PULSAR

TOGETHER FOR SUSTAINABLE AVIATION

A glimpse into European collaborative research efforts on aviation emissions and noise

2023

PULSAR has received funding from the European Union's Horizon Europe Research and Innovation programme under grant agreement No 101095395. Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting authority (CINEA) can be held responsible for them.

Table of content

Foreword

PULSAR in a nutshell

The complexity of reaching green aviation

- The difficult task of a roadmap
- Rational choices or democratic preferences?

European Commission projects (implemented by CINEA)

- Monitoring Actions - PULSAR, Impact Monitor
- Climate Impact and Operations - ACACIA, CLIMOP, BECOM
- Local Air Quality - AVIATOR, NEEDED
- Noise - ANIMA, ARTEM, PANDORA
- Hydrogen - ENABLEH2, HESTIA, EFACA
- Sustainable Aviation Fuel - JETSCREEN, TAKE-OFF
- Electric Storage & Propulsion - EASIER, HELENA, MATISSE
- Hybrid Propulsion - IMOTHEP, MAHEPA
- Airports - OLGA, STARGATE, TULIPS, ALIGHT

National projects

Foreword

For decades, aviation used to be associated with progress. This fascinating and dreamful way to move away, discover new countries and cultures, nurture personal and professional exchanges, or make business has highly enabled prospects for a better life based on open societies and economic growth.

Nowadays, however, these irenic views are highly challenged, at least in Europe. More often than ever, aviation is associated on our continent with pollution, noise, nuisances, and unsustainability. The point to know if such feelings are fairly accounting for the true impact of aviation is secondary. The fact is that a growing fraction of our fellow European citizens are demanding more environmental-friendly aviation. In this regard, the COVID crisis provided us with some respite that had not been used enough: the air traffic regained almost all its pre-crisis intensity without any major changes.

Let me underscore that such an aspiration for a better quality of life in Europe also meets the equally strong requirement for increased European competitiveness. Because environmental-friendly aircraft that are today demanded by wealthy European societies will be soon demanded too by people living in overcrowded and highly polluted conurbations elsewhere, especially in Asia. Therefore, the endless quest for more competitive aviation, a sector globally led by the European industry, is complementary to the top EU priority to build a climate-neutral, green, fair, and social Europe.

To this endeavour, the European Commission strongly supports research and innovation through its successive dedicated framework programme, especially through the just finished Horizon 2020 and the ongoing Horizon Europe. This brochure aims at giving a glimpse of research performed on environmental aviation through a selected subset of EU collaborative projects, which complement and go beyond well-known high-TRL-focused EU Joint Undertakings (such as CleanSky/Clean Aviation). It also aims at illustrating the massive effort made by the European Commission for the achievement of such key objectives.

Taking the pulse of what has been and what is being done at European and national levels, PULSAR endeavours to provide policy-makers unbiased sound recommendations on research and education and to contribute to the EU research roadmap for aviation noise and emissions, with the constant objective to keep the most competitive European aviation industry and the highest level of wellness for our fellow EU citizens.

Dr. Laurent Leylekian

European Affairs Officer
PULSAR & ANIMA projects coordinator
ONERA, the French Aerospace Lab

Propelling eUropean Leadership through Synergizing Aviation Research

PULSAR in a nutshell

The rationale for PULSAR lies in conflicting agendas: On the one hand, many international institutions strive to enact and enforce increasingly stringent policies in order to address the environmental issues at large. Such an effort leads to an inflating number of sectorial regulations or recommendations. This is for instance the case for aviation which must comply with ICAO regulations for reducing the noise at source, for CO2 emissions certification Standard and now for the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA); not to mention the engine emissions standards now complemented by the new non-volatile Particulate Matter (nvPM) mass and number engine emission Standard. The European Union spearheads such a regulatory trend through even more ambitious regulations such as the forthcoming "Fit for 55" legislative pack, which contains several new measures superseding the EU Emissions Trading System (ETS) applicable to aviation.

On the other hand, the socioeconomic evolution of the world is more unpredictable than ever. War in Ukraine and new geopolitical tensions, the collapse of abundant or accessible fossil energy resources along with the emergence of new state and non-state players may completely derail any top-down views on the development of air traffic in Europe. Let us just recall that the European GDP may drop from 15% to 9% of the World share by 2050 and that if SpaceX may have succeeded in a very state-controlled sector such as space, similar breakthrough players could pop up even more easily in a less regulated sector such as aviation.

