Brussels, 29 June 2020

D(2020)AK304
Mr. David M. Sassoli
President of the
European Parliament
Altiero Spineli Building
Rue Wiertz, 60
B -1047, Brussels

Subject: Transmission of the Clean Sky 2 Joint Undertaking Annual Activity Report 2019

Dear Mr. Sassoli,

I herewith provide you with the Annual Activity Report 2019 of the Clean Sky 2 Joint Undertaking, which includes, in subchapter 5.1, the assessment made by the Governing Board in accordance with Article 23 of the Financial Rules of Clean Sky 2 Joint Undertaking. The enclosed report was approved by the Governing Board of 25 June 2020.

Yours sincerely,

Axel Krein
Executive Director

Cc by e-mail: Monika Hohlmeier, Chairwoman of the Committee on Budgetary Control (CONT)

2019
Consolidated Annual Activity Report

In accordance with Article 20 of the Statutes of the Clean Sky 2 Joint Undertaking annexed to Council Regulation (EU) No 558/2014 and with Article 23 of the revised Financial Rules of the CS2 JU.

The annual activity report will be made publicly available after its approval by the Governing Board.

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FACTSHEET

Name	Clean Sky 2 Joint Undertaking
Objectives	a) To contribute to the finalisation of research activities initiated under Regulation (EC) No 71/2008 and to the implementation of Regulation (EU) No 1291/2013, and in particular the Smart, Green and Integrated Transport Challenge under Part III — Societal Challenges of Decision 2013/743/EU; b) 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. These can be realised through the speeding up of 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 CO2 emissions by 20 to 30 % compared to 'state-of-the-art' aircraft entering into service as from 2014; (ii) reducing aircraft NOx and noise emissions by 20 to 30 % compared to 'state-of-the-art' aircraft entering into service as from 2014.
Founding Legal Act	Council Regulation (EU) No 558/2014 of 6 May 2014
Executive Director	Axel Krein, Executive Director, from 1 February 2019 Tiit Jurimae, Interim Executive Director, from 16 September 2016 until 31 January 2019
Governing Board	Stéphane Cueille, Chairman (Safran) elected on 5 December 2018 Composition of the Governing Board: European Commission + 16 Industrial Leaders (Airbus, Airbus Defence & Space SAU, Airbus Helicopters, Dassault Aviation, DLR, Evektor, Fraunhofer, Leonardo Aircraft, Leonardo Helicopters, Liebherr, MTU, Piaggio Aero Industries, Rolls-Royce, SAAB, Safran, Thales Avionics) + Core Partners [Avio Aero, CIRA (representing two ITDs), Aernnova, United Technologies Research Center Ireland and GKN Fokker].
Other bodies	States Representatives Group; Scientific Committee; ITD/IADP Steering Committees and TA Coordination Committees
Staff	42 (40 posts filled by 31.12.2019)
2019 Budget	€304.8 million commitment appropriations; €340.4 million payment appropriations (Title V unused included)
Budget implementation	100% in commitment appropriations and 97.4% in payment appropriations (Title V not included)
Grants	9 H2020 GAMs — total value €213.9 million; 135 H2020 GAPs — total value €133.2 million.
Strategic Research Agenda	See chapter 1 and related Annex 11
Call implementation	Number of calls launched in 2019: one (CfP10) Number of proposals submitted (CfP09 and CfP10): 450 Number of eligible proposals: 448 Number of proposals retained: 114 Global project portfolio (since the setting up): 574[1] Number and value of tenders (if any): one operational tender, for a value of €0.58 million.
Participation, including SMEs	Total number of participations in funded projects: 1752[2] which consists of: 29% SMEs (515 participations), 23% IND (397 participations), 24% UNI (420 participations), 24% RES (420 participations)

[1] Not counting Leader actions and counting each funded proposal from Calls as one project. [2] Participations in CfPs and CPWs. CfP010 included, assuming successful grant preparation of all retained proposals.

FOREWORD

« Delivering on ambitious objectives »

2019 was a significant year for Clean Sky 2 JU. The European Green Deal, outlined by the new European Commission in December 2019, has set an ambitious challenge for all European citizens – it is our guiding north, illuminating the path towards climate neutrality by 2050.

Innovations developed and supported by the Clean Sky 2 programme will, when finally matured and implemented, already lower CO_2 and NO_x emissions from aircraft by up to 30%.

Tackling climate-neutral aviation is an extremely complex task, and one that requires cooperation across the board, between public sector, private industry, researchers and entrepreneurs.

Within this report, you will find the main developments of the Clean Sky 2 programme in 2019: a selection of our technologies under development, a look at our participation statistics and breakdown by country, our research output and impact, our vision for the future, and important details about the execution of the programme and overall management of the programme office.

Moreover, you will hear about the new efforts applied to creating synergies undertaken last year and a number of Memoranda of Understanding with various regions in Europe. Synergy label projects continued to grow, maximising cooperation and promoting synergies between European Structural & Investment Funds and Clean Sky.

Clean Sky has successfully engaged 902 participants across the public and private sector from 30 countries, of which 337 are SMEs, 110 are research centres and 151 are universities. To date, Clean Sky programmes have obtained 132 patents and have published 315 technical and peer-reviewed papers, including book chapters and theses written by PhD and Masters candidates.

The commitment from all sides is set to continue. At Clean Sky, we are newly energised by the European Green Deal and the support of the European Parliament. In alignment with the European institutions, we will minimise the impact of aviation on the environment through the development and demonstration of innovative technologies and continue to contribute to the success of the European aviation ecosystem.

Axel Krein
Executive Director

EXECUTIVE SUMMARY

The Clean Sky 2 Joint Undertaking is a public-private partnership (PPP) responsible for managing two major public aeronautic research programmes in the EU: the Clean Sky (CS) programme funded under FP7 which closed in 2017, and the Clean Sky 2 programme funded under the H2020 framework programme which will run until 2024. Together, these constitute a public Union funding budget of just over €2.5 billion and an approximate overall value of activities over twice this amount. As such, the Clean Sky 2 JU is the largest EU research and innovation instrument in this field, engaging a wide array of participants spanning the full innovation chain from academia and (public) research organisations, through the tiered supply chain of industry up to and including the leading aircraft, engine and systems integrators. Thanks to this integrative and collaborative approach, small and medium-sized enterprises (SMEs) have participated in Clean Sky activities several hundreds of times. This integrates newcomers into the sector and can successfully expose large industrial participants to innovative approaches from SMEs.

Clean Sky's focus is on reducing the environmental impact of aviation while maintaining and building European competitiveness and mobility. The programme is managed by the Joint Undertaking's (JU) programme office in Brussels. The JU is an autonomous Union body set up under the legal framework of a Council Regulation (on the basis of Article 187 TFEU) and operating the grants it funds in accordance with the EU financial rules and the rules of Horizon 2020. The combination of EU and private industry funding provides a flexible means to ensure stability and long-term commitment from the European Union and stakeholders regarding the funding opportunities.

The figure below highlights the objectives[1] set for the Clean Sky 2 programme:

Clean Sky 2 programme's environmental results contributing to the ACARE[2] Flightpath 2050 objectives[3]

[1] Art. 2 Council Regulation [558/2014].
[2] ACARE – Advisory Council Aviation Research and Innovation in Europe.
[3] Flightpath 2050 - Europe's Vision for Aviation:
https://ec.europa.eu/transport/sites/transport/files/modes/air/doc/flightpath2050.pdf

The year in perspective – research activities highlights of members and partners

Each of the programme areas coordinating the research, technology development and demonstration activities, i.e. the Innovative Aircraft Demonstration Platforms (IADPs), Integrated Technology Demonstrators (ITDs) and Transverse Activities (TAs), is briefly highlighted below.

- ⇨ **LPA – Large Passenger Aircraft IADP**

The Large Passenger Aircraft IADP is focusing on large-scale demonstration of technologies integrated at aircraft level on three distinct 'Platforms'.

Platform 1, which is known as 'Advanced Engine and Aircraft Configurations', aims to provide a development environment for the integration of the most fuel-efficient propulsion concepts into compatible airframe configurations and concepts targeting next generation aircraft. During 2019, the majority of demonstrators and their underlying technologies passed important milestones which have determined the change from non-specific to specific design and the associated build-up of hardware (prototypes, rigs, etc.).

Examples include:

- Active Flow Control research: a potential enabler for Ultra-High-Bypass-Ratio (UHBR) engine integration, which progressed with aerodynamic and harsh environmental testing conducted on steady and pulsed jet blowing actuators, together with full scale wind tunnel tests.
- The UltraFan® flight test demonstrator: all engine integration activities continued, redirected to leverage opportunities of the integration of hybrid electric propulsion systems.
- Open Rotor propulsion concepts: the design of Open Rotor blades including Cabin-noise assessment and trade studies at aircraft level have been completed for the Open Rotor Advanced System "ORAS" concept.
- For the open rotor propulsion concepts, the design of open rotor blades including cabin noise assessment and trade studies at aircraft level have been completed for the "ORAS" concept. In the field of hybrid electric propulsion, the design and development of several key technologies (generator, power electronics, electrical motors) has continued. The delivery of an integrated 2MW generator and power electronics fed into the commissioning of the Hybrid Electric Propulsion ground test bench.
- Platform 2 continued with its effort to develop, mature, and demonstrate novel advanced fuselage concepts and assembly methods in full alignment towards next-generation cabin and cargo architectures. The multi-functional fuselage demonstrator performed a critical design review that will drive the demonstration later on. One major achievement was the launch of the upper shell development and design activities. Cargo fire tests in a real burn chamber were completed and the environmentally friendly fire protection demonstrator unit was ready for verification tests.

Finally, Platform 3:

- Activities progressed towards maturation of the functions and technologies developed in synergy with ITD Systems, and have started their integration and testing within the large aircraft disruptive cockpit, regional aircraft active cockpit and business jet ground demonstrator test benches.
- Flight tests for selected cockpit-avionics functions and technologies have been successfully performed on large aircraft and on business jets.
- The development and integration of major demonstrators for end-to-end maintenance enabling technologies (including health monitoring, collaborative environment and line maintenance mobile tool applications) has been finalised, and the final technology demonstration has taken place

⇨ **REG – Regional Aircraft IADP**

Regional Aircraft IADP activities relating to green conceptual aircraft achieved important results during 2019.

- The third design loop was started for the TP90pax regional aircraft.
- New activities related to hybrid-electrical regional aircraft configurations were started.
- The technology maturation activities progressed substantially during this period. In particular, the detailed design phase was completed with critical design reviews (CDRs) held for Iron Bird, for FTB2, for the fuselage structural demonstrator and the outer wing box on-ground demonstrator.
- The design of experimental modifications for implementation on the Flying Test Bed 1 demo aircraft also progressed well towards the CDR, which will be held in 2020. The manufacturing and assembly of the full-scale demonstrators has started.

⇨ **FRC – Fast Rotorcraft IADP**

The Fast Rotorcraft IADP of Clean Sky 2 consists of two separate demonstrators, the NextGenCTR Tiltrotor and the RACER compound helicopter. Both projects are advancing towards the final validation of these game-changing concepts.

- The NGCTR technology demonstrator (WP1) concluded its preliminary design review (PDR) in March 2019.
- CDR readiness review was held in December 2019 to measure the progress of detailed design tasks (e.g. drawings release rate), assess the relevant risks and capture in advance warnings on the successful execution of the CDR in 2020.
- The RACER compound demonstrator (WP2) PDR actions were all completed, mostly during Q1 2019. The CDR took place in July 2019, with some actions identified and closed later in the year. A simplified process for drawing release was put in place and the long lead time items procurement and manufacturing continued. Key ground test benches of relevant sub-systems were also run (e.g. lateral shaft dynamics, electrical generation and distribution systems, systems integration rig).

⇨ **AIR – Airframe ITD**

- The technology readiness levels (TRL) for the Ultra High By-pass Ratio (UHBR) and Open-Rotor (OR) integration technologies have progressed.
- The BLADE flight test campaign was completed in August and analysis activities have been carried out. Exploitation activities by the BLADE partners will continue in 2020.
- Airframe structure demonstrators, the preliminary design review (PDR) for wing root box composite spars and the critical design review (CDR) for cargo doors structural demonstrators have both been successfully passed. Technology development for EWIPS (electrical wing ice protection system) integration on a business jet slat has continued.
- Active load control activities progressed well with very valuable results achieved on load attenuation.
- The activities for the human-centred cabin and the office centred cabin progressed significantly, passing some CDRs successfully.
- Good progress was made in other technology development areas such as: morphing leading edge technology; out-of-autoclave (OoA) composite outer wing box (COWB) thermoplastics in situ consolidation and liquid resin infusion (LRI), etc. These technologies support the FRC, REG and SAT demonstrators and passed several CDRs.
- Refinement of the major cabin interior items 3D models and preliminary stress analysis have been performed. Eco-design technology development progressed well and is on track for the preparation of the demonstration phase.
- Life cycle assessment (LCA) data collection continued in collaboration with the ECO TA.

⇨ **ENG – Engines ITD**

During 2019 all work packages (WPs) progressed significantly towards the master plan. Two WPs entered a final stage. Work package seven on lightweight and efficient jet-fuel reciprocating engines completed its R&T programme and work package three, the 'Turboprop Integrated Power Plant System (WP3)' has entered testing on the ground (TechTP demonstrator).
Further progress was made in the following areas:

- Work packages two, five and six; i.e. ultra-high propulsive efficiency (WP2), very high bypass ratio (VHBR), middle of market turbofan technology (WP5) and VHBR large turbofan demonstrator (WP6); continued with significant progress regarding the key technologies.
- In 2019 Safran began work on an engine with a bypass ratio that was increased to 25+. For the advanced geared engine configuration (WP4), the design of the two-spool rig as well as the EMVAL engine technologies demonstrator activities are approaching their preliminary and critical design reviews respectively.
- For work package eight, entitled 'Reliable and more efficient operation of small turbine engines (WP8)', the objectives for loop two were fulfilled with the assessment of conceptual aircraft fuel consumption and emissions. The programme is now entering its third loop (hybrid-electric powerplant). The GAM covering 2020-21 has been prepared by the end of 2019 in order to continue progress towards final demonstrators as per CS2DP.
- For the eco-design engine (WP9) work package, activity has been consistent with the work programme.

⇨ **SYS – Systems ITD**

In 2019, several cockpit technologies were successfully developed with most of them being integrated into the virtual system bench according to the TRL maturation plan up to TRL 5. Examples include voice recognition, tactile displays and parts of the enhanced vision system.
Progress was also made in the following areas:

- The connected cabin concept had some bricks whose TRL level was starting to increase, such as the smart belt concept, luggage detection without camera and galley concept.
- Interfaces for the cargo fire suppression demonstrator were defined and components design prepared.
- In the area of flight controls, several technologies for large and regional aircraft progressed to TRL 3-4 to prepare the demonstration activity.
- In the area of landing gear system, the direct drive wheel actuator equipment and system achieved TRL4 functional tests and new activities fostering weight reduction and competitiveness were introduced.
- High-voltage-DC components for the power network demonstration progressed towards TRL5. Similarly, activities on bricks for power generation and distribution were advancing as well to support demonstrations.
- The final architecture of the Electrical Environmental Control System (EECS) has been frozen in order to start to deploy the demonstration. Sensors and filtration components for air re-circulation in environmental control were produced and tested.
- Wing ice detection and protection technology progressed as well.
- Transversal activities on small air transport, advanced power electronics and the integrated simulation modelling framework progressed towards the final demonstrations.

⇨ **ECO – Eco-design transverse activity**

Eco-design TA continued its efforts to interact with the different ITDs/IADPs by providing guidance on data collection for different impactful selected technologies to develop more eco-friendly components. Concrete applications are being developed which apply the eco-design approach airframe, engine and systems components which are more ecological and consume fewer resources. A dedicated workshop on additive manufacturing was organised with the participation of airframes, partners and the European Union Aviation Safety Agency (EASA). Similar workshops are planned in 2020 to pinpoint other areas.

⇨ **SAT – Small air transport transverse activity**

The Clean Sky 2 small air transport (SAT) activity deals with the technology needs of small general aviation and commuter/feeder aircraft. Integration studies of technologies developed within the Airframe, Engine and Systems ITDs on 19-seat green aircraft configurations will be carried out to evaluate the benefit of different technologies at aircraft integration level. The main activities in 2019 were the management of related research and technology development across the relevant ITDs, driving and monitoring their technical activities, and the finalisation of Loop 1 for 19-seat aircraft green configuration design for several mission ranges.

⇨ **TE – Technology Evaluator**

In 2019 all WPs made good progress in supporting the global evaluation of the technologies developed in the Clean Sky 2 programme and in preparing the first global assessment which is planned for delivery mid 2020.
The technology evaluator (TE) annual review meeting was held in Cologne from 16 to 18 October. In addition, two TE-System and Platform Demonstrator (SPD) bi-annual workshops were held. The first one took place in April 2019 with the remit to deliver updates and facilitate exchanges on SPD concept models, key technologies, and attainment of specific CO_2 and NO_x goals. Another workshop took place in November 2019 and outlined the TE assumptions in relation to various scenarios and demand and fleet modelling. A TE-SPD workshop took place at the end of October and a further exchange meeting was organised with the Single European Sky ATM Research Joint Undertaking (SESAR) and EASA. Most of the activities in 2019 focused on the elaboration of the TE forecast (developments of demand, movements, and fleet) including airport capacity constraints modelling.
In addition, the scenario storylines for the first global assessment have been elaborated and reviewed by the vehicle manufacturers. This workshop gave participants the opportunity to discuss the underlying assumptions of the scenarios, as well as those for the demand forecast and fleet modelling with all CS private members and evaluators to ensure a common understanding of this major step towards the first global assessment.
Exchanges with Clean Sky 2 partners on metrics and reference aircraft continued. Further exchanges with the JU have been performed regarding the TE light projection and potential approaches to quantify benefits of Clean Sky 2 programme.

⇨ **Summary of calls for proposals in 2019**

In 2019, two calls for proposals were successfully implemented: the eighth call for proposals (CfP08) was completed in March and the ninth call for proposals (CfP09) in October 2019. With regard to the CfP08 call, 58 successful topics out of 68 topics were published (85% success rate) with a total funding request of approx. €65.3 million; time to grant performance (GAPs signed <8 months): 73%. Regarding the CfP09 call, 53 successful topics out of 55 topics were published (96% success rate) with a total funding request of approx. €70.0 million; time to grant performance (GAPs signed <8 months): 96%.

The tenth call for proposals (CfP10) was launched in May 2019 with evaluation taking place in November 2019: 56 successful topics out of 62 topics were published (90% success rate) with a total funding request of approx. €59.7 million. The call is currently under grant preparation and will be fully implemented by May 2020.

Including the tenth call, the JU also successfully launched 10 thematic topics (100% success rate), representing 19 proposals with a total funding request of approx. €26.6 million[4].

[4] *CfP10 included, assuming successful grant preparation of all retained proposals.*

All together, these tenth calls for proposals are already engaging more than 730 Partners from 28 different countries with a strong SME involvement in terms of participation and grants awarded: 42% of the Partners selected, requesting 26% of the nearly € 505 million EU funding launched via these ten calls.

- **Administrative and financial management**

Budget execution again saw a high level of implementation with 100% in terms of commitment appropriations and 97.4% in terms of payment appropriations for the operational budget.
Based on the information received so far, the reported value of the in-kind contributions arising from the operational activities (i.e. within the work plan and funded by the JU) is €572.58 million. The reported value of the in-kind contributions arising from the additional activities (i.e. outside of the work plan and not funded by the JU) is €899.84 million leading to a total of €1.47 billion of private in-kind contributions reported so far.
The residual error rate, which represents the level of errors which remain undetected and uncorrected, did not exceed 2% of the total operational expense.

- **Synergies with ESIF**

In 2019, Clean Sky and the European structural and investment funds (ESIF) continued to actively support research and innovation smart specialisation strategies (RIS3) investments within the scope of clean aviation research and innovation. Applicants were encouraged to combine their Clean Sky 2 funding with ESIF opportunities, and promote the use of ESIF to build and enhance local capabilities and skills in aviation research.

At a strategic level, Clean Sky developed close connections between Member States and regions interested in ESIF opportunities or other national/regional funds. This allows Clean Sky to build synergies and networks between industrial actors, universities, research organisations, SMEs and regional funding opportunities to further enhance the development of clean aviation technologies. Altogether, 120 regions from 28 countries have participated in Clean Sky 2 winning proposals.

To date, Clean Sky has set out frameworks of cooperation through a total of 19 Memoranda of Understanding (MoU) with Member States and regions across Europe. It outlines a strategic approach, follows the regional strategy (RIS3) and identifies the applicable ESIF regional instruments that can support potential proposals that are complementary or related to Clean Sky projects and objectives. The signature of a MoU is not a pre-condition for developing synergies with Clean Sky 2, but an incentive instrument meant to facilitate a closer interaction between Clean Sky, Member States and regions and to stimulate their participation in Clean Sky calls.

As of 2019, more than 45 ESIF and national or regional funded projects with a budget of around €50 million were leveraged through the MoUs. In 2019 the 19th Memorandum of Understanding was signed with the Nouvelle Aquitaine region in France.

Since Clean Sky 2 was launched, eleven proposals have been awarded the Clean Sky Synergy Label, and one proposal is currently under evaluation.

- **Governance**

Throughout the year, various policies and decisions outlining rules or guidelines were proposed and adopted by the Governing Board. The main ones were related to the approval of the annual activity report, adopting the updated Clean Sky 2 Development Plan, providing opinions on annual accounts and in-kind contributions and adoption of the work plan and budget for 2020-2021. Additionally, the adoption of HR implementing rules regarding the type of posts and post titles for temporary staff and conditions of employment of contractual agents, adoption of a revised organisational structure for the JU, the adoption of the revised Clean Sky 2 JU financial rules, and others.

1. IMPLEMENTATION OF THE ANNUAL WORK PLAN 2019

1.1. Key objectives 2019 and related results

The JU has implemented various tools to monitor the execution of the programme in terms of productivity, achievements, planning and risks of the operations:

- quarterly reports of the ITD/IADPs, which include information on resource consumption, the achievements and the resulting forecasts for level of project implementation;
- Steering Committees at ITD/IADP level with involvement of the CS project officers;
- annual reviews of the ITD/IADPs' performance organised by the JU with the involvement of independent experts, if necessary complemented with interim reviews and ad-hoc reviews related to specific milestones or issues;
- this monitoring information is summarised and reported regularly to the Governing Board.

The overall objectives for the Clean Sky 2 programme for the period 2018-2019 are stated below. The progress as of end 2019 is reported against each objective:

Objective in the Work Plan 2018-2019	Status	Comments
To execute the technical content as defined for the two-year period, as stabilised at the end of 2017 and upon completion of the private member accession through the four core partner calls executed from 2014 through 2017. Ensure this is adequately incorporated in the *Clean Sky 2 Development Plan (CS2DP)* and the grant agreements.	Ongoing, technical programme for 2019 largely achieved [>85%]	The technical programme as defined in December 2017 has been fully implemented in the grant agreements for private members starting in January 2018 for a period of one year. The GAMs were amended end of 2018 to extend the work statements for another year with inclusion of recent updates arising from results achieved in 2018. The execution of the technical content for the two-year period is aligned with the programme planning to completion as defined in the Clean Sky 2 Development Plan (adopted in December 2017 and revised in November 2019). All members have acceded to the programme and are active as of January 2018.
To determine in the course of 2018–2019 the definitive configuration of the programme's major demonstrators and technology development themes, based on robust risk and progress reviews based on the 2017 baseline set in the Clean Sky 2 Development Plan (CS2DP); where necessary diverting resources to safeguard the achievement of the programme's High-Level Objectives (HLOs).	Ongoing, on track	In 2019, the annual reviews organised across the IADP/ITD/TAs provided good visibility of results and progress in all the technical areas of the programme. The CS2DP was revised following the reviews, putting light on the proposed work for continuation in 2020-2021 including the planning of activities, the contribution to the High Level Objectives (HLOs), the assessment of risks and the remaining funding at completion. These elements were assessed in the last quarter of 2019 by a panel of experts, including members of the Scientific Committee. The assessment of reviewers confirmed the alignment of proposed plans with the Clean Sky 2 HLOs and their appropriateness to reach objectives at programme completion. In addition, the Scientific Committee issued a positive opinion on the revised CS2DP, adopted

Objective in the Work Plan 2018-2019	Status	Comments
		by the Board in November 2019.
To implement solutions for leveraging Clean Sky 2 funding with structural funds.	Ongoing, on track	A further MoU was signed in 2019 with the Nouvelle Aquitaine region in France, which brought the number of MoUs in force by 31 December 2019 to 19. In the framework of the MoU implementation, some Member States/regions under a MoU launched calls and funding schemes that either included topics dedicated to aeronautics and synergetic to CS2 JU or incentivised the submission of proposals complementary to JU activities and objectives. Campania (IT), Occitanie (FR), Romania and Greece launched or had already open calls during 2019. By the end of 2019, more than 45 projects, with a budget of around €50 million, were leveraged through the MoUs. These projects were selected through the national/regional calls, or awarded the Clean Sky Synergy Label. Some related projects funded in 2019 either at national or regional level are further described in section 1.11. The JU will continue implementing the MoUs in force throughout the year 2020 in view of supporting more upstream coordination with RIS3 and the implementation of more ESIF projects, and will continue identifying more best practices in view of the next framework programme. In the context of cooperation with Member States and regions, the JU participates in relevant events, contributing to the exchange of best practices and discussing potential further perspectives for implementing synergies within Horizon Europe.
To implement an effective and efficient management and governance of the programme.	Ongoing, on track	The overall management and governance of the programme is fully mature, with well-established procedures and bodies/committees. Every ITDs/IADPs/TAs reports to the Governing Board their results and performance on execution on a quarterly basis. Programme Coordination Committee (PCC) meetings are regularly organised (7 meetings in total for 2019) to monitor the programme's progress and execution. In addition, annual reviews and interim progress meetings are organised along the year. This review cycle helps in properly managing and governing the Programme through well targeted actions. Updates of the CS2 strategic documentation i.e. CS2DP and Work Plan 2018-2019 were implemented in April and November 2019 to include CfP09 and CfP10, as well as any technical revision and/or alignment. Since 2018, all grants (including GAMs) are implemented through H2020 IT Tools. All procedures were adjusted

Objective in the Work Plan 2018-2019	Status	Comments
		accordingly. Some effort would still be necessary to adapt H2020 tools to the specificities of the CS2 environment (e.g. GAMs extension, large number of beneficiaries and deliverables, in kind contributions reporting etc.).
To implement an appropriate and agreed approach for each transverse area (TA) that allows for the transversal coordination to be executed and technical synergies to be extracted.	Achieved	For each of the TAs coordination committees are fully operational and include the key members from the contributing/participating IADP/ITDs. The JU is able to monitor progress and validate grant performance through the two axes of the periodic/annual reviews related to the TA as well as receiving reporting inside each participating IADP/ITD. Some additional and 'local' monitoring systems are necessary to keep track of resource and budget usage: this is achieved within the current local systems.
To implement four further calls for proposals and to implement within these calls the additional and complementary format of "thematic topics" enabling a wide range of competing technology solutions to address broad problem-oriented topics that are geared towards the Clean Sky 2 programme-level HLOs.	Ongoing, achieved for 2019 Calls	Implementation of projects from Call 09 started in 2019. Call 10, launched in May 2019, selected projects with a starting date anticipated in Q1 2020. Thematic topics and complementary topics were included in these two calls. Call 11, prepared in 2019, will be launched in 2020. This will be the last call of the Clean Sky 2 Programme.
To widely disseminate information about the calls for proposals (for partners), in order to reach a healthy level of applications and ensure the success of the topics; including SME participation at a rate higher than 35%. To proceed with the selection of participants through these calls.	Ongoing, achieved for 2018 Calls	With a ratio of submissions to retained proposals of between 3:1 and 4:1, the JU has successfully maintained a good balance in terms of success rates for applicants versus wide and strong, open competition. SME participation (% of winning applicants) remains healthy and on target. See also the reported results on KPIs. For the thematic topics, results from Call 09 and Call 10 led to a comparable success rate as multiple projects were awarded funding. The JU believes that the ongoing and current success rate is optimal: ensuring healthy competition yet not discouraging the (significant) effort required to prepare and submit a proposal.
To ensure a time-to-grant (TTG) no greater than eight months for the calls for proposal in no less than 80% of topics and selected proposals.	Ongoing, achieved for 2019 Calls	In 2019, two calls for proposals were successfully implemented, with the eighth call for proposals (CfP08) completed in March and the ninth call for proposals (CfP09) in October 2019. TTG target was met with significant margin. This is further reported in the KPIs.
To execute at least 90% of	Achieved	Yes. 100% in terms of commitment appropriations and

Objective in the Work Plan 2018-2019	Status	Comments
the budget and of the relevant milestones and deliverables.	(estim. as of Jan 2020)	98.2% in terms of payment appropriations for the operational budget In terms of reported (fully completed) milestones and deliverables, more than 85% of deliverables and milestones planed in GAMs have been confirmed. See also paragraph 1.9 for the budget figures and commentary.
To ensure a high level of technical and process integrity in the execution of the programme, including the calls and their resulting selection of CS2 participants; and a maximum relevance of research actions performed towards the programme's goals.	Ongoing, achieved for 2019 Work Plan and Calls	For the actions (and calls) in 2019 the monitoring and control mechanisms in place have ensured the selection of work packages for the grant agreements for members, and the topics for calls were in line with the programme objectives and the work plan. The consultation of the Scientific Committee and the States Representatives Group (SRG) provided valuable inputs to both the overall work plan and – where relevant – to call topics and technical content of the IADP/ITD/TAs.
To finalise and implement the impact assessment strategy and reference framework for the TE (including the selection of and the performance levels of reference aircraft against which the progress in CS2 will be monitored); to finalise the assessment criteria and evaluation schedule for the TE for each technical area. To complete the selection of its key participants; to conduct within the timeframe of the work plan the first TE assessment of CS2 programme in order for its completion in early 2020.	Achieved	Building upon the "Light Projection" forecast started in 2018, and the collection of a first performance estimate for all vehicle models from each SPD, the set-up and configuration of the first Global Assessment of Clean Sky 2 by the Technology Evaluator was largely completed in 2019. This first full environmental assessment is planned for delivery end of June 2020, i.e. a forecast at fleet level by 2050 of the impact of new, more efficient and greener aircraft based on Clean Sky technologies. The report will also include preliminary results of the socio-economic impact assessment (including competitiveness and mobility aspects), focusing on the 'additionality' of CS2. In order to agree, finalise, and implement the impact assessment strategy and reference framework, all key participants, including external independent reviewers, have been involved in a series of dedicated workshops to determine the full assessment methodology, starting Q4 2019, and extending into Q1 2020. A first workshop was held on 29 November 2019 on the forecast scenarios, followed by a workshop on the socio-economic study (31 January 2020) and a vehicle models workshop (16 March 2020). This process is ongoing and will be finalised by April 2020, i.e. two months prior to the delivery of the final report for the 1st Global Assessment, end of June 2020.

List of Major Deliverables and Milestones achieved in 2019

System & Platform Demonstrator (SPD)	Major Deliverables
LPA	Critical Design Review for hybrid laminar flow control (HLFC) Horizontal Tail Plane (HTP) (D4)
LPA	Conceptual System & Architecture Design Report of HLFC wing (D6)
LPA	Report and the model for UHBR Powerplant integration framework (D10)
LPA	Final report on flow control ground test (D11)
LPA	Intermediate test results of the hybrid electric propulsion system (D9)
LPA	Cabin and Cargo platform modules incl. Advanced Micro PSU test specimen available and ready for integration
LPA	Delivery and testing of the OBBIGS Environmental Friendly Fire Protection demonstrator
LPA	DISCO test bench second version
LPA	Multimodal Human Machine Interface Prototype for Business Jet cockpit demonstration
LPA	REACTOR standalone technologies operational validation (TRL4)
LPA	ADVANCE maintenance solutions demonstration final reports
REG	Conventional configuration weight e balance analysis, aerodynamics and aero-acoustic integration studies - Loop 2 (WP1.1)
REG	Sub-components representative of outer wing box verification and validation (WP2.1)
REG	Flying Test Bed 1 aircraft modifications technical dossier - preliminary (WP3.1)
REG	Installation layouts and interface control drawing of the regional aircraft cabin major items of the On-Ground Pax Demonstrator Platform (WP3.2)
FRC	General requirements and objectives (GRO) – Preliminary Design Review maturity (WP1)
FRC	Next Generation Civil Tilt Rotor (NGCTR) configuration – PDR maturity (WP1)
FRC	RACER critical design review minutes of meeting (WP2)
FRC	NGCTR input to FRC mission level results in support of 1st TE global assessment (WP4)
FRC	RACER input to FRC mission level results in support of 1st TE global assessment (WP4)
AIR	Moveable demonstrator CDR
AIR	Integrated Health Monitoring Management (IWTT) for the slat demonstrator
AIR	CDR RACER's wing
AIR	Winglet morphing flight components for FTB#2 Step 1
AIR	Multifunctional flap flight components for FTB#2 Step 1
ENG	Preliminary design review report meeting (WP2)
ENG	Preliminary IPPS test report following first engine propeller to test (FEPTT) (WP3)
ENG	Engine demo critical design documentation (WP4)
ENG	UltraFan® PDR summary review (WP5)
ENG	UltraFan® PDR summary review (WP6)
ENG	Permit-to-fly documentation (WP7)
ENG	Final evaluation report (WP8)

System & Platform Demonstrator (SPD)	Major Deliverables
SYS	Enhanced Flight Vision System / Combined Flight Vision System Validation Test Plan (WP1)
SYS	Standardisation plan (WP2)
SYS	Detailed design review (DDR) Review results for electro-mechanically actuated (EMA) braking (WP4)
SYS	Update on demontrator topics' progression (WP100.1)
SAT	Annual Report (WP1)
SAT	CDR - Integration on P180 /from previous GAM) (WP3)
ECO	Updated technology list for eco-design activities in SPDs
ECO	Progress report for the eco-design technologies and monitoring
ECO	Dissemination and communication plan
TE	TE integrated planning new version
TE	Mission level report
TE	Airport level report
TE	Air Transport System (ATS) level report

System & Platform Demonstrator (SPD)	Major Milestones
LPA	SAAFIR test rig CDR (D1)
LPA	TRL3 technology and configuration review of advanced rear-end (D2)
LPA	TRL4 for HLFC HTP (D4)
LPA	HLFC wing preliminary definition of multi-physics demonstration (D6)
LPA	PDR for the UltraFan nacelle and pylon techno bricks (D10)
LPA	CDR FTD: flow control technology (synthetic jet actuators) applied on engine/pylon (D11)
LPA	Commissioning of 2MW generator and power electronics to the Airbus Hybrid-Electric Propulsion Ground Demonstrator (D9)
LPA	Critical review of key modules contributing to the multifunctional fuselage demonstrator
LPA	Handover of cabin and cargo platform modules including the Universal Cabin Interface (UCI) and printed electrics for integration to a joint demo platform
LPA	Review of industrial feasibility and assembly lead times for advanced lower centre fuselage
LPA	Review of results from advanced fastener and assembly technologies, automated inspection and predictive simulation
LPA	Review of automated cabin and cargo installation solutions in the context of the future factory concept
LPA	Operational validation in active cockpit simulator: TRL4 of standalone technologies
LPA	ADVANCE maintenance solutions TRL6
REG	Annual review (WP0)
REG	Eco-compatible technologies final assessment and validation (WP2.1)

System & Platform Demonstrator (SPD)	Major Milestones
REG	Iron Bird manufacturing & configuration review (WP3.4)
REG	Initiation of HQ & loads flight clearance for PtF (WP3.5)
FRC	CfP08 partners on contract (WP1)
FRC	FRC input to 1st TE Global assessment report (WP4)
AIR	Door demonstrator CDR report
AIR	IWTT CDR
AIR	Gust Wind Tunnel Test CDR
AIR	Wing box CDR
AIR	Down-selection for the innovative cabin architecture solutions
ENG	Preliminary design review (WP2)
ENG	First engine propeller to test (FEPTT) (WP3)
ENG	2 spool compr. rig preliminary design review (WP4)
ENG	Enablers to UltraFan® PDR (WP5)
ENG	UltraFan® PDR (WP6)
ENG	Application to Permit-to-fly (WP7)
ENG	Final exploitation plan (WP8)
SYS	C3 bench available (WP1)
SYS	Standardisation review n°2 (WP2)
SYS	Electro-motor-pump bricks available (WP3)
SYS	Short turn-around-time TRL4 review (WP4)
SYS	Flight control computing node detail design review (WP7)
SYS	Completion of 3 out of four demonstrator topics in network architectures section of the programme (WP100.1)
SYS	Automatic test generation environment complete (WP100.3)
SAT	Annual report (WP1)
SAT	PDR - Integration on P180 /from previous GAM) (WP3)
ECO	Workshop on joint themes

Environmental forecast

The environmental targets of the Clean Sky 2 programme are defined in the Council Regulation[5]:

a) To contribute to the finalisation of research activities initiated under Regulation (EC) No 71/2008 and to the implementation of Regulation (EU) No 1291/2013, and in particular the Smart, Green and Integrated Transport Challenge under Part III — Societal Challenges of Decision 2013/743/EU;

b) 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 CO2 emissions by 20 to 30 % compared to 'state-of-the-art' aircraft entering into service as from 2014;

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

The translation of the programme's high-level environmental objectives into targeted vehicle performance levels is shown below. More details about the vehicle performance levels, in particular about the reference aircraft, are available in the Clean Sky 2 Development Plan.

Conceptual aircraft / air transport type	Window[1]	ΔCO_2	ΔNO_x	Δ Noise	Target[2] TRL @ CS2 close
Advanced long-range (LR)	2030	20%	20%	20%	4
Ultra advanced LR	2035+	30%	30%	30%	3
Advanced short/medium-range (SMR)	2030	20%	20%	20%	5
Ultra-advanced SMR	2035+	30%	30%	30%	4
Innovative turboprop [TP], 130 pax	2035+	19 to 25%	19 to 25%	20 to 30%	4
Advanced TP, 90 pax	2025+	35 to 40%	> 50%	60 to 70%	5
Regional multimission TP, 70 pax	2025+	20 to 30%	20 to 30%	20 to 30%	6
19-pax commuter	2025	20%	20%	20%	4-5
Low sweep business jet	2035	> 30%	> 30%	> 30%	≥ 4
Compound helicopter	2030	20%	20%	20%	6
Next-Generation Tiltrotor	2025	50%	14%	30%	5

[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

[5] Council Regulation (EU) No 558/2014 of 6 May 2014

Indicators

The Key Performance Indicator results for the Clean Sky 2 programme for 2019 are presented in Annexes 5 to 7.

