2020
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 CO_2 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
Governing Board	Stéphane Cueille, Chairman (Safran) re-elected on 18 November 2020 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 [GKN Aerospace Sweden AB, GE AVIO, Honeywell, Univ. Nottingham, ACITURRI, ISQ].
Other bodies	States Representatives Group; Scientific Committee; ITD/IADP Steering Committees and TA Coordination Committees
Staff	42 (41 posts filled by 31.12.2020)
2020 Budget	€323.9 million commitment appropriations; €333.8 million payment appropriations (Title V unused included)
Budget implementation	97.4% in commitment appropriations and 88.1% 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 Annex 10
Call implementation	Number of calls launched in 2020: one (CfP11) Number of proposals submitted (CfP11): 191 Number of eligible proposals: 188 Number of proposals retained: 36 Global project portfolio (since the setting up): 610[1] Number and value of tenders (if any): none.
Participation, including SMEs	Total number of participations in funded projects: 1887[2] which consists of: 29% SMEs (555 participations), 22% IND (411 participations), 24% UNI (459 participations), 25% RES (461 participations)

[1] Not counting Leader actions and counting each funded proposal from Calls as one project.

[2] Participations in CfP01-11 and CPW01-04.

FOREWORD

« 2020 unforeseen challenges »

2020 was… quite a year. Back in January, no one could have predicted the Covid-19 pandemic and its impact on our lives. The aviation sector was hit particularly hard. Almost 90% of Europe's flights were grounded from March to May, and though those figures have improved slightly, current estimations predict that passenger footfall won't reach 2019 levels until 2024.

Nevertheless, difficult times present us with new opportunities.

Satellite images of pollution-free skies following the lockdowns revealed the benefits that clean, emission-free air travel could bring in the future, though not at the cost of the mass economic disruption and job losses caused by the pandemic.

The European Union is moving forwards with the European Green Deal, the Green Recovery Fund and a range of other policies and Clean Sky, in alignment with these initiatives, is determined to keep sustainability at the forefront as we move towards a greener and more prosperous future for aviation.

Although the vast majority of Clean Sky's projects have continued, Covid-19 Europe-wide lockdowns have inevitably had an impact on our progress. We currently predict a delay of approximately four to six months in the implementation of our programme.

Despite this, more than 80% of Clean Sky's key demonstrators will deliver their objectives by the end of the programme as planned. The remaining approximately 20% are being adapted in order to accommodate strategic evolutions. Within this report, you'll read about how we have adapted our projects to deliver key results on completion of the programme in order to achieve maximum success.

Some of our most promising technology includes Clean Sky's Tech TP engine demonstrator, the UltraFan technology demonstrator, RACER and Next GenCTR. Engines are at the heart of any aircraft, and the Tech TP project is working to develop a 100% European-built, sustainable, low-fuel and low-noise engine for use on general aviation and smaller commuter sized aircraft (up to 19 passengers).

The UltraFan is a technology demonstrator for the next generation of environmentally-friendly gas turbines for large commercial aircraft. By putting a power gearbox between the fan and the rear stages of the turbine, the big fan runs more slowly, thereby improving propulsion efficiency. A major challenge here has been to optimise the nacelle (engine enclosure) architecture, to minimise aircraft drag.

RACER combines an innovative wing-box design with lighter structures and improved power management efficiency, while NextGenCTR features a fixed-engine, split gearbox drivetrain concept, with an advanced flight control system, efficient nacelle architecture, advanced wing architecture and optimised tail configuration.

You can visit Tech TP, UltraFan, RACER and NextGenCTR at our new state-of-the-art online stand, developed to share our progress on a selection of our most promising technologies in 2020, where you can view our results and meet the experts.

Take a stroll around our stand and see what the future of aviation has in store!

2020 also marked an increased participation in Clean Sky 2 with the launch of Clean Sky's final Call for Proposals. Call 11 received 191 project proposals from 578 entities, a record result for Clean Sky and a clear indicator that sustainable aviation is a high priority for the sector, and that climate neutrality remains a cornerstone of European aerospace innovation going forward.

Since the closure of Call 11, Clean Sky has successfully engaged 940 participants from 30 countries across the entire aeronautics sector, of which 363 are SMEs, 113 are research centres, 156 are universities and 308 are industrial companies. To date, Clean Sky programmes have obtained 219 patents and have published 767 technical and peer-reviewed papers, including book chapters and theses written by PhD and Masters candidates. You can learn more about our different key players and EU countries' performance in the participation section of this report.

Investing in clean technologies and cutting-edge research will accelerate the EU's green agenda and drive the aeronautical sector towards environmentally-friendly alternative solutions. Clean Sky is proud to be a part of this journey towards climate neutrality and we look forward to what the future brings!

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 European Union funding budget of just over €2.5 billion and an overall value of activities approximately 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 extensively in Clean Sky activities; newcomers are successfully integrated into the sector and large industrial participants benefit from exposure to the innovative approaches of 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 EU 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 – member and partner research activity highlights

Each of the programme areas managing the various 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.

- ⇨ **Covid-19 impact on the programme implementation**

The Covid-19 pandemic and the resulting economic crisis continues to severely impact the aviation industry, encompassing the big industrial players, their supply chains and all other entities in the sector.

During this period, the Programme Office conducted an assessment of the impact of the Covid-19 pandemic on its activities with the view to identifying areas in the strategic planning in need of revision or the implementation of mitigating measures. Based on this analysis, the scope of work for the vast majority of demonstrators to be achieved in the Clean Sky 2 Programme remains unchanged. However, some delays (4-6 months on average) have been identified for approximately one-third of the demonstrators on the Programme implementation, with an unequal situation observed across the different areas of activity.

Where possible, demonstrators received funding support based on existing funding availability, with a view to reducing the risk of delays and/or potential funding shortfalls in affected areas of the programme. This measure was implemented in order to protect their contribution to the CS2 High Level Objectives.

Delays in the execution of demonstrators are a direct consequence of the pandemic but also the result of technical difficulties linked to a certain level of uncertainty inherent in R&I activities. It is worth noting however, that the contribution to the CS2 High Level Objectives is not affected as the overall programme content is preserved. Still, delays may impact the timely exploitation of results as reported in the present report (see section on JU risk management). Nevertheless, in the absence of further Covid-19 related complications (e.g. additional successive waves of lockdown measures across Europe), it is anticipated that delays will be recovered by programme's end.

- ⇨ **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'.

In Platform 1, good progress has been made in 2020 on the N+1 engine nacelle design and technology bricks for early exploitation on the long range aircraft type, and the design was nearing completion for the integration systems of UHPE engines on short and medium range (SMR) aircraft. Key decisions have been made for the future architecture of the N+2 engine generation (e.g. the open-rotor concept is now preferred over boundary layer ingestion); and the final architecture selection is scheduled for early 2022. Concerning airframe drag reduction

technologies, good progress has been made on hybrid laminar flow technologies for airfoils with a large scale horizontal tail plane demonstrator tested in Q4 2020, and TRL3 was passed for HLFC applications on wings. For radical aircraft configuration studies, significant progress was made to increase confidence and to de-risk an advanced SMR configuration for the 2035 timeframe. A distributed electric propulsion architecture has thus been selected for the scaled flight test demonstrator and the flight tests will be performed in Q1 2021.

In Platform 2, the first demonstrator parts of the multi-functional fuselage demonstrator have been produced in manufacturing trials to prepare the production process for the final demonstrator parts. The latest generation of the platform concept demonstrator was equipped with cabin and systems to show evidence for zero customisation at airframe level as an industrial approach. Cargo fire tests on the environmentally friendly fire protection demonstrator were conducted in a real burn chamber.

Finally, in Platform 3, activities on the large aircraft disruptive cockpit demonstrator moved forward, in particular for cockpit avionic functions and technology development, LIDAR flight test installation and icing flight tests campaign. For the regional aircraft active cockpit demonstrator, progress was made on the key technologies aimed at reducing pilot workload. With regard to the business jet, progress was made on activities such as multimodality and the refinement of pilot-state monitoring algorithm detection.

Covid-19 impact: All platforms have been impacted by the Covid-19 crisis, particularly resource availability, leading to the postponement of some design reviews and maturity gates from 2020 to 2021, as well as ground or flight tests (such as UltraFan®, scaled flight test). Where possible, collaborative work was performed in a virtual environment, but the most severe impact was felt in laboratory and manufacturing activities (especially for Platform 2) which led to a re-scheduling of certain work packages or prioritisation of some activities.

Mitigation plans have been implemented in close collaboration with all parties to protect results.

- ⇨ **REG – Regional Aircraft IADP**

Regional Aircraft IADP activities related to green conceptual aircraft, including hybrid-electrical configurations, continued during 2020, confirming the ambitious environmental CS2 targets initially established. Activities related to technology maturation completion and to the design of demonstrators made significant progress during this period. The detailed design phase is now complete for all full-scale demonstrators and substantial and valuable progress was made in the manufacturing and assembly of full-scale demonstrators.

Covid-19 impact: The impact of the Covid-19 outbreak was promptly and continuously assessed throughout the year, revealing an average of 4 months delay for the full-scale demonstrators.

- ⇨ **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.

- In 2020, the NGCTR technology demonstrator (WP1) successfully performed all the planned

subsystems critical design reviews and the Technology Demonstrator Critical Design gate was reached in December 2020. The latter demonstrated a level of helicopter design maturity sufficient to launch the manufacturing, assembly, integration and test phases.

- The RACER compound demonstrator's critical design review (CDR) took place in July 2019 with some actions identified and closed further between Q4/2019 and Q1/2020. The manufacturing of major sub-systems and the long lead-time items procurement continued throughout 2020. Key ground tests benches were also run (e.g. lateral shaft dynamics, electrical generation and distribution systems, systems integration rig).

Covid-19 impact: The Covid-19 outbreak had a significant impact on activities performed at SPD level. With regard to the RACER programme, Covid-19 has slowed down the manufacturing of primary systems, ultimately leading to an unavoidable 6 to 9-month delay for programme completion. The RACER master schedule was updated and the first flight shifted to Q2/Q3 2022 (representing a one-year delay). Regarding NGCTR, despite a slowing down of related activities, the mitigation action implemented (remote working and prioritisation of tasks directly contributing to the TD first flight) resulted in the achievement of all planned goals in 2020.

⇨ **AIR – Airframe ITD**

An assessment of noise reduction due to an optimised scarfed nozzle concept has been carried out, as well as additional testing activities for cabin thermal modelling. Natural laminar flow progressed well following a wind tunnel test (WTT) carried out in 2019 on a business jet (BJ) mock-up and the continuation of BLADE F/T data analysis. Manufacturing activities including tooling have started for the composite flaperon demonstrator, and assembly of structural door demonstrators performed. EWIPS BJ slats have been manufactured for testing in the icing wind tunnel. The manufacturing of BJ office cabin demonstrator items has started.
In 2020, several CDRs were completed, allowing for the commencement of manufacturing and assembly phases: RACER's wing, SAT optimised composite small scale integral demonstrators, Next Generation Civil Tilt Rotor subsystems and V-Tail, etc. Additionally, the icing wind tunnel test was completed for loop heat pipe ice protection systems and the lower skin with integrated spars and stringers was manufactured in liquid resin infusion for IIAMS tooling. An embedded SATCOM antenna was delivered to the REG IADP FTB#2 and for small air transport (SAT), the first four flight nacelle component trials on M28 aircraft were conducted. Manufacturing of automated fibre placement technologies of side-shells for RACER was completed. EcoDesign progressed well with the definition of the five flagship demonstrators, completion of 25 eco-statements, and the start of technologies down-selection. COBOT for cockpit technology TRL6 assessment has been achieved.

Covid-19 impact: 50% percent of deliverables and milestones initially planned for 2020 have been postponed to 2021, 50% of which are scheduled for the first quarter. The main demonstrators impacted were: deliveries of flaperon, RACER's wing and rotorless tail, SAT optimised composite full scale demonstrator; delays on FTB#2 Out of Autoclave (OoA) Composite Wing Box CDR and on the full scale demonstrator, and regional fuselage centre and cabin interiors contribution to full scale demonstrator.

⇨ ENG – Engines ITD

In 2020, all work packages (WPs) progressed significantly towards the master plan. WP7 on lightweight and efficient jet-fuel reciprocating engines completed its R&I programme and is now concluded. WP3, the 'Turboprop Integrated Power Plant System', which is in its final stage, continued testing on the ground (TechTP demonstrator) and the entire testing activity is scheduled for completion by the end of 2021.
Further progress was made in the following areas:

- Progress continued in WPs 2, 5 and 6 with significant progress regarding the key technologies: Ultra-High Propulsive Efficiency (WP2), Very High Bypass Ratio (VHBR) middle of market turbofan technology (WP5) and VHBR large turbofan demonstrator (WP6).
- In 2020, the work in WP2 continued on technology bricks for core engines in order to prepare the engine ground test demo. This engine demonstrator is addressing the segment for short and medium range passenger aircraft. Multiple maturation studies have also continued to consolidate the architecture for the ground test demo (GTD) of the future installed propulsive system (IPS). Several significant milestones were achieved despite the Covid-19 crisis.
- For the advanced geared engine configuration (WP4), the design of the two-spool rig, as well as the engine technology demonstrator activities, passed their preliminary and critical design reviews respectively. This progress makes the delivery of the technology evaluator target engine deck (data) possible, in line with 2nd TE Assessment planning.
- The VHBR large turbofan demonstrator (WP6) continued, making significant progress regarding the key technologies and manufacture of components. The first engine will be ready for test at the end of 2021.
- Work progressed on the reliable and more efficient operation of small turbine engines (WP8). After achieving the objectives for loop two (improvements in a conventional turbo-prop engine), the programme has entered its third loop (hybrid-electric powerplant).
- Activity on the eco-design engine (WP9), has been consistent with the work programme.

Covid-19 impact: It is anticipated that delays incurred in 2020 will be recovered by the end of 2021, primarily as a result of a recovery plan implemented by each beneficiary, although some limited supporting technology development outside the main demonstrators has been moved to 2022.

⇨ SYS – Systems ITD

In 2020, all work packages progressed in line with the SPD objectives and the year's most significant achievements are summarised as follows:

- The extended cockpit activities reached their final phase of demonstration for the majority of the technologies on a virtual system integration bench at TRL5.
- Flight control systems activity progressed in the large aircraft integrated demonstrator. The contribution to the flight test demonstration in REG IADP continued and first components were delivered to the airframer.
- There were advances in a variety of landing gear technologies. The direct drive system, which allows emission free taxiing, started its systems testing activities. The electro-hydraulic nose wheel steering concept completed the assembly of its component levels and testing was finalised to allow for demonstration on aircraft in 2021.

- The critical design review for large aircraft environmental control systems was completed and preparations are underway for the subsequent demonstration activities.
- Integrated demonstration activities for innovative electrical networks progressed although some adaption was required due to the impact of the current pandemic on partners, and to better align with airframer roadmaps.
- Cabin systems made progress in the field of sensor solutions and modules for a smart cabin environment with some mock-ups realised and first tests conducted on grey water reuse. Key components of the fire-suppression demonstrator were produced and successfully tested.
- Small air transport partners completed their test flight activities for new thermo-acoustic insulation and progressed on the other different demonstrators.

Covid-19 impact: In response to the pandemic-related 4-month delay affecting most of the demonstrations and the resulting impact on various reviews, maturity gates and tests, a recovery plan has been put in place for 2021 for the different technological domains in order to minimise the delays over the next two years. Where possible, collaborative work was conducted in a virtual environment; the most severe impact was observed where physical demonstration was required. Mitigation plans have been implemented in close collaboration with partners to protect the critical paths.

⇨ ECO – Eco-design transverse activity

Concrete applications are being developed which apply the eco-design approach for airframe, engine and systems components. This will make these elements more ecological and consume fewer resources in line with a Design for Environment (DfE2020+) across all ITDs/IADPs. Flagship demonstrators have been identified to perform the eco-design analysis in every ITD/IADP. The coordination and monitoring effort to generate lifecycle inventory data on selected technologies from SPDs is an ongoing challenge. On the basis of the lifecycle inventories received to date, a set of ground pollution potential indicators has been chosen and reports on eco-statements from LCA analyses have been issued.

Covid-19 impact: Due to Covid-19 restrictions on working hours in IADPs/ITDs, workshops have been limited to online meetings and some exchange on materials, processes and resources has been postponed to 2021.

⇨ SAT – Small air transport transverse activity

Integration studies of technologies developed within the Airframe, Engine and Systems ITDs on 19-seat green aircraft configurations were carried out to evaluate the benefit of different technologies at aircraft integration level. In the Small Air Transport Transverse Activity (SAT TA), the main tasks for 2020 were the management of SAT-related research and technology development activities across the relevant ITDs, as well as the revision of green 19-seater design, and the definition of electric/hybrid short take-off and landing (E-STOL) 19-seater commuter aircraft architecture.

Covid-19 impact: An assessment of the Covid-19 impact carried out during 2020 showed a 3-6 month average delay in the implementation of SAT-related activities across the CS2 SPD areas.

⇨ **TE – Technology Evaluator**

A major milestone in Technology Evaluator activities in 2020 was the completion of the first global assessment. For each of the assessment dimensions (i.e. mission level, airport level and air transport system level), detailed analyses were carried out to assess their purpose/perfomance in relation to the Clean Sky 2 goals in the field of environment and competitiveness.

Covid-19 impact: Due to well-managed mitigating action taken to deliver the first TE assessment as planned (most of the work was of a computational nature under the Technology Evaluator and this was performed fully remotely), there was no impact from the Covid-19 pandemic.

⇨ **Summary of calls for proposals in 2020**

In 2020, the last two calls for proposals were successfully implemented: the tenth call for proposals (CfP10) was completed in April and the eleventh (CfP11), in December 2020. With regard to call CfP10, 56 successful topics out of 62 topics were published (90% success rate) with a total funding request of approx. €58.95 million; time to grant performance (GAPs signed <8 months): 91%. The CfP11 was launched in January 2020 with evaluations taking place in July 2020: 34 successful topics out of 35 topics were published (97% success rate) with a total funding request of approx. €35.95 million. The call was under grant preparation and has been fully implemented remotely with a time to grant performance (GAPs signed <8 months) of 100%.

Including the eleventh call, the JU also successfully launched 14 thematic topics (100% success rate), representing 25 proposals with a total funding request of approx. €34 million.

Altogether, these eleven calls for proposals are already engaging more than 726 partners from 28 different countries with a strong SME involvement in terms of participation and grants awarded: with 43% of the partners selected requesting 26% of the nearly € 538 million in EU funding launched via these eleven calls.

- **Administrative and financial management**

Despite the Covid-19 crisis, the JU executed 97.6% of the operational budget. The available payment appropriations amounted to €307.0 million and 88.7% of the available funds were executed. 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 €717.65 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 €1.14 billion leading to a total of €1.86 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.

- **Governance**

Throughout the year, various policies and decisions were proposed and adopted by the Governing Board related to: the approval of the annual activity report, the ranking lists for call

11, providing opinions on the annual accounts and in-kind contributions, the adoption of the amended work plan and budget for 2020-2021, the adoption of the updated Clean Sky 2 Development plan and the Communication Strategy 2020-2024, the approval of the additional activities plan 2021 and others.

1. IMPLEMENTATION OF THE ANNUAL WORK PLAN 2020

1.1. Key objectives 2020 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 ITDs/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 2020-2021 are stated below. The progress as of end 2020 is reported against each objective:

Objective in the Work Plan 2020-2021	Status	Comments
To execute the technical content as defined for the two-year period and ensure this is adequately incorporated in the Clean Sky 2 Development Plan and the grant agreements;	Ongoing, technical programme for 2019 largely achieved [>85%]	The Programme Office conducts yearly assessments of the strategic planning and invites Members to present their proposed evolutions in case of deviations or change of strategy. Where necessary, the technical content of the Work Plan might be amended. The Clean Sky 2 Development Plan (CS2DP) was revised mid-2020 to reflect the impact of the Covid-19 pandemic on the Programme and to implement mitigation measures to maintain the objectives. The revisions were presented to the Governing Board for information and implemented in the Clean Sky 2 Development Plan, which was subsequently adopted by the Board at the end of 2020. The technical content of the Work Plan remained unchanged in 2020. An amendment is expected for activities planned in 2021 to ensure technical alignment with the revised Clean Sky 2 Development Plan.
To determine in the course of 2020-2021 the definitive configuration of the Programme's major demonstrators and technology development themes, based on robust risk and progress reviews based on the baseline set in the CS2DP; where	Ongoing, on track	The revision of the Clean Sky 2 Development Plan, endorsed by the Governing Board in December 2020, includes the planning of 106 programme demonstrators and the technology development schemes. It reflects on the current progress of the different demonstrators (based on results achieved and milestones passed so far) and includes the objectives at completion (maturity level). This is as a result of the in-depth analysis carried out by the members and the Programme Office. The list of major risks associated with the different areas of the programme was assessed and reported. To reduce the existing risks of

Objective in the Work Plan 2020-2021	Status	Comments
necessary diverting resources to safeguard the achievement of the programme's High-Level Objectives [HLOs] to start delivering the first results expected in 2021; ⇨		delays and/or potential funding shortages within certain areas linked to the Covid-19 outbreak, some demonstrators received funding support (where possible and based on funding availability) with the aim of protecting their contribution to the CS2 High Level Goals. The programme will enter the delivery phase in 2021, with 4-6 months of delays compared to the situation reported last year. The Scientific Committee confirmed that the CS2DP as currently proposed is robust and well aligned with the High Level Goals and the Work Plan. The scope and the ambition of the Clean Sky 2 Programme are preserved and the plan has the potential to contribute to the Clean Sky 2 HLGs as expected at programme end.
To implement solutions for leveraging Clean Sky 2 funding with structural funds;	Ongoing, on track	By the end of 2020, the following figures show progress in the action undertaken by the JU: **18 MoUs** · **> 50 Pilot Projects** · **> €50m regional funding** · **12 Synergy labels** The JU has developed strong support mechanisms to enable synergies with the ESIF by allowing complementary activities to be proposed by applicants to CS2 calls and by amplifying the scope of, adding parallel activities to, 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.
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 ITD/IADP/TA reports their results and performance to the Governing Board on a quarterly basis. Programme Coordination Committee (PCC) meetings are regularly organised (10 in total for 2020, of which two extraordinary meetings were added to the planning due to Covid-19) to monitor the programme's progress and execution. In addition, annual reviews and interim progress meetings are organised along the year. The review cycle helps to properly manage and govern the programme through well targeted actions.

Objective in the Work Plan 2020-2021	Status	Comments
		The current management and governance of the programme proved to be efficient in the context of the crisis, which affected the overall aeronautic sector. The robustness of the JU processes was clear from a quick adaptation to the Covid-19 circumstances. This helped to preserve the programme's High Level Goals. The JU provided support to the different contributors of the programme, mainly through amendment of their activities to address the delays identified as a direct impact of the crisis. Updates of the CS2 strategic documentation (i.e. CS2DP) were implemented in November 2020 and an amendment to the Work Plan will follow in 2021. It is worth noting that the JU re-organised all its operations from March 2020 onward so that activities were carried out fully remotely (e.g. periodic reviews, call evaluations, committee meetings, interactions with parties). The eleventh call for proposals (CfP11) was successfully processed entirely remotely, from the call launch to the grant signature.
To implement an appropriate and agreed approach for each transverse area 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 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 one further call for proposals and to include within this call 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 HLGs and to investigate essential breakthrough technologies (linked to future full and hybrid electrical propulsion	Ongoing, achieved for 2019 Calls	The eleventh call for proposals (CfP11) was the last and final call launched within the Clean Sky 2 Programme, and it included both complementary and thematic topics. The call closure deadline was postponed by two weeks to mitigate the risk of participation associated with the Covid-19 pandemic. This call received a large number of proposals: more details are provided in *Section 1.3: Calls for proposals and grant information*. The grant preparation phase for all CfP11 projects was completed with all grants signed at the end of 2020. The start of activities is anticipated in Q1 2021.

Objective in the Work Plan 2020-2021	Status	Comments
aircraft) needed to prepare a potential future clean aviation partnership;		
To disseminate information about the last call for proposals (for partners), in order to reach a healthy level of applications and ensure the success of the topics; including a level of participation from SMEs that was higher than 35%. To proceed with the selection of participants through these calls;	Ongoing, achieved for 2018 Calls	The JU has successfully maintained a good balance in terms of success rates for applicants versus wide and strong, open competition. SME participation (43% of winning applicants) remains healthy and on target. See also the reported results on KPIs. Regarding the thematic topics, results from Call 10 and Call 11 led to a comparable success rate: as multiple projects were awarded funding and SME participation is well represented (35% of winning applicants). 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 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 2020, two calls for proposals were successfully implemented (i.e. grant signed), with the tenth call for proposals (CfP10) completed in March and the eleventh call for proposals (CfP11) in December. Time to grant (TTG) target was met with significant margin (TTG < 8 months: 100% GA signed). More details are reported in the KPIs.
To execute at least 90% of the budget and of the relevant milestones and deliverables;	Partially achieved (estim. as of Jan 2020)	97.61% in terms of commitment appropriations and 88.72% in terms of payment appropriations for the operational budget. In terms of reported (fully completed) milestones and deliverables, around 80% of deliverables and milestones planned in GAMs have been confirmed in light of the main results reported below. 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 objectives.	Ongoing, achieved for 2019 Work Plan and Calls	For the actions (and calls) in 2020, the monitoring and control mechanisms in place have allowed for the monitoring and proper alignment of activities (i.e. technical work as implemented across GAMs and GAPs) and the implementation of calls together with the programme objectives and the Work Plan. The consultation with 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	Achieved	The reference framework for the impact assessment to be performed by the TE is established and confirmed in all respects, with the exception of the finalisation of the overall socio-economic framework and KPIs. These will be concluded within 2021, in line with the Objectives for the 2020-2021 period. The first full TE Assessment

Objective in the Work Plan 2020-2021	Status	Comments
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.		(of technical results and forecast environmental performance improvements) was completed in 2020, and presented to the Governing Board in November 2020. A synopsis of this assessment will be published in the first quarter of 2021.

List of Major Deliverables and Milestones achieved in 2020

Major Milestones achieved in 2020:

LPA

Demonstrators / Technology Streams (as shown in CS2DP)	Major Milestones 2020
LPA-01-D1 Enablers for integrated open rotor design	Open rotor final evaluation loop completed
LPA-01-D6 Ground-based demonstrator HLFC wing	HLFC on wing TRL3
LPA-01-D8 Radical configuration flight test demonstrator	Launch review of radical aircraft demonstrator
LPA-01-D11 Active flow control flight test demonstration	Full scale wind tunnel tests of the advanced flow control actuators completed
LPA-01-D12 Flight test demonstration of active vibration control technologies/noise prediction methods for rear-mounted engines	Final design report associated with cockpit and cabin passive noise reduction
LPA-01-D14 Boundary layer ingestion	BLI benchmark – intermediate status meeting
LPA-01-D15 Non propulsive energy (NPE)	NPE gearbox acceptance test
LPA-01-XD Cross demonstrator capabilities WP1.1	Aeroacoustic measurements – sound source localisation completed
LPA-02-D1: Next generation fuselage, cabin and systems integration	Start of the multifunctional fuselage demonstrator manufacturing phase with manufacturing trials and component testing. Set-up of the Fraunhofer Longitudinal weld rig. Fatigue prediction tool: decision gate for application on typical single aisle airframe.
LPA-02-D2: Next generation cabin and cargo functions	Review of the final validation tests in ACCLAIM and review of installation tests of the new crown module.

Demonstrators / Technology Streams (as shown in CS2DP)	Major Milestones 2020
LPA-03-D1 Disruptive cockpit	Large aircraft disruptive cockpit integrated systems management function: entry into service on system integration bench
LPA-03-D2 Regional active cockpit	Stand-alone technologies operational validation (TRL 4) for enhanced light weight eye visor
LPA-03-D3 Business jets demonstrator	Pilot state monitoring demonstration of selected fatigue state for the business jet enhanced cockpit

REG

Demonstrators / Technology Streams (as shown in CS2DP)	Major Milestones 2020
REG D3 – Full scale innovative fuselage and pax cabin demonstrator (structural demonstration); REG D4 – Iron Bird	Availability of final IVHM framework release (WP Ref: WP2.2)
REG D1 – Adaptive Wing Integrated Demonstrator – Flying Test Bed#1 (FTB1)	Experimental modifications A/C critical design review (CDR) (WP Ref: WP3.1)
REG D3 – Full scale innovative Fuselage & Pax Cabin demonstrator (Comfort/Thermal demonstrations)	Pax Cabin Demonstrator Critical Design Review (WP Ref: WP3.2)
REG D4 – Iron Bird	Iron Bird components installation (WP Ref: WP3.4)
REG D2 – Integrated Technologies Demonstrator – Flying Test Bed#2 (FTB2)	Semi-morphing wing concept: end of wing modification of regional FTB#2 (WP Ref: WP3.5)

FRC

Demonstrators / Technology Streams (as shown in CS2DP)	Major Milestones 2020
ET1.2 – D02 – Tie Down TiltRotor (TDT) Demo	A/C Critical Design Review (CDR) – WP1
ET1.2 – D02 –Tie Down TiltRotor (TDT) Demo	TD fuselage build
ET2.1 - RACER Flight Demonstrator Integration	First flight test – WP2

AIR

Demonstrators / Technology Streams	Major Milestones 2020
Technology Stream A-3 High speed airframe / Demonstrator D2-1 Composite wing root box	'Composite Wing Root Box' spars delivered for testing
Technology Stream B-1 Next generation optimised wing / Demonstrator D2-15 Composite wing for SAT	SAT wing box integral tooling manufactured
Technology Stream B-2 Optimised high lift configurations / Demonstrator D2-16 Loop heat pipe anti-ice nacelle	Tprop nacelle ice WTT completion
Technology Stream B-2 Optimised high lift	High lift for SAT WTT model CDR closure

Demonstrators / Technology Streams	Major Milestones 2020
configurations / Demonstrator D2-17 High lift device for SAT	
Technology Stream B-3 Advanced integrated structures / Demonstrator D3-24 Cabin parts for SAT structure	Ground tests of selected SAT-AM elements
Technology Stream B-4 Advanced fuselage / Demonstrator D 1-13, D1-14, D1-15	CDR for rear fuselage + V-Tail for Tilt Rotor
WP C-2 Eco-Design for airframe / WP C-2.1 Technology development	Technology development phase completed

ENG

Demonstrators / Techno Streams (as shown in CS2DP)	Major Milestones 2020
ENG 5 – VHBR – middle-of-market technology	Key underlying technologies required to deliver multi-stage IP turbine module maturity gate achieved (WP5.2.3)
ENG 6 – VHBR – large turbofan demonstrator UltraFan®	UltraFan® Tech Freeze (WP6)
ENG 8 – Reliable and more efficient operation of small turbine engines	Down-selection of most promising application hybrid-electric Maestro engine variant

SYS

Demonstrators / Techno Streams (as shown in Work Plan)	Major Milestones for 2020
D1: Extended cockpit demonstrations – WP1	Extended cockpit at TRL5 (Q4 2020)
D5: Advanced landing gears systems – WP4	• Green autonomous taxiing system TRL6 review (Q4 2020) • Short turn-around time equipment (angled wheel and tyre) TRL6 Review (Q4 2020)
D6: Electrical nose landing gear system – WP4	Lab pre-testing completed (Q2 2020)
D17: Advanced landing gear sensing and monitoring system – WP4	Landing gear loads sensing system demonstration at TRL5 (Q3 2020)
D11: Next generation electric environmental control system (EECS) for large A/C – WP6	EECS critical design review (Q4 2020)
D13: Next generation cooling systems – WP6	Vapor cycle system (VCS) critical design review (Q4 2020)
D20: De-Ice – WP7 [SAT]	TRL4 preliminary small scale test on low power de-ice system (Q2 2020)
Modelling and simulation tools for system integration on aircraft – WP100.3	MISSION core simulation environnent completed (Q2 2020)

SAT (Transverse Area)

Demonstrators / Technology Streams (as shown in CS2DP)	Major Milestones 2020
SAT D1 Aircraft Level 0 SAT D2 Wing SMH SAT D3 Safe and comfortable cabin	Summary of inputs, requirements as shared with the transversal ITDs for the development of the different technologies has been prepared.

ECO (Transverse Area)

Major Milestones 2020
SPD demonstrations: quarterly progress meetings
Eco hybrid platform workshop

TE

Major Milestones 2020
Performance of TE 1st assessment

Major Deliverables achieved in 2020:

LPA

Demonstrators / Technology Streams (as shown in CS2DP)	Major Deliverables 2020
LPA-01-D1 Enablers for integrated open rotor design	Open rotor final report
LPA-01-D6 Ground-based demonstrator HLFC wing	HLFC on wing report on TRL3 review incl. route to TRL4
LPA-01-D8 Radical configuration flight test demonstrator	Synthesis of radical aircraft configuration design exercises
LPA-01-D11 Active flow control flight test demonstration	Report on full scale wind tunnel testing of advanced flow control actuators
LPA-01-D12 Flight test demonstration of active vibration control technologies / noise prediction methods for rear-mounted engines	Final design report for cockpit and cabin passive noise reduction
LPA-01-D13 UHBR SR Integration	SA²FIR shaft line
LPA-01-D14 Boundary layer ingestion	BLI benchmark – intermediate status report
LPA-01-XD Cross demonstrator capabilities WP1.1	Report on developments concerning analysis methods for microphone array measurements
LPA-02-D1 Next generation fuselage, cabin and systems integration	First set of major manufacturing tooling CfPs status evaluation about benefits and applications – Airbus Report – Fatigue prediction by direct measurement description specific to single aisle aircraft type
LPA-02-D2: Next generation cabin and cargo	Architecture dossier for the halon-free fire

Demonstrators / Technology Streams (as shown in CS2DP)	Major Deliverables 2020
functions	protection system for the cargo hold.
LPA-03-D1 Disruptive cockpit	Large aircraft disruptive cockpit integrated systems management function evaluation report on fuel system failure use case. Large aircraft disruptive cockpit V&V strategy and roadmap update
LPA-03-D3 Business jets demonstrator	Elements of pilot state monitoring system delivered to the demonstrator *Business jet enhanced cockpit*

REG

Demonstrators / Technology Streams (as shown in CS2DP)	Major Deliverables 2020
REG D3 – Full scale innovative fuselage and pax cabin demonstrator (structural demonstration); REG D4 – Iron Bird	Summary of final IVHM framework (WP Ref: WP2.2)
REG WP2.3 – IWT demonstrator for the low power WIPS	WIPS detailed design and demonstrator design, development and delivery for IWT (Report) (WP Ref: WP2.3)
REG D1 – Adaptive wing integrated demonstrator – Flying Test Bed#1 (FTB1)	Experimental modifications electrical and mechanical parts drawings (WP Ref: WP3.1)
REG D3 – Full scale innovative fuselage and pax cabin demonstrator (comfort/thermal demonstrations)	Installation drawings of cabin interior major items (WP Ref: WP3.2)
REG D4 – Iron Bird	Iron Bird components installation report (WP Ref: WP3.4)
REG D2 – Integrated Technologies Demonstrator – Flying Test Bed#2 (FTB2)	Regional FTB#2 Demonstrator: a/c modification status and technology summary of Step 1 challenges (WP Ref: WP3.5)

FRC

Demonstrators / Techno Streams (as shown in CS2DP)	Major Deliverables 2020
ET1.1 - D01 – Wind Tunnel Model	Low and high speed WTT Reports – WP1
ET1.2 - D02 – Tie Down TiltRotor (TDT) Demo	Critical Design Review – summary note – WP1
ET1.9 - D09 – Digital Mock-up (DMU)	Final A/C Digital Mock – WP1
ET2.1 - RACER Flight Demonstrator Integration	Critical Design Review – summary note – WP2

AIR

Demonstrators / Technology Streams	Major Deliverables 2020
Technology Stream A-1 Innovative aircraft architecture / Demonstrator LPA-01-D12 Flight	Final assessment of the scarfed nozzle concept

Demonstrators / Technology Streams	Major Deliverables 2020
test demonstration of active vibration control technologies/noise prediction methods for rear-mounted engines and D3-2 Optimised integration of rear fuselage	
Technology Stream A-1 Innovative aircraft architecture / Demonstrator D3-5 Virtual modelling for certification	Synthesis of activities for cabin thermal modelling with a human thermal model
Technology Stream B-1 Next generation optimised wing / Demonstrator D2-15 Composite wing for SAT	SAT technology trade-off and development lessons learned
Technology Stream B-2 Optimised high lift configurations / Demonstrator D2-16 Loop heat pipe anti-ice nacelle	Tprop nacelle demonstrator for ice WTT results conclusions
Technology Stream B-2 Optimised high lift configurations / Demonstrator D2-17 High lift device for SAT	High lift for SAT WTT specimen
Technology Stream B-3 Advanced integrated structures / Demonstrator D3-24 Cabin parts for SAT structure	Installation of selected SAT-AM elements on the traditional airplane
Technology Stream B-4 Advanced fuselage / Demonstrator D 1-13, D1-14, D1-15	NGCTR-TD Cockpit CDR report

ENG

Demonstrators / Technology Streams (as shown in CS2DP)	Major Deliverables 2020
ENG 3 – Business aviation / short range regional TP demonstrator	Minutes of TRL review of TP demo
ENG 5 – VHBR – middle-of-market technology	Key underlying technologies required to deliver multi-stage IP turbine module maturity review summary (WP5.2.3)
ENG 8 - Reliable and more efficient operation of small turbine engines	Propeller blade manufacturing trials completed

SYS

Demonstrators / Technology Streams (as shown in Work Plan)	Major Deliverables for 2020
D1: Extended cockpit demonstrations – WP1	Extended cockpit demonstrator: technical and operational evaluation report (Q4 2020)
D2: Equipment and systems for cabin and cargo applications – WP2	C&C processes & architecture standardisation – mid term report (Q2 2020) Cabin applications development report (Q4 2020)
D3: Smart integrated wing – WP3	Bench demo HW description (Q4 2020)
D6: Electrical nose landing gear system – WP4	TRL6 test results summary (Q4 2020)
D17: Advanced landing gear sensing and monitoring system – WP4	Landing gear load sensing TRL5 assessment summary report (Q4 2020)
D9: Innovative electrical and control/command network – WP5	Power module control with Etherfly (Q2 2020)

Demonstrators / Technology Streams (as shown in Work Plan)	Major Deliverables for 2020
D11: Next generation EECS for large A/C – WP6	EECS critical design review report (Q4 2020)
D13: Next generation cooling systems – WP6	VCS critical design review report (Q4 2020)
D18: Fly by Wire – WP7 [SAT]	Fly by Wire test requirements specification (Q3 2020)
D19: Electrical power generation and distribution – WP7 [SAT]	Electrical power generation and distribution system test requirements specification (Q3 2020)
D20: De-Ice – WP7 [SAT]	De-Ice test requirements specification (Q3 2020)
D21: EMA and brake landing gear – WP7 [SAT]	Electrical landing gear and brakes high level technical requirements (Q1 2020)
D22: Comfortable and safe cabin for small aircraft – WP7 [SAT]	Assessment of standard and optimised insulation for noise and thermal control (Q2 2020)
	Seat Demonstrator 2 – Test Evaluation (Q3 2020)

SAT (Transverse Area)

Demonstrators / Technology Streams (as shown in Work Plan)	Major Deliverables 2020
SAT D2 Wing SMH	Summary of inputs, requirements and expectations for the technologies developed under AIR ITD
ENG Demo	Summary of inputs, requirements and expectations for the technologies developed under ENG ITD
SAT D1 Aircraft Level 0	Summary of inputs, requirements and expectations for the technologies developed under SYS ITD

ECO (Transverse Area)

Major Deliverables 2020
Reports on LCI Data Reception
Progress report for the Eco Design Analysis

TE

Major Deliverables 2020
TE 1st assessment report

Environmental forecast

The environmental targets of the Clean Sky 2 programme are defined in the Council Regulation[4]:

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 CO_2 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%	3
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

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

Administrative objectives – achievement

Objective 2020	Achieved in 2020 (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 2020 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.

