CLEAN SKY HIGHLIGHTS

2020
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Investing in clean technologies and cutting-edge research will accelerate the EU’s green agenda

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.

Clean Sky is proud to be a part of this journey towards climate neutrality and we look forward to what the future brings!
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 942 participants from 30 countries across the entire aeronautics sector, of which 363 are SMEs, 113 are research centres, 156 are universities and 310 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
Our goals under Clean Sky 2 are simple: we aim to reduce CO\textsubscript{2}, NOx and noise by 20-30% compared to state-of-the-art aircraft from 2014. The technologies below are the tip of the iceberg, as half of Clean Sky’s main technological achievements will surface in the next 3 years, with the final ones being delivered from 2022 onwards. Below you’ll find a sample of some of the projects that made important strides or are nearing completion. This non-exhaustive list of highlights will provide some insights into how Clean Sky is progressing to date.
**RACER – SPEEDY GREEN ROTORCRAFT TAKE TO THE SKIES**

RACER – Rapid and Cost-Effective Rotorcraft – is a full-scale fast helicopter demonstrator, featuring an innovative wing-box design, advanced rotor-less tail, lighter structures and increased efficiency in terms of power management.

RACER involves the use of forward propulsion through shaft driven propellers on short wings, complementing the main rotor providing vertical lift and hover capability. Cruising up to 400 km/h (216 kn), it aims to reduce costs by 25% per distance compared to a conventional helicopter. RACER supports the ACARE Flightpath 2050 goals to improve the mobility of EU citizens while achieving ambitious environmental objectives.

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**Goal**

To integrate cutting-edge technologies to develop and validate the compound helicopter high-speed architecture that can take off and land vertically for use in high-speed missions such as research and rescue and passenger transport.

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**Progress**

RACER’s journey began in 2014. After successfully completing its pre-design (2016), preliminary design review (2018), and critical design review (2019), the manufacturing of the major sub-system began in 2020. Despite Covid-19 restrictions, RACER made good progress in 2020; the manufacturing of the helicopter canopy, the central fuselage airframe section and the rotorless tail boom are nearing completion and the next assembly phase started in 2021.

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**Expected results and impact:**

- TRL6 by 2022
- Reduce CO₂ by 20-30%
- Reduce NOx by 20-30%
- Reduce noise by 20-30%
- Contribute to strengthening EU mobility

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**Part of Clean Sky’s Fast RotorCraft initiative**

incorporating components from the Airframe Integrated Technology Demonstrators (ITDs)
INNOVATIVE COMPOSITE ENGINE NACELLE FOR SMALL AIRCRAFT TAKES FLIGHT

There are many advantages associated with composite materials. One of those advantages is that these alternatives to traditional metal structures allow weight savings while assuring stiffness and strength requirements. Still, such technologies are not always affordable for small commuter aircraft. Clean Sky’s SAT-AM project developed a full scale engine nacelle flight demonstrator made out of composite materials to finally assess the technical and economic viability of selected technologies and manufacturing methodologies.

**Goal**
To develop technologies for the manufacture of lighter and cheaper airframes affordable for small commuter aircraft.

**Method**
R&D activities covering full product development process: optimal design and manufacturing towards a reduced number of components and manufacturing costs.

**Progress**
Within the SAT-AM project in 2020: composite and metal parts were manufactured and assembled; full scale static tests and fire tests were performed towards the achievement of the permit to fly process. As a final step of the validation process, the full scale assembled nacelle was finally mounted on a PZL-M28 aircraft and ground and flight tested.

Achieved results and impact:
- Reduction of number of elements (>35%)
- Reduction of component weight (>10%)
- More uniform structure of the nacelle
- TRL6 reached

Part of Clean Sky’s Small Air Transport initiative
INNOVATIVE COCKPIT TECHNOLOGIES FOR GREENER AND SAFER AIRCRAFT

While avionics systems and equipment account for a small part of the aircraft weight and environmental footprint, they play a central role in aircraft operations, flight optimisation, and air transport safety. Clean Sky 2 is developing promising innovative cockpit solutions for greener and safer aviation. As an example, the seamless integration of a new generation of flight management systems will ensure not only improved efficiency, flight comfort and lower direct operating costs, but also fuel savings, thus contributing to reducing the environmental impact of aeronautics by cutting CO₂ emissions.