Administrative objectives – achievement

Objective 2019	Achieved in 2019 (Yes/No/Comments)
A reliable financial management and reporting to the JU's individual stakeholders (the European Union and the private members and partners of CS) is ensured;	Yes. The JU has continued to work in accordance with the financial regulation and internal procedures in order to implement and monitor the execution of the overall budget in terms of productivity, achievements, planning and risks of the operations.
90% of GAM cost claims received are formally dealt with (validated, put on hold or refused) before end of May each year;	Yes. 100%.
The ex-post audits on H2020 projects are performed according to the plan and show a materiality of errors lower than 2% for the total programme period. The audits carried out by the Common Audit Service (CAS) for the entire research family, in particular for the Common Representative Sample, are coordinated with the audit requirements of Clean Sky 2 JU.	Yes. The majority of the planned audits have been finalised until the end of 2019 and enabled the JU to establish its specific representative error rates. Annual and accumulated error rates for the CS2 programme period are below 2%. The JU succeeded in coordinating the specific requirements for audits of CS projects with the audits performed by the CAS for the research family in total.

1.2. Research and Innovation activities

The Clean Sky 2 Joint Undertaking contributes 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.

The Clean Sky 2 programme clearly demonstrates the benefits of a true Public Private Partnership (PPP). Stakeholder participation was at a high level, including SMEs (often their first participation in the European framework programme), research centres and academia. Industry is increasingly using Clean Sky as the focus of their R&T programmes because of the efficiency and effectiveness of Clean Sky research at European level. The JU has proven to be an appropriate management body.

The Clean Sky 2 programme will deliver vital full-scale in-flight demonstrations of novel architectures and configurations. Advanced technology inserted and demonstrated at full systems level will enable step-changes in environmental and economic performance and bring crucial competitiveness benefits to European industry. This will enable the European aviation sector to satisfy society's needs for sustainable, competitive mobility towards 2050. As such, the results of the Clean Sky 2 programme will enable to create high-skilled jobs, increase transport efficiency, sustain economic prosperity and drive environmental improvements in the global air transport system.

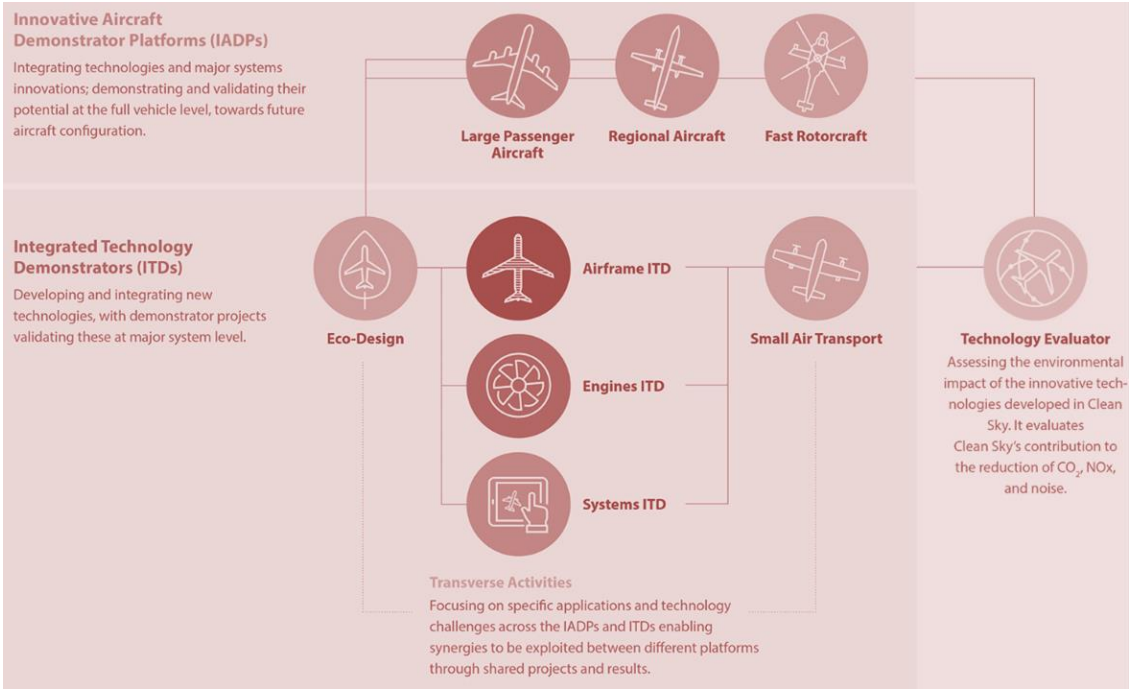
Clean Sky engages the best talent and resources in Europe and is jointly funded and governed by the European Union and the major European aeronautics companies. It utilises the key skills and knowledge of the leading European aeronautic research establishments and academic faculties. Small and medium-size enterprises and innovative sub-sector leaders will help to shape promising new supply chains.

Research and innovation actions delivering important technological advances started in Clean Sky programme were extended and continued in Clean Sky 2 programme. New architectures, such as hybrid-electric propulsion and new vehicle configurations addressing unmet mobility needs, will be evaluated with flight demonstrators. They will be essential in order to fulfil the ambitious objectives of the renewed ACARE Strategic Research and Innovation Agenda (SRIA). Conventional aircraft configurations are approaching intrinsic performance limits, as the integration of the most recent technologies are showing diminishing returns. Therefore, the need is even greater today for industry to develop materially different, substantially more environmentally-friendly and energy-efficient vehicles to meet market needs, and ensure their efficient integration in the air transport system.

Clean Sky 2 will continue to use the Integrated Technology Demonstrators (ITDs) mechanism. Its objective-driven agenda to support real market requirements providing the necessary flexibility is well suited to the needs of the major integrator companies. The CS2 programme will also focus on reinforcing interactions between demonstrations of improved systems for a better integration into viable full vehicle architectures. The Clean Sky 2 programme 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 (TAs) 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 a key function incorporated into Clean Sky 2.



Clean Sky 2 Programme Logic and Set-up

Introduction to the IADPs, ITDs and TAs

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, the vehicle demonstration platforms cover 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 from 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 on 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 two new configurations of rotorcraft 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 verified and validated technologies to be matured from their basic levels to the integration of entire functional systems. These technologies have the ability to cover quite a wide range of technology readiness levels. Each of the three ITDs covers 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 innovative flight vehicle configurations:

- Airframe ITD (AIR) including topics affecting the global vehicle-level design;
- Engines ITD (ENG) for all propulsion and power plant solutions;
- Systems ITD (SYS) covering all on-board systems, equipment and the interaction with the Air Transport System.

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 joint and shared technical and research priorities. 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 is reserved inside the relevant IADPs and ITDs to perform these activities. TA leaders were nominated and coordinate each transverse activity. Currently, three transverse activities are running in the Clean Sky 2 programme and are specified in the Statutes of the JU:

- Eco-Design TA (ECO): key materials, processes and resources related innovations considering the life cycle optimisation of technologies, components and vehicles; and continuing and securing advances from the Clean Sky programme;
- Small Air Transport TA (SAT): airframe, engines and systems technologies for small aircraft, extracting synergies where feasible with the other segments;
- The Technology Evaluator, as technology and impact evaluation infrastructure, is an essential element within Clean Sky. Impact assessments at airport and ATS level currently focused on noise and emissions will be expanded where relevant for the evaluation of the programme's delivered value. Where applicable they can include the other impacts, such as the mobility or increased productivity benefits of Clean Sky 2 concepts. The TE will also perform evaluations at an aircraft "Mission Level" to assess innovative long-term aircraft configurations.

1.3. Calls for proposals and grant information

Calls launched

In the 2019 reporting period all call activity was related to the Clean Sky 2 programme. The activities associated to these calls (and results, where available) are reported below.

General background

Up to 40% of Clean Sky 2's available funding is allocated to its 16 leaders and their affiliates in the leaders' share of the EU funding, as set out in Article 16 of the Clean Sky 2 JU Statutes. The remaining funding of at least 60% is awarded through competitive calls: calls for core partners (members) also referred to as the core partner waves (CPW), calls for proposals (CfP), and where and if applicable calls for tenders (CfT). The amount involved within this 60% is just over €1 billion.

Up to 30% of the programme's funding is available for core partners and the calls related to the selection and accession of core partners were completed over the 2014-2017 period, with the membership of the programme fully configured as of end 2017.

As per the Clean Sky 2 JU Council Regulation, at least 30% of the Clean Sky 2 funding shall be awarded via calls for proposals and calls for tenders. Industry, SMEs, research organisations (ROs) and academia are all eligible. Partners are awarded grants by the Joint Undertaking via calls for proposals (CfP). Once selected, they are invited to perform activities in specific projects within a well-defined and more limited scope and commitment than core partners, via dedicated grant agreements for partners. Partners' activities are monitored and managed by the JU in close collaboration with topic managers appointed by the members, hence ensuring the alignment of actions and the convergence of technical activity towards the programme's goals.

One key difference between the Clean Sky 2 JU calls and standard H2020 collaborative research calls is that there is no eligibility requirement to build a consortium with a minimum number of participants or representing a minimum number of Member States or H2020 associated countries. This is based on a derogation[6] received from the H2020 Rules for Participation, and is due to the fact that a selected entity, when starting an action in the programme, is joining an already established European level collaborative effort involving a large number and varied set of participants.

The Clean Sky 2 programme provides opportunities for the vast bulk of the aeronautics stakeholders in the European research area and also allows space for newcomers, including important opportunities for "cross-over" participants from outside the sector. Getting capable new companies involved in the aeronautics sector can make an important contribution to the competitiveness of the sector and to the European economy.

[6] Art 1(3)(a) of the Horizon 2020 Rules for Participation.

Calls for core partners: summary of status of implementation

All four core partner calls that were foreseen for the programme were successfully closed in 2017. This has completed on time the selection process for the Clean Sky 2 membership, with respect to the initial planning.

When accumulating the results from all four calls and the accession of the winning entities as members, the total number of core partners is now 256, of which 70 are affiliates or linked third parties. Over 58 SMEs are counted among these members of the JU. 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[7] and is updated on a regular basis.

Summary of call results to date – calls for proposals

Since the programme's start ten calls for proposals (CfPs) have been launched, with nine closed (grant preparation completed), and one under grant preparation at the time of this report's compilation (grant signature early May 2020).

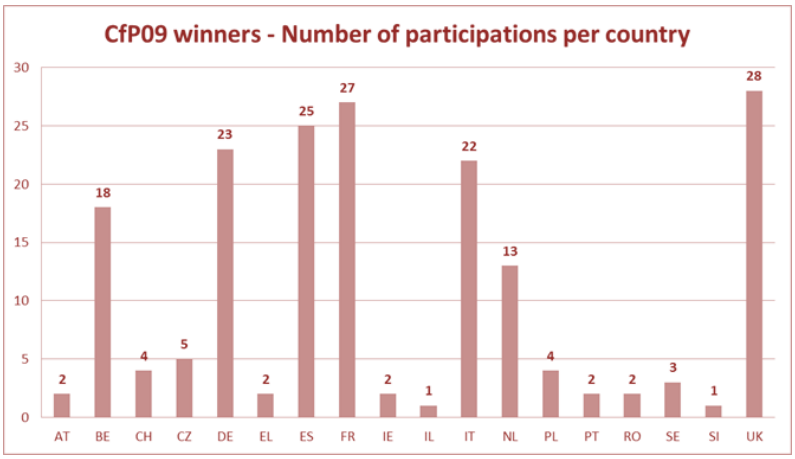
With positive feedback and support from the research community, the launch of thematic topics will continue within the remaining calls for proposals: in total, 8 topics were launched through the ninth and tenth CfPs in 2019. Thematic topics will contribute to progress made towards the high-level objectives of the CS2 Regulation, but are not necessarily linked to one IADP/ITD (demonstration activities/strategy), meaning they are "outside" the complementary framework of one IADP/ITD/TA.

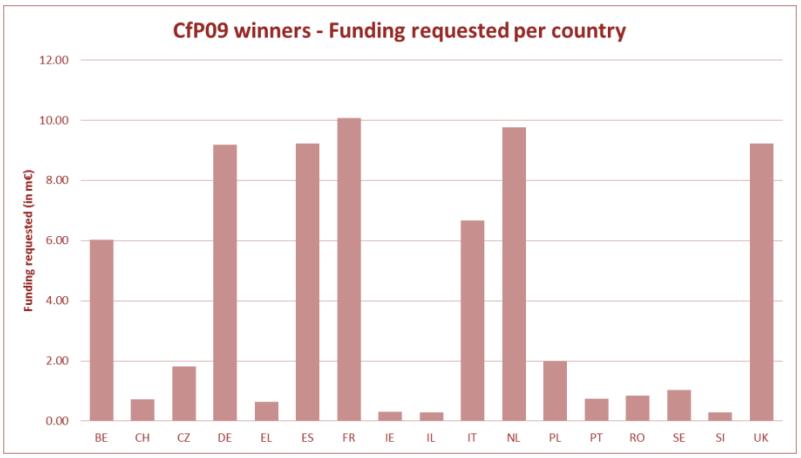
The implementation of the ninth call for proposals (CfP09) was successfully completed in October 2019:

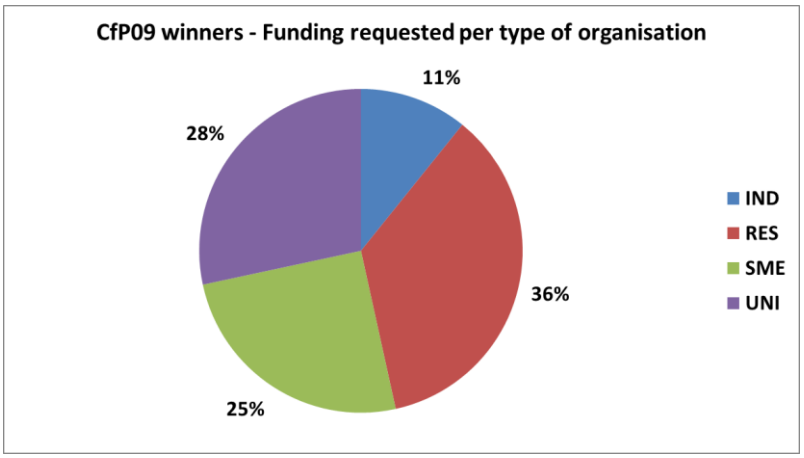
- 53 successful topics out of 55 topics published (96% success rate) with a total funding request of nearly €69.97 million of which:
  - 100% success rate for thematic topics (4 topics were launched);
  - 7 proposals retained with a total funding request of €9.0 million;
- 184 participations from 18 different countries;
- SME participation: 32%;
- 153 partners selected.

The outcome of the evaluation is summarised in the graphs hereafter:

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







The tenth call for proposals (CfP10) was launched in May 2019, with an evaluation taking place in November 2019. The key metrics of this call are shown below:

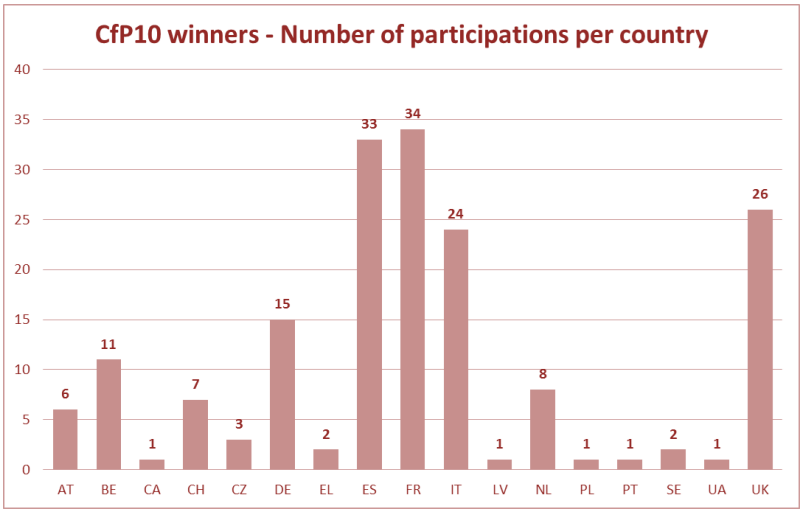
- Call comprised of 62 topics of which four are thematic topics;
- Indicative topic value of approx. €52.45 million (overview depicted hereafter) plus €15.0 million for thematic topics;
- Opening date: May 2019;
- Closing date: September 2019;
- Deadline for eight months - time to grant: May 2020.

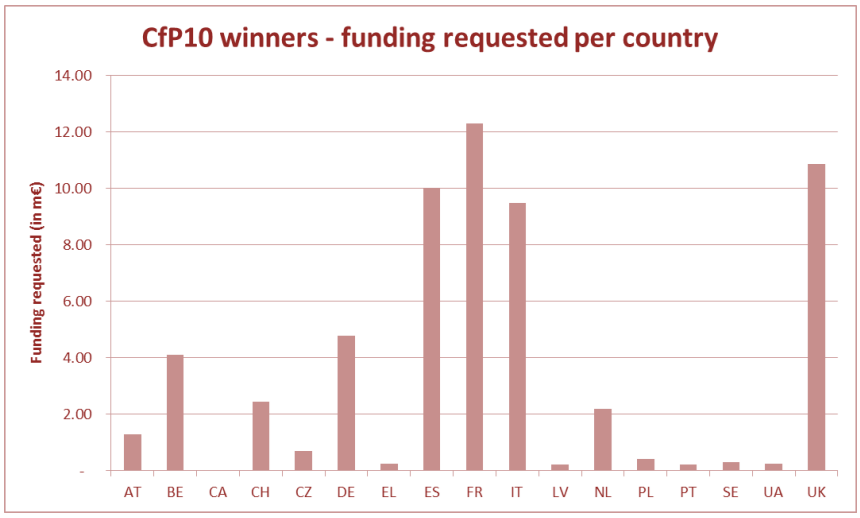
SPD Area	No. of topics	Ind. topic Funding (in M€)
IADP Large Passenger Aircraft	19	20.70
IADP Regional Aircraft	3	1.35
IADP Fast Rotorcraft	3	4.80
ITD Airframe	18	12.93
ITD Engines	2	2.35
ITD Systems	13	10.32
Small Air Transport related topics*	[2]	[1.10]
ECO Design related topics*	[1]	[1.75]
TOTAL	58	52.45
Thematic Topics	**# of topics**	**Ind. topic funding (M€)**
TOTAL	4	15

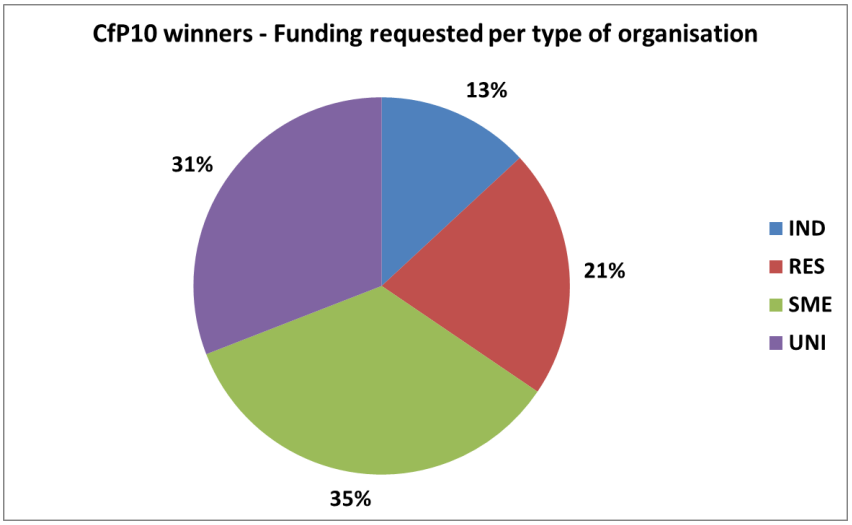
**TA related topics are proposed and embedded in the following SPDs and as follows: AIR ITD: 1 SAT topic, 0.48M€ ; SYS ITD: 1 SAT topic, 0.60M€ ; ENG ITD: 1 ECO topic, 1.75M€*

The outcome of the evaluation is summarised below and in the graphs hereafter:

- 56 successful topics out of 62 topics published (90% success rate) with a total funding request of nearly €59.8 million of which:
  - 100% success rate for thematic topics (4 topics were launched);
  - 6 proposals retained with a total funding request of €11.91 million;
- 176 participations from 17 different countries;
- SME participation: 34%;
- 144 partners selected.



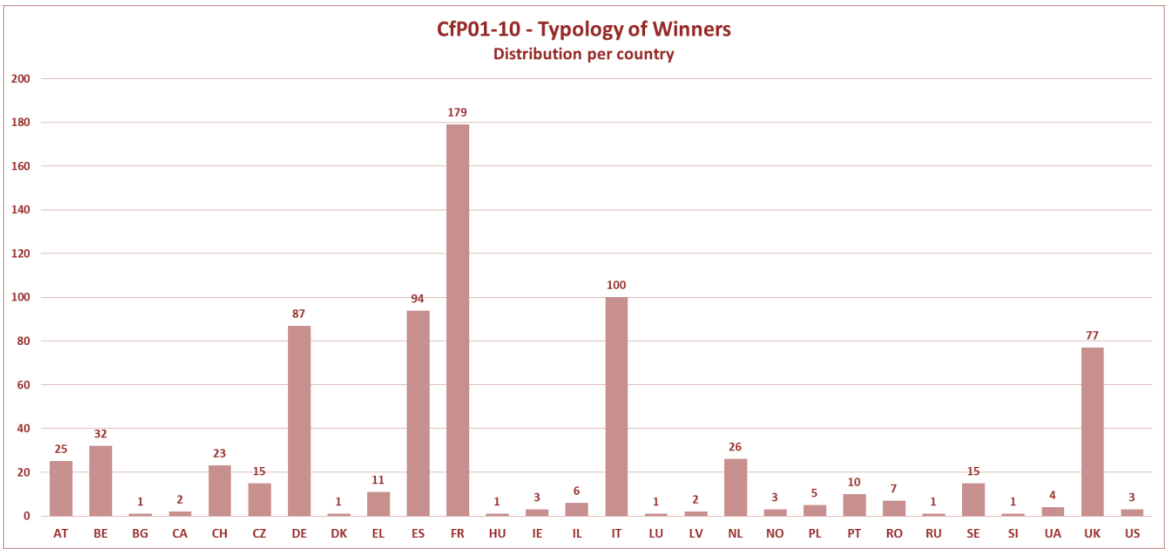


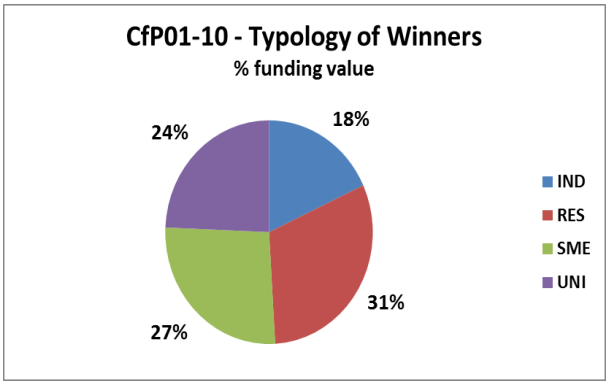


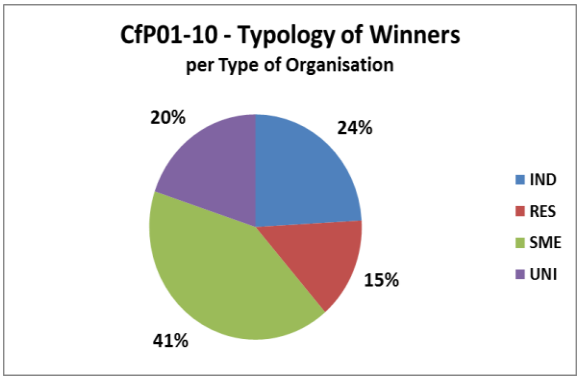
Note that the grant preparation for this call is ongoing at the time of this report's compilation. The numbers in the statistics above are therefore subject to change.

Cumulative position of the calls for proposals

By the end of 2019, ten calls for proposals were launched and evaluated, and all are fully implemented with the exception of the tenth call for proposals, currently under grant preparation. Altogether, these ten calls are already engaging more than 730 partners from 28 different countries with a strong SME involvement in terms of participation and grants awarded: SMEs make up 41% of the partners selected, requesting 27% of nearly €505 million in EU funding launched via the ten calls for proposals.







Note that the numbers in the statistics above are subject to change due to the ongoing implementation of CfP10.

Cumulative position of Clean Sky 2 participants

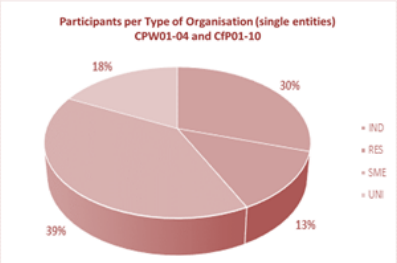
With more than 900 participants (including the 16 leaders and their affiliates) and over 1750 participations, the Clean Sky 2 programme is well on track. With the last call for proposals budget available for implementation in 2020 (still representing up to roughly €55 million) and the launch of remaining thematic topics, a significant further broadening of the participation over the remaining life of the programme is expected. This demonstrates a dynamic and open system that creates a wide array of opportunities at various project (funding) size and engagement levels for all potential stakeholders.

Overall Participation in CS2

Winning Proposals [CPW01-04 and CfP01-10]*

	LPA	REG	FRC	AIR	ENG	SYS	TE2	THT	TOTAL
IND	88	25	37	99	63	80	0	5	397
RES	95	28	42	118	47	65	12	13	420
SME	125	34	51	141	48	89	7	19	515
UNI	111	24	25	90	73	51	4	42	420
TOTAL	419	111	155	448	231	285	23	79	1752

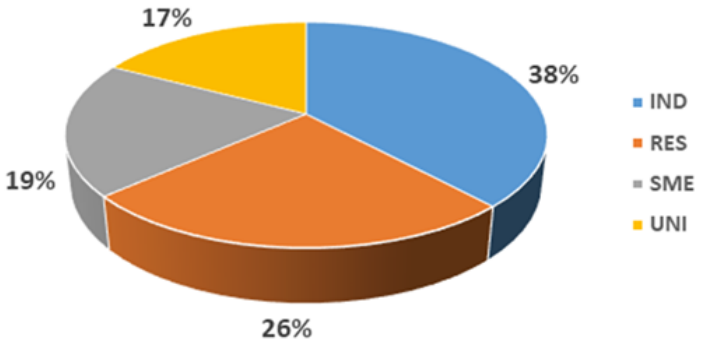
Total number of **single** entities**: **852** from **30 countries**



** Participations in CfPs and CPWs. CfP10 included, assuming successful grant preparation of all retained proposals. Leaders' actions not accounted.*

*** Multiple winners in CfPs and CPWs removed. Statistics subject to change due to the ongoing implementation of CfP10.*

Funding Request per Type of Organisation
Winning Proposals [CPW01-04 and CfP01-10)



Note that the numbers in the statistics above are subject to change due to the on-going implementation of CfP10.

1.4. Evaluation: procedures and global evaluation outcome, redress, statistics

In 2019, the evaluation of two calls was completed, namely the CfP09 and the CfP10:

Call	CFP09	CFP10
No. of Experts[8]	145	176
Gender Balance [% Female]	18%	13%
Nationalities [%]:		
France	19%	16%
Germany	12%	13%
Italy	20%	19%
Spain	10%	10%
UK	9%	5%
Others	30%	31%
Type of Organisation [%]		
Consultancy firms	0%	9%
Higher Education Establishments	33%	33%
Non-research commercial sector incl. SMEs	35%	32%
Private Non-profit Research Centres	10%	7%
Public Research Centres	2%	8%
Others	20%	11%
No. of Days claimed[9]	758	944
No. of Observers	2	2
New wrt H2020 [%]	3%	6%
Newcomers in CS call evaluation (last 3 years) [%]	3%	8%

Highlights:

1. The JU continued its efforts to improve the experts' gender balance where possible while maintaining the level of experience and aeronautical (or similar) technical background. However, it is not seen as easily improved upon beyond this level given the specificities of the technical areas and subject matter involved.
2. The balance of nationalities of the experts is representative of the domain, and inclusive with respect to a broad representation.
3. For each of the evaluation exercises concluded and submitted to the Governing Board, the Observers' Reports – with substantial detail on the expert panel breakdown in gender and nationalities, but also on the evaluation process and set-up – have been shared with the SRG. The redress rate for 2019 remained at a very good level and stayed below the KPI of 1%.

[8] Based on the total number of experts in the pool.
[9] Based on the total number of experts having attended the evaluation.

1.5. Progress against KPIs/statistics

The key performance indicators results for the year 2019 are presented in Annexes 5 to 7. The JU has included all H2020 indicators in its scoreboard, which have been established for the entire research family by the Commission, to the extent to which they are applicable to the JU. Comments to some individual indicators are provided in the annexes or in the related section of this report. In addition, the JU is presenting more detailed results of its performance monitoring in specific areas, e.g. there are comprehensive statistics and key figures provided in the section dealing with the calls.

1.6. Activities carried out in Grant Agreement for Members (GAM)

The structure and set-up of the Clean Sky 2 programme is highlighted in section 1.2, where the top-level breakdown of actions as set out in the GAMs is described. The key elements of the technical progress in 2019 are highlighted below.

→ LPA – Large Passenger Aircraft IADP

Summary of activities and progress of work 2019

The Large Passenger Aircraft IADP is focusing on large-scale demonstration of technologies integrated at aircraft level in three distinct 'Platforms' as follows:

<u>Platform 1: 'Advanced Engine and Aircraft Configurations'</u>

The major objective of Platform 1 is to provide a development environment for the integration of the most fuel efficient propulsion concepts into compatible airframe configurations and concepts targeting next generation aircraft. Overall, the propulsion concepts considered in Platform 1 range from Open Rotor engine architectures over advanced Ultra-High Bypass Ratio (UHBR) turbofans up to "hybrid" propulsion concepts (combination of combustion- and electric-based components) for different levels of electrification of the power plant.

For all these aforementioned propulsion concepts, design opportunities are being investigated to further increase the propulsion and airframe efficiency. Examples of this include the application of boundary layer ingestion (BLI) design or by exploring the potential of distributing the thrust-generating part of the power plant over the aircraft. In the context of improved engine performance and novel system architectures detailed studies for non-propulsive energy generation (NPE) will be performed to reduce the power off-take level from turbofan engines for improved thermal efficiency. In any case the validated plan will reveal full coherence, technical and financial, for UHBR integration on short range aircraft regarding airframe-engine integration tasks and engine module maturation across both, the IADP Large Passenger Aircraft and ITD Engines. To avoid detrimental effects on overall aircraft performance when integrating UHBR engines on airframe, Platform 1 is developing and demonstrating integrated flow control techniques applied at the wing-pylon interface, an area which is prone to interference effects

between wing and engine. Another important flow control activity in the reporting period is the maturation of the Hybrid Laminar Flow Control technology (HLFC) applied on tails and wing for skin-friction drag reduction.

For scaled flight test demonstration the development of the actual flight-test vehicle, the preparation of the flight test and support for the design other potential vehicles are key activities during the reporting period.

It is the overall objective of Platform 1 that all technologies developed and demonstrated are following consistent target aircraft configurations and concepts, which means that the compatibility between airframe and propulsion technologies is ensured with respect to supporting the overall CS2 objectives to reduce CO_2 emissions and nitrogen oxides (NOx) as well as contributing to the reduction of aircraft noise.

Platform 2: 'Innovative Physical Integration Cabin – System – Structure'

Platform 2 aims to develop, mature, and demonstrate an entirely new, advanced fuselage structural concept in full alignment towards next-generation cabin and cargo architectures, including all relevant aircraft systems. To be able to account for the substantially different requirements of the test programs, the large-scale demonstration will be based on a number of demonstrators, covering the next generation fuselage cabin and systems integration within the frame of the MultiFunctional Fuselage Demonstrator and the Next Generation Cabin and Cargo Functions. These major demonstrators will be supported by a number of smaller test rigs and component demonstrators in the preparatory phase of the programme. Targeting to accomplish technology readiness up to level 6, manufacturing and assembly concepts for the next generation integrated fuselage-cabin-cargo approach will be developed and demonstrated.

Platform 3: 'Next Generation Aircraft Systems, Cockpit and Avionics' including advanced systems maintenance activities

During 2019, the IADP LPA platform 3 activities were focusing on progressing the maturation of functions and technologies developed by several core partners in Platform 3 and in the ITD systems, and starting their integration and tests within the Large Aircraft Disruptive Cockpit, Regional aircraft Active cockpit and Business Jet ground demonstrator test benches. Flight tests for selected cockpit-avionics functions and technologies have been successfully performed on large aircraft and on business jets. The definition and design of the pilot workload reduction enabling functions and technologies have been partially completed. Facing the withdrawal of a major core partner a recovery plan has been put in place. Hardware test items for individual integration into the demonstrators have been delivered. The Active Cockpit Demonstrator has been set up and the final test plan for the On Ground Workload Reduction Assessment has been delivered. The integration of the Large Aircraft Disruptive Cockpit demonstrator systems integration bench has taken place, and several functions integration scenarios have been successfully tested. The plan for incremental functions integration and testing has been defined up to proof of concept to take place in 2021. The development and integration of major demonstrators for end-to-end maintenance ADVANCE enabling technologies (health monitoring, collaborative environment and line maintenance mobile tool applications) has been finalised, and the final technology demonstration of ADVANCE took place in March 2019.

Main achievements and progress of work for the year 2019

The main achievements are given per platform, with explanations provided for each of the main demonstrators embedded within the given platform.

Platform 1: 'Advanced Engine and Aircraft Configurations'

In 2019, the majority of the demonstrators and their underlying technologies passed important milestones, which determined the change from non-specific to specific design and the associated build-up of hardware (prototypes, rigs, etc.).

Advanced propulsion and engine technologies

Advanced high bypass ratio underwing turbofan engines are focused on reaching high technology readiness levels in the short term, while developments of other advanced concepts are shifting to sustain for a longer term. The technical and organisational setup of the corresponding activities and work packages were reoriented in 2018 with new or more ambitious technology roadmaps proposed for open rotor, BLI, non-propulsive energy technologies and ultra-high performance turbofan engines. In 2019, the work progressed in all of these areas at different paces (proof of concept, technology maturation,…) as illustrated below, with the aim to better characterise the potential environmental benefits arising from this new innovative concept (ranging from 2 to 10% of reduction of CO_2 emissions).

All activities are geared towards an important milestone scheduled in 2022, which aims to assess the various propulsion architecture candidates and to freeze the A/C concept reference proposed for 2030+ and beyond. The demonstators will start being built. The progress made in all those fields in 2019 can be summarised as follows:

- Open rotor propulsion concepts
  The design of open rotor blades including cabin-noise assessment and trade studies at aircraft level have been completed for the 'ORAS' concept (Open Rotor Advanced System) and work will continue in 2020, prioritisng blade design and engine vibration related noise. Potential synergies with experimental research on very high bypass ratio turbofan engine noise reduction technologies will have to be examined in 2020.

- Non-propulsive energy (NPE)
  Design activities and architecture selection linked to power electronics and electrical machines continued. The high density energy conversion system is still in the critical design phase, which is ongoing until Q1-2020. Auxiliary Power Unit performance modelling is in progress and the first aero-mechanical iterations on compressor blades and turbine blades have been completed.

- Boundary layer ingestion (BLI)
  Various assessments of the selected configuration confirmed initial expectations. With regards to engine fan design, several iterations have been done for varying parameters of

cruise Mach number and increased engine mass flow with new A/C design, including performance and operability aspects. The promising progress made on fan design studies allows us to envisage the benefits for other BLI configurations. Other configurations such as 360° BLI configurations will start in 2020.

Scaled flight test demonstrator (SFD)

The detailed design of the SFD and its subsystems were completed and presented during the CDR in June 2019. After gathering further data, it was concluded that the project could continue, taking into account different points identified during the review. Detailed CFD analyses were carried out in WP1.3.3 in order to refine the high lift design system and thus increase safety. Always with the objective of reducing uncertainties before flight, the SFD aerodynamics will be assessed during wind tunnel tests in DNW (Duits Nederlandse Wind Tunnel). Due to a technical issue in this facility, the WP1.3 planning must be reviewed with a first flight scheduled in Q1/2020.

Hybrid electric propulsion

The design and development of several key technologies (generator, power electronics, electrical motors) continued. The delivery of an integrated 2MW-MK2 Generator and MK2 Power Electronics fed into the commissioning of the Hybrid Electric Propulsion ground test bench. In parallel, thermal management/cooling technologies were further developed in 2019, planned to be ready for testing in 2020.

UltraFan®

All engine integration activities will be continued, covering for example pylon, aerodynamic and aero-acoustic integration, thermal management and bleed systems, as well as nacelle architecture and acoustic treatments, all in the context of the preparation of a full size flight test towards the end of the CS2 LPA program.

Active flow control

This technology is a potential enabler for UHBR engine integration. Several experiments have taken place to assess aerodynamic performances and/or performances under harsh environmental conditions:

- either at actuators level (3D printed full-scale actuators, steady and pulsed jet blowing) or;
- at full scale with use of a model including a 3D-printed SaOB (suction and oscillatory blowing) actuators and corresponding equipment (sensors, instruments, pipes etc.).

All results and background acquired in that field over the last years have helped to progress the knowledge and background with respect to aerodynamic performance and constraints required to implement this technology onto an aircraft. Next steps involve designing sensors that are capable of meeting aerodynamic performance with a limited amount energy.