Indicators

The Key Performance Indicator results for the Clean Sky 2 programme for 2020 are presented in Annexes 5 to 7.

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.

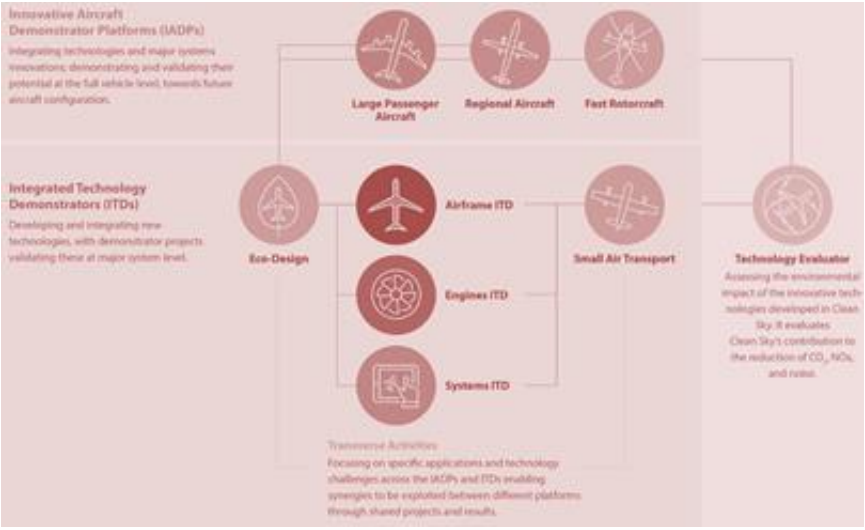
The Clean Sky 2 programme clearly demonstrates the benefits of a true Public Private Partnership (PPP). Stakeholder participation was at a high level, including SMEs (often their first participation in the European framework programme), research centres and academia. Industry is increasingly using Clean Sky as the focus of their R&I 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 the creation of 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 that started in the Clean Sky programme were extended and continued in the 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&I 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 for 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 the technology and impact evaluation infrastructure, is an essential element within Clean Sky. Impact assessments at airport and ATS level that are 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 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 2020 reporting period all call activity was related to the Clean Sky 2 programme. The activities associated with 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[5] 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.

Calls for core partners: summary of status of implementation

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

The net number of Core Partners including their affiliates and linked third parties acceding to the programme on the basis of Calls for Core Partners is over 190 with roughly 50 SMEs participating (disregarding those applications that led to participation as Core Partners via more than one call and/or in more than one IADP/ITD). The Members originate from 22 different countries: 18 Member States and four countries associated with Horizon 2020 [Israel, Norway, Switzerland and Turkey].

A detailed list with the members participating in the CS2 programme is available on the CS2 website[6] and is updated on a regular basis.

Summary of call results to date – calls for proposals

In the six years since the programme's start, a total of eleven Calls for Proposals (CfPs) were successfully launched, with the last one closing at the end of 2020 with the grant preparation completed.

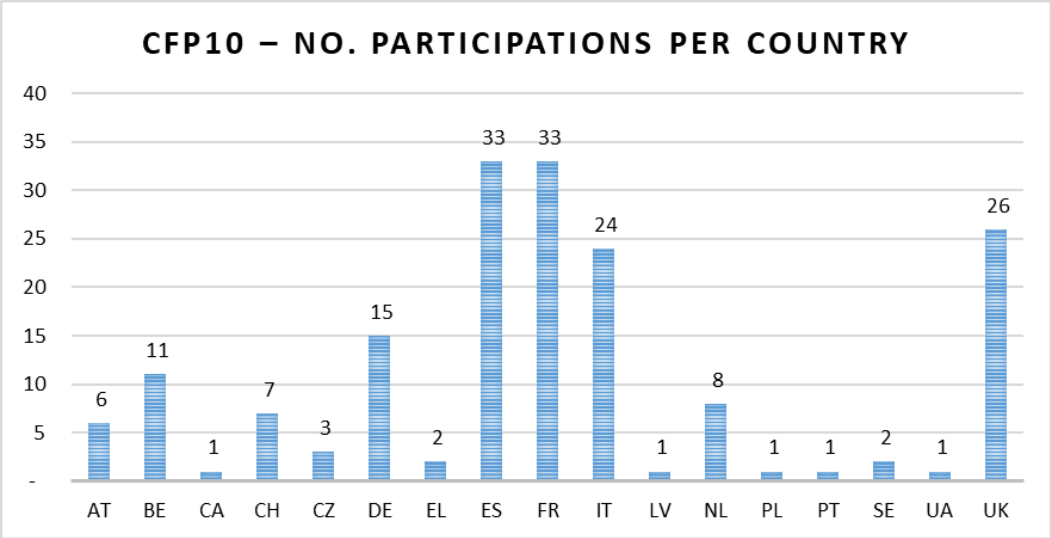
Since 2018, the JU has included Thematic Topics in the planning of the Calls for Proposals. These topics contribute to the progress towards the high-level goals in the CS2 JU Basic Act and are not specifically linked to one IADP/ITD [demonstration activities/strategy], meaning they are not 'inside' one of the current IADPs/ITDs. When including the eleventh call, the JU successfully launched 14 thematic topics (100% success rate), representing 25 proposals with a total funding

[5] Art 1(3)(a) of the Horizon 2020 Rules for Participation.
[6] http://cleansky.eu/members-0

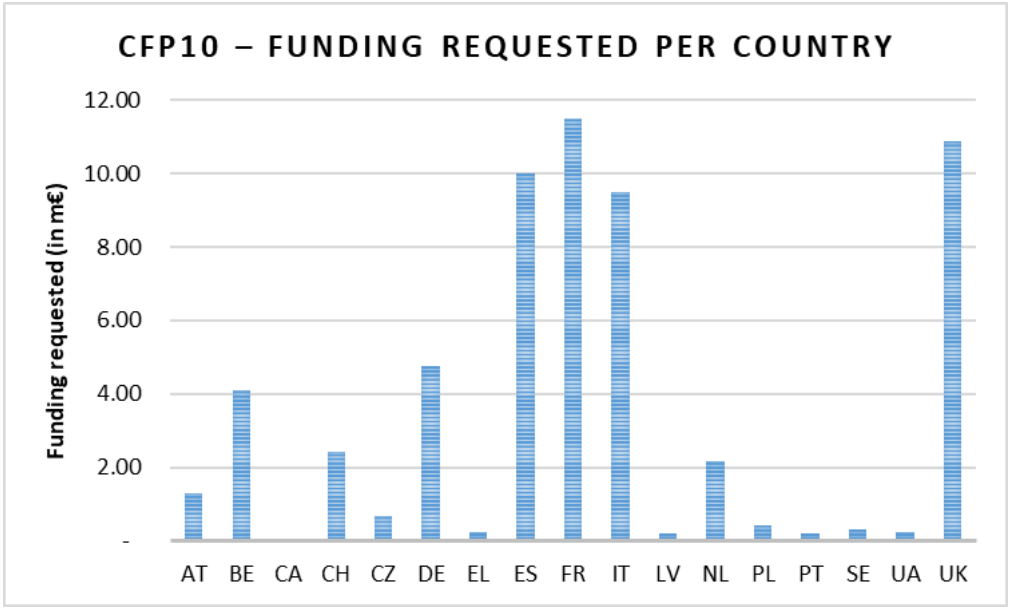
request of approx. €34 million.
The implementation of the tenth call for proposals (CfP10) was successfully completed in April 2020:

- 56 successful topics out of 62 topics published (90% success rate) with a total funding request of nearly €58.95 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;
- 175 participations from 17 different countries;
- SME participation: 34%;
- 144 partners selected.

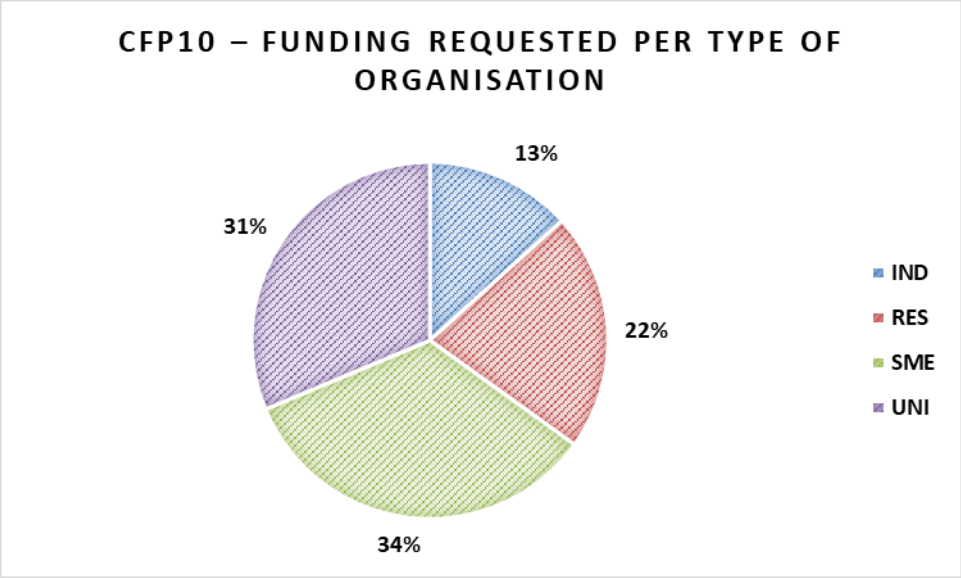
The outcome of the evaluation is summarised in the graphs hereafter:



CfP10 winners – Number of participations per country



CfP10 winners – Funding requested per country



CfP10 winners – Funding requested per type of organisation

The eleventh call for proposals (CfP11) was launched in January 2020, with an evaluation taking place in July 2020. The key metrics of this call are shown below:

- Call comprised of 35 topics of which four are thematic topics;
- Indicative topic value of approx. €30.20 million (overview depicted hereafter) plus €15.0 million for thematic topics;
- Opening date: January 2020;
- Closing date: May 2020;
- Deadline for eight months - time to grant: January 2021.

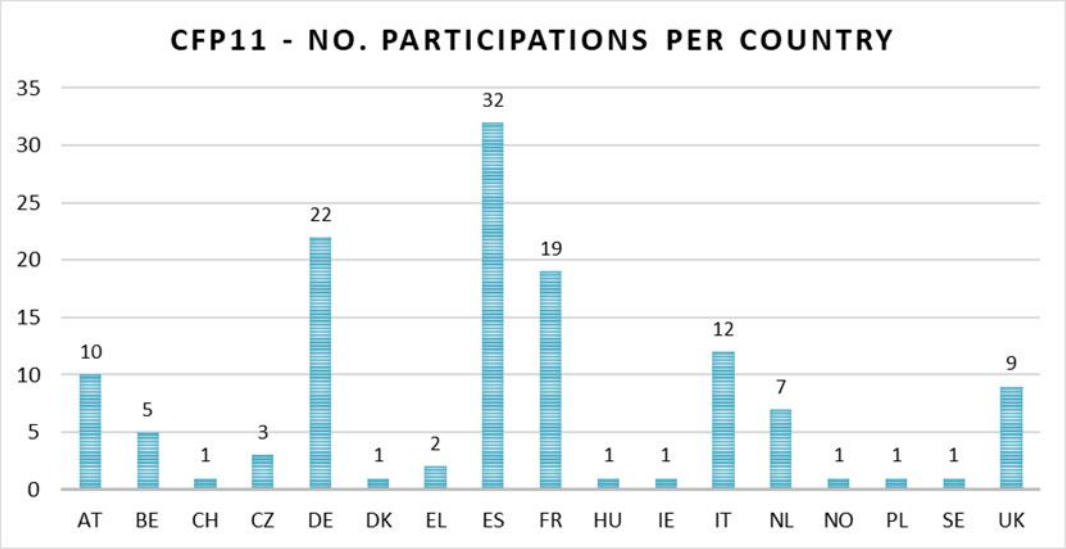
SPD Area	No. of topics	Ind. topic Funding (in M€)
IADP Large Passenger Aircraft	16	19.70
IADP Regional Aircraft	1	0.80
IADP Fast Rotorcraft	0	0
ITD Airframe	4	2.85
ITD Engines	0	0
ITD Systems	7	5.35
Technology Evaluator	3	1.50
TOTAL	31	30.20
Thematic Topics	**# of topics**	**Ind. topic funding (M€)**
TOTAL	4	15

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

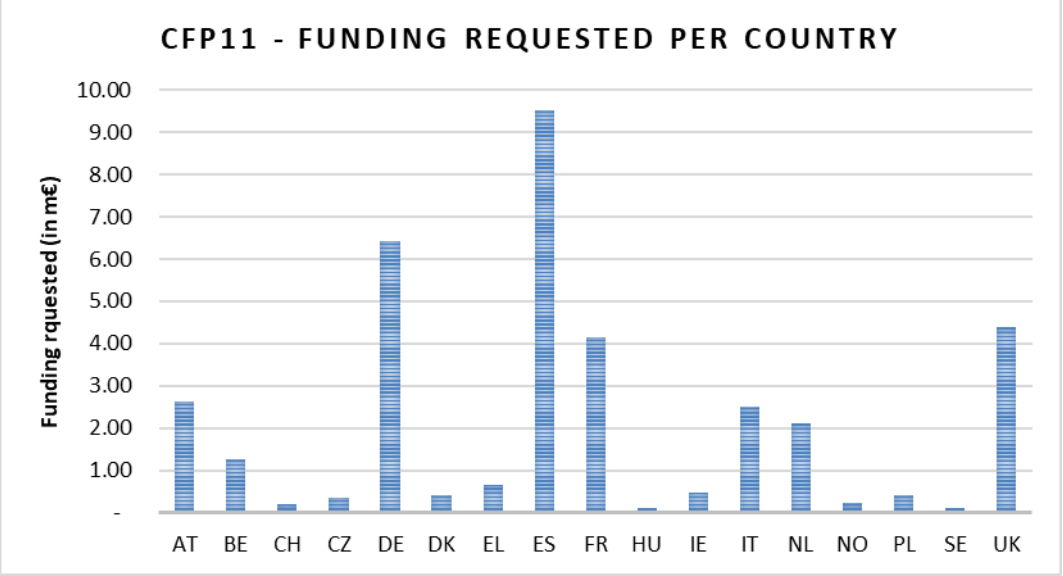
- 34 successful topics out of 35 topics published (97% success rate) with a total funding request of nearly €35.95 million of which:

- 100% success rate for thematic topics (4 topics were launched);
- 6 proposals retained with a total funding request of €6.85 million;

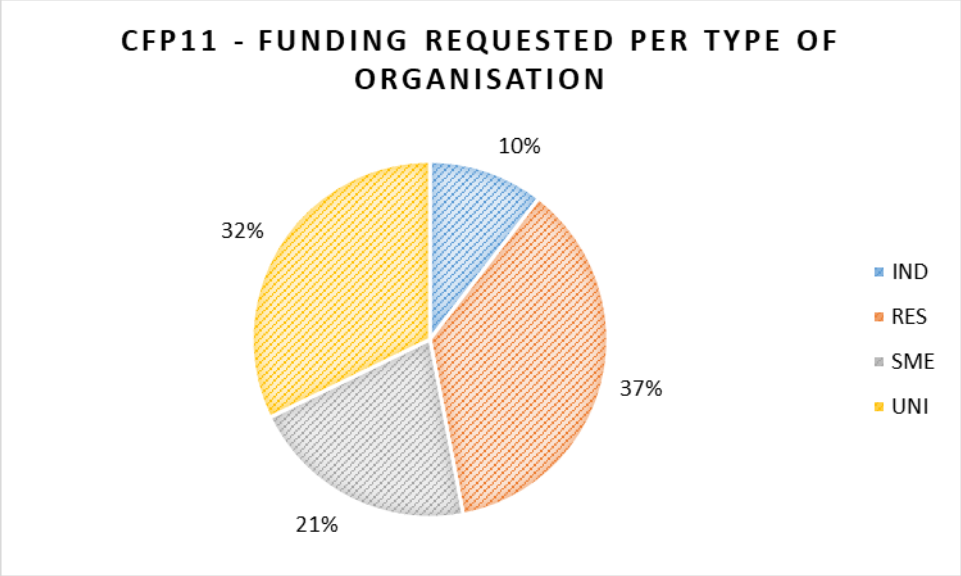
- 128 participations from 17 different countries;
- SME participation: 31%;
- 128 partners selected.



CfP11 winners – Number of participations per country



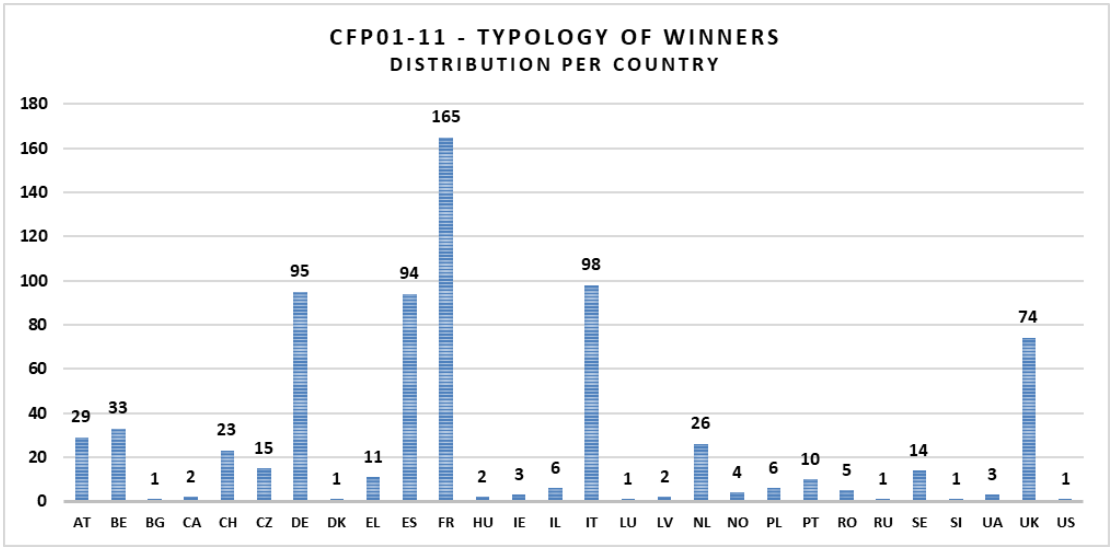
CfP11 winners – Funding requested per country

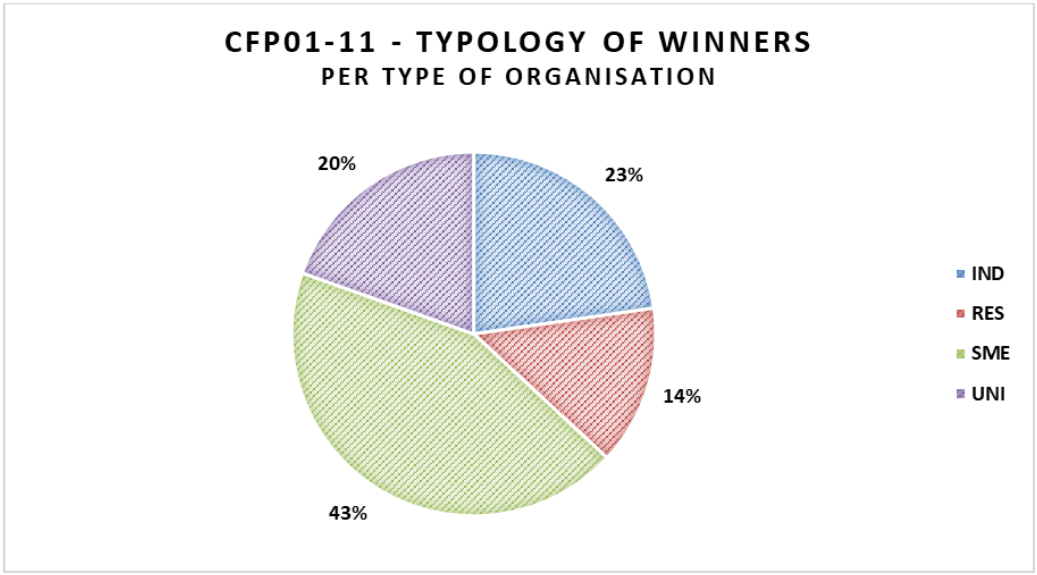


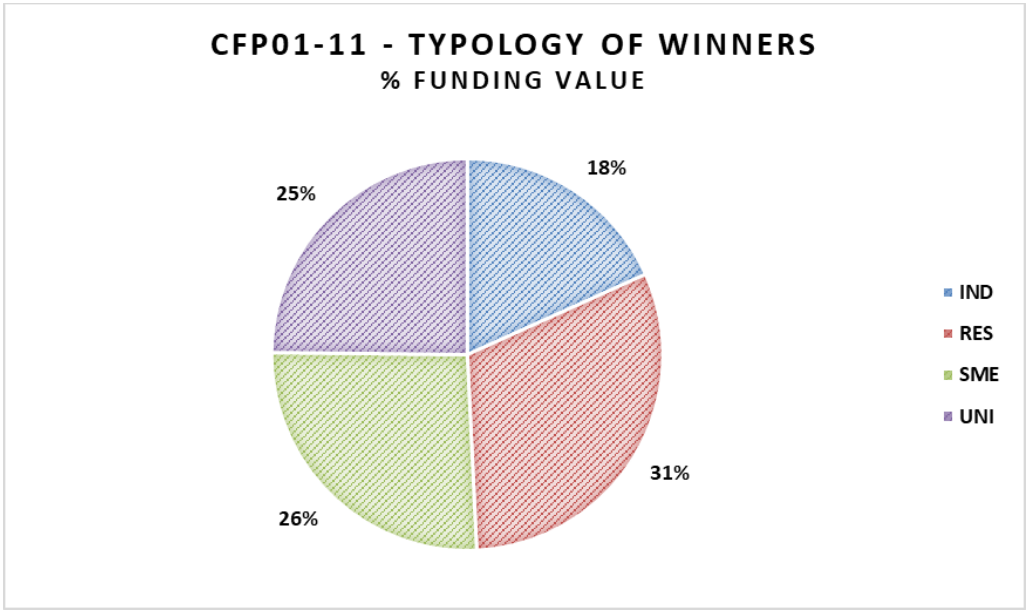
CfP11 winners – Funding requested per type of organisation

Cumulative position of the calls for proposals

In total, eleven calls for proposals were launched and evaluated over the lifetime of the Clean Sky 2 Programme, and all are now fully implemented. Altogether, these eleven calls are already engaging more than 726 partners from 28 different countries with a strong SME involvement in terms of participation and grants awarded: SMEs make up 43% of the partners selected, requesting 26% of nearly €538 million in EU funding launched via the eleven calls for proposals.




CFP01-11 - TYPOLOGY OF WINNERS
PER TYPE OF ORGANISATION
20%
23%
14%
43%
IND
RES
SME
UNI


CFP01-11 - TYPOLOGY OF WINNERS
% FUNDING VALUE
18%
25%
31%
26%
IND
RES
SME
UNI

Cumulative position of Clean Sky 2 participants

With a total of fifteen calls (four calls for core partners and eleven calls for proposals), the Clean Sky 2 Programme has created a meaningful relationship with more than 900 participants (including the 16 leaders and their affiliates) and has attracted more than 1880 participations in total, demonstrating a dynamic and open system that has created a wide array of opportunities at various project (funding) size and engagement levels for all potential stakeholders.

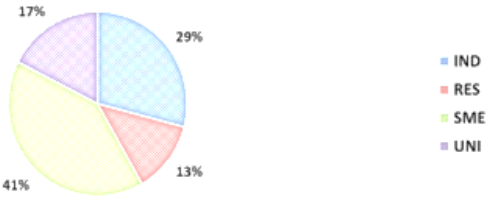
Overall Participation in CS2

Winning Proposals [CPW01-04 and CfP01-11]*

	LPA	REG	FRC	AIR	ENG	SYS	TE2	THT	TOTAL
IND	93	25	37	103	63	83	0	7	411
SME	111	28	42	124	47	76	14	19	461
RES	146	34	51	142	48	95	10	29	555
UNI	130	25	25	93	73	53	8	52	459
TOTAL	480	112	155	462	231	307	32	107	1887

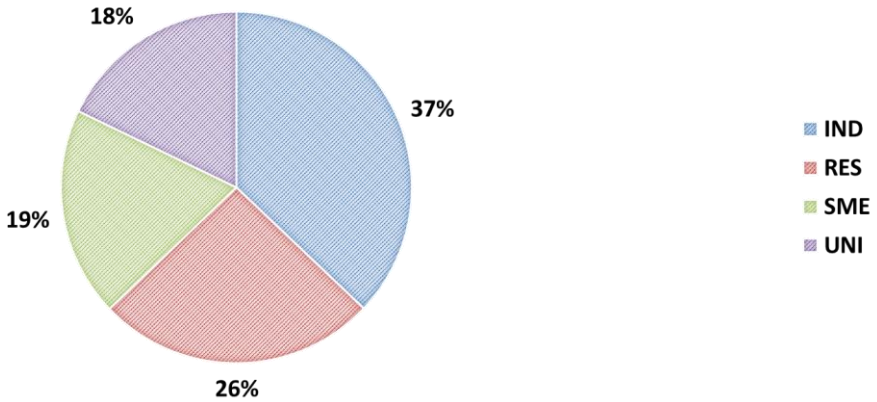
Total number of **single** entities**: **893** from **30** countries

PARTICIPANTS PER TYPE OF ORGANISATION (SINGLE ENTITY)
CPW01-04 AND CFP01-11



*Participations in CfPs and CPWs, based on the proposals details. Leaders' actions not accounted.
** Multiple winners in CfPs and CPWs removed. Leaders' actions not accounted

FUNDING REQUEST PER TYPE OF ORGANISATION
WINNING PROPOSALS [CPW01-04 AND CFP01-11]



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

In 2020, the evaluation of the last call of the Programme was completed, namely the CfP11:

Call	CFP11
No. of Experts[7]	101
Gender Balance [% Female]	20%
Nationalities [%]:	
France	16%
Germany	9%
Italy	19%
Spain	8%
UK	9%
Others	33%
Type of Organisation [%]	
Consultancy firms	0%
Higher Education Establishments	35%
Non-research commercial sector incl. SMEs	36%
Private Non-profit Research Centres	14%
Public Research Centres	2%
Others	10%
No. of Days claimed[8]	697
No. of Observers	2
New wrt H2020 [%]	6%
Newcomers in CS call evaluation (last 3 years) [%]	9%

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 2020 remained at a very good level and stayed below the KPI of 1%.

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

1.5. Progress against KPIs/statistics

The key performance indicator results for the year 2020 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 regarding 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 2020 are highlighted below.

➔ **LPA – Large Passenger Aircraft IADP**

Summary of activities and progress of work in 2020

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

Platform 1: Advanced Engine and Aircraft Configurations

Platform 1 continued the development of the environment required for the integration of the most fuel efficient propulsion concepts into compatible airframe configurations, targeting next generation aircraft. Overall, the propulsion concepts considered in Platform 1 range from Open Rotor engine architectures to advanced Ultra-High Bypass Ratio (UHBR) turbofans 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 kept being investigated to further increase the propulsive- and airframe efficiency.
In the context of improved engine performance and novel system architectures, detailed studies for *Non-Propulsive Energy Generation* (NPE) were performed to reduce the power off-take level from turbofan engines for improved thermal efficiency. These actitivites were carried out in alignment with ITD Engines activities.
The maturation of the hybrid laminar flow control technology (HLFC) applied on tails and wing for skin-friction drag reduction continued.
The development of the actual flight-test vehicle made good progress towards the preparation of the flight test, together with the design of the novel aircraft configuration planned to be tested in flight.

Platform 2: Innovative Physical Integration Cabin – System – Structure

Platform 2 continued to develop, mature, and demonstrate an entirely new and advanced fuselage structural concept in full alignment with the next-generation cabin and cargo architectures, including all relevant aircraft systems. To be able to account for the substantially different requirements of the test programmes, the large-scale demonstration received contributions from a number of demonstrators, covering the *Next Generation Fuselage Cabin and Systems Integration* in the frame of the *Multifunctional Fuselage Demonstrator* and the *Next Generation Cabin and Cargo Functions*. These major demonstrators were supported by a number of smaller test rigs and component demonstrators in the preparatory phase of the programme. With a goal of accomplishing technology readiness up to level 5, manufacturing and assembly concepts for the next generation integrated fuselage-cabin-cargo approach were developed and demonstrated. The activities for the demonstrators were supported by non-specific cross functions activities, implemented across both the IPAD LPA and the ITD Airframe.

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

In 2020, the IADP LPA platform 3 activities focused on progressing the maturation of the functions and technologies contributing to the *Large Aircraft Disruptive Cockpit*, *Regional Aircraft Active Cockpit* and *Business Jet* ground demonstrators, and continuing their integration and tests within the different aircraft demonstrators. It is worth mentioning some of the following achievements: flight tests or ground tests for selected cockpit-avionics functions and technologies performed on large aircraft and on business jet, the *Pilot Monitoring System* (PMS) successfully passed its CDR by the end of the year on the regional active cockpit demonstrator. The deliveries of hardware test items for individual integration into the demonstrators have been performed. The *Active Cockpit Demonstrator* is ready to support the final integration activities and human factors (HF) assessment of workload reduction technologies.

Main achievements in 2020

Platform 1: Advanced Engine and Aircraft Configurations

Overall good technical progress was achieved in 2020 despite the Covid-19 crisis (wave 1 and beginning of wave 2) with some delays. The Clean Sky 2 Development Plan was updated reflecting some strategic changes linked to the Covid-19 impact (e.g. discontinuation of *EFAN-X* and re-alignment of the strategy towards zero emission aircraft concept). The progress along the different demonstrators is detailed below.

Advanced propulsion and engine technologies

During the engine generation N+2 benchmark in Q2 2020, the analysis results showed less promising results for BLI (D14) than initially foreseen, leaving the *Open Rotor* and the *UHBR 2030+* leading the race. As a consequence, it was decided to increase efforts on the enablers for *Open Rotor* (D01), in order to secure the TRL3 in 2022. Progress was made on blade design, engine vibration related noise (EVRN), aerodynamic A/C maturation and light weight shielding. A kick-off meeting took place with Airbus and Safran to address cooperation on EVRN. On NPE (D15), a critical design review took place covering the gear box, electrical machine, power

electronic. Regarding *UHBR Short Range Integration* (D13), progress was made on technology bricks such as those supporting the development of critical UHBR integration technologies focused on SMR: design specificities wing close coupled pylon, and innovative TRU, with a concept down-selection made end of September. Concerning the SAAFIR test bench, the activities related to the fan design could mature. Due to Covid-19 and the resulting reduced availability of people, the beginning of the critical design review was shifted from 2020 to 2021. The 2030+ engine technology bricks were delayed due to Covid-19 in almost all activities. Up to the end of December, the impact of those delays have been closely monitored to ensure that the final objective is reached by the end of the programme. The contribution of CfP partners' activities was consistent with the work plans, where some had minor (COVID-related) delays, but were non-critical. Concerning *Common Engine Techno Bricks* (D16), and in particular the low pressure system demo (TRL5), Poland test facility validation as well as test rig design review were completed. On acoustics, the data from the Polish test facility validation test was acquired in order to enable post processing. Regarding the liners test, they were completed under cold flow conditions. For the thermal optimisation, a multi-disciplinary approach was validated.

Advanced Rear End

For the *Advanced Rear End* (D02), due to the Covid-19 crisis, the TRL3 had to be shifted from Q4 2020 to Q1 2021. In the meantime, progress has been made on manufacturing tools and hardware elements to be integrated by CfP partners. The plan remains to reach TRL6 on critical components by the end of Clean Sky 2.

Scaled Flight Test Demonstrator (SFD)

On the *Scaled Flight Test Demonstrator* (D03), hardware elements were delivered and assembled on the aircraft platform. Due to Covid-19, the verification/validation activities were delayed; the first flight tests that should have taken place in December were postponed to Q1 2021.

Radical Aircraft Configuration

On the *Radical Aircraft Configuration Demonstrator* (D08), significant progress was made to provide confidence and to de-risk a radical configuration for an advanced small/medium range (SMR) airliner for the 2035 timeframe. By the end of September, the feasibility review had confirmed the possibility to adapt the existing *Scaled Flight Test Demonstrator* into a *Distributed Electric Propulsion Scaled Flight Test Demonstrator*.

