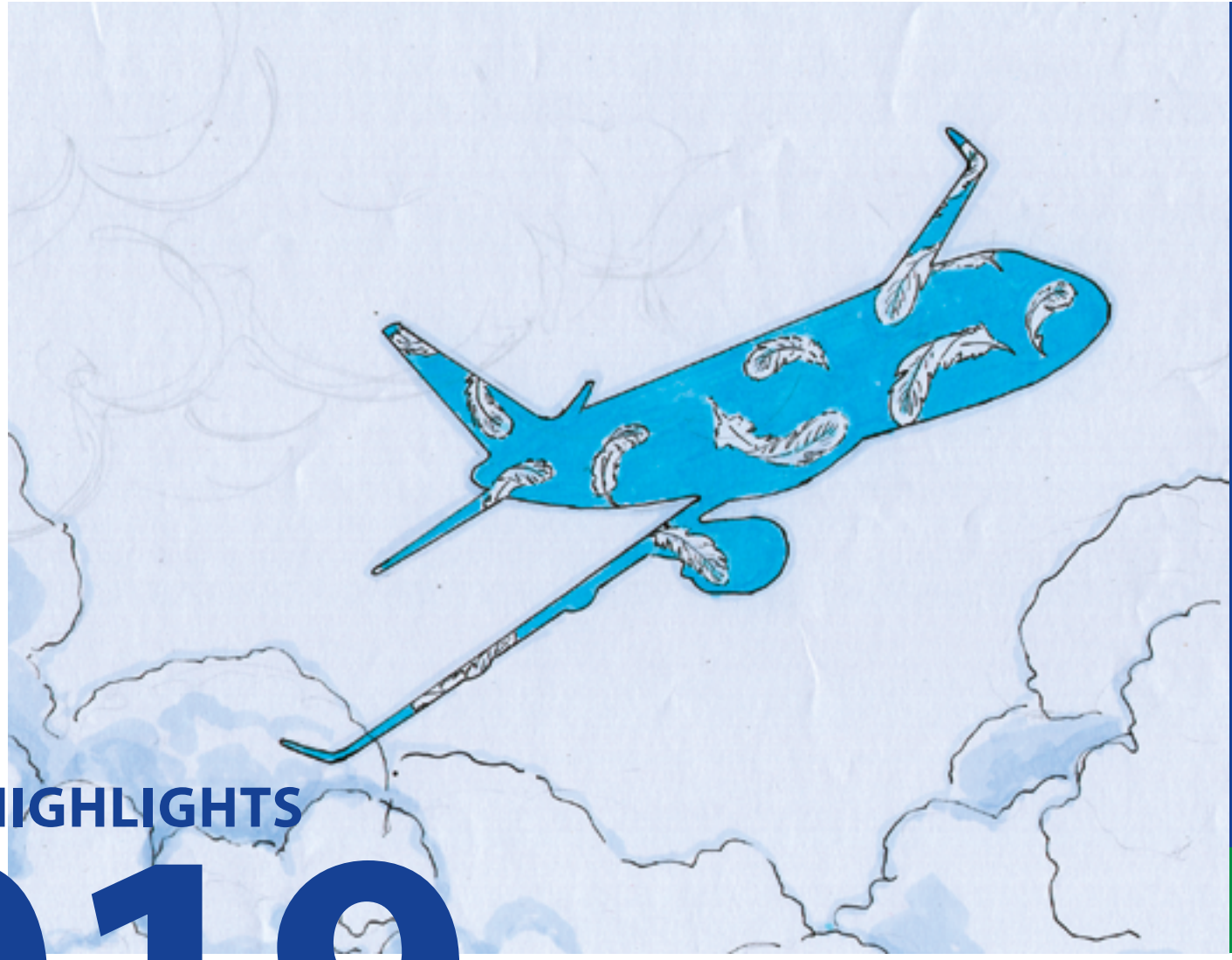
Clean Sky 2
JOINT UNDERTAKING



CLEAN SKY HIGHLIGHTS

2019

Horizon 2020
European Union Funding
for Research & Innovation

The contents of this report are based on Clean Sky's Annual Activity Report, 2019.

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A Clean Aviation Partnership for the European Green Deal

2019 has been a significant year for Clean Sky.

We are delivering on our ambitious objectives of reducing CO_2 emissions and noise levels in aircraft. Research and innovation in aeronautics are crucial for Europe, and European Public-Private Partnerships are proven catalysts for delivering innovative technological results.

Now, halfway through the programme, it is very gratifying to see that our vast ecosystem of researchers and engineers is delivering cutting-edge results for greener aviation in fields such as propulsion, systems, aerostructures, aerodynamics and overall aircraft configuration. These technologies are targeted for integration into global airline and operator fleets within the next two decades. A selection of these key Clean Sky 2 technologies are portrayed in the following pages and I invite you to discover them and many more on www.cleansky.eu.

At the same time, we have supported our private industry, research organisations and university stakeholders in formulating a new vision towards climate-neutrality for aviation by 2050. This vision aligns well with the European Green Deal, as outlined by the new European Commission, which set an ambitious challenge for all European citizens. The European aviation sector is playing its part in making our environment carbon-free.

Technologically speaking, initial analysis has identified a number of ambitious zero- and low-emission concepts, from full-electric to hybrid-electric solutions for the regional and the short-range product categories. Hydrogen or low-carbon fuel-powered architectures using advanced aircraft configurations and ultra-efficient gas-turbines will cover the medium- and long-range segments.

Foreword

2019

Innovations developed and supported by the Clean Sky programme are proving to be a solid basis for further steps towards climate neutrality. Clean Sky is confident that we can make a strong contribution to the mission-driven objectives of the Horizon Europe programme. The goal of climate-neutral aviation is extremely ambitious but nevertheless within our grasp. In order to achieve this, we will need to build a powerful partnership of all public and private actors in the field. A well-defined Innovation Architecture, linking the technology roadmaps of complementary initiatives at European and Member State level, will be essential for the success of this endeavour.

This report tells the story of Clean Sky 2, and outlines some of the innovative technologies currently under development. You will see our participation statistics and breakdown by country, our research output and impact, and our vision for the future. Clean Sky has successfully engaged more than 900 actors across the public and private sector, of which, approximately 340 are SMEs, 110 are research centres, 150 are universities and 300 represent industry.

For the past decade, Clean Sky has been striving to minimise the impact of aviation on the environment through the development of innovative technologies and we will continue to make a strong contribution to the success of the European aviation ecosystem.

Axel Krein
Executive Director

Technical Highlights 2019

Our goals under Clean Sky 2 are simple: in a nutshell, we aim to reduce CO_2 emissions by 75%, NO_x by 90% and noise emissions by 65% compared to the aircraft that entered into service in 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.

1. The Next Generation MultiFunctional Fuselage Demonstrator — leveraging thermoplastics for cleaner skies

The Next Generation MultiFunctional Fuselage Demonstrator (MFFD) project is examining the full potential of thermoplastic composites to help future European airliner production to become faster, greener, and more competitive. A fuselage barrel made of thermoplastic composites weighs less because fasteners are no longer needed, and the materials are more recyclable. Thanks to this initiative, Europe's aircraft assembly lines will be better placed to respond to the 5% growth rate of the global air transport market, while reaching green objectives.