HLFC (hybrid laminar flow control) technology applied on horizontal tail plane

TRL4 was passed in 2019, covering both performance and manufacturing aspects. The assessment of adhesive bonding and joining options for laminar flow, as well as the manufacturing of a segment of the full-scale demonstrator of micro-drilled outer skin were

almost complete in 2019.

HLFC technology applied on wing
The preliminary design activities have been completed, encompassing the integrated wing design with allowable surface tolerances, leading edge shielding concept, and ice protection. TRL2 was successfully passed in October 2019.

Platform 2: 'Innovative Physical Integration Cabin – System – Structure'

Multi-functional fuselage demonstrator (MFFD)
Most of the activities started in 2018 continued in 2019. Following the Preliminary design review the initiation of technology working groups led to a concurrent specific design process on stringer/frame stiffened thermoplastic composite skins with integrated system elements and cabin interfaces, an advanced cargo door concept with door surrounding and interfaces, integrated fuselage lining and wiring, cabin and cargo structure and modules pre-equipped with systems. Big focus was put as well on the detailed design and preparation of tooling and manufacturing infrastructure for a pre-production phase from 2020 onwards. The material delivery to partners has been supported and a wide exchange on the relevant fuselage thermoplastic material for testing performed. First test campaigns and numerical simulations, dedicated to benchmark the welded skin joints of thermoplastic fuselage shells, have been performed for assessment in terms of performance and damage tolerance behaviour. The critical design review of the MFFD was passed end of 2019 where the baseline design and the digital mock-up for the demonstrator were agreed. This major milestone was preceded by the launch of the upper shell development and design activities as of September 1st, 2019 and confirmed good progress and confidence in results achieved in 2019 to proceed with manufacturing of the different major components in 2020.

Next generation cabin and cargo functions
Demonstrators and test specimens for an advanced Movable Passenger Service Unit are available for passenger service channel (PSC) integration or integration into a PSC-less cabin in 2020. For the cabin and cargo platform, the elaboration of all system-cabin interfaces were elaborated, the tolerance compensation principles were defined and the installation jig definition completed. The evaluation boards of the Universal Cabin Interface (UCI) are available for environmental testing and for the validation and verification campaign.

Cargo fire tests in a real burn chamber were completed and the Environmental Friendly Fire Protection demonstrator unit was ready for verification tests. The first test results were available at the end of 2019. Based on the results of the printed electrics system concept, in 2019 the focus was on the testing of material combinations and environmental impact studies. The development of design rules and the challenge to be compliant with the existing electrical infrastructure and industrialisation aspects are extended with activities in 2020. For the automated cabin and cargo lining and hat-rack installation method, the main focus in 2019 was on the final installations at the validation platform at IFAM Stade.

Next generation centre fuselage
A floor module concept was selected that showed a reduction of almost two-thirds in the number of interfaces with the center fuselage, using new concepts to clip it with fast

connections and no drilling, and an easy access to systems.

Further work in 2019 included:

- creation of a mock-up of a keel beam fixed by lug and hole-to-hole demonstrator;
- delivery of two Digital Mock-Ups of center fuselage architecture using Carbon Fibre Reinforced Polymer (CFRP) and major composite design principles on carbon fibres;
- selection of the main landing gear bay;
- assessment of innovative manufacturing solutions for the keel beam.

By the end of 2019, the demonstrator had reached TRL3 and further progress to reach TRL4 would require significant effort. In the absence of a decision that was yet to be made concerning the future aircraft design, the decision was made to suspend this activity and to properly capture all results attained.

Non-specific cross functions & ITD airframe

The activities were oriented on competitiveness aspects (reduction of recurring cost-lead time) and environmental impact on materials for composite assemblies, sensing technologies for manufacturing composite and metallic parts. This is to support the above mentioned demonstrators amongst others. In parallel, a design tool for multi-scale complex structures was conducted.

Platform 3: 'Next Generation Aircraft Systems, Cockpit and Avionics' including advanced systems maintenance activities

Large aircraft disruptive cockpit demonstrator:

For cockpit avionics functions and technologies development, the GPS-aided MEMS AHRS prototype flight tests data collection campaign took place, and open loop simulations were performed. The virtual platform core processing module has been delivered to core partners for integration of applications. The smart air system sensor interface with utility system platforms has been developed up to TRL3. In relation to cockpit functions and technology flight tests, the LIDAR flight test installation was completed, dry air flight tests took place, ready for icing conditions flight test campaigns in 2020. The software defined radio flight tests preparation was completed.

The disruptive cockpit demonstrator systems integration bench has been upgraded to version two, including new fuel system model to support new flight warning function, new flight management and interactive displays versions. The incremental integration and scenarios tests roadmap has been completed.

Regional aircraft active cockpit demonstrator:

The active cockpit demonstrator set-up has been significantly progressing towards completion including the visual system, sound system, avionics infrastructure and the enhanced lightweight eye visor. The aircraft monitoring chain ground support systems have been delivered and integrated. Their testing phase has started in standalone mode, preparing for further workload reduction evaluation scenarios to be performed.

Ground and flight tests demonstration for business jet
In 2019 a flight testing and evaluation phase took place for the approach stabilisation function. The delivery of multi-modal human-machine interface prototypes for integration and testing on Business jet simulator have allowed TRL4 to be reached on force sensing and pilot state monitoring data collection launch. The dual head-up display has been integrated and successfully tested on the BJ simulator.

End-to-end maintenance demonstrator
The integration of prognostics, integrated health monitoring and management (IHMM), remote maintenance solutions platform and end-to-end (E2E) maintenance solutions were performed and demonstrated in 2019. The global original equipment manufacturer (OEM) impact assessment was performed. The project was successfully closed in November 2019.

Implementation of call for proposals in the period 2019

By end of 2019, there were a total of 101 projects selected through calls for proposals from the first call which provided the three LPA Platforms with complementary activities.

All these topics were and are providing important contributions to the LPA main R&T work programme, examples are included in the 'Main Achievements 2019' chapter above. As done in previous years, in LPA most of the call for proposal partners are connected by implementation agreements to enable a close cooperation with shared use of sensible background data and generated foreground.

As main results achieved in 2019 from partners, we can highlight projects DEMETER and AIRMES which contributed with a very substantial share of R&T activities and thus the key achievements and progress of work to closure of activities WP3.6 'Advance'.

Launched in May 2019, 18 further LPA topics, in majority related to a variety of Platform 1 demonstrators, have been published in the course of CfP10 in May 2019. The start of activities is expected in the second quarter of 2020 upon completion of the grant preparation which started in October 2019.

A final batch of 16 LPA topics is scheduled for publication in January 2020 as part of the final CleanSky 2 CfP11, activities are planned to start in quarter four of 2020.

→ REG – Regional Aircraft IADP

Summary of activities and progress in 2019

Regional Aircraft IADP activities related to green conceptual aircraft achieved important results during 2019. Upon completion of the second design loop and on delivery to the technology evaluator (TE) of the aircraft simulation models (ASMs), it was determined that the ambitious environmental targets, established in the initial phase of CS2 programme, could be achieved for the green conceptual aircraft TP90pax as well as for the innovative TP130 pax aircraft concept. TP130 pax aircraft concept reached TRL 3 at the end of the 2nd loop design. No additional effort was considered in this field due to the absence of a clear exploitation route. More opportunities are arising in the field of hybrid-electrical regional aircraft, and the decision was made in 2019 to redirect efforts towards this promising area. Results in terms of emissions and noise of the

future regional multimission aircraft (70pax) also achieved a very important step showing that they are aligned with respect to the targets that were originally proposed for Clean Sky 2. The technologies' maturation activities, as well as the design and manufacturing of full-scale demonstrators, made substantial progress in this period. In particular, the detailed design phase was completed with the critical design reviews (CDRs) held for the Iron Bird, the Flying Test Bed 2 (FTB2), the fuselage structural demonstrator and the outer wing box (OWB) on-ground demonstrator. The design of the experimental modifications to be implemented on the Flying Test Bed 1 (FTB1) demo aircraft also achieved good progress toward the CDR to be held next year.

The manufacturing and assembly of full-scale demonstrators started:

- FTB2 components made available by relevant core partners were assembled on the demonstration aircraft;
- the skeleton of the Iron Bird was manufactured and the manufacturing is in progress for other components for this demonstrator;
- manufacturing/assembly tools are being made available for the fuselage structural demonstrator as well as for the OWB on-ground demonstrator.

Three Demonstrator Management Committee (DMCs) batches were held during 2019, one for each full-scale demonstrator (total twelve DMCs in 2019) with the participation of all involved beneficiaries. Eco-design activities progressed with good achievements for the Stage 0 pilot activity as well as for the Stage 1 activity, both agreed with ECO TA; first sets of life cycle inventory (LCI) data were delivered by REG IADP to ECO TA, as planned.

Major achievements in 2019

High efficiency regional aircraft (WP1)

Main achievements for the green concept regional aircraft studied in this workpackage are summarised hereafter.

- TP90Pax Regional Aircraft Conventional Configuration: the aircraft simulation model green and cost-efficient conceptual aircraft with noise module (Loop 2) was prepared; the software model for costs evaluation was completed. Design Loop 3 activities started: Top level aircraft requirements (TLARs) and the aerodynamic requirements were issued, technologies targets were defined.
- TP130Pax Regional Aircraft Innovative Configuration: the aircraft simulation model green and cost-efficient conceptual aircraft with noise module (Loop 2) was prepared. Final activities for this configuration related to small-scale wind tunnel tests activities progressed.
- Hybrid-Electical Regional Aircraft Configuration (40Pax class): new activities on hybrid-electrical regional aircraft configuration were defined; TLARs for H-E regional a/c configuration issued; preliminary configuration sizing was done and engine requirements were prepared.
- Multimission Aircraft, 70 Pax class: contribution to the TE was provided based on the developed methodology of noise evaluation and considering in the Loop 2 the first results of all technologies related to FTB2 across Clean Sky 2 platforms: REGIONAL IADP, AIRFRAME ITD and SYSTEMS ITD.

Technologies development (WP2)

For the innovative structural technologies of the adaptive wing: manufactured panels and manufacturing trials for process development; executed tension test on liquid resin infusion (LRI) stringer run-out and compression test survey on stiffened panel; prepared tests on LRI spar section, rib and curved stiffened panel including installation of sensors for verification and validation of LRI process and structure health monitoring (SHM); a 5m mid-scale demonstrator (representative of lower panel configuration) was manufactured and characterised.

For the innovative air vehicle technologies of the adaptive wing, the detailed design and CDRs of morphing devices and loads control and alleviation system were successfully completed; the second session of aircraft level assessments of same technologies is in progress and will be completed early in the upcoming period; full scale structural demonstrators manufacturing for advanced winglet (AWL), innovative wingtip (IWT)and multifunctional trailing edge (MTE) was started, test rig preparation is in progress; a full-scale structural test is planned in the next period; morphing devices high speed wind tunnel models preliminary design is completed (PDR completed); final design phase in progress (CDR), completion planned early in the next period.
A first (engineering) release of the integrated vehicle health management (IVHM) framework was released.

For the on-board systems technologies: the technical specification for the innovative wing ice protection demonstrator (WIPS) was issued, as well as the assessment of WIPS TRL 3. Equipment parts for the electrical landing gear system were launched into production and the qualification test readiness review (freezing of engineering test set-up configuration) was performed. The Environment Control System PDR was successfully passed and the critical design opened. The Advanced Electrical Power Generation and Distribution System (EPGDS) achieved significant progress through the relevant CfP projects with the finalisation of critical designs and the commencement of manufacturing phases. The innovative propeller wind tunnel was selected and the detailed design of the low noise propeller concept started.

Activities on the flight control system and electro-mechanical actuation (EMA) also achieved significant progress: CDR for EMA aileron, winglet and wingtip were successfully closed; EMA and related control units are in manufacturing phase; purchase orders for main components have been placed.

Demonstrations (WP3)

Adaptive wing integrated demonstrator (FTB1 and OWB)

- FTB1 Demonstrator: Progressing with the detailed design of the aircraft experimental modifications to be introduced on the flying test bed aircraft in order to install the innovative movable surfaces (AWL, IWT) on the wing tip. Defined the load control and alleviation system electrical architecture and interfaces, preliminarily identified the structural reinforcement needed for the wing. Produced the engineering drawings for the manufacturing of the Morphing WingLet and Innovative WingTip as a test article for the ground structural test.
- OWB Ground Demonstrator: The critical design review (CDR) of the outer wing box (OWB) ground demonstrator was successfully completed. The preparation of bond assy models was started, including features needed for assembly tolerance management with partners of the VADIS CfP Project.

Fuselage/passenger cabin demonstrators

The CDR of the fuselage structural demonstrator was successfully completed, leading to the completion of the design phase. Parts model modifications were needed due to manufacturing constraints coming from CfP projects and the preparation of bond assy models started. First manufacturing and assembling tools were made available. The enhanced definition of the interface control drawing for all of the major On-Ground Pax Cabin Demonstrator was completed, defining additional and detailed features of the major cabin items with respect to the structural and system parts. Safety requirement analysis for lab thermal test bench integration of the cabin demonstrator started.

Iron bird demonstrator

The most relevant results were achieved in the finalisation of the architecture through the following reviews:

- CDR opening on February;
- skeleton and aileron test bench CDR closure in May;
- cabin dummy CDR closure in June;
- electrical integration test bench (EITB) and wingtip test bench CDRs closure in October;
- winglet test bench, engineering test station (ETS) and software architecture CDR closure in December.

The manufacturing of the skeleton was completed and it is in progress for the other components.

FTB2 demonstrator

During 2019 activities were focused on three main topics:

- closure of demonstrator design at aircraft level with support of core partners and partners - at this point the conclusions of the low-Reynolds wind tunnel tests have been remarkable, and they provided valuable experimental data to ensure the aerodynamic shapes of the new innovative control proposed for the in-flight demonstrator;
- progress on the on-ground actuation rigs (major demonstrator from AIRFRAME ITD closely linked to FTB2) up to reaching test readiness review (TRR); and
- availability on-dock of the main structural components of FTB2 (ailerons, spoilers, flaps and winglets from CPs).

FTB2 modifications started reaching the milestone of first assembly of wing structural components. Two principal events were organised at platform and programme level where the first hardware was exhibited to CSJU and CS2 members with the main progresses related to the in-flight demonstrator.

2019 was a key year for core partners activities that allowed the delivery of components for FTB2 (step 1 configuration): ailerons and spoilers. This milestone paved the way to raise two of the core partner technology lines up to TRL 6: jig-less assembly concept and minimum quantity lubrication (MQL) machining strategies. Technology assessment on the additive manufacturing of a critical part was also performed, the manufacturing process couldn’t reach a high enough maturity level to allow the part to be included in the FTB2 aileron. Important progress was also done in the flexible-assembly concept (which also benefits from the jig-less technology) with

the set-up of the assembly jig that would assemble three different components (centre wing box and left hand and right hand external wings for FTB2 Step 2). Centre wing box elementary parts were also manufactured in 2019. Additionally, a structural PDR milestone was passed for the external wing component and its corresponding assembly process (activity which has links with AIRFRAME ITD).

Technologies development/demonstration results evaluation (WP4)
The aircraft simulation models (ASMs) for the green concept regional aircraft TP90Pax and TP130Pax were delivered to the TE in March. Afterwards, support was provided for the integration of such models into TE evaluation tools. In the frame of interactions with ECO TA, first sets (preliminary version in June and updated version in December) of life cycle inventory (LCI) data were delivered by LDO VEL for the Stage 0 (Pilot activity) related to the replacement of hard chrome plating on steel as well as for the Stage 1 activity on composite outer wing boxes.

Implementation of call for proposals in the period 2019
In 2019, 26 complementary actions of projects (GAPs) were running with the goal of converging on final demonstration targets.

→ FRC – Fast Rotorcraft IADP

Summary of activities and progress in 2019

The NGCTR technology demonstrator (WP1) concluded its preliminary design review (PDR) in March 2019. This achievement allowed design activities to further ramp up entering into the subsequent phase of detailed design. A CDR readiness review was held in December 2019 to measure the progress of detailed design tasks (e.g. drawings release rate), assess the relevant risks and capture in advance warnings on the successful execution of the CDR in 2020.

The RACER compound demonstrator (WP2) PDR actions were all closed, mostly during Q1 2019. The CDR took place in July 2019, with some actions identified and closed further in the year. A simplified process for drawing release has been put in place, allowing the drawing release weekly rate to increase. Long lead time items procurement and manufacturing continued in accordance. Key ground tests benches were also run (e.g. lateral shaft dynamics, electrical generation and distribution systems, systems integration rig) or prepared (e.g. main gear box bench adaptation module). Continuous cooperation took place with core partners and partners, in particular clarifying expected delivery dates, and the latest tuning of substantiation means for permit to fly.

Major achievements in 2019

NextGenCTR (WP1)

<u>Management and coordination and design integration.</u>
The integrated master schedule of NGCTR TD was updated following the PDR and maintained with regular reviews with each major stakeholder (technical leaders, manufacturing engineers, partners, vendors). The budget allocated, including the contingencies for the up-to-date risks, was shown to be sound and correctly calibrated regarding the effort required and the resources

planned. Substantial effort was spent in the lead, support and integration, as required, of all the calls for partners active to date. Joint development teams with several partners were established and, where already existing, consolidated to ensure fruitful collaboration and buy-in towards the challenges set by NGCTR-TD 1st flight.

Tiltrotor system design.
Several wind tunnel tests were performed in 2019 on aircraft configurations with increasing adherence to TD baseline configuration, leveraging on tail and wing models provided by the core partners LIFTT and T-WING, respectively. The main objective of these tests was the characterisation of tail shape (V- vs- T-) in order to validate model predictions, increase the reliability of future analyses and, ultimately, support tail shape selection for the TD.

Transmissions systems
The NGCTR-TD drive system architecture was refined to improve system efficiency and overall aircraft performance. Detailed design was started thereafter ensuring full cooperation from the very beginning between the partners responsible for manufacturing, which minimised design change iterations.

Rotors systems
The NGCTR-TD rotors new components design started as planned. In parallel several iterations of kinematic analyses were performed to mitigate the risk of interferences between rotors and flight controls, feeding back into their concurrent design.

Airframe structures
Structure design was developed in synergy with both the FRC IADP and AIR ITD core partners, with specific focus on wing, fuel system and tail integration. All of the major structural components passed the PDR and entered into the detailed design phase. Nacelle design was brought to PDR level by Leonardo in order to fit with the schedule of the upcoming Call09, which was awarded by the JU in July. Call09 project, led by the consortium TRAIL, was started after summer. A wing mock-up was manufactured and will be maintained to (progressively) validate wing architecture in terms of parts installability and overall maintainability.

Electrical and avionic systems
Flight control system architecture was defined and bids for FCS components were launched and responded to, providing the elements for the subsequent selection. A flight control simulation rig was commissioned including active inceptors that are planned to be introduced into the TD cockpit. Avionics layout was frozen to enable the start of harness design.

Airframe systems
Fuel system design was developed in strict conjunction with DEFENDER, DIGIFUEL and TWING partners by means of monthly joint development team meetings, in order to optimise systems integration and reduce the risk of scope creeps. Powerplant installation, with specific focus on FCS SW integration with engine FADEC, was further developed with General Electrics. GE delivered the first Engine model for integration into Leonardo FCS SW, enabling the start of development of the relevant flight control laws. The relevant CDR was held in December.

RACER (Rapid and cost-effective rotorcraft) (WP2)

RACER flight demonstrator integration

The maturation of the major interfaces was almost closed in 2019. Only a few sub-systems for internal interfaces are behind this maturity. A simplified drawing release process could also be defined, to accelerate progress towards manufacturing. The following of long lead time items sourcing (through procurement and/or manufacturing, and partnerships) has been a key priority of the year. Fine-tuning of the final testing and assembly logic of the RACER demonstrator was carried out. Information was communicated to all stakeholders, so as to empower system responsible, and ease on time and on quality deliveries.

Finally, after this complete testing and assembly analysis, it was decided before 2019 Intermediate project reviewR, to postpone the first flight date to mid-2021. The key reason for this decision is to have more time and margins for ground tests and assembly.

RACER airframe integration

The manufacturing of the central fuselage structure progressed. The manufacturing of several big primary structure metallic parts could be completed by the end of the year. Regarding secondary structure, the Romanian cluster manufactured composite panels, with a quality considered as acceptable for the demonstrator. Flightworthy composite panels should be ready in 2020 as planned.

Landing system activities progressed as expected. Ground qualification expectations for permit to fly (PtF) were finalised. Concerning cabin and mission equipment, features that ensure the crew's safety (i.e. demoisting of wind shields), and working condition regulations (i.e. internal noise) were pursued, as planned. Demoisting could benefit from the National Additional Activity project on new environmental control systems.

RACER dynamic assembly integration

For Lifting Rotor, few activities took place to finalise the modifications required on the legacy rotor that was employed for the first flight phase. This included detailed design and manufacturing. Additional national activities on a new main rotor were also pursued. This project outcome should come well after first flight, so has no impact on the first flight's expected date. Concerning the Lateral Rotor, work with the propeller supplier has progressed as planned, according to the propeller definition which was frozen in 2018. Variable gains for lateral rotor endurance test were performed under dusty conditions. A contract for a National Additional Activity on the new lateral rotor pitch control could finally be agreed.

Detailed design reviews for both lateral gear boxes (LGB) and accessory gearboxes (AGB) were passed, and procurement of parts was launched and is under close monitoring. Progress was also made for the high speed input stage (HSIS), with semi-finished parts for gear manufacturing available and bearings manufacturing ongoing. The lateral gear box power rig detailed design review was passed, and the rig manufacturing is ongoing. The main gear box preliminary design review was performed, while the procurement of long lead-time items (LLTI) is ongoing. Technology maturation activities will continue, including manufacturing trials for new power gear material and additive manufacturing component tests.

Concerning powerplants, the fuel system was frozen. First fuel tank bladder toolings were released and manufactured. The qualification test plan for the fuel system has been harmonised with the partner. The National Additional Activity project regarding engine adaptation for high voltage compatibility achieved all its 2019 milestones.

For the actuation system, relevant progress was made on the hydraulic system in terms of detailed design and component procurement. The triumph actuation systems (member of the COSTAR consortium, in charge of manufacturing and testing of RACER) asked to leave the programme. Relevant activities were performed to assess the impact and define the way forward.

RACER On-board System Integration

Key electrical equipment were sourced through GAPs and procurement (e.g. power converter, high voltage controller, starter/generator) and were shipped to the leader's facility. This allowed those systems to be plugged into the electrical generation and distribution system (EGDS) bench. EGDS architecture and mechanical interfaces (links to structures) were frozen. Principle wiring diagram was delivered, and human and network protection were defined for HV equipment.

The CDRs related to avionics and sensors and flight control, guidance and navigation, antennae, sensors, radios, grips, TCAS, and weather radar were closed. All sensor suppliers were defined and the first tests regarding collective grip prototypes on avionic benches were perfromed. Tests on avionics started and finally, the 4D Flight Management System (FMS) was delivered for ground bench tests.

Eco-design (WP3)

NGCTR-TD sub-system candidates for use in the life cycle assessment(LCA) were identified, as related to the key enabling technologies under development in the programme. These sub-systems were selected considering an appropriate mix between level of ambition and data availability/sustainability for such a complex and in-depth LCA.

LCA activities related to RACER are almost completed. Upscaling to a complete vehicle, or a fleet, was launched. A new LCA software for ECO needs was deployed, and engineers were trained on how to use it. Several selected sub-projects for ECO-TA related materials and processes are progressing well, across the demonstrator.

Technology Evaluator (WP4)

Several meetings and reviews were held throughout the year to share, mature and consolidate NGCTR and RACER contributions to the TE. The relevant data packs, for both reference and concept vehicles, were delivered and discussed with the TE community.

Implementation of Call for Proposals in the period 2019

43 complementary actions of projects (GAPs) were running with the goal of converging on final demonstration targets. A lot of work was done to progress the calls for partners that had been

effective to date and promptly start the ones that were awarded during wave nine and ten throughout the year.

→ AIR – Airframe ITD

Summary of activities and progress of work in 2019

The airframe ITD is addressing the full range of aircraft types and is structured around three major activity lines split into technology streams or work packages: high performance and energy efficiency (HPE), high versatility and cost efficiency (HVC), and eco-design (ECO).

<u>High performance and energy efficiency (HPE)</u>

Under this activity line, innovative aircraft architectures are investigated with the aim to demonstrate the viability of some of the most promising advanced aircraft concepts by identifying the key potential showstoppers and exploring relevant solutions, elaborating candidate concepts and assessing their potential. Advanced laminarity technologies such as those related to extended laminarity will also be developed as this is considered to be a key technological path to make further progress on drag reduction, and could be applied to major drag contributors, especially the nacelles and wings. High speed airframe activities will be focused on the fuselage and wings by enabling better aircraft performance and quality of the delivered mobility service, with reduced fuel consumption and no compromise on overall aircraft capabilities (such as low speed abilities and versatility). Novel controls will introduce innovative control systems and strategies to make gains in overall aircraft efficiency. It will contribute to sizing requirement alleviations thanks to smart control of the flight dynamics. Finally, novel travel experience will 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 potential in terms of weight saving and eco-compliance.

<u>High versatility and cost efficiency (HVC)</u>

Under this activity line, next generation optimised wing boxes will lead to progress in aero-efficiency and to the development of better, more durable, affordable and lighter-weight wing structures through the design, build and 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. On the other hand, optimised high lift configuration activities will progress the aero-efficiency of wing, engine mounting and nacelle integration for aircraft that serve local airports thanks to excellent field performance. Advanced integrated structures will optimise the integration of systems in the airframe along with the validation of important structural advances, and will make progress on the production efficiency and manufacturing of structures. Finally, advance fuselage activities, that also include cockpit and cabins, will introduce new concepts of fuselage to support future aircraft and rotorcraft. More radical aero structural optimisations could lead to further improvements in drag and weight in the context of growing cost and environmental pressure, including the emergence of new competitors.

Eco-design (ECO)

Eco-design related activities, embedded in the airframe ITD, are mainly focused on developing environmentally sound technologies, and on performing life cycle assessment activities to quantify the benefits brought by the newly developed technologies. The eco-design thematic areas target the two following environmental benefits: lower impacts during the production of aircraft parts, the maintenance phase and end-of-life of the aircraft.

Major achievements in 2019

- **High performance and energy efficiency (activity line A)**

Innovative aircraft architecture (technology stream A-1)
With respect to 'Optimal engine integration on rear fuselage', further analyses have been done to decompose the different benefits/losses of several boundary layer ingestion (BLI) concepts. Additionally, preliminary assessment of aircraft installation effects on noise reduction due to the scarfed nozzle has been performed using a simplified methodology: no detrimental effects are anticipated at this stage, but it is to be confirmed by a more robust method.

With respect to 'UHBR and CROR configuration', the objective to progress on TRL for the Ultra High By-pass Ratio (UHBR) and Open Rotor (OR) integration technologies has been reached in the various CfP projects running in 2019; these projects deal with firstly, the development of multidisciplinary optimisation framework of novel UHBR and OR propulsion concepts, secondly, near and far-field acoustic propagation of a pushing wing mounted propeller-based propulsion, and thirdly, design, manufacturing and testing of innovative shielding and protections for uncontained engine rotor failure impact. With respect to 'Novel high performance configuration', the final down-selection workshop for short to medium range airliner (SMR) and Bizjet (BJ) missions was held in mid-November and two configurations are now in the selection pool for SMR, blended wing body (BWB) and strut-braced forward swept wing (SBFSW), as well as two configurations for BJ, large fuselage and three-surfaces.

Finally, with regards to the activities on 'Virtual Modelling for certification', at the end of 2019, all the activities were kicked-off. In 2020, all the tasks will run at full speed. For instance, in 2019 the following activities were concluded:

- for safety: composite fuel tank for lightning, comparison and synthesis of the available techniques to integrate electrical model of fasteners within finite difference-time domain (FDTD) model;
- for prediction of aerodynamic loads at high Reynolds: detailed design of the WT mock-up (CDR to be held early 2020);
- for cabin thermal modelling with a human thermal model: cabin thermal test campaign in the Falcon BJ A/C T23 section available at Fraunhofer facilities.

Advanced laminar airflow (technology atream A-2)
With respect to 'Laminar Nacelle', activities continued to assess the effect of 3D surface imperfections by performing numerical investigations of laminar-turbulent transition using boundary-layer instability theory. Manufacturing of tooling items has started towards 3D demonstrations of access door integration into laminar regions on nacelle fan cowling doors. Moreover, a BJ mock-up incorporating the NLF nacelle and HTP was delivered in Q2 and tested

in Q3. Analysis was almost completed in 2019 and will be documented in 2020.

In the 'NLF smart integrated wing' work package, BLADE 2019 F/T campaign was completed in August, and analysis activities were carried out until the end of the year. The deliverable 'BLADE Flight Test Data Analysis: insect' was issued in November, and two others have been elaborated in December, i.e. 'BLADE Flight Test Data Analysis: imperfections' and 'BLADE Hot-film Results. Exploitation activities by the BLADE Partners will continue in 2020 with the support of Airbus. Additionally, flight tests of laminar treatments to assess their durability were pursued in 2019, and the final synthesis will be elaborated in 2020. Finally, the manufacturing of NLF leading edge (NLF-LE) ground based demonstrator (GBD) items has started, including the associated test stand. The aim of this demonstrator is to validate the fulfilment of step requirements of leading edge design by designing, building and assembling a NLF-LE GBD onto a wing-box segment under gravity-induced realistic deformations with novel test stand concept.

With regards to 'Extended Laminarity', activities are ongoing on the tailored skin single duct (TSSD) vertical tail plane (VTP) leading edge wind tunnel demonstrator: aerodynamic design and structural design have been completed and the stress analysis report for the wind tunnel test has been compiled. Activities are also ongoing relating to the post-processing of low speed wind tunnel tests carried out in January on an innovative HLFC concept combining anti-contamination and suction devices. The main objectives of these tests were to evaluate the added efficiency of a passive anti-contamination device (ACD) and active micro-perforated suction panel to avoid turbulent flow along the wing leading edge. The tests improved the understanding of driving parameters of the micro-perforated panels system (such as porosity, hole diameter, suction rate) effects on maintaining a laminar flow for increasing leading edge Reynolds numbers.

<u>High speed airframe (technology stream A-3)</u>

With respect to 'Multidisciplinary wing for high and low speed', the wing root box (WRB) composite spars PDR was passed in early July, and CDR is planned early 2020; manufacturing of demonstrator parts and test articles has also started. Tests will happen in 2020 and 2021. The composite stiffened wing lower panel from an existing BJ CDR was held in July, and tooling design and manufacturing is ongoing. Co-cured multi-spar flaperon detailed design has been realised, and the CDR was passed in November.

In the 'Tailored Front Fuselage' work package, state-of-the-art analysis is finalised for attachment between windshields and surrounding structure, and the finite element (FE) model exchange process is being set up. Five innovative windshield fastening concepts have been agreed upon, however, the weight decrease potential of the new designs has not yet been determined, and thus the demonstration perimeter for the next phases of the project cannot yet be determined; however, with regards to windshield heating, icing wind tunnel tests were completed in December.

With regards to 'Innovative shapes and structure', the CDR for cargo doors structural demonstrators has been passed and the manufacture of assembly jigs has been started; additionally, progress has been achieved with assembly sequence for doors into fuselage.

<u>Novel control (technology stream A-4)</u>

With regards to 'Smart Mobile Control Surfaces', activities dealing with electrical wing ice

protection system (EWIPS) integration on a BJ slat have continued: after the BJ slat CDR in May 2019, the two-heater mat sets were delivered and controlled for the two IWT test slats (the main one and the spare one) and the heater mats were then bounded onto the slat skins in a pressurised autoclave. Prior to that, the slat parts were specially modified to be compatible with the heater mats. The CIRA IWT is planned in November 2020. Moreover, with respect to innovative movables for next generation aircraft, the selection of two concepts for further development has been performed, i.e. one multifunctional trailing edge flap, and one morphing/adaptive outer wing/winglet. A generic development plan and demonstrator specific development plans have been elaborated, and loads assessment has started for winglet and flap demonstrator.

With respect to 'Active Load Control', load attenuation around 5-6% along the wing span has been reached by advanced digital control design on a Generic Business Jet Aircraft (GBJA); WTT are in preparation for 3D wing shape gust load alleviation (GLA) tests validation. Initiation of flutter control activities for GJBA will be done in 2020.

Novel travel experience (technology stream A-5)

With regards to 'Human Centred Cabin', activities on crew operations/smart galley (digitalised and connected galley) have been re-shaped with two work streams: normal operation (service) and abnormal operation (safety); for normal operation, galley operation has been identified as being the main pain point. A first analysis allowed down-selecting two concepts for galley automation; for abnormal operations, abnormal tasks have been identified and analysed to understand pain points and need of cabin crew action. Incident report workshops have been organised to identify fields of improvement. Moreover, for the cabin rest area (multifunctional area for single aisle a/c) activities, the 3D-modelling for the chosen concept has been completed, as well as a wooden mock-up; production and assembly of prototype has been launched, and a draft test plan for operational assessments is available.

With respect to 'Office Centred Cabin', 3D definition of the mock up has been completed and the CDR was held mid-December; a first draft of test matrix definitions is available; an acceptance review of a full-size demonstrator will take place in 2020, as well as first testing activities.

- **High versatility and cost efficiency (activity line B)**

Next generation optimised wing (technology stream B-1)

For RACER's wing, the preliminary design review and critical design reviews have been held and major actions are closed. The manufacturing of elementary parts and the assembly tooling phase has started. With regards to the prediction of noise emission for certification cases, update of flight conditions, identification of low-noise cases, improvement and validation of the computational methodology have been performed.

For SAT optimised composite wing, the first batch of small scale integral demonstrators and lower skins have been manufactured, inspected and assessed. Final automation technologies down-selection was done. The test rig conceptual design is now complete, and the structural health monitoring (SHM) of bond-line integrity demo has been manufactured. Technical works

are focused on having a critical design review by Q1 of 2020.

The flying test bed #2 (FTB#2) morphing winglet has been manufactured, assembled and delivered to REGIONAL IADP and installed on the FTB#2.

For the affordable loads alleviation system, step 1 configuration and related actuator prototypes have been integrated on the 'On Ground FTB#2 Wing Actuation Rig' for starting qualification activities prior to integration on REGIONAL IADP FTB#2.

Morphing leading edge system-level analysis and design of kinematics and actuation system have been completed including the redundant actuator; a preliminary design review (technology scope) was held at the end of the year.

Optimised high lift configurations (technology stream B-2)

For the high lift wing turbo prop nacelle configuration, the loop heat pipe anti ice system was manufactured and delivered of the heat transport passive system. The system integration into the intake wind tunnel model with condensing lines was done to complete the wind tunnel test in Q1 of 2020.

The multifunctional flaps with independently actuated tab developed and manufactured in AIR ITD were delivered for integration in the REG IADP Flight Test Bed#2.

Concerning the advanced composite external wing box, the test campaign was completed for CFRP liquid resin infusion technology up to subcomponent level for highly integrated wing box covers and spars. The CFRP thermoplastic in situ consolidation technology test pyramid for wing covers was achieved up to design detail level and initiated for the subcomponents (one shear panel has been tested successfully). The preliminary design review for the out-of-autoclave composite wing demonstrator was held.

Regarding high lift technologies for small aircraft, the CDR for the down-selection of the high lift concept was held at the end of July 2019. The blown flap concept for the 19 seats SAT A/C airfoil was selected for wind tunnel testing in 2020. Wind tunnel model aerodynamic design was implemented.

Advanced integrated structures (technology stream B-3)

For advanced integrated empennages for regional, a short description of the stiffened co-cured panel of the torque box were done, and engineering requirements of the innovative empennage's leading edge for thermoplastic material and welded joints were established.

For the structural embedded antenna, the critical design review was closed and manufacturing started. Antenna's functional tests have started and were performed for one panel. The antenna is ready for installation in the REG IADP Flight Test Bed#2.

The wind tunnel test mock-up with the integration of the ice protection system based on induction technologies was manufactured. All the icing wind tunnel tests were performed.

For HVDC electrical generation and distribution, the design was frozen at 15 kW. It was shown through lab testing for the 15 kW functionality beyond 15'. The activities are progressing to be ready for a successful critical design review by Q1 2020.

For the spoilers and ailerons driven by elector-mechanical actuators (EMAs), the designs were frozen and the manufacturing of the firsts units were done by SYSTEMS ITD.

The critical design review for the ergonomic cockpit has been passed and the manufacturing of the final ergonomic mock-up cockpit is now almost finished. For SHMS technologies, the first composite panels have been manufactured. The PDR for interior noise material selection was passed with actions.

For SAT effective joining methods the finite element method (FEM) mode is now finished. For SAT jigless and fatigue tests for phase 1 and 2 were performed and the specification of the third fatigue test phase has been done; additionally the demonstrator manufacturing and assembly has started.

For the fast rotorcraft airframe integration activities, many of the important toolings have been manufactured for doors, canopy, cowling and emergency exits, horizontal stabiliser torsion boxes and tail boom skins.

Advanced fuselage (technology stream B-4)
For RACER's tail, the critical design review was passed for components and tooling and the first parts manufacturing has started and is being delivered.

For the next generation civil tilt rotor, the preliminary design reviews were completed for all fuselage modifications, nacelle and V-Tail, including a back-up plan for crew seats incorporated into the design, and weight optimisation. Maturation of out-of-autoclave (OOA) technology to TRL4 and manufacturing of multiple 0.3m C-Spars were done.

For regional centre fuselage technologies, the first fuselage stiffened panel was manufactured with automated fibre placement (AFP). The fuselage structural components testing is currently ongoing, tool drop impacts were executed on curved composite stiffened panels and two window frames were tested.

For regional cabin interiors, following the conclusions of the preliminary design review, refinement of the major cabin interiors items 3D models and preliminary stress analysis have been performed.

- **Eco-design (activity line C)**

C-1: Eco-design management and ECO TA link
The new simplified aircraft and industry model from the ECO transverse activity (TA) was introduced to the airframe eco-design participants. The mapping for vehicle economic ecological synergy and eco-design analysis (VEES/EDAS) was updated for most of the activities.

