRL3	TRL4	TRL5		
		REG WP2.3 - IWT Demonstrator for the Low Power WIPS	1											
				TRL Maturity						TRL3	TRL4	TRL5		
		SYS - D18. Fly by Wire	2	5										
				TRL Maturity			TRL2		TRL3		TRL4	TRL5		
		SYS - D20. Low power de-ice for SAT	1	5										
				TRL Maturity					TRL3		TRL4	TRL5		
		SYS - D15. Primary In-Flight Ice Detection Systems	2	6										
				TRL Maturity					TRL3	TRL4	TRL5	TRL6		
		SYS - D14. Advanced Electrothermal Wing Ice Protection Demonstrator	3	6										
				TRL Maturity				TRL3		TRL4		TRL5	TRL6	
		SYS - D3. Smart Integrated Wing Demonstrator	1	5										
				TRL Maturity				TRL3		TRL4		TRL5		
		SYS - D4. Innovative Electrical Wing	2	6										
				TRL Maturity				TRL4			TRL5		TRL6	
		SYS - D10. HVDC Power Management Centre Demonstrator for large A/C	1	5*										
				TRL Maturity					TRL3		TRL4			TRL5
		SYS - D9. Innovative Electrical and control/Command Networks for distribution systems - Demonstration	3	5										
				TRL Maturity					TRL3			TRL4	TRL5	
		SYS - D19. Electrical power generation and distribution for SAT	2	5										
				TRL Maturity					TRL3	TRL4		TRL5		
		SYS - D13. Next Generation Cooling system Demonstator	2	6										
				TRL Maturity						TRL 3		TRL 4	TRL 5/6	
		SYS - D16. Thermal Management demonstration (Avant Test Rig)	2	6										
				TRL Maturity							TRL3	TRL4	TRL5	TRL6
		AIR-D3-16 Ultra low power ice protection [WP A-4.1.1.6]	1	5/6										
				TRL Maturity					TRL 3	TRL4		TRL4/5		
		SYS - D8. Non propulsive energy generation	4	5										
				TRL Maturity				TRL3		TRL4	TRL5			
	Landing Systems	SYS - D17. Advanced Landing Gear Sensing & Monitoring System	1	5										
				TRL Maturity			TRL3		TRL4		TRL5			
		SYS - D21. EMA and brake LG	1	5										
				TRL Maturity						TRL3	TRL4	TRL5		
		SYS - D5. Advanced Landing Gear Systems	5	6										
				TRL Maturity					TRL3	TRL4	TRL5	TRL6		
		SYS - D6. Electrical Nose Landing Gear System	2	6										
				TRL Maturity			TRL3	TRL4	TRL5		TRL6			
		SYS - D7. Electrical Rotorcraft Landing Gear System	3	4										
				TRL Maturity			TRL3	TRL4						
	Non-Propulsive Energy Optimization	LPA-01-D15: Non-Propulsive Energy Optimization for Large Aircraft	4	5										
				TRL Maturity				TRL2		TRL3		TRL4	TRL5	
Optimal Cabin and Passenger Environment	Environmental Control System	SYS - D11. Next Generation EECS Demonstrator for large A/C	1	6										
				TRL Maturity					TRL3			TRL4	TRL5	TRL6
		SYS - D12. Next Generation EECS Demonstrator for Regional A/C	1	4										
				TRL Maturity						TRL3	TRL4		TRL5	
	Innovative Cabin Passenger/Payload systems	AIR-D2-8/9/10/11 Ergonomic flexible cabin [WP 5.1]	1	6										
				TRL Maturity				TRL3	TRL4	TRL5	TRL6			
		LPA-01-D12: Flight test demonstration of active vibration control technologies/noise prediction methods for rear-mounted engines	2	5										
				TRL Maturity				TRL4		TRL5				
		SYS - D2. Innovative Cabin and Cargo technologies	1	5										
				TRL Maturity						TRL3	TRL4		TRL5	
		SYS - D22. Comfortable & Safe Cabin for SAT	3	4										
				TRL Maturity					TRL3		TRL 4	TRL5		