Goal:
To produce an 8-metre long thermoplastics fuselage barrel – a world first!

Expected results and impact:

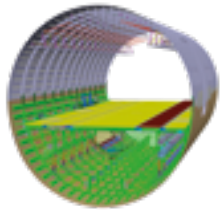
- √ Reduce fuselage weight by 1 tonne
- √ Increase recyclability of materials
- √ Increase fuselage build rate to 70-100 per month: current rate is 60 per month
- √ Flexibility in assembly & increased possibilities for customisation
- √ Cost reduction ensuring European competitiveness
- √ TRL5 by 2023

Method:
Validating high potential combinations of airframe structures, cabin, cargo and system elements using composite thermoplastics, innovative design principles and advanced system architecture within a next generation cabin.

Underpinning all of this is the application of Industry 4.0 opportunities including design for manufacturing and automation.

Progress:
Successfully passed its Critical Design Review in November 2019. Components manufacturing is starting in 2020 and integration into sub-assemblies will follow in 2021. The final assembly of the MFFD is expected in 2022-23.

Part of Clean Sky 2's Large Passenger Aircraft initiative



2. HYPERDRILL: A drill that punches super tiny holes in aluminium can help make planes more aerodynamic

A "super smooth" laminar air flow, as opposed to a turbulent air flow, creates less skin-friction drag and is therefore more fuel efficient. Airliners of the future could benefit from fuel savings of up to 10% using a technique called Hybrid Laminar Flow Control, whereby part of the airflow around an aircraft is sucked through microholes in its skin, significantly improving the aerodynamics. Clean Sky's HYPERDRILL project is developing a unique and ultra-efficient production process for the manufacture of these perforated skins.

Goal:

To design and build a high throughput laser micro-drilling prototype machine for drilling tiny holes in titanium sheets at a speed of over 300 holes per second, enabling the large-scale industrial production of aircraft "skins" that make use of Hybrid Laminar Flow Control.

Expected results and impact:

- √ The drill will generate millions of holes of less than 100 µm per diameter, on titanium panels up to 5x2m
- √ High speed drilling at over 300 holes per second means that the industrial production process will be ultra-efficient
- √ TRL5 by 2022

Progress:

The micro-drilling machine assembly was completed in December 2019. The monitoring and control systems are now being set up and the drilling progress adjusted. Production of the first panels is expected in the first quarter of 2020.

Part of Clean Sky 2's Large Passenger Aircraft initiative
Contributes to the Hybrid Laminar Flow Control (HLFC) Large Scale Demonstrator

© Tekniker

3. ADVANCEing the digitalisation of aircraft maintenance

ADVANCE focused on optimising end-to-end maintenance activities within an aircraft operator's environment. It proved that airline maintenance processes can be fully digitalised and the project also used innovative means to enhance decision support and access to information, delivering greater efficiency in the operations, thus reducing delays, improving passenger satisfaction and increasing airline profitability.

Goal:
To improve aircraft maintenance and to reduce operational disruption caused by unscheduled maintenance. In Europe, 5.8% of all flights are delayed due to direct aircraft technical causes and consequential delays on subsequent flights; the cost of these disruptions is estimated to be €2.8 billion per year.

Expected results and impact:

√ TRL4 at aircraft level passed in 2019

Method:
Developing digital solutions and innovative service scenarios for aircraft maintenance, tools for maintenance scheduling optimisation and dispatch and a documentation app for mobile services.

Progress:
The ADVANCE maintenance demonstrator was presented at a closure event in November 2019. ADVANCE reached TRL4 at aircraft level, and most of the technologies implemented have also passed TRL5/6.

Part of Clean Sky 2's Large Passenger Aircraft initiative

© ADVANCE

© Bockfilm

4. All systems go: Europe's aviation is en route towards Hybrid Electric Propulsion

As the 2020s kick off, regional and short-medium range aviation is entering a new age where fuel-efficient turbine-powered aircraft could be complemented by small hybrid electric powered airliners. Hybrid electric flight is also a major stepping stone towards the longer-term dream of pure electric and truly carbon-neutral (without offsetting) emission-free aviation for all flights, in alignment with the aims of Europe's Flightpath 2050 goals. Clean Sky is nurturing the essential techno-bricks needed to advance the science of hybrid electric propulsion.

Goal:
To investigate the challenges of a high-power hybrid electric propulsion system, such as thermal effects, electric thrust management, altitude and dynamic effects on electric systems, and electromagnetic compatibility issues.

Expected results and impact:

- √ Critical technology bricks development and test such as Hybrid Electric Power (HEP) Generation System (2MW) and thermal management
- √ Proof of concept of an hybrid architecture in the Mega-Watt range and risks/benefits identification of an hybrid propulsion concept for future exploitation
- √ Functional integration test and flight test demo in 2021

Method:
Technology and component development and ground testing.

Progress:
In 2019, the manufacture of the main components such as the propulsion motor was completed, and sub-system testing was started. After all equipment test benches are commissioned, full functional integration testing will be performed in order to prepare the flight campaign currently planned to start end of 2021.

Part of Clean Sky 2's Large Passenger Aircraft initiative

5. DECOROUS: Actuators supporting high lift of aircrafts equipped with larger engines

Installing ultra-high bypass ratio (UHBR) fans is one way to tackle the environmental issues associated with air travel. However, they also interfere with the mechanical high-lift devices at the wing's leading edge. Active Flow Control (AFC) techniques can alleviate this problem, and successful application of AFC requires the availability of robust and reliable actuators, which are being developed by DECOROUS.

Goal:

DECOROUS aims to develop AFC actuators, including a two-stage, no-moving-parts fluidic actuator system, which will solve the lift issue and also reduce noise.

Expected results and impact:

√ Develop a small-scale 2-stage no-moving-parts fluidic actuator system called a Pulsed Jet Actuator (PJA)

√ TRL4 by 2019

© Airbus and DLR

Methods:

The DECOROUS partners used a combination of numerical and experimental methods to develop the Pulsed Jet Actuator (PJA). The small-scale actuator was tested in two wind tunnel test campaigns in a cryogenic test facility in Cologne, Germany. A full-size actuator was then developed, constructed and qualified in a laboratory.

Progress:

The full-size actuator was qualified in 2019. Positive effect of active flow control on max lift coefficient has been demonstrated compared to the impact of a cut-out on the high-lift configuration at low speed Mach (Ma ≈ 0.2) with low blowing momentum coefficients.

Part of Clean Sky 2's Large Passenger Aircraft initiative

© Airbus and DLR

6. New wing technologies for future regional aircraft concept

Multi-mission aircraft are suitable for a variety of purposes, including transport of people and goods, fire-fighting and search-and-rescue. They need increased operational flexibility, including low speed performances, ability to operate on reduced ground infrastructures and dual transport services. Clean Sky 2 tackles this by developing such an aircraft, which will also lead to weight, drag and load reductions, contributing to its goals of reduced emissions and noise levels.