In such a changing environment, PULSAR tasks to deliver recommendations to policy-makers for orienting research and innovation on environmental aviation, i.e., on the way to reduce aviation noise and (carbon dioxide and non-carbon dioxide) emissions. In this regard, PULSAR will consider a handful of different global scenarios, optimistic ones, and pessimistic ones. The project will also consider a list of various existing or possibly forthcoming enablers, whatever technologies or procedures. Partners of the consortium will then assemble a database of such enablers with their expected impact on various indicators related to noise and emissions and for various time horizons. Of course, such a job will heavily elaborate upon past and ongoing European projects, such as those introduced herein. The key point of the project lies in crossing scenarios with enablers. In other words, we are aiming at determining the environmental impact (and maybe even the relevance) of given aircraft technologies in the selected scenarios.

PULSAR has received funding from the European Union's Horizon Europe Research and Innovation programme under grant agreement No 101095395. Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting authority (CINEA) can be held responsible for them.

It will especially help to determine whether the considered technologies will help to comply with regulations and to which extent and in which scenarios they will be meaningful. Ultimately, PULSAR will advance on such assessments to provide recommendations and support the European Commission in its hard mission of selecting the most promising enablers in order to bring them up to the market.

Besides this primary objective, PULSAR has two other important missions. The first one is to screen the existing educational offer on aviation sciences across Europe and to check how far this offer encompasses environmental issues. Taking into account the probable gaps and lacks in this domain and the strong related need of the European aviation industry, PULSAR is then likely to propose some additional curricula to relevant universities and training institutions.

This educational roadmap will be a key complement to the research roadmap as preparing for the future means not only planning research topics but also training dedicated experts able to address them.

Last, PULSAR is also tasked to address the broadest audience of European citizens concerned with aviation and especially aviation environmental issues. Our conception of such a communication is certainly not only top-down but bidirectional: PULSAR's ambition is not only to detail what is actually performed at the research level to improve the environmental performance of aviation but also to integrate critical standpoints that may be expressed with its own views, analyses, and conclusions. The present brochure may be rightfully considered as a first attempt to introduce recent research works that could be integrated in commercial aircraft at mid-horizon.

The complexity of reaching green aviation

The difficult task of making a roadmap

The primary goal of PULSAR is to shape some research roadmap for environmental aviation. As for any prospective work, it is a hard task. First, nobody knows what could occur in the next decades. The COVID crisis is an iconic example of an unexpected event with global consequences. In the future, similar crises may arise again and some disruptive ideas or concepts may emerge too. Nowadays, for instance, great hopes are placed in Artificial Intelligence but the true impact of such a technology in the forthcoming years is still difficult to quantitatively assess from a general standpoint and even more for aircraft design. However, the situation is even trickier because some technologies at the research level may be dismissed at an operational level. Various reasons may lead to such a dismissal, for instance, the lack of regulatory incentive, the extra cost, or even some reluctance of end-users. For instance, the European Commission and its agency CINEA, among others, supported many research works on disruptive aircraft concepts such as blended-wing body aircraft or Prandtl box wing aircraft that may lead to less fuel consumption and less pollution. Yet, airport infrastructures would probably need to be adapted for operating the former and the public readiness for the latter is questionable.

That is why PULSAR is going to rely on a set of scenarios, which will directly derive from overall assumptions. Such scenarios will encompass hypotheses on technology maturity but above all on the overall socioeconomic conditions that may arise at a global level. Clearly, the acuteness of more stringent environmental norms in a future world globally based on the rule of law and free movement of persons, goods, and services could be strongly different from a future world fragmented into blocks. And even within the most favorable assumptions, it could happen that the lack of energy resources may lead to circumventing or disregarding such environmental norms. That is why PULSAR will strive to assess the environmental impact of aviation fleets around a selected set of European airports under different conditions and with differentiated dates for entry in service of promising technologies. This overall process will be partly based on numerical simulation and partly on judgments of experts gathered in a workshop as the impact of some enablers is too sophisticated to be addressed by straightforward computations. Ultimately, PULSAR aims to present which environmental steps forward could be achieved through technologies and which ones would rather need policy intervention or adaptation of the regulation. Recommendations to policymakers will be based on these outcomes.

Rational choices or democratic preferences?

Like its predecessor ANIMA (which focused on noise), PULSAR will face the limits of rational choices. Many if not most people believe that decisions stemming from science and technology are purely rational. This is not always the case and almost never the case when human beings are involved. A given technology or enabler may lead to some benefits for some people and some drawbacks for others. For instance, a few years ago, the Civil Aviation Authority of an EU Member State tested a new flight route objectively lowering the noise over densely populated areas close to the airport at the expense of slightly increasing the noise in more scarcely inhabited ranges where there was previously no aviation noise. Such change led to some vivid protests from these ranges whereas most of the beneficiaries of this option did even not notice the improvement. In the end, the experience was abandoned despite the objective increase in the quality of life for most people.