Goal

To develop enablers for a new generation of crew-centric mission-oriented cockpits with decision-making help and assistance that allow for enhanced safety and more effective missions while sustaining the reduction of CO₂ emissions. Combining electronic flight bags with the improved flight management system allows the crew to perform flight management tasks more efficiently (i.e. assisted by tablets they can use both on ground and in flight, paperless cockpit).

Method

The project involved the development of innovative technological avionics enablers and their integration into ground demonstrators (e.g. pilot evaluations in immersive cockpit simulators and technical performance evaluations on virtual system integration benches with the representative system architecture).

Progress

In 2020, several technological cockpit enablers were demonstrated at TRL5 in the Extended Cockpit demonstrator of the Systems Integrated Technology Demonstrator. Some selected technologies (such as flight management system and cockpit display system including large touch screens) were integrated and demonstrated in the Disruptive Cockpit demonstrator of the Large Passenger Aircraft Integrated Aircraft Demonstrator Platform (IADP).

Expected results and impact:

- Contribution to CO₂ emissions (up to 2%)
- Reduction of direct operating costs (improved mission efficiency and fuel cost savings)
- Enhanced safety
- 87 requests for patent

Part of Clean Sky Systems initiative

contributes to the Disruptive Cockpit Demonstrator of the Large Passenger Aircraft IADP
eMAESTRO - HYBRID ELECTRIC ARCHITECTURES FOR SMALL AIRCRAFT

Within the Engines Integrated Technology Demonstrator, technology developments are taking place to improve the efficiency of thermal engines for small and regional aircraft in order to improve their environmental performance:

- 18% CO₂ reduction in the turboprop engine
- 24% NOx reduction
- noise reduction including propeller by 10 dBA

An additional performance improvement for CO₂ reduction (up to 15%) is expected thanks to the implementation of hybrid-electric technologies in a near future. A new activity was initiated with the aim to identify and design an architecture suitable for small aircraft. Two architectures were studied to identify the one providing the highest environmental benefits, with series hybrid selected.

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**Goal**

To mature the hybrid electric architecture’s technologies for small air transport, and to contribute to the achievement of the Clean Sky targets.

**Method**

The investigation into the engine architecture’s performance was carried out using an in-house built hybrid system simulator, which integrated all the engine’s sub systems.

**Progress**

After defining the engine requirements, the down-selection of the most promising architecture was made, with the series hybrid finally selected as the least polluting one. Now the team is focused on a deeper characterisation of the architecture’s sub systems, to finalise a preliminary configuration and estimate its overall performance.

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Expected results and impact:

- Key sub system review and performance analysis by 2021
- Additional CO₂ reduction expected

Part of Clean Sky’s Engines initiative
NEW ECO-FRIENDLY CABIN DESIGN FOR REGIONAL AIRCRAFT MIXES COMFORT WITH SUSTAINABILITY

Clean Sky’s new cabin demonstrator for regional aircraft applications combines sustainability with comfort to create a human-centric, eco-friendly concept, taking into consideration the needs of passengers and crew members. The fuselage structural demonstrator includes a lightweight and low-cost thermoset, thermoplastic composite components manufactured through innovative thermoforming, compression moulding, resin transfer moulding, additive manufacturing, automated fibre placement and liquid resin infusion processes to reduce weight and manufacturing costs.

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**Goal**
- To integrate innovative structural technologies at full scale level.
- To improve the physical cabin environment in terms of comfort and well-being on board regional aircraft.

**Method**
Validating structural items, developed with innovative technologies minimising costs and weight, and major cabin items, developed with innovative technologies maximising flight experience, in a real full-scale aircraft environment.

**Progress**
Five full-scale fuselage structural demonstrator stiffened panels were successfully manufactured and the respective design requirements compliance verification was achieved. The cabin demonstrator’s critical design review was successfully passed in December 2020. The two regional full-scale on-ground integrated demonstrators are on track for demonstration in 2022 and 2023.