Goal:

To develop a more electric regional aircraft with reduced weight, drag and load that can be used for a variety of missions as it is optimised for more advanced high lift performances and increased efficiency in the climb and descent phases.

Expected results and impact:

- √ TRL6 by 2023
- √ First flight test in 2021
- √ Final flight test in 2023

© Airbus Defence and Space Future Regional Multimission concept

Method:

Different innovative technologies like affordable flight control systems, electromechanical actuation systems for movable surfaces, loads reduction systems, innovative aerodynamic devices and new materials and structures optimisation (composite and metallic) at aircraft level are being developed for use in this demonstrator.

Progress:

In 2019, some components were already delivered, including the morphing winglets. Morphing winglets aim to reduce weight at component level by 15%, reduce drag by 5% and alleviate loads by 10%. A wind tunnel model with a wing span of 3m was finalised at the end of 2019. A wind tunnel test will validate the feasibility of the Flying Test Bed #2 design in 2020.

Part of Clean Sky 2's Regional Aircraft initiative, incorporating components from the Systems and Airframe Integrated Technology Demonstrators (ITDs)

7. Novel helicopter configurations provide a new mobility approach

The Fast Rotorcraft initiative consists of two separate demonstrators, Next Generation Civil Tiltrotor (NGCTR) and the RACER (Rapid And Cost-Efficient Rotorcraft). The RACER demonstrator almost defies categorisation. It's a type of rotorcraft that combines the vertical agility of a helicopter with the pace of a fixed-wing aircraft, while encompassing cost-efficient and environmentally sustainable attributes. Next Generation Civil Tiltrotor 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 demonstrator will also cut noise, NO_x and CO_2 emissions.

RACER

Goal:

To utilise cutting-edge technologies to develop a compound rotorcraft that can move in a way that neither conventional helicopters nor fixed wing aircraft can currently cover sustainably.

Expected results and impact of RACER:

- √ TRL5/6 by 2021
- √ Cruise speed in excess of 400 km/h
- √ Reduce CO_2 by 20%
- √ Reduce NO_x by 25%
- √ Reduce noise by 25%

Progress:

In 2019, RACER passed its Critical Design Review and also successful stress and design audits were performed on the wing design.

Part of Clean Sky 2's Fast Rotorcraft initiative

© Airbus Helicopters

Next Generation Civil Tiltrotor

Goal:

To develop an environmentally-friendly tiltrotor aircraft that can take off and land vertically without airports for use in specialised missions.

Expected results and impact of Next Generation Civil Tiltrotor:

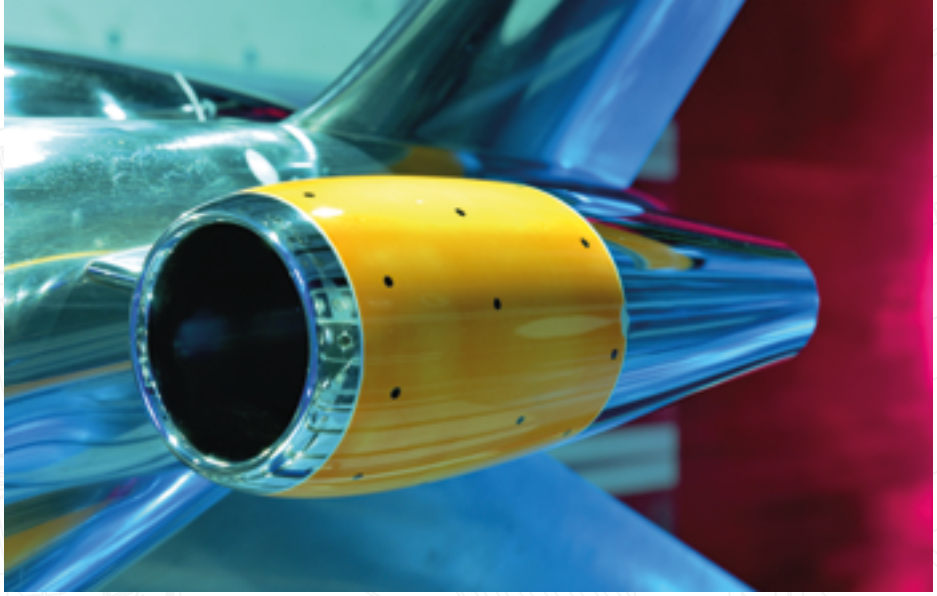
- √ TRL5/6 by 2023
- √ Reduce CO_2 by 50%
- √ Reduce NO_x by 14%
- √ Reduce noise

Progress:

Next Generation Civil Tiltrotor finished its Preliminary Design Review, and several wind tunnel tests were performed to validate the helicopter configurations leveraging on tail and wing models.

Part of Clean Sky 2's Fast Rotorcraft initiative

© Leonardo



8. Using temperature-sensitive tech to increase aircraft performance

Wind tunnel tests are an essential phase in the process of pre-flight aircraft R&D. But simulating laminar and turbulent airflow at scale, and identifying the transition zone between the two in realistic operating conditions, is a complex undertaking. Clean Sky's BinCola project successfully leveraged temperature-sensitive technologies to address the challenge.

Goal:
To investigate the use of extended laminarity in the nacelles (engine housing) and horizontal tail plane (HTP) to reduce drag and increase aerodynamic performance. An improved laminarity will contribute to the efficiency of the aircraft and hence reduce fuel consumption and pollutants.

Expected results and impact:

- √ Contribution to Business Jet Demo
- √ Reduction of overall aircraft drag by 2-3%

Method:
Contrary to the classical method which provokes a surface heat flux by step-changing the flow temperature in a wind tunnel, the visualisation of the transition zone was carried out by means of Temperature Sensitive Paint (TSP) heated by either an infrared laser array or an embedded layer of carbon nanotubes heated up by electricity. Uniquely cryogenic wind tunnel testing conditions were required.

Progress:
A scaled model of the aircraft was tested with TSP heated with laser arrays in September 2019.

Part of Clean Sky 2's Airframe initiative and contributes to Clean Sky 2's Natural Laminar Flow Business Jet Horizontal Tail Plane

9. TechTP Demonstrator: from sketches on paper to reality

Clean Sky's TechTP engine demonstrator project paves the way for a 100% European-built sustainable, low fuel and low noise engine for use with general and small commuter-sized aircraft (up to 19 passengers), and is on track for the next phases of its development and testing regimes.

The first delivered key demonstrator of Clean Sky 2!

Goal:
To deliver a turboprop engine for business, short range, regional or commuter-class aircraft.

Expected results and impact:

- √ TRL5 by 2021/2022
- √ Reduction in CO_2 of between 12-20%
- √ Reduction of noise by five decibels

Method:
The TechTP engine is derived from the Ardiden 3 core engine which is used for helicopter applications. Apart from the changes in core engine technologies, TechTP requires the development of main enabling technologies including innovations in propellers, power and accessory gearboxes, engine and propeller controls, air intake and nacelles. A total of eleven Clean Sky projects will be integrated into the final demonstrator.