This example illustrates how so-called "rational choices" cannot bypass local democracy where assemblies of involved stakeholders would collectively decide the balance point equilibrating the various and sometimes divergent interests. The choice above could become even trickier within PULSAR when considering the combined effects of noise and emissions. We might come to some dilemmas consisting in choosing between lowering noise at take-offs and landings for local communities or lowering CO_2 emissions against global warming. Should this case arise, which option will be better? And who will decide?

European Commission projects implemented by CINEA

The next pages provide quick introductions of some European Commission collaborative research & innovation projects implemented by the European Climate, Infrastructure and Environment Executive Agency (CINEA) on environmental aviation. As previously underscored, these projects aimed at increasing the competitiveness of the European aviation industry and at improving the compliance of this key sector with the objectives of the Green Deal. The overall EU budget implemented by CINEA for aviation research and innovation amounted to more than 600 million euros in Horizon 2020 — the previous framework programme (2024-2020) — via 125 projects.

This brochure lists some of the projects that have been supported either within Horizon 2020 or through its successor programme Horizon Europe (2021-2027).

The comprehensiveness of the addressed topics illustrates how challenging are the tackled issues. Some are dealing with the downstream impact of aviation. For instance, some projects are striving to improve the local air quality around airports by improving aircraft combustion chambers. Some other projects are focusing on better characterizing or better measuring such emissions along with the local diffusion processes. At a larger scale, some other projects are trying to connect the dynamics of engine-emitted species (either carbon dioxide or other species especially nitrogen oxides and soot) with some atmospheric models in order to derive, and possibly to lower, the impact of aviation on global warming.

Upstream, there are also some projects inquiring about the impact on local air quality and on global warming of potential new fuels such as "Sustainable Aviation Fuels" (SAF) or Hydrogen.

In addition, some projects are exploring electric propulsion too, including various intermediate hybrid electric architectures and prospective full electric propulsion ones. For electric propulsion, research projects on batteries and storage of electric energy are of course crucial.

Whatever the propulsive systems, some other projects are studying the aviation noise impact. Such an impact is addressed at the airport level by some projects examining traffic patterns, regulations enforcement, and the empowerment of neighboring communities. Some other projects are attempting to lower the noise at the source. This may imply some new engine architectures but even with similar propulsive systems, some key achievements are possible through innovative low-noise designs for aircraft. That is why some research projects focused on such designs, which can also bring significant advantages in terms of fuel consumption. However, even promising research projects cannot ensure their solutions will be adopted by the market, as market rationale may completely differ from environmental causes. Besides European Union projects, this brochure is also introducing four major programmes on environmental aviation respectively held in France, Germany, and the Netherlands. These examples achieve a quite fair (albeit not complete) illustration of what is done in Europe to make aviation more environmentally friendly. PULSAR is committed to integrating the whole effort in a single roadmap supporting policy-makers in orienting research for the greater benefit of EU competitiveness and the well-being of its citizens.

The EU-funded Impact Monitor project will deliver a coherent and comprehensive framework and toolbox aiming to become the reference choice for technology and policy assessment of the environmental, economic, and societal impacts of European aviation R&I. and toolbox aiming to become the reference choice for technology and policy assessment of the environmental, economic, and societal impacts of European aviation R&I.

In addition, the project also aims at better connecting European aviation R&I with education and skills actors, as well as communicating this R&I to key stakeholders (including society) by demonstrating the capabilities of the framework and toolbox. In particular, Impact Monitor will make the framework and toolbox accessible to students and the broader community via the Impact Monitor Academy. The project will develop the framework and toolbox by advancing in an innovative way credible and successfully applied approaches used by the European Commission Better Regulation guidelines and toolbox and European Commission projects TEAM_Play, Clean Sky TE, and AGILE/AGILE 4.0. The project will demonstrate the framework and toolbox's capabilities in three use cases addressing exemplary innovations and education of students and the broader community via the Impact Monitor Academy.

These three case studies will be related to different streams among European R&I categories: Aircraft technologies and concepts, operations, policies, and regulations. The expectation is therefore to highlight the possibility to connect smoothly the aircraft level, the airport level, and the whole air transport system through various relevant metrics. In this respect, the flexibility of the framework will be key and such examples are expected to illustrate how versatile it could be for enabling the assessment of both technologies and regulations.

G.A. 101097011

2,2M BUDGET	24 MONTHS DURATION
HORIZON EUROPE	IMPACT MONITOR.EU

ACACIA

Advancing the Science for Aviation and ClimAte

ACACIA is focusing on advancing knowledge on the non-CO2 effects of aviation on climate, comprising contrail cirrus, nitrogen oxides, and aerosol indirect effects. The ACACIA project aims at improving scientific understanding of those climate effects that have the largest uncertainty.