Laminarity

The *Hybrid Laminar Flow Control (HLFC) on Wing Demonstrator* (D06) successfully passed the TRL3 in October, with 6 months' delay, mainly due to the crisis. Concerning *HLFC on Horizontal Tail Plane* (HTP) (D04) and the large scale demonstrator, good progress has been made on the assembly process, tolerance management (including steps and gaps), compressor and water uptake, all of which were finalised in Q4 2020. A TRL 5 review is planned in first half of 2021.
For the NLF on HTP (D05), the negotiations to attract a partner to take over the activities that ended in 2019 did not succeed. This means that the target TRL5 for those activities (assembly, quality surface measurement, assessment) on a NLF HTP representative demonstrator will not be achievable.

Active Flow Control
The *Active Flow Control* (D11) progressed well, with some completion of WTT activities.

Active Vibration Control Technologies
For the *Active/Passive Solutions for Vibration and Noise Control Demonstrator* (D12), the end of the partner activity could be reached with a final efficiency assessment. The correlation between test results and prediction particularly at a low pressure gradient and low flow velocity showed satisfactory results.

UltraFan®
Regarding the UltraFan® Flight Test Demonstrator (D10), Rolls-Royce continue to plan for flight testing of the UltraFan® in 2024, even with the impacts from Covid-19. At aircraft integration level, the nacelle integration preliminary design review was held on May 2020. The nozzle rig testing was successfully completed, and the pylon detail design launched. The first air inlet part was manufactured and delivered. In parallel, the acceleration of technology bricks for early exploitation (application LR TRL6 Q1-2022), as well as the NLF inlet with pNAI (pneumatic anti-icing) lip-liner, and also the nacelle acoustic liners (WTT at ONERA also requested and under evaluation), could progress.

Hybrid Electric Propulsion
Regarding the *Hybrid Electric Propulsion System Demonstrator* (D09), on April 2020, Airbus and Rolls-Royce officially announced the closure of the flight demonstrator project E-Fan X. For both partners, all research efforts are now focused on development of technology bricks that would help in decarbonising the aviation industry.

As a consequence:

1) Airbus reviewed and assessed all potential solutions for electric propulsion systems, which had been investigated up to now, and proposed adaptations at the technology brick level, which will be essential to meet the key objectives of sustainable aviation, i.e. zero-emission aircraft.
2) The original Rolls-Royce scope and ambition i.e. delivery of an electrical machine and power electronics for power generation system ground testing were unchanged, albeit delayed due to the findings/learning from initial component testing, and the impact of Covid-19.

<u>Platform 2: Innovative Physical Integration Cabin – System – Structure</u>

Within the Next Generation Fuselage, Cabin and Systems Integration work package, the activities in 2020 were based on the outcome of the CDR in November 2019. This enabled the commencement of the transition to the real hardware phase of the project. During the reporting period the interdisciplinary design activity continued in parallel to the manufacturing trials and resulted in some real part manufacturing, depending on the results of trials and associated material testing.

All activities were impacted by Covid-19. Engineering work continued in a more or less virtual environment. The most severe effect was on laboratory and manufacturing activities, which

made it necessary to re-plan certain work packages. In terms of technical achievements the acquisition of production tools went on with the continuation for small and medium size tooling as well as with the procurement for the upper/ lower shell skin moulds. First demonstration parts like stringers, frames, beams and skin panels have been already produced in manufacturing trials to prepare the production process for the real demonstrator parts. This also concerns parts for the integration and demonstration of the cargo door, where a specific design review paved the way for the production start. The engineering tasks were progressed in specific working groups to further refine the digital mock-up (DMU) and to integrate the outcomes from manufacturing test as well as from material tests into appropriate design principles. Especially on the chosen thermoplastic material LM-PAEK all partners have been provided with the needed amount of raw material to perform manufacturing of specimen and mechanical testing.

Regarding the Next Generation Cabin and Cargo Functions work package, the following progress was made:

- a test specimen for a customised Passenger Service Unit (PSU) was made available for passenger service channel integration;
- integration of cabin and systems components to assess the feasibility of a zero customisation approach at airframe as an industrial approach;
- completion of the digital design and the simulated integration of the equipped large crown module demonstrator including a (semi-) automated pre-assembly and integration of new large cabin modules – this proved the ability to automate the assembly of standard-substructure-components whereas complex assembly-processes for systems-integration should be done manually;
- the decision was made to accelerate two major technological bricks enabling fuel cell application from 2021 onwards as an optimised power supply solution;
- the Universal Cabin Interface (UCI) became ready for demonstration in a near-production environment – the UCI concept (centralised software platform enabling functions, content and data everywhere) was integrated in the future-industrial-line-demonstrator, ready for environmental testing and validation/verification campaign;
- completion of both cargo fire tests in a real burn chamber and in-house tests for the verification of the *Environmental Friendly Fire Protection Demonstrator*;
- testing of material combinations and environmental impact studies on the printed electrics system concept together with the development of design rules to make it compliant with the existing electrical infrastructure and industrialisation aspects – the customised electronics were embedded into the décor surface and the technology was validated via the validation platform with a preliminary automated productions demonstration;
- demonstration and installation of the automated cabin and cargo lining and hat-rack installation method performed in-situ by CfP partners.

Regarding the Next Generation Centre Fuselage work package, the decision was made by Airbus to stop the project as part of a strategic re-orientation to support projects with higher impact in the context of Clean Sky 2.

Within the Non-specific Cross Functions and ITD Airframe work package, all contributing activities to building the demonstrator reported above continued (with a reduction of recurring

cost-lead time – environmental impact on materials for composite assemblies, sensing technologies for manufacturing composites and metallics, a design tool for multi-scale complex structures). The Covid-19 impact induces prioritisation of R&I activities by rescheduling vibration sensing technology development. Therefore the focus in 2020 was more on the development of a digital solution representation of the airframe or one of its components, enabling prediction of the fatigue behaviour for a concurrent loads. It will reduce inspection tasks load-reducing test costs and lead time.

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

Regarding the activities related to the *Large Aircraft Disruptive Cockpit Demonstrator*, the progress made to date is listed below.

- The development of cockpit avionic functions and technologies continued. The GPS-aided MEMS AHRS prototype flight test data collection campaign took place, and open loop simulations were performed. The virtual platform core processing module was delivered for applications integration. The smart air system sensor interface with the utility system platform has been developed up to TRL3.
- The LIDAR flight test installation was completed and dry air flight tests have taken place, ready for an icing conditions flight test campaign in 2020. The software defined radio (SDR) flight test preparation was completed.
- New models such as fuel and engine systems models as well as the first part of the integrated system management system were successfully integrated on the test bench devoted to systems integration (DiscoBench) together with three new incremental versions of the flight management and interactive displays function. The validation of the ATN-IPS function and the preparation of the SDR integration were completed.

Regarding activities related to the Regional Aircraft Active cockpit demonstrator, the following progress was made:

- completion of the definition and design of the pilot workload reduction enabling functions and technologies;
- *Pilot Monitoring System* (PMS): CDR passed and stress model developed and validated;
- *Voice Command* (VC): development completed and start of the integration of the first prototype into the active cockpit simulator;
- Readiness of the *Active Cockpit Demonstrator* (after successful assembly) to support the final integration and human factor evaluation of each of the workload reduction technologies being developed such as the enhanced lightweight eye visor (ELWEV).
- The *Aircraft Monitoring Chain Ground Support System* (AMCGSS) is in its very final integration stage, almost ready to start with the human factor assessment. Covid-19 restrictions affecting access to facilities delayed the final integration.
- *Cockpit Automated Procedures* (CAPS) function standalone testing is finished and its integration phase is its very final stage.

Regarding activities related to the ground and flight tests demonstration for Business Jet, the progress made to date is listed below.

- The monitoring of the pilot fatigue state progressed thanks to the use of a multi-sensor

approach. The algorithm detection on sleep and state of drowsiness in pilots was improved thanks to data acquired on a ground simulator or in flight. TRL4 was successfully passed at the end of 2020.

- Good progress in the field of the utility building blocks integration for cockpit towards the system integration objective: PCB boards design freeze, manufacturing, software and hardware implementation, rack packaging design, software and testing of the configuration tool framework. The TRL4 system integration gate was passed at end 2020.

With respect to the end-to-end maintenance demonstrator (ADVANCE), the last contributing partners' activity was successfully completed. This work package project has been formally closed and the last deliverables were achieved on time by September 2020. The ADVANCE final and closure report has been updated with the latest PACMAN achievements.

Implementation of complementary grants awarded through call for proposals

During the period, 81 Grant Agreements for Partners awarded from Call 1 to Call 09 were active and 32 new ones were implemented in 2020, as an outcome of the selection of projects from Call 10 and Call 11. All these projects are complementing the activities implemented in the LPA IADP Grant Agreement for Members and are contributing to results described above.

➔ **REG – Regional Aircraft IADP**

Summary of activities and progress of work in 2020

Regional Aircraft IADP activities related to green conceptual aircraft continued during 2020, confirming the ambitious environmental targets established in the initial phase of CS2 program. The activities related to technology maturation completion and to the design of demonstrators achieved very important progress with the detailed design phase completed for all full-scale demonstrators – CDRs passed by the FTB1 demonstrator, the *Pax Cabin Ground Demonstrator*, *Wing Ice Protection System* (WIPS) and *Innovative Propeller*.

The manufacturing and assembly of full-scale demonstrators achieved substantial and valuable progresses too, such as:

- FTB2 wing structural modification of demo aircraft completed; manufacturing of central wing box on-ground demonstrator completed;
- five composite stiffened large panels manufactured for the *Fuselage Structural Demonstrator*, in synergy with Airframe ITD;
- manufacturing completed for the skeleton and several test benches of the *Iron Bird* and installed in lab facility of this ground demonstrator;
- important steps achieved for the manufacturing/assembly tools of the fuselage and outer wing box (OWB) on-ground demonstrators.

The impacts of Covid-19 outbreak were promptly and continuously assessed during the year; they were mainly regarding delays. Recovery actions for 2020 tasks were implemented enabling the above achievements to be reached within the year. Some key deliverables, related to the innovative wing tip experimental ground validation, engine mounting system ground demonstrator and ECS model for pax cabin demonstrator were re-planned and a recovery plan

was established with the aim to ensure delivery in 2021. It also includes the assessment results of impacts (4-months' average delay for full scale demonstrators) caused by the Covid-19 outbreak. Thanks to schedule margins allocated in the REG IADP planning since the beginning of the programme, several final demonstrations are still expected by the end of year 2022, while others will conclude in 2023 well within the CS2 timeframe for technical activities completion.

Major achievements in 2020

High Efficiency Regional Aircraft (WP1)

The main achievements for the green concept regional aircraft studied in this workpackage are summarised below.

- TP90Pax Regional Aircraft Conventional Configuration: Power plant requirements for the conventional final platform (Loop 3) were issued. Within Loop 3, relevant modifications for this aircraft configuration will come from WP2.3.6 *Innovative Propeller*. During 2020, support for propeller down-selection of the innovative low noise propeller was provided.
- TP130Pax Regional Aircraft Innovative Configuration: A wind tunnel testing campaign was completed using a small model with movable flap and tail (elevator and rudder). A final version of the deliverable *Small Scale Lateral Wind Tunnel Test* was released, which also includes the control of aircraft performance. The activity stopped at TRL3.
- Hybrid-Electical Regional Aircraft Configuration (40Pax class): A first study for the architecture with wing tip electric motors was performed and the deliverable containing a detailed assessment of this configuration was issued. A second study was started relating to a regional aircraft configuration with distributed electric propulsion (DEP) on the wing.
- Multimission Aircraft, 70 Pax class: contribution to the TE First Technology Assessment was provided, based on the developed methodology of noise evaluation with due consideration of cross-ITD/IADP contribution across Clean Sky 2 to FTB2 platforms and the adequate mission average mix. All Clean Sky 2 objectives were achieved.

Technologies Development (WP2)

The main achievements for the innovative structural technologies of the adaptive wing are summarised below.

- Material and process technologies development – A manufacturing trial of mono-stringers made up of multiaxial dry materials was fabricated to assess infusion circuit concept and process parameters; non-destructive and destructive characterisation on specimens extracted from manufacturing trials were executed for internal quality verification. The manufacturing of the large curved stiffened panel in liquid resin infusion (LRI) was completed and dummy ribs have been also assembled to the panel.
- Structural tests: The correlation of analysis prediction and results of LRI stringer run-out tested under tension load was completed; the manufacturing of LRI lower configuration stiffened panels started. The manufacturing of the wooden fixtures and metallic potting frames for impact and compression testing of the LRI large panel was completed; testing setup for the LRI spar section was completed by AG2; test design of the LRI curved stiffened panel and of the LRI rib was started.

The main achievements for the innovative air vehicle technologies of the adaptive wing are summarised below.

- Morphing concepts – structural ground demonstrators: *Advanced WingLet* (AWL) manufacturing and test set up was completed and structural tests started. Multifunction trailing edge (MTE) and innovative wing tip (IWT) demonstrator manufacturing progressed.
- Load control and alleviation-aeroservoelastic wind tunnel (WTT3) for control laws validation: Test started.
- Large low speed wind tunnel model (WTT1): model completed, shipping to WT facility postponed due to Covid-19.
- Large high-speed wind tunnel model (WTT2): wing box model manufacturing and morphing concepts models manufacturing progressed.
- Morphing devices high order multibody modelling: modelling completed, initial predictions of ground tests in progress
- Future electric wing monitoring system demonstrator for compliant structures: electronic design finalised, manufacturing and implementation of demonstrator completed.

The Integrated Vehicle Health Management (IVHM) framework software was released.

The main achievements for the on-board systems technologies are summarised hereafter:

- the CDR for the innovative *Wing Ice Protection Demonstrator* (WIPS) was performed and the WIPS TRL 4 assessment review was done;
- Manufacturing progressed for the equipment parts of the electrical landing gear (ELG) system; ELG test rig parts (dummy landing gear, counter load system) were manufactured;
- The advanced EPGDS achieved significant progress through the relevant CfPs' partner's contribution with the finalisation of critical designs and progress of manufacturing. For the ECS, the test objectives and interfaces were defined. The innovative propeller wind tunnel has been selected and the CDR was achieved; finally, the wind tunnel test models manufacturing started.

The main achievements for the flight control system and electro-mechanical actuation (EMA) are summarised hereafter: TRR for aileron, winglet and wingtip EMAs were successfully closed; aileron EMAs were manufactured; winglet and wingtip EMA parts were manufactured.

Demonstrations (WP3)

Adaptive Wing Integrated Demonstrator: Flight Test Bed 1 (FTB1) and Outer Wing Box (OWB)

- FTB1 Demonstrator: The detailed design of the aircraft experimental modifications which will be introduced on the flying test bed aircraft in order to install the innovative movable surfaces (*Morphing WingLet* and *Innovative WingTip*) on the wing tip were finalised. The aircraft experimental modifications critical design review was successfully passed, providing evidence that critical aspects of the design were properly assessed through analyses, simulations, schematics, drawings and with acceptable technical risks. This allowed the project to proceed with parts fabrication and components/equipment purchasing.
- OWB Ground Demonstrator. The update of OWB demonstrator CATIA parts related to ;iquid resin infusion upper and lower panels including features needed for assembly tolerance

management with partners was completed. Check and integration of model tools has also started. The fabrication of the tool chain for the upper panels manufacturing is almost completed. The purchase order for the lower panel tool chain fabrication was placed. The update of OWB demonstrator CATIA parts related to spars and ribs following design iterations was completed; tolerances and annotations on spars and ribs digital mock ups respectively progressed. The design of the respective layup and curing tooling for spars was completed and the spars tooling NC programming progressed.

Fuselage / Passenger Cabin Demonstrators

Five full-scale composite stiffened panels of the *Fuselage Structural Demonstrator* were manufactured in synergy with AIR ITD – WP B-4.3 with an automated lay-up system. Manufacturing of tools for fuselage structural items fabrication started in the framework of relevant CfP projects. Good progress was achieved for the assessment of possible impacts on the major cabin items design for the implementation of the vibro-acoustic actuators in the demonstrator for the second testing comfort phase. The full-scale *Pax Cabin Demonstrator* critical design review was held. The installation drawings for the cabin demonstrator ancillary systems in the testing lab were initiated. Test requirements for the cabin demonstrator testing phase were set out together with the major stakeholders. A lab-scale demonstration was performed for the NDI method.

Iron Bird Demonstrator

Once the architecture was fully finalised, the manufacturing of the components started. Good progress was made regarding the manufacturing of parts with the completion of several items that were also delivered and assembled in the Iron Bird facility, such as the skeleton, the aileron test bench, the winglet test bench, the wingtip test bench.

The software models were completed in standalone mode, and their real time conversion is in progress, aiming to be completed soon to proceed with the verification tasks. The electrical components manufacturing/procurement also achieved significant progress.

FTB2 Demonstrator

In 2020, activities were focused on three main topics as laid out below.

- Completion of high Reynolds wind tunnel test campaign in ONERA F1 facilities with regional FTB2 Step 1 configuration (power – off conditions). Experimental results matching CFD and Reynolds effects show proper tendencies to achieve experimental permit to fly. Tests were done with a model prepared in collaboration with partners that provided valuable experimental data to ensure the aerodynamic shapes of the new innovative control proposed for the in-flight demonstrator.
- The on-ground actuation rig activities made progress (major demonstrator from AIRFRAME ITD closely linked to FTB2). TRR (Test Readiness Review) was achieved and validation campaign of handling qualities, flight control laws and crews were performed;
- Progress was made towards the permit to fly clearance with airworthiness authorities for Step 1 configuration. Discussions on compliance check list are close to the end.

FTB2 modifications started reaching the milestone of first assembly of wing structural components. The FTB2 fuselage modification (cockpit controls, electrical and hydraulics) achieved good progress and on-ground tests are planned for the next period in 2021. Regarding

the ground demonstrator within WP3.5, the centre wing box demonstrator was completed achieving another important milestone in the maturation of the flexible jig concept, which partially builds up in the jig-less concept explored in the aileron assembly. In the case of the centre wing box demonstrator, it was possible to validate the applicability of these technologies to very large components (11m span). These achievements were shared in an open workshop in November. Progress was also made in the engine mounts demonstrators with the manufacturing of their elementary parts. The engine mounts demonstrators suffered relevant impact from the Covid-19 crisis and will be integrated into the centre wing box in the first half of 2021. The activity on the external wing demonstrator was slowed down. However, it was possible to continue activities in the flexible clamping concept that will be applied in the manufacturing of the elementary parts of the inner external wing demonstrator.

WP4 – Technology Development / Demonstration Results Evaluation

- Delivery of the two aircraft model concepts (90 & 130 seats, reference and green A/C) to the Technology Evaluator, and contribtion/support to the TE First Assessment.
- Review of flagship demonstrators contributing to Eco-TA activities and updated life cycle inventory (LCI) data delivered to Eco-TA (Stage 0 activities related to the replacement of hard chrome plating on steel and liquid resin infusion for the composite outer wing box).

Implementation of complementary grants awarded through call for proposals

During the period, 22 Grant Agreements for Partners awarded from Call 1 to Call 09 were active and 4 new ones were implemented in 2020, as an outcome of the selection of projects from Call 10 and Call 11. All these projects are complementing the activities implemented in the REG IADP Grant Agreement for Members and are contributing to results described above.

➔ FRC – Fast Rotorcraft IADP

Summary of activities and progress of work in 2020

The NGCTR technology demonstrator (WP1) successfully held all the planned subsystem critical design reviews during the year and its aircraft critical design review in December. The risk assessment was updated following the Covid-19 crisis outbreak in March, steering the programme scope for the rest of the year towards tasks strictly related to TD critical path in order to protect programme long term objectives.

Within the RACER compound demonstrator (WP2) activities, the release of drawing has continued according to the schedule. Furthermore, the manufacturing of a major sub-system progressed in 2020. Key ground test benches were also run (e.g. lateral shaft dynamics, electrical generation and distribution systems, systems integration rig) or prepared (e.g. main gearbox bench adaptation module). Due to the Covid-19 impact, the RACER master plan was revised (manufacturing phase impacted) leading to the postponement of the first flight to 2022.

Major achievements in 2020

NextGenCTR (WP1)

- Management, coordination and design integration: The integrated master schedule of NGCTR TD was continuously monitored with regular reviews with each contributing party (technical leaders, manufacturing engineers, partners). The technology demonstrator CDR at aircraft level was successfully held in December. The aircraft final architecture (as proposed at CDR) confirms the expected operational and safety requirements without any major issue either on first flight or the subsequent flight envelope opening and expansion. The CDR proved that the technology demonstrator (TD) design was mature as required to launch aircraft manufacturing, assembly, integration and test.
- Tiltrotor system design: Assessment of TD performance, exploring the flight envelope and identifying the potential capabilities was done. Assessment of TD aeroelastics features was done resulting in no criticalities on the wing. Assessment of actuating system loads with completion of the formal verification for aileron and ruddervator surfaces was performed for the CDR.
- Transmissions systems: Drive train PDR was performed in April 2020, with a new configuration designed to comply with the weight target assigned at TD preliminary design review (PDR) in 2019. Detailed design started thereafter, with the concurrent involvement of manufacturing, engineering and procurement. Supply of long lead time items (e.g. raw materials, castings, forgings) were initiated.
- Rotors systems: Design of the longitudinal and lateral swashplate arms progressed on schedule with a focus on clearing any potential interferences between rotors and flight controls. The design of the above items as well as the others with the new design for the TD was finalised to the level of subsystem CDR, successfully held in December.
- Airframe structures: Structure design progressed across the FRC IADP and AIR ITD. All of the major structural components, including the nacelle under the TRAIL project, reached the required CDR maturity level by November 2020. Concerning the wing, a manufacturing technique to obtain the spars integrated with upper panel and curved spar was developed. Movable surfaces were also designed together with relevant driving and locking mechanisms. Concerning aerodynamics, a 2D wind tunnel model for dynamic aerodynamic measurements has been manufactured.
- Electrical and avionic systems: Electrical and avionic system CDRs were successfully held. Release of electrical drawings continued for aircraft equipment layouts/installations, including wiring diagrams and cable assemblies. Hardware selection of flight control systems (FCS), remote electronic units (REU) and active inceptors (AI) was completed. Development of the FCS core computing unit was continued. The engine SW model was integrated , along with the FCS control laws baseline 2.0 and aeromechanics database model, into the first pilot-in-the-loop simulation environment representative of the TD.
- Airframe systems and final assembly: Achievement of the design for subsystems up to CDR maturity level for environmental control systems, hydraulics and related basic systems. Design also progressed to a satisfactory level for the engine mounts' system compatible with transmission angular and axial misalignment requirements. Fuel tanks and fuel distribution system CDRs were passed, followed by the complete fuel system CDR in November.

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

The progress on the RACER demonstrator project is given along the four multifunctional Technology Areas. In 2020, the main focus was on the manufacturing of relevant sub-system activities following the closure of the CDR in 2019.

RACER flight demonstrator integration

Activities in 2020 were mainly focused on the closure of interfaces to assure the integration of the different sub-systems. Drawings release acceleration has also been a key 2020 priority, so as to launch as many manufacturing activities as possible. Prototype activities have been continued in preparation for the manufacturing and assembly of the demonstrator. The manufacturing of RACER parts (e.g. central fuselage, tail, wing, panels, lateral gear boxes, etc.) were impacted by the Covid-19 pandemic with the closure of industrial plants and/or reduced capabilities across the EU (3 to 4 months of non-recoverable delay). It led to a reorganisation of the prototyping activities (assembly logic reshuffling and optimisation, work preparation for purchase and manufacturing of parts for the demonstrator). The preparation of the flight tests and the management of all ground tests to be performed for the permit to fly have also been started. The first flight has been postponed to 2022.

RACER airframe integration

The manufacturing of the central fuselage structure progressed and is almost finished. The manufacturing of all central fuselage primary elements, including several big primary structure metallic parts, was completed. Fuselage assembly jigs were also completed, and fuselage pre-assembly has started. The full central fuselage final assembly should be completed by February 2021. Assembly manufacturing and assembly of canopy and rotorless systems were finalised. All the parts of the RACER tail in particular were delivered and shipped, for the final assembly of the tail, and integration of relevant systems (e.g. antennae, harness, and a few other components). The development of landing system activities progressed as expected. The manufacturing of the landing gear legs/actuator systems major components is ongoing and ground qualification expectations for permit to fly (PtF) finalised. Concerning cabin and mission equipment, the crew's safety aspects (i.e. demoisting of windshields), and working condition regulations (i.e. internal noise) were pursued. Support from the National Activity project on new environmental control systems was obtained.

RACER dynamic assembly integration

Lifting and lateral rotors, design activities have been completed and the purchase of materials has continued. Also, reused main rotor components were reserved in the parts manufacturing flow. Detailed design for lateral gear box (mobility discovery) was completed, and manufacturing could be completed for a significant number of parts. Design of the main gear box (MGB) made significant progress. Manufacturing of MGB components (including wheels, housings, etc.) could be performed. A test plan for lateral gear box (LGB) has been defined and the MGB master plan of the TD has been revised to mitigate late delivery of LGB and MGB. While the development of MGB is still at risk, some recovery actions are ongoing. Concerning powerplants, the manufacturing of the fuel system is almost completed. The contribution of the national programme (engine adaptation for high voltage) made the first RACER engine run possible. The second engine components were manufactured, and assembly started by end 2020. Concerning the actuation systems of movable surfaces, recovery actions that were

implemented by the end of 2019 made good progress (in particular with a ground bench demonstration of a new flap actuator concept).

RACER on-board system integration

Key electrical equipment activities were completed by contributing partners and external parties (e.g. power converter, high voltage controller, starter/generator) and were shipped to the assembly 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. However, several CfP partners experienced difficulties linked to the Covid-19 pandemic, requiring adapation of the initial technical contribution envisaged. After deep analysis, the electrical architecture had to be changed at short notice, with additional work (e.g. principle wiring diagram, then detailed drawings…). The avionics system integration rig bench was continued in 2020, still with flight tests crew.

Eco-design (WP3)

The activity was focused on life cycle assessment (LCA) and environmental analyses. More in detail, preliminary LCA at entire RACER level was performed based on manufacturing and assembly processes, parts weight and materials, consolidated with data collected. Concrete implementation of ECO-related materials and processes took place in 2020. A new LCA software for ECO needs was used in support. Several selected sub-projects for ECO-TA related materials and processes are progressing well, across the demonstrator, and presented for selection (composite structures demonstrator, casted titanium, mechanical transmission surface treatments). Similarly, the strategy for the NGCTR Life Cycle Assessment was defined, and in coordination with all parties. It is worth mentioning that relevant flagship ECO-related demos with a focus on additive manufacturing for complex or primary structures or on out-of autoclave composite are identified on both demostrators. The main NGCTR sub-systems, confirmed as eco-related for their development activities performed in WP1, are as follows:

- airframe structures: upper skin highly integrated CFRP wing box;
- transmission systems: tiltrotor drive system main casing;
- airframe structures: tiltrotor nacelle structure.

Technology Evaluator (WP4)

Mission scenario and analysis approach have been defined; during 2020, further analyses were provided for NGCTR and RACER, based on selected missions typical for both aircraft and chosen technologies. The relevant data packs, for both reference and concept vehicles, were delivered and discussed with the TE. A collaboration with contributing CfP partners was established on both demonstrators. NGCTR TE first assessment was developed within the TE Transverse Area. The impact in terms of productivity and competitiveness of the NGCTR Tiltrotor Concept aircraft, which is subject to TE assessment, was continuously analysed vs. the concurrent evolution of NGCTR TD design. RACER first assessment was developed within the TE. As RACER is intended to be exploited first for emergency medical services and search and rescue, an analysis is ongoing to introduce more relevant indicators (e.g. long hover in mountain SAR, surface covered, time to hospital, tbc). The selected reference A/Cs as well as on-the-mission targets used for comparison with RACER and NGCTR are subject to discussions in the absence of existing references for comparison.

Implementation of complementary grants awarded through calls for proposals

During the period, 39 Grant Agreements for Partners awarded from Call 1 to Call 09 were active and 3 new ones were implemented in 2020, as an outcome of the selection of projects from Call 10 and Call 11. All these projects are complementing the activities implemented in the FRC IADP Grant Agreement for Members and contributing to results described above.

➔ **AIR – Airframe ITD**

Summary of activities and progress of work in 2020

Assessment of noise reduction due to an optimised scarfed nozzle concept has been carried out, as well as additional testing activities for cabin thermal modelling. Natural Laminar Flow progressed well with the exploitation of the wind tunnel test (WTT) carried out in 2019 on a Business Jet (BJ) mock-up and BLADE Flight Test (F/T) data analysis continuation. Manufacturing activities including tooling have started for the composite flaperon demonstrator, and assembly of structural door demonstrators was performed. Electrical wing ice protection systems (EWIPS) for BJ slats have been manufactured for testing in Icing Wind Tunnel. Manufacturing of BJ office cabin demonstrator items has started. Several critical design reviews (CDR) were closed allowing for the commencement of manufacturing and assembly phases: RACER's Wing, SAT optimised composite small scale integral demonstrators, Next Generation Civil Tilt Rotor subsystems and vertical tail plane (VTP), etc. FTB#2 Morphing Winglet flyable components have been installed on the aircraft. The icing wind tunnel test was completed for loop heat pipe ice protection systems. Lower skin with integrated spars and stringers was manufactured in liquid resin infusion for tooling. An embedded SATCOM antenna was delivered to REG IADP FTB#2 and SAT first 4 flight nacelle component trials on M28 aircraft were flown. Manufacturing in automated fibre placement technologies of side-shells for RACER was completed. EcoDesign progressed well with the definition of the 5 flagship demonstrators, completion of 25 eco-statements, and start of technologies down-selection. Collaborative robot (COBOT) for cockpit technology TRL6 assessment has been achieved.

Covid-19 impact

50% of deliverables and milestones initially planned for 2020 have been delayed to 2021, 50% of them scheduled for the first quarter of 2021. Main demos impacted: deliveries of flaperon, RACER's wing and rotorless tail, SAT optimised composite full scale demonstrator; delays on FTB#2 OoA composite wing box CDR and on the full scale demonstrator, and regional fuselage centre and cabin interiors' contribution to the full scale demonstrator.

Major Achievements in 2020

- **High Performance & Energy Efficiency (Activity Line A):**

Innovative Aircraft Architecture (Technology Stream A-1)

With respect to *Optimal engine integration on rear fuselage*, detailed investigations at aircraft level concerning the common inlet and side fuselage nacelle configurations have been conducted to prepare the configuration down-selection workshop. Concerning scarfed nozzle, the assessment of the noise reduction due to an optimised scarfed nozzle concept has been

realised.
With regards to *UHBR and CROR configuration*, activities have continued to study specific topics such as design/manufacturing and testing of innovative shielding and protections for uncontained engine rotor failure impact. On the open rotor, the partner activities on CROR engine debris impact came to an end and will be completed in 2021 for what concerns the assessment of impact and mechanical tests. In addition, for the activities related to aero-acoustic experimental characterisation of a CROR engine, WT tests are in advanced state of preparation. With respect to *Novel high performance configuration*, the assessment of the down-selected novel high performance configurations has continued to confirm the performance benefits with higher fidelity tools. For the small-middle range (SMR) mission, further progress has been achieved on the detailed wing shape/twist definition and meshing for the blended wing body (BWB) configuration to perform aerodynamic analysis. The preparation of the wind tunnel test (WTT) of the down-selected new business jet (BJ) configuration, i.e. large fuselage configuration, has started to be able to perform the tests in 2022. In parallel, overall aircraft design activities have been pursued on the same configuration (large fuselage concept) in order to further assess the overall performance and ensure the consistency between the WTT and the numerical activities.

Finally, with regards to the activities on *Virtual Modelling for certification*, activities have continued as planned for the six tasks.

- T1 External acoustic loads modelling: activities completed for loads modelisation with engine thrust reverser deployed and for modelisation of loads induced by near field jet noise.
- T2 Rapid dynamic / crash modelling for safety: initiation of the work involving a CfP partner project on test matrix for dynamic tests and simulation activities.
- T3 Safety for composite fuel tank for lightning: softare (S/W) development ongoing, and application on two case-studies, i.e. small composite box and composite wing.
- T4 Model based integrated systems analyses and synthesis: activities have restarted on the verification of fail-safe aircraft system architectures; a case study has been selected; the electrical power generation, distribution and conversion system; the development of the problem-solving model is in progress.
- T5 Prediction of aerodynamic loads at high Reynolds: the manufacture of the model was completed at the end of 2020. Instrumentation is ongoing, and WTTs are scheduled in 2021.
- T6 Cabin thermal modelling with a human thermal model: realisation of additional tests for improved dehumidification, different airflow split, transient mission profiles, local comfort means and effect of solar radiation. Refurbishment for first test series is completed and tests ongoing.

Finally, involvement of EASA has been agreed and is to be organised for each task in the course of 2021.

<u>Advanced Laminar airflow (Technology Stream A-2)</u>
With respect to *Laminar Nacelle*, activities have been dedicated to the design and validation of a structural concept of BJ laminar nacelle, with a particular focus on Hybrid Laminar Flow Control (HLFC) technologies. The exploitation of the WTT carried out in 2019 on a BJ mock-up incorporating the Natural Laminar Flow (NLF) nacelle and Horizontal Tail Plan (HTP) has been

completed.
Within *NLF Smart Integrated Wing*, BLADE F/T data analysis has been continued (a workshop between BLADE partners has been held at the end of the year), in conjunction with additional developments to further mature NLF concepts. In particular, two WTTs are under preparation for late 2021, the first one being focused on an analysis of surface default effects and unsteady transition location measurement in transonic conditions on a 2D laminar airfoil, and a second one on the study of a high aspect ratio laminar wing at low speed.

The activities related to *Extended Laminarity* have been continued to develop innovative Hybrid Laminar Flow Control (HLFC) concepts such as:

- Chamberless design concept: ground demonstration consists in a WTT on a HLFC leading edge segment of which manufacture and assembly have been completed by end 2020 in close collaboration and coordination with CfP partners;
- Combination of an Anti-Contamination Device (ACD) and a suction device: a synthesis report was issued at the end of 2020 giving the analysis of previous WTT; 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 & Low Speed*, manufacturing activities including tooling have started for the composite flaperon demonstrator, and for the spars of the composite wing root box (WRB) demonstrator. For the latter case, testing on components is ongoing. The activities related to *Tailored Front Fuselage* have been focused on one hand on finite element (FE) model exchanges between the airframe manufacturer and windshield manufacturer – the windshield model has been successfully integrated into the airframer's design loop – and on the other hand, on the exploitation of icing and water accumulation tests performed on windshield samples. With regards to *Innovative Shapes & Structure*, following the CDR of the cargo door demonstrator carried out in 2019, manufacturing activities are ongoing in coordination with LPA IADP WP2 for the multifunctional fuselage demonstrator. The assembly of three structural door demonstrators were performed at the end of 2020.

<u>Novel Control (Technology Stream A-4)</u>
With regards to *Smart Mobile Control Surfaces*, the development of the mixed thermal ice protection including mechanical integration, related simulation tools and electrical architecture have continued, as well as the investigation into ultra-low power icing protection using piezoelectric technology. The EWIPS BJ slats have been manufactured for testing in Q2 2021 at the CIRA icing wind tunnel (IWT). In addition, with respect to innovative movable concepts, three demonstrators are in scope i.e. *Morphing Winglet*, *Multifunctional Flap Mechanism*, and *Morphing Pressure Cells*. Design activities are ongoing for all of them, and one PDR has been already passed for the Multifunctional Flap Mechanism.

Activities on *Active Load Control* have consisted of modelling for flutter control and for gust load alleviation (GLA); for the latter subject, the preparation of a GLA transonic WTT is ongoing, as the design and manufacturing of an innovative gust generator and a wall-mounted half-wing model has been undertaken by a CfP project. With regards to flutter control, activities to

prepare a flutter WTT on a BJ Horizontal Tail Plane (HTP) existing model were initiated in 2020. Finally, activities to develop and mature a virtual sensing approach to supplement/replace the angle of attack (AoA) or speed information in case of sensor faults or failure of measurement consolidation process were started mid 2020 and will continue in 2021.