Progress:
Tests on the ground have been carried out successfully. In 2020, with the help of the ACHIEVE project, an engine adaptation towards more electrical aircraft will start. TRL5/6 is expected to be reached by early 2020. The work on assessment of performances will be finalised by 2021.

Part of Clean Sky 2's Breakthroughs in Propulsion Efficiency initiative

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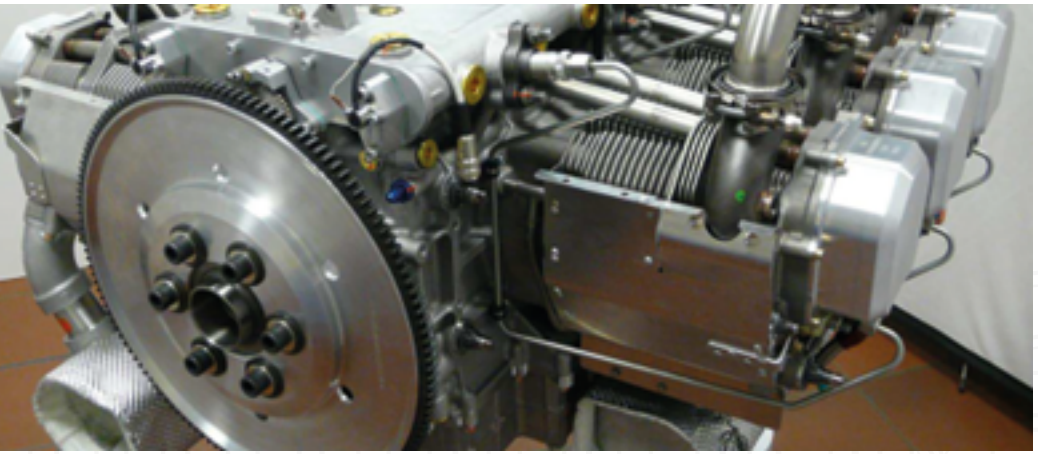


10. Eco-friendly engine generation for small, fixed-wing aircraft

With power-plant solutions ranging from piston/diesel engines to small turboprop engines, these Clean Sky technologies will provide new solutions to replace old gasoline leaded fuel pistons or small turbines for single and twin engine aircraft. The scope includes the development of a new 6-cylinder internal combustion engine and the optimisation of its installation in a 9/10-seat aircraft, as well as core engine technologies testing for power density improvement, or evolutions on equipment like turbochargers, propellers and control system.

Goal:

To produce a lightweight compression ignition engine using kerosene as a fuel instead of leaded gasoline. This type of engine would increase fuel efficiency as well as reducing pollutant emissions and increasing the reliability and cost-efficiency of services.

Expected results and impact:

- √ TRL5 by 2019
- √ Decrease CO_2 emissions by 30-60%
- √ Reduced noise due to low speed of engine and propeller rotation
- √ Increase in payload or carrying capacity of aircraft

Method:

In 2019, researchers investigated an alternative 6-cylinder engine architecture. They tested the integration and optimisation of aircraft installation for such an engine. They also examined technology improvements on core engines (power density), turbochargers, propellers and engine control systems.

Progress:

- Power target reached (400hp)
- Brake specific fuel consumption target almost reached (<10%)
- Engine demonstrators have run a total of 230 hours without any mechanical issue

Part of Clean Sky 2's Breakthroughs in Propulsion Efficiency initiative

11. Innovative aero tech could boost Europe's SAT manufacturing capabilities

Achieving four-hour door-to-door mobility across Europe requires new thinking when it comes to the SAT (Small Air Transport) category of aviation. Clean Sky's SAT-AM project is investigating ways to reduce manufacturing and maintenance costs for aircraft in the 4-19 passenger range.

Goal:
To develop technologies for manufacturing lighter and cheaper airframes while maintaining (or increasing) the reliability.

Expected results and impact:

- √ TRL5/6 by 2020
- √ Reducing the number of components by 35%
- √ Reducing weight by 10%
- √ Reducing manufacturing costs by more than 25%
- √ Jigless assembly of the cabin

Method:
Different manufacturing technologies are being investigated including friction stir welding, additive manufacturing, high speed machining, out of autoclave technology, and super-hydrophobic coatings. The technical feasibility and benefits of these technologies will be assessed in comparison with traditionally produced components.

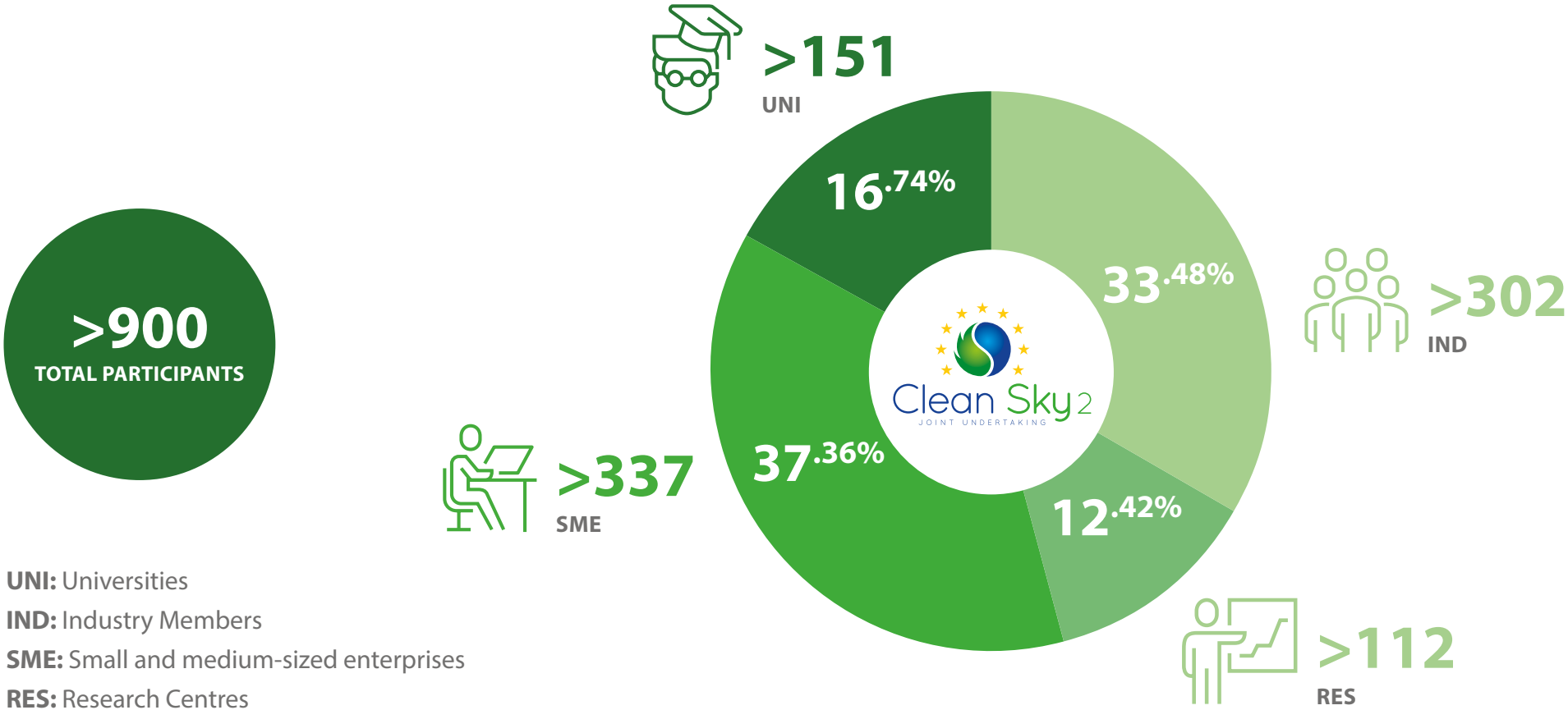
Progress:
In 2019, the assessment of results was completed while relevant test activities started towards receiving the permit to fly of the engine nacelle flight demonstrator.