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**Expected results and impact:**
- Reduction of structural weight by 2% compared to state-of-the-art technologies in 2014
- Reduction of manufacturing costs by 20% compared to state-of-the-art technologies in 2014
- Reduction of cabin interiors weight by 8%
- Improvement of cabin comfort and wellbeing
- Implementation of new eco-compatible materials and processes TRL6 by 2023

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Part of Clean Sky 2’s Regional Aircraft initiative incorporating major components from the Airframe Integrated Technology Demonstrators (AIR ITDs)

© – Leonardo Aircraft PAX Demonstrator
A ROYAL SOLUTION FOR SMALL-MEDIUM RANGE AIRCRAFT: THE CROWN MODULE

The ‘Crown Module’ is the upper part of the fuselage that includes the ceiling area of the aircraft and hosts a wide variety of cabin components. A novel concept of the Crown Module seeks to decouple the cabin and the airframe by standardising the interfaces between the airframe and the customised cabin and systems components. Environmental benefits arise from weight savings. Both the Multi-Functional Fuselage Demonstrator and the crown module contribute to the same objective of integrating the structure, the systems and the cabin elements in a better way. The partners plan to demonstrate (i.e. install) the crown module inside the MFFD (the 8m long fuselage).

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**Goal**

To provide a platform with the following goals:
- Enable the integration of systems and cabin architecture in the fuselage perimeter
- Reduce reconfiguration time and cost (zero customisation in airframe)
- Less weight, costs and lead times; consider structural and industrial concepts

The Crown Module demonstrator will be integrated into the Multi-Functional Fuselage Demonstrator in 2023.

**Method**

A pre-assembled module will be designed and manufactured, that will be shipped to the fuselage to demonstrate that this module can be installed into the aircraft in a single mounting step.

**Progress**

In 2020, a module demonstrator equipped with cabin and systems was tested in a representative environment. Semi-automated pre-assembly and integration of the module was successfully performed bringing evidence for zero customisation at airframe as an industrial approach.

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**Expected results and impact:**

- Reduce lead time and reconfiguration costs
- Weight savings of more than 100kg per aircraft with consequent fuel reduction
- Production waste reduction and lesser use of tooling & hardware thanks to standardised and modular approach

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Part of Clean Sky’s Large Passenger Aircraft initiative

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NEXT STEPS FOR TECH TP DEMONSTRATOR: MAKING ENGINE MAINTENANCE EASY

Clean Sky’s Tech TP engine demonstrator project paves the way for a 100% European-built sustainable, low fuel and low noise engine for business aviation and short range regional application for example commuter aircraft (up to 19 passengers). Tech TP aims to validate the technologies required to develop a new-generation turboprop engine that will feature a compact, lightweight architecture as well as offering 15% lower fuel consumption and CO₂ emissions compared to current engines.

Tech TP will form the basis for developing a turboprop derivative of the Ardiden 3 (a turboshaft engine), ready for integrating into future aircraft designs by leveraging the skills of European partners. Previously, a successful first engine test was completed and the engine was validated. On the journey to increase the maturity of the demonstrator, maintenance is an essential ingredient to foster its potential exploitation. In addition to the environmental footprint reduction, Tech TP is also focused on offering competitive maintenance costs.

**Goal**

The Tech TP nacelle has been designed to allow easy access to the engine and line replaceable units (LRU). This will enable simple maintenance tasks to be carried out and will reduce direct maintenance costs (DMC).

**Method**

Multi-skilled teams worked in tandem on a digital mock-up defining the best engine integration and nacelle design to fulfil maintenance requirements.

**Progress**

In 2020, a maintenance review was performed on the Tech TP test rig in Tarnos. Featuring a 7-blade propeller and a nacelle, it is representative of an aircraft installation. The review highlighted that all periodic maintenance tasks would be easily feasible, leading to valuable recommendations for a better customer experience.