Putting all aviation effects on a common scale will allow for providing an updated climate impact assessment. ACACIA aims at a breakthrough in the understanding and quantification of the overall impact of aviation aerosol on both ice and liquid clouds. This is achieved by assessing newly available modeling capabilities across scales, from the aircraft plume and cloud-resolving to the global scale. ACACIA takes advantage of high-quality observational data from aircraft in-situ measurements, remote sensing, and dedicated laboratory experiments. Here, climatological results from long-term observations are combined with data from field campaigns for the design of proof-of-concept studies for aviation climate impact mitigation. Eventually, concepts for new observing systems and strategies are formulated with the goal to constrain numerical models and theories with data. When dealing with prevailing uncertainties of climate effects, a systematic and mathematically formulated concept allows us to treat them in a transparent way, such that trade-offs between different mitigation strategies can be evaluated explicitly.

Finally, the project strives for the knowledge basis necessary to allow strategic guidance for future implementation of mitigation options, that is, to give robust recommendations of no-regret strategies for achieving reduced climate effects from aviation. Due to a better understanding of aviation's non-CO_2 climate effects, the project delivers the necessary input for eco-efficient planning of flight trajectories, which will allow a substantial reduction of aviation-induced climate change at the same transport capacity. Additionally, ACACIA explores mechanisms for how international aviation can align with the temperature goal as well as the greenhouse gas balance goal of the Paris Agreement.

G.A. 875036

2,9M

BUDGET

42

MONTHS DURATION

HORIZON 2020 | SOCIETAL CHALLENGES

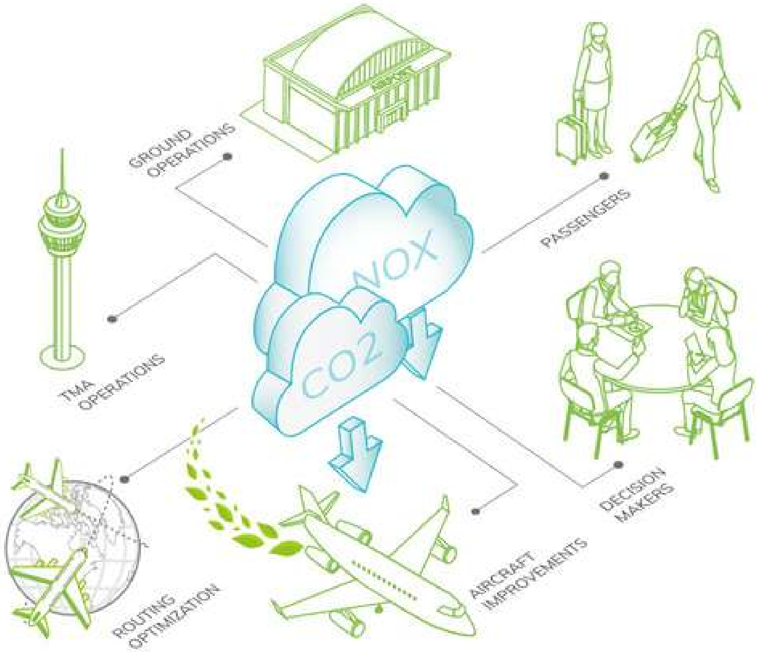
ACACIA-PROJECT.EU

Climate Assessment of Innovative Mitigation Strategies towards Operational improvements in Aviation

ClimOP aims at investigating the aspects of aviation operations that can be innovated to reduce the climate impact of the aeronautic industry. With its results, ClimOP aims to contribute to the FlightPath 2050 goals of reducing CO_2 emissions by 75% and NOx emissions. To ease the fulfillment of the main goal, ClimOP activities have been grouped into 5 sub-tasks:

1. Select operational improvements to reduce the climate impact of aviation;
2. Assess the climate impact produced by the selected operational improvements;
3. Evaluate the impact of the operational improvements on aviation stakeholders;
4. Determine harmonized "mitigation strategies", defined as the combination of a set of compatible operational improvements and the regulations and policies which can support the implementation of these improvements accounting for the impact on the level playing field.
5. Produce policy recommendations to foster the application of mitigation strategies.

ClimOP identified eight Operational Improvements that would sensibly reduce aviation's share of emissions if implemented. These Operational Improvements encompass all aspects of aviation, from ground operations and infrastructure improvement to inflight operations and ATM. Furthermore, the Operational Improvements have been designed not only taking into consideration their climate impact but also the impact they would have on stakeholders when implemented. Three mitigation strategies have been identified that can potentially foster the relevant stakeholders to implement these measures. ClimOP consulted Airlines, ANSPs, Airports, Original Equipment Manufacturers, and passenger associations, to produce results feasible for their necessities and consistent with the purpose of reducing the climate impact of aviation.