9. Overview of Major Risks

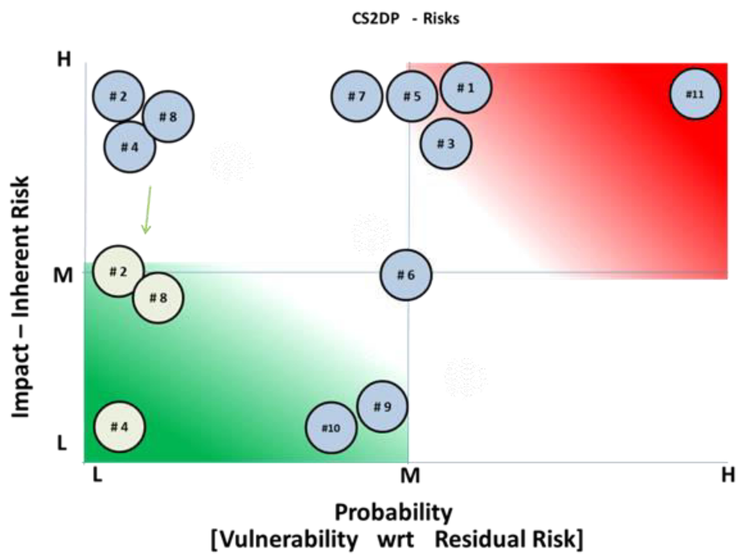
#	Risk Description	Likelihood (H/M/L)	Impact (H/M/L)	Impact Category†	Mitigation Plan	Residual Risk
1	Execution of the technical activities in Clean Sky 2 may not result in the achievement of the High-Level Goals [HLGs] as stated in the Regulation.	M	H	R/T/S	Define the contribution of every IADPs/ITDs/TAs to the Clean Sky 2 High Level Objectives and quantify their environmental contribution to the different A/C concepts as per defined in the Technology Evaluator. Elaborate and maintain for key demonstrators/ technologies an estimate of the expected environmental improvements and monitor the progress towards the fulfilment of the objectives. Perform a first assessment at TE level and propose programme re-orientation in case of failure to meet the Clean Sky 2 High Level Objectives. Define 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.	H
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..	L	H	T/S/C	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.	M
3	Technical setbacks in one or several IADPs / ITDs / TAs may result in under achievement of milestones and deliverables and/or a significant over/ under-spending of annual budget.	M	H	T/S/C	Review each quarter and advise GB where issues arise. Monitor technical execution through timely execution of milestones and deliverables. Assess technical difficulties during ad-hoc or regular reviews and propose a mitigation plan to fix the technical issues. Re-balance the budget within ITDs/IADPs to align the level of financial execution for a given year with available funding budget and re-balance the budget across ITDs/IADPs to maintain a proper level of financial execution for a given year. Revise the CS2DP and the WP where needed and Use GAM Amendment process to officiate.	H
4	The minimum 30% of the Clean Sky funding devoted to Partners' activities may not be reached at completion of the Clean Sky 2 programme	L	H	R/T/S	Monitoring of partners' funding allocation and execution on a yearly basis. Increase of Partners' activities (to take into account risk of failed topics in the last 2 calls and the risk of underexecution of Partners' funding linked to delays beyond CS2 timeframe or underexecution or failure of projects) thanks to increased Calls for Proposals funding, 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	L

#	Risk Description	Likelihood (H/M/L)	Impact (H/M/L)	Impact Category†	Mitigation Plan	Residual Risk
					Programme's HLGs.	
5	Planning for cost and effort for complex, large ground and flight demonstrators (10-year programme) may lack maturity and/or accuracy, leading to delayed completion of technical activities or reduced scope of activities.	M	H	S/T/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. Seek for funding opportunities through other instruments (national level or other EU initiatives) or increase the level of additional activities required to meet the programme objectives. Implement a robust "Gate" process for major demonstrators [in particular flight demonstration], and perform the assessment of the progress during annual reviews. Assess any opportunities to re-orientate some activities (between 1st Level Work Packages and/or between IADPs/ ITDs) with the objective to maximise benefits vis à vis HLG.	H
6	Competences and resource to successfully enable the completion and test of flight demonstrators may be underestimated or insufficient	M	M	S/T/C	Clearly identify the required competences and resources and closely monitor thru 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.	M
7	The number of scientific papers produced at completion of Clean Sky 2 (100 per year) might be lower than anticipated, causing insufficient dissemination of the CS2 programme results to the research community. Likewise the number of applications for patents may fail to reach the target of 366 in total, indicating a lack of exploitation activities triggered through the CS programmes.	M	H	R/S	The JU continuously monitors the dissemination activities at conferences, symposia, and the production of papers disseminated on a yearly basis. The JU also monitors applications for patents. Dedicated action plans are established per ITDs/IADPs/TAs on D&E with quantified figures until completion of the programme. The JU continuously reviews and assesses the reasonableness of the target setting for the number of papers and patents for each SPD.	H
8	Data from the IADP/ITDs required for the TE may be late, incomplete or insufficiently mature.	L	H	T/S	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.	M
9	The strong interdependencies between IADPs (as provider of requirements	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	L