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Expected results and impact:

- Periodic maintenance tasks will be feasible with standard tools
- Easy access for maintenance

Part of Clean Sky’s Engines initiative
UP, UP AND AWAY: THE FIRST ECO-FRIENDLY TILTROTOR TAKES OFF

Next Generation Civil Tiltrotor (NGCTR) is a passenger aircraft that can take off and land vertically without airports, making it ideal for a range of specialised missions such as medical evacuation and search-and-rescue. The aircraft is also speedy, cruising at up to 280 kts (500 km/h), almost twice the speed of typical helicopters. All that, and it’s eco-friendly too. The idea is to increase speed and payload while simultaneously reducing fuel burn and improving the vehicle’s range.

**Goal**
To utilise cutting-edge technologies to develop a more environmentally-friendly tiltrotor aircraft that can take off and land vertically without airports for use in specialised missions.

**Progress**
The development of the NGCTR started in late 2014. After the successful completion of the pre-design activities (2016) and the preliminary design review (2019), the demonstrator design was further matured in 2020. The critical design gate review at aircraft level started successfully in December 2020 and will continue until mid-2021. The next phases involve the release of drawings, procurement of materials and commencement of the manufacturing of major sub-systems. The aircraft assembly and ground testing will be completed in 2022 in view of a full-scale flight-testing in 2023.

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**Expected results and impact:**
- Flight test campaign by 2023
- Reduce CO₂ by 20-50%
- Reduce NOx by 10-20%
- Reduce noise by 20-30%
- Contribute to strengthening EU mobility

**Part of Clean Sky’s Fast RotorCraft initiative**
including components from the Airframe Integrated Technology Demonstrators (ITDs)

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FUTURE REGIONAL MULTIMISSION FOR SUSTAINABLE AIRCRAFT

The Regional Multi-Mission aircraft concept is able to operate under extreme conditions, making it perfect for a variety of purposes, such as the transport of people and goods, fire-fighting and search-and-rescue, fisheries patrols, pollution monitoring and control. These aircraft need to have increased operational flexibility and low speed performances as well as the ability to operate on reduced ground infrastructures and dual transport services. Clean Sky 2’s concept will also incorporate weight, drag and load reductions, contributing to its goals of reduced emissions and noise levels.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Method</th>
<th>Progress</th>
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<tbody>
<tr>
<td>To provide in-flight demonstration of high TRL technologies applicable to regional aircraft and suited for a wide variety of missions, optimised for more advanced highlift performances and increased efficiency in the climb and descent phases.</td>
<td>Affordable flight control systems, electromechanical actuation systems for movable surfaces, loads reduction systems, innovative aerodynamic devices and new materials and structures optimisation will be used, from theoretical studies to flight tests.</td>
<td>The wing modifications for the Step 1 configuration have been successfully performed, including the addition of the morphing winglets. The wind tunnel test campaign has also been completed and the analysis results are ongoing. Power-on testing started at the end of 2020. At the same time, on-ground demonstrators are fully operative and preparing for in-flight demonstration.</td>
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</table>

**Expected results and impact:**

- TRL6 by 2021
- Weight reduction of 4%
- 2.5% increase in aerodynamic efficiency in cruise
- 15% decrease in manufacturing lead time

Part of Clean Sky’s Regional Aircraft initiative incorporating components from the Airframe and Systems Integrated Technology Demonstrators (ITDs)

© – Airbus DS
Robots and smart automation will be the norm in the factories of the future. Clean Sky’s ACCLAIM cluster and LABOR projects are improving the fuselage, cabin and cargo assembly process using new technologies. The use of cooperative robotics, artificial intelligence and simulation technologies will enhance product quality, accelerate productivity rates and reduce costs. The result will be lighter, faster and more flexible robotic systems which will streamline the assembly processes leading to maximum results with minimum environmental impact. These initiatives are tackling this challenge from two distinct viewpoints – large passenger aircraft and regional aircraft.

LABOR – Lean robotised Assembly and cOntrol of composite aeRostructures

**Goal**
To develop medium-size robots for the assembly of fuselage panels equipped with smart tools, human-robot collaboration and distributed software architecture.