A demonstrator synthesis report update was produced, summarising roadmaps and confidence levels for 19 eco-design demonstrators. Approximately 85 technologies will deliver LCI data from the Airframe ITD to ECO TA core group. There has been good progress in data collection sheet delivery at technology level in 2019, and a consistency check is expected at the end of 2020. The bill of materials/bill of processes (BoM/BoP) delivery for the 19 demonstrators has started. The first eco-statements are expected in Q2 2020.

An eco-design synthesis report was elaborated placing a focus on the projects monitored by ECO TA ('stage 0' and 'stage 1' projects). Aside from the airframe eco-design work packages, there are additional development activities delivering LCI data. First economic impacts assessments were started for some of the technologies in scope.

C-2: Eco-design for airframe

The technology development is on track to prepare the demonstration phase which will start in 2021. Mainly fuselage parts (thermoplastic, thermoset, metallic) and interior parts (seating structures, seating cushions, lightweight furniture (drawer box, handrail) will be investigated, and a composite aircraft wheel for landing gear systems will be demonstrated. Several CfPs are linked to these activities, in particular in the field of material recycling. Synergies of the activities have been identified to work together on several demonstrators starting 2020 and 2021.

C-3: New materials and manufacturing

The work is in the finalisation phase. The activities linked to efficient manufacturing, additive manufacturing efficient testing, robotics and other assisted manufacturing technologies collected LCI data and developed a tool for technology efficiency evaluation. The final test for validation for a new tool was done and the TRL5 assessment review was held. With regards to a future leakage identification system, final validation tests for all of the systems (fuel, hydraulic and pneumatic) were done and TRL6 assessment review was held. Two door hinges were developed for the cargo door demonstrator from HVC and will go further on the LPA demonstrator. In 2020, the focus will be on digitalisation and the connected factory.

Implementation of call for proposals in the period 2019

As of December 2019, a total of 110 CfP topics were running in the AIR ITD (wave 1 to wave 9). Sixteen further GAP projects were about to sign their contracts (CfP wave 10) and four more were about to be published for wave 11.

→ ENG – Engines ITD

Summary of activities and progress of work in 2019

Ultra-high propulsive efficiency (UHPE)

Multiple maturation studies to optimise the integrated power plant system (IPPS) architecture have been completed. Significant progress on the various key enabling technologies for UHBR applications has been achieved. These include low speed fan maturation, boosters, high pressure (HP) combustors, high-speed low-pressure turbines, transmission systems, low material technologies and nacelles.

Turboprop for short range regional aviation
Manufacturing and assembly of the Tech TP are completed. The first Tech TP run took place in June thanks to the commitments of all the core partners and partners. The demo test phase has been started. The gas turbine components maturation have progressed as well, and the combustion chamber high altitude relight test has started.

Advanced geared engine configuration
The compression system activities focused on completing the testing of the second build of the inter compressor duct rig have been performed. The conceptual design of the two-spool rig has been nearly completed and will be closed with the preliminary design review (DR3) in early 2020. EMVAL engine demonstrator activities focused on completing the detail design phase will be closed with the critical design review (DR5) in early 2020 as well.

Very high bypass ratio (VHBR) middle of market turbofan technology
Important and valuable technical progress was delivered. This includes significant work to further develop low speed fan technology and model-based systems engineering on the UltraFan® architectural concepts to further enhance their feasibility, which resulted in test demonstrations throughout the first half of 2019. The low speed fan test confirmed the expected efficiency and operability of the UltraFan® fan design and provided significant quantities of data to validate aerodynamic, aeromechanic and noise tools.

VHBR large turbofan demonstrator
The key highlight was the successful passing of the UltraFan® Stage 2 Exit review. The Stage 3 Exit review has been initiated in December 2019.

Lightweight and efficient jet-fuel reciprocating engine
Significant progress was achieved leading to the completion of the R&T programme at TRL 5. This includes in particular the full-scale 6-cylinder engine demonstration on ground at full power, the full-scale propeller demonstration test, and the validation test campaign of the new engine controls.

Reliable and more efficient operation of small turbine engines (WP8)
Loop 2 objectives were fulfilled with the assessment of aircraft fuel consumption, CO_2, NOx and noise emissions for both reference and green A/C. The program is now entering its third loop. The main goal for loop 3 will be to identify a suitable hybrid-electric configuration of the engine. One of this year's main achievements has been the successful testing of the additive manufacturing combustor, carried out in September 2019 in collaboration with the CfP START.

Eco-design engine
Activities concentrated on additive manufacturing, CFRP re-use and recycling and advanced engine manufacturing and delivered its first analysis.

Major achievements in 2019

Ultra-high propulsive efficiency (UHPE) demonstrator (WP2)
The activity has made significant progress. As far as the engine ground test demo (GTD) is concerned, multiple maturation studies have been completed in order to optimise the IPPS architecture. The equipment's packaging has also been completed, thus addressing one of the main risks identified in the target architectures and linked to the complexity vs the engine target compactness. As far as key technologies maturation is concerned, a first loop on the advanced low speed fan architecture was made. Maturation activities on the nacelle have continued. Following TRL3 validation in 2018, an acoustic demonstrator design has successfully reached the CDR milestone in April 2019. The tools and parts have been available for assembly since December 2019. The GTD configuration has led to the cross-section of the transmission system modification. One additional technical brick has reached TRL3 and the reduction gear box (RGB) has reached TRL4, following completion of dedicated test campaign. The low-pressure turbine module tests have been performed; the comparison of results with CFD have shown good correlation of unsteady losses and confirmed the predictions. The tests have supported the TRL4 review for the turbine vane frame (TVF) aerodynamics scheduled in November 2019. The test rigs dedicated respectively to the component for splines and the gearbox attitude test have reached the CDR milestone this year.

Turboprop ground demo for SR regional aviation (WP3)
2019 has been a fruitful year for the turboprop integrated power plant system (IPPS) as most design and manufacturing activities have been completed. Core partners and partners delivered all their contributions (PAGB, nacelle, air inlet, craddle, propeller, PCU, dampers, heat exchanger etc) to allow Safran HE to test the Tech TP first engine in June. The Tech TP final configuration with 7 blades propeller became available and the intensive testing phase was started in October 2019 to be completed in 2020.

Safran HE organised an event on October 17th in Tarnos with all stakeholders to celebrate this great first run achievement and to share Safran HE’s vision on Tech TP’s test plan and future opportunities for application.

Gas turbine components maturation activities progressed well too, with PAGB test rig manufacturing, and mixed compressor test rig manufacturing and assembly which will be ready for testing in early 2020. Also, a new combustion chamber test for high altitude relight has been initiated at ONERA.

Advanced geared engine configuration (WP4)
The inter compressor duct rig testing facility at DLR successfully tested the first and second build. These test results are the basis for the two spool compression system rig tests planned for 2021. The conceptual design of the two spool rigs is progressing according to plan with advancements of the compressor design and the definition of the test surroundings.

The expansion system engine demonstrator passed the interim design review DR4 mid-year and has released the long lead items in hardware procurement for purchasing. The critical design of the engine demonstrator has been completed and the finished parts drawings have been prepared for quotation. The technology development has been continued and manufacturing

trials for the casted blade and the ceramic matrix composite (CMC) segments in adequate geometries have been completed. Based on what was learned from the manufacturing trials, the project plan has been adjusted with the test campaign now scheduled for 2021.

Very high bypass ratio (VHBR) middle of market turbofan technology (WP5)
An alternative aluminium alloy has been matured and casting trials of test specimens have been made. The mechanical test campaign was initiated and will be completed in 2020. The low speed fan (LSF) rig test and analysis activities were completed in 2019. The data obtained from the rig confirmed the pre-test predictions and provided further confidence on the proposed low speed fan design. Moreover, several key predictive tools and methods have been calibrated using data from this rig, which will enable enhanced design space understanding for future design iterations.

The VT-2 aero rig (multistage IPT) has been tested and the VT-4-3 aero rig tests results have been post-processed and analysed.

Regarding PGB, the first component of the AORBIT rig arrived at University of Nottingham.

The critical design review for the bearing chamber module has been completed and components are currently being procured. Experiments on the bearing shed rig are progressing well providing highly detailed information and linking with high-fidelity CFD simulations on the bearing inlet simulator. Relevant scientific papers have been presented at a number of events including ASME Turbo Expo, the Multiphase Flow Conference, Dresden and the Paris Airshow.

NG-Turb test facility circuit virtualisation has been used to predict operational parameters and constraints for campaign planning. Rig test phase 1 has been prepared and the hardware mounted for use at end of 2019. Further rig and facility hardware upgrades, which will be tested in phase two, were studied and the mechanical design partly started in Q3/2019. The blisk repair activity has successfully read across the down-selected microstructure to target component geometry. The mechanical validation testing continues to provide results showing that the application requirements can be achieved. In-situ experiments continue to provide a unique insight into the complex interactions that take place within and around the melt pool which are driving the improvement and validation of our process models which is key to our future alloy repair development strategy.

VHBR large turbofan demonstrator (WP6)
Boeing 747-400 has been acquired which will test the next generation of cutting-edge technologies for engines including the UltraFan® demonstrator. ITP saw the achievement of the IPT subsystem detail design review (DTA5) and the start of long lead time items manufacturing. Whilst the ICC passed its preliminary design review in January 2019, the critical design review kick-off was held in November. ICC-sectors have successfully been cast and welding of the forerunner ICC is completed. The UltraFan® programme successfully passed its Stage 2 Exit review in the first quarter of 2019. The programme is now making good progress towards its Stage 3 Exit in December 2019. Contributors to the Stage 2 review success were multi-stage IPT, structural systems and externals.

Lightweight and efficient jet-fuel reciprocating engine (WP7)
The previous testing was aimed at several innovative designs for some part of the core engine. 2019 has seen the conclusion of this activity with the post-test analysis that allowed the identification of the most promising technologies amongst those tested. The validation of design evolutions for the turbocharger was concluded in 2017. The development of a propeller able to withstand the specific operating conditions of a Jet-A engine was continued and successfully finished in 2019. The work has been focused on performing and completing successfully the test campaign on the full-scale propeller. The post-test review was completed in early December 2019. As its main successful outcome, the demo propeller reached sufficient maturity (TRL5) to enable a development programme, which has concluded the research programme. Development of a new 6-cylinder engine architecture in 2019 was completed with the test campaigns for the demo engines. As main outcomes, the demo engines have completed 230 running hours and have reached the targeted power of 400hp. The ground test engines have also demonstrated a significant fuel burn reduction. The associated activities are now completed. The components of engine control system have been delivered and assembled early 2019 to build two hardware demonstrators for advanced engine controls. The following test campaign has run successfully, and the post-test review has been done in December. The main objectives have been reached (completing the programme activities).

Reliable and more efficient operation of small turbine engines (WP8)
The loop 2 engine data have been post-processed, assessing aircraft fuel consumption, CO_2, NOx and noise emissions for both reference and green A/C. Following this achievement the project is now entering loop 3, which involves a hybrid-electric configuration. The team progressed on virtual engine transient model design and focused on setting the strategy for the hybrid-electric trade studies. The detailed design of aero and acoustic low-noise propeller was realised. The team continued the development of the Reduction Gear Box technologies, with a focus on direct gas quenching characterisation, which has been successfully applied to test coupons.

The extended analysis of Axial-Centrifugal Compressor Vehicle (ACCV) and blowdown tests continued in 2019 and the impact of the potential bleed requirement and its influence on compressor stability was carried out.
The inner and outer liners of the combustor were successfully manufactured, assembled, instrumented and entered tests (special thermal paintings has been applied). The full annular test was successfully carried out in September and the test results analysis is ongoing. The activities relating to advanced cooling have started.

Eco-design engine (WP9)
The work related to manufacturing was focused on boundary limits assessment in additive manufacturing, for eco-design process optimisation. The research on CFRP material re-use and recycling has continued. In the area of eco-design approach in engine parts, advanced manufacturing the selection of parameters for the Reference Blisk Design Model has been achieved in 2019. An inlet guide vane (IGV) was selected as another, additional test case.

Implementation of Call for Proposals in the Period 2019
At this stage and as of December 2019, a total of 13 CfP topics are running in the ENG ITD for calls eight and nine. The two projects for call ten have just been awarded and will be reported in the AAR in 2020.

→ **SYS – Systems ITD**

Summary of activities and progress of work in 2019

In 2019, several cockpit technologies were successfully developed with the most of them integrated in the virtual system bench according to the TRL maturation plan up to TRL 5. Examples are voice recognition, certified tactile displays and parts of the enhanced vision system.

The cabin and cargo technologies progressed during the second year of activity. The connected cabin concept comprises some bricks that are starting to increase their TRL level such as the smart belt concept, luggage detection without camera and the galley concept. Interfaces for the fire-suppression demonstrator were defined and components design prepared.

For flight control several technologies progressed to TRL 3-4 to prepare the demonstration activity. The installation of more electric network technologies and components onto ground based demonstrators for large aircraft progressed according to plan. The development of electro-mechanical actuators progressed in line with the REG IADP plan and were finalised to flight testing.

In the area of landing gear systems, the direct drive wheel actuator equipment and system achieved TRL4 functional tests, new activities fostering weight reduction and competitiveness have been introduced.

High-voltage-DC components for the power network demonstration progressed towards TRL5. Similarly, activities on bricks for the power generation and distribution were advancing as well to support demonstrations.

Concerning the aircraft loads technology development and integrated demonstration, the final architecture for the Electrical Environmental Control System (EECS) has been frozen to deploy the demonstration. Sensors and filtration components for air re-circulation in environmental control were produced and tested. Wing ice detection and protection technology progressed as well to align with the plan.

In the area of small air transport, progress on all demonstrators has been made. A high number of design reviews was conducted enabling prototype production, for example of electro-mechanical actuation and passenger seats.

Transversal activities on advanced power electronics and the integrated simulation modelling framework progressed towards the final demonstrations. Some progress was made on eco-design as well regarding environmentally friendly processes.

Major achievements in 2019 by work package

<u>Innovative extended cockpit (WP1)</u>

Very large tactile display units were improved (multi-touch & palm rejection capability) and the work on the next generation of eyes-out cockpit products was pursued (very high brightness & compact full color micro display). The voice recognition system achieved

technology readiness level (TRL) 5, and the vocal dialogue in natural language with a virtual assistant reached TRL3. The crew monitoring system progressed to TRL 3. Innovative modular computing platforms with passive cooling were explored at TRL 3.

As far as avionics functions are concerned, the advanced concept of mission-oriented systems management achieved TRL 3. The work on active obstruction detection sensor for modular surveillance system was pursued. The innovative pilot aids of the flight management system were matured up to TRL5 and the permanent resume trajectory reached TRL6.

Regarding navigation, the innovative concept of modular inertial reference unit achieved TRL 5, based on brand new generation of inertial measurement unit and MEMS accelerometer. Some new disruptive technologies (MEMS gyroscope, resonant fibre optic LASER gyroscope) were also explored at low TRL.

Evaluation of innovative test means was pursued (modeling and simulation as a service, pilot behaviour monitoring for avionic system evaluation).

Regarding integrated modular communications, flight trials were prepared using distributed VHF remote radio units. Furthermore, most of the aircraft and ground network functions of the ATN/IPS & multi-link demonstrator were specified.

With regards to Enhanced Vision and Awareness, the high performance computer platform achieved TRL5 and the EFVS/CFVS is integrated and ready for validation.

Cabin and cargo systems (WP2)

Based on the identified criteria, a proposal for the future optimised cabin processes and operations was elaborated and released. Standardisation work as defined in the standardisation plan was performed. Several partners have joined the standardisation group for secure wireless media independent messaging (ARINC CSMIM).

With regards to the cabin system, the connected seat development has significantly progressed. Smart belt concept and luggage detection without camera have reached a TRL3 maturity. Sensors for predictive maintenance have been selected. The development of the sensor module has started. Regarding the wireless radio module for the seat, the specification and design were finalised. Design of the multi-radio access point was started. The interfaces for personal electronic devices on demonstrator were determined based on a market survey.

For cabin power management, the cabin load analysis has been finalised. A power management concept dedicated to the galley was developed. The prototype implementation has started in order to demonstrate the validity of the concept using a modified oven.

Regarding the connected galley and trolley, the galley concept reached TRL3 while the connected trolley concept is still under review including several potential technologies. Communication interfaces were defined. Impacts and benefits of the new system were analysed. Preparation for building prototypes for first tests has started.

With regard to cargo systems, the first experimental components for the novel waste water system, which reuses grey water for toilet flushing, were developed and setup. Specification of the nitrogen vessel valve for the halon-free fire suppression system was completed. First designs for the valve were developed. The interfaces between the fire suppression test rig, the

knock-down system and the on-board inert gas generation system (OBIGGS) were defined in order to prepare integration.

The global demonstration strategy was unchanged and the detailed organisation and implementation of demonstrators is expected to begin in 2020.

Innovative electrical wing (WP3)

The work package continued its activities regarding all aspects of flight controls ranging from innovative actuation controls, through mature full electrical actuation equipment and novel hydraulic power supply.

On the smart integrated wing demonstrator aimed for large aircraft, the main part of the electronic control network has been installed according to the Phase 2 plan. The network consists of electronic controllers, cabling and equipment for testing. Basic functions were implemented and have shown good results. The technology bricks for the hydraulic power supply have been matured, with TRL6 tests of the most important electro-motor-pump being completed. Finally, a proof-of-concept setup has been set up for testing of control logics. Testing will yield results during 2020.

Activities on the electro-mechanical actuators (EMA) for regional aircraft achieved the closure of design and good progress regarding manufacturing of prototypes at TRL 3-4 for the REG IADP test program. The first units were delivered for the regional ground test rig. According to testing results, it has been necessary to launch some modifications to the design leading to a second step of tests. Some partners' related work has also been re-scheduled. Actuators will be flight tested later in the program.

With regard to the smart active inceptors, important progress consisted of de-risking and revisiting requirements and design, leading to an architecture and prototypes optimisation.

Landing gear systems (WP4)

The bricks needed for the development of an electro-hydraulic actuation system for main landing gears (EHA MLG) have been specified. The direct drive system was assembled and tested in order to achieve TRL4. The first prototype of an angled rim wheel began to undergo testing in order to reach TRL4. Additional bricks leveraging weight and competitiveness have been integrated this year into the current activities.

The local hydraulic system for nose landing gear (NLG) has been further developed and prepared for integration on an Airbus aircraft for roll testing and TRL6 in 2020. The test system was produced and the installation and demonstration details have been defined.

Activity on braking systems has been redirected following the exit of the member from the programme. Composite low-complex structure demonstrator has continued its testing as needed for TRL6 demonstration. Activity on more complex composite parts has been re-oriented to address MLG structure and is to begin in 2020.

Sensor and monitoring activities faced strong technical hurdles in 2019. The project nevertheless advanced to achieve a TRL5 in 2020.

Innovative electrical network (WP5)

With regards to the aircraft electrical architecture, the trade-offs for innovative installation architectures have been finalised. In addition, technologies definition to support the principles of innovative installation architecture have been achieved. The HVDC no-break power unit specifications and internal control system (ICS) definitions were refined. Concerning the HVDC sources parallel operation, simulations of failure cases and support to lab tests and model calibration have been performed.

With regards to power generation, the digital ground control unit achieved TRL5 and the demonstration of its operation on the HVDC network has been initiated. The disconnect function for high speed starter-generation has progressed with the selection of the concept.
The optimisation of the power electronics module (PEM) filtering and the development of battery charger control laws of the DC-DC converter have been achieved.

With regards to the innovative electrical network over time-sensitive networking, development for aeronautics has been further developed and successfully instantiated in different kinds of control architectures. With respect to wiring health-monitoring, improved post-TRL4 tests have been realised on system benches for parallel and serial electrical arcs' detection and localisation. In relation to power management for a large aircraft demonstrator, preliminary sizing with regards to components preliminary design, preliminary mechanical integration and preliminary system design: control/command and power have been achieved.

The development of PEM technology bricks progressed towards TRL5/6 maturity with the aim to be reached by the end of 2020 in order to support delivery in 2022 to the High-Voltage-DC electrical power network demonstrator.

Major loads (WP6)

The final architecture of the Electrical Environmental Control System (EECS) was frozen in 2019. A component PDR (including a vapour cycle system) was performed and passed with positive feedback. Risks were identified well and the means to mitigate them was clearly planned. The next milestone for EECS is the critical design review (CDR), scheduled for mid-2020.

The development of air quality smart monitoring solutions with ozone and volatile-organic-compounds (VOC) sensors continued with the production of laboratory prototypes. A first prototype of hybrid adsorption-photocatalytic air filter aiming at removing pollutants and odours from aircraft cabin has been realised.

For the adaptive Environmental Control System, the laboratory testing of air treatment and air sensor system was conducted; the HEPA+VOC and CO_2 filters prototype, the CO_2 sensor and control logic were integrated and tested. A report on the system verification and demonstration of the 1% fuel saving was completed; including simulation results that show the potential for 1% fuel burn reduction. Although the TRL4 gate was not achieved in 2019, the demonstration significantly helped the team to understand strengths and weaknesses of the system. The lessons learnt will be leveraged to improve the prototypes, thus helping in achieving TRL4.

Concerning the electrical wing ice protection system (eWIPS), the activity in 2019 was focused on successfully reaching Technology readiness level TRL4 for de-ice architecture, as well as on defining the ice wind tunnel test plan and demonstrator specification.

All planned work was carried out on the primary in-flight ice detection system (PFIDS). Following the ice wing tunnel (IWT) tests in July, TRL4 for the ice accretion rate (IAR) function was confirmed in December 2019.

For the airborne interferometric ice sensor (AIIS) TRL 3 is to be assessed in January 2020. Risk mitigation might require an alternative technology for icing conditions detection, which was assessed for TRL2 at the end of 2019.

Small air transport (WP7)

In 2019, progress on all demonstrators for small air transport were achieved. In particular, for the fly-by-wire system demonstrator, the preliminary design review of the air data sensor and critical design review of primary surface actuator and flight control computer have been completed.

The critical design review of electrical power distribution system and preliminary design of both the electrical power generation system and the integrated demonstration rig have been initiated.

The preliminary design review for the low power de-icing system demonstrator has started.
Concerning the electrification of landing gear, preliminary design review of both electro-mechanical braking and electro-mechanical retraction actuator have been completed.
Regarding cabin demo for small aircraft, interior panels for a thermo-acoustic solution advanced in production according to plan, while design documentation for manufacturing of crashworthy configurable seats has been released.

Concerning the integrated demonstration of a SESAR-compatible SAT cockpit, the tactical separation system, advanced weather awareness system, flight reconfiguration system and compact computing platform reached TRL5; while the navigation system made progress towards TRL4. Further scope extension to include all the above functionalities in one integrated mission management system has been agreed.

Power electronics and electrical drives (WP100.1)

The power electronics work in 2019 has been focusing on the optimisation of space for power converter topologies using emerging semiconductor devices and the associated modulation. Electrical machines and drives have developed and validated a scalable tool for evaluating the impact of actuation component placement in localised as well as distributed configurations on system weight, reliability and performance. Work on developing degradation models of electrical machines has progressed according to plan with accelerated lifetime tests feeding into an extensive validation exercise.

A key highlight for 2019 has been the work completed on the thermal insulation qualification of low voltage electrical machines. A technical workshop was held with all major stakeholders

in the Systems ITD community, which resulted in a good dissemination of the findings and identification of potential areas for exploitation of the technologies by Systems ITD leaders.

Product life-cycle optimisation - eco-design (WP100.2)

Eco-design activities continued to identify and mature environmentally friendly materials and processes for aircraft systems. Two main axes can be highlighted. The first one refers to green surface treatments and coatings, which reduce environmental impacts and comply with REACH regulation. The second one was on composites and light alloys with improved properties, for lighter components and emissions reduction with prototyping phase initiated in 2019.

Model tools and simulation (WP100.3)

The project developed and completed the final version of the prototype of the core simulation environment, focusing on tool integration and usability to achieve collaborative, iterative, open, modular, adaptable and agile design and test processes for complex multi-physical systems.

The aircraft and system design platform progressed toward the final integrated demonstration by finalising key activities such as the landing gear and engine modelling and the demonstration of the thermal platform. The virtual testing campaign for actuation systems in collaboration with airframers was fully defined in 2019 with engineering activities and demonstrators planned for 2020.

Implementation of call for proposals in the period 2019

As of December 2019, a total of 70 CfP topics were running in the SYS ITD (Wave 1 to Wave 9). Nine further GAP projects were about to sign their contracts (CfP Wave 10) and seven more were about to be published for wave 11.

→ ECO – Eco-design transverse activity

Summary of activities and progress of work in 2019

Integrating ecological and socio-economic effects, the eco-design transverse activity (TA) contributes to the promotion of new approaches, within industry and partners in Clean Sky, that aim to develop more sustainable products, ensuring the future competitiveness of European aviation industry.

Eco-design is a novel approach in aeronautics that aims to assess materials, processes and resources employed along the entire aircraft life cycle, assisted by the development and integration of fundamental methodologies, tools and databases into a comprehensive and applicable process. Based on its structuring in eco themes, eco-design enables an extended life cycle analysis, going far beyond aircraft operation, to enable standardised, consistent and comparable analysis in assisting the development of airframe, engine and system components. During 2019, under the eco-design TA coordination, a consolidation of the scope of work with SPDs was performed, supported by an extended technology mapping and data collection.

A set of projects in the area of surface treatments, composites, additive manufacturing and recycling technology progressed to deliver life cycle inventories (LCI) to perform eco

assessments supported by environmental indicators. Thematic workshops with participation of members and partners have been performed as well.

The objective of the action is to contribute towards the evaluation of Clean Sky 2 technologies from an economic perspective, together with providing guidelines for the adoption of 'Design for Environment' approaches in the development of new products.

Major achievements in 2019

Eco-design TA continued its effort to interact with the different ITDs/IADPs in providing guidance on data collection for the different selected technologies having an impact to develop more eco-friendly components. A series of status reports on the coordination activity was provided including the updated technology list and the progress of ongoing projects. The action also promoted a series of LCI workshops with SPDs, organised to ensure a proper delivery and an improved understanding of the methodology and its requirements. Considerations regarding eco design tools to be used, also for non-experts, for analysis and visualisation have also been discussed among the participants to the action.

Some concrete use cases have been developed to apply the eco design approach in providing more ecological and less resource-consuming airframe, engine and systems components. For example, an engine blisk was developed to demonstrate the eco design potential. The action was refocused during the year to assess the single technologies in a more aggregated way in order to analyse more complex assemblies.

A dedicated workshop on additive manufacturing was organised with the participation of airframes, partners and EASA. Other similar workshops are planned in 2020 which will focus on other themes.

The definition of the 'Design for Environment' approach and workflow will be a key milestone in 2020. Some additional cross valuable themes have been proposed in the area of water saving, energy storage, supply and transmission, material flow and logistics. Their development will depend on the confirmation of the core activity and the opportunity to provide added value to the action output. Some initial dissemination and communication was also performed.

Implementation of call for proposals in the period 2019

Several partner projects with eco-design relevance are performed in the different SPDs. A specific topic on additive manufacturing to enhance engine component design and process optimisation has been started. New candidate topics for future calls (i.e. composite re-use and recycling) have been launched or published giving the opportunity to new entities to implement the eco-design approach.

→ **SAT – Small Air Transport Transverse**

Summary of activities and progress of work in 2019

The integration studies of technologies developed within the Airframe, Engine and Systems ITDs on 19-seat green aircraft configuration progressed in 2019 in line with the defined work plan. The maturity level of the technologies developed in the AIRFRAME, SYSTEMS, ENGINE ITDs was continuously monitored, and consolidated master plans were defined toward the final demonstrators. The 19 seats Green A/C Loop 1 was finalised in 2019 considering the main outputs of the other main ITDs (Airframe, Engine and Systems). Interactions with technology evaluator (TE) activities allowed the definition of mission model analysis and market demand of 19-seat aircraft analysis.

Major achievements in 2019

A 19 seat Green Loop 1 Aircraft has been designed considering the main outputs of the other main ITDs (Airframe, Engine and Systems). The following technologies were considered for integration into the green A/C design loop:

- low cost composite wing box and engine nacelle – AIR ITD;
- innovative high lift devices – AIR ITD;
- affordable small aircraft manufacturing of metallic fuselage – AIR ITD;
- affordable fly-by-wire architecture for small aircraft (CS-23 certification rules) – SYS ITD;
- more electric systems replacing pneumatic and hydraulic aircraft – SYS ITD;
- advanced avionics for small aircraft, to reduce pilot workload, paving single pilot operations for 19 seats – SYS ITD;
- advanced cabin comfort with new interiors materials and more comfortable seats – SYS ITD;
- alternative engine with reduced fuel consumption, emissions, noise and maintenance costs for 19 seats aircraft – ENG ITD.

The mission analysis of green aircraft for several missions (200 nm, 300 nm, 400 nm, 600 nm, 800 nm) have been carried out and the estimation of CO_2, NOx and noise emissions has been accomplished, as well as the definition of green aircraft block fuel. Contribution to the high level environmental goals was assessed through the first model assessment which was delivered to the technology evaluator (TE) with the following estimates:

- reduction of block fuel and CO_2 emission of about 20%;
- NOx reduction of about 25%;
- Noise reduction of about 10 dB(A) at the certification point (i.e. about 17 dB(A) with respect to the maximum certification limit).

Preliminary activities in terms of mission model and market demand analysis of 19-seat aircraft were performed.

Implementation of call for proposals in the period 2019

22 complementary SAT-related projects (GAPs) were running across the different ITDs with the goal of converging on final demonstration targets. Much work was conducted to progress calls

for partners effective to date and promptly start those awarded in wave 9 and 10 throughout the year.

→ **TE – Technology Evaluator**

Summary of activities and progress of work in 2019

WP0 was concentrated on general project management tasks.

Within WP1 the activities focused on call planning and the elaboration of topic descriptions in relation to the CfP 11 calls round. Further discussions focused on the elaboration and finalisation of three proposals for CfTs (i.e. dealing with the 'TE-IS', 'Catalytic Effects' and 'Competitiveness'). Exchanges with Clean Sky 2 partners on metrics and reference aircraft continued. Further exchanges with the JU have been performed regarding the TE light projection and potential approaches to quantify benefits of participation in the Clean Sky 2 programme. Additionally the TE annual review meeting was held in Cologne from 16-17 October .

WP2 strengthened the interfaces between the TE and IADPs, ITDs and TAs. The dialogue was intensified by regular monthly conference calls. Topics discussed were mainly the finalisation of the TE light projection, the 'Techno2Models' table and the TE calls and dissemination activities. Bilateral conference calls and coordination meetings with a limited number of parties involved were also conducted to reach progress in relation to the TE forecast and scenarios in preparation for the first global TE assessment, which is scheduled for mid-2020. In addition, two TE-SPD bi-annual workshops were held. The first one took place in April 2019 and had the objective to deliver updates and exchange on SPD concept models, key technologies, and attainment of specific CO_2 and NOx goals. Another workshop was held in November 2019 and outlined the TE assumptions in relation to the scenarios and demand and fleet modelling. A TE-SPD workshop took place end of October. A further exchange meeting was organised with SESAR JU and EASA.

In WP3 the focus was on the preparation and delivery of all SPD aircraft concept models in preparation for the foreseen mission level reports and – with an extended focus – on the first global TE assessment. In this respect, the framing TE-SPD bi-annual workshop in April 2019 provided a good opportunity to discuss the status and progress on SPD models, to identify gaps and to decide upon the way forward. Furthermore, during the course of the year 2019 plausibility checks of the aircraft models were done by the TE. Another major task consisted of the management of the TE CfP09 project 'TeDiMo' on technology diffusion modelling. The project has not yet been finalised but the findings will be used in the first global assessment. In WP4 major progress was reached in the project 'CLAIRPORT'. The airport simulations at the microscopic level were finalised. Noise and emission level calculations to prepare the environmental impact assessments on airport level for the first global assessment were started. In WP5 the focus was on the preparation of the first global assessment. The project 'DEPART2050' has delivered results for the environmental assessments of the compound rotorcraft and the tiltrotor aircraft. The mobility impact had also been assessed.

Special emphasis was put on the elaboration of the TE forecast (developments of demand, movements, and fleet) incl. airport capacity constraints modelling. The forecasts for SAT, for

BizJet and for rotorcraft (originally done by CIRA in the projects 'FORSAT', 'FORJET', 'FORROT') were also updated by the TE due to criticism of the involved SPDs. Furthermore, the scenario storylines for the first global assessment have been elaborated and reviewed by the vehicle manufacturers. In addition, the second TE-SPD bi-annual workshop in November 2019 provided an opportunity to discuss the underlying assumptions of the scenarios as well as those for the demand forecast and fleet modelling with all CS manufacturers and evaluators to ensure a common understanding of this major step towards the first global assessment. Further ATS work concentrated on topic management for the three CfP09 calls 'GLIMPSE 2050', 'OASyS' and 'TRANSEND' to complete the focus of the mission level assessments in relation to the second global assessment. Four additional calls for CfP 11 were elaborated by the TE in parallel (see chapter 3). In WP6 the CfT for the planned TE information system was elaborated including a detailed description of the scope, the corresponding objectives and the technical requirements for the system. In WP7 the TE dissemination and exploitation plan and activities were updated. A TE specific set of icons was developed to strengthen the awareness of the TE and to illustrate the manifold assessment levels. Additional animations for the 'Omniglobe' spherical projector with visualisation of the forecast and scenario results were implemented and shown at the Clean Sky 2 event in March 2019, during the Aerodays in May 2019 and during the IATA conference 'Wings of Change' in November 2019. The major achievement of the TE in 2019 included the delivery of the concept aircraft models. In addition, a major step towards the first assessment concentrated on the completion of the forecasts and scenarios up to the year 2050.

Implementation of call for proposals in the period 2019

Regarding the TE call for proposal round 05, two corresponding calls referring to the projects 'CLAIRPORT' and 'DEPART 2050' to support the activities in WP 4 were running according to plan in 2019. The SAT/business jet/rotorcraft forecasts were finalised within 2019. With respect to the TE call for proposal round 07, the 'technology diffusion' project called 'TEDIMO' started in December 2018 and is on track. Final results are expected in mid-2020 and will be incorporated into the mission level assessments conducted within WP3. In relation to the TE call for proposal round 09, three calls were elaborated for this calls round dealing with (1) alternative fuels and propulsion ('TRANSCEND'), (2) overall air transport system vehicle scenarios ('GLIMPSE 2050') and (3) regulation and policy scenarios ('OASyS'). Call winners were nominated in 2019 and the corresponding kick-off meetings were conducted in Q4/2019. For the TE call for proposal round 11, four calls for proposals were elaborated.

- Limits to aviation growth (deleted by CSJU)
- Environmental impact of design range operations of aircrafts
- Airport level assessments of:
    - rotorcraft
    - aircraft

1.7. Calls for tender

In 2019 one operational call for tender[10] was launched and awarded: 'Open tender to award a joint direct service contract for provision of an independent study on use of hydrogen and fuel cells for aircraft propulsion'. The aim of this independent study it to investigate the potential of fuel cell and hydrogen technologies in the field of aircraft propulsion. Among several technical challenges for the integration of these technologies in the aviation system, a number of issues need to be overcome (non-exhaustive):

- design of fuel cell based power trains to meet aircraft specific duty cycles and form/fit/function requirements such as but not limited to volume and mass targets;
- design of hydrogen-fuelled gas turbine based power trains to meet aircraft-specific duty cycles and form/fit/function requirements such as but not limited to volume and mass targets;
- redesign of the aircraft, including its sub-systems, to accommodate the required amount of hydrogen storage and meet customer demand in terms of costs (capital and maintenance) and reliability, availability and maintainability (RAMS);
- determination of safety, airworthiness and certification requirements and future standards.

Besides tackling the technical challenges stated above, and requiring significant research and innovation (R&I) investments from the aviation sector, an initial study was needed to:

- understand if and how fuel cell and/or hydrogen based propulsion architectures are suitable for aircraft propulsion, and in which aircraft category (payload/range/mission) and with which potential benefits in terms of aircraft performance and emissions;
- identify technical and non-technical barriers for the implementation of fuel cell and hydrogen technologies in the aviation sector and highlight needs in terms of research and innovation (R&I), regulation and standards, as well as (market and economic) conditions;
- identify and understand the deployment challenges related to production, logistics and infrastructure that are compatible with airport operations and air transport networks.

The study under this procurement should identify the potential for fuel cell and/or hydrogen based aircraft propulsion and produce recommendations on future activities with particular focus on R&I efforts in this field in the next decade and policy to support the potential market adoption thereafter. The contract was awarded to consultancy company McKinsey Solutions SPRL, was signed on 2 December 2019 for a total value of the contract: €0.58 million.