#	Risk Description	Likelihood (H/M/L)	Impact (H/M/L)	Impact Category†	Mitigation Plan	Residual Risk
	and as integrator) and ITDs (as provide of a/c components, systems and solutions) can cause delays in the overall programme in case of (technical/schedule) problems.				supporting the individual grants in financial/legal aspects	
10	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 liaise closely with the JU for specific and difficult cases to find 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)	L
11	In case of a hard Brexit, a significant share of the CS JU work programme may not be covered anymore, jeopardising the proper execution of the CS2 projects on all levels (Partners, Core Partners and Leaders).	H	H		The JU has analysed possible scenarios in line with the guidance of the Brexit Working Group of the Common Implementation Centre of the Commission. The extension of the Brexit date agreed by the EU Council up to 31/01 still leaves all possible options open from possible no deal scenario to the ratification of a Withdrawal Agreement. The situation will be closely monitored. Other funding sources might step in and take over funding for British beneficiaries.	H

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

Marci chart



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€ **Transverse activities**	**SAT** 4% IADPs/ITDs values - M€	Resulting Indicative Allocation - M€
			[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.

Since the beginning of the Programme, several financial evolutions took place, leading to budget transfer from one ITD/IADP to another, in order to ensure the implementation of the work with a maximum of efficiency.

The different evolutions in Programme content and related funding estimates are summarised as follows:

- Transfer of technical activities for a total of €7.67 million from AIR to SYS (agreed in 2015/16).
- Transfer of technical activities for a total of €7.50 million from AIR to SYS (agreed in 2017).
- Transfer of technical activities for a total of €2.00 million from AIR to REG (agreed in 2017).
- Transfer of technical activities for a total of €15.98 million from LPA to ENG (agreed in 2018).
- Transfer of technical activities for a total of €0.50 million from REG to SYS (agreed in 2019).
- Transfer of technical activities for a total of €2.15 million from AIR to FRC (agreed in 2019).

In addition, the initial funding envelope for call for proposals initially defined in every ITD/IADP has evolved, leading to the following evolutions:

- Reduction of the funding budget dedicated to Partners (CfP budget) of €11.35 million in SYS.
- Reduction of the funding budget dedicated to Partners (CfP budget) of €5.72 million in LPA.

ECO TA activities made progress in 2018 in structuring the content of activities across the different areas, with maximum funding defined as follows:

- LPA €8.00 million;
- REG €2.00 million;
- FRC €1.50 million;
- AIR €6.50 million;
- ENG €6.50 million;
- SYS €3.50 million.

A remaining funding envelope of €5 million will be assigned to further activities in the course of 2020, based on priorities defined on ECO TA and on impact arising from different proposed activities.

Finally, in the field of SAT, some minor adaptations with a reduction of €0.60 million compared to the last agreed funding planning appeared on the Programme development, resulting with the following figures:

- AIR € 24.45 million (+€0.30 million);
- ENG € 17.25 million (+ €0.75 million);
- SYS € 22.65 million (- €1.65 million).

Table 2 shows the indicative allocation of funding per IADP/ITD or TA (in M€), following the different evolutions as depicted above.