G.A. 875503

3M BUDGET	42 MONTHS DURATION
HORIZON 2020	CLIMOP-H2020.EU

BeCoM

Better Contrail Mitigation

At the heart of BeCoM stands the enhancement of the physical representation of ice clouds and the treatment of ice supersaturated regions (ISSRs), which improves the prediction of persistent contrails, hence allowing the integration of contrail schemes in the existing policy framework to enable eco-efficient trajectories.

Aviation contributes to about 5% of the total anthropogenic climate change when including non-CO2 effects, e.g., contrail formation and the impact of NOx emissions on ozone and methane. Among various non-CO2 effects, the contrail-cirrus radiative forcing is the largest (~2/3) with large uncertainties. The most critical affecting factor is the huge weather-induced variability of the radiative impact of individual contrails. This is the quantity that, BeCoM will predict better since the knowledge of the individual radiative forcing is the basis for avoidance of just those contrails that contribute most to the overall climate impact. Once this is standard, it will be possible to formulate adequate mitigation measures and develop policy-driven implementation schemes.

BeCoM will address the uncertainties related to the forecasting of persistent contrails and their weather-dependent individual radiative effects. BeCoM focuses on 1) obtaining a larger and higher resolution database of relative humidity and ice supersaturation at cruise levels for assimilation into numerical weather prediction (NWP) models; 2) providing a more adequate representation of ice clouds in their supersaturated environment in the NWP models; and 3) validation of the predictions to determine and reduce the remaining uncertainties of contrail forecasts.

To facilitate the assimilation and validation process, BeCoM will develop a novel hybrid artificial intelligence algorithm. Based on the contrail prediction, BeCoM will develop a policy framework for effective contrail avoidance through a trajectory optimization approach. BeCoM will enable a better understanding of contrail's climate impact and formulate recommendations on how to implement strategies to enable air traffic management to reduce aviation's climate impact. The BeCoM consortium builds on its knowledge and expertise covering a wide spectrum from atmospheric science and climate research to aviation operations research and policy development.

G.A. 101056885

4,4M BUDGET	48 MONTHS DURATION
HORIZON 2020	BECOM-PROJECT.EU

AVIATOR

Horizon 2020
European Union Func
For Research & Inova

Assessing aViation emission Impact on local Air quality at airports: TOwards Regulation

AVIATOR adopts a multi-level measurement, modeling, and assessment approach to develop an improved description and quantification of the relevant aircraft engine emissions, and their impact on air quality under different climatic conditions.

For this purpose, engine particulate and gaseous emissions in a test cell and on-wing from an in-service aircraft have been measured to determine pollutant plume evolution from the engine exhaust. This provides an enhanced understanding of primary emitted pollutants, specifically the nvPM and vPM (down to 10nm), and the scalability between the regulatory test cell and real environments. On the other hand, AVIATOR has developed and deployed across multiple airports, a proof-of-concept low-cost sensor network for the monitoring of UFP, PM, and gaseous species such as NOx and SOx. Transport and impact of emissions from aircraft engines and APU have been monitored in this more complex environment through high fidelity and sensor measurements. Campaigns were complemented by high-fidelity modeling of aircraft exhaust dynamics, and microphysical and chemical processes within the plume.

CFD, box, and airport air quality models have been applied, providing validated parameterizations of the relevant processes, applicable to standard dispersion modeling on the local scale. Working with the regulatory community, AVIATOR is developing improved guidance on measuring and modeling the impact of aircraft emissions with specific reference to UFP. Acknowledging the uncertainty surrounding the health impacts of UFP, AVIATOR is working with the public health community to develop methodologies for the representative sampling of aircraft emissions. Finally, AVIATOR will provide airports and regulators with tools and guidance to improve the assessment of air quality in and around airports.

G.A. 814801

6,3M
BUDGET

36
MONTHS DURATION

HORIZON 2020

AVIATOR PROJECT.EU

NEEDED

Next generation data-driven reference European models and methods

NEEDED aims at, delivering the next-generation data-driven reference European models and methods to estimate present and future aircraft emissions (pollutants and noise), achieving TRL 4 at the end of the project. NEEDED will advance the state of the art by:

1. Improving the accuracy of the reconstruction of aircraft operations by using real-world ADS-B data.
2. Advancing emission inventories for current and future aircraft technologies, while delivering more accurate pollution dispersion models.
3. Extending the applicability of the ECAC Doc 29 noise model to future aircraft technologies.
4. Performing more accurate estimation of the number of people affected by local air transport operations by using dynamic population maps.