Part of Clean Sky 2's Small Air Transport and Airframe initiatives

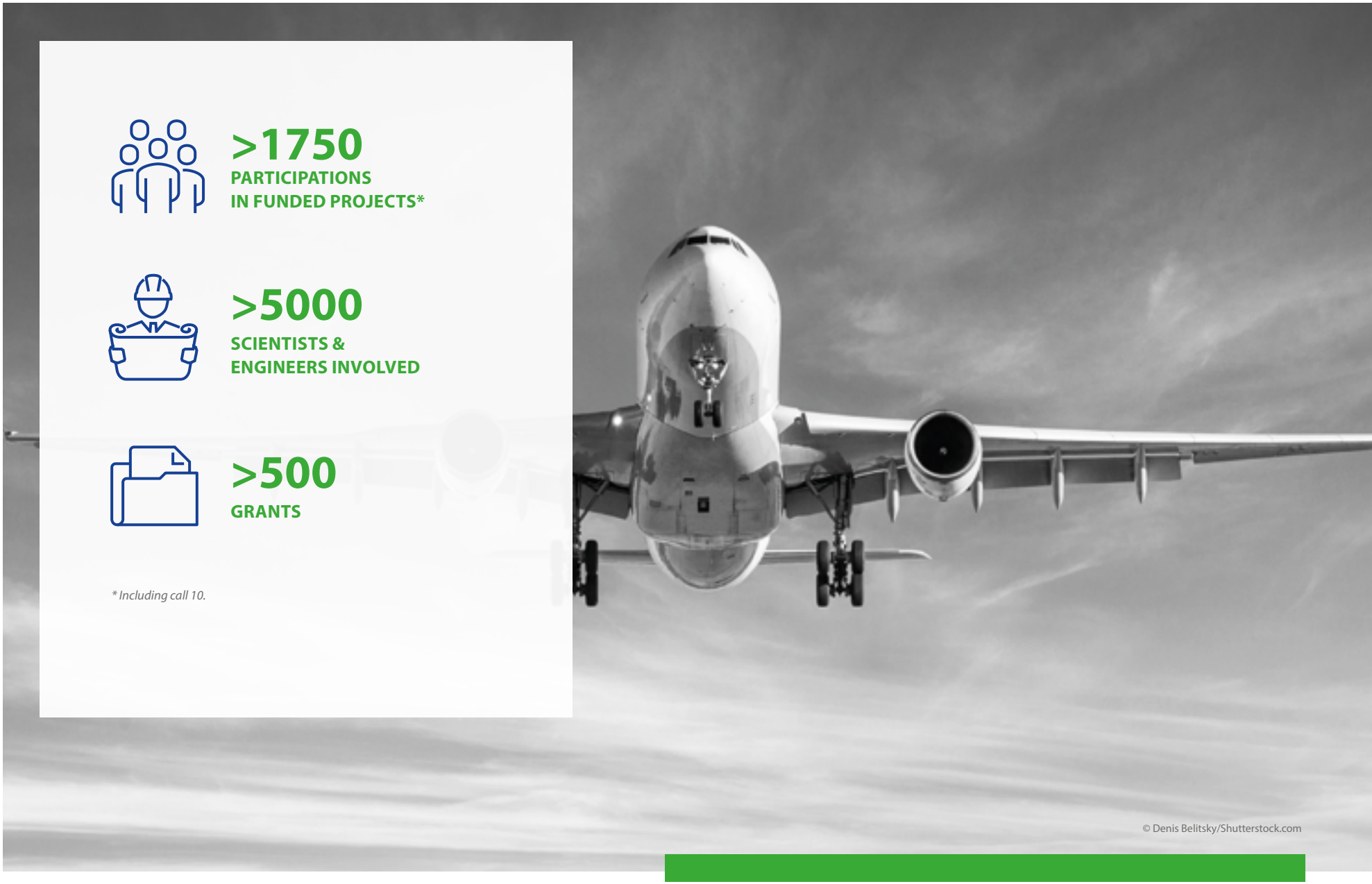
Who is taking part in Clean Sky 2?

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. By the end of 2019, out of the 11 calls planned in Clean Sky 2, ten calls for proposals had been launched and evaluated. The data presented in this section of the report refers to the ten calls completed.



UNI: Universities
IND: Industry Members
SME: Small and medium-sized enterprises
RES: Research Centres