**Method**
A lean and flexible automated solution has been developed, consisting of a jig and two medium-size robots on moving platforms. A multimodal perception system powered by artificial intelligence monitors the collaborative workspace for safe human-robot collaboration.

**Progress**
The main achievements are the increased automation level and the improvement of quality standards, production and efficiency rates as well as real time adaptability.

ACCLAIM - Automated Cabin and Cargo Lining And Hatrack Installation Method

**Goal**
To develop specific technology building bricks to automate aircraft cabin and cargo assembly tasks using the capabilities of the latest generation of robots, sensors, and control units.

**Method**
The ACCLAIM cluster includes these four complementary partner grants:
- SIMFAL aids the assembly planning through simulation of an aircraft final assembly line
- CALITO focuses on the design and manufacture of sidewall panels and hatracks
- EURECA enhances human/robot cooperation in cabin and cargo assembly tasks
- VISTA handles inspections after the installation phase

**Progress**
All projects successfully ended in 2020 and concluded with a live demonstration in a representative industrial cabin and cargo environment, demonstrating the potential of automation technologies applied to cabin and cargo installation.

**Expected results and impact:**
- LABOR & ACCLAIM: TRL6 at the end of the project
- Empower workforce
- Enable increase of productivity rates while reducing costs
- Support European competitiveness
- Human-robot collaboration approach
- LABOR: Development of lean robotic cell and smart inspection tool for robotic inspection

Part of Clean Sky’s Airframe and Regional Aircraft initiatives

Part of Clean Sky’s Large Passenger Aircraft initiative
Fuel-efficient, low-emission, low-noise propulsion systems are the way of the future. New technologies are being developed for the low-pressure turbine and high-pressure compressor, and two demonstrators are being built to validate these. Integrated optimisation of the compression system will lower engine length and weight, thereby reducing fuel burn. New lighter-weight and more temperature-resistant low-pressure turbine materials, including advanced ceramic matrix composites, as well as novel turbine exit case design concepts further increase turbine efficiency and reduce specific fuel consumption by supporting higher cycle temperatures.

**Goal**

Key technologies for the next generation geared turbofan engine have been developed and demonstrated, concentrating on compact, lightweight compression systems and high-temperature expansion systems with advanced aero and design features.

**Method**

Demonstration of advanced technologies through design, build and test of a low pressure turbine for a demonstrator engine. Regarding the compressor, an innovative two-shaft rig has been developed.

**Progress**

In 2020 the conceptual design of the two-spool compressor rig and its test set-up was completed, with development in progress. Tests of the intershaft bearing on a dedicated rig have started. The engine demonstrator for which the design is in progress will profit from developments at component level.

**Expected results and impact:**

- Higher thermal efficiency in engines due to higher overall pressure and bigger fan diameter (bigger bypass ratio)
- CO₂ reduction of up to 10% for the 2nd generation of geared turbofan engines

Part of Clean Sky’s Engines initiative
PURSUING THE ELECTRIC AVENUE: NEW ENVIRONMENTAL CONTROL SYSTEM FOR LARGE AIRCRAFT

Reducing fuel consumption, emissions and noise have led to a new approach when it comes to designing systems. One way to achieve these objectives is to go electric! Clean Sky 2 has improved architectures for environmental control systems based on electrical technologies combined with an integrated vapour cycle system for increased cooling efficiency and an improved cabin environment. In particular, the extension of thermal management beyond its current perimeters with a potential increase of mutualisation of aircraft resources and components allows:

- significant fuel consumption reduction through more efficient use of aircraft energies,
- improvement of aircraft availability by increasing system reconfiguration capabilities.

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### Goal
To design the next generation of electrical environmental control systems to answer the needs for loads management, thermal management, air quality and cabin comfort.

### Method
After architecture selection, a risk-driven development approach was set up, from technological bricks (supported by a series of complementary grants) until integration at system level. The key technological bricks developed were an air cycle turbomachine, vapour cycle centrifugal compressor, mini-channel heat exchanger, and overall system control laws.

### Progress
The electrical environmental control system architecture for large aircraft configuration was optimised in partnership with the airframer, and frozen after a preliminary design review. The critical design review was successfully passed in 2020.