State of play as of September 2019

IADPs / ITDs / TAs	(1) Allocation - M€	(2) Reapplication ECO - M€	(3) Reapplication SAT - M€	(4) = (1) + (2) + (3) Allocation incl. TA Redistribution - M€
LPA	486.80	8.00		494.80
REG	103.20	2.00		105.20
FRC	187.86	1.50		189.36
AIR	289.90	6.50	24.45	320.85
ENG	281.28	6.50	17.25	305.03
SYS	225.41	3.50	22.65	251.56
TE	17.16	-	-	17.16
ECO GAM	-	6.06	-	6.06
ECO funding for re-distribution		5.00		5.00
SAT GAM	-	-	3.00	3.00
Reserve for Thematic Topics	44.66			44.66
TOTAL	1,635.87	39,06	67,35	1 742.68
Deviation wrt to max funding value of 1 716 M€ (over commitment)				-26.68

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

Notes:
(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 (€67.35million) is redistributed to the AIR/ENG/SYS ITDs in accordance with the information received from SAT Leaders and confirmed by Leaders in July 2019).

The JU's intention is to launch call for proposals for a total indicative topic funding value well in excess of the minimum of 30% of the Programme funding value, with a view 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.

In absence of confirmation mid-2018 of all planed topics until the last call for proposals and in the light of the Programme funding execution available at the end of year 2017, the JU mitigated the risk of non-execution of the CfP envelope via the inclusion of a new type of topic called "Thematic Topic". CfP planning includes Thematic Topics as from the eighth Call for proposals and this will continue until Call eleventh (the last call of the Programme). So far, these topics successfully contributes in widening 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, a maximum of €45 million in total is earmarked for Thematic Topics over the last four calls for proposals (CfP08-CfP11).

The current distribution of the Programme funding between the different category of participants (Leaders, Core Partners and Partners) is given in the following table:

State of play as of July 2019

Funding envelope to completion (in M€)	Allocation according to Regulation		2019 CS2DP	
	in %	in M€	in %	in M€
Leaders	<40%	<686.4	38.71%	684.28
Core Partners	<30%	<514.8	28.3%	496.75
Calls for Proposals / Tender	>30%	>514.8	31.94%	561.64
TOTAL	1 716		1 742.68 (max. funding of 1 716)	
Of which Thematic Topics in CfPs			approx. 45 M€	
Of which over commitment			approx. 27 M€	

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

Notes:
(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.

As depicted in Table 3, the funding value of activities proposed for implementation in the Programme currently exceeds the maximum funding available for operational activities in Clean Sky 2 by approximately €27 million. This over commitment (corresponding to less than 2% of the Programme funding) is proposed in light of the lesson learnt from the Clean Sky Programme experience and will therefore help the Programme in executing the minimum funding of 30% on call for proposals. Indeed, over the next four years (end 2023), there is a need for the JU to anticipate any project failure, delays in execution of projects or rejection of costs claimed on ineligibility grounds, leading to a lower execution rate than expected for Grant Agreement for Partners (GAP projects from CfPs). In addition, the re-assignment of unused planned funding potentially caused by failed topics in the last two calls of the Programme cannot be envisaged as no further Calls for Proposals is foreseen beyond 2020. The overall situation is therefore mitigated by means of an over commitment of activities to be funded without offsetting the current Programme content and will be monitored on a yearly basis by the JU. In this context, it is worth noting that 60% of the over commitment value is devoted to Thematic Topics and might be adjusted at the time of granting decisions of projects awarded in the last two calls based on their final success rate.

Where necessary, adjustment to the funding is planned in the final years with a view to ensure alignment with the maximum funding available of €1 716 million allocated to the overall Programme.

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 five years, all four Core Partner Calls that were foreseen for the Programme have been successfully launched and closed. The conclusion of the negotiations for the fourth and final Call for Core Partners took place at the end of 2017. This completed the selection process for the Clean Sky 2 Core Partners and for the membership, on time with respect to the planning made at the start of the Programme.

On the basis of the four calls launched, and the successful grant implementation with the candidate Core Partners resulting from these calls, the JU has established a preliminary planned allocation over the Programme's life of approximately 98% of the foreseen Core Partner funding (which is up to €514.8 million according to the Regulation). The remaining "unallocated" Core Partner funding, included in their funding budget, 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 over 190 with roughly 50 SMEs participating. The Members originate from 22 different countries: 18 Member States and four countries associated to Horizon 2020 [Israel, Norway, Switzerland and Turkey].