>1750
PARTICIPATIONS IN FUNDED PROJECTS*

>5000
SCIENTISTS & ENGINEERS INVOLVED

>500
GRANTS

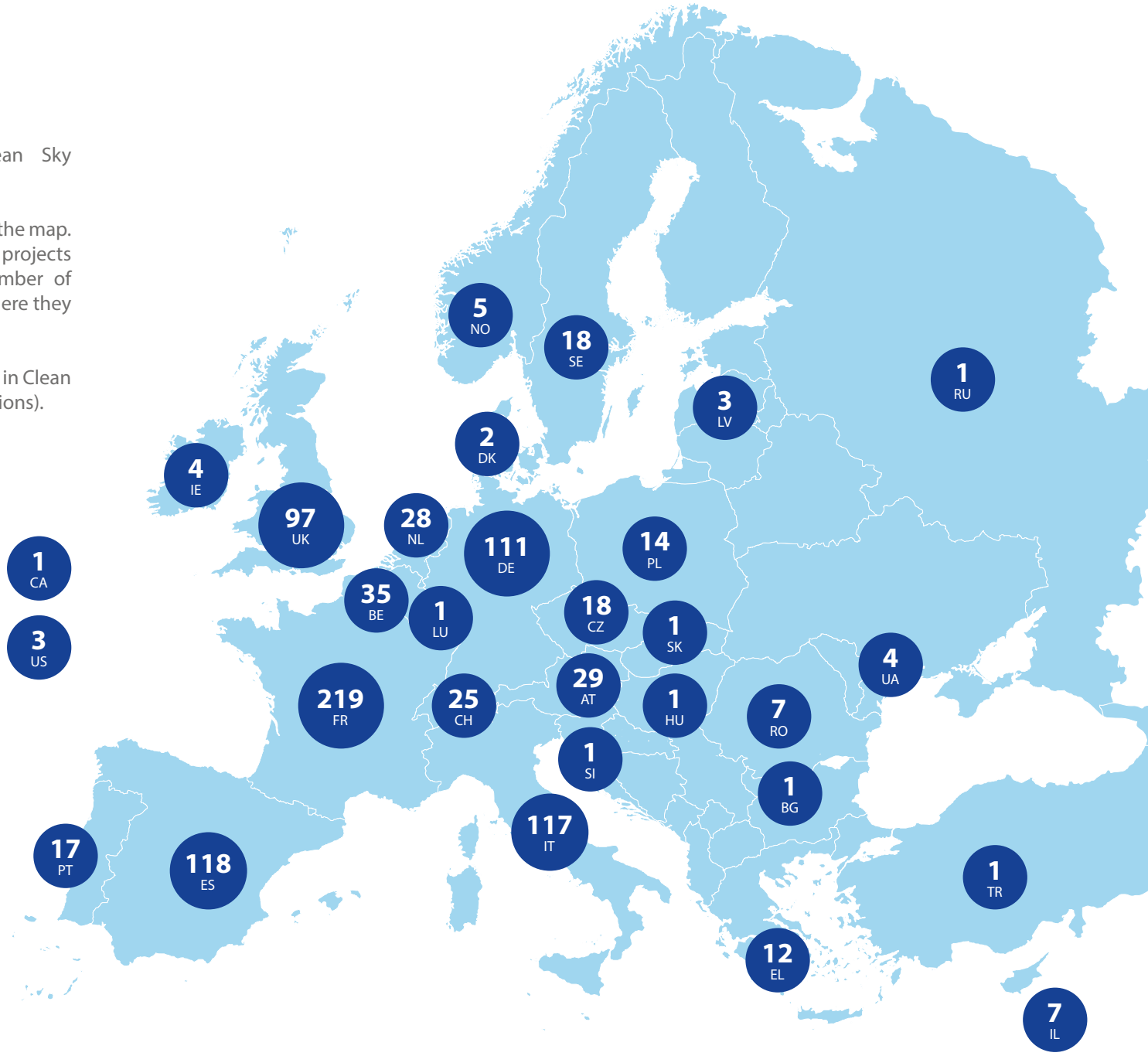
** Including call 10.*

Country distribution

The figures indicate the number of Clean Sky participating organisations per country.

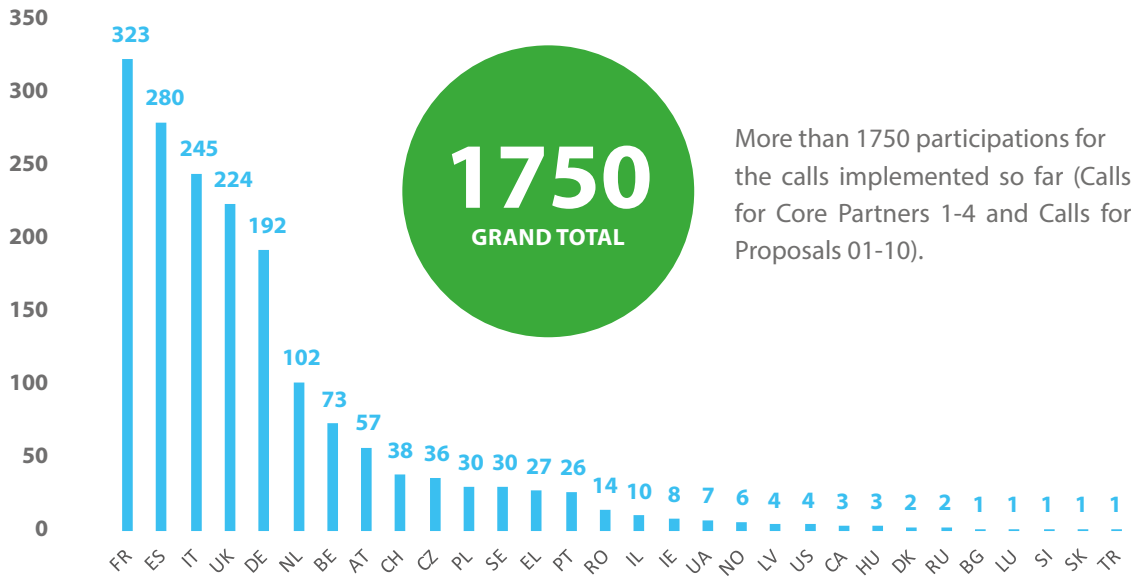
Participating organisations are counted once in the map. They may however participate in multiple projects Therefore, in the participation chart, the number of participations takes into account all projects where they were involved.

This map shows more than 900 entities involved in Clean Sky 2 across 30 countries (excluding leaders' actions).



Number of participations

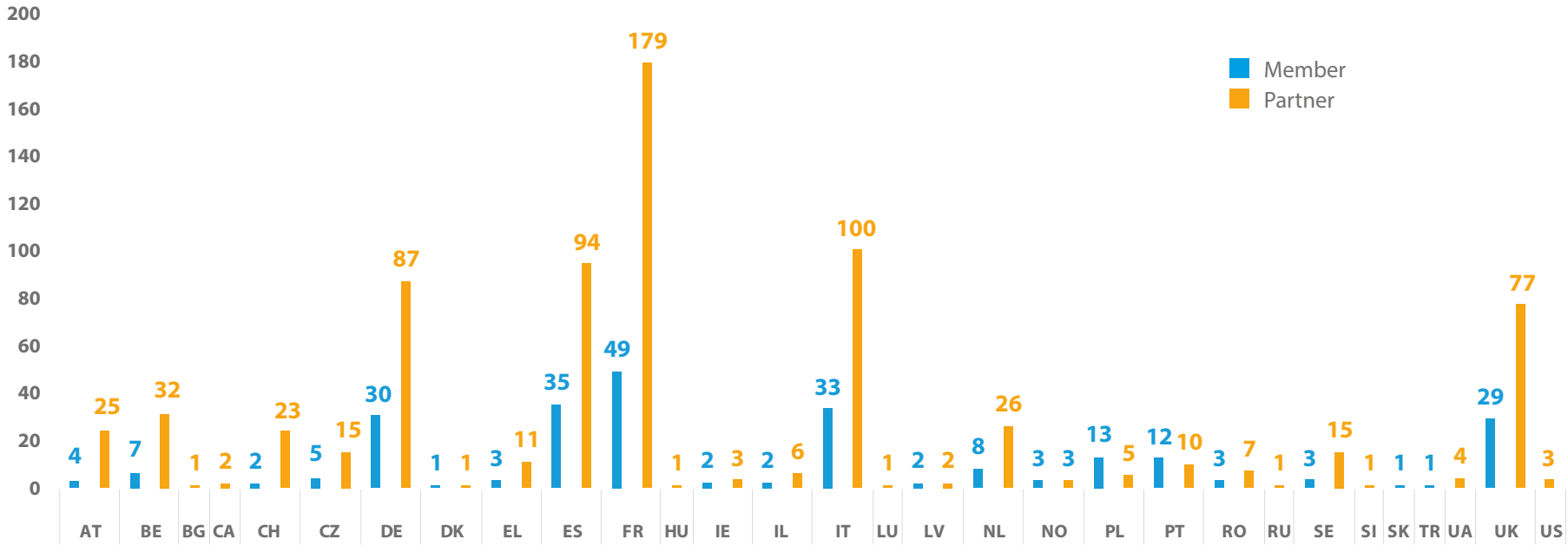
This graph shows the number of times that a country has taken part in a Clean Sky 2 project - referred to as participations. The data displayed here includes Calls for Core Partners 1-4 and Calls for Proposals 01-10.