These activities are complemented by (I) local air quality (LAQ) and experimental noise measurements performed at Rotterdam Airport, (II) validation of the NEEDED toolchain in a 30-week pilot study involving three airports, and (III) delivery of a methodology to optimise the flight patterns for minimum detrimental impact on the population in present and future scenarios. The project aims to function as a technology enabler, laying the methodological groundwork for facilitating the entry into the service of transformative aircraft technologies while capitalising on the potential of ADS-B data. NEEDED ensures its impact on the next generation of Air Traffic Management (ATM) regulation and policies through the direct involvement of EUROCONTROL.

G.A. 101095754

4,4M
BUDGET

48
MONTHS DURATION

HORIZON EUROPE

NEEDED-PROJECT.EU

ANIMA

Aviation Noise Impact Management through Novel Approaches

ANIMA aimed at developing new methodologies, approaches, and tools to manage and mitigate the impact of aviation noise, enhancing the capability of the aviation sector to respond to the growing traffic demand.

ANIMA was not a technology-driven project but examined how noise affects people, and how airports enforce regulations and empower neighboring communities in the prospect of reaching a consensus with all airport end-users and stakeholders.

The project developed in several directions: assessing the way noise regulations are practically implemented by airports and how the latest related scientific findings are taken into account; refining the very concept of annoyance, especially in its relation with non-acoustical factors; providing tools that allow assessing some annoyance indicators in connection with the flight traffic around airports. These outcomes eventually materialized in a Best Practice Portal allowing authorities and airports to understand and implement tailored measures to engage their communities and to lower their annoyance with regard to their specific local situation. It also provided them with a versatile Noise Management Toolset with can be used to forecast the impact of traffic changes on noise impact but also on the annoyance of neighboring communities.

Therefore, ANIMA partakes in the International Civil Aviation Organisation's (ICAO) objectives in terms of Community Engagement for aviation environmental management. These efforts complement the traditional ICAO's balanced approach based on the Reduction of Noise at Source (Technology Standards), Land-use Planning and Management, Noise Abatement Operational Procedures, and Operating Restrictions.
Besides, another important role of ANIMA was to maintain and enrich the European Research Roadmap for Aviation Noise. Such a role led ANIMA to coordinate a wide network of European experts and to screen related European and national projects. This overarching role has been taken over and extended by PULSAR for noise and emissions.

G.A. 7696271

7,6M

BUDGET

48

MONTHS DURATION

HORIZON 2020

ANIMA-PROJECT.EU

ARTEM

Aircraft noise Reduction Technologies and related Environmental iMpact

Horizon2020-project "ARTEM" explored novel technologies and developed methods for the reduction of emitted noise for the aircraft of the future.

Started in December 2017, the project was set up in order to help close the gap between noise reductions obtained by current technologies - as already applied or being matured in large EC technology projects such as OpenAir and CleanSky - and the long-term goals of ACARE, i.e. a noise reduction of 65% for each aircraft operation in the year 2050 compared to the reference year 2000 value.

Therefore, ARTEM took up innovative ideas and concepts for efficient noise reduction by novel liner concepts and investigated the potential of noise shielding, dissipative surfaces, and meta-materials. The interaction of all relevant aircraft components of future aircraft is expected to contribute significantly to the overall noise footprint due to novel configurations (e.g. blended wing body) and the close integration of the propulsion system. These effects were assessed using analytical tools, low- and high-fidelity numerical simulations, and dedicated experiments — aiming at low-noise design solutions and improvements of tools and optimization strategies.

readiness level (TRL) of 3 to 4. A final assessment has been obtained by comparative testing, benchmark activities, and benefits analysis for the most-promising technologies on industry-based technology evaluators.

Several open-access scientific publications and pre-competitive exchanges amongst the 24 partners including also non-EU-countries have strengthened the European research for sustainable aviation. By close ties to EC-funded project AERIALIST, the latest meta-materials results could be included in the exploitation phase while ARTEM-generated results and configurations are further considered and explored within EC-funded projects ANIMA, INVENTOR, ENODISE, and others.