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

Summary of Call results to date – Calls for Proposals

In the five years since the Programme's start tenth Calls for Proposals (CfPs) were successfully launched and nine closed with the grant preparation completed. Grant Agreements for projects awarded through the first eight CfPs are now running, engaging approximately 590 unique entities from 27 different countries with a strong SME involvement. Indeed, over 40% of the Partners selected are SMEs, with a funding request of roughly 25% over €381 million of EU funding committed until Call eight. This trend is expected to continue with the last three calls of the Programme.
Most of the projects from Call ninth will start in the last quarter of 2019. The selection and awarding of projects from Call tenth will take place by the end of 2019 with earliest project start date fixed in the second quarter of 2020.
The last call for proposal (eleventh call) will be launched early 2020 with the ambition to start projects by the end of year 2020 at the earliest. The total funding value of this call is fixed to approximately €45 million.

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

Since 2018, the JU includes Thematic Topics in the planning of the Calls for Proposals. These topics contribute to the progress towards the high-level objectives in the CS2 JU Basic Act and are not specifically linked to one IADP/ITD [demonstration activities/strategy], meaning they are not “inside” one of the current IADPs/ITDs.

So far, six Thematic Topics in total were launched through the eighth and ninth Calls for Proposals. These topics have contributed to an increased participation observed in the Programme, with 13 projects awarded. The JU expects a further increase in the participation through Call tenth and Call eleventh with eight topics launched for a total funding value of approximately €30 million. The total funding assigned to this new mechanism should reach approximately €45 million, corresponding to less than 3% of the overall CS2 Programme funding.

Programme execution to date (Leaders and Core Partners)

The current graph provides the funding execution profile until Programme completion for the Members’ activities (considering that Partners’ activities follow the same trend). The funding percentage mentioned for a given year corresponds to the cumulative level of funding achieved at the end of the given year. The overall picture can be summarised as follows:

- Half-way mark reached in 2019;
- Two-thirds of programme effort and funding will be reached by early 2020;
- Demonstrator programme building towards peak in the last three years of the Programme.

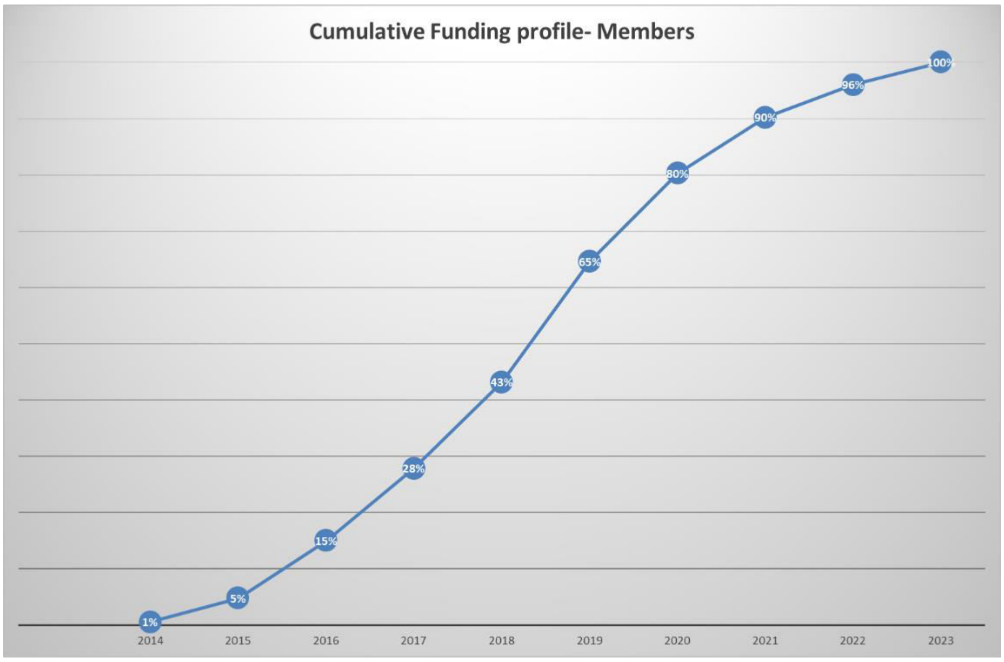


Figure: Funding profile for Members’ activities (GAMs)

12. CS2 Links to Other Programmes

12.1. Synergies with other European, national and regional programmes

In accordance to its founding Council Regulation of May 2014, Clean Sky 2 has been called to develop synergies with the European Structural Investment Funds (ESIF). To meet this target, Clean Sky 2 is implementing a coherent and comprehensive policy strategy and an action plan on synergies with 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 has developed a 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.