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Expected results and impact:

- Contribution to small-medium range CO₂/NOx objectives
- Compressor size and weight reduction (-30% and -40% respectively)
- Eco-friendly design
- Reliability improvement (+20%)
- Mutualisation with other major loads and dispatch capability improvement
- TRL6 by 2023

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**Part of Clean Sky Systems initiative**
# SCALED FLIGHT TESTING: THE NEW WAY TO DE-RISK FUTURE DISRUPTIVE AIRCRAFT CONFIGURATIONS

Flight test activities are always time-intensive and resource-heavy. At Clean Sky, we are developing a smaller flight test model which could be used to investigate dynamic manoeuvres and certain qualities that cannot be evaluated or validated properly in wind tunnel and iron bird tests. This means that a disruptive technology (or configuration) can be quickly de-risked, saving time and costs for development, clearance, ground and flight testing compared to a real aircraft. This new innovative approach will pave the way for the design and development of new technologies such as distributed electric propulsion which will be assessed on this novel platform, featuring 6 electrically-driven propellers that will be installed on the wing.

## Expected results and impact:
- TRL5 by 2023
- Contribute to strengthening competitiveness of EU industry

## Part of Clean Sky’s Large Passenger Aircraft initiative

## Goal
- To demonstrate that the behaviour of a full-scale aircraft can be predicted with a dynamically scaled model
- To develop a scaled flight test model for testing disruptive aircraft technologies

## Method
First, the scaled aircraft platform design was designed, and then the component parts, including systems such as flight and guidance controls, were developed. Detailed computational fluid dynamics analyses are being conducted to refine the high lift design system and thus increase safety. In tandem, theoretical computations are being performed to finalise the high fidelity aerodynamic database of the SFD and assess the differences of overall aircraft behaviour for the different scales. To verify the design, it is tested first in wind tunnel tests and then through real flight tests. By comparing the data collected with references from full scale aircraft measurements, the suitability of the scaled flight aircraft can be evaluated.

## Progress
The classical scaled flight demonstrator (SFD) detailed design was finalised and components were manufactured and assembled in Q3 2020. In Q4, many subsystems were integrated and the overall testing including flight test instrumentation took place. The mission flight test was discussed between airspace navigation service providers to allow the Dutch permit-to-fly to be extended to Italy. The SFD will be fully qualified and flight-tested in 2021. In the meantime, a distributed electrical propulsion architecture featuring 6 electrically-driven propellers and fitted with the existing SFD was selected. The original scaled flight demonstrator prototype will then be modified so as to fit the needs of the distributed electric propulsion configuration (integration of propellers on the wing, electric wiring, adaptation of the flight control system, etc.).
REDUCING DRAG THANKS TO HYBRID LAMINAR FLOW CONTROL TECHNOLOGIES APPLIED ON WING

Integrating the most fuel-efficient propulsion concepts into compatible airframe configurations is a key challenge for aviation innovators. Reduction of drag during flight is one of the crucial lever arms to reduce fuel burn and to increase the environmental efficiency of an aircraft. Hybrid laminar flow control (HLFC) technology is one of the major aerodynamic enablers to reduce friction drag during cruise flight for long-range aircraft, and Clean Sky 2 is contributing to the development of the climate-neutral aircraft of the future.

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**Goal**

To develop and demonstrate an innovative and simplified HLFC system that will be applied and integrated on a wing, including the development and integration of all needed major sub-modules/components.

**Method**

Conceptual design of a novel HLFC concept including the development and integration of all needed major sub-modules/components, (i.e. hybrid laminar flow control leading edge, joint leading edge/front spar, high-lift system on leading edge, hybrid laminar flow control systems, wing ice protection system) and validation by means of representative ground based demonstrators will allow to prove the system integration by the end of Clean Sky 2 (TRL4).

**Progress**

An important milestone was reached by end of 2020 – the project reached TRL3 for the design of the wing concept. Candidate solutions for sub-parts were matured (removable outer skin-concept, variable porosity, inductive WIPS, integration suction rubs). First parts will be assembled and tested in 2021 and a more accurate manufacturing cost assessment will become available.