Novel Travel Experience (Technology Stream A-5)

With regards to *Ergonomic flexible cabin*, the crew operations / smart galley technical scope was extended in 2020 i.e. not only focusing on the galley, but also on developing solutions for crew workload reduction inside the whole cabin. In this field, further progress on digitalised and connected galley related to normal operations (service) has been achieved. For the multifunctional cabin rest area, the demonstrator installation tests have been completed, and the plan for its installation has been defined. Functional and operational tests have started. Additionally, with respect to in-seat ventilation, completion of human machine interface (HMI) has been achieved, and thermal comfort simulations have started. With regards to *Office Centred Cabin*, the activities performed on the scale one BJ office-centred cabin demonstrator have allowed for the passing of the acceptance review for all of the demonstrator items. The manufacturing of those items is now ongoing, with a target in 2021 for the on dock date (ODD) at the venue where the demonstrator will be tested.

- **High Versatility and Cost Efficiency (Activity Line B):**

Next generation optimised wing (Technology Stream B-1)

For *RACER's Wing*, CDRs at aircraft and system level were performed and pending actions were being tracked to secure the flight test campaign. The manufacturing of tooling and parts started and was partially completed. Lower wing, upper wing and cradle design data sets were released and component manufacturing started, with the completion of the lower wing components. For *SAT Optimised Composite Wing*, the CDR was passed at the beginning of the year and four small scale integral eemonstrators were manufactured, inspected and assessed. The small scale demo testing campaign then started. The robotic pick-and-place adaptive gripper design and assembly was completed. The composite lay-up for full scale 7m wing demonstrator was defined. Finally, activities were focused for the CDR preparation for the 7m full scale wing demonstrator's innovative tooling. For the *Morphing Winglet*, the curved spar structure tests were completed. The flying components were delivered and installed on REG IADP FTB#2, as well as delivering the check stress documentation supporting the FTB#2 Step 1 permit to fly. For *Affordable Loads Alleviation System*, the Step 1 configuration, permit to fly qualification test started in the on ground FTB#2 wing actuation rig supporting the permit to fly for REGIONAL IADP FTB#2: integration tests between primary and back-up control for aileron were performed, multifunctional flap tab logics adjusted and flap load cases being completed, and multifunctional flap system full integrated test being performed. In addition, pilots started validation and evaluation (flight control laws and handling qualities crew evaluation).

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 integrated into the intake ice wind tunnel model and was tested, proving the performance of this new anti-ice system.

The *Multifunctional Flaps* with independently actuated tab were integrated in the REG IADP

Flight Test Bed#2 (FTB#2) and the flaps' structural analysis for permit to fly documentation was released. Additive manufacturing technologies such as aluminium scalm alloy tab tracks fairings were installed on REG IADP FTB#2. As well, the full FTB#2 wings have been equipped with innovative additive manufactured tailor-made sealing profiles in newly combined thermoplastic elastomeric material.

Concerning the *Advanced Composite External Wing Box*, the tooling and infusion system for CFRP liquid resin infusion technology were delivered and a first full-size manufacturing trial of the highly integrated wing box covers and spars was produced. CFRP thermoplastic in-situ consolidation technology test pyramid for the upper wing covers continued, after solving the process problems that arose during the consolidation between stringers and skin laminates. A compression panel was tested successfully and three panels (shear panel, compression thick and stringer run out) needed for panel testing completion in 2021 were manufactured.

Regarding *High Lift Technologies for Small Aircraft*, the flap tunnel model design and the blowing trailing edge modules were manufactured. Wing tunnel model assembly is being completed for its testing in 2021.

Advanced integrated structures (Technology Stream B-3)

For *Advanced Integrated Empennages for Regional*, all the efforts were focused on the release of drawings at component and tooling levels. In addition, innovative manufacturing equipment was defined and manufacturing on some tooling parts were started. For *Thermoplastic and Multifunctional Leading Edge*, the test matrix definition was completed for welding technologies and for the ice protection systems integration.

For *Aileron and Spoiler Driven by Electro Mechanical Actuators (EMA)*, EMA's assembly started and is now in progress; a prototype hardware for electronic control units was produced, in order to start functional tests and qualification tests. For the *Structural Embedded Antenna*, the final qualification tests were closed and accepted for aircraft installation into REG IADP FTB#2. Finally, the flyable component with the composite panel was delivered to start the installation. For *Induction Ice Protection Technologies*, the two wing models were tested under icing conditions, with the following conclusions: the technology can be applied to ice protection, and CFRP is heated by induction too. Detailed assessment of the final validation was done .

For *HVDC Electrical Generation and Distribution*, a detailed technical review meeting was performed. The power distribution unit can be considered close to a CDR.

For *Interior Noise Attenuation and Impact Protection*, detailed design was underway, supported by the coupon manufacturing complete and numerical analysis. Validation testing for the impact resistant solution was started and will be finalised at the beginning of 2021. For *Structure Health and Monitoring (SHM) Technologies*, all the efforts were focused on preparation for the PDR on the composite panel, which will take place at the beginning of 2021. For *Lighting and Bird Strike Functional Tests and Electromagnetic Compatibility Technologies*, lightning strike and electromagnetic compatibility tests on the composite-metal cockpit were completed. For the *Ergonomics Regional Cockpit*, the final mock-up was manufactured and it's expected to be ready for final validation at the beginning of 2021.

SAT Effective Joining Methods are supported by two CfP projects and preparations are underway for the manufacturing and static test phase for the typical joints between composite nacelle panel (CNP) and metallic fuselage to evaluate benefits of the level of innovations. For *SAT Jigless Assembly Technologies*, the aileron demonstrator was manufactured and assembled. In

addition, cabin demonstrator was manufactured and assembled, as well as the nacelle demonstrators that were installed on M28 aircraft. Flight test campaigns started at the end of the year.

For *Fast Rotorcraft* airframe integration activities, a horizontal surface torsion box injection tooling was delivered. Trimming system parts were accepted and tail boom skins tooling were completed, ready to finish the RACER's rotor-less assembly by beginning of 2021. In addition, technical activities continued with the delivery of the rear avionic door and doorframe prototypes and cabin door tooling manufacturing started. The final side-shells for RACER were manufactured with automated fibre placement technologies and delivered to FRC IADP.

Advanced fuselage (Technology Stream B-4)

For *RACER's Tail*, the tail boom skins were delivered and the other parts manufacturing is being completed. Assembly tooling was mostly delivered. A critical design review was held for the ground test jig, which has now entered the manufacturing process.

For the *NGCTR-Technology Demonstrator* structures subsystems (e.g. cockpit, tail), detailed design reached CDR maturity level during the year, enabling the start of fuselage build in July, and completion of its on-the-jig stage by the end of the year.

For *Regional Fuselage Technologies*, four fuselage stiffened panels were manufactured with automated fibre placement (AFP). A shear static test was executed on a flat panel. For *Design Against Distortion Activities*, the design of calibration and validation use-cases and the selective laser melting machine characterisation planning were started. For a smarter fuselage development, activities focused on the manufacturing, mechanical testing and numerical modelling of stiffened panels as well as the development of the cost model. Flat stiffened panels were tested for residual strength. SHM tests on flat panels were finalised.

For *Regional Cabin Interiors*, the evaluation of the innovative technologies was performed for environmental friendly materials applications, after relevant critical design reviews. The assessment based on test results for innovative passive noise and vibration reduction solutions was completed.

- **Eco-Design (Activity Line C):**

C-1: Eco-design management and ECO TA link

The mapping of the eco-design activities for vehicle economic ecological synergy and eco-design analysis (VEES/EDAS) was updated for the new flagship demonstrator approach started in June. The partners are improving the simplified LCI technology description. An update of the demonstrator synthesis report was produced, summarising roadmaps and confidence levels for 19 eco-design demonstrators and the aggregation to the flagship demonstrators. More than 85 technology developments are delivering LCI data from the Airframe ITD to ECO TA core group. The delivery of the Bill of Materials / Bill of Processes (BoM/BoP) for the demonstrators has started. An Eco-Design Synthesis Report was elaborated with the focus on the technical content of the projects implemented through ECO TA. First economic impacts assessments were started for some of the technologies in scope. More than 25 eco-statements were performed from ECO TA leader for the delivered AIRFRAME activities.

C-2: Eco-Design for Airframe

In the *Eco-Design for Airframe* work package, the technology development is in its final step 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. First demonstrator definition reports were delivered and will be harmonised with the flagship demonstrator approach. Several CfP projects are linked to these activities, in particular in the field of material recycling. More synergies across the activities are identified on several demonstrators starting in 2021.

C-3: New materials and manufacturing

The work is in the finalisation phase. The technologies, tools and devices, for a more digitalised and connected factory, aimed to reduce energy consumption and waste significantly. The model (software and hardware) prototypes to start and complete the technology validation are now available. The COBOT technology for cockpit was tested in a real aircraft cockpit, achieving a TRL6 assessment. The final validation will be completed for the rest of the technologies at the beginning of 2021. Eco-benefits were defined and quantified for the different technologies and ECO parameters.

Implementation of complementary grants awarded through calls for proposals

During the period, 90 Grant Agreements for Partners awarded from Call 1 to Call 09 were active and 20 new ones were implemented in 2020, as an outcome of the selection of projects from Call 10 and Call 11. All these projects are complementing the activities implemented in the AIR ITD Grant Agreement for Members and contributing to the results described above.

➔ **ENG – Engines ITD**

Summary of activities and progress of work in 2020

For the *Ultra-High Propulsive Efficiency (UHPE) Demonstrator (WP2)*, the technology maturation plan has started delivering results, increasing the understanding of the key technological bricks and contributing to decrease the technical risks for the engine ground test demo (GTD). For the *Turboprop Integrated Power Plant System (WP3)*, the Tech TP demonstrator performance test campaign was completed. The power and accessory gear box (PAGB) test rig was almost completed in 2020 and commissioning activities started. Finally, a more electric PAGB ready to embed the *Achieve* electrical motor was designed and manufactured. For the *Advanced Geared Engine Configuration (WP4)*, compression system activities focused on the completion of the conceptual design of the two-spool rig. The preliminary design review (DR3) and the test concept review were passsed. The engine demonstrator detail design activities have been completed, the critical design review (DR5) has been passed mid-2020. For the *Very High Bypass Ratio (VHBR) Middle of Market Turbofan Technology (WP5)*, LP turbine rig testing was successfully completed. Hardware timescales in line with rig pass to test (PTT) in Q3 2021. The PGB BoM (Bill of Materials) for the first ground test engine has been defined. TRL4 for the alternative structural casting material was achieved according to plan.

For the *VHBR Large Turbofan Demonstrator (WP6)*, the engine programme has progressed to detailed component design release and manufacture of engine hardware for the engine development plan (EDP). Engine build has been launched, and parts are now being received into finished parts stores. The first engine will be ready to test by the end of 2021. For the *Reliable and More Efficient Operation of Small Turbine Engines (WP8)*, activities related to the power

gearbox and to the compressor axial centrifugal compressor vehicle (ACCV) test results have been completed. The hybrid electric architecture architecture for the SAT application was selected, while the combustor investigation on additive have continued. For the *Engine Eco Design (WP9)*, the activities on demonstrator parts have contributed to enrich the life cycle inventory database, in particular with the demonstrator Blisk.

Major Achievements in 2020

For the Ultra-High Propulsive Efficiency (UHPE) Demonstrator (WP2), multiple maturation studies have continued to consolidate the architecture for the ground test demo (GTD) of the future installed propulsive system (IPS). Functional analyses have been initiated at component level as well as maturation studies on modularity and maintainability. As part of the maturation on nacelle, the acoustic inlet demonstrator was successfully assembled in early 2020, to validate the manufacturing readiness level (MRL) 6. The integral drive system (IDS) for the gearbox has completed the design phase for module testing. As far as the high speed low pressure turbine is concerned, maturation activities have delivered results contributing to the de-risking of the full design. A test campaign with a low pressure module started in June 2020 to contribute to the maturation. All parts for the advanced turbine rear frame (TRF) demo have been received and the assembly is planned for 2021. Sectors of turbine vane frame (TVF) have been rig-tested to investigate the aerodynamics of the turbine; five different builds have been tested overall to consolidate flow path and airfoils designs. The Covid-19 crisis has however induced an estimated delay of 5 to 12 months, depending on the activities.

For the *Turboprop Integrated Power Plant System (IPPS) (WP3)*, the year 2020 has been impacted by the Covid-19 crisis but WP3 activities progressed in line with the plan even if some were rescheduled earlier or later depending on resource availability. The main activities performed in 2020 were:

- test phase completion of the Tech TP demonstrator target configuration (7 blade propeller, full authority digital engine and propeller controls, nacelle) including performance assessment, control system, oil interruption tests and maintenance review;
- several partial ground demo tests of gas turbine components and modules have been launched to demonstrate technologies performance and maturity, such as mixed flow and inlet guide vane (IGV) compressor performance rig tests, drained bearings partial tests, tri-sector combustor injector flame-out partial tests;
- preparation of Tech TP engine hybridisation demonstration embedding electrical motor;
- PAGB partial test bench preparation for endurance test;
- manufacturing of optimised compressors for robustness test;
- start of manufacturing of turbine blade out partial test rig components.

For the *Advanced Geared Engine Configuration (WP4)*, significant progress was made in the compression system regarding the design and preparation of the two spool compressor rig. The conceptual design was completed, including full definition of the aerodynamic design, structural and rotor dynamic assessment, defintion of secondary air system and corresponding thermals. The preliminary design review was passed. Correspondingly, the test setup, intrumentation requirements, measurement systems concept etc. were defined and reviewed in the test concept review which was also passed. The expansion system engine demonstrator passed its critical design review DR5 mid-year and has released the finished parts for machining. Finished

parts drawings have been aligned with suppliers and completed. Trial parts have been evaluated in first article inspections and machining of engine parts has been released. The technology development has continued and acceptance tests for the casted blade and the CMC segments have been defined and prepared. Based on the Covid-19 situation, schedule impacts have been evaluated and communicated to the JU and external reviewers. The project plan has been adjusted with the test campaign now starting early in 2022.

For the *Very High Bypass Ratio (VHBR) Middle of Market Turbofan Technology (WP5)*, the alternative aluminium alloy for ICC has matured and casting trials of a full sector of a structural component were performed, resulting in achievement of TRL4. For the NSHIP (Near-net shape Hot Isostatic Pressed) casing material, the astroloy powder HIP ballistic test campaign has been completed. The first casing for UltraFan engine 1 has been completed.

Within WP5.2.3, the VT-4-2 and VT4-2 a single stage OGV rig tests supporting aerodynamic design and analysis of the IP Turbine have been successfully completed.

As part of WP5.3.1 (PGB), *the AORBIT*, which is the partners project regarding construction of orbiting journal bearing, has been successfully completed. The rig is fully operational and test results were generated. Work on CfD simulation has continued and has made significant progress. Production release models supplied by CfP partners have been tested on simplified test scenarios. The material and data to support the TRL4 gate review were prepared. NG-Turb test facility circuit virtualisation was used (developed through WP5.7) to predict operational parameters and constraints for campaign planning has continued to progress. The test matrix planning has been finalised and the design phase of the new strut casing has started.

For the *VHBR Large Turbofan Demonstrator (WP6)*, the UltraFan® demonstrator will be tested on a flight test bed aircraft operated by the engine manufacturer. The nacelle integration PDR has been completed and pylon detailed design launched. The flight test instrumentation is progressing to plan with the instrumentation sketch documents provided to partners. The nacelle component PDR is planned for Q1 2021. Following the achievement of the IPT subsystem detailed design review (DTA5) in 2020, this has enabled the manufacture of components for the UltraFan® engine 1 to progress , with key components completed ready for the IPT module build in 2021. The CDR was completed in November 2019, which has then progressed to intermediate compresspor casing (ICC#1) manufacture and near completion in 2020.

The UltraFan® programme successfully passed its Stage 3 Exit review in December 2019, allowing the release of component designs for manufacture with now over 1 000 parts already in stores for engine 1 build. Design for assembly and build pack construct has moved into the computer aided process planning system. The engine will be ready for test at the end of 2021.

For the *Reliable and More Efficient Operation of Small Turbine Engines (WP8)*, 2020 has been focused on the kick-off of hybrid electric activities and the completion of some loop 2 tasks.

In WP8.1 the team started the eMAESTRO architecture activity. A close collaboration with Piaggio has led to the down-selection of the most promising architecture – the Series Hybrid one. Moreover, progress was made on the virtual engine transient model design.

WP8.2 tasks related to the reduction gear box have been completed, validating the direct gas quenching heat threatment with a dedicated test campaign. The activities on the propeller blade manufacturing have not been performed due to Covid-19 impact. In WP8.3 the extended analysis of ACCV and blowdown tests have been concluded, while the impact of potential bleed requirements and their influence on compressor stability was examined.

In WP8.4 all additive combustor test data was collected post process, assessing the new NOx emissions with this technology. Based on the test results, a series of additional activities have been planned for 2020-2021, in order to better investigate the cooling technique.

For the *Eco-design Engine (WP9)*, WP9.1 concentrates on additive manufacturing. During 2020, test specimens were manufactured and characterised to gather life cycle inventory (LCI) data. The purpose of the project is to focus on boundary limits assessment in additive manufacturing, for eco-design process optimisation.

The WP9.2 is dedicated to a composite fibre recycling process (CFRP) re-use and recycling..The WP9.4 is dedicated to the engine parts advanced manufacturing. More than 20 LCI data sheets have been gathered on the reference blisk design model. A manufacturing analysis has also been performed on an inlet guide vane (IGV), which is rig-test relevant.

Implementation of complementary grants awarded through calls for proposals

During the period, 69 Grant Agreements for Partners awarded from Call 1 to Call 09 were active and 2 new ones were implemented in 2020, as an outcome of the selection of projects from Call 10 and Call 11. All these projects are complementing the activities implemented in the ENG ITD Grant Agreement for Members and contributing to the results described above.

➔ SYS – Systems ITD

Summary of activities and progress of work in 2020

The extended cockpit activities reached their final phase of demonstration for most of technologies on a virtual system integration bench at TRL5. The connected cabin concept progressed with more bricks passing TRL3 maturity and advancing towards TRL4. Key components of the fire-suppression demonstrator were produced and tested successfully. For flight control technologies, manufacturing hardware for demonstration was running, producing first units for demonstrations on equipment and system level as well as for flight test demonstration. First component testing results were achieved, paving the way for further integration. In the area of *Landing Gear System*s, the direct drive system achieved TRL4. In parallel, the new wheel rim for short turn around time (TAT) has achieved TRL4 as well. The landing gear sensing system has completed integration and testing of the system closing with a TRL5 achieved. The electrical power network system was focused on the demonstrator redefinition and on the preliminary demonstrator for disruptive distribution. In parallel, high-voltage-DC technologies were matured by partners and through the partner projects. Similarly, activities on bricks for the power generation side have advanced as well.
The electrical environmental control system (EECS) critical design review (CDR) was passed. Concerning electrical wing ice protection system (eWIPS), the activity of 2020 was mainly focused on building the test matrix for the future ice wind tunnel (IWT) test. Sensors and filtration components for air re-circulation in environmental control were optimised based on

the test results obtained. In the area of *Small Air Transportation*, progress on all demonstrators has been made. The new thermo-acoustic insulation concept was demonstrated on aircraft and in a flight test campaign. Avionics for small SAT achieved TRL5 for a number of major elements, preparing progress for some more. *Eco-Design* activities were pursued to mature environmental friendly materials and processes for aircraft systems. The global vision was consolidated and presented in a flagship demonstrator plan.

Transversal activities on disruptive electronics progressed, focusing on power electronics, electrical architectures, electrical drives, electrical machines and reliability and packaging technologies. Meanwhile the transversal activity regarding an integrated simulation framework passed its demonstration of the platform core environment to TRL5.

Even though the Covid-19 pandemic impacted most of the demonstrations with an average of 4 months' delay during the year on some reviews, maturity gates and tests, a recovery plan has been put in place for 2021 for the different technological domains in order to minimise the delays over the two years. Where possible the collaborative work was pursued in a virtual environment and the most severe impact was seen where physical demonstration was expected. Mitigation plans have been implemented in close collaboration with partners to protect the critical paths.

Major achievements in 2020

Innovative Extended Cockpit (WP1)

The overall *Extended Cockpit* was demonstrated in a ground lab environment on a virtual system integration bench, thus achieving TRL5. The work on the next generation of eyes-out cockpit products was pursued (very high brightness and compact full colour micro display). The performances of the intelligent 'natural crew assistant' were evaluated in a cockpit demonstrator in several flight phases. The crew monitoring system achieved TRL5 in a cockpit environment for drowsiness and incapacitation. Furthermore, the use of an adapted pilot behaviour monitoring system as an innovative test means for supporting avionics certification activities with a focus on human factors achieved TRL5. With the support of the partners, the work on active obstruction detection sensors for a modular surveillance system was completed, and the extended strategic navigation functions of the flight management system progressed. Regarding integrated modular communications, aircraft and ground network functions of the ATN/IPS and multi-link demonstrator were specified and a first set of functions was developed. With regards to enhanced vision and awareness, TRL4 was achieved with a lab demonstration comprising of a flight vision system / combined flight vision system with a high resolution synthetic vision system enabled by a high performance system platform. The work package will be finalised in 2021 with different partner projects contributing to the scope.

Cabin and Cargo Systems (WP2)

Developments for different elements continued with regards to the *Cabin and Cargo Systems work package*.

For the connected cabin, the connected seat, electronics hardware and software for sensor module have been developed and the printed connected board (PCB) manufactured. The first trial tests have been performed successfully. For cabin power management, the seat power box (SPB) hardware mock-up and related preliminary testing was done, however Covid-19

impacted on the activities related to the power management concept dedicated to the galley that was put on hold. A mock-up of the validation of wireless communications between the multi-radio communication gateway test-platform and several radio modules was started. A first seat prototype has been developed with time-of-flight sensors and embedded software for objects 3D cloud points constructions. TRL4 is ongoing, targeted to be achieved in Q1 2021. Standardisation work as defined in the standardisation plan continued and the internal standardisation review was performed.
With regard to cargo systems, the setup of the endurance test rig for the novel waste water system, which reuses grey water for toilet flushing, was completed. The formation of biofilm growth and its effect on different components, as well as the performance of different spray-ring and spray-nozzle configurations for flushing the toilet bowl, was studied using digital image correlation.
For the halon-free fire suppression system, the first prototypes of the integrated discharge valve and the pressure reducer were built. They were tested with respect to their key functions. A test bench for additional tests (e.g. under vibration loads) was designed and setup. In an extended trade-off study, additional fire suppression system configurations with on-board inert gas generation system (OBIGGS) were studied. The main focus was to compare a dual-use OBIGGS configuration for fuel tank inertion and fire suppression with a dedicated OBIGGS for fire suppression only.

Innovative Electrical Wing (WP3)

The activities started to produce more hardware for testing and integration into ground and flight demonstrations. The smart integrated wing demonstrator for large aircraft was equipped with additional electronic network and control components according to Phase 2 requirements on top of the components provided through national projects. This is showing some delays due to Covid-19. The design of a power pack demonstrator for the novel local hydraulic supply was completed. Before, major bricks passed TRL6 and the system concept passed compliance testing. Innovative electrical flight control activities for regional aircraft completed the assembly of the first actuators including their control units and achieved component level testing before their delivery to the regional aircraft ground test rig for integration. Partner projects are contributing to the technology development and hardware availability. Smart Active Inceptors', as novel cockpit controls architecture has been frozen. Design work and subsequent manufacturing of mechanical backup and electronic boards were completed with the contribution of partner projects. Testing of those components has been initiated. The global demonstration strategy was unchanged, and the detailed implementation of demonstrators is expected to continue in 2021.

Landing Gear Systems (WP4)

The direct drive system for green autonomous taxis has been assembled, and the system tests have been started, already achieving TRL4. The first prototype of an angled rim wheel for short turn-around time (TAT) has undergone thermal and mechanical tests. Additional modelling activities have also been planned in 2021 as a way forward to reduce the weight of the wheel and hence optimise the system.
Some of the bricks like the metallic motor sleeves needed for the development of an electro-hydraulic actuation system for the *Main Landing Gears* initiative have been manufactured and are ready to be tested. Progress was made regarding additional bricks like composite structural parts that reduce weight and a brake maintenance optimisation system that can improve

competitiveness. The design of the lightweight composite main landing gear strut was completed, and the design of supporting testing and tooling required for the test article manufacturing was also finalised. A preliminary analysis of brake sensing systems was completed with requirements for the sensing technology, communications, controls and prognostic health monitoring (PHM) algorithms defined.
Preparations for an on-aircraft demonstration of a local electro-hydraulic nose landing gear system progressed, with all safety tests on equipment now completed. Shipment of the system to the ground rig for integration before going onto the aircraft has been initiated. In parallel, the design for installation on the aircraft has been prepared as well.
The landing gear sensor system capable of integration into a landing gear environment has completed its objectives. In 2020 the system, including fibre optic load sensors, fibre harness and an interrogator capable of operating in a standard avionic rack was installed and tested at the landing gear test facility. The testing demonstrated the accurate measurement of landing gear loads from the novel fibre based strain sensors. Completion of system studies into safety, reliability, and industrialisation enabled the completion of the TRL5 assessment.

Innovative Electrical Network (WP5)

Regarding electrical generation aspects, technology maturation progressed on the digital generator control unit used to prepare the demonstration on a DC generation channel. Starter-generator activity progressed as well regarding mechanical disconnect and the converter was improved. The battery system entered its second phase, reaching a step in maturity that enables it to operate in the network. Electrical distribution aspects were continued on the high speed digital bus and network components development.
With regards to the aircraft network simulation, the EPC (Electrical Power Center) and ECU (Electrical Control Unit) models specification has been finalised and delivered. In parallel, support has been provided to investigate parallel source operation. Nevertheless, also due to Covid-19, a significant activity addressed test on means redefinition with a physical description of the preliminary demonstrator for innovative distribution set-up was finalised to continue the demonstration in 2021. Some partner projects contributed to important features of the network such as the high voltage hybridisation converter and simulations of hybridisation with HVDC Battery. Some other projects will start working on local power conversion and safe HVDC standard parts in 2021.
The development of high level maturity technological bricks for power electronics modules like silicon carbide, air cooling technologies and modular PEM integration, was finalised in 2020. Some hardware tests were successfully performed and a TRL5-6 maturity was reached. The work package was significantly impacted by Covid-19. The global demonstration strategy was in some case reoriented.

Major Loads (WP6)

As a major milestone, the electrical environmental control system (EECS) critical design review (CDR) was held in 2020 with the airframer. The scope also included the combined vapour cycle system. The conclusion was positive and the manufacturing of the demonstrators can be started. The next step is to perform the risk driven development analyses. Models will be calibrated based on partial hardware component demonstration and previous data allowing reaching the appropriate representativeness. Some important partner projects related to the cabin comfort topic were finalised in 2020. Air sensor demonstrators were evaluated with ozone. Regarding cabin air filtering, some ageing tests were successfully performed at

partners' facilities using a full-scale demonstrator able to assess pressure drop requirement. The activity will be finalised in 2021.

For the adaptive environmental control system (aECS), a decision gate took place in 2020 and concluded that the system would not be tested at the aircraft-level test bench and that the final demonstration would take place at the partner test bench instead. Modelling and simulation activities focused on an electrical adaptive ECS demonstrated that the aECS controller is capable of optimally controlling the system. Improvements were made to the CO_2 filter assembly and to the air sensing system to reduce the size and weight and to optimise the systems performance. Concerning the electrical wing ice protection system (eWIPS), the activity mainly focused on building the test matrix for the future ice wind tunnel (IWT) test. Partners made an effort to re-synchronise the planning because of the impact of Covid-19.The activity on the ice detection system progressed as well with a redefinition of the base technology which is to be investigated.The global demonstration strategy was in some cases reoriented.

Small Air Transport Activities (WP7)

All demonstrators reported good progress. For the fly-by-wire system demonstrator in particular, the preliminary design review of the air data sensor as well as the critical design reviews of both the primary surface actuator and flight control computer were passed. The IMASAT fist unit manufacturing and the relevant components validation process has been started and is currently ongoing. The unit will be delivered in early 2021. Critical design reviews of electrical power generation and distribution system enabling technologies, along with the one of the corresponding integrated demonstration rig, were passed. The critical design review for the low power de-icing system demonstrator has started. Concerning the electrification of landing gear, critical design reviews of both the electro-mechanical braking and electro-mechanical retraction actuator have been completed.

Regarding cabin demo for small aircraft, advanced interior panels for a thermo-acoustic solution were integrated into the cabin, and they were flight and ground tested. The results were evaluated within the deliverables, while the seat demonstrator 1 was tested according to crashworthiness regulations, these results were presented by the deliverable as well.

The tactical separation system (TSS), advanced weather awareness system (AWAS) and compact computing platform (CCP) technologies achieved TRL 5 and progressed with integration for lab testing before flight demonstration. The flight reconfiguration system (FRS) technology significantly progressed as well but due to technical issues with the HW units, TRL 5 is planned to be achieved in Q1/2021. The low-cost integrated navigation system (NAV) technology achieved TRL 4. The affordable surveillance system (SURV) requirements and a design concept were defined. The integrated mission management system (IMMS) was initiated and progressed with requirements definition.

Power Electronics and Electrical Drives (WP100.1)

The work focused on different aspects such as the optimisation space for power converter topologies using emerging semiconductor devices and the associated modulation. The thermal insulation qualification of low voltage electrical machines was completed. Moreover, a new modulation strategy to reduce common-mode voltage and balance capacitor voltage for a three-level neutral-point-clamped power converter in aircraft electric starter-generator system was developed based on a three-level neutral-point-clamped (3L-NPC) converter. Electrical machines and drives work has focused on developing degradation models of

electrical machines. However, closures due to Covid-19 resulted in laboratory work being postponed.

Product life-cycle optimisation (WP100.2)

Eco-design activities were pursued in 2020, in order to mature environmental friendly materials and processes for aircraft systems. The global vision was consolidated and presented in a flagship demonstrator plan related to the electrical environmental control system. The life cycle inventory (LCI) reporting activity could not be conducted as expected due to the pandemic, but measures were taken to recover the situation in 2021.

Model tools and simulation (WP100.3)

The final software core environment incorporating extended TRL5+ capabilities based on stakeholders' and users' feedback was completed in late 2020 with an underlying framework significantly extended towards workflow management capabilities for customised process support in multitool engineering environments. The thermal aircraft platform and integrated thermal architecture modelling was completed as well as the electrical architecture modelling and analysis execution. In order to demonstrate the overall framework, a virtual testing demonstrator was planned in 2020.The execution of model-in-the-loop (MiL) test campaigns were completed and software-in-the-loop (SiL) as well as virtual processor-in-the loop (VPiL) test campaigns were started. However, the final onsite commissioning of the HiL test bench was delayed as a result of the global Covid-19 crisis.

Implementation of complementary grants awarded through calls for proposals

During the period, 68 Grant Agreements for Partners awarded from Call 1 to Call 09 were active and 11 new ones were implemented in 2020, as an outcome of the selection of projects from Call 10 and Call 11. All these projects are complementing the activities implemented in the SYS ITD Grant Agreement for Members and are contributing to results described above.

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

Summary of activities and progress of work in 2020

During 2020, the set of projects progressed in the areas of surface treatments, composites, metals, additive manufacturing, and recycling technology to deliver lifecycle inventories (LCI) to perform eco assessments on the base of certain environmental indicators. The coordination and monitoring effort to receive lifecycle inventory data on selected technologies from SPDs progressed and reports for the delivery of lifecyle inventory data from SPDs to eco-design has been established. On this basis a consequent monitoring and in scope analysis has been brought in place for the report to the different parties involved.

Following the technology mapping as well as existing demonstrator cohorts, particular flagship demonstrators in the scope of CS2 have been defined across all IADPs/ITDs to draw on the environmental impact capturing major items such as multifunctional fuselage, human centered cabin, advanced wing design, composite and metallic airframe structures, major systems treatments and equipment integration, engine components and future connected factories. The

available lifecycle inventory data has been turned into eco-statement reports through LCA analyses, which were issued and provided to the IADPs/ITDs. This involved the respective technologies, exploratory scenarios and grouped ground pollution potential indicator assessments. This carries the Design for Environment (DfE2020+) guidance reporting. The necessary mapping processes for the programme involve the risk of complex interpretation. In this context, the Eco Hybrid Platform (EHP) is being utilised to help with the interpretation and visualisation. A workshop on the EHP took place with industry, and its conception and realisation progress was explained in the form of two deliverables. Due to Covid-19 and part-time working situations in IADPs/ITDs, workshops were limited to online meetings and some exchanges on materials, processes and resources were postponed to 2021.

Implementation of complementary grants awarded through calls for proposals

Several partner projects with related eco-design relevance are being performed in the different SPDs or as thematic topics. In 2020, specific projects were started on composite re-use and recycling, on recycling of large scale composite structures and on the lifecycle evaluation of energy storage supply and transmission for hybrid-electric aircraft concepts.

➔ **SAT – Small Air Transport Transverse**

Summary of activities and progress of work in 2020

The management of SAT-related research and technology development activity across the relevant ITDs continued, ensuring the transverse coordination of work implemented across the ITDs ENG, AIR and SYS and contributing to the revision of Green 19-seater design, and the definition of E-STOL (Electric/hybrid Short Take-Off and Landing) 19-seater commuter aircraft architecture.

Major achievements in 2020

The following key steps were performed in 2020:

- WP1: An assessment of the Covid-19 impact in the SAT related activities across the CS2 SPDs was implemented during 2020 which has revealed a 3-6 month delay in the implementation of relevant actions. This delay forced a shift to the right for the SAT GAM activities and the SAT Demo Master Plan was updated accordingly.

- WP2: two configurations were analysed in 2020:
  - The Green 19-seater EIS2025 (Entry Into Service 2025), integrating CS2 technologies matured at PDR and CDR level, including:
    - the conventional turboprop engine developed within the ENG ITD (WP8) – for this configuration, engine data have been received and post-processed;
    - the relevant activities related to affordable manufacturing of airframe, leading to the delivery of a front fuselage full-scale demonstrator and to flight testing of engine nacelle demonstrator, and several small scale demonstrators were manufactured in order to improve the technologies, methodologies and processes before manufacturing the full scale composite wing box demonstrator, including optical fibres SHM system developed within the AIR ITD;

- MEA (More Electric Aircraft) architecture CDRs outcome and FbW (Fly-by-Wire) PDR outcomes from the SYS ITD.

In 2020, results data were shared and collected to further refine and validate the designed Green Aircraft.

- The E-STOL 19-seater EIS2032 (Entry Into Service 2032), using hybrid power train and CS2 technologies coming from the ENG ITD. For this configuration, the architecture was finalised and preliminary allocation studies carried out.

Moreover, WP2 provided support to the Technology Evaluator and delivered the A/C model, reporting the state of progress towards the high-level objectives of the Clean Sky 2 Programme.

- WP3: the preliminary integration studies of technologies developed within the SYS ITD SAT demonstrator *Aircraft Level 0* was carried out. The final outcome will be delivered in 2021 due to late CDR closure of some SYS ITD technologies caused by both technical issues and the Covid-19 outbreak impact. Furthermore, preliminary activities for the SAT demonstrator *Safe and comfortable cabin demo*, integrating safe and comfortable structures and avionics for safe and comfortable operation, have been successfully completed. In particular, with reference to the safe and comfortable structures, results from integrated thermo-acoustic insulation system developed within the SYS ITD's (CfP partner) was analysed. These analyses will address new improvements to the thermo-acoustic insulation system that will be tested in final flight tests. On the other hand, dynamic tests of crashworthy passenger seats have been concluded and are being analysed to include improvements on demonstrators which will be verified during final 2022 flight tests. Avionic solutions for safe and comfortable operation investigated TSS (Tactical Separation System), AWAS (Advanced Weather Awareness System), FRS (Flight Reconfigurable System), and CCP (Compact Computing Platform) TRL 5 (Technology Readiness Level 5) prototypes lab validation have been matured. Moreover, a complete design of low-cost integrated navigation and surveillance system was performed.

➔ **TE – Technology Evaluator**

Summary of activities and progress of work in 2020

WP0 focused on general project management tasks and the corresponding activities in the field of cost, schedule and risk management. Also, the TE first assessment report was finalised.