To support and implement such synergies with ESIF, Clean Sky 2 encourages the applicants to the calls to submit complementary activities during either the submission or the implementation of a project. While in the context of the cooperation with Member States/Regions, Clean Sky 2 promotes the signing of a Memorandum of Understanding (MoU)[1]: which is an important and effective instrument and which 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 that can identify thematic objectives or align the regional funding instruments to support possible pilot projects[2]. A quality label may also be awarded to the complementary activities via an independent evaluation process. This "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.

By October 2019, nineteen MoU have been signed with Member States/Regions and more than sixty Member States/Regions have been identified to include aeronautics or areas which correlate to the Clean Sky 2 Programme as thematic areas/priorities for ESIF funding within their RIS3. Additionally, ten Clean Sky Synergy Labels have been awarded to complementary activities, related to Clean Sky Programme, while more than forty pilot projects have been supported by ESIF with a budget around €50 million.

The coherence and complementarity with National Programmes in the Member States is also considered by 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.

Clean Sky 2 currently continues to monitor, support and encourage the implementation of the current MoU. The effective and operational implementation of some MoU has resulted in the increase of the submitted pilot projects and the expectations for more. However, in view of the next framework programme, the MoU policy procedure will be reviewed in order to ensure more effective synergies and investments in the sector. Shared roadmaps and alignment of programmes will be considered at both national and regional level. The interested MS and regions

[1] http://cleansky.eu/structural-funds-and-regions

[2] Article 37 of the H2020 RfP provides that, in case of cumulative funding, the grants may not cover the same cost items.

should ensure their intention to invest in aeronautics activities related to Clean Sky 3 programme and objectives and should provide long-term financial commitments.

Additionally, Clean Sky 2, based on the experience of the current synergies and the MoU network, is building a strategy for more effective and efficient synergies, as well as a strengthened cooperation with the ‘aeronautics’ Member States and Regions. These synergies can be also built on the significant efforts and results stemming from national programmes in the EU Member States, and can stimulate a smart use of structural funds directed via the Research & Innovation Smart Specialisation Strategies in the next framework programme.
The new framework programme Horizon Europe[1] encourages synergies not only with ESIF but also with other EU programmes and funding schemes. In this context, Clean Sky is considering to enable synergies with other European Partnerships and EU Research Programmes; national research and innovation programmes; European structural investment funds and financial instruments. This initiative will not only leverage efforts and create synergies and multiplier effects across technology domains, but also across European, national and regional boundaries Combining resources and funding will produce a substantial leverage effect, and help reach the challenging objective of deep decarbonisation.

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;

[1] Any action within the context of Horizon Europe will depend on the proposed European Partnership on Clean Aviation being confirmed.

- 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;
- the content of the CS2DP and the list of technologies to be developed during the CS2 work programme;
- the topics in the EASA research plan, as basis for consideration of the CS2JU members;
- the preparation of the new European Aviation Environmental Report by end 2018.

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. In addition, any EASA contributions shall comply with the EASA's constituent act and financial rules. 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 (in a sort of consultation process) is active for 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 Rotor Craft (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)
MoU:	Memorandum of Understanding
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 September 2019 and all figures are indicative):

Theme	Demonstration area	Programme Area [IADP/ITD/TA]						Demonstrator / Technology Stream	Contribution *			Funding	Funding
		LPA	REG	FRC	AIR	ENG	SYS		E	M	C	RoM m€	RoM m€
Breakthroughs in Propulsion Efficiency (incl. Propulsion-Airframe Integration)	Advanced Engine/Airframe Architectures	✈			✈			Optimised integration of rear fuselage	✈		✈	532.3	93.9
								Novel high performance integration	✈		✈		
								Optimal engine integration on rear fuselage	✈		✈		
								UHBR Short Range Integration	✈		✈		
								Enablers for Integrated Open Rotor Design	✈		✈		
								Advanced Rear-end	✈		✈		
								Common Technology Bricks for Future Engines	✈		✈		
	Ultra-high Bypass and High Propulsive Geared Fans	✈			✈	✈		UHPEdemonstrator for SMR Aircraft	✈		✈		354.0
								VHBR – Middle of Market Technology	✈		✈		
								VHBR – Large Turbofan Demonstrator UltraFan™	✈		✈		
								UltraFan Flight Test Demonstration	✈		✈		
								Validation of scaled flight testing	✈		✈		
								Radical Configuration Flight Test Demonstrator	✈		✈		
								UHBR integration	✈		✈		
								Advanced Geared Engine Configuration	✈		✈		
	Hybrid Electric Propulsion	✈						Hybrid Electric Ground Test Bench	✈	✈			27.9
	Boundary Layer Ingestion	✈						Boundary Layer Ingestion	✈		✈		14.2
	Small Aircraft, Regional and Business Aviation Turboprop				✈	✈		Large Tprop Nacelle Integration	✈	✈	✈		42.3
								Business aviation / short range Regional Turboprop Demonstrator	✈	✈	✈		
								Small Aircraft Engine Demonstrator	✈	✈	✈		
								Small Aircraft Turbine Engine					
			✈					REG WP2.3 - WTT Demonstrator for the Innovative Propeller	✈	✈	✈		