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**Expected results and impact:**

- Reduce drag friction by 5-8% (up to 10% if cumulated with results provided by HLFC applied on vertical and horizontal tail plane)
- Reduce CO₂ and NOx by at least 5%
- TRL4 by 2023

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Part of the Large Passenger Aircraft initiative
**ACHIEVING LIGHTNESS - EFFICIENTLY!**

Lighter, optimised and innovative structural solutions are made possible by using materials such as composites. Used widely across Clean Sky’s projects, these materials reduce CO₂ emissions, energy consumption and costs, and speed up manufacturing processes. As these materials become the primary structure for use at an industrialised scale, there have been significant advances in automated fibre placement of prepregs, dry fabrics and thermoplastics. Full scale prototypes of structural elements have been produced with out-of-autoclave processing and tested for quality. A thermoplastic fuselage is becoming a reality thanks to welded thermoplastic stringers.

<table>
<thead>
<tr>
<th>Goal</th>
<th>Advancements in composite material manufacturing to produce large-scale primary structural components for Clean Sky demonstrators.</th>
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<tbody>
<tr>
<td>Method</td>
<td>Automated dry fibre placement (AFP), using heated tools supported by robots and cobots, out-of-autoclave (OoA) processes for thermosets and thermoplastic AFP including <em>in situ</em> consolidation, processes digitalisation (Digital Infusion Centre), etc.</td>
</tr>
<tr>
<td>Progress</td>
<td>Maturation of technologies leading to ground/flight tested demonstrators.</td>
</tr>
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**Expected results and impact:**
- Up to 15% reduction in energy usage
- At least 25% reduction in scrap
- Up to 20% cost savings (with a minimum viable number of production parts)

Part of Clean Sky’s Large Passenger Aircraft, Airframe, Regional Aircraft, Fast Rotor Craft and Small Air Transport Initiative

© – Institute of Aircraft Design, University of Stuttgart
With the 1st Global Assessment, the year 2020 has been a milestone in the timeline of activities of the Technology Evaluator and the Clean Sky 2 programme. Based on a set of 11 concept aircraft, designed on the basis of various advanced technologies developed under the CS2 programme (aerodynamics, engines, airframe, systems), the Technology Evaluator has performed a first assessment at three major levels:

- **Innovation potential at Mission level**
  Clean Sky 2 Concept Aircraft are compared with 2014 Reference Aircraft on relevant missions regarding emissions and noise. The results are the basis to quantify the success level versus the CS2 environmental goals.

- **Realistic impact at Airport level**
  A typical day at representative EU-airports (fleet mix from 2014 historical and 2035/2050 forecast data) is compared for a fleet with and without Clean Sky aircraft and analysed regarding emissions and noise.

- **Aviation footprint at Air Transport System level**
  A year with all global flights (fleet mix from 2014 historical and 2035/2050 forecast data) is compared for a fleet with and without Clean Sky aircraft and analysed regarding emissions and noise.
It is crucial to target the earliest entry into service date for the next generation of aircraft.

There is an urgent need to accelerate the technology maturation process by promoting and supporting research investments, in order to “skip a generation”, and achieve climate-neutral aviation by 2050.

At fleet level (Air Traffic System), according to the present forecast (high scenario), approximately 75% of global available seat kilometres (ASK) will be operated with aircraft expected to carry Clean Sky 2 technologies in 2050, while 25% of global ASKs will still be operated by aircraft with 2014 reference technologies, not yet retired.

By applying the performance improvements obtained for each concept aircraft, an overall reduction of CO₂ and NOx emissions of about 15% and 31% per seat kilometre can be expected for the year 2050 high fleet scenario as compared to a 2050 global traffic scenario incorporating only 2014 reference technology.
Participation

Clean Sky has successfully established a robust innovation network and quality supply chain in the aviation sector, motivated to drive cleaner, greener aviation forward.