G.A. 769350

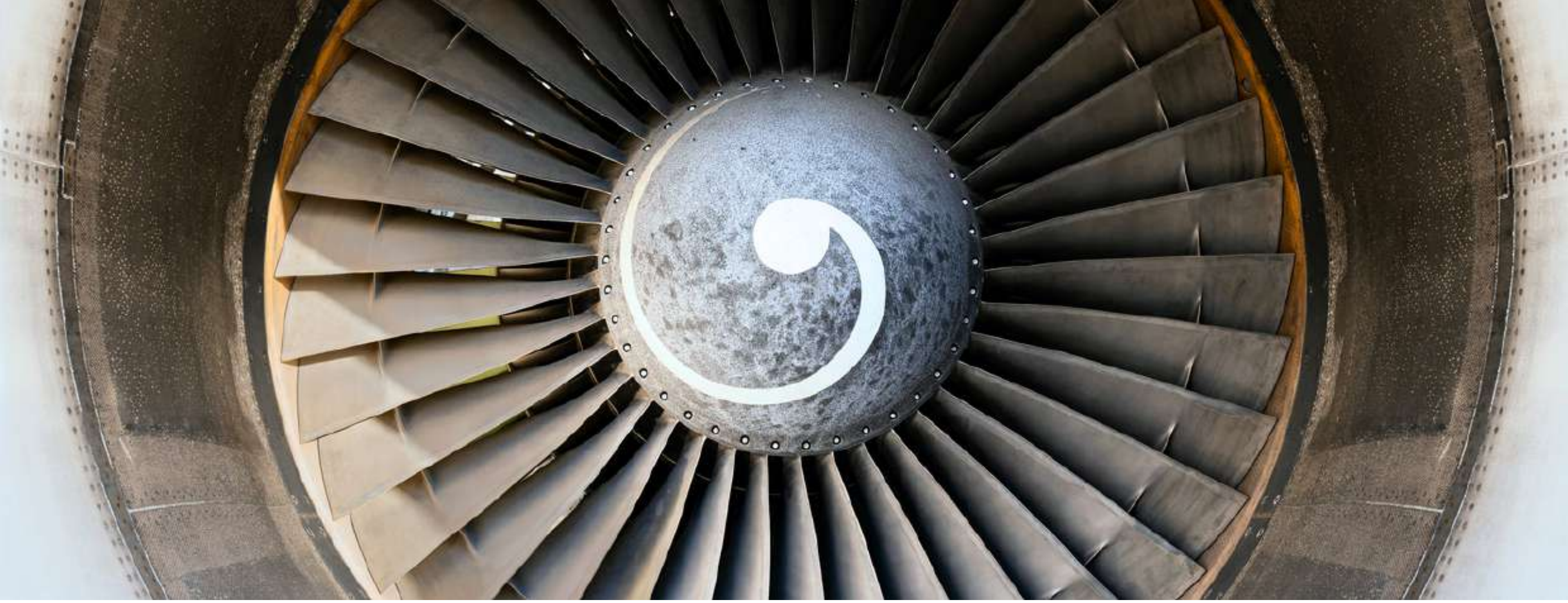
7,9M BUDGET	**54** MONTHS DURATION
HORIZON 2020 | RIA	DLR.DE/ARTEM

Open Fan Validation for Carbon-free Aircrafts

Open fan has high propulsive efficiency combined with the elimination of the nacelle drag and weight which has been always appealing to replace high by-pass ratio ducted fans and reduce CO2 and NOx emissions.

The Clean Sky 1 (CS1) and Clean Sky 2 (CS2) programs have made relevant efforts to pursue the contra-rotating open rotor (CROR) concept as well. Though CROR has not made it to market, progress has been done reducing noise levels to that of ducted fans.

Turbomachinery simulations have been perfected for decades and are essential to close the gap between the concept and the detailed implementation of the product. However, open rotors exacerbate existing problems (e.g. blade-to-blade variations even for small angles of attack, strong coupling between CO2 and noise emissions, etc.). Moreover, open fans lack publicly available data or test cases preventing researchers from validating their ideas.



The first global assessment of CS2 reported an expected noise reduction of -9dB in the innovative TP 130 pax project with respect to the last generation of ducted fans though at a lower flight Mach number. This project aims to obtain relevant noise and performance experimental data of an unducted single fan (USF) for short/medium-range aircraft with two objectives. Firstly, confirm that about 5-10 dB noise reduction is achievable at the expense of a slight penalty in fan efficiency, and secondly, validate and expand the scope of numerical tools. An experimental database with the key results of the projects will be built to unlock the application of the USF for SAF, Hydrogen, and Hybrid-electric engine and aircraft configurations.

G.A. 101096156

4,2M BUDGET	48 MONTHS DURATION
RIA	N/A

ENABLE·H2

ENABLing cryogEnic Hydrogen based CO2 free air transport

ENABLEH2 provided thought leadership through revitalising enthusiasm in liquid hydrogen (LH2) research to exploit the fuel's unique environmental benefits for civil aviation.

This was achieved by maturing key technologies to achieve zero mission-level CO2 and ultra-low NOx emissions, demonstrating safety and long-term sustainability that won't be possible with Jet A-1, LNG, or Sustainable Aviation Fuel.