Advances in Wings, Aerodynamics and Flight Dynamics	**Advanced Laminar Flow Technologies**	✈			✈			Laminar nacelle NLF laminar wing NLF BJ HTP NLF Leading Edge GBD Innovative HLFC (TSSD) Innovative HLFC (Combining ACD+Suction) Sacrificial layersheets, functional clear coat NLF smart integrated wing Extended laminarity	✈		✈	**180.0**
								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	✈		✈	
	Regional Aircraft Wing Optimization		✈		✈			Morphing Winglet		✈	✈	
								Morphing Leading Edge, Intelligent Loads Alleviation System			✈	
								Advanced Composite External Wing Box	✈	✈	✈	
								Multifunctional Flap		✈	✈	
								D2 - High Lift Advanced Turboprop – Flying Test Bed#2 (FTB2)		✈	✈	
								Innovative Wing: Load Control and Load Alleviation, Outer Wing Box Structure, Morphing Structures - Winglet/Wingtip, Drag Reduction passive devices		✈	✈	
								Innovative Flight Control System including EMA for Winglet/Wing			✈	
								Innovative Flight Control System with EMAs for Aileron and for Winglet/Wingtip		✈	✈	
								Load Control/Load Alleviation System		✈	✈	
								REG WP 2.1 - WTT Demos for Innovative Air Vehicle Technologies (DN, Morphing flap, NLF,..)		✈	✈	

Innovative Structural / Functional Design - and Production System	**Advanced Manufacturing**		✈		✈			Advanced multifuntional CFRP for regional aircraft fuselage	✈		✈	178.2	29.2
								Metallic cargo door			✈		
								Flaperon		✈	✈		
								Composite Wing for SAT	✈		✈		
								Automated assembling of SAT structures			✈		
								Effective joining methods of hybrid structures for SAT structure	✈		✈		
								Jigless assembling for SAT structure	✈		✈		
								Innovative shapes & structures	✈		✈		
								Eco-efficient factories of the future	✈		✈		
								Assisted composite manufacturing by collaborative robots	✈		✈		
								Door Hinge	✈		✈		
	Cabin & Fuselage	✈	✈		✈			LPA Cockpit Innovative Structural Component		✈	✈		136.3
								Major Components for REG fuselage			✈		
								Cabin parts for SAT structure		✈	✈		
								Tailored front fuselage		✈	✈		
								Low cost material, process, manufacturing, assembling technologies for regional aircraft fuselage			✈		
								Affordable and low weight regional aircraft pax cabin	✈		✈		
								Next Generation Fuselage, Cabin and Systems Integration	✈	✈	✈		
								Next Generation Cabin & Cargo Functions	✈	✈	✈		
								Next Generation Lower Center Fuselage	✈		✈		
	Innovative Solutions for Business Jets				✈			Composite Wing Root Box		✈	✈		12.7
								Composite stiffened wing lower panel from an existing BJ		✈	✈		
								Optimized BJ cockpit structure with load-bearing windshields		✈	✈		
								Composite (half) central wing box for BJ		✈	✈		
								Composite central wing box panel for BJ		✈	✈		
								Noise shielding tail plane		✈	✈		
								Novel high performance configurations		✈	✈		
								Multidisciplinary wing for high & low speed		✈	✈		
Next Generation Cockpit Systems and Aircraft Operations	**Cockpit & Avionics**	✈	✈		✈		✈	Highly Integrated Cockpit		✈	✈	158.6	146.6
								Disruptive Cockpit Large Aircraft		✈	✈		
								Extended Cockpit Demonstrations		✈	✈		
								Enhanced functions and technologies ground and flight tests on Business jet		✈	✈		
								Affordable future avionic solution for SAT		✈	✈		
								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		✈	✈		12.0