Within WP1, the activities concentrated on the CfP partners' activities and the preparation of some CfTs to be launched soon. Those refer to socio-economic effects of the Clean Sky 2 programme (including competitiveness, the additionality of CS and Covid-19 impacts on aviation), further vehicle-specific forecasts in relation to rotorcraft, SAT and BJ and one on climate impact and local air quality assessments.
WP2 was dedicated to strengthening the interfaces between the TE and the IADPs, ITDs and TAs, including the following aspects: preparation and conduction of the first global assessment, monitoring of the the TE master schedule and the deliveries, the preparation of calls (including

the implementation of CfP projects) and the long-term planning for the second assessment. Additionally, three TE-SPD workshops were held: the first one provided a general overview of the economic assessments of the TE, while a second one dealt with the 'vehicle models' considered in the first global assessment and planned updates for the second global assessment. In addition, one workshop was held to discuss the preliminary results of the first assessment while a further workshop was conducted in September 2020 to discuss the final results and the first TE assessment report.

WP3 concentrated on the conduction of the mission level assessment for all vehicle models of the Clean Sky 2 partners to prepare the TE mission level report as a major part of the first global assessment report. The mentioned TE workshop on 'vehicle models' was used in this respect to review and discuss the progress on SPD models, and to check needed updates for the second assessment also taking into consideration potential inputs from ENG, SYS and AIRFRAME. In addition, another major task included the management of the CfP contributing to TE projects.

In WP4 the noise and emission calculations for the first TE assessment at airport level was completed.

In WP5 the focus was on the preparation and conduction of the first global assessment. One CfP project was delivered and updated results for the environmental assessments of the compound rotorcraft and the tiltrotor aircraft. Thus, the impact assessments on the environment could be finalised in the first half of the year 2020 as well as the impact assessments on mobility and the economy.

With regards to WP6, the Clean Sky 2 Joint Undertaking dropped the corresponding call for tender for a *TE Information System* during the course of the year 2020. Thus, no progress can be reported in relation to this topic.

Major achievements in 2020

The major achievement of the TE in 2020 included the preparation and conduction of the first global assessment as well as the elaboration and finalisation of the first global assessment report.

Implementation of complementary grants awarded through calls for proposals

During the period, 6 Grant Agreements for Partners awarded from Call 1 to Call 09 were active and 3 new ones were implemented in 2020, as an outcome of the selection of projects from Call 10 and Call 11. All these projects are contributing to the TE activities as described above.

1.7. Calls for tender

Due to operational reasons, three initially planned operational calls for tenders[9] were moved from 2020 to 2021, slightly modifying their scopes and merging two into one single study.
In accordance with the updated calls for tenders planning, the JU will launch the following two calls for tenders in 2021:

Call for tenders			
SUBJECT	**TYPE OF PROCEDURE**	**VALUE IN EURO**	**SCHEDULE (estimated launch of a new PP or signature of a SC)**
Study on climate impact metrics and effects related to the CS2 results, including 'local effects' and non-CO_2 effects[10]	Open call for tenders	Max. 1.000.000	2nd-3rd Quarter of 2021
Air transport system scenarios in 2050 (incl. multimodal solutions)[11]	Open call for tenders	Max. 750.000	4th Quarter 2021

1.8. Dissemination and information about project results

In 2020, a series of actions were implemented aimed at raising awareness among the beneficiaries about the importance of dissemination and exploitation (D&E) of the projects' results. The activities implemented were tailored to the specific situation of the projects, depending on the different projects' implementation stages:

- during the Information Days, a detailed presentation on dissemination and exploitation rules under Horizon 2020 (H2020) was provided to ensure compliance with D&E before the submission of proposals;
- during the two kick-off meetings organised after the projects were awarded in the frame of Call 10 and Call 11, a detailed presentation on the necessary steps was given to ensure compliance with D&E rules under Horizon 2020 and promote the benefits of project results.

Concerning the projects already in the course of implementation, specific actions were implemented with the aim of reinforcing the D&E aspects (open access of published peer-reviewed papers; quality of plans for dissemination and exploitation (PDER), data management plans (DMP) and results, compliance with H2020 rules.
Regarding the result of the activities implemented last year, an important increase compared to

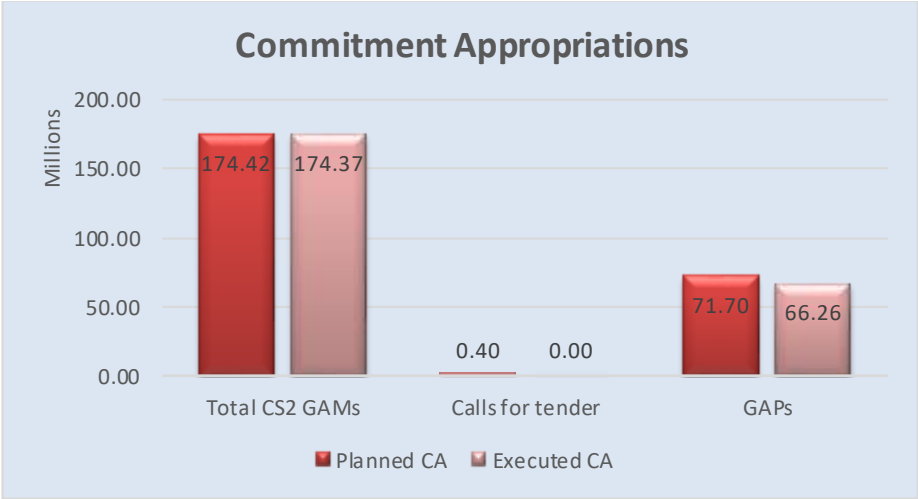
[9] Ref. CSJU.2019.OP.01, Contract notice ref.: 2019/S-170-414488, Contracting authority: Clean Sky 2 Joint Undertaking (CS2JU) – Leading contracting authority and Fuel Cells and Hydrogen 2 Joint Undertaking (FCH2 JU)
[10] To be launched under "TE" budget allocation
[11] To be launched under "TE" budget allocation

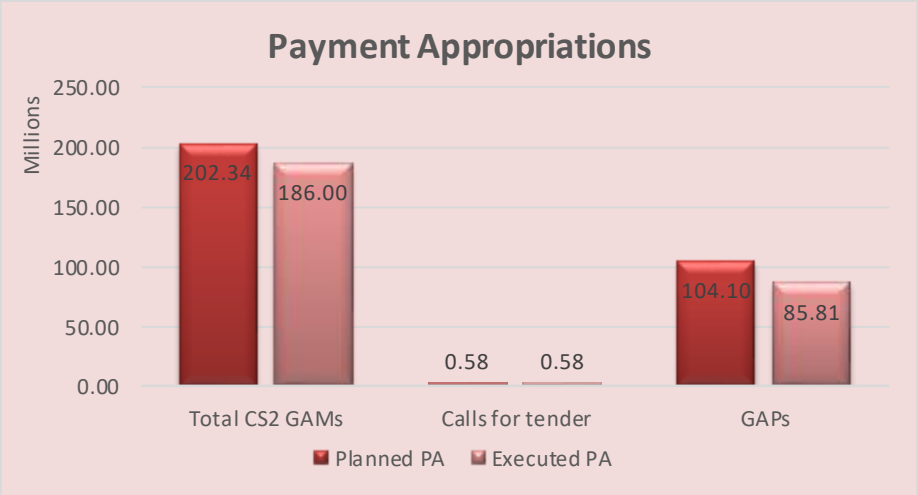
the previous year has been noted. In 2020, the number of reported peer-reviewed and technical papers increased by 35% compared to the period 2014-2019; the number of thesis/book chapters by 26% and participation in conferences by 23%. Overall a good performance has been noted for all SPDs. Additional effort is required by some SPDs in timely encoding publications in the portal and in complying with Article 29 of the grant agreement. (see separate annex in the KPIs section).

1.9. Operational budget execution

In 2020 the JU managed the Clean Sky 2 programme (Horizon 2020) with a corresponding amount of commitment appropriations of €246.5 million. Despite Covid-19, the JU executed 97.6% of the operational budget. The available payment appropriations amounted to €307 million and 88.7% of the available funds were executed.
The under-execution of the GAMs 2018-2019 resulted in an amount of about €35 million not excuted and partly explains the high cash position of the JU at year end (+ €77 million).

Title IV CS2 Budget execution	Executed CA	Executed PA
LPA	107,540,000.00	80,016,090.73
REG	500,000.00	8,331,560.06
FRC	3,499,910.39	12,947,884.15
AIR	55,984,974.74	39,548,822.98
ENG	3,499,985.90	20,666,542.75
SYS	2,442,591.48	21,754,791.44
TE	100,000.00	803,821.34
ECO	699,900.00	1,786,406.25
SAT	100,000.00	143,372.55
Total CS2 GAMs	***174,367,362.51***	***185,999,292.25***
	100%	***92%***
Calls for tenders	**0.00**	**579,600.00**
	0%	**100%**
GAPs	**66,256,398.75**	**85,810,206.36**
	92%	**82%**
Total CS2 Operational	**240,623,761.26**	**272,389,098.61**
	98%	**89%**





Budget evolution

The Governing Board adopted the original 2020 budget for Clean Sky 2 Joint Undertaking for the amount of €319.5 million in commitment appropriations and €315.5 million in payment appropriations in November 2019.

In 2020 the Governing Board adopted two budget amendments. In April 2020, 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 final budget adopted by the Governing Board in December 2020 for implementation amounted to €323.9 million in commitment appropriations and €333.8 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 Final Accounts 2020, the JU has validated certified contributions to the value of €518.34 million. A breakdown by area of the projects is provided below[12].
The difference between the reported and certified values is linked to the grant reporting cycle, for 2018 and 2019 values were only partially validated[13], while for 2020 only the estimates received from members are available and the certification of these amounts in the final period of the ongoing GAMs[14].

ITDs/IAPDs	GAM 2014 – 2020 JU contribution*	Reported IKOP by private members 2014-2020*	Certified and validated by JU IKOP 2014-2019	Still to be certified IKOP
AIRFRAME	171,669,001	122,276,958	103,719,688	18,557,270
ECO-DESIGN TA	3,252,125	3,848,885	2,895,987	952,897
ENGINES	184,114,278	169,088,260	144,226,644	24,861,616

[12] Including the estimated amounts by private members for 2020.
[13] For GAMs ENG and LPA, the values will be validated during 2021.
[14] The duration of the current GAMs is 2020-2021 and the final reporting will take place in March 2022.

ITDs/IAPDs	GAM 2014 – 2020 JU contribution*	Reported IKOP by private members 2014-2020*	Certified and validated by JU IKOP 2014-2019	Still to be certified IKOP
FAST ROTORCRAFT	97,643,901	91,904,883	69,873,600	22,031,283
LARGE PASSENGER AIRCRAFT	224,227,684	180,408,216	132,114,967	48,293,249
REGIONAL AIRCRAFT	57,778,717	49,792,956	41,112,202	8,680,754
SMALL AIR TRANSPORT	1,095,442	598,504	408,096	190,408
SYSTEMS	123,182,166	98,509,308	86,021,854	12,487,454
TE	2,824,985	1,217,920	962,844	255,076
TOTAL	**865,788,299**	**717,645,890**	**581,335,883**	**136,310,007**

IKAA certification and validation

The IKAA value of €1.14 billion reported includes a total amount of €838.12 million fully certified by the members' external auditors and validated by the Governing Board (GB) for the period 2014-2019. This value has also been provided to the GB for its opinion in accordance with Artide 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 2014-2020 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.

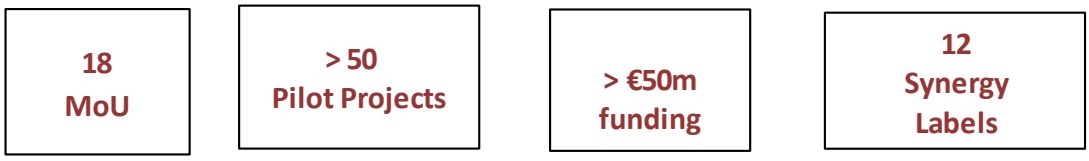
At the end of 2020, at programme implementation level, the JU incurred 71% of the total programme expenditure[15], whereas the members already provided 86% of the expected total in kind contribution, with the IKAA rate of 119%. Assuming that the current trend will be constant for the remaining years 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 2014-20 m€	Achieved %
Max. Union contribution for operational expenditure	1,716.00	1,222.66	71%
Max. total EU contribution to operational cost of private members (leaders/core partners/associates)	1,201.00	870.17	72%
Min. expected in kind contribution from private members to the Joint Undertaking (IKOP + IKAA)	2,155.00	1,861.82	86%
Min.private members in kind contribution from additional activities (IKAA)	965.00	1,144.17	119%

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[16] 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.

By the end of 2020, the following figures show the progress in the action undertaken by the JU:



Synergies between ESIF and Clean Sky maximise the specific value added of Smart Specialisation Strategies (S3) investments such as the capacity to effectively support 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

[15] 2014-17 are validated and certified figures, the 2018-19 figures are based on reported values provided by the Members.

[16] 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."

the level of European competitiveness of stakeholders in this area.

Action plan

At strategic level, and despite the Covid-19 crisis in 2020, 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

In 2020, the CS2 JU continued its bilateral contact and cooperation with a number of interested Member States and regions based on the RIS3 priorities mapping drawn up by the CS2 JU.

The number of MoUs in force is 18 (see map below of the existing MoU cooperation). However, the consequences of the Covid-19 crisis and the restrictions all over Europe limited the communication with other interested European regions and in some cases countries/regions postponed some of their activities.

MoU implementation in 2020

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 else incentivised the submission of proposals complementary to JU activities and objectives. Through the 18 MoUs signed to date, 13 additional pilot projects were launched in 2020, bringing the total to date to 52 with a budget of more than €50m. Some examples of calls launched or new projects funded in 2020 are provided below.

Campania (IT)

A second regional call was in place during 2020, which allocated €15m 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. Until the end of 2020, nine pilot projects had been supported by the two regional calls.

A notable project awarded in 2020 concerns the T-TECH which implements synergies and complementarities with the activities planned under the FRC platform for Leonardo Helicopters Division through the T-WING project and in addition under the Airframe (AIR) platform for the Small Air Transport (SAT) initiative through the SAT-AM and OPTICOMS projects. In these areas, 'CIRA' participates as a Core Partner of the Clean Sky 2 JU. T-TECH will deliver a demonstrator constituted by the NGCTR-TD morphing surface for flight demonstration (TRL6 according to H2020 definition), with thermoplastic composite, novel customised aluminum alloys (ALM) structural parts, equipped with a guided wave-based SHM system with embedded sensors and protected against lightning by means of an innovative cold sprayed metallic protection.

Occitanie (FR)

In 2018 Occitanie launched the R&I call 'Readynov', which is expected to be open until 2021, and includes 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 to support proposals linked to Clean Sky 2 topics, by referring to the CS2 JU work plan in terms of scope. By end of 2020, this call had supported eight pilot projects with a budget of around €4.5m.

Västra Götaland region (SE)

In the context of the MoU framework, the Swedish Agency for Economic and Regional Growth, confirmed funding support on the project REPLAB-2 in 2020.

Greece

A funding scheme, within the framework of the MoU, was launched to support complementary activities to Clean Sky 2 calls with a budget of €2 million. This scheme aims to support either proposals with a Clean Sky Synergy Label, or proposals highly ranked in the reserve list of the last Clean Sky calls.

Castilla La Mancha

Within the framework of the MoU, the regional call 'Innova Adelante' was launched and focused on RIS3 priorities. The pilot project ANNPRESS was supported through this call. Its activities are planned under the AIR platform for the Airbus D&S FTB#2 winglet (Work Package B-1.3.1) through the OUTCOME project and in addition under the LPA platform for Airbus' rear end full composite structure demonstrator (Work Package 1.2) through the REAREND project, in which Aernnova participates as a Core Partner of the Clean Sky 2 JU.

Portugal

The Innovation National Agency (ANI) launched the national call 'AVISO', which supported two projects with a budget of around €5.9m in the context of the MoU cooperation.

The project GAVIÃO aims to go a step forward on the aircraft structures design, manufacturing and integration process development, structural health monitoring and non-destructive testing activities performed within PASSARO.

The project ReCAP is seen as a new complementary activity because is highly aligned with the PASSARO objectives and, in particular, with the targeted developments on new composite technologies for aircraft structures and components. Both projects are aligned with the Clean Sky 2 programme high-level objectives for structures, proposing activities that are complementary to activities being performed in the AIRFRAME-ITD, as well as in the LPA-IADP.

The JU will continue implementing the MoUs in force throughout the year 2021 in view of supporting more upstream coordination with RIS3 and the implementation of more ESIF projects, and will continue identifying best practices in view of the Clean Aviation Partnership.

Clean Sky Synergy Label

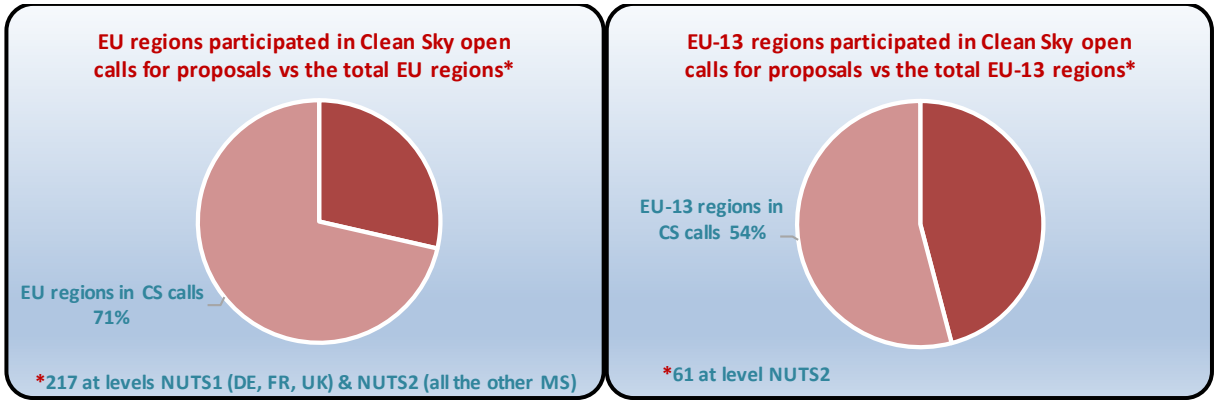
In 2020, one more complementary proposal was awarded the quality certification of the Clean Sky 2 Synergy Label and was highly recommended for support through ESIF.

- DADTOFLY – ESIF complementary activities in the area of the Thematic Topics.

In addition, the JU was asked by some regions under MoUs 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 regions in CS2 calls. According to the data, by the end of 2020, 155 regions out of 217 EU regions (at levels NUTS1 for DE, FR, UK & NUTS2 for all the other Member States) from 28 countries, have participated in Clean Sky open calls (see figure below).



The participation of EU-13 in Clean Sky calls was also notable. As is depicted above, 33 (54%) out of 61 regions in EU-13 Member States participated in Clean Sky 2 calls, while almost half of

those applicants participated in winning proposals.

Additionally, within the context of activities dedicated to synergies, Clean Sky organised the workshop 'Clean Sky building synergies with the regions: Innovation and Technologies created in the European aeronautics regions' in the context of the 10th EASN Virtual International Conference in September 2020.

2. SUPPORT TO OPERATIONS

2.1. Communication Strategy and activities

2020 was an unprecedented year for Clean Sky. The Covid-19 pandemic hit the aviation industry particularly hard, with flights grounded, lockdowns and travel restrictions in place across the world. Clean Sky's communications actions were in turn disrupted: as airshows and other events were cancelled, we found ourselves having to quickly adapt to the new situation in order to continue to share Clean Sky's news and key messages.

Covid-19 restrictions on mobility and its consequences on team organisation and project timings also affected how to enforce the overall aim of Clean Sky's communications. The goal to communicate on the progress and results of the many projects working towards our environmental goals to reduce emissions and noise levels from aircraft, in the context of a broad and collaborative European public-private partnership under Horizon 2020, was in principle the same. In practice however the new situation deeply affected some communications areas such as public relations and institutional affairs, events and publications.

Consequently, a creative strategy focusing on brand new digital/online actions and media partnerships was worked out and put in place, to have Clean Sky messages heard and disseminated, to reach new audiences and to build our positive reputation as a European partnership that delivers results.

In addition to that, the Clean Sky 2 communications strategy for 2021-2024 was discussed and endorsed by the Governing Board at its December meeting, paving the way for the years to come before the conclusion of the programme.

Communications actions took place in 2020 in four main strands: 1) impactful content creation; 2) enhanced digital projects; 3) digital events; and 4) wide-reaching press partnerships.

Impactful content creation to reach wide audiences

Clean Sky worked closely with Members and partners to produce new and updated, impactful content to showcase Clean Sky key facts and figures and technology results to date.

A key piece of content in 2020 was the design, production and publication of the report *Highlights 2019*. This brochure focused specifically on achievements of the CS2 programme in the previous year, and included up-to-date facts and figures as well as sections on synergies with regions and the future. Although it was also disseminated by post, the brochure performed well online in a digital format, helped by an attractive design.

Two additional publications were produced in 2020 – special editions of *Skyline* magazine

focusing on universities and SMEs in Clean Sky. These publications included pieces from project participants from both categories, industry associations, and MEPs.

Another action was the creation of 20 stories on Clean Sky 2 results, covering all technology platforms, which built on the successful batch of stories produced in 2019. A promotion campaign on social media took place throughout 2020 to share these stories more widely. Another batch of 30 articles was initiated at the end of 2020, for publication in spring 2021.

Regular news articles on the website increased throughout 2020, with more inputs from Clean Sky's programme unit to produce short, catchy pieces of news.

In terms of visual content creation, 20 new illustrations were created for various Clean Sky events and concepts: for example, images for the PhD Award, SMEs, innovative configurations, hydrogen-powered aviation, green engines, the online stand and more.

Finally, a brochure was produced by all eight Joint Undertakings highlighting the JUs in numbers; advantages for research and innovation brought about by the programmes; and some key project highlights. The brochure was initially planned to be presented at an event at the European Parliament, but as all events were cancelled, more emphasis was put on online dissemination instead, including the production of short videos/gifs for social media.

All content was harmonised with EU branding, with mentions of Horizon 2020 funding and a Europe-wide level of collaboration.

Enhanced digital projects

Throughout 2020, Clean Sky continued to invest in digital communications through www.cleansky.eu and social media channels.

With the cancellation of physical events and airshows (particularly ILA Berlin/Aerodays and Farnborough), digital communications took centre stage as a way to share Clean Sky's messages and reach new audiences. The highlight of 2020's digital actions was the launch of Clean Sky's brand-new and first ever online stand in November, which aimed to replicate an airshow in virtual format. The effort required was huge, from defining the concept and choosing an external technical partner, to coordinating with Members to arrange interactive models and visits to their premises to film interviews, to finalisation of the design and launch. Promotion started strong with a dedicated section on the Clean Sky website, a week of mentions in Euractiv's *The Capitals* newsletter, and social media posts which saw a lot of shares from Members involved and the Horizon 2020 accounts. Promotion is set to continue going into 2021 with a social media strategy and more press partnerships. After two months of the stand being online, there were 2538 individual visitors, close to 8000 pages and from 61 countries.

Other digital highlights included a revamped homepage for www.cleansky.eu, to make key content more easily accessible for visitors while modernising the look-and-feel of the website. Coupled with frequent updates for news, events, publications and more, this led to an 18% increase in visitors to the website.

Clean Sky's monthly digital newsletter *E-News* greatly increased its subscriber list, in part due to the hydrogen-powered aviation webinar held in July where participants could agree to receive *E-News* when they registered. A specific action to attract new subscribers was also launched which encouraged Clean Sky staff to include a graphic and link in their email signatures. The *E-News* format itself was enhanced and updated with a new header image and enhanced design.

On social media, actions included more frequent posts and greater coordination with the European Commission, notably by amplifying messages from the Commission President and other top-level figures on European measures to mitigate the effects of the Covid-19 pandemic on citizens.

Measurable increases can be reported:

- ⇨ Website: 154 790 total visits, viewing 355 803 pages.
  - Top 10 countries of visitors: Belgium (24.5k), France (17.5k), UK (14.3k), US (14.1k), Germany (14.1k), Spain (10.5k), Italy (9.7k), Netherlands (6.3k), Sweden (3k), Poland (2.7k)
  - Top pages visited: Homepage (81k), News (30.7k), Events (19k), Calls (15.6k), Vacancies (12.1k), Key documents (11.8k), Aviation (9k), Innovative technologies (7k), Discover (5.7k), Regional aircraft (4k)
- ⇨ Social media saw big increases compared to 2019:
  - Twitter: 152 Tweets, 518k impressions, 505 new followers
  - LinkedIn: 123 posts, 277k impressions, 2031 new followers
  - YouTube: 13 new videos posted to the Clean Sky playlist

Digital events

The Aerospace Europe Conference (AEC), held in Bordeaux in February, was the only physical event of 2020 to go ahead. The Communications team managed an information stand and supported the keynote speech of the Executive Director, as well as engaging in onsite communications including social media.

As physical events and airshows were then cancelled due to the Covid-19 pandemic, Clean Sky successfully pivoted to online events and webinars to make our voice heard. The first of these to be organised by Clean Sky was carried out jointly with FCH Joint Undertaking and McKinsey, as the final step of a study into hydrogen-powered aviation. Strong promotional efforts were made (website, social media, Politico ads) which resulted in some 1900 registrations. This was followed by good media coverage among the aeronautics/hydrogen specialised press.

Clean Sky also organised the annual Best PhD Award event online, with high-level speakers including representatives from the aviation industry, academia, research institutions, SMEs. The event gained a lot of attention on social media and was reported on in Politico Pro's Mobility newsletter.

Additionally, Clean Sky participated in external high-profile aviation events to raise awareness of our goals and achievements while expanding our community. Actions included promoting the event through the Clean Sky website, E-News and social media; coordinating with the organisers on practical and technical aspects; preparing briefings and presentations for the Executive Director; and writing news articles and social media posts covering key messages afterwards. These events included the EASN Conference (2 Sept), a webinar held by the European Parliament's Sky and Space Intergroup (30 Sept), Innovair's annual event (29 Oct), Berlin Aviation Summit / Aerodays (24 Nov) and Aeromart Toulouse (3 Dec). Clean Sky's participations drew interested questions from the audiences during these events and interest afterwards on social media.

Wide-reaching press partnerships

To continue to reach new audiences and share our messages, Clean Sky explored several media

partnerships in 2020. A paid promotion was placed in Air & Cosmos magazine's November special edition on rotorcraft, highlighting two of Clean Sky 2's flagship projects (RACER and NextGen CTR) and directing readers to the Clean Sky online stand. In addition, Clean Sky sponsored Euractiv's daily newsletter *The Capitals* for one week (30 November – 4 December) to amplify our promotion actions for the online stand, recent edition of Skyline, and the hydrogen study. This partnership also included a nine-month series of special content, which started in December 2020 with a very well-received article by the Executive Director, and which will continue into 2021.

Other actions

Regarding procurement: with the cancellation of events, several contracts and purchase orders had to be amended which required close cooperation with Clean Sky's Legal and Finance teams. One open tender was launched, for a media monitoring tool. Additionally, Clean Sky continued implementing the large Communications Framework Contract in four different lots, which runs from 2018-2021.

In 2020 the Head of Communications was supported by a Contract Agent, an Interim, and an in-house consultant writer/editor.

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. By decision of 4 November 2019, DG BUDG accepted certain CS2 JU derogations and rejected other derogations. The revised Financial Rules were adopted on 27 January 2020 following a Governing Board written procedure.

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

The EU General Court delivered its judgement on 25 November 2020[17] in the Case T-71/19 *BMC vs CS2 JU*, related to the non-selection of an applicant in the CS2 JU call for proposals (CFP08). The application to the EU General Court had been lodged on 6 February 2019 by the company BMC against both the CS2 JU and the European Commission requesting the annulment of the CS2 JU decision of 10 October 2019 (non-selection of the proposal) and the CS2 JU decision of 6 December 2018 (outcome of the redress procedure). By judgement of 25 November 2020, the

[17] http://curia.europa.eu/juris/document/document.jsf?text=&docid=234332&pageIndex=0&doclang=FR&mode=req&dir=&occ=first&part=1&cid=15127499

EU General Court rejected all seven legal pleas raised against the JU following the legal proceeding (written phases and a hearing on 2 September 2020) and condemned BMC to pay the JU the legal expenses of the case. The judgement, considering its legal aspects and financial risks associated, is an important precedent for the JU as an organisation / Union body entrusted with the management of part of H2020 with its specific legal framework. It also confirms that the JU is functioning well and that its operating framework and procedures have a high level of compliance and transparency. The judgement also provides useful legal elements in terms of EU case-law that will be of interest and possible reference for the wider H2020 framework. A detailed report will be provided by the JU at the Governing Board of March 2021 after the expiry of the applicable procedural deadline on a possible appeal.

In 2020, three new cases (T-649/20, T-721/20, T-767/20) were lodged by the JU against the JU beneficiary Alpha Consulting for the enforcement of debt recoveries by the General Court in the framework of the respective Grant Agreements.

In 2020, the five cases (T-268/17, T-269/17, T-270/17, T-271/17, T-318/17) lodged in 2017 against the JU beneficiary Revoind were still ongoing. The JU requested on 25 September 2020 to the General Court that the judgements be delivered by default in the absence of any defence having been lodged by the identified defendant who was finally notified of the applications following legal transformations of the company status. In parallel to the legal proceedings, the European Antifraud Office (OLAF), which was notified by the JU of possible fraud cases, opened a case on Revoind and required in December 2020 to the JU precautionary measures to be considered.

Ombudsman cases

The Ombudsman case (141/2018/VB)[18] was positively closed by the Ombudsman with a communication sent to the JU on 13 May 2020 informing that the JU had acted in full compliance with its operating framework and rules including intellectual property rights and without identifying any maladministration case.

Data protection

The new Regulation 2018/1725[19] was adopted on 23 October 2018 and entered into force on 11 December 2018. An update on actions taken in the year 2020 is laid out below.
In accordance with the JU Action Plan, important actions were performed in the course of 2019 which were complemented with key legal acts and additional actions in 2020 to ensure compliance with Regulation n° 2018/1725 such as:

[18] Decision in case 1491/2018/VB on the alleged failure by the Clean Sky 2 Joint Undertaking to protect the complainant's patent rights in the context of a project financed under the Horizon 2020 programme.
[19] 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.

- adoption by the Governing Board of the written procedure No. 2020–02 decision on internal rules on restrictions of certain rights of data subjects (and its publication (OJ L 215, p. 21);
- publication on the CS2 JU website of the public register (GDPR Central) on processing operations involving personal data in accordance with Article 31 of Regulation n° 2018/1725;
- performance of a joint JU *Data Protection Impact Assessment* (DPIA) with the support of an external contractors (Specific Contract No S2R 20.01 implementing Framework contract No OC/EFSA/FIN/2019/01)
- preparation of the draft JU Executive Director decision on the DPO implementing rules in accordance with Article 45 of Regulation n° 2018/1725 (EDPS opinion pending before adoption expected in Q1 2021);
- carrying out a mapping exercise on the transfer of personal data to third countries (JU letter of 12 November 2020, ref. D(2020)AK622;
- providing support to the *Stakeholders Management* project under the Clean Sky Improvement plan and ensuring data protection compliance.

Update on ongoing issues in the year 2020

Clean Sky 2 JU and the European Commission should conclude a *Memorandum of Understanding (MoU) on the joint controllership for the processing of personal data for the registration and the management of grants and experts in the context of the EU Research programmes, collected via the 'Funding and Tenders Portal' pursuant to Article 28 of Regulation (EU) 2018/1725*. The MoU template or similar type of legal instrument is under definition by the Commission services.

Clean Sky 2 JU has drafted a data breach procedure, which was sent to the EDPS for review. Once feedback has been obtained from the EDPS, adoption of this internal procedure by the JU will be arranged.

Following the outcome of the joint JU DPIA on Microsoft Services, it was determined that there were 42 data protection risks in Microsoft Office 365 and other cloud based services. Therefore, Clean Sky 2 JU is working with the other JUs to mitigate these risks. A joint procurement is also being launched to outsource some of the mitigation measures. In addition to the DPIA on Microsoft Services, the ILA between the European Commission and Microsoft (DI/07670) was amended in order to provide for more favour rable data protection clauses. Clean Sky 2 JU is in contact with Microsoft in order to incorporate a checkbox declaration on personal data processed by Microsoft on behalf of Clean Sky 2 JU into our enrolment with Microsoft via an amendment.

Data Protection and Covid-19

Since the start of the Covid-19 pandemic, new data protection concerns have been raised by the EDPS, for example the use of video-conferencing tools for meetings and events, temperature checks and contact tracing. Clean Sky 2 JU does not perform temperature checks, nor contract tracing. However, regarding the data protection risks of video-conferencing tools, the use of Zoom and Teams software has been strongly discouraged within the EU Institutions

due to insufficient data protection safeguards. A study of the CSIRT network on the security and privacy assessment of different tools is expected to be published soon, which Clean Sky 2 JU can assess.

Consultation of the DPO

The CS2 JU Data Protection Officer team set up meetings with colleagues from communications, programme management, IT and audit in order to ensure compliance and document their processing operations. The DPO team followed the communications and guidance from the EDPS and the Commission DG RTD Common Support Centre, attended meetings and trainings organised by the EDPS and the DPO network and worked in cooperation with the other JUs also in view of identifying possible sharing of tasks and resources efficiency in the field. Good examples in 2020 were the joint coordination on the preparation of the Governing Board rules on data subject restrictions, the launch and management of the joint procurement to perform a Data Protection Impact Assessment (DPIA) of Microsoft Services and other tasks that were shared among the JUs DPO services.

Preparation of the future "European Partnership on Clean Aviation"

Upon the request of the Commission, the JU provided an additional set of legal comments to the CIC following a dedicated exchange on the SBA preparatory process led by the Commission and further supported in the course of 2020 the legal exchanges on the SBA preparatory process with the provision of legal analysis and advise to support the Commission preparatory process based on the JU operating experience.

The JU provided legal advice and supported a number of preparatory documents requested by the Commission as part of the overall preparatory process of the future European Partnership for Clean Aviation (EPCA) JU including aspects related to the early configuration in the Strategic Research and Innovation Agenda (SRIA) of the future governance, legal and operating framework of the future JU. The JU also supported with the legal preparation of the *Call for expression of interest* launched by the Commission in August 2020.

In the framework of the *Legal Mechanism Group,* the JU delivered preliminary inputs on the Horizon Europe Model Grant Agreement and carried out a preliminary identification of the specificities and legal requirements of the future JU that will be considered under Annex V of the Horizon Europe Model Grant Agreement.

The JU also provided legal advice in close coordination with the Commission services and supported private stakeholders in the preparation and delivery in October 2020 of the *ex ante* conditionality, legally required under the Horizon Europe Regulation, related to ex ante long-term commitment by the private partners of the future JU. This process materialised during the private stakeholders' hand-over to the Commission of a Memorandum of Commitment (MoC) on the future EPCA JU.

2.3. Budgetary and financial management

Title 1 & 2	Budget (€ m)	Executed (€ m)	% rate
CA	8.5	7.8	92.0
PA	10.5	7.2	68.5

Title 1 & 2 – Staff and administrative expenditures:

The administrative expenditure of the JU has been impacted by Covid-19 particularly concerning payment appropriations.
For commitment, the JU achieved a good performance with an execution of 92%. The negative impact of Covid-19 is more tangible in payment (less meetings, missions, events etc.) with a final execution at 68.5%.
Staff expenditure budget (Chapter 11) was mainly used for the statutory staff of the JU (43 posts filled in at 31.12.2020), although other external interim support was also hired by the JU to cope with the increased workload (Chapter 12).
Late payments have been well under control with only 10 late payments out of 1 143 payments made during the year.