[10] Ref. CSJU.2019.OP.01, Contract notice ref.: 2019/S-170-414488, Contracting authority: Clean Sky 2 Joint Undertaking (CS2JU) – Leading contracting authority and Fuel Cells and Hydrogen 2 Joint Undertaking (FCH2 JU)

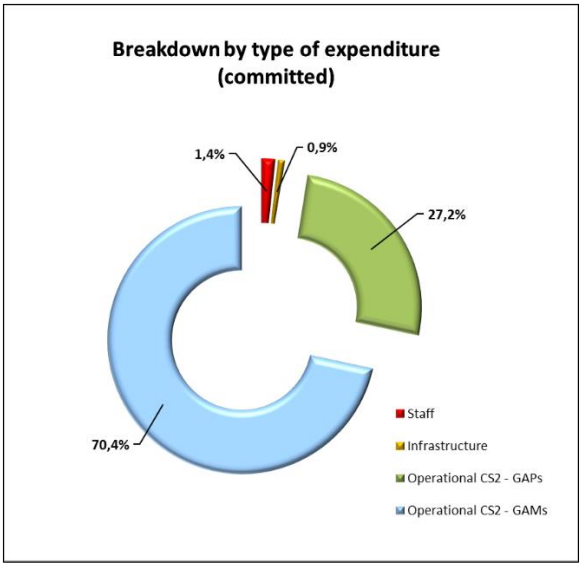
1.8. Dissemination and information about project results

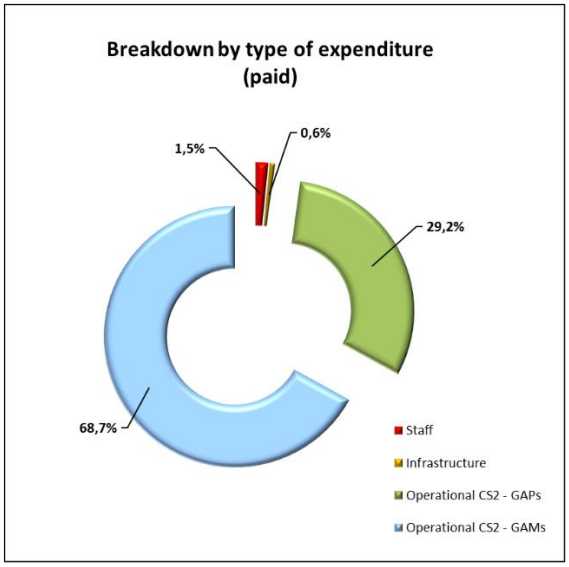
In 2019 a series of actions aimed at raising awareness among the beneficiaries about the importance of dissemination and exploitation of the results of the projects were implemented. The JU has paid particular attention to the preparation and improvement of the drafting of the dissemination and exploitation plans by the beneficiaries providing accurate guidelines during the negotiation phase. In addition, during the Clean Sky 2 Info Days (26-27 March in Valladolid, 7 May in Toulouse, 11 June in Brussels) and the kick-off meetings of the winning projects, an accurate information and awareness campaign has been put in place regarding the dissemination and exploitation of the results of the projects, and showing what benefits can be achieved. The information has been communicated through presentations focused on the open access policy, the H2020 rules governing the dissemination and exploitation and about the benefits that can be obtained from an efficient and effective dissemination and exploitation of the results. In order to ensure the achievement of the targets fixed for the KPIs on dissemination and exploitation (D&E) (minimum number of papers and patents) and reduce the risks of failure, the JU monitors the progress made by the beneficiaries in terms of dissemination and exploitation activities twice a year. As a result, the dissemination activities increased by about a third while exploitation activities quadrupled (see separate annex in the KPIs section).

1.9. Operational budget execution

In 2019 the JU managed the Clean Sky 2 programme (Horizon 2020) with a corresponding amount of commitment appropriations of €291.3 million. The JU executed 100% of the operational budget. The available payment appropriations amounted to €324.9 million and 97.4% of the available funds were executed.

Title IV CS2 Budget execution	Executed CA	Executed PA
LPA	66,580,000	82,432,561
REG	20,829,000	15,255,759
FRC	32,369,800	26,872,989
AIR	0	21,937,934
ENG	39,743,375	36,027,781
SYS	48,790,865	32,261,107
TE	1,969,810	1,100,443
ECO	1,900,100	449,988
SAT	1,744,339	210,656
TOTAL CS2 GAM	213,927,289	216,549,217
	100%	*100%*
Call for tender	579,600	0
	100%	0%
GAPs	76,818,854	99,782,174
	100%	*92%*
TOTAL CS2 OP	**291,325,743**	**316,331,391**
	100%	**97%**





Budget evolution

The Governing Board adopted the original 2019 budget for Clean Sky 2 Joint Undertaking for the global amount of €294.9 million in commitment appropriations and €327.8 million in payment appropriations in November 2018.

In 2019 the Governing Board adopted two budget amendments. In April 2019, the budget was amended in order to adjust the commitment and payment appropriations – as a consequence of the correction of the estimated carry-over. The main purpose of the second amendment of November 2019 was to transfer unused funds to Title 5 since the funds will be needed in the following years until the closure of the programme.

The final budget adopted by the Governing Board in November 2019 for implementation amounted to €302.7 million in commitment appropriations and €338.1 million in payment appropriations. The complete details of these amendments are made publically available under the section 'Key Documents' on the JU's website.

1.10. In-kind contributions

In-kind contributions (IKC) are provided by the private members throughout the lifetime of the programme. The amounts are set out in the Clean Sky 2 JU Regulation:

	H2020 (m €)
Max. Union contribution for operational expenditure	1.716
Max. total EU contribution to operational cost of private members (leaders/core partners)	1.201
Min. expected in kind contribution from private members to the Joint Undertaking (IKOP + IKAA)	2.193
Minimum private members in kind contribution for additional activities – in-kind (IKAA)	965

H2020 programme:
The private members can provide their in-kind contributions in two ways under the H2020 programme: in-kind contributions from operational (JU funded) projects, i.e. unfunded share of costs on JU projects (IKOP) and in-kind contributions from implementing the so-called additional activities (IKAA).

IKOP certification and validation
According to the Clean Sky 2 JU regulation, all costs to be taken into account as IKOP must be certified. The IKOP values mentioned in the table below show both the reported and the certified and validated amounts to date. As of the cut-off date of the Provisional Accounts 2019, the JU has validated certified contributions to the value of €273.9 million. A breakdown by area of the projects is provided below[11].
The difference between the reported and certified values is linked to the grant reporting cycle, as for 2018 and 2019 only the estimates received from members are available and the certification of these amounts in the final period of the ongoing GAMs[12].
In 2019 the procedure for the management of in-kind contributions was revised in order to reflect the transfer of all the GAMs to H2020 EC grant management tool.

ITDs/IAPDs	GAM 2014 – 2019 JU contribution*	Reported IKOP by private members 2014-2019*	Certified and validated by JU IKOP 2014-2017	Still to be certified IKOP
AIRFRAME	145,579,758	107,440,075	56,971,531	50,468,544
ECO-DESIGN TA	2,478,114	2,914,124	1,583,133	1,330,992
ENGINES	156,897,596	146,296,886	79,542,406	66,754,480
FAST ROTORCRAFT	80,267,056	67,350,327	25,886,798	41,463,530
LARGE PASSENGER AIRCRAFT	166,469,068	135,526,951	43,621,358	91,905,593
REGIONAL AIRCRAFT	46,922,413	41,008,181	18,936,109	22,072,071
SMALL AIR TRANSPORT	686,140	408,096	254,349	153,747
SYSTEMS	102,481,737	92,042,441	46,684,566	45,357,876
TE	2,030,866	984,694	371,351	613,343
TOTAL	**703,812,748**	**593,971,775**	**273,851,600**	**320,120,175**

[11] Including the estimated amounts by private members for 2018.
[12] The duration of the current GAMs is 2018-19 and the final reporting will take place in March 2020.

IKAA certification and validation

The IKAA value of €899.84 million reported includes a total amount of €620.0 million fully certified by the members' external auditors and validated by the Governing Board (GB) for the period 2014-2018. This value has also been provided to the GB for its opinion in accordance with Article 8 (2) (i) of the Statutes of the CS2 JU.
The additional activities underlying the values validated by JU management to date and reported for the period 2014-2019 consist of:

- *preparation of test aircrafts/platforms including infrastructure for flight testing;*
- *development and testing of advanced component technologies, modelling, control systems and materials systems for the engine demonstrator programme;*
- *development of accompanying manufacturing methods and techniques, e.g. for laminar wings;*
- *development of supporting technologies, e.g. research and technology development of architectures, technology bricks and other enablers for systems and airframe;*
- *aircraft architecture design process;*
- *new manufacturing and assembly techniques;*
- *composite manufacturing processes;*
- *activities concerning the innovative passenger cabin;*
- *configuration optimisation tools;*
- *development of various technologies/materials lowering operating and life cycle cost;*
- *Counter-Rotating Open Rotor related complementary activities;*
- *Landing Gears complementary activities;*
- *preparation of simulated environment for integration of early developments.*

At the end of 2019, at programme implementation level, the JU incurred 56% of the total programme expenditure[13,] whereas the members already provided 69% of the expected total in kind contribution, with the IKAA rate of 93%.
Assuming that the current trend will be constant for the remaining years of H2020 programme, the private members will exceed the overall €2,155.00 million IKC obligation as required by the Council Regulation.

	Targets CS2 Regulation m€	Actual 2014-19 m€	Achieved %
Max. Union contribution for operational expenditure	1,716.00	958.29	56%
Max. total EU contribution to operational cost of private members (leaders/core partners/associates)	1,201.00	707.08	59%
Min. expected in kind contribution from private members to the Joint Undertaking (IKOP + IKAA)	2,155.00	1,493.82	69%
Minimum private members in kind contribution from additional activities – in-kind (IKAA)	965.00	899.84	93%

[13] 2014-17 are validated and certified figures, the 2018-19 figures are based on reported values provided by the Members.

1.11. Synergies with the European Structural and Investment Funds (ESIF)

The Clean Sky 2 Joint Undertaking is called by its founding Council Regulation (EU) no. 558/2014 of 6 May 2014[14] to develop close interactions with European Structural Investment Funds (ESIF) and to underpin smart specialisation efforts in the field of activities covered by the CS2 JU.

Since the year 2015, the following figures show the progress in the action undertaken by the JU:

Synergies between ESIF and Clean Sky maximises the specific value added of Smart Specialisation Strategies (S3) investments such as the capacity to support effectively aeronautics capacity building and the exploitation of research results for raising the overall social/economic impact of European aeronautics sector.

In this context, the JU strongly supports synergies with ESIF by allowing complementary activities to be proposed by applicants to CS2 calls and by amplifying the scope, adding parallel activities or continuing CS2 co-funded projects/activities through ESIF in synergy with the Clean Sky 2 Programme and its technology roadmap. The JU also promotes the use of ESIF to build and enhance local capabilities and skills in fields related to the programme, in order to enhance the level of European competitiveness of stakeholders in this area.

Action plan

At strategic level, the JU is continuing the implementation of the action plan on synergies with Member States and regions that are interested in investing ESIF or regional funds into the aeronautics area and other related technologies in this domain. In this regard, the JU is developing close interactions with the interested Member States (MS) and regions in Europe and is discussing, based on the priorities set out in their Smart Specialisation Strategies (RIS3), a possible cooperation and the most appropriate modalities for developing synergies depending on the level of interest and commitment which the Member State/region may decide to engage with.

Regional cooperation on synergies with the CS2 JU – the MoU framework

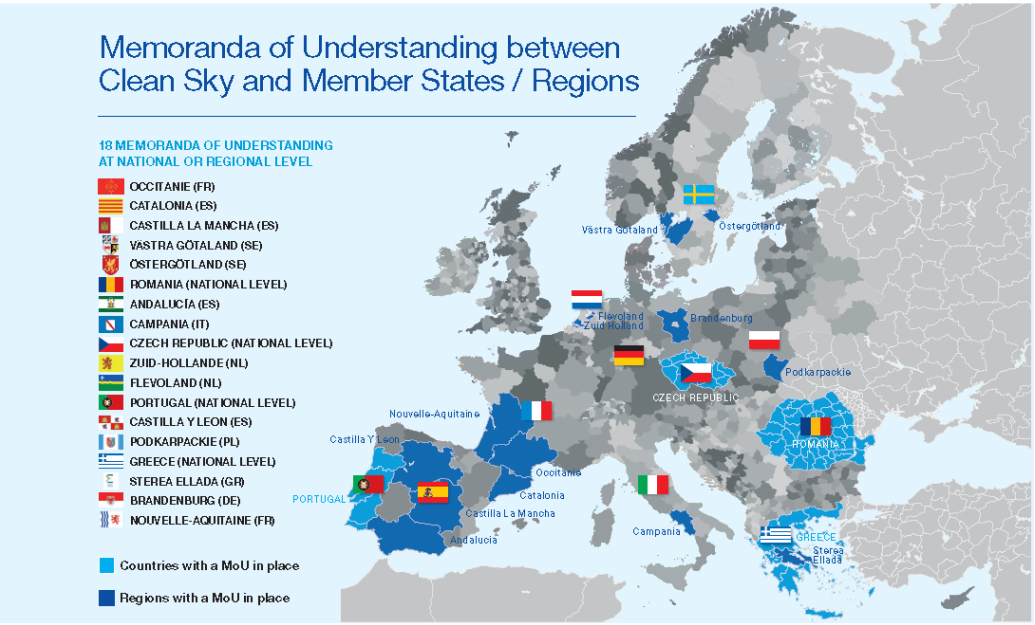
Based on its experience over these years, CS2 JU considers the signature of a MoU framework to be an important and effective tool to implement synergies and take a strategic approach towards the coordination of activities and alignments of efforts.

In 2019, the CS2 JU continued its bilateral contact and cooperation with a number of interested

[14] See in particular Recital 21: "the CS2 JU should seek to develop close interactions with the ESIF, which can specifically help to strengthen local, regional and national research and innovation capabilities in the area of the Clean Sky 2 Joint Undertaking and underpin smart specialisation efforts."

Member States and regions based on the RIS3 priorities mapping drawn up by the CS2 JU.

A further MoU was signed in 2019 with Nouvelle Aquitaine region in France, which brought the number of MoUs in force to 18 (see map below of the existing MoU cooperation). This may be followed by the signature of a few other possible cooperation agreements in the year 2020 within the estimates provided in the CS2 JU Development Plan to ensure consistency with the overall programme strategy and development.



State Representative Group - Working Group on synergies

A Working Group (WG) that had been set up in 2017 to discuss and explore the ways for synergies between national/regional programmes and CS2 JU, continued the meetings during 2019 and delivered a report entitled 'Towards a more advanced coordination between Clean Sky 2 JU and Member States programmes, and implementation of synergies'.

In 2019, the SRG WG focused on:

- Data collection on national programmes/funding schemes, and links with CS2 objectives and ITDs/IADPs through 'country fiche' papers;
- Elaboration of country level analysis on possible synergies and drawing up of 'country fiches' for the following Member States: IT, ES;
- Delivering the final report to the Governing Board.

MoU implementation in 2019

In the framework of the MoU implementation, some Member States/regions under a MoU launched calls and funding schemes that either included topics dedicated to aeronautics and synergetic to CS2 JU or incentivised the submission of proposals complementary to JU activities and objectives. Additionally, more than 40 projects with a budget of more than €50 million were leveraged through the MoUs. Some examples of calls launched or new projects funded in 2019

are provided below.

Campania (IT)

A second regional call was launched on 15 November 2019, which allocated €20 million of available funding for regional aeronautics priorities aligned to the Clean Sky 2 programme. The aim is to fund enabling systems and technologies in aeronautics to accelerate innovation processes in the local industry.

This is the second call launched by the region as part of the Memorandum of Understanding signed with Clean Sky, which aims to promote synergies between European research and innovation funds and the ESIF funds managed by the Campania Region. The results of the call in terms of contribution to the MoU and leveraged project will be announced in 2020.

A notable project awarded in 2019 concerns the 'Production and control of innovative and multifunctional nano-structured materials and devices with antimicrobial and anticorrosive efficacy', from AIR/ ECO synergy areas; budget € 1.53 million.

Occitanie (FR)

In 2018 Occitanie launched the R&I call 'Readynov 2018'* (successor of Easynov 2016 and Readynov 2017), which included a part dedicated to aeronautics and related industries. The call covers a number of topics related to aeronautics technologies in line with Occitanie RIS3 priorities and aims also to support proposals linked to Clean Sky 2 topics, by referring to the CS2 JU work plan in terms of scope. This call is still currently open for the submission of proposals.

A notable project awarded in 2019 was BRAMETAL: New processes for metal-Alumina brazing; from LPA/AIR synergy areas; budget € 0.82 million.

Romania

A national call/open submission scheme that had been launched since 2016 by the National Authority for Scientific Research and Innovation of Romania (ANCSI), that can support complementary projects to Clean Sky activities, is still open. In 2019, two complementary proposals from ENG synergy area: REMASTER (development of research infrastructure for emerging advanced composite materials dedicated to innovative stator ogv technologies for aircrafts engine noise reduction – budget of €1.48 million) and INFRASEAL (development of research infrastructure for rotating labyrinth seals characterisation labyrinth seals for higher parameters engines; budget €1.99 million) were awarded the Clean Sky Synergy Label and considered for funding support through this call.

Greece

A funding scheme within the framework of the MoU was pre-announced to support complementary activities to Clean Sky 2 calls with a budget of €2 million.

The JU will continue implementing the MoUs in force throughout the year 2020 in view of supporting more upstream coordination with RIS3 and the implementation of more ESIF projects, and will continue identifying more best practices in view of the next framework programme.

Clean Sky Synergy Label

In 2019, three more complementary proposals were awarded the quality certification of the Clean Sky 2 Synergy Label and were highly recommended for support through ESIF.

- INFRASEAL – ESIF complementary activities in the area of Engine ITD
- REMASTER – ESIF complementary activities in the area of Large Passenger Aircraft LPA
- SAINT – ESIF complementary activities in the area of Airframe AIR

In addition, the JU was asked by some regions under MoU to act in the regional evaluation committees or deliver a synergy assessment to contribute to the regional evaluation process of R&I proposals received under the regional calls.

Regional participation in Clean Sky 2

The JU has also elaborated a statistical analysis regarding the participation of the regions in CS2 calls. According to the data, by the end of 2019, 120 regions from 28 countries have participated in CS2 winning proposals.

Additionally, within the context of activities dedicated to synergies, in June 2019 Clean Sky organised a conference at Le Bourget on 'Aligning the research efforts with Member States and Regions'. Speakers representing the European Commission, national governments, regions working with Clean Sky and aviation industry leaders came together to discuss Clean Sky's cooperation and synergies with a number of Member States and European regions.

2. SUPPORT TO OPERATIONS

2.1. Communication Strategy and activities

In 2019 Clean Sky 2 entered a very dynamic phase reflecting on the steady progress of many projects that are underway towards the goal to reduce emissions and noise levels from aircraft. The innovative technologies under development within the programme and increasingly broader partnerships across Europe are central to Clean Sky's advocacy and communication activities, given the high expectations of target audiences from both the political side and from potential industrial and scientific stakeholders.

In addition, Clean Sky aligned even further with the European Commission's communications on Horizon 2020 and its successor Horizon Europe by sharing messages and referring to the far-reaching EU innovation vision and policy in connection with demonstrations, events, and news about the programme. Consequently, outcomes from Clean Sky's cutting-edge research are increasingly seen and recognised by both the Clean Sky community and the public at large as achievements of the European Union.

Communication activities build on the communication strategy adopted by the Governing Board on a multiannual basis. Throughout 2019, Clean Sky worked with its institutional and industrial members on the basis of the 2019-2020 Advocacy and Communications Strategy. That strategy is fully designed to support the needs of the organisation at a time of political and public

consultations and discussions on the future of the European partnerships for aviation.

Within this particular context, the key communication priorities in 2019 were: demonstration of Clean Sky 2's successful project outcomes, positive reputation, expanding networks, brand building and visibility. To this end, the communications strategy in 2019 took place in three main strands: 1) accelerating content creation to explain Clean Sky to European citizens and consolidating EU branding; 2) stepping up digital communications; and 3) delivering impactful events and printed publications.

Accelerating content creation to explain Clean Sky to European citizens, and consolidating EU branding

CS2 JU and its members made a substantial investment in producing relevant, impactful content to showcase key facts and figures and technology results to date.

This vision translated into the production and completion of 45 stories on Clean Sky 2 programme results across the different technology platforms with a wide digital promotional campaign taking place throughout 2019. Building upon those stories, a sequel of 20 more success stories was initiated in autumn 2019, and is expected to be completed and ready for publication in early 2020.

In 2019 the branding of Clean Sky activities and results improved substantially. The Joint Undertaking team, private members, SMEs, research organisations and universities made a significant effort to brand the results of Clean Sky as such, but more critically, as part of the European Union's Horizon 2020 programme, by posting the EU emblem clearly and large enough in all sorts of deliverables including hardware, videos and social media posts.

Stepping up digital communications

Throughout 2019, Clean Sky continued to invest in the digital strategy anchored on www.cleansky.eu and social media channels, as well as stronger coordination of Clean Sky communications with those of the European Commission and industry, universities and research centres.

The highlights were: a) stepping up on social media by creating more relevant and frequent messaging, as well as further coordination with the European Commission's Research and Innovation services and industrial leaders, leading to increased traffic and wider outreach to more communities; hip; b) Questions & Answers live event aiming at responding to a wide array of questions from Clean Sky members; and c) development of a digital application on a tactile screen to demonstrate future aviation technologies;

In 2019, measureable increases are reported in visits, impressions, followers and likes in:

- **Twitter** with 117 tweets, 432.5K tweet impressions and 473 new followers bringing the total to 2219 by the end of 2019;
- **LinkedIn** groups with almost 4000 followers and still growing;
- **YouTube** with 5 new videos added to the playlist on the Clean Sky channel;

- **www.cleansky.eu** with a total number of more than 340 472 of page-views, with an ample geographical spread in Europe and globally. Most visited pages were calls for proposals, vacancies, key documents, events and key technologies.

Delivering impactful events and printed publications

Following a tested and successful model, Clean Sky organised its own events and used external high profile aviation events to raise awareness of goals and achievements while expanding its community. The following large events took place in 2019: Clean Sky 2 Info Days across Europe, Aerodays in Bucharest in April, and the major Paris Air Show (Le Bourget) in Paris in June.

Clean Sky's participation at Aerodays and the Paris Air Show continued in partnership with the European Commission under the motto "*EU investment in aviation*". Stands at both events showcased some 20 pieces of innovative hardware developed within the programme, demonstrating the progress achieved towards the goal of reducing CO_2 emissions and noise levels produced by aircraft while strengthening European competitiveness.

In addition, the Clean Sky annual award for Best PhD took place during Aerodays in 2019.

Both Aerodays and the Paris Air Show gave Clean Sky and the European Commission the opportunity to welcome many visitors and interact with the public at large, including during the public weekend at Le Bourget, thus demonstrating concrete results to the wider community to emphasise a positive message of the EU's investment in research and innovation.

Publications remain a useful tool to regularly address internal and external audiences. Clean Sky's communications included 'Skyline' magazine, which is published three times per year, and the electronic monthly E-News. Both have seen their dissemination lists optimised to ensure that different services of the European Commission, Members of the European Parliament (MEPs), national representatives specialising in research from the 28 Member States and not least new partners are kept abreast of Clean Sky news on innovative technologies, broader partnerships and key events. This has enabled the expansion of Clean Sky news and activities to other networks, such as partners' own newsletters for example, thus improving visibility and brand support.

On the procurement side, in 2019 Clean Sky carried on fully implementing a large Communications framework contract for four different communications lots that runs from 2018-2021.

2.2. Legal and financial framework

New Financial Regulation

The Regulation (EU, Euratom) 2018/1046 on the financial rules applicable to the general budget of the Union, repealing Regulation (EU, Euratom) No 966/2012 (2012 Financial Regulation) was adopted in 2018. The derogations requested by the CS2JU refer to the revised Model Financial Regulation, which was adopted as a consequence of the new EU Financial Regulation. By decision of 4 November 2019, DG BUDG accepted certain CS2JU derogations and rejected other derogations.

In November 2019 the JU launched a written procedure for the approval of its revised Financial Rules, in line with recommendations from the European Commission. The revised financial rules were adopted in January 2020.

Governance decisions

A set of Governing Board decisions related to the set-up of the governance and functioning of the JU were adopted by the Board as listed under subchapter 3.1 of this document.

Closed, reopened or new court cases

In 2019, a case was lodged in the General Court against the JU by an unsuccessful applicant in the CfP08. This case is still ongoing; the CS2 JU is awaiting judgment from the General Court.

In 2017, five new cases were lodged by the JU against a company for the enforcement of debt recoveries by the General Court in the framework of the respective Grant Agreements. The five cases were still ongoing in 2019; in two of the cases the European Antifraud Office (OLAF) was involved (see chapter 4.6 Risk Management and Conflict of Interest).

Data protection

The new Regulation 2018/1725[15] was adopted on 23 October 2018 and entered into force on 11 December 2018. In 2018 the JU started the analysis of the new legislative framework and preparatory work to ensure timely compliance with the expected new rules as recommended by the EDPS by letter of 12 October 2017.

In 2019 the JU performed the following main steps:

- updated privacy statements;
- updated the cookie notice and policy on the website;
- drafted implementing rules to be adopted by the Governing Board (decision on restrictions, data breach procedure);
- updated the register on data processing operations and published it on the website;
- updated internal policies and documents (e.g. privacy statements, contractual clauses) on the data protection aspects related to the launch and management of the calls for proposals, of procurement, grants and experts and the conflicts of interest and related declarations of interests.

To this end, the JU Data Protection Officer/Assistant informed the staff on the new Regulation and set up meetings with colleagues from communications, IT and audit in order to raise awareness of the new framework in view of ensuring compliance of their processing operations. The DPO and their assistant followed the communications and attended meetings and trainings

[15] Regulation (EU) 2018/1725 of the European Parliament and of the Council of 23 October 2018 on the protection of natural persons with regard to the processing of personal data by the Union institutions, bodies, offices and agencies and on the free movement of such data, OJ L 295, 21.11.2018.

organised by the EDPS and worked in cooperation with the other JUs also in view of identifying possible sharing of tasks and resource efficiency in the field.

Steps to carry out:

- Publish joint JU internal rules on data breaches in the Official Journal of the European Union;
- Update JU processing operations on GDPR central and publish it on the website.
- Conclude a Memorandum of Understanding between Clean Sky 2 Joint Undertaking and the European Commission on joint controllership.

Horizon Europe Model Grant Agreement

As the Commission is working on the new framework programme for Horizon Europe, CS2JU has provided inputs on the draft Model Grant Agreement to the Commission. In 2020, CS2 JU will communicate its specificities to the Commission.

2.3. Budgetary and financial management

Title 1 & 2	Budget (€ m)	Executed (€ m)	% rate
CA	8.2	8.2	99.92
PA	8.7	6.9	79.17

Title 1 & 2 – Staff and administrative expenditures:

The administrative expenditure of the JU had again a very high rate of use in 2018 showing a reliable budgetary planning for this part of the JU budget:

- For commitment, the execution rate was 99.92%, slightly higher than 98.4% in 2018
- For payments, the rate achieved reached 79.17% in 2019, lower than 93.1% in 2018

Staff expenditure budget (Chapter 11) was mainly used for the statutory staff of the JU (38 posts filled in at 31.12.2019), although other external support was also hired in by the JU to cope with the increased workload (Chapter 12).

The JU made a provisional commitment with a value of 0.8 million euro for the Ex-Post Audits carried out by the Common Implementation Centre of the EC. As no payments linked to the Ex-Post Audits were processed, the payments consumption was impacted.

2.4. Procurement and contracts

List of contracts signed in the year 2019 (>15.000 EURO)

Contractor	Framework contract Y/N	Selection procedure used	Document Reference	Subject	Signature Date	Amount (€)
Start People	Yes	Order Form	OF no 2018/209 implementing framework contract no IMI.2016.FWC/018	Interim Staff Services	09/01/2019	17,016.45
ESN	Yes	Specific Contract	Specific contract no SC-02/FWC-CSJU.2017.OP.01-LOT4-02 implementing Framework Contract n° CSJU.2017.OP.01-LOT4-01	CS website services from 1 April 2019 to 31 March 2020	07/02/2019	72,000.00
TMAB	Yes	Order Form	OF no 2019/46 implementing Framework Contract no CSJU.2017.OP.01-LOT3-01	Support to CS at Le Bourget 2019	13/03/2019	51,930.00
TMAB	Yes	Order Form	OF no 2019/45 implementing Framework Contract no CSJU.2017.OP.01-LOT3-01	Support to CS at Aerodays 2019	13/03/2019	48,610.00
M. Velardo	Yes	Amendment to Direct Contract	Amendment no 1 to DC/CSJU.2017.NP.01/1	Legal support in litigations	03/04/2019	30,000.00 AMD-value 60,000.00 total value of the contract
20STM	Yes	Order Form	OF no 2019/83 implementing FWC.CSJU.2017.OP.01-LOT2-01	CS visualisation-interactive table	23/05/2019	34,262.00
Microsoft-Comparex	Yes	Order Form	OF no 002.Y2 implementing FWC DI/07470	Annual renewal of Microsoft Licences for 2018-2019 with Comparex	29/05/2019	18,796.98
TMAB	Yes	Order Form	OF no 2019/140 implementing FWC.CSJU.2017.OP.01.LOT3-01	Support to CS annual event 20-21 April 2020, Brussels	29/09/2019	124,104.00

Contractor	Framework contract Y/N	Selection procedure used	Document Reference	Subject	Signature Date	Amount (€)
EU-Turn	Yes	Order Form	OF no 2019/152 implementing FWC.CSJU.2017.OP.01-LOT1-01	20 CS2 results articles Paul Sillers	16/10/2019	36,000.00
TMAB	Yes	Order Form	OF no 2019/151 implementing FWC.CSJU.2017.OP.01-LOT3-01	Support to CS stand at Aerospace Europe Conference, 25-28 February 2020, Bordeaux - France	15/10/2019	19,950.00
Collins Editorial Consulting	No	Direct Contract	DC/CSJU.2019.NP.02	Provision of professional writer/editor services	12/12/2019	144,000.00
McKinsey Solutions SPRL	No	Direct Contract	DC/CSJU.2019.OP.01	Independent study on the use of hydrogen and fuel cells for aircraft propulsion	02/12/2019	579,600.00
EU TURN	Yes	Order Form	OF no 2019/171 implementing FWC.CSJU.2017.OP.01-LOT1-01	CS Merchandise order/promotional items October 2019	22/11/2019	20,932.50
ADS Group Limited	No	Purchase Order	PO no 2019/197	Stand Farnborough 2020	18/12/2019	68,000.00
Telmaco SA	Yes	Order Form	OF no 2019/198 implementing FWC.SCIC-2016-S5-3471731	Purchase of beamers, click share equipment and cables for CS meeting rooms	20/12/2019	18,293.71
Bechtle Brussels NV	Yes	Order Form	OF no 2019/212 implementing FWC.DI/07630-(MEQ IV)	Order Form for laptops, mice, bags	20/12/2019	19,043.50

2.5. IT and logistics

In 2019 the new year began, as usual, with a maintenance and upgrade window over the holiday period.
Over the Easter holiday a major project to equip the large meeting rooms with audio visual equipment was implemented. This flexible system permits the joining / division of meeting spaces, new projectors and portable monitors, conference microphones, fixed and portable loudspeakers etc. The new facilities have been very well appreciated and extensively used. It has resulted in a big reduction in the cost and disruption of frequently renting such equipment. Such is the success that a new upgrade is already planned to extend the system to the other meeting rooms.

In 2019 two new photocopiers were purchased and ten workgroup printers as well as other items of ICT equipment.

During 2019 a second dedicated line to the data center (DC) in Hamburg was installed to provide additional redundancy. Also, a European Commission encrypted communication system (Testa) was installed in the data centre by the Joint Undertakings and two other EU bodies who are hosted at that DC. This provides redundancy for the Testa system in our Brussels office and is a key element of business continuity and disaster recovery planning. Testa is critical to CS2 JU given the large number of EC system used in our processes.

Contracts were signed in 2019 for the following important ICT projects:

- upgrade of the wired network in the White Atrium building (including switches) which is now ten years old;
- upgrade of the WiFi Network which is also ten years old and under capacity;
- enhancement of ICT equipment in the meeting rooms;
- the purchase and installation of security cameras in the areas of the building;
- video conferencing facilities for the meeting rooms as a pilot project for the rest of the building.

During 2019 CS2 JU joined or activated several more EC Framework Contracts for various ICT services.
At the beginning of 2019 CS began to use the HR system of the Commission, Sysper, which has been of much benefit. No other system on the market can comply with the staff regulations and other unique requirements of CS. Further enhancements to this are planned.
2019 was year one of the four year ICT service contact recently procured. This was implemented with new governance, KPIs and other measures to enhance the delivery of ICT services. During 2019 workshops were organised to help in reviewing strategic options for the future of ICT at the Joint Undertakings. Subjects such as Office-365, Unified Communications technology, virtual working, collaborative workspaces, etc. were reviewed so that ICT decisions can be taken more quickly.

2.6. Human Resources

The JU establishment plan for 2019 contained a total of 42 statutory staff (TA and CA) and two SNEs with 40 posts filled at the end of the 2019. In 2019 the JU launched the recruitment process of 6 positions. In addition to the statutory posts, the JU relies on external service providers such as the webmaster, the IT services firm shared with the other JUs, five interims and one trainee to provide extra support to the JU.

With the written procedure no 2019 – 06, the Governing Board adopted a new organisational structure with Legal and Communication directly reporting to the Executive Director.

The Governing Board adopted implementing rules for giving effect to the Staff Regulations regarding the engagement and use of contractual agents in the agencies. The JU also further implemented the use of Sysper2, the time and personal data management tool of the Commission.

In cooperation with the other JUs, Clean Sky also worked on the implementation of the anti-harassment policy: the selection of the confidential counsellors has been completed and the policy and key actors have been defined. An information session specific for Clean Sky staff washeld in April 2019.

The Executive Director started his service on 1 February 2019. In order to consolidate the team spirit, the JU organised two team events, which succeeded in reinforcing the cohesion among colleagues and to introduce all staff to the Executive Director.

In accordance with the decision of the Governing Board regarding the reclassification system, in 2019 the JU has performed the reclassification exercise and as a result eight staff members were reclassified.

3. GOVERNANCE

3.1. Governing Board

In 2019, the Governing Board was composed of 23 members: the Commission, with 50% of the voting rights; the 16 founding members of Clean Sky 2 Joint Undertaking, and six core partner representatives of the ITDs/IADPs in the Clean Sky 2 programme. In 2019, the representatives of core partners were Avio Aero, CIRA (representing two ITDs), Aernnova, United Technologies Research Center Ireland and GKN Fokker.

The Chairman of the Governing Board was Stephane Cueille (Safran) and the Deputy Chairman was Marco Protti (Leonardo Aircraft).

The Clean Sky 2 Joint Undertaking Governing Board had three meetings in 2019, on:

- 9 April 2019
- 27 June 2019

- 21 November 2019

In 2019 the Governing Board adopted the following key documents in its meetings:

Meeting 9 April 2019

- Decision of the Governing Board adopting the Third Amended Bi-annual Work Plan and Budget 2018 - 2019
- Decision of the Governing Board approving the Annual Audit Plan 2019 of the Internal Audit Capability

Meeting 27 June 2019

- Decision of the Governing Board approving the Annual Activity Report 2018 including the corresponding expenditure
- Opinion of the Governing Board on the Final Accounts and Budgetary Implementation Report 2018

Meeting 21 November 2019

- Decision of the Governing Board adopting amendment no 4 to the Clean Sky 2 Joint Undertaking Bi-annual Work Plan and Budget 2018-2019
- Decision of the Governing Board adopting the Bi-annual Work Plan and Budget 2020 – 2021
- Decision of the Governing Board adopting the updated Clean Sky 2 Development Plan

Decisions by written procedure

The following written procedures decisions were adopted:

- Written Procedure 2019–01 Governing Board opinion on the in-kind contribution related to additional activities declared by the Leaders and Core Partners of the Clean Sky 2 Joint Undertaking for the period 2014-2017
- Written Procedure 2019–02 Decision of the Governing Board approving the additional activities plan 2019
- Written Procedure 2019– 03 Decision of the Governing Board approving the Ranking Lists of the selected proposals of the Call for Proposals 9 (CFP09)
- Written Procedure 2019–04 Decision of the Governing Board on types of posts and post titles for temporary staff
- Written Procedure 2019–05 Decision of the Governing Board on the general provisions for implementing Article 79(2) of the Conditions of Employment of Other Servants of the European Union, governing the conditions of employment of contract staff employed under the terms of Article 3a thereof
- Written Procedure 2019–06 Decision of the Governing Board on the approval of the revised organisational structure of the Programme Office

And the following ones were launched in 2019 for adoption in early 2020:

- Written Procedure 2019–07 revised Financial Rules of the Clean Sky 2 Joint Undertaking
- Written Procedure 2019–08 Decision of the Governing Board on the non-application of the Commission Decision on the maximum duration for the recourse to non-permanent staff in the Commission services
- Written Procedure 2019– 09 Decision of the Governing Board approving the Ranking Lists of the selected proposals of the Call for Proposals 10 (CFP10)
- Written Procedure 2019–10 Decision of the Governing Board approving the additional activities plan 2020

Most of the decisions were adopted unanimously or almost unanimously, showing a smooth and efficient decision-making process. Each Governing Board is prepared by a 'Sherpa Group' meeting, chaired by the JU. The GB acted according to its adopted Rules of Procedures.

3.2. Executive Director

The Executive Director is the legal representative and the Chief Executive for the day-to-day management of the JU, in accordance with the decisions of the Governing Board, in line with Article 10 of the CS Statutes.

In 2019, Tiit Jurimae, continued to serve as Interim Executive Director until 31 January 2019. The newly appointed Executive Director, Axel Krein, took up duties on 1 of February 2019.

The coordination role of the Executive Director is supported by the organisational structure of the JU programme office, providing for dedicated responsibilities in all units. The JU's management acts on the basis of its quality system, which is described in the JU's Quality Manual. Interactions with the SPDs are mainly governed by the Management Manual. All grant management processes applied by the JU are designed to a large extent by the Commission through the H2020 tools and other EC systems.

3.3. Steering Committees

Each Integrated Technology Demonstrator (ITD) and each Innovative Aircraft Demonstration Platform (IADP) in charge of specific technology lines within the CS and CS2 programmes is governed by a Steering Committee, as described in article 11 of the Statutes. The Steering Committees are responsible for technical decisions taken within each ITD/IADP and in the TE and have met regularly in the course of 2019. The relevant project officer, supported when needed by the Head of Unit or the Executive Director, attends these meetings. The Executive Director in particular chairs the TE Steering Committee meetings.

Technology Evaluator and other Transverse Activities

The Technology Evaluator, as a Transverse Activity, monitors and assesses the environmental and societal impact of the technological results arising from individual ITDs and IADPs across all Clean Sky activities, specifically quantifying the expected improvements on the overall noise, greenhouse gas and air pollutants emissions from the aviation sector in future scenarios in comparison to baseline scenarios. Eco-Design and Small Air Transport Transverse Activities are in charge of the coordination of their activities in cooperation with ITDs and IADPs.