1750
GRAND TOTAL

More than 1750 participations for the calls implemented so far (Calls for Core Partners 1-4 and Calls for Proposals 01-10).

Members and Partners



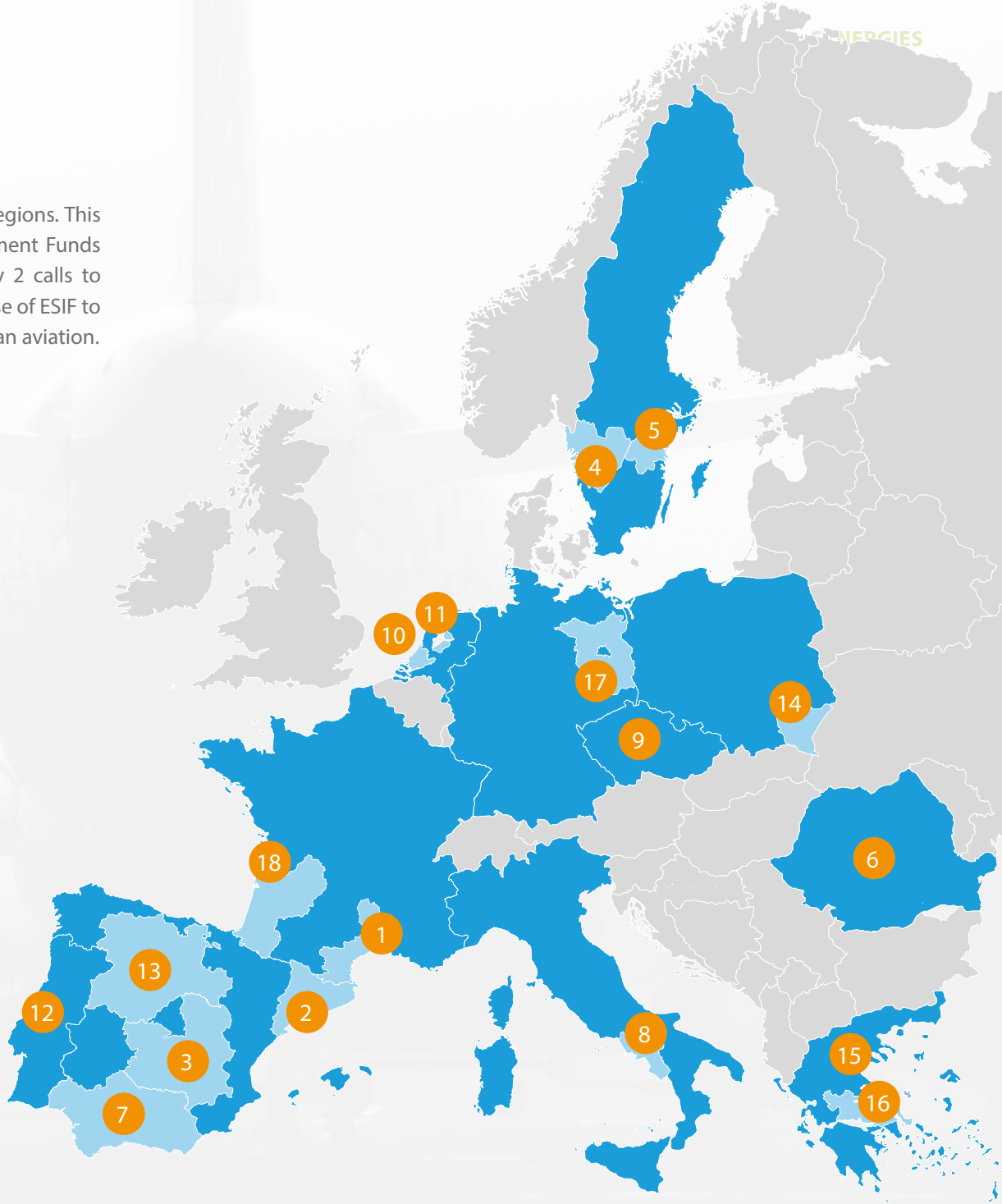
Synergies

18

Memoranda of Understanding (MoU) with Member States & Regions across Europe

To date, Clean Sky has signed 18 Memoranda of Understanding (MoU) with Member States and Regions across Europe. The MoUs are important tools that set out the framework of cooperation going forwards. They outline a strategic approach, follow the regional strategy (RIS3) and identify the applicable European Structural and Investment Funds (ESIF) regional instruments that can support potential proposals complementary or related to Clean Sky projects and objectives. However, the signature of a MoU is not a pre-condition for developing synergies with Clean Sky 2: rather it is an incentive instrument that can enable the Member States and Regions to develop closer interactions with Clean Sky and stimulate their participation in Clean Sky calls.

Clean Sky is actively supporting smart specialisation in European regions. This work is done within the European Structural and Regional Investment Funds (ESIF). Clean Sky actively encourages applicants to the Clean Sky 2 calls to combine their funding with ESIF opportunities, and promotes the use of ESIF to build and enhance local capabilities and skills in fields related to clean aviation.



MoUs with regions

1. Occitanie (FR)
2. Catalonia (ES)
3. Castilla-La Mancha (ES)
4. Västra Götaland (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

At a strategic level, Clean Sky is developing close connections between Member States and Regions that are interested in investing ESIF or other national/ regional funds into the clean aviation sector. This will enable Clean Sky to build synergies and networks between industrial actors, universities, research organisations, SMEs and regional funding opportunities to further the development of clean aviation technology. Altogether, 155 regions from 28 countries have participated in Clean Sky 2 calls, with more than half of these regions located in Italy, Germany, Spain, France and the UK. Winning proposals come from 121 regions.

45 PROJECTS | €50 MILLION

By the end of 2019, more than 45 projects with a budget of around €50 million were leveraged through the MoUs. In addition, the 18th Memorandum of Understanding was signed with the Nouvelle-Aquitaine region in France.

Three proposals – INFRASEAL, REMASTER and SAINT – were awarded the Clean Sky 2 Synergy label in 2019. This is a quality label that is awarded to complementary activities proposed by either a successful applicant in a Clean Sky 2 call or by a Clean Sky 2 beneficiary during the implementation of a Clean Sky project. The awarding of the Clean Sky Synergy Label entitles these proposals to compete for funding in national and regional calls that support synergies between Clean Sky Joint Undertaking and ESIF. Since the launch of Clean Sky 2, 12 proposals have been awarded the Clean Sky Synergy Label, and one proposal is currently under evaluation.