2.4. Procurement and contracts

List of contracts signed in the year 2020 (>15.000 EURO)

Document Reference	Framework contract Y/N	Subject	Selection procedure used	Contractor	Amount (€)
OF no 22/2020 implementing FWC.HR.R1.PO.2018.004	Yes	HR study CS2 and future programme	Order Form	Deloitte	52,130
Specific Contract no 55 implementing FWC.DI/07410	Yes	Voice Communication Services 2020 for all JUs	Specific Contract	BT Global Services Belgium Bvba	120,000
Specific Contract no SC-03/FWC/CSJU.2017.OP.01-LOT 4-01 implementing FWC/CSJU.2017.OP.01-LOT 4-01	Yes	CSJU website services	Specific Contract	TMAB Business Events NV	72,000
amendment no 1 and no 2 to OF 140/2019 - implementing FWC/CSJU.2017.OP.01-LOT 3-01	Yes	CS annual event 2021	AMD-Order Form	TMAB	118,409
DC/CSJU.2020.NP.02	No	Legal services related to advice in the preparation	Negotiation procedure without	Michela Velardo	21,500

Document Reference	Framework contract Y/N	Subject	Selection procedure used	Contractor	Amount (€)
		of litigation proceedings and legal representation before the relevant courts	prior publication of a contract notice		
OF no 56/2020 implementing FWC.DI/7722	Yes	Microsoft ILA Scenario C2	Order Form	Insight Technology Solutions Belgium	33,627
SPECIFIC CONTRACT N° 01_04 implementing Framework Contract No: BUDG/19/PO/01	Yes	Audit and certification of the annual accounts of Clean Sky 2 Joint Undertaking for the years ended 31/12/2020 and 31/12/2021	Order form awarded via FWC with reopening of competition	Baker&Tilly	42,215
OF 2020/58 implementing FWC.CSJU.2017.OP.01-LOT1-01	Yes	Skyline and illustrations	Order Form	EU-Turn	15,516
OF 2020/71 implementing FWC.CSJU.2017.OP.01-Lot 3-01	Yes	Virtual exhibition stand for Aerodays and more	Order Form	TMAB Business Events NV	150,000
PO no 2020-72	No	EurActiv Partnership	Low value negotiated procedure	EurActiv	20,000
OF 85/2020 implementing FWC n° HR/R1/PO/2018/004	FWC	Second phase of Deloitte HR study on CS2JU and future programme consisting of three streams	Order Form	Deloitte	179,850
PO no 82-2020	Direct service contract	Provision of specialized coaching services for the 10 managers of Clean Sky 2 Joint Undertaking, CSJU.2020.NP.05	Middle value negotiated procedure	Mercuri Urval	55,000

2.5. IT and logistics

The year 2020 began, as usual, with a maintenance and upgrade window over the winter holiday period. In late January the JU took a delivery of portable video conferencing equipment just before video conferencing was to become a central part of the new way of working.

After the Covid-19 pandemic was declared, rapid action was taken to ensure that all staff were equipped with the ICT materials needed for extended teleworking. This included not only laptops for all staff, but also large screens with webcams, headsets and conference loudspeakers, external keyboards, mobile phones, 4G data sticks etc.

The logon protocols were adapted for frequent remote working as were the processes for software updates and support which would have to be done remotely. Office landlines were put on call forward and a presentation was given on the IT aspects of the *New Way of Working*. Support was provided to staff who had individual issues with home office facilities. Teleconference accounts for all staff were already in place, but these were refreshed as needed

and additional consumption planned.

In spite of this disruption and extra workload, ICT facilities continued to function well and a high level of productivity was maintained even though teleworking has remained the norm for far longer than initially expected. In addition, the annual ICT work plan was kept on schedule.
All WiFi access points in the building were replaced and their number increased, together with the replacing of network switches for the cable network. Altogether, WiFi and wired network upgrade was a major project involving expenditure of almost €250k shared by the six Joint Undertakings who use the building.

The teleconferencing equipment in the common meeting rooms of the JUs, which was installed in 2019, was further improved in 2020 by a project to integrate it with the landline telephone system. Also, the equipment in the rooms was enhanced with low noise cooling systems following user feedback.

During the summer, the encryption equipment for secure communication with the European Institutions was decommissioned. Similar equipment that the JUs installed in the EU Agency Cloud Data Centre had by then been proven reliable. This removed the last critical hardware dependency in the building, thereby ensuring a more robust business continuity capability. In spring 2020 the JU deployed the mission management module of the Commission. This provides many advantages for planning, approving and reimbursing of missions. It provides a paperless workflow, rule enforcement, monitoring and budget planning functions and integration with our accounting system.

During 2020 a major study was conducted with Deloitte consultants to identify the measures needed to transition to Microsoft Office 365, which is the long term ICT strategy. This was known as the DPIA Project (Data Protection and Privacy Impact Assessment). The outcome was a long and detailed list of measures to be taken to ensure a legally compliant and secure deployment of Office365. Before the end of 2020 work had already begun on the highest priority measures to allow the deployment on a phased basis during 2021. The usual background tasks of office hardware procurement and support contracts continued as normal in 2020.

On the non-ICT logistics and building domain, there was not a lot of change as the building remained largely unoccupied for most of the year. The main change was the installation of disinfectant gel dispensers at many points and the placement of health notifications concerning Covid-19 precautions. Maximum occupancy levels for rooms and elevators were defined. Perspex shields were installed where necessary.

2.6. Human Resources

The JU establishment plan for 2020 contained a total of 42 statutory staff (TA and CA) and two SNEs with 43 posts filled at the end of the 2020. In 2020 the JU launched the recruitment process of 3 positions (HoU Operations, FG III Programme coordination assistant, AST3 Legal Assistant).

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, nine interims and one consultant in communications (English Writer) to provide extra support to the JU.

The JU also further implemented the use of Sysper2, the time and personal data management tool of the Commission. In accordance with the decision of the Governing Board regarding the reclassification system, in 2020 the JU has performed the reclassification exercise and as a result three staff members were reclassified.

3. GOVERNANCE

3.1. Governing Board

In 2020, 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 GKN Aerospace Sweden AB, GE Avio, Honeywell, Univ. Nottingham, Aciturri and ISQ .

The Chairman of the Governing Board Stephane Cueille (Safran) and the Deputy Chairman Marco Protti (Leonardo Aircraft) were reconfirmed in their roles on 18 November 2020.

Due to the Covid-19 pandemic, the Clean Sky 2 Joint Undertaking Governing Board could no longer meet physically and instead held four meetings in 2020 organised via webex facilities, on:

- 21 April 2020
- 24 June 2020
- 6 October 2020
- 18 November 2020

In 2020 the Governing Board adopted the following key documents via written procedure:

- Written Procedure 2020-04 Opinion of the Governing Board on the Final Accounts and Budgetary Implementation Report 2019
- Written Procedure 2020-05 Decision of the Governing Board approving the Annual Activity Report 2019 including the corresponding expenditure
- Written Procedure 2020-06 Decision of the Governing Board approving the Ranking Lists of the selected proposals of the Call for Proposals 11 (CFP11)
- Written Procedure 2020-07 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 2014-2019
- Written Procedure 2020-08 Governing Board Decision on the acceptance of the in-kind contribution related to operational activities provided by the private members to the Clean Sky Joint Undertaking through the execution of the Clean Sky Programme (FP7) following implementation of ex-post audit results
- Written Procedure 2020-09 Governing Board opinion on the in-kind contribution related to operational activities declared by the Leaders and Core Partners of the Clean Sky 2

Joint Undertaking through the execution of the Clean Sky 2 Programme (H2020) Grant Agreements 2014-2019

- Written Procedure 2020-10 Decision of the Governing Board approving the Communications Strategy 2021-2024
- Written Procedure 2020-11 Decision of the Governing Board approving the additional activities plan 2021
- Written Procedure 2020-12 Decision of the Governing Board adopting the updated Clean Sky 2 Development Plan
- Written Procedure 2020-13 Decision of the Governing Board adopting the Amended Biennial Work Plan and Budget 2020 – 2021

Most of the decisions were adopted unanimously or almost unanimously, showing a smooth and efficient decision-making process. Each Governing Board (GB) 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.

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 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 though remotely in the course of 2020. 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 pollutant 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 2020, the Scientific Committee met 5 times: 31 January, 26 March, 9 July, 7 October and 16 December.

The Scientific Committee is 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 Clean Sky 2 programme's research and innovation actions with respect to the achievement of the environmental Clean Sky targets. In 2020, there was no new Call to be launched and the consultation on CfP11 was completed in 2019. However, there has been a substantial revision of the Clean Sky 2 Development Plan, for which the SciCom was consulted and delivered a summarised report in early November 2020. Clean Sky 2 JU has continued to involve the SciCom members as reviewers in the Annual Reviews and the Interim Progress Reviews of the CS2 programme. The SciCom delivered individual reports about each SPD review meeting and a consolidated summary report concerning the main outcomes and recommendations of all Annual and Interim Reviews meetings for the Governing Board's information (see Annex 10).

Other activities include an informal discussion which was held in the January meeting about the analysis of the Clean Aviation SRIA presented by the CS2 JU to the SciCom in confrontation with the vision document resulting in no major comments about the content of the current SRIA. Both documents are in good alignement. A number of SciCom members have been involved in the evaluation of a call for additional funding requests launched by the Operational Unit in Q3 2020, as well as in the evaluation process of the CS Academy Best PhD Award in April 2020. Upon the request of the SRG group, a discussion and exchange with the SRG members was arranged during the July meeting. The vision document 'Next Decade European Aeronautics Research Programme (2020-2030)', delivered in May 2019 and already shared with the SRG members was shared again with the new members of the SRG.

The term of the SciCom members was supposed to end in December 2020 after a 3-year mandate. Following the decision No. 304 of the Executive Director of November 24, 2020, their appointment was extended until the end of 2021 or, if the Clean Aviation partnership is established sooner, until the new regulation enters into force.

Currently provision has been made for three meetings in 2021: 15 March, 14 June and 13 September.

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 2020 the SRG met four times and organised one informal teleconference:

- 29 January, Brussels
- 28 April, informal teleconference only for SRG members
- 1 July, via Webex
- 9 October, via Webex
- 11 December, via Webex

The SRG was informed and regularly consulted in 2020 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.

Key actions:

- the Chair team launched a survey regarding the role of SRG – the outcomes of this survey were presented at the January meeting;
- after the April informal meeting, the SRG distributed the paper *Inputs of the States Representatives on Clean Aviation Partnership*;
- during the July meeting, SRG discussed the *Synergies with National Programmes* and a consolidated paper with the positions of Member States was prepared and distributed;
- the SRG's representatives participated in CS3PG and in the configurations WG3 *Operating Principle*s and WG4 *Innovation Architecture*.

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.

4. INTERNAL CONTROL FRAMEWORK

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

In the year 2020 the JU focused on the assessment of the new Internal Control Principles, which had 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 the audit reports received from external and internal auditors as well as the anti-fraud measures in place.

4.1. Financial Procedures

The CS2 JU Financial Rules are aligned with the model Financial Regulation for public-private partnership bodies[20]. 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[21].

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, 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 processes.

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, the whole grant management is operated via SyGMa/Compass, including GAM signature, pre-financing, GAM amendments, costs validation and payment.

Awareness of the JU's Members about the main financial rules of grant management 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.

[20] 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.
[21] Ref. CS-GB-Writ proc-2019-07 Revised Financial Rules.

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.

The closure of the GAMs 2018-2019 has been strongly delayed for the majority of GAMs due to several IT issues encountered with SyGMa/Compass. One of the main issues was linked to the workflow COPA (complementary payments) for which many interactions with the helpdesk took place. Finally, three GAMs had to be closed, first manually by the financial officer in ABAC.

Due to Covid-19 the annual financial workshop was organised remotely achieving a high participation of more than 150 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, most common errors, in-kind contributions, legal aspects of the grant agreements, ex-post audits).

Furthermore, the JU has organised info days and kick-off meetings, following the publication of the last CS2 call for proposal, 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 are provided in the Annual Ex-post Audit Report 2020, which will be available 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 audit activities for H2020 grants are fully centralised in the Common Audit Service (CAS) of DG R&I. 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[22]. 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 Procedure for implementing the H2020 Ex-post Audit Strategy, 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 of DG R&I (CAS), 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 2020:

(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 of DG R&I (CAS) 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 2020 and coverage

For the calculation of the audit coverage, the accumulated audited value of H2020 projects covered by the EPA exercises 2016 to 2020 is compared to the accumulated total amount of validated cost claims for H2020 projects at the end of year 2020.

(A) Specific CS2 JU sample

The audit sample for 2020 was established in line with the H2020 Audit Strategy and the Clean Sky 2 JU implementing procedure. It comprises the following elements:

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

- Representative sample

  - Most significant cost claims selected at random (the population was stratified to achieve a certain coverage of the most significant cost claims).
  - Cost claims from previous representative samples[23]

For H2020 projects, 52 new audits, covering 83 cost claims, were launched until October 2020, out of which, 42 provided final results until the closure of the final accounts 2020.

Additionally, the results of five audits stemming from the 2019 representative sample were considered final and included in the 2020 reporting.

The total audited value of the JU specific sample reported in 2020 was € 97 758 797 (validated project costs).

Table 1: Audit exercise 2020

Audit exercise 2020 H2020 programme	Total	GAMs	GAPs	GAMs & GAPs	GAMs & GAPs
		2015	2016	2017	2018
audited value	97 758 797	308 624	26 032 082	52 355 032	19 063 058
number of cost claims	73	1	10	38	24
number of audits	47	1	2	23	21

Table 2: Audit coverage

Accumulated audit coverage until end of 2020	
	Euro
Total audited value from EPA exercises 2016 to 2020 (a)	205 109 922
Total amount of validated cost claims (b)	1 211 523 332
Coverage (a) / (b)	16.93%

(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.

[23] The audit of some participations of earlier selections had to be postponed, as the concerned beneficiaries had been subject to audit shortly before, either by CS2 JU or other granting authorities of the H2020 programme.

Table 3: Scope of CAS audit exercise 2020 – corrective audits on CS2 projects

Audit exercise 2020 H2020 programme	Total	GAMs	GAPs	GAMs & GAPs	GAMs & GAPs
		2015	2016	2017	2018
audited value	8 732 730	1 222 973	6 551 481	73 119	885 158
number of cost claims	19	5	11	1	2
number of audits	15	2	10	1	2

Through these samples, an additional coverage for the Clean Sky 2 H2020 operational payments of 4% could be achieved.

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

Out of 57 audits launched, 47 provided final results and were used for the error rate calculation 2020. Despite the difficult situation for a number of beneficiaries under the Covid19 restrictions and the limitations for the auditors to carry out field visits, the status of completion of the planned audits did not deteriorate significantly as compared to the previous years.

Table 4: Status of audits included in H2020 audit exercise 2020

Status of audits included in H2020 audit exercise 2020	number
Total number launched[24] and results not yet reported	57
Immature results	10
Pre-final reports received	2
Final reports received	45
Audits included in the final audit results 2020	47

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

[24] Two audits stemming from the JU representative sample 2020 have been cancelled in line with the "Guidance Note on the management of cases of audited beneficiaries under liquidation" endorsed by the CIC Executive Committee in 2016

errors is 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.[25]
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 2020, amounts to **1.60%.**

The corresponding rate for the individual audit exercise of the year 2020 is at **1.94%.**

Table 5: Summary of error rates

Summary of H2020 error rates for the H2020 programme (accumulated results of 2016 to 2020):	
Representative error rate (RepER%) =	-1.60%
Systematic error rate (RepERsys%) =	-1.09%
Residual error rate (ResER%)=	-0.91%

The error rates reported for the year 2020 – 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 2020, the residual error stays well below the targeted threshold of 2%.

IV. Extension of audit findings

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 are 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 audit.
From 164 finalised audits stemming from earlier EPA exercises and concerning beneficiaries of Clean Sky 2 JU, extension of systematic audit findings has been launched in 35 cases. 80% of these cases have been successfully closed until the end of 2020.

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

Table 6: H2020 extension of audit findings until EPA 2020

	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[26] (% 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	83%
EPA 2020	42	97 758 797	7	5 965 956	43%
Total	**164**	**205 109 921**	**35**	**33 495 490[27]**	**80%**

The audit extension for the EPA exercise of 2019 and 2020 is ongoing, 7 cases are in the implementation phase.

V. Implementation of audit results

Overpayments identified in the EPA exercise 2019 for H2020 projects had been implemented until the closure of the JU's Final Accounts 2019 at a rate of 71%. The implementation rate has meanwhile increased further to 88%.[28]

For overpayments detected in H2020 audits of the EPA exercise 2020, the implementation rate is at 79% in May 2021 and is expected to arrive at 100% until the closure of the AAR 2021, 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 83% of the total impact of detected errors and extension of audit findings.

[26] The implementation of the correction is done by CS2 JU, in the case of 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.

[27] In addition to the corrections achieved through the CS2 EPA samples, the extension exercise covers 4 beneficiaries, who have been audited for other than Clean Sky projects.

[28] The implementation of the audit extension of three cases was delayed since the concerned beneficiaries requested an extension of the deadlines due to Covid-19 impact. The cases are expected to be finalised by the end of June 2021.

Table 7: Implementation achieved

ACCUMULATED Total corrective action for H2020 EPA exercise 2016- 2020 - 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 (%)
657 082 225	-5 060 043	-3 677 174	-3 064 273	83.33%

VI. Materiality applied for specific audit exercises

The control objective is to ensure for the Clean Sky 2 JU 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 dedicated Annex 9 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 2020, 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 3.46% of the 2020 audited expenditure. The accumulated detected error for the years 2016 to 2020 of this type of sample currently amounts to 2.28%.

The representativeness of this error rate is limited as the selection of the samples has not been based on a consistent methodology for random sampling and the coverage achieved is only at 4.09% (see section II above). The difference to the annual detected error rate of the specific representative sample of Clean Sky 2 JU[29] is caused by the results of one audit in the non-representative sample with a very significant audited value, which provided for a high individual (non-systemic) detected error.

[29] i.e. 1.60%

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 with a total of 467 expected results have been selected. By the end of 2020, cost claims amounting to EUR 24.3 billion have been submitted by the beneficiaries to the services.

The error rates at 31 December 2020 are:

- Representative detected error rate[30]: **2,95%**
  The rate is based on the 334 representative results out of the 467 expected in the 3 Common Representative Samples.
- Cumulative residual error rate for the Research and Innovation Family DGs: **2,16 %**
  The rate for DG R&I alone amounts to **2,24 %**.

As in 2019, the above-presented error rates need 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 H2020 control strategy can only be fully measured and assessed in the final stages of the programme, once the ex-post control strategy has been fully implemented and systematic errors have been detected and corrected.

As a result of the COVID-19 pandemic crisis and related travel limitations during 2020, the Common Audit Service (CAS) – in line with the instructions of the Commission – had to postpone on-the-spot missions until further notice. To minimise the impact of COVID-19 on the implementation of the audit campaign, the CAS converted traditional in-house audit assignments into desk audits, in line with international best practice and auditing standards. Regarding outsourced audits, the CAS instructed the audit firms to perform remotely the maximum possible amount of audit tests while complementing those with on-the-spot audit missions once travel restrictions were eased.

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.

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[30] In the year 2020, the Commission re-defined its methodology for calculating the Horizon 2020 error rates in line with the European Court of Auditors' observations in its 2018 and 2019 Annual Reports. The methodology applied is described in the related annex of the AAR of DG R&I on 'Materiality criteria'. As of January 2020, the application of the revised methodology resulted in an error rate higher, on average, by 0,41 % in comparison to the error rate calculated by applying the methodology used in the past on the same samples. Consequently, the detected error rate for 2020 calculated according to the methodology used in the past has been corrected by adding 0.41%.

Given the results of the audit campaign up until 2020, and the observations made by the European Court of Auditors in its 2018 and 2019 Annual Reports, the Common Implementation Centre (CIC), in close cooperation with DG BUDGET, the Secretariat General of the Commission (SecGen) and the Internal Audit Service (IAS), are defining actions aiming at reducing further the multiannual error rate of Horizon 2020. Actions include further simplification, increased use of simplified forms of funding, consultation with the stakeholders, focused communication campaigns, and enhanced training to internal project officers and External Audit Firms performing audits on behalf of the Commission. It should be noted that although the start of the implementation of these actions will be immediate, their positive effect in the form of reduction in the multiannual error rate may take time to materialise.

IX. Assessment of the ex-post audit results

As described in the materiality criteria in the dedicated Annex 9 of this report, the control objective of the JU is to ensure, 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 H2020 programme.

The audit approach for H2020 grants is based on the H2020 Audit Strategy and the related implementing procedure of CS2 JU[31].

The results of the CS2 JU EPA process 2020 provide information on the legality and regularity of the validation process for GAM and GAP execution 2014 to 2018 for the H2020 programme. The EPA results of the year 2020 do not directly relate to the entire H2020 expenditure incurred by the JU until the end of 2020. 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 Clean Sky programme up to a certain point of time.

The accumulated direct audit coverage of the validated financial statements pertaining to GAMs and GAPs of the years 2014 to 2018 is 17%. The additional coverage achieved through corrective audits launched by the CAS on Clean Sky 2 grants is 4%.

The accumulated results established in the H2020 samples of the years 2016 to 2020 reflect a representative error in favour of Clean Sky 2 JU in the validated operational expense of 1.60%, compared to 1.30% for the accumulated audit exercises until 2019.

The H2020 accumulated residual error rate stemming from 5 annual audit exercises amounts to 0.91%, maintaining a similar level of error as in the previous year.

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 2020.

The results from audits pertaining to the specific samples carried out on the Clean Sky 2

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

expenditure as well as the samples of the CAS (CRS and other corrective audits), indicate, that 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%.
A reserve for the Horizon 2020 expenditure incurred until the year 2020 is therefore not considered necessary.

4.4. Audit of the European Court of Auditors

In 2020, the JU was audited on its annual accounts 2019 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 2019[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 2020 comprises also a review and analysis of several horizontal topics common to all JUs (staff management, business continuity during the Covid-19 pandemic and Cyber security).

Due to the COVID-19 pandemic, the Court performed the two audit missions for the 2020 financial year as a desk review at the Court's premises from 7 to 11 December 2020.
The auditors performed remotely detailed transaction testing and checks of the internal control procedures established by the JU, to ensure compliance with the legal framework for the reliability of the accounts and the legality and regularity of the underlying transactions.

For the audit of the 2020 operational expenditure, the Court has continued the audit approach introduced in 2019 and undertook audits directly at beneficiaries' level for all Joint Undertakings in the H2020 programme. The results of these audits are presented in the annual report of the Court for the year 2020.

4.5. Internal Audit

The internal audit functions of Clean Sky 2 JU were carried out in 2020 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.

<u>Internal Audit Service (IAS):</u>

- ***Audit in 2020***

In 2020 the IAS finalised an audit, which had been planned in the Strategic Audit Plan of the IAS for the years 2019 to 2021. The topic of the audit dealt with the JU's processes related to the implementation phase of grants under the H2020 programme.

The scope of the audit included the following areas:

- overall grant implementation control strategy;
- monitoring, reporting, payments, ex-ante and ex-post checks and reviews;
- dissemination, exploitation and communication of the results;
- suspension of payments, early termination of grant agreements and recovery orders;
- management of amendments;
- management of experts in the context of project reviews.

Recommendations were issued by the IAS regarding:
- the JU's fraud risk assessment and anti-fraud controls (*very important*);
- a risk-based approach for the ex-ante validation of grant payments and reports (*very important*);
- monitoring of project dissemination, exploitation and communications (*important*).

In December 2020 the JU agreed with the IAS on the required actions to strengthen the related controls. Until the date of this report, the actions pertaining to all three recommendations have been implemented by the JU. The IAS performed a follow-up audit and concluded in June 2021 that these three recommendations have been adequately and effectively implemented and are therefore considered closed.

- ***Follow-up on significantly delayed recommendations***

In February 2021, the JU received the annual report of the IAS for 2020, which highlighted two recommendations stemming from a previous audit on performance management and one recommendation concerning the JU's grant management as significantly delayed.

At the date of this report, the JU has requested from the IAS the closure of one of these delayed recommendations, as it has been considered implemented in the meantime. The assessment of the IAS has not been received yet. For the two remaining recommendations, which deal with the TE assessment of the socio-economic impact of the Clean Sky 2 program and with a specific process in the JU's calls management, the JU has requested a further extension of the deadline. A summary of the status of the recommendations is also presented in Annex 11 of this report.

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 2020[32] summarises the activities performed during the year 2020 with reference to the approved annual audit plan[33]. The audit plan has been fully implemented, except for the envisaged assurance audit on data protection management, which has been replaced by a risk assessment.

For the year 2020, the IAO confirmed to the GB her organisational independence according to

[32] Annual Report 2020 of the Internal Audit Officer, dated 05.02.2021
[33] Annual Audit Plan of the CS2 JU Internal Audit Capability, approved by the GB on 28.04.2020

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. However, these processes of the JU were fully covered by other auditors, like the European Court of Auditors (ECA) and the Internal Audit Service of the Commission (IAS), either through assurance audits or through risk assessment.

Like in previous years, in 2020 the IAO coordinated the JU's ex-post audit process. The entire activity and results for the year 2020 are presented in subchapter 4.3 of this report. Throughout the year, the IAO ensured the proper coordination of the CS2 JU audit process with the Common Audit Service and the Common Implementation Centre. First input has been provided also to the Horizon Europe audit strategy for research grants.

Other main areas of the IAO activities have been:

- coordination of JU risk management;
- advice on JU assessment of Internal Control Principles;
- fraud risk assessment for developing the CS2 Antifraud Strategy;
- support for revising the JU's document management.

With a view to the antifraud measures of the JU, the IAO holds 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, refer to sections 2.2 and 4.6.

In the field of assurance audit, the IAO has monitored the implementation of recommendations from other auditors, in particular from the Internal Audit Service of the Commission, and provided ample support to the JU management for developing the appropriate actions.

At the end of 2020, the IAO has updated her risk assessment of the JU's internal control system and has identified some risk areas, which were not specifically monitored by the JU management. All of the respective risks provided for a medium or low risk level and are therefore not described in this report. They will be considered in the JU's self-assessment of the internal control system and in the global JU risk assessment. Detailed information on the IAO risk assessment is provided to the JU management in the annual IAO report 2020.

4.6. Risk management, conflict of interest, fraud prevention and detection

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.

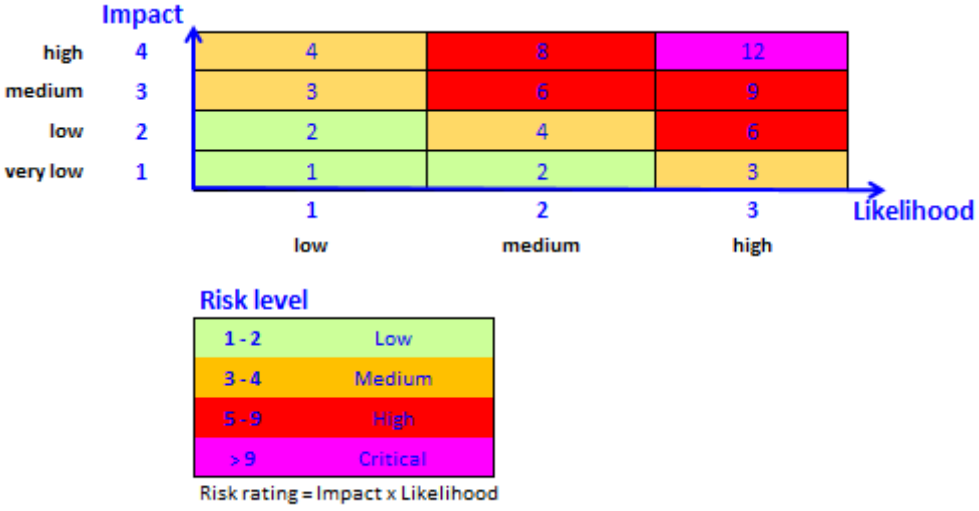
The complexity of the JU activities, with the involvement of many stakeholders participating in the execution of the programmes with a variety of often interconnected activities, calls for assessing and managing risks at the different levels of activity of all actors:

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

The responsibility for risk management in the JU including the identification and implementation of mitigating actions is with the Executive Director and the Programme Office, supported by the CS2 Programme Coordination Committee. Risks to be considered in the year 2020 were described in the CS2 Development Plan and in the Grant Agreements for 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 2020-21 to which the following assessment refers (see the table further down in this section). With a view to the significant impact of the Covid-19 crisis on the programme's beneficiaries in the course of 2020, the JU performed a dedicated risk assessment to evaluate the potential impact on the implementation of the annual programme for the year 2020, but also on the expected results at programme level. An extraordinary GB meeting took place on this subject on October 6, 2020.The main risks for the JU relate to the operational objectives of the programme and to some core management processes, which in turn 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:



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	Likelihood	Impact	Impact Category*	Mitigation actions	Residual Risk
Achievement of high-level goals Execution of the technical activities in Clean Sky 2 may not result in the achievement of the High-Level Objectives as stated in the Regulation.	M	H	Operational Reputational	Continued close monitoring of the contribution of IADPs/ITDs/TAs to the Clean Sky 2 High Level Objectives (HLOs) and quantification of their environmental contribution to the different aircraft concepts as defined in the Technology Evaluator. Tracking of the expected environmental improvements for each of the key demonstrators/technologies. First full assessment of the Technology Evaluator performed. Some programme re-orientations implemented where needed to ensure progress to the CS2 HLOs is secure. Define objectives for the IADPs/ITDs in all areas of qualitative goals of the Regulation [e.g. competitiveness and mobility] and monitor progress towards these goals through periodic assessments with the TE and by the JU directly via supporting studies and coordination and support actions, where necessary.	H

Risk Description	Likelihood	Impact	Impact Category*	Mitigation actions	Residual Risk
Implementation of the Clean Sky 2 Development plan may be hampered due to: **• Change in priorities of private Members and reduction of leverage effect of EU funding: 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.** **• Delays in execution of grants: Technical setbacks, delays in execution of grants and business continuity risk in one or several IADPs / ITDs / TAs may result in under-achievement of milestones and deliverables and/or a significant over / under-spending of annual budget.** **• Lack of funding linked to technical difficulties or lack of robustness of resources / financial planning vs demonstration objectives: 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.** **COVID-19 impact: The economic crisis may cause significant delays in the research activities of all SPDs, due to the breakdown of companies and/or their supplier chains.** **The economic crisis in the aviation industry may enhance the described risk as research activities may temporarily lose priority due to lack of funds in industry.** **As immediate effect of the restrictions on mobility, organisations may not be able to ensure the execution of research work as proposed in the CS2DP.**	M	H	Operational Reputational	The implementation of the CS2 Development Plan progressed with a revision established to take into account the COVID-19 impact together with a number of technical reorientations. The impact assessment of COVID-19 carried out in 2020 confirms that the scope of work for the vast majority of demonstrators to be achieved in the Clean Sky 2 Programme remains unchanged. However, some delays (4-6 months on average) have been identified for approximately one-third of the demonstrators on the programme implementation, with an unequal situation observed across the different areas of activities. Re-orientations of the R&I actions and funding allocations, with the objective to maximise benefits vis à vis HLOs were implemented and reflected in the CS2DP and Work Plan, with ITDs/IADPs GAM amended. Monitoring was ensured as usual through quarterly reports, the Annual and Intermediate Progress Reviews under the Governing Board. supervision Each IADP/ITD deployed a risk management and 'through to completion' plan. to support a proper project execution.	H

Risk Description	Likelihood	Impact	Impact Category*	Mitigation actions	Residual Risk
Multi-annual budget planning and execution **Lack of adequate plans on the ITDs' sides 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).**	M	H	Financial	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 in September. In particular, towards the end of the programme, the JU management assesses the allocation for the budget to completion and revises in agreement with the SPD leaders the final individual SPD budgets. The JU achieved a 100% allocation of the operational budget for the FP7 programme. In the extraordinary GB of 6 October 2020, some Members indicated that the impact of Covid-19 would be more severe than initially anticipated in the analysis performed earlier in 2020, and that this could result in some cases in a reduced execution in 2021. The 2020 operational budget execution reached 97.61% in terms of commitment appropriations and 88.72% in terms of payment appropriation.	H
Loss of funding due to bankruptcies in Covid-19 aftermath **The increase in the bankruptcy rate amongst the JU's beneficiaries may cause high loss of pre-financing.**	H	H	Financial	Reinforced monitoring is being used in order to monitor the financial risk linked to bankruptcies and to limit the financial losses to the extent possible. Evidence for distribution of funds to the consortium by the coordinators of projects is requested with the aim of monitoring high amounts of pre-financing. The provisions included in the CS2 grant agreements regarding the obligation to notify economic difficulties to the JU have been specifically addressed in the last Financial Workshop carried out by CS2 JU in October 2020.	H
Specific budget execution for 2020 including the impact of Covid-19 crisis **The current unexpected dramatic disruption of all activities in administration, economy and mobility may lead to high uncertainties for the JU's budget management, which may result in significant underspending of the budget 2020 as compared to the approved budget plan.**	H	H	Financial	The overall budget execution has been slightly lower than 2019: 97.42% for CA and 88.05% for PA. On the operational budget side, we refer to the description of the risk n12 and the related mitigation measures. On the administrative budget side, the underspending has been higher in terms of payment appropriations (68.5%) due to the COVID-19 impact on costs related to missions, meetings and events. The administrative commitment appropriations have been executed up to 92%. In the last quarter 2020, the JU has closely monitoredthe reallocation of funding between the individual SPDs in order to achieve a high budget execution rate whilst ensuring sound financial management.	H
Market uptake of research results **The maturity of certain demonstrators at programme**	M	H	Operational	The JU maintained an early warning capability through quarterly reports, the Annual and Intermediate Progress Reviews and where	H

Risk Description	Likelihood	Impact	Impact Category*	Mitigation actions	Residual Risk
completion may be lower than expected (Covid-19 or technical difficulties) hampering the timely exploitation of results.				necessary alerted the Governing Board. An assessment of the impact of Covid-19 on market forecasts and the potential uptake of CS2 technology will be included in the planned socio-economic impact study to be launched in 2021 (this was delayed in order to allow a comprehensive analysis of the repercussions of the pandemic and the current crisis in aviation. Where appropriate, a re-alignment of activities will be proposed to maximise the timely exploitation of results. A revision of the CS2DP and of the WPs was implemented and the GAM Amendment process used to officiate the changes.	
Impact category: Reputational; Operational; Financial					

Conflict of interest

In 2020 the JU continued to apply the decisions adopted by the Governing Board regarding the rules on the prevention and management of conflicts of interest applicable to the bodies of the Joint Undertaking[34] and to the JU staff members[35]. 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)[36], 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 has developed IT tools, which enable the JU to perform similarity checks for individual projects during the entire grant management phase.
In the year 2020, the JU established its specific Clean Sky 2 Antifraud Strategy. Based on a

[34] Ref. CS-GB-Writ Proc 2016-15Rules on CoI_JU Bodies.
[35] Ref. CS-GB-2017-10-19 CoI decision JU staff.
[36] Issued by the Common Implementation Centre and latest version adopted by the Executive Committee in November 2019

dedicated fraud risk assessment, the risk levels for individual budget areas and types of activity have been evaluated as follows:

Type of expenditure / non-expenditure area	Total amount (Mill Euro)	Fraud risk - likelihood	Fraud risk - Impact[37]	FRAUD RISK - OVERALL
Grants	1 716	*Low*	*High*	*Medium*
Research integrity	-	*Low/Medium*	*Medium*	*Medium*
Experts management	6	*Very Low*	*Medium*	*Low*
Procurement	50	*Very Low*	*Medium*	*Low*
Administrative and other	22	*Very Low*	*Medium*	*Low*
Internal fraud	-	*Low*	*Medium*	*Low/Medium*
In-kind contribution	2 155	*Low*	*Medium*	*Low/Medium*
GRAND TOTAL (M€)	3 949			

An action plan has been developed by the JU management to further strengthen the JU's controls to prevent and detect fraud. An awareness training for the JU's staff has already taken place in November 2020. In the year 2020, the JU followed up on two alleged fraud cases, which had been notified to OLAF in 2018, and on which OLAF opened investigations. The cases are still on-going. No new case has been reported to OLAF by Clean Sky 2 during 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.

As input for the assurance on the functioning of the JU's internal control system, a global assessment has been performed taking into consideration the application of the JU's agreed internal control principles, results of controls throughout the reporting year, exception reports, specific control weaknesses or risks identified and recommendations received from the JU's auditors.