3.4. Scientific Committee

The Scientific Committee (SciCom) is an advisory body to the Governing Board. In 2019, the Scientific Committee met 6 times, approximately every two months: 25 January, 28 February, 29 April, 02 July, 11 October and 28 November. The Scientific Committee was consulted on various key documents, mainly providing opinions and recommendations regarding the CS2 JU Work Plan priorities and the Calls for Proposals launched, but also advising on the technical, scientific and programmatic relevance of the Clean Sky 2 programme's research and innovation actions with respect to the achievement of the environmental Clean Sky targets.
In particular, the SciCom members were involved as reviewers in the Annual Reviews and the Interim Progress Reviews of the CS2 programme. The reviewers delivered the reports and a summary concerning the main outcomes and recommendations of the Annual and Interim Reviews meetings for the Governing Board information.

- The SciCom reviewed and assessed the description of the topics of CfP11. The analysis targeted the expected progress beyond the state of the art, the level of contribution towards the CS2 objectives, the CS2DP and the demonstrators. In addition, technical feasibility, correlation with past and ongoing projects at European level and the CS2 SPDs were assessed as well. The Work Plan 2020-2021 and the CS2 Development Plan were reviewed also.
- The SciCom was consulted also in relation to the publication of the TE Light Projection report and synopsis. Their recommendation was not to publish any of those documents as the assumptions for the fleet forecast by 2050 were not clearly understood.

At the request of the Interim Executive Director in 2018, the SciCom started preparing a document to illustrate their vision on the future European aviation research programme. To this end, all the main stakeholders (including the European Commission) and the SciCom were invited to participate in two workshops to present their ideas about the aircraft of the future. A first workshop was held on in November 2018, and a second one was held on 24 January, 2019. The preparation work for a vision document continued well into 2019 and was concluded by the submission of a formal report entitled 'Next Decade European Aeronautics Research Programme (2020-2030)', dated 26 May 2019. This document was presented to the Governing Board in June 2019 and shared with the SRG members as well as all participants to both workshops.

3.5. States Representatives Group

The States Representative Group (SRG) is an advisory body to the Clean Sky 2 Joint Undertaking, established in accordance with Article 14 of the Council Regulation.

The SRG consists of one representative of each EU Member State and of countries associated with the Horizon 2020 programme. It is chaired by one of these representatives and two co-chair representatives.

To ensure that the activities are integrated, the Executive Director attends the SRG meetings and the Chair of the SRG attends as an observer at the Governing Board. The secretariat is ensured by the JU.

During 2019 the SRG met three times:

- 8 February, Brussels
- 29 May, Bucharest
- 23 October, Brussels

The SRG was informed and regularly consulted in 2019 as required by the Statutes on the progress of the programme towards achievement of its targets, on any update of strategic orientation such as the launch of the 'thematic topics', on the level of SME participation and in particular on the adoption of the work plan and its amended versions, on the calls for proposals and on the development plan. The lists and topic descriptions of the calls were subject to specific consultations as part of the Governing Board consultation procedure and before official publication on the H2020 Participant Portal. The opinions provided by the SRG were duly taken into consideration by the JU as part of its review. The SRG also received and discussed the independent reports on the call evaluations from the independent observers.

The SRG was also regularly informed on the development of the different ITDs/IADPs/TAs, on the milestones of major demonstrators and the assessment of the Technology Evaluator.

The States Representative Group expressed its support on the continuation of the Clean Sky Joint Undertaking instrument under the next framework programme (Horizon Europe), based on a joint position paper that had been endorsed by SRG and ACARE.

4. INTERNAL CONTROL FRAMEWORK

Clean Sky 2 JU implements an internal control framework applicable at all levels of management and designed to provide reasonable assurance that operations are effective and efficient, but also that the financial reporting is reliable and the JU complies with applicable laws and regulations.

In the year 2019, the JU focussed on the assessment of the new Internal Control Principles, which haved been introduced in 2018. Furthermore the JU's risk management process has been streamlined as one of the main pillars of the Internal control system.

Ex-ante and ex-post controls of the operational expenditure have been maintained as strong and robust as in previous years. A detailed description is provided in the following subchapters.

The Internal Control Coordinator of the JU has performed an assessment of the entire internal control system of the JU, taking into account also the audit reports received from external and internal auditors as well as the anti-fraud measures taken by the JU. No critical risks have been identified as a result of this assessment.

4.1. Financial Procedures

The CS2 JU Financial Rules are aligned with the model Financial Regulation for public-private partnership bodies[16]. The JU has prepared a revision of its Financial Rules to comply with the new Regulation and has agreed with the Commisison one major derogation (see section 2.2. of this report). The new CS2 FR were adopted in early 2020[17].

All internal financial workflows of the JU are described in the CS2 Manual of Financial Procedures, which presents the financial circuits for the implementation of the JU budget. The financial circuits concern all financial operations taking into account the lean structure of the JU and any risks associated with the management environment and the nature of the financing operation. The financial procedures are established on the basis of the following risk considerations:

- The administrative budget of the CS2 JU (represents only about 4% of its total budget)
- For the management of the H2020 grants, the JU uses the EC tools and aligns its processes with the agreed workflows for the entire H2020 user community.
- In order to ensure the accounting data quality, CS2 JU applies an extra layer of control on all payments and recovery orders by opting for the manual validation by the accounting officer in the Reporting and Payment process.

[16] Commission Delegated Regulation (EU) 2019/887 of 13 March 2019 on the model Financial Regulation for public-private partnership bodies referred to in Article 71 of Regulation (EU, Euratom) 2018/1046 of the European Parliament and of the Council, OJ L 142, 29.5.2019, p. 16–42.

[17] Ref. CS-GB-Writ proc-2019-07 Revised Financial Rules.

Financial procedures in the JU are also based on the controls embedded in the accounting system ABAC and the EC H2020 tools for grant management (SyGMa / Compass).

Hence, after the transfer of the CS2 GAMs from the CS2 JU in-house system (GMT2) to the H2020 tool, the whole grant management is operated via SyGMa / Compass, including GAM signature, pre-financing, GAM amendments, costs validation and payment.

In 2019, the validation of cost claims, reporting of IKC and periodic payments for GAMs were carried out in the EC H2020 tools (SyGMa / Compass) for the first time. Awareness of the JU's Members about financial and administrative changes was raised during the annual Financial Workshop (see also futher below).

As a consequence of the migration to the EC tools, the reporting on IKOP had to be adapted. The IKOP guidance has been revised taking into account the new approach of reporting total project costs and has been communicated to all Members. This new procedure applies to the reporting of IKOP for the period 2018-2019. A local Microsoft Access based tool has been created by the JU to ensure a robust IKOP validation process, which provides the basis for a reliable recognition in the JU's Annual Accounts.

4.2. Ex-ante Controls on Operational Expenditure

A key element of the ex-ante controls applicable to H2020 grants of CS2 JU is the related guidance issued by the Commission and applicable to all H2020 stakeholders.
The simplified ex-ante control approach allows only limited checks when assessing the periodic reports and cost claims. Therefore, considering the complexity of the GAMs and their high budget values, CS2 JU has implemented more detailed checks for the validation of the GAMs costs claims since the beginning of the programme (detailed reporting and validation of Use of Resources for costs claimed, interactions between coordinators and CS2 JU Project and Financial Officers, reinforced internal review through internal meetings until final validation).
Regarding the Certificates of Financial Statements (CFS), CS2 JU has established an individual approach with its Members, which provides for a biannual certification even if not required according to H2020 rules.

In order to improve the quality of the periodic reporting of members and partners, CS 2 JU has organised several events. Two WebEx sessions were performed, focussing on the financial requirements of the CS2 grant agreements to ease the submission of final reports for the GAPs participants.

Like in previous years, the annual financial workshop was organised achieving in 2019 a participation of more than 120 CS2 JU members. The event combined general sessions and thematic workshops dealing with a wide range of topics which are essential in the context of GAM reporting (financial rules, eligibility criteria, In-Kind contributions, legal aspects of the grant agreements, ex post audits and reporting in the H2020 tools).

Furthermore , the JU has organised Info days and Kick-off meetings, following the publication of calls for proposals, to share key information on the grant management.

4.3. Ex-post Control of Operational Expenditure and Error Rates identified

I. Introduction

The results of the EPA process represent a significant element of the Internal Control System of the JU. Besides the summary in this report, further details regarding scope and results of the audits will be provided in the Annual Ex-post Audit Report 2019, which will be available in its final version on the website of Clean Sky 2 JU.

The main objectives of the ex-post audits are:

- To assess the legality and regularity of the validation of cost claims performed by the JU's management, through the achievement of a number of quantitative targets;
- To provide an adequate indication on the effectiveness of the related ex-ante controls.
- To provide the basis for corrective and recovery activities, if necessary.

The scope of the audits performed during the year 2019 comprised only H2020 grant agreements and their expenditure.
The audit activities for H2020 grants are fully centralised in the Common Audit Service (CAS) of the Common Implementation Centre. This contributes to a consistent harmonised audit approach for the totality of H2020 projects and aims at reducing the audit burden for beneficiaries who participate in projects with several granting authorities of the H2020 Research family[18]. The implementation of the audit results remains under the responsibility of Clean Sky 2 JU.
On the basis of the H2020 Audit Strategy and in line with the related Clean Sky 2 JU implementing procedure, the JU is establishing its specific audit results for the H2020 programme on the basis of its individual samples drawn from the CSJU population of grants..
In addition, cost claims pertaining to Clean Sky 2 projects also form part of the Common Representative Sample (CRS) of the Common Audit Service, which is the basis for calculating the results of the ex-post audits for the entire H2020 Research family.
Furthermore, cost claims of Clean Sky 2 projects will be included in various samples of corrective (risk based) audits established by the CAS.
The Common Representative Sample of the CAS (CRS) provides an estimate, via a representative sample of cost claims, of the overall level of error in the Research Framework programmes, across all services involved in its management.
Whilst the CRS is therefore a basic indicator of legality and regularity for the Framework Programme as a whole, Clean Sky 2 JU aims to assess its particular population to provide specific assurance on the legality and regularity regarding the JU's individual operational expenditure.
Due to the specific samples taken for the Clean Sky 2 JU population of grants, as described in the following sections, explicit evidence has been made available to draw conclusions on the error rate prevailing in the specific population of grants of the Clean Sky 2 JU.

Taking into account the above mentioned audit layers the following samples are considered relevant for the assurance of the Executive Director of Clean Sky 2 JU for the year 2019:

[18] Group of Commission services, Agencies and Joint Undertakings implementing the H2020 programme

(A) Specific sample of Clean Sky 2 JU for H2020 projects (including only representative audits)

(B) Sample of corrective (risk based) audits of the Common Audit Service covering Clean Sky 2 H2020 projects

(C) Common Representative Sample (CRS) of the CAS covering H2020 projects for all H2020 stakeholders, including Clean Sky 2 JU

II. Scope of the audit exercise 2019 and coverage

For the calculation of the audit coverage, the accumulated H2020 projects audited value covered by the EPA exercises 2016 to 2019 is compared to the accumulated total amount of validated cost claims for H2020 projects at the date of the closing of the Final Annual Accounts 2019.

(A) Specific CS2 JU sample

The audit sample for 2019 was established in line with the H2020 Audit Strategy and the Clean Sky 2 JU implementing procedure. It comprises the following elements:

- Representative sample
  - Most significant cost claims selected at random (the population was stratified to achieve a certain coverage of the most significant cost claims).
  - Remaining cost claims selected at random.

The sample consisted of cost claims pertaining only to Members. In the first four annual audit exercises (from 2016 to 2019) no Grant Agreements for Partners (GAPs) have been selected as part of the representative JU sample, since auditable cost claims were still limited in numbers at the time of selecting the sample for 2019.

For H2020 projects, 70 new audits, covering 76 cost claims, were launched until March 2019, out of which 63 provided final results until the closure of the final accounts 2019

Additionally, the results of nine audits stemming from the 2018 representative sample were considered final and included in the 2019 reporting.

The total audited value of the JU specific sample reported in 2019 was € 46,038,348.19 (reported validated project costs).

Table 1: Audit exercise 2019

EPA exercise 2019 H2020 programme			
	Total	**GAMs 2016**	**GAMs 2017**
audited value	46,038,348	3,141,705	42,896,643
number of cost claims	77	10	67
number of audits	72	9	63

Table 2: Audit coverage

Accumulated audit coverage until end of 2019

	Euro
Total audited value from EPA exercises 2016 to 2019 (a)	107,351,124.57
Total amount of validated cost claims(b)	825,728,181.00
Coverage (a) / (b)	13.00%

(B) Sample of corrective (risk based) audits of the Common Audit Service of DG R&I (CAS) covering Clean Sky 2 H2020 projects

In addition to the Clean Sky 2 JU representative samples, cost claims pertaining to Clean Sky 2 JU projects have also been audited as part of the corrective (risk based) samples selected by the CAS. The JU does not consider them as representative for the specific Clean Sky 2 error rate calculation.

In 2019, 54 audits were launched by the CAS on Clean Sky 2 projects, covering 71 validated cost claims stemming from Clean Sky 2 GAMs 2014, 2015 and 2016. Out of these, 48 audits provided final results until the closure of the final Annual Accounts 2019.
Additionally, the results of 4 audits stemming from the 2018 corrective sample of the CAS are included in the 2019 reporting.

The total value of audits stemming from the corrective CAS samples reported in 2019 was €40,776,504.14 (reported validated project costs). Through these samples, an additional coverage for the Clean Sky 2 H2020 operational payments of 5% could be achieved.

III. Status of audits and results (error rates) of the specific samples

Out of 79 audits launched, 72 provided final results and were used for the error rate calculation 2019.

Table 3: Status of audits included in H2020 audit exercise 2019

Status of audits included in H2020 audit exercise 2019	number
Total number launched and results not yet reported	79
Immature results	7
Pre-final reports received	3
Final reports received	69
Audits included in the final audit results 2019	72

Error rates:

The representative error rate is an indicator of the quality of the ex-ante controls as it gives an estimate of errors that remain undetected after the ex-ante controls have been performed.

As no risk based audits have been performed the detected error is representative. Based on the results of the final audit reports, detected errors are corrected and extension of systematic errors are calculated and implemented following the related rules of the Clean Sky 2 grant agreements. Under this assumption, the residual error rate is calculated and contributes to the assurance on the legality and regularity of the Clean Sky 2 JU's operations.

The (ex-post) residual error rate indicates the 'net-errors' that remain in the total population after implementing corrective actions resulting from the ex-post controls including extrapolation of systematic errors to non-audited cost claims.[19]

The accumulated representative error rate in favour of Clean Sky 2 JU for the H2020 programme expenditure, identified in the audited cost claims of the audit exercises of the years 2016 to 2019, amounts to 1.30%.

The corresponding rate for the individual audit exercise of the year 2019 is at 1.11%.

Considering the implementation of corrective measures, the accumulated residual error rate amounts to 0.92%, the annual result for the year 2019 is 0.63%.

The residual error for the entire H2020 programme stays well below the maximum materiality threshold of 2%.

Table 4:

Summary of H2020 error rates for the H2020 programme (accumulated results of 2016 to 2019):	
Representative error rate (RepER%) =	-1.30%
Systematic error rate (RepERsys%) =	-0.70%
Residual error rate (ResER%)=	-0.92%

[19] *The residual error rate is calculated according to the formula described in Annex 9.*

The error rates reported for the year 2019 – accumulated and annual – confirm the level of error as identified in the previous years for the H2020 projects of Clean Sky. On the level of the programme and the actual year 2019, the residual error stays well below the maximum materiality threshold of 2%.

IV. Extension of audit findings

All extension of audit findings pertaining to FP7 audits have been finalised and results implemented.

The extension of audit findings stemming from H2020 audits is done according to common criteria for the entire H2020 Research Family. This means that systematic errors identified in individual cost claims of H2020 projects will be corrected in all projects of the concerned beneficiaries including those funded by other granting authorities. For efficiency reasons, the minimum threshold for the audit extension is an average systematic error of 2% identified in the individual audits.

From 122 finalised audits stemming from earlier EPA exercises and concerning beneficiaries of Clean Sky 2 JU, extension of systematic audit findings has been launched in 28 cases. Nearly 50% of these cases have been successfully closed until the end of 2019.

Table 6: H2020 extension of audit findings until EPA 2018

	Finalised Audits	Value of audited cost claims	Extension of audit findings launched (numbers of cases)	Value of corrected unaudited cost claims after extension	Extension of audit findings Implemented[20] (% of numbers of cases)
EPA 2016	6	13,067,875	0	-	-
EPA 2017	16	27,132,196	4	3,720,391	100%
EPA 2018	28	21,112,705	6	5,455,076	100%
EPA 2019	72	46,038,348	18	18,354,067	16%
Total	**122**	**107,351,124**	**28**	**27,529,534**	**46%**

The audit extension for the EPA 2019 exercise is ongoing, 15 cases are in the implementation phase. The extension exercise covers also 5 beneficiaries, who have been audited for other than Clean Sky 2 projects

[20] The implementation of the correction is done by CS2 JU, in the case of the on-going projects, through withholding the overpaid amounts from the next payment to the coordinator and, in the case of closed projects, through recovery orders directly sent to the beneficiary.

V. Implementation of audit results

H2020 overpayments identified in the EPA exercise 2018 had been implemented until the closure of the JU's Final Accounts 2018 at a rate of 85%. The accumulated implementation rate[21] has meanwhile improved further to 93%.

For overpayments detected in H2020 audits of the ex-post audit exercise 2019, the implementation rate is at 53% in May 2020 and is expected to arrive at 100% until the end of 2020, when the extension of audit finding cases will have been assessed and closed by the dedicated unit in the Common Audit Service.

On programme level, the accumulated corrections implemented so far for the H2020 programme until the date of this report represent 71% of the total impact of detected errors and extension of audit findings.

ACCUMULATED Total corrective action for H2020 EPA exercise 2016-2019 - implementation achieved				
Audited value (of audited and unaudited cost claims)	Adjustments (detected error and extension of findings) in favour of CSJU	related overpayment	recovered overpayment (€) (i.e. adjustments booked in the system for next payment or RO issued)	recovery rate (%)
347,046,255	-2,270,608	-1,715,559	-1,211,331	70.61%

VI. Materiality applied for specific audit exercises

The control objective is to ensure for the CS H2020 programme that the residual error rate, which represents the level of errors which remains undetected and uncorrected, does not exceed 2% of the total expense recognised until the end of the programme. 2% is therefore the materiality level set for the JU. A detailed description of the materiality criteria applied for the assessment of the audit results with a view to the assurance declaration of the Executive Director of the JU is provided in a section 5.5 to this report.

VII. Results of non-representative ex-post audits pertaining to the sample of corrective (risk based) audits of the CAS covering Clean Sky 2 H2020 projects

In the year 2019, a detected error rate resulting from the sample of corrective (risk based) audits selected by the CAS covering Clean Sky 2 H2020 projects has been established and represents 1.95% of the 2019 audited expenditure. The accumulated detected error for the years 2016 to 2019 of this type of sample currently amounts to 2.02%

The representativeness of this error rate is limited as the selection of the samples has not been

[21] Following Article 21.5 of the H2020 GA, the CSJU implements audit adjustments in on-going projects through deducting the rejected costs from the payment to the project coordinator for the next reporting period.

based on a consistent methodology for random sampling and the coverage achieved is only at 4.94% (see section II above). The difference to the detected error rate of the specific representative sample of Clean Sky 2 JU is caused by the results of one audit in the non-representative sample, which provided for an unusually high individual (non-systemic) detected error.

VIII. Results of the Common Representative Sample (CRS) of the CAS covering H2020 projects for all H2020 stakeholders, including Clean Sky 2 JU

The Horizon 2020 audit campaign started in 2016. At this stage, 3 Common Representative Samples (CRS) with a total of 467 expected results have been selected. By the end of 2019, cost claims amounting to EUR 16.2 billion have been submitted by the beneficiaries to the services. The error rates at 31 December 2019 are:

Representative detected error rate: 2.78%[22]

- The rate is based on 298 representative results out of the 467 expected in the 3 CRS. Taking into account the results of draft audit reports, the rate rises to 3.30%.
- Cumulative residual error rate for the Research and Innovation Family: 2.15%
- The rate is expected to rise to around 2.31% when taking into account the results of the draft audit reports.
- The rates for DG R&I alone amount to 2.24% respectively 2.40%.

As in 2018, the above-presented error rates needs to be treated with caution. Since not all the results of the 3 CRS are yet available, the error rate is not fully representative of the expenditure under control. Moreover, the nature of expenditure in the first years of the programme may not be totally representative of the expenditure across the whole period. As H2020 is a multi-annual programme, the error rates, and especially the residual error rate, should be considered in a time perspective. Specifically, the cleaning effect of audits will tend to increase the difference between the representative detected error rate and the cumulative residual error rate, with the latter finishing at a lower value.
Due to its multi-annual nature, the effectiveness of the control strategy of the Research and Innovation Directorates-General can only be fully measured and assessed in the final stages of

[22] Following a comment of the Court of Auditors in its annual audit 2018, stating that the Commission methodology for the calculation of the error rate lead to an understatement of the error rate the extent of which could not be quantified, the Commission currently adapts its methodology for the calculation of Horizon 2020 error rate in line with the Court's observations starting with the 2020 ex-post audit campaign.
For a sample of audits from the years 2018 and 2019, the Commission applied the revised methodology and arrived at an understatement of 0.34% in that sample. In the reporting of the results 2019, the Commission increased its actual error rates established on the basis of the old methodology, by a general mark-up of 0.34% to mitigate the risk of a potential understatement of the error rate pertaining to the 3 CRS.

the FP, once the ex-post control strategy has been fully implemented and systematic errors have been detected and corrected.
As last year, there is evidence that the simplifications introduced in Horizon 2020, along with the ever-increasing experience acquired by the major beneficiaries, affect positively the number and level of errors for all H2020 stakeholders.

IX. Assessment of the ex-post audit results

The results of the ex-post audit exercises 2016 to 2019 relate to validated cost claims for GAMs of the H2020 programme.

As described in the materiality criteria in the Annex 9 of this report, the control objective of the JU is to ensure for the H2020 Clean Sky programme, that the residual error rate, which represents the remaining level of errors in payments made after corrective measures, does not exceed 2% of the total expense incurred until the end of the programme.

The audit approach for H2020 grants is based on the H2020 Audit Strategy and the related implementing procedure of CS2 JU[23].

The results of the CS2 JU EPA process 2019 provide information on the legality and regularity of the validation process for GAM execution 2014 to 2017 for the H2020 programme. The EPA results of the year 2019 do not directly relate to the entire H2020 expenditure incurred by the JU until the end of 2019. However, the JU's EPA strategies are implemented through an on-going process, which produces accumulated results applicable to the entire expense incurred for the CS programme up to a certain point of time.
The accumulated direct audit coverage of the validated financial statements pertaining to GAMs of the years 2014 to 2017 is 13%.
The additional coverage achieved through corrective audits launched by the CAS on Clean Sky 2 grants is 5%.

The accumulated results established in the H2020 samples of the years 2016 to 2019 reflect a representative error in favour of Clean Sky 2 JU in the validated operational expense of 1.30%, compared to 1.44% for the accumulated audit exercises until 2018.

The H2020 accumulated residual error rate stemming from the first 4 audit exercises amounts to 0.92%, compared to 1.11% for the first three exercises, until year 2018.

The accumulated audit coverage of the validated H2020 financial statements pertaining to GAMs for the years 2014 to 2017 is 13%. In view of the moderate errors detected, the level of assurance provided through these audit results is considered adequate for the reporting of the year 2019.

The results from audits pertaining to the specific samples carried out on the Clean Sky 2 expenditure as well as the samples of the CAS (CRS and other corrective audits), indicate, that

[23] Clean Sky 2 JU Procedure for implementing the H2020 Ex-post Audit Strategy, dated 01.12.2016

over the multiannual period, and especially considering the envisaged level of the overall audit coverage of Horizon 2020 expenditure of Clean Sky2, the residual error rate is likely to stay below 2%.

In conclusion, Clean Sky 2 JU considers that the error rate for its individual population of H2020 grants will fall below the materiality level established, so it does not consider a reserve for Horizon 2020 expenditure of the year 2019.

4.4. Audit of the European Court of Auditors

In 2019, the JU was audited by the European Court of Auditors as set out in the Statutes. The results of these audits were published in the Court's Annual Report on the EU Joint Undertakings for the financial year 2018[1]. As in previous years, the Court issued a positive opinion to the JU on the reliability of the annual accounts and on the legality and regularity of the underlying transactions.

The scope of the Court's annual audit for the year 2019 comprised also a review and analysis of several horizontal topics common to all JUs (staff management and level of staff turnover, follow-up of the implementation of the JUs' action plans regarding the 2017 evaluation reports, synergies and cooperation among the JUs).

The findings and comments raised by the Court during the two audit visits performed until June 2019 have been taken up by the JU and actions have been developed to further improve the procedures of the JU and enhance controls.

4.5. Internal Audit

The Internal Audit functions of Clean Sky 2 JU have been carried out in 2019 by the Internal Audit Service of the Commission (IAS) and by the Internal Audit Officer of Clean Sky 2 JU (IAO) according to Art. 28 and Art 29 of the Clean Sky 2 JU Financial Rules.

Internal Audit Service (IAS):

In May 2019, the JU received a new Strategic Audit Plan of the IAS for the years 2019 to 2021. Based on a comprehensive risk assessment the IAS has selected 3 potential audit subjects for the next three years, for which the auditors consider the risks as significant. The related audits will focus on the JU's operational processes (grant management), the implementation of the new Internal Control Principles and the new rules for data protection.

The first audit pertaining to the new planning was started by the IAS in November 2019, the topic being the implementation of grant agreements under the H2020 programme. The auditors

[1] Annual audit of the European Joint Undertakings for the financial year 2018, dated 18.12.2019.

aim to assess the internal control system in place for the processes related to grant implementation with a view to the adequacy of their design and functioning. No audit results were communicated to the JU until year-end.

Related to previous audits carried out by the IAS in 2018 and before, the JU has endeavoured to implement the recommendations made by the auditors following the agreed action plans. The areas concerned are linked to (1) the coordination with the Common Implementation Centre of DG Research and Innovation (CIC), including implementation of CIC tools and services, (2) the performance management established by the JU and (3) the management of the calls for proposals.

From eleven significantly delayed recommendations as of year-end 2019, three were considered 'Very Important' by the auditors. Until 30 January 2020, five of these recommendations have been closed by the IAS through a follow-up audit, leaving 6 recommendations still open. Out of these two are considered Very Important.

The JU will work on the remaining open recommendations and strives to achieve the closure of most of them until mid-2020.

As in the years before, no critical residual risk levels regarding the JU's main business processes and internal controls were notified by the IAS to the JU management in 2019.

In Annex 11 of this report, an overview is provided on the type of all recommendations issued by the IAS to CS2 JU, which have not been fully implemented until 30 January 2020.

Internal Audit Officer (IAO):

Under the responsibility of the Governing Board, the IAO carries out the function of the Internal Audit Capability as described in the CS2 Financial Rules. The IAO's Annual Report 2019[24] summarises the activities performed during the year 2019 with reference to the approved annual audit plan[25].
Whereas the planned consultancy work has been fully provided, the envisaged assurance audit has not been performed but had to be shifted to the year 2020. Adaptations of the audit plan have been made during the year in order to focus on the most significant internal control risks, e.g. the proper execution of the ex-post audit process, but also to cover the enhanced workload in the quality management process, which forms part of the responsibilities of the combined post of the IAO and the Quality Management Officer.

For the year 2019, the IAO confirmed to the GB her organisational independence according to the IIA standards.
For some specific activities and processes of the JU, for which the IAO took over direct operational responsibility, the IAO highlighted to the GB a potential lack of objectivity for assurance audits. However, these processed of the JU were fully covered by other auditors of

[24] Annual Report 2019 of the Internal Audit Officer, dated 30.01.2020
[25] Annual Audit Plan of the CS2 JU Internal Audit Capability, approved by the GB on 9th April 2019

the JU, like the European Court of Auditors (ECA) and the Internal Audit Service of the Commission (IAS), either through assurance audits or risk assessment.
Through the specific insight of the IAO in the JU's business processes throughout the entire year, the IAO function provided its contribution and added value in particular through consultancy and advise.

Like in previous years, in the year 2019 the IAO has focused to a large extent on the coordination and implementation of the JU's ex-post audit process. The entire activity and results for the year 2019 are presented in chapter 4.3 of this report. Throughout the year, the IAO ensured the proper coordination of the CS2 JU audit process with the CAS and the Common Implementation Centre and provided input towards the improvement of the applied methodology.

In addition to the coordination of the ex-post audit process of the JU, the IAO provided 2019 consultancy services in order to advise the JU's management on further improving the processes and enhancing the necessary controls. The main areas of these consultancy activities of the IAO have been:

- JU risk management
- JU assessment of Internal Control Principles
- CS2 JU Antifraud measures
- Document Management
- Sensitive posts
- IKC management

With a view to the antifraud measures of the JU, the IAO owns the function of the Antifraud Correspondent of CS2 JU and liaises with OLAF and the FAIR committee. The latter deals with the global Antifraud Strategy and related activities in the entire Research sector of the Commission. Regarding the status of cases reported to OLAF, please see Chapter 4.6.
In the field of assurance audit, the IAO has monitored the implementation of recommendations from other auditors, like the European Court and the IAS, and provided ample support to the JU management.
At the end of 2019, the IAO has updated her risk assessment of the JU's core business processes and has identified some significant risk areas, which were not specifically noted in the JU's own risk assessment. The most significant risks noted by the IAO concerned the following areas:

I. Assessment of the High Level Objectives of the CS2 programme as output of the Technology Evaluator

The TE assessment may not be feasible in the envisaged time frame. The delay may cause uncertainties for the steering of the current programme, but also for the decision on the succession programme both for private and public stakeholders.

The TE process as currently managed, may raise doubts on the performance of its tasks as described in the Statutes of the CS2 JU with a view to optimising the performance of ITDs and

IADPs as well as providing input for GB decisions on optimising the programme execution[26].

II. Assessment of the Internal Control System

The assessment of the new Internal Control Principles (ICP) by the Internal Control Coordinator of the JU has not been finalised until the end of 2019. A number of ICPs may not be fully applied, the most prominent ones concerning:

- systematic assessment of the Internal control system (ICP 16);
- monitoring of achievement of HLGs as per CS2 Regulation and assessment of impact (ICP 6 and 12);
- mitigation measures for risks related to sensitive posts (ICP 4);
- recording of exceptions for accountability (ICP 5 and 12);
- antifraud risk assessment for internal JU process and administrative budget (ICP 10).

III. JU risk assessment

The JU's risk management process may lack a full integration into the JU's business processes due to some open actions:

- update of the CS2 JU Risk Management Manual and the related part in the Management Manual, including the risk reporting approach of the SPD leaders;
- integration of the results of other specific risk assessments carried out in the JU into the global risk assessment exercise, concerning for example fraud, sensitive posts, accounting systems etc.

More risks of less individual importance have been listed by the IAO. The JU management is aware of all risk areas and is committed to implement mitigating actions.

The JU's Internal Audit Officer (IAO) and the Internal Audit Service of the Commission are regularly updating their risk assessment of the JU's main business processes. A summary of results from the IAO's risk assessment is reported in the Internal Audit Officer's annual report, as mentioned above.

[26] Statues of the CS2 JU Regulation, Art. 12

4.6. Risk management and conflict of interest

As one major element of its Internal Control Framework, the JU assesses and manages, through a dedicated process, the potential risks, which may be detrimental to achieving its objectives.

The complexity of the JU activities, with the involvement of many stakeholders participating in the execution of the programmes with a variety of often interconnected activities, calls for assessing and managing risks at the different levels of activity of all actors:

- Joint Undertaking organisation level
- CS2 programme level
- ITD/IADP/TA level (risks pertaining to the WP objectives and performances)

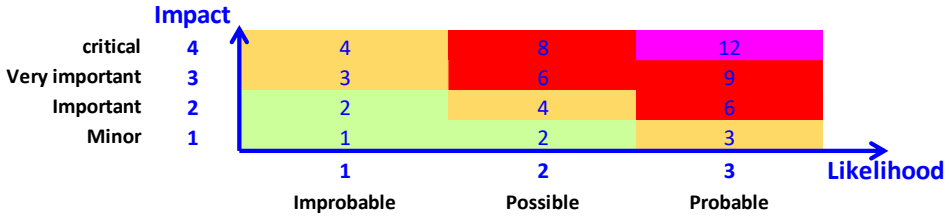
The responsibility for risk management on JU level including the identification and implementation of mitigating actions is with the Executive Director and the Programme Office, supported by the CS 2 Programme Coordination Committee.

Risks to be considered in the year 2019 were described in the CS2 Development Plan, in the Grant Agreements of Members and Partners, in individual risk registers of the SPD Leaders reported regularly to the JU's Programme Office and in the Steering Committees. All risks, including the SPDs' risks, which had an impact on the objectives of the programme, were captured in the global JU Risk Register, which provides for an evaluation of the risk level and description of the mitigating activities.

The JU had provided an analysis of the relevant risks in the work plan 2018-2019 to which the following assessment refers (see table in ths section).

The main risks for the JU relate to the operational objectives of the programme and to some core management processes, which could have an impact on the operational and financial implementation of the overall programme.

With respect to the methodology used, the JU follows the Impact/Likelihood concept:



Risk level	
1 - 2	Low
3 - 4	Medium
5 - 9	High
> 9	Critical

Risk rating = Impact x Likelihood

The impact is the potential consequence should the potential event materialise. The likelihood reflects the residual impact of the event, taking into account the mitigating actions which are planned or have been taken.

The different types of risks are assessed according to the following criteria:

Impact level	Financial *(measured in % of annual budget; depending on the risk, the reference could be the total JU budget or subcategories [titles, lines])**	Reputational	Operational
4 - Critical	Impact > 10%	Strong reputation or political impact with key stakeholder	Failure would create major disruption to critical activities
3 - High	2% < Impact < 10%	Major reputation or political impact with key stakeholder	Failure would create major disruption to very important activities
2 Medium	1% < Impact < 2%	Some reputation or political impact with key stakeholder	Failure would create some disruption to important activities
1- Low	0% < Impact 1%	Impact primarily internal	Failure would disrupt minor activities

Table of CS2 JU risks with high level of importance:

Risk Description	CS Process	Summary of actions and risk mitigation
Execution of the technical activities in Clean Sky 2 may not result in the achievement of the High-Level Objectives [HLOs] as stated in the Regulation	*Manage the programme*	The risk related to the achievement of the HLOs prevailed throughout the year 2019 as a full TE assessment has not yet been carried out. Nevertheless, the first TE light projection results did not give rise to any concerns that the technical programme would lead to a shortfall in performance / research results versus the CS2 Regulation's HLOs. The elaboration of qualitative objectives (i.e 'SMART' objectives) related to societal impact of the technologies developed in the IADPs and ITDs has been initiated (organisation of workshops within the TE, launch of a tender). A more precise definition of KPIs, including preliminary results should be made available in 2020. In anticipation of the preparation of GAMs 2020-2021, the contribution per ITDs/IADPS/TAs to the Clean Sky 2 HLOs as stated in the CS2 Regulation was assessed to confirm the expected results at completion. No significant adjustments to the technical content of the programme is considered necessary. In this context, the performance of the CS2 projects has to be measured against the HLOs as set in the CS2 Regulation, which contribute to other agendas'

Risk Description	CS Process	Summary of actions and risk mitigation
		objectives e.g. Flightpath 20250, but are not identical. The residual risk is still considered high.
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.	*Manage the programme*	Close monitoring of quarterly reports and performance assessment has been carried out during Annual Review Meetings (ARM) and Intermediate Progress Reviews (IPR). In 2019, industrial companies kept their strategic or technical priorities unchanged. Only non-strategic modifications/adaptations happened, leading to a realignment of the CS2DP. The revision of the programme content was not significant. With a view to the significant part of the programme execution still to come in the following years, the residual risk is still considered high.
Technical setbacks in one or several IADPs / ITDs / TAs may result in under-achievement of milestones and deliverables and/or lead to a significant under-spending of annual budget.	*Manage the programme / Manage the IADPs/ITDs*	Review of technical progress has been done on a quarterly basis (based on quarterly reports issued on each ITD/IADP/TA); likewise, an assessment of technical achievements has been performed in 2019 for all SPDs during the ARM and IPR. Financial execution has been assessed in 2019 at mid-year triggering the decision to amend Grant Agreements (mainly GAMs) in order to align technical progress with funding expenditures forecast of end 2019. The residual risk is considered high.
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.	*Manage the programme / Manage the IADPs/ITDs*	A revision of the plan to completion of major demonstrators has been done on the occasion of the CS2DP update in 2019 incorporating results of the assessment of critical risks during the 2019 ARMs and changes which occurred since 2017. The current version of the CS2DP reflects the outcomes of the critical reviews passed over the last 2 years (PDR, CDR) and the re-assignment of activities and budget between work packages. The current plan is deemed robust and the JU will hold members more clearly accountable for the delivery of results at programme completion on the basis of the plan. The residual risk is considered high.
Some costs may be overrun, and some participants may be unable to carry on until	*Manage the programme / Manage the*	Close monitoring of quarterly reports and performance assessment were carried out during ARM and IPR.

Risk Description	CS Process	Summary of actions and risk mitigation
completion. Competences and resources to successfully enable completion of the technical work programme may be insufficient.	*IADPs/ITDs*	Some overruns were identified in different areas of the programme on either GAMs or GAPs but in a limited manner. Those that are not deemed critical led to a minor reduction of the ambition at completion. Where the risk already materialised for some major demonstrators, members were asked to consider increased contributions to keep their input to HLOs unchanged. The residual risk is considered high.
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.	*Manage the programme / Manage the IADPs/ITDs*	This risk was identified in 2019 and a specific action was triggered to mitigate it. Specific objectives were defined per ITD/IADP/TA and the ambition exposed in the documentation released for the preparation of GAMs 2020-2021 was properly assessed. While the objective is ambitious, it is considered as achievable. Continuous monitoring is required. The residual risk is still considered high.
Lack of adequate plan on ITD side at the level of CA and PA during the execution of the multi-annual budget may hamper the execution of the full operational budget (re-inscription of the credits to ensure maximised programme execution)	*Manage the budget*	Throughout the year, the JU monitors the financial execution of the budget on the level of the individual SPDs, e.g. during the annual reviews in June and the mid-term reviews (based on Q2 results, in September. In particular towards the end of the programme, the JU management assesses the allocation of the budget to completion and revises in agreement with the SPD leaders the final individual SPD budgets. The action is ongoing and requires continuous monitoring until end of programme execution. The residual risk is considered high.