Future Aviation Partnership

In the current political and societal context of a developing climate emergency, aviation must address its contribution to global warming with more urgency than ever, so as not to jeopardise its role and the massive benefits the sector provides to Europe's citizens. This represents a massive and systemic challenge for the aviation community. Achieving climate neutrality within the sector will require an integrated approach spanning technology providers and innovators, manufacturers and operators, public sector authorities and travellers.

Working together, public and private actors can fast-track the required research and technology efforts and their market uptake, to bring aviation in line with a 'net-zero' emissions and climate-neutral Europe, while continuing to provide safe, affordable and reliable air transport options to citizens and businesses. The pathway to this renewed aviation system must however maintain the sector's admirable safety record, its fundamental economics and its competitiveness in order to achieve the transformation needed.

A joint effort will ensure that energy needs and fuel consumption are reduced, sustainable aviation fuels are developed and deployed for economically viable use, and that air operations and networks are optimised to fully exploit new aircraft and systems capabilities.

Industry partners, SMEs, universities and research organisations have already demonstrated their commitment to such a partnership through the signing of a Joint Declaration in 2019, which was presented to Jean-Eric Paquet, Director-General for Research and Innovation at the European Commission.

If the envisioned programme of development and deployment emerges, new aircraft with game-changing energy-efficient technologies and 'green operations' would reduce emissions in the 2050 fleet by between one third and one half compared to operating today's best available aircraft.

Combined with using sustainable (low net carbon) fuels, new aircraft in operation in 2050 could achieve a 90% reduction in net emissions compared to today's aircraft and fuels.

Support from the EU institutions and Member States will be crucial in ensuring success. Achieving these objectives is likely to require €12 billion in total research spending across the EU and Member States over the next decade. Significant gearing of EU funds will materialise from private sector and EU Member States. Moreover, several times this amount will be invested from the private sector thereafter.

€12 BILLION
in research spending in Europe in the next decade

The technical proposal for a Clean Aviation Partnership, proposed by the stakeholder group, sets out a shared, dynamic and impact-driven roadmap to achieve its vision. This roadmap is comprised of three main thrusts:

Hybrid electric and full electric architectures: driving research into novel (hybrid) electrical power architectures and their integration; and maturing technologies towards the demonstration of novel configurations, on-board energy concepts and flight control.

Ultra-efficient aircraft and engine architectures: to address the short, medium and long-range needs with innovative aircraft architectures making use of highly integrated, ultra-efficient gas turbines.

Disruptive technologies to enable hydrogen-powered aircraft: to enable aircraft and engines to exploit the potential of hydrogen as a non-drop-in alternative zero carbon fuel, in particular liquid hydrogen.

The flight path to climate neutrality

By **2030**

- Progressive fleet replacement already underway;
- Today's best-in-class aircraft that are currently entering the fleet and replacing older models will continue to result in roughly 2% better fuel consumption – and lower emissions – per unit of production (i.e. per Revenue Passenger Kilometre / RPK);
- Accelerated deployment and use of sustainable low carbon fuels in the coming decade, together with optimised 'green operations' will deliver at least a further 10% emissions reduction;
- Technologies stemming from the Clean Sky and Clean Sky 2 programmes, complemented where possible with early results from Clean Aviation programme activities, will allow retrofit or systems upgrade opportunities in the operating fleet in limited cases, and deliver a modest further contribution;
- The research and technology developed and demonstrated during the Horizon Europe period will have determined the configuration of a new breed of low emissions aircraft exploiting the research results of Clean Aviation;
- The first wave of these new, radically re-designed aircraft will be on offer before 2030, with an entry into commercial service from approximately 2035.

The European Commission's legislative proposal for a European Partnership for Clean Aviation is expected by 2020.

By **2050**

- Based on new aircraft designs realised thanks to technologies developed through and beyond the Clean Aviation Partnership, and entering the market from 2030 onwards, the transformation towards full use of sustainable fuels and – where feasible – zero-CO_2 energy sources, climate-neutral aviation will be achieved.

The ingredients for success

To achieve impact, the European aeronautics sector will need as pre-conditions for success:

1. Adequate funding and financial support for a programme aiming for a large-scale technology revolution in aviation

2. Strong, pro-active European Union support regarding global regulation, standards for and certification of future products, supported through a strong and strategic alignment with EASA

3. Close alignment with EU policy enabling a faster market uptake of green aircraft

4. Decisive and rapid acceleration in the production and deployment of sustainable aviation fuels under favourable economic conditions for all operators

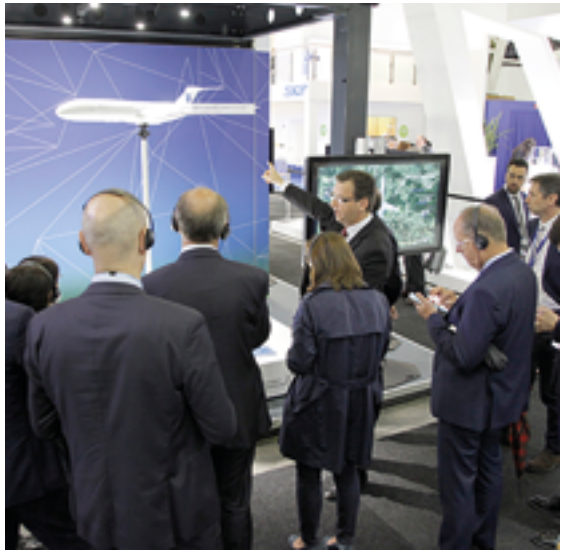
Events

Clean Sky at Le Bourget

Clean Sky had an exciting week at Le Bourget from 17-23 June! Highlights included the signature of a Joint Declaration on a future Clean Aviation partnership, a conference giving an insight into Clean Sky's work with synergies with Regions and Member States, and a Memorandum of Understanding signed with the French region of Nouvelle-Aquitaine.

Clean Sky at AERODays

From 27-29 May Clean Sky was in Bucharest for AERODays, with a joint exhibition stand with the European Commission and a busy conference programme. Axel Krein presented achievements of the Clean Sky 2 programme in a keynote speech on Tuesday 28 May, focusing on how Clean Sky technologies are working to reduce the environmental and climate impact of aviation. Throughout the three-day event, many Clean Sky projects were also presented by technical experts in breakout sessions. A particular highlight was the ceremony for the Clean Sky Academy's Best PhD Award, which recognises outstanding research work by young scientists in applied sciences and engineering for aeronautics. This year's winner is Dr. Roberto Merino-Martinez, for his thesis 'Microphone arrays for imaging of aerospace noise sources'.



Clean Sky 2
JOINT UNDERTAKING

If you want more information about Clean Sky 2, you can download our publications, read about our technologies and sign up to our newsletter at www.cleansky.eu.

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