An assessment of the Internal Control Principles (ICPs) has been carried out at the end of the year on the basis of the following elements:

- a review of the compliance documents available in the JU for each internal control principle according to the *EC list of reference documents related to the ICPs as far as applicable for CS2 JU*

[37] Materiality and/or reputational impact.

- the analysis of the set of 80 internal control monitoring indicators and their results for the year 2020
- the review of the functioning of the 17 ICPs as well as the identification of the improvements needed

The results of the internal control monitoring indicators are complemented by other sources of information stemming in particular from audits of the ECA, the IAS and the IAC of Clean Sky 2 JU, but taking into consideration also the results of internal surveys, studies from external consultants, self-assessment and consultation with responsible staff members.

According to the assessment results, no significant control weaknesses have been identified for the year 2020. The review of the functioning of the 17 ICPs shows that out of the five components of the internal control system, three are functioning well with only minor improvement needed and two components are functioning, but with some improvements needed[38]. No component has been assessed as partially or not functioning.

Two very important issues were raised by the IAS at the end of the year 2020, as described in chapter 4.5 of this report. The reported control weaknesses were included in the global assessment of the internal control system of the JU. As mitigating measures were already started by the JU management until December 2020 during the course of the audit, the remaining deficiencies did not put into question the effectiveness of the concerned controls and principles.

As an overall conclusion, the results of the internal control assessment carried out during the year 2020, confirm that the Clean Sky control system is working efficiently and effectively despite some deficiencies. Furthermore, it ensures an adequate risk management process by the JU's management for monitoring the key objectives of the JU.
Finally, the assessment provides reasonable assurance that, overall, suitable controls are in place and working as intended; risks are being appropriately monitored and mitigated and necessary improvements and reinforcements are being implemented.

[38] The JU applies a system of 17 ICPs as developed by DG Budget for application in the Commission. The system is based on the COSO model of Internal Control and distinguishes btween 5 areas (components) of an internal control system: Control environment, Risk assessment, Control activities, Information and Communication as well as Monitoring activities.

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 2020

The Governing Board of the Clean Sky 2 Joint Undertaking has taken note of the Annual Activity Report 2020 (Authorising Officer's report), the provisional version of which was made available on 25 February 2021 and the consolidated version on 21 May 2021.

The Board is of the opinion that the Annual Activity Report accurately reflects the implementation of the 2020 activities of the Joint Undertaking from both an operational and administrative point of view.

The Board is pleased to note that since the closure of the last call of the CS2 programme, the Joint Undertaking has successfully engaged 940 participants from 30 countries across the entire aeronautics sector, of which 363 are SMEs, 113 are research centres, 156 are universities and 308 are industrial companies.

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 of the effects of the Covid-19 crisis and its impact on the programme implementation. It expresses its appreciation for the outlook that the expected delays are modest and manageable (more than 80% of Clean Sky's key demonstrators estimated to deliver their objectives by the end of the programme, while the remaining 20% are being adapted in order to accommodate strategic evolutions); and encourages all partners to work together in order to achieve maximum success.

Despite the Covid-19 pandemic crisis, the Board appreciates the good rate of budget execution achieved in 2020 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 to meet the objectives as set out in the relevant the grant agreements in terms of the achievement of milestones, deliverables and the optimum use of resources assigned.

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 continue to make and to ensure the timely reporting of in-kind contributions.

The Board is pleased to note the new efforts applied to creating synergies and the growing number of strategic Memoranda of Understanding put in place with the various regions in Europe, promoting synergies with European Structural & Investment Funds. The implementation of these projects 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 of the good dissemination and exploitation results, with Clean Sky programmes having obtained 219 patents and published 767 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 control framework 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 H2020 audits are duly implemented and processed and that the ex-post audits results in 2020 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 notes the 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 a number of IAS recommendations by the JU management and encourages the JU team to address any remaining open issues with the IAS as indicated in the AAR.

Done in Brussels, June 2021

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 2020 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 2020 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 2020.

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].

I 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.

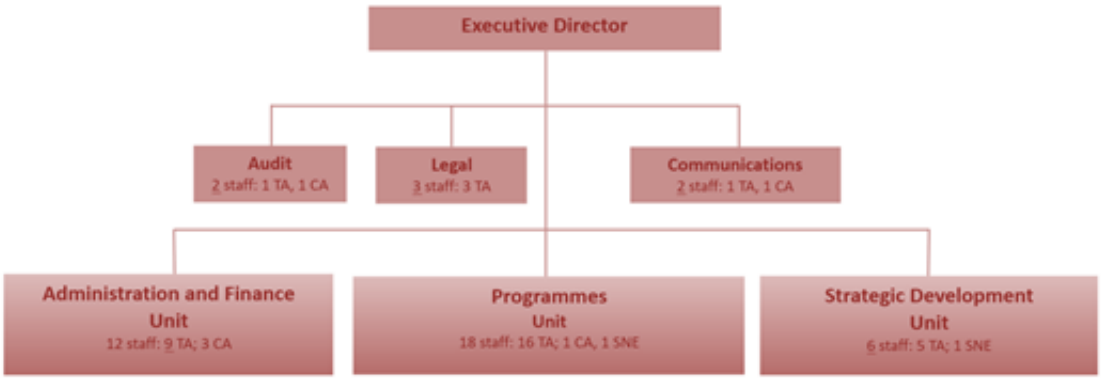
Brussels, 25 February 2021

(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



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 2020		Staff population actually filled at 31.12.2020	
	Off.	TA	Off.	
AD 16				
AD 15				
AD 14		1		1
AD 13				
AD 12				
AD 11		2		2
AD 10		4		4
AD 9		10		10
AD 8		3		3
AD 7		3		3
AD 6		9		9
AD 5				
Total AD		***32***		***32***
AST 9				
AST 8				
AST 7		1		1
AST 6				
AST 5		3		3
AST 4				
AST 3				
AST 2				
AST 1				
Total AST		***4***		***4***
TOTAL TA		**36**		**36**
CA FG IV		1		1
CA FG III		5		5
CA FG II				
CA FG I				
Total CA		***6***		***6***
TA+CA		***42***		***42***
SNE		***2***		***1***
TOTAL (TA+CA+SNE)		**44**		**43**

3. Publications from projects

Clean Sky 2 programme 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 31 December 2020 as submitted to date.

Description	ITD	Dissemination 2014-2020				
		Papers	Thesis/ Book chapters	Conferences	Other Diss.	Total
	AIR	129	11	91	7	238
	ECO	8	0	23	5	36
	ENG	79	10	62	12	163
	FRC	64	1	52	5	122
	LPA	242	8	184	3	437
	REG	94	0	83	29	206
	SAT	2	0	0	0	2
	SYS	129	8	102	8	247
	TE 2	15	0	8	0	23
	THT	5	0	3	1	9
	Total JU	767[39]	38[40]	608[41]	70[42]	1483

4. Patents from projects

Consolidated table of all patent requests for the full Clean Sky 2 programme. The following table includes both confidential and non-confidential patents.

Description	ITD	Patents applications 2014-2020
Patent statistics	AIR	20
	ECO	-
	ENG	19
	FRC	23
	LPA	13
	REG	8
	SYS	136
	TE 2	-
	THT	-
	Total JU	219

[39] Includes peer reviewed papers and technical papers
[40] Master and PhD theses, book chapters
[41] Oral presentations to workshops, conferences, symposia
[42] Flyers, exhibitions, web releases, press articles, videos, publications, posters

5. Scoreboard of Horizon 2020 and common KPIs

Description	Targets	2020 Results	2019 Results	Comments
	H2020 Results			
SME - introducing innovations of participating SMEs	No target set	Not reported	Not reported	Information not yet available; will be addressed in the tender "socio economic impact"
SME - Growth and job creation in participating SMEs	No target set	Not reported	Not reported	Information not yet available; will be addressed in the tender "socio economic impact"
Patent applications and patents	> 366 patents	Patent applications:87	Patent applications:132	The target is established on programme level by 2024.
Demonstration activities (number of demonstrators and technology streams)	35	34: L1 demonstrator 106: L1-L2 demonstrator	35: L1 demonstrator 102: L1-L2 demonstrator	
Redress after evaluations	<2% of proposals (excluding PP submission related redress requests)	2.61% 5 out of 191 proposals	0.4%	
Time to grant (TTG)	80%	CFP10 = 86,21 CFP 11 = 100%	CFP 8: 73% CFP 9: 96 %	
Time to pay (TTP) Operational budget	95%	99%	98%	

Description	Targets	2020 Results	2019 Results	Comments
Vacancy rate (%)	0%	2%	4.5%	
Budget implementation/ execution	95% in PA	Total CA:97.4% Total PA: 88.1% Oper. CA: 97.6% Oper. PA: 88.7% Admin CA: 92% Admn PA: 68.5%	97.4% in PA	
Time to pay (TTP) Administrative budget	> 95%	99%	98%	

6. Indicators for monitoring cross-cutting issues

Description	Targets	2020 Results	2019 Results	Comments
	H2020 Results			
Country distribution (EU Member States and Associated countries) - ***numbers***	EU 28: 95% Associated: 5%	GAPS : (CFPs 1 to 11) EU : 94.33% Associated : 4.77% Others: 0.90%	GAMs: EU 28: 97,17% AC: 2,27% GAPs: EU 28: 94,07% AC: 5,41% TC (Third Countries): 0,52%	GAMs signed GAPs applications/ participations
Country distribution (EU Member States and Associated countries) - ***financial contribution***	No target set	GAPs: (CFPs 1 to 11) EU: 97,19% - 865 million euro AC: 2,81% : 25 million euro	GAMs: EU: 98,6% AC : 1,4% GAPs: EU 28: 96,8% AC: 3,2%	GAMs signed GAPs applications/ participations
SME participation - financial contribution	At least 13%	GAPS - CFPs 1 to 11 : 25.87%	GAPs: 25,11% GAMs: 3,77%	

Gender balance - Programme participation	No target set	Female participation rate: 31%	Female participation rate: 30%	
Gender balance - Project coordinators	no target	Female rate of coordinators 17%	Female participation rate: 16%	
Gender balance - Advisors and experts	No target set	Female Participation Rates: 19% in Evaluations (CfP11) 12% in Annual Reviews and Technical Reviews (IPR) 10% in the SciCom	Female Participation rates: 15% in evaluations (CfP09, CfP10) 9% in Annual Reviews and Technical Reviews (IPR) 25% in the SciCom	
Third-country participation	No target set	GAPs : 0.54%	GAPs: 0,53% (7 partners from US-RU-CA) GAMS: Not Applicable	
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 53,7% in funding: 53,5%	Leaders= 100% Core Partners: 100% Partners = in number 54,3% in funding: 53,9%	Funding % assigned to IA topics decreased in 2019 compared to 2018 due to introduction of Thematic topics (labelled RIA).
Demonstration activities within IAs	70%	Not reported	Not reported	

Scale of impact of projects (High Technology Readiness Level)		*Result only at end of programme*	*Pending. To be included in the consolidated version of this report*	Based on CS2DP 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: 64% SME: 16% All: missing GAPs : IND : 16% SME : 31% All: missing	GAMs: IND: 65% SME:16% All: 81% GAPs: IND : 16% SME: 31% All: 47%	
Horizon 2020 beneficiaries from the private for profit sector - financial contribution	not more than 80%	GAMs: IND: 79% SME: 4% All: missing GAPS : IND : 18% SME: 26% All: missing	*GAMs :* *IND:79%* *SME:4%* *All: 83%* *GAPs:* *IND : 18%* *SME: 25%* *All: 43%*	
EU financial contribution for PPP	580.63[43] M€	CA: 311.4 M€ PA: 311.4 M€	CA: 298,7 M€ PA: 323,2 M€	100% of the EU contribution is cashed in 2018 and 2019

[43] CA for the period 2018-2019.

Private sector contribution including leverage effect	On programme level: 125%[44]	IKOP reported: 717.65 million IKOP certified: 581.34 million IKAA reported: €1,144 million IKAA certified: €838,13 million The executed EU contribution by the private Members represents 71% of the total envelope while the reported IKC is equal to 82% of the overall target *(declared, not fully certified figures)*	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	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 : 157 Technical papers : 43 Thesis : 3 Book : 5 Conference participation : 115 Other Dissemination Activities : 3	Peer Reviewed papers: 188 Technical papers: 113 Thesis: 4 Book: 10 Conference participation: 296 Other Dissemination Activities: 12	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 country	<25% from one country	CfP11 Italy 20.0% France 12.6% Spain 9.5% UK 9.5% Germany 8.4%	CfP09: Italy 20% France 19% Germany 12% Spain 10% UK 9%	The countries most highly represented are named. All are safely below the the

[44] Not applicable as annual target.

		Greece 8.4% Belgium 6.3% Netherlands 4.2% Romania 4.2% Ireland 3.2% Others 13.7%	Others 30% CfP10: Italy 19% France 16% Germany 13% Spain 10% Greece 6% UK 5% Others 31%	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	CfP11 Private for profit organisation = 36% Higher or secondary education establishment = 36% Research Organisation = 12% Public Organisation = 2% Other = 14%	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%	

Participation of Research and Technology Organisations and Universities in PPPs (Art 187 initiatives)	At least 25%	GAPs : share of participants : RES: 25.69% UNI : 27.02% Share of contrib. : RES : 31,29 UNI:25.28% ---------- GAMs: share of participants : RES:11.98% UNI : 6.96% Share of contrib. : RES : 14.62% UNI: 3.13%	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%	
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%	0.91%	0.92%	

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

Description	Targets	2020 Results	2019 Results	Comments
	H2020 Results			
Call topics success rate	> 90%	97%	96.4%	
WP execution deliverables versus plan	100%	77%	93%	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%	16.9%	13.0%	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 2020 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 2020 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 2020 – 31 December 2020).

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 2020. Assets are comprised mainly of the fixed assets, pre-financing incurred for the execution of the grant agreements and balances with the central treasury[45]; 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 substantially increased compared to 2019 mainly due to the underexecution of the GAM 2018-2019 and the effects of the Covid-19 pandemic (2019: €1.9 million, 2020: €76.97 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 2020 show a positive balance of € 84.9 million.

The positive balance is a cumulative effect of the non validated member's in kind contributions of the CS2 programme and the received, but not yet used EC and private member contribution

[45] Since 2017 the treasury of CS2 JU is 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'.

(prefinancing given and available cash at year end). The 2018-2019 in-kind contributions were approved by the Governing Board later in 2021, while the 2020 values will be validated after the closure of the 2020-2021 GAM in 2022.

Main tables:

BALANCE SHEET		
ASSETS	**31/12/2020**	**31/12/2019**
A. NON CURRENT ASSETS		
Property, plant and equipment (net)	128,982.00	101,142.00
Intangible assets (net)	3,133.00	31,758.00
TOTAL NON-CURRENT ASSETS	**132,115.00**	**132,900.00**
B. CURRENT ASSETS		
Short-term pre-financing	**161,767,195.85**	**185,467,601.57**
Short-term pre-financing Clean Sky JU	161,767,195.85	185,467,601.57
Short-term receivables	**79,688,330.36**	**19,119,210.51**
Short term receivables - recoveries from members and partners	2,660,150.26	987,839.34
Deferred charges and accrued income	55,251.12	191,105.62
Central treasury liaison accounts	76,972,928.98	17,940,265.55
Cash and cash equivalents	**0.00**	**0.00**
TOTAL CURRENT ASSETS	**241,455,526.21**	**204,586,812.08**
TOTAL ASSETS	**241,587,641.21**	**204,719,712.08**
LIABILITIES	**31/12/2020**	**31/12/2019**
C. NET ASSETS		
Contributions received from Members (EU & industry)	2,289,001,136.24	1,973,361,198.24
Contributions in kind received from Members (Industry)	1,174,301,658.01	867,952,442.92
Contributions used during previous years	(2,984,870,261.18)	(2,510,688,137.64)
Contributions used during the year (EOA)	(393,529,926.32)	(474,182,123.54)
TOTAL NET ASSETS	**84,902,606.75**	**(143,556,620.02)**
D. CURRENT LIABILITIES		
Members contribution to be validated	**136,310,007.19**	**318,985,107.30**
Accounts payable and accrued charges	**20,375,027.27**	**29,291,224.80**
Amounts payable - consolidated entities	0.00	0.00
Amounts payable - beneficiaries and suppliers	12,186,443.85	23,914,409.12
Amounts payable - other	53,788.38	75,847.44
Accrued charges	8,134,795.04	5,300,968.24
Provision for risks and charges - short term	**0.00**	**0.00**
Provision for risks and charges - short term	0.00	0.00
TOTAL CURRENT LIABILITIES	**156,685,034.46**	**348,276,332.10**
TOTAL LIABILITIES	**241,587,641.21**	**204,719,712.08**

STATEMENT OF FINANCIAL PERFORMANCE		
	2020	**2019**
REVENUES		
NON-EXCHANGE REVENUES		
Recovery of expenses	1,835,086.57	1,595,566.79
Exchange gains	2,855.53	0.00
TOTAL NON-EXCHANGE REVENUES	**1,837,942.10**	**1,595,566.79**
OPERATIONAL EXPENSES		
Operational expenses funded by CSJU in cash	264,371,536.43	306,266,493.17
Operational expenses contributed in kind by members	123,674,114.98	162,568,549.23
TOTAL OPERATIONAL EXPENSES	**388,045,651.41**	**468,835,042.40**
OPERATING EXPENSES		
Staff expenses	4,569,157.76	4,190,605.75
Administrative expenses	2,750,817.23	2,751,290.87
Total administrative expenses	**7,319,974.99**	**6,941,896.62**
Other operating expenses		
Exchange losses	2,973.67	33.96
Total other operating expenses	**2,973.67**	**33.96**
TOTAL OPERATING EXPENSES	**7,322,948.66**	**6,941,930.58**
OPERATING RESULT	**(393,530,657.97)**	**(474,181,406.19)**
FINANCIAL INCOME		
Interest on late payment (income)	1,121.93	995.11
Total financial income	**1,121.93**	**995.11**
FINANCIAL EXPENSES		
Financial expenses	390.28	1,712.46
Total financial expenses	**390.28**	**1,712.46**
FINANCIAL RESULT	**731.65**	**(717.35)**
ECONOMIC RESULT OF THE YEAR	**(393,529,926.32)**	**(474,182,123.54)**

CHANGES IN NET ASSETS AND LIABILITIES		
	EURO	EURO
Net Assets		
Balance as of 31st December 2019		**(143,556,620.02)**
Contributions received from members during the year 2020:		
Private members Clean Sky 2 Programme (H2020) (cash)	4,261,950.00	
EC Clean Sky 2 Programme (H2020) (cash)	311,377,988.00	
Other members contributions in kind from 2008-2019 validated in 2020	306,349,215.09	
Total contributions in 2020		**621,989,153.09**
Economic Outturn for 2020		**(393,529,926.32)**
Balance as of 31st December 2020		**84,902,606.75**

CASH-FLOW	
31.12.2020	
	2020
Economic result of the year	**(393,529,926.32)**
Operating activities	
Amortisation and depreciation	90,026.12
Non-cash expenses in-kind	123,674,114.98
Cash contributions from Members (EC & Industry)	315,639,938.00
Increase/(decrease) in provisions for risks and liabilities	0.00
(Increase)/decrease in pre-financing	23,700,405.72
(Increase)/decrease in exchange receivables and non-exchange recoverables	(60,569,119.85)
Increase/(decrease) in payables and accruals	(8,916,197.53)
Other non-cash movements	0.00
Net Cash Flow from operating activities	**89,241.12**
Investing activities	
(Increase)/decrease in intangible assets and property, plant and equipment	(89,241.12)
Net Cash Flow from investing activities	**(89,241.12)**
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

The assessment of the effectiveness of the CS2 JU control system for H2020 grants is based mainly, but not exclusively, on ex-post audits' results. The effectiveness is expressed in terms of detected and residual error rate, calculated on a representative sample.

This chapter 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

Multiannual approach

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 H2020 programme, 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 (corrective measures of audits), this error level is to be adjusted by subtracting:

- errors detected and corrected as a result of the implementation of audit conclusions in audited financial statements;

- errors corrected as a result of the extension of systematic audit results to non-audited cost claims issued by audited 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:

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

Where:

$\sum$ **(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 €.[46]

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. extension of systematic audit findings).

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

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%).

[46] In 2020 the Commission re-defined its methodology for calculating the Horizon 2020 error rate for all audits closed as from 01 January 2020. The main change in the methodology is that in cases of systemic errors, the denominator used in the error calculation is the sum of costs actually audited and not the sum of all accepted costs. The audits performed within the samples selected by CS2 JU are not affected by this methodological change.

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.

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.

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

$\sum$ **(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.

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 INTERIM PROGRESS REVIEWS OF CLEAN SKY 2 (12/2020)

1. ORGANISATION AND PERCEPTION OF THE REVIEW PROCESS

The review process implemented in Clean Sky 2 (CS2) involves Annual Reviews (ARs) and follow-up Interim Progress Reviews (IPRs) approximately six months later. As a supplement to this structured process, focused *ad hoc* reviews of specific Work Packages are undertaken, when deemed necessary by the expert reviewers and CSJU Project Officers. The Scientific Committee (SciCom) consider this review process to be an important instrument for monitoring, informing and, where necessary, re-adjusting the CS2 programme. It continues to play an important role by enabling an efficient alignment of the CS2 programme activities, across all SPDs, towards the CS2 targets.

The CSJU, SPD Coordinators and Expert Reviewers continue to report a high level of trust, fairness and collaborative spirit in the review process. Valuable guidance has been generated and implemented, supporting the success of the programme.

The Annual Review Meetings (ARM) and Interim Review Meeting (IRMs) also provide a forum for Expert Reviewers to discuss with SPD Coordinators best practices (e.g. in project management or in reporting) and synergies (in engineering topics) that have been identified in the different SPDs. One benefit of this engagement is that technical workshops on selected topics have been organised for the benefit of the CS2 community.

The procedure adopted for the CS2 Interim Progress Review Meetings in Q4 2020 was based on the remote-meeting format implemented for the ARMs that took place in May/June 2020. The following multistep review process was implemented in lieu of physical meetings:

1. Review material (PowerPoint slides, reports, deliverables) was prepared and made available to the reviewers approximately two weeks before the scheduled remote meetings;
2. Questions were then prepared by the reviewers, where clarification or further information was needed;
3. Written answers and/or revised PowerPoint slides addressing the reviewers' questions were prepared by the SPD management (in several cases this information was provided in advance of the meeting);
4. Q&A (questions and answer) sessions with the reviewers were held via WebEx to address specific concerns, present follow-up questions, or challenge the answers provided.

This remote review process offers certain advantages over the traditional in-person meeting (e.g. no travel cost and no travel time, reduced carbon footprint). However, the actual time required for meeting preparation and meeting participation increased. As with the ARMs, the reviewers' experiences of the remote (WebEx) meetings varied – in some cases, the meetings ran smoothly, whereas in others, difficulties were encountered (e.g. timekeeping, broadband signal interruptions and misunderstandings resulting from inadequate or poor communication). It is widely agreed that information exchange can be efficient through this process; however, meaningful discussion and debate can also be stifled. These additional discussions outside of the formal review presentations provide the reviewers with additional insights into progress and perceived future challenges which may be withheld due to industrial sensitivities.

Noting the difficult circumstances under which individuals and organisations have been operating over the past months, the reviewers would like to pay tribute to the SPD management teams and everyone involved in the Interim Progress Reviews. Despite the challenges imposed by these circumstances, the reviewers were unanimous in their opinion that comprehensive and meaningful reviews were possible.

It is apparent that Covid-19 pandemic has had a significant impact on the work of the beneficiaries in all SPDs. Following the ARMs, all SPD coordinators were tasked to conduct a detailed assessment of the impact of Covid-19 and to prepare recovery plans. This formed one of the key elements considered at the recent IRMs. In particular, the question as to whether the recovery plan was sufficiently robust was to be considered by the expert reviewers.

A general delay of 3-4 months was reported for most activities. In some cases, especially for demonstrators which require significant industrial supply chain inputs, longer delays are reported. This is quite natural considering the pandemic situation. However, the mitigation actions require a certain level of robustness and should in any case ensure a delivery of results before the end of 2023 including margins. Tendencies of de-scoping or reducing ambitions should be identified and stopped. This is an activity which will require continued monitoring as additional waves of the pandemic become apparent. In some SPDs (e.g. ENG), the introduction of PERT type reporting to the major demonstrator activities will provide an important regular (currently quarterly) drumbeat to inform the CSJU Project Officers of issues and progress of mitigation actions.

2. ADMINISTRATION AND MANAGEMENT

For CS2 a high standard of project management continues being evident across all SPDs. This is reflected in the improvement of the quality of presentations and of reporting. This is even more remarkable as the multistep review process described above requires more attention and adherence to the review process scheduling compared to a standard review. Good compliance with the requirements of this new type of review was reported and, in some cases, even more detailed assessments could be carried out. However, in at least one review the procedure deviated due to late availability of material, which seriously hampered a smooth review process.

Financial aspects are assessed and reported during Annual/Interim Reviews across all SPDs in an open and transparent manner. Across most SPDs the level of achievement (deliverables and milestones) did not match the resources spent. In many cases the resource implementation was close to nominal, while at Q3 less than 50% of planned milestones were met and deliverables were submitted. While being a matter of concern, in many cases a recovery scenario was presented providing good evidence, that the programme is still under control.

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 associated mitigation strategies. It is important to provide the risk probability, severity and the remedies envisaged. Although requested at every review, this obvious information is often still not presented with sufficient detail.

With the new risk of the pandemic impacting the programme the reviewers recognised that some related high-level risks either resulting from the pandemic itself or from the re-scheduling initiated are not covered sufficiently.

The reporting on dissemination and exploitation is not following a common scheme across all SPDs, which makes the assessment more difficult. In some SPDs there was no overall reporting on achievements in those performance dimensions. Instead, single WPs and demonstrators reported individually. It is recommended to implement a common reporting scheme for those KPIs.

3. OVERVIEW OF TECHNICAL PROGRESS IN CS2

3.1 LARGE PASSENGER AIRCRAFT (LPA) IADP

The 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). The Interim Progress Reviews of the three platforms took place separately in November 2020, following the process outlined earlier.

Several specific objectives for this IRM had been established – these included: (1) to give feedback to the reviewers on recommendations arising from the last Annual Review Meeting (ARM); (2) to provide an interim status update on progress made in 2020: (3) to assess the impact of Covid-19 on progress and future plans; (4) to evaluate the TE and ECO design activities; (5) to evaluate the dissemination, communication and exploitation plans and achievements; and (6) to review, where appropriate, the evolution of the CS2DP. The overarching impression of the reviewers, despite the difficulties posed by the Covid-19 pandemic, that satisfactory reviews of the three LPA IADP Platforms was completed. Additional remarks on the three platforms are given below.

3.1.1 LPA PLATFORM 1

The IRM for LPA 1, which took place remotely (via WebEx) on 24–25 Nov. 2020, was conducted in a professional and constructive manner. Overall, the reviewers were satisfied with the organisation of the IRM and the material presented. The LPA team has completed a good initial assessment of the impact of Covid-19 and a recovery plan has been formulated. A general delay of ~3 months was reported for many activities.

The person month (PM) spend was reported to be close to original planning (91% of the planned PMs for 2020 up to end Q3 was consumed). However, output has fallen behind. With respect to the original GAM for 2020 (at Q3), 33% of key deliverables had been submitted and 22% of major milestones achieved. It was reported that many of the outstanding deliverables are nearing completion and a more representative picture will be available by Q4/2020. The management team reported high confidence that their recovery plan is robust and that the revised milestone schedule (until end-February 2021) is achievable. Several new key deliverables and milestones have been proposed (to be added via the GAM amendment); however, at the time of the IRM, this was still under negotiation with the CSJU as changing the 2020 baseline would alter the KPIs (Key Performance Indicators).

LPA 1 is organised by "top" demonstrators: D01 (Enablers for Integrated Open Rotor Design); D02 (Advanced Rear-End); D03 (Validation of Scaled Flight Testing); D04 (HLFC on Tails: Large Scale Ground Based Demonstrator); D05 (Natural Laminar Flow Demonstrator for HTP); D06 (Ground Based Demonstrator on HLFC Wing); D08 (Radical Aircraft Configuration); D09 (Hybrid Electric Propulsion Ground Demonstrator); D10 (UltraFan Flight Test Demonstration); D11 (Active Flow Control, AFC); D12 (Active/Passive Solutions for Vibration and Noise Control); D13 (UHBR Short-range Integration); D14 (Boundary Layer Ingestion, BLI); D15 (Non-Propulsive Energy, NPE); D16 (Common Technology Bricks for Future Engines); and XDC (Common Numerical Methods and EM).

The high-level technical progress report, presented at the IRM, showed steady progress in 2020, but with some delays, for this large, complex platform. At the ARM (May 2020), several major issues had been identified and discussed; updates were provided at the IRM. In D05, the withdrawal of GKN-Fokker means that the whole demonstrator will not be completed (as a new partner could not be found). For D09, the impact of the closure of the E-Fan X flight demonstrator (announced earlier in the year) was addressed. For D08, a specific review had been held (7 July 2020); this was positively assessed, and the "go-ahead" decision was confirmed. For D14, it was announced at the IRM, following an Airbus review, that the focus

is shifting back to OR (open rotor) propulsion architectures and that BLI (Boundary Layer Ingestion) work will be ramped down. Significant revisions were also presented for D02, D10 and D13. The reviewers noted that the draft CS2DP Part B is incomplete and did not fully align with the descriptions presented at the IRM; it was recommended that the Part B be updated.

Dissemination and communication activities were severely impacted by Covid-19 in 2020. LPA 1 has already exceeded the modest total target of 123 technical papers for leaders and core partners. The reviewers have expressed concern in the relatively low number of peer-reviewed journal papers included in this total. Also, complete visibility of the output of GAP/CfPs is lacking.

A new funding risk has emerged in 2020. Of the €820k funding available for contingencies (per CS2DP), only €150 k is available for unexpected risk mitigation. Considering the size of the remaining budget and the uncertainties due to Covid-19, the reviewers considered this funding reserve to be insufficient. It was, however, stated at the IRM that any new funding risks (i.e. outside those already identified) could be accommodated through national programmes or self-funding. The reviewers recommended that a more comprehensive and robust mitigation plan be prepared for the scenario that funding reserves get depleted before the end of CS2.

It can be concluded that LPA Platform 1 continues to be effectively managed with good leadership. Despite the difficulties associated with Covid-19 and the need for remote working, a satisfactory review was undertaken. The reviewers complimented the LPA Platform 1 team on what was achieved this year under difficult circumstances. Many challenges, however, remain to be addressed due to the pandemic over the coming months.

3.1.2 LPA PLATFORM 2

The WebEx meeting (19 Nov. 2020) was well planned and managed. LPA Platform 2 consists of four work packages. WP 2.1 and WP 2.2 are each preparing a major ground demonstrator, WP 2.3 is now closed, and WP 2.4 is developing several technologies, designed to support the first three WPs and are also linking the activities with the ITD AIR and the Transverse Activities of Eco Design.

Covid-19 has had a significant impact on all CS2 activities. A good assessment of the impact of Covid-19 has been undertaken by the LPA 2 management team. The master plan shows progress being made in 2020 in all active WPs, albeit at a reduced rate. Several delays are identified, but, importantly, it is also stated that there will be no impact on the TRL maturation plan. A significant funding risk has emerged in 2020, with the reduction in funding reserves.

A general delay of ~3 months was reported for many activities. As regards the 31 key deliverables in the original GAM for 2020, it is expected that 19 will be delivered in 2020, 4 by the end of February 2021, and 8 have been replanned for 2021. The person month (PM) data indicates that by Q3, 72% of the 924 PM planned for 2020 had been consumed. In other words, the PM spend is close to the original planning; however, due to Covid-19 and other delays incurred in 2020, output has fallen behind. It was, however, reported that many of the outstanding deliverables are nearing completion and there appears to be high confidence that the newly defined targets will be met. It was stated that several new deliverables would be added via the GAM amendment – however, at the time of the IRM, this was still being negotiated with the CSJU.

Information on GAPs/CfPs by way of a new two-slide template (for each GAP) is considered to be a good development. This allows for a more complete picture of activities to be presented, without necessarily taking up a lot of time during the meeting. Regarding dissemination, communication and exploitation (D+C+E), it was reported that 50 peer-reviewed papers have been published to date, which is approaching the overall target of 58. The relatively low number of journal papers (2 planned for 2020) is cause for

concern. Furthermore, the distinction between peer-reviewed and non-peer reviewed articles has not been made clear. Nine patents have been achieved, with a target of 21.

LPA 2 comprises three active work packages – some highlights are presented below.

WP 2.1 (Next Generation Fuselage Cabin and Systems Integration): The MFFD (Multifunctional Fuselage Demonstrator) remains one of the flagship demonstrators in CS2, with a high priority for completion due to the extensive range of innovative topics addressed and the significant potential for environmental and socio-economic impacts. It is noted that the top-level objectives are essentially unchanged. It was, however, stated that TRL 5 will not be achieved for all technologies.

WP 2.2 (Next Generation Cabin and Cargo Functions): The main objective of this WP is to demonstrate RC (recurring cost), lead time and environmental benefits of highly integrated cabin elements, designed for automation. The objectives of this WP have not been changed. There is still the aim to reduce about 350 kg in weight in the cabin by introducing the new cabin platform, the universal cabin interface (UCI) and the electric printings. Some cabin technologies have the potential to be integrated as retrofit in the actual SA (single aisle) fleet. Two new items are listed: the new hat rack and the new sidewall. The new hat rack is stated to reduce the cabin weight by 500 kg and the new sidewall panels by 20 kg. This is enormous and details will be reported during next ARM 2021.

WP 2.4 (Non-Specific Cross Functions): The WP is home to a large number of CfPs, which continue to generate interesting IP directed towards the LPA2 demonstrators, but with exploitation potential in many other areas. This is facilitated in part by the close links to AIR ITD. Good progress was reported. WP 2.4 continues to be well managed, with a significant potential for dissemination and exploitation.

Despite the difficulties associated with Covid-19 and the need for remote working, a satisfactory interim review of the LPA IADP Platform 2 has been undertaken. The reviewers complimented the LPA Platform 2 team on what was achieved this year under difficult circumstances.

3.1.3 LPA PLATFORM 3

The IRM of LPA3 (Next Generation Aircraft Systems, Cockpit and Avionics) took place on 12 November 2020. The remote review (WebEx) was well prepared and relevant material including slides as well as a tracking document on the recommendations issued in prior reviews were provided well in advance.

The status of technical progress, technical challenges and impact of Covid-19 was very well presented. A good transparency on the current situation was provided by the management. The overall picture provides good evidence, that despite the significant Covid-19 induced slippages an appropriate recovery is presented, that the related impact is limited and that the project is under control. It is appreciated that lessons learned in risk management from the first Covid-19 wave are being implemented in light of a second wave.

However, because of the Covid-19 pandemic and the resulting delays and financial issues, the industry had decided to re-scope a significant number of activities and to prepare an amendment for the GAM 2020-2021. In general, the impression was received, that the (re-)planning of activities as presented is to some extent driven by available funding: instead, it should be focused on contributing to the CS2 objectifies and those of LPA3.

In all presentations the consequences of this GAM Amendment Plan has to a significant level already been considered to be agreed. Therefore, the reported progress was unfortunately referring to different planning states. In addition, it was recognised that the reporting partially was carried out according to the achievements registered in the EMIS system, not the EC platform. A strict adherence to the contractually

agreed procedure is recommended to allow a clear and sound monitoring of the project.

The end-of-year budget implementation was forecast to be €11.05m versus a planned €12.37m (89%). The financial reserve in GAM 2019-2020 was proposed for additional work in the GAM Amendment, reducing the reserves for contingencies and risk reduction. This is not supported by the reviewers as highest priority should be given to securing the demonstrators. Instead, it is recommended to increase the robustness in planning of the coming years protecting the achievement of targets and contribution to CS2 within objectives.

Assuming that no additional funding from the CSJ2U could be made available it might be necessary to reprioritise the activities within the LPA3 Demonstrators and possibly within LPA in total. In this reprioritisation it is of great importance that the focus will be on the CS2 High Level Objectives and flagship demonstrators.