Conflict of interest

The JU continued to apply in 2019 the decisions adopted by the Governing Board on the rules on the prevention and management of conflicts of interest applicable to the bodies of the Joint

Undertaking[27] and to the JU staff members[28]. The related processes, for instance concerning Members of the JU's Governing Board, experts of evaluation procedures, panels for procurement and recruitments applied consistently the required precautionary measures to identify potential conflicts.

Fraud prevention and detection

The Clean Sky 2 programme is covered by the Common Antifraud Strategy for the Research family (CAFS)[29], which addresses the fraud risks of the entire sector of Research in the European Commission. An action plan for detective and preventive measures is linked to this global antifraud strategy, which all stakeholders implement in close coordination with the Commission. One of the major issues addressed is the detection and prevention of double funding, for which the Commission is developing appropriate IT tools for analysing data pertaining to the research sector including the CS programmes.In the year 2019, the JU followed up on two alleged fraud cases, which had been notified to OLAF in the previous year, and on which OLAF opened investigations. The cases are still on-going.
Another case of potential fraudulent behaviour of a beneficiary with impact on Clean Sky2 grants dating back to the FP7 programme, could be closed until the date of this report. Based on a detailed report of OLAF, the JU was able to exclude subsequently any financial impact on Clean Sky 2 projects and did not incur any losses.

No new case has been reported to OLAF during 2019.

In 2020 the JU will enhance its precautionary measures to prevent and detect the risk of fraud following the related guidance provided by DG R&I in December 2019[30] and through a continued awareness training for its staff.

In addition, the JU has started setting up an Antifraud Strategy (CS2 JU AFS) regarding the JU's internal processes and specific budget not covered by the CAFS. The CS2 JU AFS will be finalised in 2020.

4.7. Compliance and effectiveness of Internal Control

The Executive Director, together with the Internal Control Coordinator and the JU staff at all levels ensured the implementation of the internal control framework according to the JU's principles and rules.

The assessment of the Internal control system of the JU has been done on a continuous basis taking into account dedicated performance indicators on all levels of the JU's business

[27] Ref. CS-GB-Writ Proc 2016-15Rules on CoI_JU Bodies.
[28] Ref. CS-GB-2017-10-19 CoI decision JU staff.
[29] Issued by the Common Implementation Centre and latest version adopted by the Executive Committee in November 2019
[30] EU Grants: Guidance note — Quick checks to detect fraud risks: V1.0 – 16.12.2019

processes.
Specific areas have been assessed where significant risks of control weaknesses were identified. Finally, as input for the annual assurance of the Executive Director, a global assessment has been performed taking into consideration results of controls throughout the reporting year, exception reports, specific control weaknesses or risks identified and recommendations received from the JU's auditors.
In addition, regarding the reliability of the financial reporting, the ICC has also considered the outcome of the validation of the accounting system performed by the Accounting Officer of the JU.

As a specific task in the year 2019, the ICC performed the initial self assessment of the entire set of the new Internal Control Principles applicable for the JU since end of 2018. The assessment had not been completely finished until year-end, but allowed the ICC to identify a few deficiencies, which were evaluated as minor. They concern the need to update some of the internal documents on a more regular basis and to increase awareness of staff members about the existing code for prevention and mitigation of CoI. Further more although an overall Anti-fraud Strategy exists, some anti-fraud measures are missing or delayed (ICP 7). An action plan to address these deficiencies will be agreed at the management level in 2020. The majority of the principles were positively assessed, for example it has been confirmed that the existing reporting lines are efficient and the authorities and responsibilities are appropriate for the pursuit of the JU's objectives (ICP3).

As a result of the ICC's assessment and as recommended by the Internal Audit Officer of the JU, the description of the control environment pertaining to some of the principles will be further finetuned.

A major element of internal control for the JU managment are the recommendations received by the internal and external auditors. The ICC has in particular assessed the impact of the very important recommendations of the Internal Audit Service regarding the JU's grant management and the corresponding action plans.

The register of exceptions provided for two exceptions during the year 2019 in the area of grant management. Appropriate preventive actions have been taken for the future. No financial implications were caused.

As an overall conclusion, the results of the internal control assessment carried out during the year 2019, confirm that the Clean Sky control system is working efficiently and effectively despite some deficiencies. It provides for an adequate risk management process by the JU's management for monitoring the key objectives of the JU. It provides reasonable assurance, that the financial reporting is reliable, and the compliance with applicable laws and regulations is fulfilled.

5. MANAGEMENT ASSURANCE

5.1. Assessment of the Annual Activity Report by the Governing Board

GOVERNING BOARD OF CLEAN SKY 2 JOINT UNDERTAKING
ASSESSMENT OF THE ANNUAL ACTIVITY REPORT 2019

The Governing Board of Clean Sky 2 Joint Undertaking took note of the Annual Activity Report 2019 (Authorising Officer's report), the provisional version of which was made available on 28 February 2020 and the consolidated version on 22 May 2020.

The Board is of the opinion that the Annual Activity Report sets out the relevant highlights of the implementation of the 2019 activities of the Joint Undertaking from both an operational and administrative point of view.

The Board is pleased to note the broadening of the Clean Sky 2 programme main contributors (902 participants in total from 30 countries) welcoming in particular the large number of small and medium enterprises (337), research centres (110) and universities (151).

The Board is pleased to note the successful implementation of the thematic topics that enable competing technology solutions to address problem statements geared towards the programme's high-level objectives, and the positive involvement from the RTD community.

The Board appreciates the good rate of budget execution achieved in 2019 and encourages the members to maintain it further. It encourages all participants to the programme to continue to meet the targets set out in the Clean Sky 2 Development Plan and in the grant agreements for achievement of milestones, deliverables and optimum use of resources assigned.

The Board is pleased to note that the new efforts applied to creating synergies and the growing number of strategic Memorandum of Understanding, put in place with the various regions in Europe promoting European Structural & Investment Funds and Clean Sky synergies. The projects implementation has a visible impact in strengthening the R&I innovation capacity of the European aeronautics regions while complementing the programme and supporting its overall objectives.

The Board takes note that the in-kind contributions of the private members are brought in at a satisfactory level to meet the commitments made by the private members, in particular with reference to the additional activities provided. It encourages the members to further report in-kind contributions for operational projects.

The Board takes note of the good dissemination and exploitation results, with Clean Sky programmes having obtained 132 patents and published 315 technical and peer-reviewed papers and encourages the members and the Programme Office to continue the dissemination efforts by highlighting the programme's achievements and impact.

The Board notes that no critical risks have been identified regarding the JU's main business processes and internal controls and is pleased to note the further development and strengthening of the risk management approach, in particular enhancing the systematic monitoring of technical and financial risks in the projects.

The Board takes note that the JU has fulfilled its monitoring tasks through the implementation and usage of dedicated key performance indicators for the achievement of strategic research and management objectives.

The Board acknowledges the peak effort in programme execution now underway, and the high workloads resulting from this for the JU programme office, as well as for the private members, and states its appreciation for the efforts and progress made.

The Board takes note that the H2020 audits are duly implemented and processed and that the ex-post audits results in 2019 audit exercise meet the target of achieving a residual error rate below 2%. Further actions to maintain the applied preventive and remedial measures as well as to continue a robust audit process for the H2020 programme will be supported by the Board.

The Board regrets the relatively high number of open recommendations issued by the Internal Audit Service of the Commission addressing certain control weaknesses in the JU processes in the area of performance management and handling the calls for proposals. The Board appreciates the recent closure of 5 IAS recommendations by the JU management and encourages the JU team to address all open issues with the IAS until June 2020 as indicated in the AAR.

Done in Brussels, 24 June 2020

Stéphane Cueille
(signed)
Chairman of the Governing Board

5.2. Elements supporting assurance

Besides the dedicated supervisory activities of the Executive Director, the main elements supporting the assurance are:

- the reporting of the Head of Administration and Finance (who is also the internal control coordinator of the JU);
- the assessment of the Internal Control System by the Internal Control Coordinator of the JU
- the reporting of the Head of Unit for Programmes;
- the reporting of the Head of Unit for Strategic Development;
- the reporting of the Head of Legal;
- the reporting on the accumulated results of the ex-post audit processes from 2011 to 2019 and the related implementation;
- the information received from the Data Protection Officer;
- the results of audits of the European Court of Auditors to date;
- the reporting of the Internal Audit Officer and the Internal Audit Service of the Commission;
- the overall risk management performed in 2019 as supervised by the Executive Director;
- the key performance indicators in place;
- the dedicated ex-ante controls of the JU's operational expenditure;
- the private members' reporting of in-kind contributions.

5.3. Reservations

No reservation is entered for 2019.

5.4. Overall conclusion

Not applicable.

5.5. Declaration of assurance

I, the undersigned, Axel Krein, Executive Director of Clean Sky 2 Joint Undertaking

In my capacity as authorising officer by delegation

Declare that the information contained in this report gives a true and fair view[1]*.*

State that I have reasonable assurance that the resources assigned to the activities described in this report have been used for their intended purpose and in accordance with the principles of sound financial management, and that the control procedures put in place give the necessary guarantees concerning the legality and regularity of the underlying transactions.

This reasonable assurance is based on my own judgement and on the information at my disposal, such as the results of the self-assessment, ex-ante and ex-post controls, the work of the internal audit capability, the observations of the Internal Audit Service and the lessons learnt from the reports of the European Court of Auditors for years prior to the year of this declaration.

I confirm that I am not aware of anything not reported here which could harm the interests of the Joint Undertaking.

Brussels, 28 February 2020

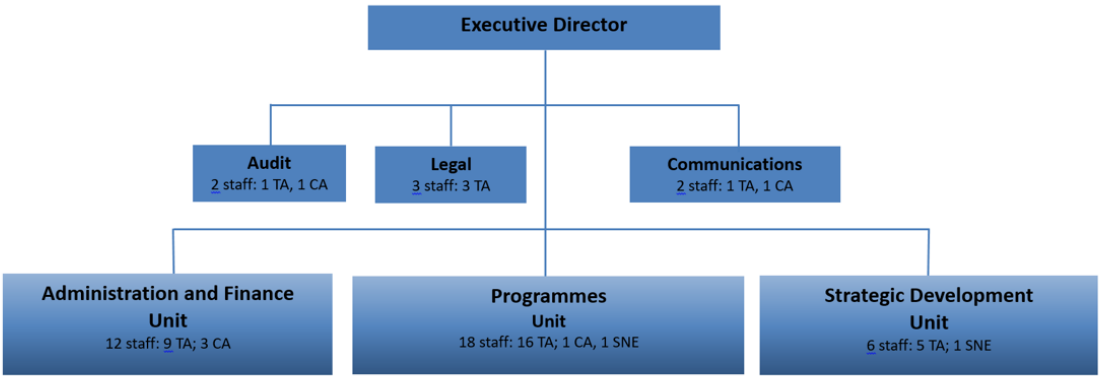
(signed)

[1] True and fair in this context means a reliable, complete and correct view of the state of affairs in the Joint Undertaking.

ANNEXES

1. Organisational chart

Annex - Revised Organisational structure of the Programme Office – 2019



The Establishment Plan foresees 44 staff in total, out of which 42 staff members [36 Temporary Agents (TA) + 6 Contractual Agents (CA)] and 2 Seconded National Experts (SNE).

2. Staff establishment plan

Category and grade	Establishment Plan 2019		Staff population actually filled at 31.12.2019	
	Off.	TA	Off.	
AD 16				
AD 15				
AD 14		1		1
AD 13				
AD 12				
AD 11		2		2
AD 10		4		3
AD 9		10		6
AD 8		1		2
AD 7		5		5
AD 6		9		6
AD 5				
Total AD		***32***		***30***
AST 11				
AST 10				
AST 9				
AST 8				
AST 7		1		1
AST 6				
AST 5		3		2
AST 4				1
AST 3				
AST 2				
AST 1				
Total AST		***4***		***4***
TOTAL TA		**36**		**34**
CA FG IV		1		1
CA FG III		5		4
CA FG II				1
CA FG I				
Total CA		***6***		***6***
TA+CA		***42***		***40***
SNE		***2***		***2***
TOTAL (TA+CA+SNE)		**44**		**42**

3. Publications from projects

Clean Sky 2 has had a significant increase in dissemination activities, especially in terms of peer reviewed and technical papers as shown in the following table. This table represents `the status of the dissemination at the end of November 2019.

Description	ITD	Dissemination 2014-2019				
		Papers	Thesis/ Book chapters	Conferences	Other Diss.	Total
	AIR	63	2	44	2	111
	ECO	13	0	14	3	30
	ENG	30	5	48	0	83
	FRC	8	1	10	1	20
	LPA	87	4	98	6	195
	REG	45	0	35	0	80
	SYS	55	2	48	0	105
	TE 2	0	0	0	0	0
	Total JU	301[31]	14[32]	297[33]	12[34]	624

4. Patents from projects

Consolidated table of all patent requests for the full Clean Sky programme. The patents related to System did not appear on the IT tools for the moment. Soon they will be uploaded

Description	ITD	Patents 2014-2019	
		Applications 2014-2019	Granted 2009-2017
Patent statistics	AIR	1	-
	ECO	-	-
	ENG	1	-
	FRC	21	-
	LPA	1	-
	REG	-	-
	SYS	108	-
	TE 2		
	Total JU	132	-

[31] Includes peer review papers and technical papers
[32] Master and PhD theses, book chapters
[33] Oral presentations to workshops, conferences, symposia
[34] Flyers, exhibitions, web releases, press articles, videos, publications, posters

5. Scoreboard of Horizon 2020 and common KPIs

Description	Targets	2019 Results	2018 Results	Comments
H2020 Results				
SME - introducing innovations of participating SMEs	No target set	Not reported	Not reported	Information not yet available
SME - Growth and job creation in participating SMEs	No target set	Not reported	Not reported	Information not yet available
Patent applications and patents	> 366 patents	Patent applications:132	Patent applications: 24	The target is established on programme level by 2024.
Demonstration activities (number of demonstrators and technology streams)	35	35: L1 demonstrator 102: L1-L2 demonstrator	Not reported	
Redress after evaluations	<2% of proposals (excluding PP submission related redress requests)	0.4%	1.7%	
Time to grant (TTG)	80%	CFP 8: 73% CFP 9: 96 %	CfP06: 97% CfP07: 97%	Uncertainties stemming from the Brexit negotiations led to a lower score during the CfP08 Grant Preparation.
Time to pay (TTP) Operational budget	95%	98%	97%	

Description	Targets	2019 Results	2018 Results	Comments
Vacancy rate (%)	0%	4.5%	10%	Two retirements during 2019.
Budget implementation/ execution	95% in PA	97.4% in PA	98.2% in PA	
Time to pay (TTP) Administrative budget	> 95%	98%	99%	

6. Indicators for monitoring cross-cutting issues

Description	Targets	2019 Results	2018 Results	Comments
H2020 Results				
Country distribution (EU Member States and Associated countries) - ***numbers***	EU 28: 95% Associated: 5%	GAMs: EU 28: 97,17% AC: 2,27% GAPs: EU 28: 94,07% AC: 5,41% TC (Third Countries): 0,52%	GAMs EU 28: 97.9% AC: 2.1% --------- GAPs: EU 28: 95.9% AC: 3.7% TC: 0.4%	GAMs signed GAPs applications/ participations
Country distribution (EU Member States and Associated countries) - ***financial contribution***	No target set	GAMs: EU: 98,6% AC : 1,4% GAPs: EU 28: 96,8% AC: 3,2%	GAMs EU 28: 99.4% AC: 0.6% --------- GAPs: EU 28: 96.5% AC: 3.5% TC : 0%	GAMs signed GAPs applications/ participations
SME participation - financial contribution	At least 13%	GAPs: 25,11% GAMs: 3,77%	GAPs: 24.3% GAMs 3.3%	

Description	Targets	2019 Results	2018 Results	Comments
Gender balance - Programme participation	No target set	Female participation rate: 30%	Female participation rate: 22%	
Gender balance - Project coordinators	no target	Female participation rate: 16%	Female participation rate: 13%	
Gender balance - Advisors and experts	No target set	Female Participation rates: 15% in evaluations (CfP09, CfP10) 9% in Annual Reviews and Technical Reviews (IPR) 25% in the SciCom	Female Participation rates: 19% in evaluations (CfP07, CfP08) 18% in Annual Reviews and Technical Reviews (IPR) 25% in the SciCom	
Third-country participation	No target set	GAPs: 0,53% (7 partners from US-RU-CA) GAMS: Not Applicable	4 participations from CA, RU, US. No attributed contribution	
Innovation Actions (IAs): Share of projects and EU financial contribution allocated to Innovation Actions (IAs)	Leaders: 100% Core partners: 100% partners: 70%	Leaders= 100% Core Partners: 100% Partners = in number 54,3% in funding: 53,9%	Leaders= 100% Core Partners= 100% Partners = in number 56.53% in funding: 57.53%	Funding % assigned to IA topics decreased in 2019 compared to 2018 due to introduction of Thematic topics (labelled RIA).

Description	Targets	2019 Results	2018 Results	Comments
Demonstration activities within IAs	70%	Not reported	Not reported	
Scale of impact of projects (High Technology Readiness Level)		*Pending. To be included in the consolidated version of this report*	zero	Based on CS2DP revision adopted in November 2019, the maturity plan per demos at programme completion: • TRL3: 9 • TRL4: 11 • TRL5: 46 • TRL6: 36
Horizon 2020 beneficiaries from the private for profit sector - number of participants	not more than 60%	GAMs: IND: 65% SME:16% All: 81% GAPs: IND : 16% SME: 31% All: 47%	*GAMs* *IND: 70%* *SME: 10%* *RES: 1%* *(all) 81%* ---------- *GAPs* *IND: 19%* *SME: 30 %* *(all) 49 %*	
Horizon 2020 beneficiaries from the private for profit sector - financial contribution	not more than 80%	*GAMs :* *IND:79%* *SME:4%* *All: 83%* *GAPs:* *IND : 18%* *SME: 25%* *All: 43%*	*GAMs* *IND: 82.4%* *SME: 1.4%* *RES: 0.4%* *(all 84.2%)* ---------- -- *GAPs* *IND: 23%* *SME: 26%* *(all 49%)*	

Description	Targets	2019 Results	2018 Results	Comments
EU financial contribution for PPP	580.63[35] M€	CA: 298,7 M€ PA: 323,2 M€	CA: 364,7 M€ PA: 331 M€	100% of the EU contribution is cashed in 2018 and 2019
Private sector contribution including leverage effect	On programme level: 125%[36]	IKOP reported: €594 million IKOP certified: €274 million IKAA reported: €900 million IKAA certified: €620 million The executed EU contribution by the private Members represents 60% of the total envelope while the reported IKC is equal to 68% of the overall target	IKOP reported: €431 million IKOP certified: €274 million IKAA reported: €802 million IKAA certified: €620 million The executed EU contribution by the private Members represents 42% of the total envelope while the reported IKC is equal to 57% of the overall target	The IKC certification for 2018-19 will be provided in 2020
Dissemination activities	At least 100 per year (papers, thesis, book chapters, conferences and other dissemination activities)	Peer Reviewed papers: 188 Technical papers: 113 Thesis: 4 Book: 10 Conference participation: 296 Other Dissemination Activities: 12	Peer Reviewed papers: 52 Technical papers: 52 Thesis: 4 Book: 1 Conference participation: 176 Other Dissemination Activities: 176	The information on dissemination activities for the year 2019 was more precise than in previous years, therefore the number of "other dissemination activities" declined.
Distribution of proposal evaluators by	<25% from one country	CfP09: Italy 20% France 19%	CfP07: France 19% Germany 10%	The countries most highly represented are named. All are

[35] CA for the period 2018-2019.
[36] Not applicable as annual target.

Description	Targets	2019 Results	2018 Results	Comments
country		Germany 12% Spain 10% UK 9% Others 30% CfP10: Italy 19% France 16% Germany 13% Spain 10% Greece 6% UK 5% Others 31%	Italy 18% Spain 10% UK 14% Others 29% CfP08: France 18% Germany 9% Italy 20% Spain 14% UK 9% Others 30%	safely below the the 25% limit. The category "others" is a large mix of countries with only 1 or a few experts participating.
Distribution of proposal evaluators by type of organisation	<66% from one sector	CfP09: Higher education establishments: 33% Non-research commercial sector including SMEs: = 35% Public Research Centers: = 2% Private Non-profit Research Centers: = 10% Consult. firms: 0% Others = 20% Higher education establishments: 33% Non-research commercial sector including SMEs: = 32% Public Research Centers: = 8% Private Non-profit Research Centers: = 7% Consult. firms: 9% Others = 11%	For CFP 07: Higher Education Establishments: 31% Non-research commercial sector including SMEs: 22% Consult. firms: 6% Public Research Centers: 8% Private Non-profit Research Centers: 5% Others: 28%	

Description	Targets	2019 Results	2018 Results	Comments
Participation of Research and Technology Organisations and Universities in PPPs (Art 187 initiatives)	At least 25%	GAMS: *Number of participants*: RTO :12% UNI: 7% Total:19% *Financial contribution:* RES:14% UNI:3% Total:17% ---------- - GAPS: (nbr of part.) RES : 26% UNI: 27% Total: 53% Financial contribution : GAPS: RES :33% UNI: 24% Total : 57%	GAMs: *Number of participations:* RTO: 11.7% UNI: 7.8% Total : 19.5% *Financial contribution :* RTO: 13.4% UNI: 3.6% Total: 17% ---------- - GAPs: *Number of participations:* RES: 26% UNI: 25% Total = 51% *Financial contribution* RTO: 31% UNI: 22% Total: 53%	
Ethics efficiency: % of proposals not granted because of non-compliance with ethical rules Time to ethics clearance for proposals invited to grant	<2% 45 days	0%; clearance time < 45 days	0%; clearance time < 45 days	
Residual error rate	<2%	0.92%	1.11%	

7. Scoreboard of KPIs specific to Clean Sky 2 Joint Undertaking

Description	Targets	2019 Results	2018 Results	Comments
H2020 Results				
Call topics success rate	> 90%	96,4%	91%	
WP execution deliverables versus plan	100%	93%	87%	These are based on Q4 Reports (Q1-Q4 Cumul) from the different SPDs and coherent with the level of resources spent.
Ex-post audit coverage	20%	13.0%	12.2%	As our audit results do not imply a risk, that the error rate of maximum 2% is exceeded, we keep the audit burden for our beneficiaries as low as possible and reduce the coverage as compared to the target.

8. Final accounts

The main tables of the Final Accounts 2019 of the CS2 JU are comprised of the Balance Sheet, the Statement on Financial Performance, the Statement of changes in Net Assets and the Cash Flow Analysis. A detailed explanation to assets and liabilities of the JU and to the economic result of the year 2019 is provided in the Notes to the Final Accounts, which form part of the Final Accounts document itself.

Economic Outturn

The Statement on Financial Performance presents the economic result of the CS2 JU in the reporting period (1 January 2019 – 31 December 2019).

The most substantial components are the operational expenses incurred in-cash and in-kind for implementing the aeronautical research programmes funded by the JU. The operating expenses ('administrative expenses') cover the running costs of the JU.

As a result of the specific accounting rules applied by CS2 JU, the funds received from the Commission and from the other members of the JU are shown as contributions received from Members in the Net Assets of the Balance Sheet and not as revenue in the economic outturn.

The non-exchange revenues represent adjustments for contributions from Members previously recognised in the Net Assets due to subsequent changes in already validated cost claims (e.g. through ex-post audits) and miscellaneous administrative revenues.

Balance Sheet

The Balance Sheet reflects the financial position of the CS2 JU at 31 December 2019. Assets are comprised mainly of the fixed assets, pre-financing incurred for the execution of the grant agreements and balances with the central treasury[37]; liabilities include the 'Net Assets' on one side and current liabilities such as amounts payable, accruals and provisions on the other.

The available funds at the year-end increased compared to 2018 (2018: €12,8 million, 2019: €17,9 million).

The main fixed asset items are the IT and audivisual equipment.

The balance of the Net Assets at the end of the reporting period presents the accumulated contribution received by the JU from its Members (the Commission, industry and research organisations), which has not yet been received for funding the research programme.

The Net Assets in the Balance Sheet of the JU's Final Accounts 2019 show a negative balance of €-144 million.

The two main elements are the outstanding pre-financing (most of the 2020 GAM pre-financing was paid in December 2019) and the non-validated Members' in-kind contribution. The declared

[37] In 2017 the treasury of CS2 JU was integrated into the Commission's treasury system. Because of this, CS2 JU does not have any bank accounts of its own. All payments and receipts are processed via the Commission's treasury system and registered on intercompany accounts which are presented under the heading 'exchange receivables'.

in-kind contributions related to 2018 and 2019 have not been certified at the date of the preparation of the Final Accounts which are recognised as oprational expenditure in the EOA but not yet in the Net Assets. The in-kind contributions are planned to be approved by the Governing Board later in 2020.

The negative Net Assets do not indicate any risk of solvency, but are the consequence of the accounting method applied according to the specific accounting rules and guidance provided by the European Commission for the Joint Undertakings.

Main tables:

STATEMENT OF FINANCIAL PERFORMANCE			
	Ref.	**2019**	**2018**
REVENUES			
NON-EXCHANGE REVENUES	**4.3.1**		
Recovery of expenses		1.595.566,79	1.092.614,73
Exchange gains		0,00	173,26
TOTAL NON-EXCHANGE REVENUES		**1.595.566,79**	**1.092.787,99**
OPERATIONAL EXPENSES	**4.3.2**		
Operational expenses funded by CSJU in cash		306.266.493,17	247.955.402,12
Operational expenses contributed in kind by members		162.568.549,23	165.835.427,75
TOTAL OPERATIONAL EXPENSES		**468.835.042,40**	**413.790.829,87**
OPERATING EXPENSES	**4.3.3**		
Staff expenses		4.190.605,75	4.335.220,58
Administrative expenses		2.751.290,87	2.648.090,18
Total administrative expenses		**6.941.896,62**	**6.983.310,76**
Other operating expenses			
Exchange losses		33,96	152,58
Total other operating expenses		**33,96**	**152,58**
TOTAL OPERATING EXPENSES		**6.941.930,58**	**6.983.463,34**
OPERATING RESULT		**(474.181.406,19)**	**(419.681.505,22)**
FINANCIAL INCOME	**4.3.4**		
Interest on late payment (income)		995,11	3.142,55
Total financial income		**995,11**	**3.142,55**
FINANCIAL EXPENSES			
Financial expenses		1.712,46	3.445,10
Total financial expenses		**1.712,46**	**3.445,10**
FINANCIAL RESULT		**(717,35)**	**(302,55)**
ECONOMIC RESULT OF THE YEAR		**(474.182.123,54)**	**(419.681.807,77)**

BALANCE SHEET			
ASSETS		**31/12/2019**	**31/12/2018**
A. NON CURRENT ASSETS	**4.1.1**		
Property, plant and equipment (net)		101.142,00	103.457,00
Intangible assets (net)		31.758,00	123.888,00
TOTAL NON-CURRENT ASSETS		**132.900,00**	**227.345,00**
B. CURRENT ASSETS			
Short-term pre-financing	**4.1.2**	**185.467.601,57**	**164.971.534,47**
Short-term pre-financing Clean Sky JU		185.467.601,57	164.971.534,47
Short-term receivables		**19.119.210,51**	**15.503.185,87**
Short term receivables - recoveries from members and partners		987.839,34	2.578.947,98
Deferred charges and accrued income		191.105,62	83.098,02
Central treasury liaison accounts		17.940.265,55	12.841.139,87
Cash and cash equivalents		**0,00**	**0,00**
TOTAL CURRENT ASSETS		**204.586.812,08**	**180.474.720,34**
TOTAL ASSETS		**204.719.712,08**	**180.702.065,34**
LIABILITIES		**31/12/2019**	**31/12/2018**
C. NET ASSETS			
Contributions received from Members (EU & industry)	**4.2.1**	1.973.361.198,24	1.645.595.765,84
Contributions in kind received from Members (Industry)		867.952.442,92	867.952.442,92
Contributions used during previous years		(2.510.688.137,64)	(2.091.006.329,87)
Contributions used during the year (EOA)		(474.182.123,54)	(419.681.807,77)
TOTAL NET ASSETS		**(143.556.620,02)**	**2.860.071,12**
D. CURRENT LIABILITIES			
Members contribution to be validated	**4.2.2**	**318.985.107,30**	**156.850.621,66**
Accounts payable and accrued charges		**29.291.224,80**	**18.948.774,21**
Amounts payable - consolidated entities		0,00	142.275,94
Amounts payable - beneficiaries and suppliers		23.914.409,12	8.711.444,06
Amounts payable - other		75.847,44	42.436,76
Accrued charges		5.300.968,24	10.052.617,45
Provision for risks and charges - short term		**0,00**	**2.042.598,35**
Provision for risks and charges - short term		0,00	2.042.598,35
TOTAL CURRENT LIABILITIES		**348.276.332,10**	**177.841.994,22**
TOTAL LIABILITIES		**204.719.712,08**	**180.702.065,34**

Changes in Net Assets and Liabilities	**EURO**	**EURO**
Net Assets		
Balance at 31 December 2019		**2,860,071.12**
Contributions received from members during the year 2019:		
Private members Clean Sky 2 Programme (H2020)	4,760,173.40	
EC Clean Sky 2 Programme (H2020)	323,005,259.00	
Other members contributions in kind from 2008-2019 validated in 2019	0.00	
Total contributions in 2019		**327,765,432.40**
Economic Outturn for 2019		**(474,182,123.54)**
Balance at 31 December 2019		**(143,553,123.02)**

CASH-FLOW	
31.12.2019	
	2019
Economic result of the year	**(474.182.123,54)**
Operating activities	
Amortisation and depreciation	135.414,77
Non-cash expenses in-kind	162.568.549,23
Cash contributions from Members (EC & Industry)	327.765.432,40
Increase/(decrease) in provisions for risks and liabilities	(2.042.598,35)
(Increase)/decrease in pre-financing	(20.496.067,10)
(Increase)/decrease in exchange receivables and non-exchange recoverables	(3.616.024,64)
Increase/(decrease) in payables and accruals	10.342.450,59
Other non-cash movements	(434.063,59)
Net Cash Flow from operating activities	**40.969,77**
Investing activities	
(Increase)/decrease in intangible assets and property, plant and equipment	(40.969,77)
Net Cash Flow from investing activities	**(40.969,77)**
Net increase/(decrease) in cash and cash equivalents	0,00
Cash and cash equivalents at the beginning of the period	0,00
Cash and cash equivalents at the end of the period	**0,00**

9. Materiality criteria

This annex provides a detailed explanation on how the Clean Sky 2 JU defines the materiality threshold as a basis for determining significant weaknesses that should be subject to a reservation to the annual declaration of assurance of the Executive Director.
Deficiencies leading to reservations should fall within the scope of the declaration of assurance, which confirms:

- A true and fair view provided in the AAR and including the Annual Accounts
- Sound financial management applied
- Legality and regularity of underlying transactions

As a result of its multiannual nature, the effectiveness of the CS2 JU's controls can only be fully measured and assessed at the final stages of the programme's lifetime, once the ex-post audit strategy has been fully implemented and systematic errors have been detected and corrected.
The control objective is to ensure for the CS programmes (FP7 and H2020) that the residual error rate, which represents the level of errors that remain undetected and uncorrected, does not exceed 2% of the total expense recognised until the end of the programme (see explanations to the weighted average residual error rate underneath).

This objective is to be (re)assessed annually, in view of the results of indicators for the ex-ante controls and of the results of the implementation of the ex-post audit strategy, taking into account both the frequency and importance of the errors found, as well as a cost-benefit analysis of the effort needed to detect and correct them.

Notwithstanding the multiannual span of the control strategy, the Executive Director is required to sign a statement of assurance for each financial year. In order to determine whether to qualify this statement of assurance with a reservation, the effectiveness of the control systems in place needs to be assessed not only for the year of reference but also with a multiannual perspective, to determine whether it is possible to reasonably conclude that the control objectives will be met in the future as foreseen. In view of the crucial role of ex-post audits, this assessment needs to check, in particular, whether the scope and results of the ex-post audits carried out until the end of the reporting period are sufficient and adequate to meet the multiannual control strategy goals.

Effectiveness of controls

The basis to determine the effectiveness of the controls in place is the cumulative level of error expressed as a percentage of errors in favour of the CS2 JU, detected by ex-post audits measured with respect to the amounts accepted after ex-ante controls.

However, to take into account the impact of the ex-post audit controls, this error level is to be adjusted by subtracting:

- Errors detected and corrected as a result of the implementation of audit conclusions;
- Errors corrected as a result of the extrapolation of audit results to non-audited cost claims issued by the same beneficiary.

This results in a residual error rate, which is calculated in accordance with the following method:

1) REPRESENTATIVE ERROR RATE

As a starting point for the calculation of the residual error rate, the representative error rate will be established as a weighted average error rate identified for an audited representative sample.

The weighted average error rate (WAER) will be calculated according to the following formula:

$$\mathbf{WAER\%} = \frac{\sum \mathbf{(er)}}{\mathbf{A}} = \mathbf{RepER\%}$$

Where:

∑ (er) = sum of all individual errors of the sample (in value). Only the errors in favour of the JU will be taken into consideration.

n = sample size.

A = total amount of the audited sample expressed in €.

2) RESIDUAL ERROR RATE

The formula for the residual error rate below shows how much error is left in the auditable population after implementing the outcome of ex-post controls. Indeed, the outcome of ex-post controls will allow for the correction of (1) all errors in audited amounts, and (2) systematic errors on the non-audited amounts of audited beneficiaries (i.e. extrapolation).

$$\mathbf{ResER\%} = \frac{\mathbf{(RepER\% * (P-A) - (RepERsys\% * E)}}{\mathbf{P}}$$

Where:

ResER% = residual error rate, expressed as a percentage.

RepER% = representative error rate, or error rate detected in the representative sample, in the form of the Weighted Average Error Rate, expressed as a percentage and calculated as described above (WAER%).

RepERsys% = systematic portion of the RepER% (the RepER% is composed of complementary portions reflecting the proportion of systematic and non-systematic errors detected) expressed as a percentage.

P = total amount of the auditable population of cost claims in €.
A = total amount of the audited sample expressed in €.
E = total non-audited amounts of all audited beneficiaries. This will consist of all non-audited cost statements for all audited beneficiaries (whether extrapolation has been launched or not).

This calculation will be performed on a point-in-time basis, i.e. all the figures will be provided as of a certain date for the specific annual audit exercise actually performed.

However, in order to arrive at a meaningful residual error rate for the entire cumulative period covered by ex-post audits during the execution of each of the two CS programmes, the weighted average residual error rate (WAvResER%) shall be calculated for the whole duration of the programme until the end of each audit period according to the standard formula for a weighted average (sum of weighted terms (=term multiplied by weighting factor in relation to the population in value (p)) divided by the total number of terms) as follows:

$$\sum_{\mathbf{n}} \mathbf{(Res\ ERi * pi)}$$

$$\text{WAvResER\%} = \frac{\sum_{i=1}^{n} p_i}{n}$$

The control objective is to ensure that the residual error rate of the overall population (recognised operational expense) is below 2% at the end of each of the CS programmes.

If the residual error rate is less than 2%, no reservation would be made.

If the residual error rate is between 2 and 5% an additional evaluation needs to be made of both quantitative and qualitative elements in order to make a judgment of the significance of these results. An assessment needs to be made with reference to the achievement of the overall control objective considering the mitigating measures in place.

An additional correction effect may be considered in the assessment of the legality and regularity of the transactions of Clean Sky 2JU through implementation of audit results outside of the specific JU samples.
The Common Representative Audit Sample (CRAS) or risk-based samples of the CAS may cover additional CS cost claims, which are not part of the specific sample of the JU.
Furthermore, errors could be corrected through extension of systematic audit findings on unaudited JU cost claims, which do not stem from JU representative audits.

$$\text{AddErCorr\%} = \frac{\sum(\text{AddErDet}) + \sum(\text{AddErSyst})}{P}$$

$\sum$(AddErDet) = error detected outside of the specific JU sample (samples of the CAS).

$\sum$(AddErSyst) = financial effect of extension of systematic audit findings on unaudited JU cost claims, which do not stem from JU representative audits.

In case the residual error rate is higher than 5%, a reservation needs to be made and an additional action plan should be drawn up.
These thresholds are consistent with those retained by the Commission and the Court of Auditors for their annual assessment of the effectiveness of the control systems operated by the Commission. The alignment of criteria is intended to contribute to clarity and consistence within the FP7 programme and the H2020 programme.

In the case where an adequate calculation of the residual error rate during or at the end of the programmes is not possible, for reasons not involving control deficiencies but due to e.g. a limited number of auditable cost claims, the likely exposure to errors needs to be estimated quantitatively by other means. The relative impact on the Declaration of Assurance would then be considered by analysing the available information on qualitative grounds and considering evidence from other sources.

Adequacy of the scope

The quantity and adequacy of the (cumulative) audit effort carried out until the end of each year is to be measured by comparing the planned with the actual volume of audits completed.

The data is to be shown per year and cumulated, in line with the current AAR presentation of error rates.

The Executive Director should form a qualitative opinion to determine whether deviations from the plan are of such significance that they seriously endanger the achievement of the control objective for the programmes. In such case, he would be expected to qualify his annual statement of assurance with a reservation.

A multiannual control strategy requires a multiannual perspective to assurance

It is not sufficient to assess the effectiveness of controls only during the period of reference to decide whether the statement of assurance should be qualified with a reservation, because the control objective is set in the future. The analysis must also include an assessment of the likely performance of the controls in subsequent years and give adequate consideration to the risks identified and the preventive and remedial measures in place. This would then result in an assessment of the likelihood that the control objective will be met in the future.