The structure of Clean Sky 2 enables all actors in the aviation space to collaborate and share ideas easily. Researchers can learn what the industry’s needs are, and SMEs can gain access to much bigger industrial giants and their facilities. In turn, industry benefits from the innovative potential of SMEs and the deep specialised knowledge of the research centres.
PARTICIPATION

30 PARTICIPATING COUNTRIES

> 500 GRANTS

> 5000 SCIENTISTS & ENGINEERS INVOLVED

> 1987 PARTICIPATIONS IN FUNDED PROJECTS
The figures indicate the number of Clean Sky participating organisations per country. Participating organisations are counted once in the map. They may however participate in multiple projects. Therefore, in the participation chart, the number of participations takes into account all projects where they were involved.
This graph shows the number of times that a country has taken part in a Clean Sky 2 project - referred to as participations. The data displayed here includes Calls for Core Partners 1-4 and Calls for Proposals 01-11.
Clean Sky 2 is an open and inclusive Horizon 2020 programme, involving participants from all over Europe. The entities that answered Clean Sky 2’s calls for proposals (CIP01-CIP11) represented 155 out of a total of 217 EU regions.

12 Clean Sky Synergy Labels have been awarded to date. These quality labels are awarded to complementary activities proposed by Clean Sky 2 beneficiaries, which enables those activities to be supported for funding by the European Structural Investment Funds (ESIF).
The strategic collaboration with Member States and regions has been highly successful and has resulted in the signature of 18 MoUs at national or regional level. Through the 18 MoUs signed to date, 13 additional pilot projects were launched in 2020, bringing the total number of projects funded by ESIF to 52 with a budget of more than €50 million.

MoUs with regions
1. Occitanie (FR)
2. Catalonia (ES)
3. Castilla-La Mancha (ES)
4. Vastra Gotaland (SE)
5. Östergötland (SE)
7. Andalucia (ES)
8. Campania (IT)
10. Zuid-Holland (NL)
11. Flevoland (NL)
13. Castilla y León (ES)
14. Podkarpackie (PL)
16. Sterea Ellada (GR)
17. Brandenburg (DE)
18. Nouvelle-Aquitaine (FR)

MoUs with Member States
6. Romania
9. Czechia
12. Portugal
15. Greece
A future aviation partnership under Horizon Europe: Clean Aviation

Throughout 2020, the Clean Sky community supported the ongoing efforts of the European Commission and the wider European aeronautics sector in shaping the case for a renewed public-private partnership for aeronautics within the framework of Horizon Europe.

Preparation efforts towards this proposed new European Partnership for Clean Aviation included the finalisation of a Draft Strategic Research and Innovation Agenda (SRIA), which was submitted to an extensive public consultation in the second quarter of the year. Over 1500 valuable comments and suggestions were received and processed by the JU team on behalf of the prospective private members into the Draft SRIA, which was published in July.
This research agenda will allow the aviation sector to meet the challenge set for the European Green Deal. The roadmap linked to this SRIA is designed to enable decisive steps in rapidly developing and introducing safe, reliable, and affordable low- to zero- emission air transport, and to concurrently ensure Europe’s industrial leadership is maintained and strengthened throughout the transition to a climate-neutral Europe.

The trajectory towards climate-neutral aviation is achievable. But it is contingent on an exceptional research and technology effort to reduce energy needs and fuel consumption, while ensuring safety and competitiveness; and the fast-tracked research, development and deployment of sustainable aviation fuels and energy carriers to support the roll-out of a new breed of aircraft with entirely new configurations. These aircraft must enter the air transport system in the 2030s to have any serious impact by 2050.

Through the completion of this (draft) strategic research agenda, the aviation community engaged through Clean Sky provided a landmark contribution to the European Commission’s impact assessment determining the case for a renewed public-private partnership. In September of this year this culminated in the successful conclusion of this assessment via the Regulatory Scrutiny Board.

A further key milestone concerned the successful conclusion in October by candidate ‘Founding Members’ of the proposed Clean Aviation partnership of a Memorandum of Commitment (MoC). The MoC, signed by 29 entities, demonstrates the strong commitment of the sector, through cumulative in-kind contributions of up to 3 billion euros (conditioned by reasonable and proportionate funding by the European Commission).
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