Demonstrator D1 (Disruptive Cockpit Demonstrator DisCo) can be considered as one of the CS2 Flagships. While in general good progress and convergence has been recognised, in a number of activities either a reduction in ambition (IMBALS, LIFI, speech to text) or a request for funding increase (LIDAR, GPAHRS) has been observed. In addition, for the overall DISCO demonstration the number of technologies to be integrated and demonstrated seems to be significantly reduced compared to the previous reporting (e.g. 2018).

For the Active Cockpit the contribution to the CS2 High Level Objectives is regarded as limited. The change in demonstration platform towards a more general A330 MRTT cockpit simulator has reduced the potential of larger impact to some extent. In addition, the withdrawal of SAAB and GEAS reduced the overall ambition significantly and downgraded the Active Cockpit Demonstrator to a more general technology demonstrator (TRL4). The initially targeted TRL5 for the Active Cockpit seems meanwhile unachievable in the scope of CS2. A request for additional funding originates from the transfer of activities between members, caused by the abovementioned withdrawal. It needs to be clearly demonstrated what benefits the continuation of these activities would bring against the budget to be implemented. So far this has not been demonstrated convincingly.

For the Business Jet enhanced cockpit ground and flight demonstrations, the objectives are relatively short term and mainly focused on the increase of safety and the decrease of the weight of cockpit utility management functions

D3 as such is planned to achieve TRL 6 in 2022. The TRL6 is considered as average TRL across the different technologies, which may deviate in final TRL. By now it is not yet fully clear, to what extent an integrated demonstration can be expected and what elements will go into flight testing. Therefore the level of clarity in the ambition is not sufficient, which requires a more balanced differentiated view on the final achievements.

3.2 REGIONAL AIRCRAFT (REG) IADP

REG IADP originally aimed at demonstrating technologies with benefits for three different future aircraft types (70, 90 and 130 pax). These aims remain with the slight modification that the scope has since 2019 expanded to also include a conceptual study of a 40 pax hybrid electric aircraft. The demonstration activities is achieved by two flight test demonstrator programmes – one provided by Leonardo (FTB#1) and one by Airbus DS (FTB#2), alongside with ground test demonstrators (an Outer Wing Box (OWB) structure, fuselage/cabin demonstrator and Iron bird). Technologies to be verified are provided from other ITDs as well as via development performed in separate work packages within IADP REG.

The IRM included an overview of activities with particular emphasis on achievements since the ARM (June

2020). It thereby included status of the major demonstrators, key tests programmes, updates of the project plan and budget. From the IRM it was confirmed that the main demonstrator master plan, besides some revisions and delays due to Covid-19, remains intact. Overall, the plan is not changed, although there have been delays for almost all work packages and demonstrators. As a consequence, several key milestones and deliverables have been delayed, but overall targets seem not yet critical.

The recommendations from last ARM (June 2020) were all answered during the IRM, either separately by the project management or integrated in discussions with individual work packages. The REG IADP management have made an appropriate initial assessment of the impact of Covid-19.

Generally, a 4 month average delay on the full scale demonstrators are currently expected. Between 9 and 12 months are reported in individual WPs. Thanks to scheduled margins allocated in the original planning final demonstrations are expected to be concluded within the framework of CS2, many by end of 2022, others in early 2023.

Two top-level risks have been reported and highlighted; funding availability for step 2 flight test programme of FTB#2 (multi-mission aircraft) and Fuselage/Pax Cabin demonstrator. Reports on actions taken to mitigate risks were provided. The top-level risks will require attention from all involved parties during subsequent period.

Regarding dissemination, communication and exploitation, the programme is in a reasonably good position. It was reported that 101 technical papers have been published to date which is reasonable. However, the number of patents remains low.

In terms of technical achievements, initial results from the hybrid-electric 40-50 pax reference aircraft concept study, initiated in WP1 since 2019, was reported. While yet more work is needed, first indications point towards fuel saving potential for certain flights despite a weight penalty.

Specific sub-technology developments are conducted within WP2. This includes development of composites manufacturing, wing structures and components, load control systems, electrical power generation and distribution system (EPGDS), flight control systems (FCS) to mention a few. The impression is that progress continues, but the rate of progress is clearly affected by Covid-19. Many important milestones and deliverables are, as a consequence, delayed and postponed to 2021.

Four demonstration tasks are performed within work package 3. In WP 3.1 the work is focused on two technology demonstrators (Flight test bed, FTB#1 and a ground demonstrator, Outer wing box, OWB). It was positively noted that a detailed flight operations timeline plan, starting from September 2021 to October 2022 was developed during the period and is currently in place. The schedule is challenging but appear realistic.

In WP 3.2 progress with respect to fuselage structural demonstrator and full-scale cabin demonstrator was reported. Progress include completion of fuselage panel structures. For the cabin demonstrator the fact that hardware for the demonstrator is manufactured both within REG IADP and also supplied from other ITDs appears to provide challenges that need to be resolved. The Pax Cabin CDR is planned for the last quarter of 2020. It will remain an important demonstrator.

In WP3.4 the Iron bird developments were reported. The IRM provided a good overview of the status on the manufacturing and assembling of the Iron Bird components. The work develops largely according to plan although delays due to Covid-19 are reported.

Activities and progress with respect to wing and systems integration for FTB#2 was also reported. Actual modifications towards step 1 flight tests are in progress providing good evidence that this part of the

demonstrator activities will be completed within CS2. Step 2 flight test programme is however currently at risk mainly due to a reported lack of funding. Developments with respect to Step 2 FTB#2 will consequently be an important item on the 2021 ARM agenda.

Within WP4 the interaction with TE transversal activities were progressing via support on up-to-date input on mission performance data. Eco-design activities have since previous been focused on two manufacturing processes; replacement of hard chrome plating and liquid resin infusion composite processing. A first Eco-Design Flagship Demonstrator (FSD), the outer wing box, has been defined.

3.3 FAST ROTORCRAFT (FRC) IADP

The IRM for FRC took place remotely on 3 – 4 November 2020. The reviewers acknowledge the remarkable progress of NGCTR compared to the last ARM on the wing, nacelle, tail and fuselage development as well as toward the CDR gates. Joint teams have been created for the development of complex subsystem (e.g. fuel systems). The reviewers acknowledge the remarkable progress of RACER compared to the last ARM toward the manufacturing and delivery of the fuselage which has benefited from an excellent on-site support given by RACER team. The joint team AH/INCAS/ROMAERO has recovered most of the delay and secured fuselage delivery of the hardware by 12/2020 expressing its commitment towards the final project objectives.

Covid-19 had a significant impact on the AIR ITD and FRC IADP programmes. The reviewers are convinced that a good initial assessment of the impact of Covid-19 and efficient reactions to diminish consequences have been undertaken by the management teams, who are working hard to mitigate delays.

NGCTR: The June 2023 first flight date pre-announced in the last ARM review is confirmed. The reviewers, however, share the view that the situation is dynamic, and a continuous monitoring shall be implemented to avoid further delay. Critical path analysis regarding deliveries needed for the first flight have been presented. A general delay of 3 to 4 months was reported for some activities planned in 2020 (e.g. aircraft CDR). Reviewers acknowledged that priority has been put by the project management on de-risking major design activities. KPIs as defined for WP1 in 2020 are confirmed (13 out of 13 deliverables and 3 out of 3 milestones). As a broad assessment, it is apparent that the planned person months (PMs) in 2020 will reach 90% of the initial forecast.

RACER: The August 2022 first flight date pre-announced in the last ARM review is protected. The reviewers, however, share the view that the situation is dynamic, and a continuous monitoring shall be implemented to avoid further delay. Critical path analysis regarding flight deliveries have been presented related to:

1. Main Rotor Head (MRH) delivery need date 09/08/2021 (current plan foresees 15/11/2021)
2. Engine to MGB Link need date 10/05/2021 (current plan foresees 25/10/2021)
3. MGB delivery need date April 2022

For both demonstrators NGCTR and RACER, the main activities in WP3 are focused on Life Cycle Assessment Analysis (LCA). The LCA methodologies selected for both demonstrators are similar. The actual level of research progress is also similar and adequate, what was stated at ARM2019 report. Due to the long-lasting issue with IPR agreements with Leader of Eco-Design TA, in 2020 both LH and AH initiated extensive contacts with Eco Design TA. The common AH and LH meeting with ECO design leader was organized. These contacts led to better understanding of mutual positions but (again) not finalized in formal agreements.

NGCTR: three consortia T-Wing, AMATHO and TRAIL were selected to contribute to eco-design analysis.

RACER: After the remarkable progress till IPR in 2019, there were not many new results presented in ARM 2020 and IPR 2020 meetings. The main achievements in 2020 declared by AH were the implemented RACER LCA upscaling methodology and oral agreement with ECO-TA on activities to be covered and on a way to proceed. The RACER Eco activities are on "stand-by mode" waiting for final agreement with ECO-TA

In Technology Evaluator (TE) remarkable progress was recognised during 2019. LH and AH have agreed about common approach of synchronizing the contents of presentation on TE results for both demonstrators. Since then, during the reporting period further analysis are provided. The analyses are based on selected missions typical for both aircraft and selected technologies.

NGCTR analysis are provided for two-time scales within the CS2 period and the beyond for which some partners develop technologies Cat 2 and Cat 3 related to full scale 20+pax tiltrotor. In reported period LH attended all the CCs and Workshops of the Technology Evaluator (TE), developed a methodology for assessing SAR missions.

RACER team completed the list of assessed technologies. Some steps towards exploitation were recognized. However, there are still issues regarding adequate reference aircraft for compound helicopter.

NGCTR: Regarding dissemination, communication and exploitation, the NGCTR project lacks from showing relevant progresses in delivering dissemination and communication actions but it is expected to become more intensive as the project will complete the design phase. Regarding patents, LH (and AH) expressed its difficulty to flow down the global objectives at Partner's level as they have no contractual relationship with these Partners and some companies have a policy limited patents submission. Similar it is unclear to the reviewers the LH position toward the IADP defined targets. A general exploitation plan for a potential product is unchanged, but the current epidemical situation indicates the increase of importance of medical services and efficient individual transport. FRC activities might contribute to this.

RACER: Regarding dissemination, communication and exploitation: The RACER is in a reasonably good position but expected to become more intensive as the project will enter into the validation phase. General exploitation plan for a potential product is unchanged, but the current epidemical situation indicates the increase of importance of medical services and efficient individual transport. FRC activities might contribute to this. A new roadmap has been presented which is extended to a dual use exploitation for a modified version of the RACER aircraft.

The CS2DP has been updated. The level of ambition still high. Following an assessment of performed activities with respect to the original scope, the TILTHEX (ALM Heat Exchanger) has been discontinued July 2020. For the heat exchange activities Leonardo Helicopters will move from the ALM to a more conventional technology.

3.4 AIRFRAME (AIR) ITD

The IRM 2020 for AIR ITD was held on 20 - 21 October 2020 as a remote WebEx meeting. The ITD AIR is supporting all IADPs with technologies and about 80 smaller demonstrators. AIR has three Technology Streams (TS): TS-A: High Performance & Energy Efficiency (HPE); TS B: High Versatility & Cost Efficiency (HVC) and TS C: ECO Design.

The TS HPE targets technologies that directly lead to more efficient airframes for commercial aircraft and is mainly supporting LPA. HPE is managed by Dassault Aviation and Saab and also involves as leaders Airbus (AIB) and Fraunhofer (FHG) and six core partners.

The TS HVC consists of four different WPs related to the design, manufacture and the ground testing of innovative wing structures for Rotorcraft, Regional Aircraft and Small Air Transport. Three Large Demonstrators, which will be integrated into large IADP Flight Demonstrators (Wing for RACER demonstrator, Morphing Winglet and Intelligent Loads Alleviation System) and two demonstrators for technology maturation (Composite Wing for Small Air Transport, Morphing Leading Edge) will be developed in this Technology Stream.

The TS C ECO Design is fairly large, and a lot of technologies (over 80) will be assessed. The reviewers have pushed to concentrate on flagship demonstrators FSD. 5 FSDs have been recently proposed at last ARM.

Generally good progress is reported in all TS. Specific highlights are described below:

Covid-19 has had a significant impact on the AIR ITD programme. A general delay of 3 to 4 months was reported for most activities. In some cases, longer delays (6 to 10 months) are reported. The revised planning shows that 11 out of 41 deliverables and 15 out of 47 milestones have been delayed to 2021. In a small number of cases, final delivery of a demonstrator has been delayed to 2022. As a broad assessment, it is apparent that 96% of the planned person months (PMs) for the period Q1 to Q3 2020 were consumed; however, many of the outputs have been delayed. This will require careful monitoring, financial control and flexibility going forwards. Regarding the ongoing GAPs, 30% report a high impact of Covid-19 and required an amendment.

Regarding dissemination, communication and exploitation, the project is in a reasonably good position. It was reported that 187 technical papers have been published to date, which is above target for Q3 2020 (166). However, the current "production rate" needs to be increased a little over the remaining years to meet the final target (for 2023). The new initiative to track citations of published articles is welcomed, as this provides another way of measuring research impact. Concerning patents, the picture is less positive (currently at ~50% of target). Based on the output to date and the current trajectory, the final target (2023) will not be met. This requires further attention and a dedicated effort to protect the intellectual property of the excellent work being undertaken. It was, however, noted that identified exploitation opportunities are now more visible with the new reporting formats

The reviewers are of the opinion that a satisfactory interim review of the AIR ITD has been undertaken, despite the difficulties associated with Covid-19 and the need for remote working. The reviewers would like to compliment the AIR ITD team on what was achieved this year under difficult circumstances.

3.5 ENGINES (ENG) ITD

As usual with ENG ITD reviews, the IPR was comprehensive and covered responses to the ARM recommendations and updated progress in line with the CS2DP and associated GAM. The organisation of the remote review over 2 days was effective although at times the WebEx system (audio via telephone, presentations via computer/tablet) caused some issues. The preparation process was excellent. Reviewers received information with sufficient time to generate consolidated comments and questions with several of the work package providing responses prior to the meeting which was appreciated. All TA's were involved (SAT, TE and ECO) together with Airbus (link to LPA). This reflects on the strong management of the ENG ITD.

The positive, encouraging signs noted during the last ARM were confirmed during this intermediate review, with a relative resilience to the Covid-19 crisis and significant progress in the majority of activities. Although it is a dismal and severe event with considerable impacts, the crisis is occurring at a time when the programme is mature. The excellent level of communication, coordination and synergies - combined with the programmes' momentum supported by Senior Management - have limited the negative impacts of slowed down or disturbed activities. Nevertheless, a number of delays are still evident in the majority

of work programmes. However, despite main targets relating to technology development and demonstration being maintained, the level of associated risk, primarily to the timeline, increased. This may be further compounded by the nature of uncertainty evident in research activities. It will require continued intensive efforts from all actors, including tight monitoring, optimisation of work, resources including the supply chain and time utilisation, to achieve the stated outputs, within the remaining time available within the CS2 programme.

The reviewers acknowledged and appreciate the significant overall progress and achievements obtained by all WPs, in spite of the adverse circumstances, thanks to the high involvement of all actors in their work, also visible in the preparation of the review. A number of technical questions remain open, which were detailed in relevant sections of the reviewers' report. The pandemic is far from being over, and its impacts will need to be continuously monitored and updated. As major demonstration activities approach their final stages, a one page "PERT" style report was provided by WP's as suggested during the last annual review meeting. This provides a more effective "drum beat" system supporting tool as well as assisting the CSJU Project Officer in his task of monitoring the major demonstration activities. This was appreciated by the reviewers and the JU Project Officer as a good step in the right direction. The suggestion is made to extend this effective tool to ensure programme success.

In connection with the pandemic impacts, budget aspects were addressed in the material presented and discussed during the review. Questions related to budget underspending, GAM values and amendments, activity transfers, remaining financial resources, those needed to complete the work programmes and any other relevant aspect will need to be addressed in a comprehensive and clear manner prior to presentation at the next annual review meeting. In respect of several work packages, WP3 being the most significant, the current budget (GAM 2020-2021) is inadequate for the planned demonstrator testing activities which will be complete in 2021. This should be addressed to ensure the budget reflects the planned activities as stated. (note for WP3 this has been completed). The CS2DP was reviewed in detail and questions were raised relating to each work package. It was confirmed that all ENG WP demonstrators would be incorporated in the TE CS2 2nd (final) Global assessment. This should be reinforced within the CS2DP documentation by the ENG ITD when the relevant work descriptions mature.

Significant progress was noticeable regarding the depth of coordination with aircraft manufacturers, which satisfies the essential need to ensure the best match of future aircraft and engines. This also contributes to optimising the outcome of the work package activities, without impacting the demonstrator committed completion timeline which 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. This has been addressed effectively within this review with presentations from Aircraft manufacturers, together with the TE presentation and discussions. This demonstrated once again the strong relationships and level of integration for ENG ITD technologies across the whole CS2 platform programme. Further progress was also noted in the interaction with ECO TA.

3.6 SYSTEMS (SYS) ITD

The interim review on SYSTEMS took place on 20 – 21 October 2020. Because of the Covid-19 pandemic, the meeting was held remotely by WebEx. Unfortunately, and despite strong intervention from the Project Officer, the required review material was provided very late, in some elements even only during the meeting. This prevented the simultaneous visibility of all required elements in a structured way. It hampered assessing the credibility of plans to completion and associated main risks to fully achieve the project's objectives. In addition, it was not possible to focus the online meeting to the most important elements. Instead, all the presentation material had to be delivered and assessed which was a very inefficient procedure. This late delivery is considered as not appropriate in terms of the process. In addition, for WP5 D10 the demonstrator owner was not present to provide explanations and reply to

questions, which required a follow up meeting on Nov. 4th.

The progress of the ITD is significantly impacted by the Covid-19 pandemic, technical challenges as they lie in the nature of any innovation activity and changing interest in the members. A clear and convincing assessment of these challenges and the impact on the work plan is presented by the coordinators. While 40% of the demonstrators seem not to be impacted, the majority of demonstrators are impacted by delay, cancellation, or scope reduction.

Mitigation and re-planning were presented, but the assessment of the related risks (e.g. when shifting activities to Q4/2023) where not presented convincingly. The statistics of achievements via deliverables submitted or milestones achieved are subject to a major concern at the first glance. At the end of Q3 a resource consumption of 70% was reported against achievements of 30% deliverables and 26% milestones. However, evidence is provided, that the ITD is still under control and a convergence towards an appropriate level of achievement is visible. In any case it is expected to ensure that implementation of funds and achievements correlate sufficiently at least at the end of the current GAM (2021).

The extended cockpit demonstrator is well on track, while suffering from the cancellation of SAAB activities and a major delay in IMC ITN/IPS & multilink demo of one year and the cancellation of flight trials of single channel VHF.

WP 2 Cabin & Cargo Systems lacks an appropriately quantified impact assessment at a/c level. In addition, the expected final integrated demonstration as well as workflow (especially between ET 1 and the WP) would need some further maturation.

D3 Smart integrated Wing: An adapted scheduling is presented, sufficiently safeguarding the planned objectives in reasonable time. The related risks seem to be under control. The proposed transfer of funding from LPA to SYS for Liebherr Lindenberg seems to be well justified in order to achieve the D3 objectives and support the programme goals.

On WP 4 Landing Gear Systems significant delays of up to 18 months are reported across almost all ETs. In addition, a degradation of ambition has been recognised for D5-ET4 Short TAT from the final TRL 6 in 2020 to TRL5 in mid-2022. At the same time a request for additional funding is presented without clear justification.

In the area of major loads (WP5, eECS, PEM) more funding is requested. This request is not supported at the time being as not sufficient evidence of the alignment of the related activities between the partners has been demonstrated and the related benefit has not yet been demonstrated convincingly.

The remaining work packages are progressing well.

3.7 SMALL AIR TRANSPORT (SAT) TA

The SAT review was conducted (remotely on 1 day), led by the SAT TA Coordinator Piaggio. The review documentation and reference material were received by the reviewers on time. The PowerPoint presentations were of a high standard and reflected considerable effort on behalf of the project team. Questions were generated by the reviewers prior to the meeting. In the presentations, the reviewers' questions were addressed – in almost all cases the answers that were provided were satisfactory. Reviewers were given an opportunity to ask follow-on questions and to challenge answers, if necessary. Overall, the reviewers were satisfied with the organisation of the IRM and the material presented but the meeting was somewhat lengthy making it difficulty in keeping up with the allotted times. But it covered effectively all formal agenda activities. The lack of personal interactions to support further understanding and strengthen communication was perceived as a disadvantage. Unfortunately, some issues were

evident regarding system sound perturbations but fortunately they were very few. In the future, these meetings should have a duration of at least 1.5 days, as some presentations were slightly rushed to avoid exceeding the available time. The reviewer's private meeting was also cut short for this reason.

Many aspects could be clarified directly visiting the labs and monitoring the progress of the hardware, however, due to the situation, the organisers did their best to show all the progress of the WP with pictures, graphs and data. The master plan of the three work packages is not significantly changed from before, although there have been delays for almost all activities mainly because of Covid-19. The financial situation is nearly unchanged, minor corrections are necessary because of shifted activities from 2020 to 2021 (Covid-19 impact). All activities will complete within the SAT TA budget.

SAT, as a transverse activity, relies on outputs from the ITDs. Covid-19 has had a significant impact on the AIR ITD program. At the ARM (20 June 2020), the reviewers asked for a more detailed assessment of the impact of Covid-19 on SAT TA activities (i.e. the impact on milestones, deliverables and finances) for the IRM. The reviewers are of the opinion that a good initial assessment of the impact of Covid-19 has been undertaken by the SAT TA management team; they are working hard to mitigate delays, where possible. The reviewers, however, caution that this work is not finished, as the situation is dynamic and ever-changing.

A general delay of 3 to 4 months was reported for most activities. In some cases, longer delays (6 to 10 months) especially of partner's activities are reported. The revised planning shows that 2 out of 7 deliverables and 2 out of 4 milestones have been delayed to 2021. As a broad assessment, it is apparent that 87% of the planned person months (PMs) for the period Q1 to Q3 2020 were consumed; however, many of the outputs have been delayed. The reviewers share the view that these figures do not fully represent effective status of activities, however, as many of the outputs have been delayed, a careful administrative assessment is requested to assure consistency between use of resources vs. delivery in 2020 as well as to properly prepare the amendment to the GAM 2020-2021. This will require careful monitoring, financial control and flexibility going forward. Regarding the ongoing GAPs, about 50% report a high impact of Covid-19 and some technical difficulties and require a time extension. The reviewers share the view that these figures do not fully represent effective status of activities, however, as many of the outputs have been delayed, a careful administrative assessment is requested to assure consistency between use of resources vs. delivery in 2020 as well as to proper prepare the amendment to the GAM 2020-2021.

Regarding dissemination, communication and exploitation, the project is in a reasonably good position. It was reported that 27 technical papers have been published to date 13 were published in 2020. This figure includes all SAT related publications from TE, AIR, ENG, and SYS ITDs. The leaders are asked to push all partners to improve the dissemination activities especially from ENG ITD where target values are not yet appointed. Conferences and other dissemination activities suffered because of Covid-19. Concerning patents, the picture is less positive. Only SYS ITD filed 8 patents and 5 exploitable foreground activities. This requires further attention and a dedicated effort to protect the intellectual property of the excellent work being undertaken.

The main technological achievement in 2020 was the completion of several ground tests and related activities; studies for the integration of new subsystems for preparing functional tests. Preparatory work for demonstrator B (engine nacelle for flight tests) and the documentation/report/tests necessary for permit to fly could be finalised in 2020. The engine nacelle was also installed on the Pezetel M28 airplane wing in 2020. A definition of TLAR and a preliminary architecture of the green aircraft were established, and first mission and market assessments were elaborated, which will be used by TE.

3.8 ECO-DESIGN (ECO) TA

The ARM was held jointly with the IRM. It was preceded by a Progress Meeting in June 2020, in which SPDs presented to the CSJU and reviewers selected major technology Flagship Demonstrators (FSDs), suited to be developed as final eco-statements by the end of 2023. The aim was focusing data collection to eco-statement preparation more than in the past. Fourteen eco-FSDs were presented in different programme areas.

The organisation of the one-day ARM/IRM was good. Not all previous recommendations from reviewers had been fulfilled. A key deliverable i.e. deliverable 07 (DfE2020+&Global KPI Outturn) was delayed and is now expected in Q4 2020. Its submission should be closely monitored.

Good progress has been made. Close collaboration between Airbus and Fraunhoferhas been established and all SPDs have presented an FSD plan (details in the full report). The involvement of ENG and SYS is a major step forward as compared to CS1. The volume of data in the Aviation Environmental Database –of critical importance for LCA- has been extended. Progresses have also been made as to the web-based interface, the Eco Hybrid Platform (EHP), which allows access to data for CS2 users. SPDs manifested considerable interest for this instrument.

However insufficient actions have been taken to refocus the ECO TA activities in line with the FSDs' approach agreed in June 2020. The most urgent activities concern the lack of a master plan for 2020-2023 and the reformulation of the CS2DP Part B. The master plan should incorporate detailed milestones & deliveries, updated indicators and KPIs, should be consistent with the GAM and CS2DP and should synchronise with technology development in SPDs. Furthermore, CS2DP Part B should be revised to be better aligned with the FSD approach, include the Master Plan, and urgently re-submitted to the JU before the end of this year.

As to SPDs' input delivery to FhG, the reviewers recommend that each SPD should clearly define its FSDs, the relevant reference component, the related and pragmatic indicators and the roadmap till the final assessment of the eco statement, which should be completed before the end of CS2. Some SPD indicated dates for LCI delivery are inconsistent with this objective.

The question of how to select a reduced number of pragmatic indicators to serve as decision-making tool is still open. The reviewers reiterate the need to define a reduced group of key indicators, in agreement with SPDs, to evaluate the environmental features of the different technologies. Deliverable 07 DfE2020+&Global KPI Outturn, due in Q4 2020, is expected to contain this selection.

Concerning legal governance, some progresses have been reported. However, it emerged that negotiations are still pending on this critical issue. It has been recommended to urgently define a legal agreement between FhG and SPDs on data ownership, confidentiality, access rights.

The coordination and information exchange with the other Clean Sky2 partners have been very much improved since the previous ARM. There is a single exception in the case of the Technology Evaluator (TE). Although the Eco TA work may have small repercussion in the total aircraft performance evaluation, it seems reasonable to maintain an information exchange to determine those aspects that could be included in the TE work.

As to dissemination and communications activities, the reviewers consider that the communication part was well covered but miss some elements, like technical papers or PhD/Master thesis that could have improved the dissemination part.

Overall, the reviewers agreed that ECO TA is at a critical juncture and needs close monitoring. Accordingly,

the reviewers proposed to organise ARM-2021 of ECO Design in Q2/2021.

3.9 TECHNOLOGY EVALUATOR (TE)

The remote ARM provided an opportunity to review in detail the progress, including responses to recommendations from the Annual Review held in October 2019. No formal Interim Review was held in 2020 but a series of workshops supported by SPDs focused on defined activities supporting the first Global Assessment (GA) delivered in September 2020 and to also prepare for the second GA to be delivered at the end of CS2.

As this was a remote review, documentation and presentation slides were requested with sufficient time for preparation prior to the review. Unfortunately, because of the pandemic, this was not possible for many of the SPD inputs. Following the previous ARM recommendation, the review was increased to 2 days. However, the agenda was still pressurised which is not ideal when reviewing remotely. Improved planning will be required if remote assessment is needed again in the future but the 2 day (minimum) review schedule should be kept.

It is clear, that this TE Transversal Activity (TA) is of prime importance to the CS2JU, even if it has only ~1% of the total funding budget. The methodology adopted and the required interaction from the SPDs has increased in year with a series of workshops focused on key activities to support the first GA and preparation for the 2nd (final) GA. The first GA report, providing interim results, was delivered on June 30, 2020. A shorter publishable synopsis document containing results and observations is anticipated for completion at the end of Q4 2020. The results, developed pre-pandemic, align to other global studies and also show constraints imposed by future airport capacity limitations. The analysis of aircraft type and flight duration for the primarily large passenger aircraft suggests environmental impact benefits may be achieved by introducing a higher capacity aircraft (400 / 450 PAX) designed for and operating over ~2000 km together with a design and range optimised 190 PAX platform. It is recommended that these are developed as concept platforms for the 2nd GA incorporating as many CS2 developed Technology Bricks applicable to the concepts.

It is evident, with the presence of all IADPs, ITDs and TAs (except ECO) at the review, communication with and between these pillars has improved. This is critical to the development of concept vehicles from CS2 Technology Bricks. The IADPs and SAT TA are in the main responsible for the aircraft models and associated environmental assessments aligned to their platforms. Airframe, Engine and Systems ITDs provide in the main Technology Bricks which may be integrated into sub-systems and in the case of Engines full engine models. Each of these ITDs conducts environmental benefit assessments at the appropriate level. There are still some discrete areas of communication improvement to support the second GA but these are visible and being addressed in the near term.

The second GA is now in preparation with supporting CfP activities, several of which have finished or are in progress, with the remainder at contract negotiation stage. Additional Calls for Tender (CfTs) have been defined and are with the CSJU for action. Results from CfPs, near or at completion, were provided at the review together with an understanding of the CfPs currently in progress or under negotiation but due to start imminently. These outputs collectively support enhanced understanding of the global picture for platform types not evaluated in CS2 providing technology evaluation impact statements for incorporation in the final CS2 assessment.

In the near term there are several key activities to address. Significant effort and understanding are required to ensure that the impact of increasingly stringent climate change policies is reflected in the forecasting scenarios and perhaps to develop a model to analyse the long-term impact of aviation policy on emissions to capture direct and indirect effects including potential trade-offs between impacting elements. To develop Mission Level assessments, all concept vehicles need to be defined. There will be a

natural evolution in many cases from the first GA but, where gaps have been identified which would generate additional environmental benefit, consideration should be given to developing new concept aircraft models. These concept models will be led by DLR in addition to the planned LR++ with support from the IADPs, ITDs and SAT to offer suitable Technology Bricks for incorporation. Concept aircraft models currently being considered include an SMR (A321 Neo like) 190 PAX vehicle and an SMR higher capacity (people mover) 400 / 450 PAX vehicle both optimised for up to ~ 2000km operational routes. In addition, consideration needs to be given to the sizing rules. For the Airbus-led main passenger platforms SMR+ and SMR++ seat capacity has increased, which makes comparison with the reference platform difficult. Thought also needs to be given as to how environmental metrics should be generated to allow effective comparisons and linkage of the results to global environmental metrics. To support this the reviewers have proposed continuation of the successful workshop series involving all SPD partners, relevant CfP partners and other interested parties. Topics and an appropriate timeline are suggested below and reiterated with more detail in the reviewers' report:

- concept model definition and technology brick selection, including potential new concept designs and realistic EIS dates (Q1,2021);
- benchmarking global environmental metrics at mission level to support sizing rule changes – this includes clarification of the suitability of reference aircraft. Also, metrics and benchmarking of environmental results at ATS level (Flightpath 2050) (Q2, 2021);
- impact of Covid-19 and climate change policy (Q3/4, 2021).

The involvement of the regulatory and informed authorities (EASA, EUROCONTROL, ICAO CAEP) remains an important element in supporting the assessments and is evident in TE activities. The DLR methodology (especially the airport capacity constraints assumption) is recognised by EASA and is being assessed by CAEP for inclusion in its next assessment round, which if successful will ensure that the methodology adopted in Clean Sky 2 is recognised globally. This is a significant continuing improvement from initial Clean Sky activities.

4. SPECIFIC ITEMS

4.1 Internal and External Links

Unfortunately, the pandemic prevented major achievements in collaborative working. Still, the required level of exchange has been observed. It is expected that connecting within CS2 and with external programmes will be taken up in 2021.

In general, good synergies by aligning and linking CS2 funded activities to national and industrial research activities have been recognized. It is recommended to strengthen these links. Several Clean Sky workshops (e.g. on composites, laminar flow surfaces) took place remotely in 2020.

4.2 Call for Proposals (CfPs)

CfP 12 was the final call in CS2. A good level of response has been recognised. All in all the CfP instrument including the Thematic Topic scheme is highly supported by the SciCom members.

4.3 CS2 Environmental Impact

Since 2019, the SPDs were tasked to generate *impact assessment* reports to quantify the high-level environmental targets achievable in CS2. The approach adopted by the various SPDs varied and the level of detail as well as the level of quantification provided also differed. While the basic principle is now well established and considered beneficial for attributing achievements to the demonstrators, the reviewers recommend to follow a more harmonized approach and to target always a quantification of the expected

or achieved impact. There is still, however, some room for improvement to fully capture all aspects of the diverse SPDs.

4.4 Dissemination, Communication and Exploitation

The management of dissemination, communication and exploitation still are at different levels in the different SPDs. In certain SPDs, dissemination managers have been appointed, while in others the task is undertaken by the coordinator or an assistant. Still, and despite continuous recommendations made by reviewers, the level of dissemination still falls below expectation. A more strategic approach has to be undertaken with regard to the planning, monitoring and reporting of dissemination activities. In some cases, no pro-active dissemination planning is visible (or only planning with insufficient ambition). It is recognised that the pandemic significantly hampers the dissemination events. However, for the coming years a stringer ambition is expected.

The exploitation planning is still not sufficiently mature in some SPDs. Although targets for patterns have been established, the visibility of patent applications and IP development is unclear in some cases.

Prof. Peter Hecker
Chairman of the Scientific Committee
Prof. Trevor Young
Vice-Chairman of the Scientific Committee

Submitted on behalf of the Clean Sky Scientific Committee in December 2020

11. Summary of recommendations issued by the IAS significantly delayed

Content and significance of recommendation	Audit title	Deadline for implementation (original target date)	Status
Recommendation No 1 *(very important):* The performance framework: objective setting and linking all stages of the programme	Performance management[47]	31/03/2019	The recommendation has been downgraded by the IAS to *important*. In May 2021 the JU has requested an extension of the delay for implementation until June 2022.
Recommendation No 2 *(important):* Guidance on Horizon 2020 and role clarification	Grant process (from the identification of the call topics to the signature of the grant agreement)[48]	30/06/2017	In May 2021 the JU has requested an extension of the delay for implementation until October 2021.
Recommendation No 3 *(important):* Monitoring and reporting on the performance of Horizon 2020 projects	Performance management	30/06/2018	The recommendation is considered implemented by the JU and has been sent as ready for review to the IAS in May 2021

[47] 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
[48] 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, audit report dated 15.11.2016

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
EASA	European Aviation Safety Agency
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
ATN/IPSIMA	Aeronautical Telecommunication Network/Internet Protocol Suite Integrated Modular Avionics
BJ	Business Jet
CAA	Computational Aero-Acoustics
CAE	Computer Aided Design
CDR	Critical design review
CFD	Computational Fluid Dynamics

CFRP	Carbon Fibre Reinforced Polymer
CG	Centre of Gravity
CNT	Carbon Nano Tube
CROR	Contra-Rotating Open Rotor
CWB	Central Wing Box
DfE	Design for Environment
DMC	Demonstrator Management Committees
DMU	Digital Mock-Up
EDAS	Eco-Design Analysis
eECS	Environmental Control Systems
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
FTB1	Flying Test-Bed no. 1
FTB2	Flying Test-Bed no. 2
HLFC	Hybrid Laminar Flow
HMI	Human Machine Interface
HPE	High Performance and Energy Efficiency
HVC	High Versatility Costs efficiency
HVDC	High Voltage Direct Current
ICS	Interface Control Drawings
IGV	Inlet Guide Vane
IHMM	Integrated Health Monitoring Management
IPS	Ice Protection System
IVHM	Integrated Vehicle Health Management
LCA	Life Cycle Assessment
LG	Landing Gear
LRI	Liquid Resin Infusion
MFFD	Multi-Functional Fuselage Demonstrator
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
RACER	Rapid And Cost-Effective Rotorcraft
SHM	Structural Health Monitoring
TE	Trailing Edge Or Technology Evaluator
UHBR	Ultra-High Bypass Ratio
UHPE	Ultra-High Propulsive Efficiency
VEES	Vehicle Ecological Economic Synergy
WRB	Wing Root Box