10. Results of technical reviews

Clean Sky Scientific Committee

A summary of Annual Progress Reviews of Clean Sky 2 programme (2019)

1. ORGANISATION AND PERCEPTION OF THE REVIEW PROCESS

The review process in Clean Sky 2 (CS2) has been adopted from that utilised in Clean Sky (CS) and is continuously developing over the lifetime of Clean Sky. The CS2 JU, ITD Coordinators and Expert Reviewers reported unanimously a high level of trust, fairness and collaborative spirit in the review process. Valuable guidance was generated and implemented, supporting the success of the programme. The scheme of Annual Reviews (ARs) and follow-up Intermediate Progress Reviews (IPRs) six months later has proven to be very valuable and efficient.

The Scientific Committee (SciCom) still considers the Annual Reviews, as well as the Intermediate Progress Reviews, as being an important instrument of monitoring and re-adjusting the CS2 programme where required. It continues to play an important role by enabling an efficient alignment of the programme activities, across all SPDs, towards the CS2 targets.

Although the review proves matured to a great extent some adjustments regarding the reporting schemes (e.g. on risk management, dissemination activities, planning updates, etc.) are required. This recommendation has already been proposed at prior reviews, but has not been implemented effectively in all of the SPDs. Due to the introduction of a new progress review reporting process, this becomes more important in providing data and information by the consortia aligned to review reporting templates. This recommendation was already proposed several times, but has been not sufficiently implemented. In order to achieve coherence in reporting across the programme, it is recommended to maintain compliance with rules laid down in the CS2 management manual and to refer to related KPIs for reporting at Annual Review meetings.

As recommended in the past years,instruments like Technology Watch or the Joint Integrated Master Plan (both adopted, for example, in CS GRA) have provided insights into technology roadmaps and the opportunity to better identify delays and risk areas, and also to monitor progress. These are now evident in the review presentations, with differentiation of technologies for demonstration (TRL 5/6) and technology development. Demonstrators also include technologies being developed with other EC, national, regional and internal funding – these are now evident in pictorial or schematic form in the technology roadmaps developed for some SPDs (e.g. ENG, LPA, REG). This should be encouraged across all SPDs.

2. ADMINISTRATION AND MANAGEMENT

For CS2 a high standard of project management is evident across all SPDs. This is reflected in the improvement of the quality of presentations (although in some cases better alignment to the Annual Review agenda is required), and in the majority or reviews documentation was made

available to the reviewers in adequate time to study the material and prepare effectively for the review. This has to be maintained in order to ensure efficient and effective review meetings.

Financial aspects are assessed and reported during Annual Reviews across all SPDs in an open and transparent manner. In some SPDs, the number of major deviations in spending as well as in achievements (milestones and deliverables) appears to be increasing. In some SPD work packages (WP) (e.g. FRC WP2) financial challenges could become the main show stopper for efficient completion of demonstration phase.

Risk management is a key component in ensuring the demonstrators or technology work packages remain on schedule. Whilst high level risks are detailed at reviews, these should be specific and relate to high impact programme activities with associate mitigation. It is important to provide the risk probability, severity, and the remedies envisaged. This obvious information is often not presented with sufficient detail. The use of PERT charts (or equivalent) is encouraged for key technology elements within work packages or SPDs, especially when aligned to ground or flight test demonstration. This provides a quick mechanism for prior review and gives confidence that risks are actively managed. For major demonstration activities the production of these charts on a quarterly basis for the CS2 Project Officers would ensure all parties are informed of progress timelines and associated issues as the CS2 programme overall reaches a critical stage in its delivery.

3. OVERVIEW OF TECHNICAL PROGRESS IN CS2

The Annual Review Meetings (ARMs) were held in April to June 2019, with the exception of ECO, TE and SAT TA, which will take place later in 2019.

In the Annual Reviews, further shaping and alignment of content across all SPDs had been identified to support realistic timeframes and effective demonstration. This re-alignment has improved the chances of identifying and managing synergies between related technology developments. Most SPDs have taken up the recommendations pro-actively and significant progress has been observed. Most SPDs have made good progress in identifying synergistic work elements both within the particular SPD and with associated SPDs.

LARGE PASSENGER AIRCRAFT (LPA) IADP

The ARM followed a similar format to that adopted in previous years. The meeting was well planned and well organised. There was, however, one notable exception: insufficient time

had been allocated to LPA 1 (a recommendation on this point has been made by the reviewers for the next ARM). Discussions were conducted in an open and frank manner, with a constructive engagement and sharing of views. The vast majority of the previous recommendations and comments made by the reviewers have been addressed in a satisfactory manner. The general standard of the presentations was very good. The LPA Annual Report provided an acceptable summary of the progress made in 2018.

LPA IADP comprises three platforms: Platform 1 (advanced engine and aircraft configuration),

Platform 2 (innovative physical integration of fuselage-cabin-system- structure) and Platform 3 (next generation aircraft systems, cockpit systems and avionics). Platform-specific comments are given below.

LPA PLATFORM 1

Overall, it is apparent that good technical progress has been made within all work packages in Platform 1 in 2018. The demonstrator roadmap presented at the ARM (with key milestones, decision gates and TRL maturation targets) provides a much clearer view now of what will take place (compared to the 12 months ago). In respect of KPIs (Key Performance Indicators), very good performance for 2018 was reported. All key deliverables were submitted on time and only 3 major milestones were delayed. The PM (person months) spend was only slightly below that planned for the year. The quality of the key deliverables was seen to vary considerably from very good to unacceptably poor (specific recommendations have been made by the reviewers). In regard to dissemination activities, the level of output for a programme of this magnitude continues to be well below expectation. A greater level of strategic planning is needed.

The key decision taken in July 2017 to shift the focus in CS2 away from CROR (contra- rotating open rotor) engines resulted in the need to completely re-scope the planned activities for LPA WP 1.1 and WP 1.2. This rescoping process continued throughout 2018 into 2019. The reviewers were not satisfied with the progress made in WP 1.1 at the IPRM (21-22 November 2018). Consequently, a special one-day review of WP 1.1 took place on 19 February 2019. A clearer vision of the WP plan was presented by the project team at this special review; however, shortcomings in the supporting documentation (i.e. the WP 1.1 proposal) were noted. At the ARM (May 2019), these remaining points were addressed. The reviewers thus recommended that the Proposal of WP1.1 Re- scoping ("Advanced Engine Design & Integration for Large Passenger Aircraft", version 3.09, 31 March 2019) be accepted as the baseline for future work.

The scope of WP 1.2 (Advanced Rear End Demonstrator, D02) has been under almost continuous revision since mid-2017. At the ARM in May 2018, an outline of the revised proposal for WP 1.2 was presented; however, the global vision and objectives lacked clarity. What was presented at the ARM in May 2019, reflects a significant step-up in terms of ambition and clarity of objectives. Several new concepts were outlined for the first time (e.g. a new forward-swept HTP and an area-ruled rear fuselage with double- curvature skin profile). Performance improvement targets have been defined.

Progress on the LPA 1 demonstrators is generally "on track" (some slips regarding the established timelines were reported). A few specific highlights follow. The UltraFan flight test demonstrator (D10) preparation is ongoing, nacelle anti-ice technology has been selected and improved short inlet nacelle aerolines have been agreed. Following the kick-off meeting in January 2018, the design concepts for demonstrator D06 (full-scale hybrid laminar flow ground based demonstrator of a representative wing) have matured considerably. In demonstrator D08 (radical aircraft configurations), good technical progress was reported; the process to down-select concepts for scaled flight tests (in WP 1.6.3), however, remains unclear. Interesting IP continues to be generated concerning Active Flow Control (Demonstrator D11); the demonstrator strategy and route to final application remains unclear.

LPA PLATFORM 2

The reduction of budget to now 85,4 M€ has led to major reorientations for the platform. However, the overall objectives of platform 2 have not been changed: 1t weight reduction at fuselage level and 1 M€ recurring cost reduction at fuselage level with a fuselage build rate of 70-100 per month.

In WP 2.1 Airbus has adopted the request from the reviewers, to rethink the involvement of US partners in this WP. The Airbus/partner consortium will now manufacture the upper fuselage shell within the consortium. The GAM Amendment with respect to upper shell fuselage partnership will be revised accordingly. The door- surround structure for the cargo door will now be part of the lower fuselage shell and the GAM will be modified accordingly. Several risks have been identified, but all proposed mitigation plans are well established and convincing. The overall progress in this WP as shown during the presentation has been very positively accepted by the reviewers.

WP 2.2 addresses cabin aspects such as novel Passenger Service Units (PSU), hydrogen powered galleys, printed electrics, and several other technologies, which are now part of the revised Airbus "Cabin of the Future" concept. Good progress has been shown.

WP2.3 concerns a new manufacturing concept for the "centre fuselage". The objective is the reduction of manufacturing time for the final assembly line. The very ambitious work from the beginning has lost a lot of the initial momentum and the Airbus internal strategy has reduced the priorities for this tasks.

WP 2.4 addresses materials and processes, testing development and new concepts for the "Future factory". A lot of small technology items are progressing well and providing good potentials elements for future exploitation.

All in all this WP 2 is progressing well, despite some major reorientations.

LPA PLATFORM 3

The LPA 3 review was carried out in a clear and constructive manner. The material was well prepared and fully served the purpose of the review. However, in some WPs the reporting was not sufficiently transparent, homogenous and traceable. It is recommended to stick to reporting the progress compared to the planning and less the objectives and initial intentions per WP.

The answers to recommendations from launch reviews, Annual Reviews and Interim Reviews were provided in a separate word document. This tracking option is highly appreciated by the reviewers; however, the document appears to be incomplete.

The quality of the key deliverables, submitted to the CS JU was superficially assessed by the reviewers. In general, the quality was good.

The dissemination planning still has weak points. Not only that this level is by far too low

compared to the budget implemented in LPA3, but also a plan with objectives and target numbers of publications at different levels is not sufficiently elaborated.

Some significant risks are reported, e.g. that the Demonstrator development does not fit with industrial priorities set by each member, difficulties to agree upon IP ownership in collaborative activities. These risks are a concern and require mitigation. In addition, the full list of risks was not visible to the reviewers and therefore an adequate assessment of risks during the review could not be ascertained by the reviewers. Finally, the withdrawal of GE and a failure regarding the ASCENT coordinator led to significant risks in schedule, ambitions and results.

In LPA 3 the principle of Thematic Topics in the CfP's has proven its ability to deliver a very positive impact in LPA3. For example, the CfP on cognitive computing has resulted in three winning proposals covering the scientific area in a complementary manner and raising significant interest in the IADP. It is strongly recommended to continue with this successful and convincing scheme.

For the Disruptive Cockpit (DISCO) good technical progress and good synergies with programmes outside CS2 are reported. However, the complementarity between LAP3 and SYS is still not fully clear in all domains. While a long list of technologies is covered in this WP, the progress not equally visible for all areas of innovation. It is recommended to continuously verify the maturity road map. The framework for single pilot operations (SPO) needs to be better prepared (involving EASA, SESAR, and other stakeholders).

The Active Cockpit reports good technical progress as well. Some foreseeable technical challenges are materializing, e.g. on the BAe Systems Enhanced Light Weight Eye Visor ELWEV. The continuation of those activities, which originally were planned by GE, appears as still not being sufficiently transparent and efficient. In addition, synergies between the DISCO and Active Cockpit Demonstrators have not yet not fully been recognized. The exploitation strategy seems still to be unclear.

For the Business Jet (BJ) demonstrator significant technical and schedule risks remain in acquiring the data for the Pilot State Monitoring, as a tentative CfP08 failed. Not many

activities are foreseen after 2021. It is recommended to provide a strategy for the BJ technology developments in CS2 after 2021 and for the after CS2.

The ADVANCE demonstrator has delivered excellent results. The project will close soon and has been extremely successful.

REGIONAL AIRCRAFT (REG) IADP

The work in IADP REG is centred around demonstrating technologies with benefits for three different future aircraft types (70, 90 and 130 pax). The demonstration activities is in practice achieved by two flight test demonstrator programs, one provided by Leonardo (FTB#1) and one by Airbus DS (FTB#2), alongside two ground test demonstrators (a fuselage/cabin demonstrator and an Iron bird). Technologies to be verified are provided both from other ITDs as well as a development stream channelled through a separate work package within IADP

REG. The 2019 ARM showed evidence of continued good progress towards the overall goals of the program.

One outcome of the ARM is that Leonardo is now proposing to compliment the plan by freezing the high-level TP 130 development activities after conclusion of a second iteration loop. Instead of a third loop, they propose using corresponding resources towards exploratory studies on hybrid-electric aircraft architectures. The reviewers expressed their provisional support to the change but pointed out that a detailed research plan is needed before launch of the activity. Airbus DS will continue their focus on developing technologies for their multi-mission aircraft in the 70 pax class. Similarly, all other technology development and demonstration activities remains as previously planned.

The work package dedicated to IADP REG specific technology development was thoroughly presented and discussed. A variety of technologies are developed; ranging from composites manufacturing, thermal management, electrical power generation, to mention a few. The majority of the technology development streams are currently in a phase where they are up and running with concrete and targeted activities aiming towards delivery according to the overall demonstration plan. Some delays were reported but none of such severity that they currently impose unmanageable risks for the overall program. The partners provided credible mitigation and recovery plans.

Leonardo presented progress with respect to FTB#1 through the reporting of the closure of PDR in February 2019 and progress on flight test instrumentation planning. Progress with respect to FTB#2 was also shown. The fuselage/cabin as well as the iron bird ground demonstrator programs are progressed to a stage where actual manufacturing of components have been initiated (e.g. through the launch of CfP-projects). First deliveries of hardware are expected during 2019.

Information was provided showing that the link and interchange of information with TE TA works. Efforts labelled by CS2 as Eco-design were also visible but no output in terms of eco-statements etc, was provided. This contributes to making the topics appear arbitrarily selected. The synergies between REG IADP and ECO TA needs strengthening.

All milestones and key deliverables during the period were achieved. The programme is well managed in terms of resources, expenditures, technical progress and risks. Management includes a well-advanced procedure for exploitation, dissemination and communication. Despite this the overall performance in terms of dissemination, particularly of scientific publications, is below expectations.

FAST ROTORCRAFT (FRC) IADP

There are two distinct flying demonstrators. Due to commercial confidentiality issues, the two reviews were, again, held separately, with each of the lead companies: Leonardo (WP1) and Airbus Helicopters (WP2). The common activities related to WP3 Eco design and WP4 Technology Evaluator as well as WP5 Management were also discussed during both meetings. Traceability of both projects WP1 and WP2 statuses was improved by presenting clearly critical paths, budget status, prospects of delays in completing subsystems and possible problems

expected in their final integration.

WP1, Next Gen Civil Tilt Rotorcraft (NGCTR), after realigning in 2017 is on the track with unchanged target to perform the first flight in 2023. The main project activities are within three time and technical scope frames: (1) necessary to perform the first flight in reduced scope of flying hours and only helicopter mode, (2) the full flight tests and 3) preparation technologies for large scale tiltrotor. The consortia of partners are active in developing crucial components like V-tail, wing, fuselage, transmission and flight control system. The technology challenges appear not completely solved, which may lead to delay of crucial components delivery. This situation should be carefully monitored and remedied found as soon as possible. The Preliminary design reviews (PDRs) of the key technologies and the whole system were performed in 2018. The budget spending is ramped up in 2018, as expected.

The development plan is prepared leading to demonstrator flight in 2023, which should be monitored very carefully, especially regarding the parts and systems, which have no backups (FCS, transmission, etc.) and many deliveries are planned at the last moment before the first flight. (This presents a very high risk and will need carefully monitoring to ensure the flight occurs within the CS2 programme timeframe

The permit to fly is planned to be obtained but at a very late stage of demonstrator preparation, so again closer collaboration with EASA and local authorities should be secured and visible early enough.

For the WP2 demonstrator RACER the demonstrator architecture is frozen as it was presented at the Paris Air Show in 2017.

The visible good progress has been achieved in 2018, with many PDRs completed and reduction of crucial technology issues to a few but very important ones. The situation in development of wing, main gear box and propellers looks critical both in terms of first flight date (2020) and budget requirements. Additional non-Airbus Helicopter funding is notsecured as was expected, despite commitment of financing from national projects. Hence, there is still a possibility that project activity could stop just after first demonstrator flight. Such a failure is considered as unacceptable and every effort must be made to save the basic RACER evaluation for first flight, within CS2 framework schedule based on a revised and de- scoped action plan.

For the first time the WP3 Eco Design and WP4 Technology evaluator activities were aligned for both demonstrator platform. WP3 activity still needs more coordination with general methodologies developed in this transverse action. In WP4 for both demonstrators the reference aircraft and mission-based demonstrators' evaluation were decided. The IPR and financial issues should also be solved ASAP for both WPs.

AIRFRAME (AIR) ITD

The ARM for AIR ITD took place in Linköping, Sweden on 21–23 May 2019. The meeting, which was hosted by Saab, was very well organised, with an appropriate agenda. The presentations were of a high standard (using the excellent PowerPoint template developed within this ITD). The reviewers were satisfied with the manner in which prior recommendations

have been considered by the project team. A record of reviewers' recommendations, together with actions taken or rebuttal comments, is maintained as a "live" document. There was a marked increase in dissemination activities in 2018. Despite this improvement, the overall performance in terms of dissemination is considered to be low for a project of this size.

AIR ITD continues to be well managed by an experienced team. The "synergies action plan", which was initiated two years ago, has been updated and identifies topics for "synergies" workshops in conjunction with other SPDs. The topics for the next two workshops are Structural Health Monitoring (November 2019), and anti-erosion/anti-contamination of aircraft leading edges (Q1/Q2 2020).

The structure of this ITD is complex, with extensive links to LPA, REG and FRC SPDs as well as to ECO and SAT TAs. The technical WPs are now structured under three Technology Streams (TS): TS-A (High Performance and Energy Efficiency), TS-B (High Versatility & Cost Efficiency) and TS-C (eco). Good progress in almost all WP's was reported for 2018; specific issues identified by the reviewers pertaining to individual WPs were reported in the Technical Review Report. Certain concerns regarding TS-C (Eco) were raised by the reviewers at the ARM (concerning the methodologies, data collection and KPIs).

As an overall performance assessment, it is evident that the majority of the programme objectives for the reporting period were achieved. The objectives for the next reporting period (2019) are well established and are still relevant. Nevertheless, the program is still in a challenging mode regarding schedule and cost. At this critical time in CS2 (programme midpoint), it is seen that the level of effort (spent funding) for AIR ITD is a little below what was planned (the affected WPs and beneficiaries were identified, together with explanations for these departures from the planning). It is vital that the level of effort be maintained – and increased where needed – over the next few years to achieve the stated goals. High confidence was expressed at the ARM that the underspend can be addressed.

Specific reallocations of budgets are being considered to address the evolving challenges within the programme.

ENGINES (ENG) ITD

The annual review was successful, as, generally speaking, the ITD Engine has been progressing reasonably well since the last annual review, in spite of a few delays, justified in most cases, and a few milestones and deliverables outstanding. A large amount of work has been accomplished, and significant achievements were noted. However, in one case (WP2), the consideration of a major programme re-orientation, due to strategic reasons associated with technical reorientation of the engine target BPR. This raised important questions and issues, notably in terms of delayed demonstrator tests, increased risks and potential funding issues. A further 2 year delay with ground test demonstration is proposed with demonstration now scheduled for the final months of the Clean Sky programme. Irrespective of the specific WP leader funding issues, Core Partners and Partners budgets have been already nearly completely, leaving open questions for relating to additional contracts and finance required to reach demonstration.

The structure of management of ITD Engine works very well as shown by the information provided, including milestones and deliverables, dissemination plan, etc.

The review was well-organized with good presentations overall, containing a lot of meaningful technical information.

The presentations continued providing visibility and explanations of linked national, EC and company funded activities, supporting the various demonstrator builds. This was appreciated. There are a number of visible challenges still inherent in programme delivery including the critical activities associated with WP2. New challenges will also arise as work packages reach conclusion. How these will be addressed quickly and effectively will be a measure of the effectiveness of the Engine ITD's leadership in future reviews There is continuing progress with demonstration activities although in other work package, apart from WP2, some time lines have slipped Some high profile demonstration programmes still contained critical timelines and demonstration technical risks mainly aligned to resource and test bench priorities. This is visible in WP6 concerning the UltraFan flight test although some positive elements exist with flight platform agreement between Airbus and Rolls Royce and also the attention of Rolls-Royce senior management to the work programme and timeline. Strong coordination with aircraft manufacturers is essential to ensure the best match of future aircraft and engines as well as an optimised outcome of the work package activities without impact on the demonstrator commitment timeline. Comment to deliver key demonstration activities within Clean Sky 2 programme timelines is a key stakeholder metric. The full benefit of technologies developed in the Engine ITD can only finally be assessed by integration of the "technology" engine within an airframe and by flight demonstration.

The programme continues to deliver innovations in all work package. The experts still believe that these could benefit from shared learning respecting commercial sensitivities across work packages and other Clean Sky SPD's.

Interaction with ECO TA has made significant progress, with three active work packages now connected with ECO Design funded activities and plans are in place, however, significant questions and challenges will need to be addressed to achieve valued outputs in the required timeframe. TE involvement was noted but not discussed in detail as the TE is due to report with its first formal assessment scheduled for delivery in 2020.

SYSTEMS (SYS) ITD

In most WPs the work appears to be progressing well. The dissemination and exploitation planning deserve a bigger intention and more ambition. Even if within the GAM the planned update for 2019 is foreseen, this was not presented in the AR. It is recommended to do so at the next AR in detail.

For the Extended Cockpit activities the link with LPA Platform 3 for upscaling of matured technologies should be further developed. The progress on certification and exploitation needs to be reported in greater detail. In the area of cabin and cargo technologies it is highly recommended to provide a summary of innovation related to each technology, in order to evaluate the current state of the technologies, the progress and the achievements and the

perspectives towards an exploitation path.

For the Electrical Wing good progress was reported, but closer collaboration between stakeholders of the electrical architecture and the electrical wing is required. It is recommended to provide an explanation about the possible risks in the future due to the integration of both demonstrators, emphasizing the mitigation planning and exploitation path for the different A/C.

The WP on Landing Gear Systems reports a high probability of risk with severe impact in some topics. A mitigation plan should be proposed. It is recommended to monitor the activities.

On Power electronics more transparency and reporting on the level of innovation in technologies, their application, and the TRL roadmap is requested.

As a major concern it was identified that in the field of Eco design some activities have been launched (e.g. on surface treatments), but a clear strategy, planning and prioritization of ECO relevant topics is lacking. A clear definition of what is intended to support life cycle assessment (LCA) for Eco design TA is required both for the SPD as well as for the IPR.

The interfaces with LPA and Regional have improved and a closer collaboration with face to face meetings and more synergetic exchanges have been reported. Nevertheless, further improvement is required, especially in interfaces, redundancy of topics and technologies, and the identification of links between different topics.

It is recommended to quantify and to provide clearly the targets per each major task and the direct or indirect interface to the Technology Evaluator (TE) in order to assess the benefits related to the planning and the resource consumption as well as the achievements in terms of milestones and deliverables.

Deliverables and achievements have been delayed by a few months in many cases. The resulting impact and the risks should be evaluated and reported.

The level of disseminating of both innovation and results has improved, but it is strongly recommended to develop an effective dissemination planning and reporting, including dedicated workshops, updating the Systems achievements published on the CS2 website, social networks etc.

It is recommended to identify European industries interested in the further development and exploitation of the in CS2JU SYSTEMS ITD developed technologies.

SMALL AIR TRANSPORT (SAT) TA

There are no comments on SAT TA as the annual review will take place after submission of this report.

ECO-DESIGN (ECO) TA

There are no comments on ECO TA as the annual review will take place after submission of this report.

TECHNOLOGY EVALUATOR (TE)

There are no comments on TE TA as the annual review will take place after submission of this report.

4. SPECIFIC ITEMS

Internal and External Links

In general, it is felt that cross-SPD links are maturing. Balancing and refinement is still necessary to avoid overlaps and to simplify interfaces between SPDs. Links to external bodies have been established. Meetings with EASA to discuss relevant technical developments have continued – for example, on FRC, Single Pilot Operations. These meetings appear to be valued at EASA level, helping to identify and mitigate potential hurdles in exploitation and deployment.

With SESAR continuous coordination is taking place. In this area the momentum should be maintained to ensure an efficient synchronisation of defining relevant functions and operational concepts for Air Traffic Management (ATM).

For the major demonstration programmes, where regional, national or private company funding is included, a reasonable indication of these activities has been included in the reviews. This is visible now in a number of SPDs, which is a positive indicator.

Call for Proposals (CfPs)

The CfP process remains appropriate. However, in some SPDs (e.g. LPA) CfP partners were not invited to the review. The reporting on the achievements from CfP projects was limited. The specific contribution of CfPs into the programme and the demonstrators should be presented in greater detail, as they have proven to be a major building block in the programme.

The Thematic Topics have become a true success story. A significant interest from proposers has been identified resulting in an impressive number of submitted proposals. In addition it has been positively recognized that per temathic topic CfP, multiple winners may be allowed covering a certain area in a complementary manner. High interest from SPD members is reported in following the THT activities and entering in to close collaboration. This is highly beneficial.

In some cases, SPDs have fully utilized their CfP budgets. However, in some SPDs it appears questionable if all funding dedicated to CfPs can be implemented in a justified manner. On one hand the budget appears too high, on the other hand a lack of sufficiently justified topics has

been identified. It is recommended to analyse these situations and consider a shift of budget to another SPD.

Targets and Reference Aircraft

For CS2, additional targets beyond environmental savings have been defined. Here a more detailed methodology of assessing those performance indicators as well as the metrics are required. It is recommended to urgently elaborate on these issues.

As the assessment paths seem to become more complex (partially in SPDs, partially in TE, some technologies not being assessed at all) an action should be defined at JU level to analyse the evaluation strategy and decide on measures.

CS2 Environmental Performance

Taking into account the TE light projection indications, a deeper analysis of the implications of these findings is to be confirmed by the first formal assessment scheduled for 2020. This should be supported by scenario variations and sensitivity analysis.

5. FUTURE ACTIONS

Dissemination activities for research conducted in CS2 are now being reported; however, no clear definition of dissemination targets for some SPDs are evident. In some SPDs Dissemination and Exploitation (D&E) Managers have been appointed, while in others this has not (yet) taken place. The JU has started an action on the "open access policy to support the implementation of data management plans at SPD level in a compliant manner. In any case a stronger commitment to an ambitious dissemination planning is requested. The current dissemination level is by far too low compared to the implemented budget.

In terms of exploitation opportunities, a more standardised procedure for early identification of exploitation opportunities is recommended, while respecting company confidentiality concerns.

SPDs such as ENG ITD have agreed a process with the CS2 Project Officer which is working effectively. In some other SPDs less credible and convincing exploitation elements have been presented. This is especially valid in those cases, where academia is missing industrial partners to bridge the "valley of death" to industrialisation.

The introduction of new technologies, including new manufacturing elements, requires certification. Airworthiness and certification issues, and associated progress, are now more visible in the development plan with clear links, if necessary, to the IADPs that may act as the focus. This activity is a crucial element to future exp oitation.

Prof. Peter Hecker
Chairman of the Scientific Committee

Prof. Trevor Young
Vice-Chairman of the Scientific Committee

11. Annex : Summary of recommendations issued by the IAS

Content and significance of recommendation	Audit title	Deadline for implementation	Implementation activity	Status
Reassess the timing of the first H2020 TE assessment Monitor, that *feedback is provided by the TE to ITDs and IADPs as provided in the CS2 Regulation;* Analyse the global TE assessment results against the targets set and prepare timed action plans; Report on the JU's overall performance on an annual basis, notably regarding progress towards achieving the high level objectives. *Recommendation downgraded from Very important to Important*	Performance management [38]	31/03/2019	The TE assessment has been postponed to 2020; the JU monitored instead the work performed by the TE in a light projection assessment. As a compensation for the delayed TE assessment, the JU has performed at the end of 2019 an impact assessment with a view to achieving the environmental objectives as per CS2 Regulation on the level of each GAM project.	Preparing a reply to the IAS with evidence of actions performed and explaining the JU's decision to implement alternative measures in response to the recommendation
Establish how the high level objectives and the associated targets defined for technologies under individual SPDs in the CS2DP cascade down to the topics in the calls for proposals and the (signed) grant agreements for Partners. In the validation of the annual technical reporting of Members for GAMs, assess the contribution of	Performance management	31/03/2019	Since CFP 8, the definition of topics includes reference to the HLO of the CS programme. During the elaboration phase of topics, the POs assess the contribution of the proposed topic to the GAM (either to a WP	Preparing a reply to the IAS with evidence of actions performed and explaining the JU's decision to implement alternative measures in response to the recommendation

[38] IAS Audit Report IAS.A2-2017-W CLEANSKY-001 - Performance management of the Clean Sky 2 Joint Undertaking activities, audit report dated 20.11. 2017

Content and significance of recommendation	Audit title	Deadline for implementation	Implementation activity	Status
the outcome of the work delivered under the GAPs to the achievement of the respective strategic SPD objectives. *Important recommendation*			or a demonstrator or a technology) and link the GAM contribution to HLOs and the contribution of the topic to the GAM. The contribution of the outcome of the work delivered under the GAPs to the achievement of the respective strategic SPD objectives is done in the Annual Reviews of the GAMs.	
Develop the methodology for measuring progress under the CS2 Programme towards achievement of targets for the competitiveness/industrial leadership (Mobility/Connectivity, Employment, GDP impact, etc.) objectives and reflect it in CS2DP and the BAWP; Demonstrate in the CS2DP and BAWP how the (environmental) high-level objectives flow down to the level of each SPD and further to individual work packages and projects. Elaborate in CS2 DP and BAWP on any realignment of the objectives;	Performance management	30/06/2019	The process is on-going, several workshops on feasibility of establishing qualitative criteria for measuring competitiveness will be performed during the year 2020, the first one end of January. In the CS2DP, the HLOs are broken-down per reference A/C and individual SPDs are implementing technologies, thus delivering contribution to	Preparing a reply to the IAS with evidence of actions performed and explaining the JU's decision to implement alternative measures in response to the recommendation

Content and significance of recommendation	Audit title	Deadline for implementation	Implementation activity	Status
SMART objectives established for the various work packages within each SPD should clearly flow through from the BAWPs to the Calls for Proposals and to the individual projects. *Very Important recommendation*			HLOs. The CS2DP (version Nov.2019) provides vision at programme completion and the BAWP (2020/21) implements part of the work described in the CS2DP. The Scientific Committee assessed the alignment of the CS2DP with the BAWP and provided their opinion to the GB. As mentioned in the recommendation above, the definition of topics includes reference to the HLO of the CS programme.	
Implement a common approach to record internally the topic review, ranking and decision on topics to be presented for GB approval including information on the criteria used for the selection or rejection. Formalise in this context the consultation of the	Grant management – CfP process[39]	30/06/2019	The process has been revised and a clear track is available now from the topic review and ranking made by the POs to the decision of the Executive Director on the	Preparing the evidence for the implementation of the recommendation

[39] IAS Audit Report IAS.A2-2016-CLEANSKY-001 - H2020 Grant Process (from the identification of the call topics to the signature of the grant agreement) in the Clean Sky 2 Joint Undertaking (Clean Sky 2 JU), audit report dated 15.11.2016

Content and significance of recommendation	Audit title	Deadline for implementation	Implementation activity	Status
Scientific Committee on the scientific priorities of the Work Plan. *Important recommendation*			topics selected for GB approval. All the process is described in the CS2 JU Management Manual and the outcome of the process is evidenced in the PO assessment table for each call. The final call text documentation is sent to SRG Members and Scientific Committee for consultation.	
Reinforce guidance and monitoring on Grant Agreement preparation, documenting the changes to the proposals and their justification *Important recommendation*	Grant management – CfP process	31/03/2019	Guidance on the grant preparation process has been developed and is applied through standard forms for the GPR	Preparing the evidence for the implementation of the recommendation
For the CFP process, finalise the update and alignment of the existing JU guidelines with H2020 rules, e.g. for expert recruitment; ensure that relevant internal and external Clean Sky 2 actors take note of and follow the updated guidance. *Important recommendation*	Grant management – CfP process	31/12/2018	In the meantime, the CS2 MM has been further updated and is aligned with the H2020 rules. The related chapters for expert recruitment together with the H2020 IT tools provide sufficient guidance to the POs. The expert briefings at the time of the initiation of the contracts clearly	Preparing a reply to the IAS with evidence of actions performed and explaining the JU's decision to implement alternative measures in response to the recommendation

Content and significance of recommendation	Audit title	Deadline for implementation	Implementation activity	Status
			highlight the risk of CoI and how to alert the JU on potential issues.	

12. List of abbreviations and project acronyms

Abbreviations

AAR	Annual activity report
A/C	Aircraft
ATM	Air Traffic Management
CA	Commitment Appropriations
CDR	Critical design review
CfP	Call for Proposals
CfT	Call for Tender
CS2DP	Clean Sky 2 Development Plan
EC	European Commission
GAM	Grant Agreement for Members
GAP	Grant Agreement for Partners
GB	Governing Board
IAO	Internal Audit Officer
IKOP	In Kind contributions from Operational Projects
ITD	Integrative Technology Demonstrator
IADP	Innovative Aircraft Demonstrator Platform
JU	Joint Undertaking
JTP	Joint Technical Programme
PA	Payment Appropriations
PDR	Preliminary design review
QPR	Quarterly Progress Report
SPD	System & Platform Demonstrator
SRG	States Representative Group
TA	Transversal Activity
TE	Technology Evaluator
ToP	Type of Action
TP	Technology Products
TRL	Technology readiness level
TTG	Time To Grant
WP	Work Package

Project Acronyms

ACD	Anti-Contamination Device
ADVANCE	Advanced Value and Service driven Architectures for Maintenance
AFC	Active Flutter Control
AFP	Automatic Fibre Placement
AM	Additive Manufacturing
ASCENT	Active Simulator Cockpit Enhancement
ASM	Aircraft Simulation Model
AStA	Approach Stabilization Assistant
ATN/IPSIMA	Aeronautical Telecommunication Network/Internet Protocol Suite Integrated Modular Avionics
BJ	Business Jet
C&C	Cabin & Cargo
CAA	Computational Aero-Acoustics

CAE	Computer Aided Design
CDR	Critical design review
CFD	Computational Fluid Dynamics
CfP	Call for Proposals
CFRP	Carbon Fibre Reinforced Polymer
CG	Centre of Gravity
CNT	Carbon Nano Tube
CROR	Contra-Rotating Open Rotor
CWB	Central Wing Box
DAPAGPAHRS	Digital Active Phased Array radar GPS aided Attitude and Heading Reference System
DfE	Design for Environment
DMC	Demonstrator Management Committees
DMU	Digital Mock-Up
E2E	End to End
EASA	European Aviation Safety Agency
EDAS	Eco-Design Analysis
eECS	Environmental Control Systems
EFB	Electronic Flight Bag
EFFP	Environmentally Friendly Fire Protection
EGDS	Electrical Generation and Distribution System
EHA	Electro-Hydraulic Actuation
EMA	Electro-Mechanical Actuation/Actuator
EMC	Electro-Magnetic Compatibility
EoL	End-of-Life
EPGDS	Electrical Power Generation and Distribution System
EWIPS	Electrical Wing Ice Protection System
FCPG	Fuel Cell Powered Galley
FTB1	Flying Test-Bed no. 1
FTB2	Flying Test-Bed no. 2
GAM	Grant Agreement for Members
GAP	Grant Agreement for Partners
GCU	Generator Control Unit
GPAHRS	GPS aided Attitude and Heading Reference System
HLFC	Hybrid Laminar Flow
HLU	Hand Lay-Up
HMI	Human Machine Interface
HPE	High Performance and Energy Efficiency
HVC	High Versatility Costs efficiency
HVDC	High Voltage Direct Current
ICD	Interface Control Documents
ICS	Interface Control Drawings
IHMM	Integrated Health Monitoring Management
IMA	Integrated Modular Avionics
IMACS	Integrated Modular Aircraft Cabin systems
IPS	Ice Protection System
ISV	In-Seat Ventilation
IVHM	Integrated Vehicle Health Management
IWTT	Icing Wind Tunnel Test
LCA	Life Cycle Assessment
LG	Landing Gear
LiFi	Light Fidelity (Bi directional data transmission by light)

LLTI	Long Lead-Time Items
LRI	Liquid Resin Infusion
LSF	Low Speed Fan
MFFD	Multi-Functional Fuselage Demonstrator
MLE	Modified/morphing Leading Edge
MPR	Materials, Processes And Resources
MPSU	Movable Passenger Service Unit
MQL	Minimum Quantity Lubrication
NBPU	No Break Power Unit
NGCTR-TD	Next Generation Civil Tilt Rotor related Technology Demonstrator
NLF	Natural Laminar Flow
OBIGGS	On Board Inert Gas Generator System
OoA	Out-of-Autoclave
OWB	Outer Wing Box
PAGB	Power & Accessory Gear Box
PDR	Preliminary design review
PED	Personal Electronic Device
pFHA	preliminary Subsystems Function Hazard Assessment
RACER	Rapid And Cost-Effective Rotorcraft
RCCB	Remote Control Circuit Breaker
SAA	Sulfuric Acid Anodizing
SFR	System Functional Review
SHM	Structural Health Monitoring
SSPC	Solid State Power Controller
TE	Trailing Edge Or Technology Evaluator
TRL	Technology Readiness Levels
UHBR	Ultra-High Bypass Ratio
UHPE	Ultra-High Propulsive Efficiency
V&V	Verification and Validation
VEES	Vehicle Ecological Economic Synergy
WP	Work Package
WRB	Wing Root Box

From: TROFIN Laura (CLEANSKY)
Sent: 30 June 2020 11:36
To: SASSOLI David Maria
Cc: KREIN Axel (CLEANSKY) ; SASSOLI David, President ; HOHLMEIER Monika
Subject: D(2020)AK304 - Clean Sky 2 Joint Undertaking Annual Activity Report 2019

Dear Mr. Sassoli,

On behalf of Mr Axel Krein, the Executive Director of Clean Sky 2 Joint Undertaking, please find enclosed a cover note and the Annual Activity Report 2019.

Regards,

Clean Sky 2
Laura Trofin

Strategic Development Unit
White Atrium Building | TO 56 | B-1049 Brussels | Belgium
Phone: +32 2 541 8226

Enclosures:

- Cover note
- Annual Activity Report 2019

Sent by e-mail and regular mail