Novel Aircraft Configurations and Capabilities	**Next-Generation Civil Tiltrotor**			✈	✈			Fuselage nose for NextGenCTR		✈	✈	**222.6**	**109.5**
								Fuselage Central Section for NextGenCTR		✈	✈		
								Fuselage Tail Section of NextGenCTR		✈	✈		
								Wind Tunnel Model Test		✈	✈		
								NextGenCTR's Tie Down / Flight Demonstrator (Ground & Flight)		✈	✈		
								NextGenCTR's drive system components and assembly – demo		✈	✈		
								NextGenCTR's wing assembly - demo		✈	✈		
								Engine-nacelle integration - demo		✈	✈		
								Fuel system components - demo		✈	✈		
								Flight control & actuation systems and components - demo		✈	✈		
								Digital Mock-Up (DMU)		✈	✈		
								Tail Components [Airframe ITD only]		✈	✈		
								NextGenCTR Concept Aircraft Technologies		✈	✈		
	RACER Compound Helicopter			✈	✈			Pre-assembled RACER airframe		✈			**110.1**
								Rotorless Tail		✈	✈		
								Door for RACER Rotorcraft		✈	✈		
								Wing for RACER Rotorcraft		✈	✈		
								RACER Flight Demonstrator Integration		✈	✈		
								RACER Airframe Integration		✈	✈		
								RACER Dynamic Assembly Integration		✈	✈		
								RACER On-board Systems Integration		✈	✈		
	Regional Innovative Configuration		✈					REG WP1 - TP90 Pax Configuration		✈	✈		**2.9**
			✈					Long Term (TP130 pax Configuration)		✈	✈		

Aircraft Non-Propulsive Energy and Control Systems	Electrical Systems		✈		✈		✈	Smart Integrated Wing Demonstrator			✈	158.0	109.3
								Innovative Electrical Wing			✈		
								Power Generation	✈		✈		
								EPGD - Electric-Power Generation and Distribution	✈		✈		
								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			✈		
								All Electrical Wing			✈		
								EWIPS integration on a BJ slat			✈		
								Travelling wire bundel for EWIPS on slat			✈		
								Ultra low power ice protection			✈		
								Nacelles Airframe integration by means of multi-disciplinary			✈		
	Landing Systems		✈				✈	Advanced Landing Gear Systems	✈		✈		32.2
								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	✈		✈		
	Non-Propulsive Energy Optimization for Large Aircraft	✈						LPA-01-DX4: Non-Propulsive Energy	✈		✈		14.5
	Low Power WIPS		✈					Low Power WIPS	✈		✈		2.1

Optimal Cabin and Passenger Environment	**Environmental Control System**		✈				✈	Next Generation EECS Demonstrator for large A/C	✈	✈		**59.0**	**20.8**
								Next Generation EECS Demonstrator for Regional A/C	✈	✈			
								Advanced Systems integration, E-ECS and Thermal Management	✈	✈			
	Innovative Cabin Passenger/Payload systems	✈	✈		✈		✈	Flight test demonstration of active vibration control technologies/noise prediction methods for rear-mounted engines	✈	✈	✈		**38.2**
								Equipment and systems for Cabin & Cargo Applications		✈	✈		
								Human centered cabin design for regional aircraft		✈	✈		
								Comfortable & Safe Cabin for Small Aircraft		✈	✈		
								Smart galley		✈	✈		
								Multi-functional cabin rest area		✈	✈		
								In-seat ventilation		✈	✈		
								Virtual Reality		✈	✈		
								Full scale mock-up of the BJ office centered cabin		✈	✈		
								Compact Shower System		✈	✈		
								Trapdoor for underfloor access		✈	✈		
								Galley equipment		✈	✈		
								Major components for REG human centred cabin		✈	✈		
								Hybrid Aircraft Seating Structure		✈	✈		