Jet A-1 has relatively narrow combustion flammability limits which present several challenges for low-NOx combustion. Hydrogen's wider flammability limits enable leaner combustion with lower flame temperatures. The high molecular diffusivity and flame speed also offer good mixing and reduced residence times, so significant reductions in NOx are possible. Micromix combustion provides rapid fuel and air mixing without the risks of auto-ignition and flashback from premixing. The project has advanced ultra-low-NOx hydrogen micromix combustion technology through numerical and experimental research on injector arrays and combustor segments and altitude-relight studies.

ENABLEH2 investigated LH2 fuel tanks, fuel system design and integration, and more efficient disruptive propulsion technologies enabled by the heat-sink potential of LH2. It also matured technologies for compressor-integrated cooling, intercooler, and turbine rear structure integrated cooling, using heat exchangers to preheat the hydrogen. Models were also developed to evaluate energy efficiency, emissions, life-cycle CO2, and operating costs for LH2-fuelled aircraft.

The benefits and economic viability of LH2 were quantified relative to best-case scenario projections for Jet A-1, biofuels, and LNG.

ENABLEH2 has generated best-practice safety guidelines for LH2 at aircraft, airport, and operational levels, and delivered comprehensive roadmaps for introducing LH2.

To maximise the technical rigour and impact of the project, ENABLEH2 developed an active Industry Advisory Board comprising key civil aviation stakeholders: Abengoa, ACI, Airbus, Air Liquide, ATI (FlyZero), Clean Aviation, Dassault Aviation, EASA, easyJet, Gexcon, IAG, HyEnergy, IATA, ICAO, IMI, Infosys, Lufthansa Technik, MHPS, MOOG, MTU, Reaction Engines, Rolls-Royce, Siemens, and Total.

3,9M

BUDGET

51

MONTHS DURATION

HORIZON 2020

ENABLEH2.EU

G.A. 769241

Holistic dEmand response Services for European residenTIAl communities

To reduce climate impact of aviation, decarbonisation is a major challenge. Current combustion chambers are burning hydrocarbon fuels,such as kerosene or, more recently, emerging SAF products.

Hydrogen is also considered today as a promising energy carrier but the burning of hydrogen creates radically new challenges which need to be understood and anticipated. HESTIA specifically focuses on increasing the scientific knowledge of the hydrogen-air combustion of future hydrogen fuelled aero-engines. The related physical phenomena will be evaluated through the execution of fundamental experiments. This experimental work will be closely coupled to numerical activities which will adapt or develop models and progressively increase their maturity so that they can be integrated into industrial CFD codes.

Different challenges are to be addressed in HESTIA project in a wide range of topics:

- Improvement of the scientific understanding of hydrogen-air turbulent combustion: preferential diffusion of hydrogen, modification of turbulent burning velocity, thermoacoustics, NOx emissions, adaptation of optical diagnostics;

- Assessment of innovative injection systems for H2 optimized combustion chamber: flashback risk, lean-blow out, stability, NOx emission minimisation, ignition;

- Improvement of CFD tools and methodologies for numerical modeling of H2 combustion in both academic and industrial configurations.

To this end, HESTIA gathers 17 universities and research centres as well as the 6 European aero-engine manufacturers to significantly prepare in a coherent and robust manner for the future development of environmentally friendly combustion chambers.

G.A. 101056865

5M

BUDGET

48

MONTHS DURATION

HORIZON EUROPE

HESTIA-PROJECT.EU

Environmentally Friendly Aviation for All Classes of Aircrafts

EFACA project intends to promote an aviation sector more climate and environmentally-friendly with the development of new technologies by using electric and hybrid thermoelectric propulsions and new sustainable fuels to replace fossil fuels.

The EFACA project includes three experimental demonstrations:

1. A gearbox combining a gas turbine with electric motor for hybrid propulsion systems;
2. Phase cooling system for hydrogen fuel cells to reduce thermal losses, increase efficiency and enlarge altitude operating range relative to liquid cooling;
3. A complete laboratory liquid hydrogen fuel system including cryogenic tank and fuel lines and vaporization and combustion.

Emissions and noise are considered, comparing current levels with environmental targets to identify greening technologies to close the gap.

In addition to the CO_2 objectives, non-CO_2 emissions (water vapour, nitrogen oxides, sulfur oxides, aerosols and particles, contrails, and contrail cirrus) are also considered in this project, as well as the noise disturbance of near airport communities.

The greening technologies include battery power for small short-range aircraft and synthetic aviation fuels for large long-range airlines. All these activities contribute to a road map for the greening of aviation, indicating for each class of aircraft, the most suitable technologies and likely maturation time scales.

G.A. 101056866

3,8M

BUDGET

48

MONTHS DURATION

HORIZON EUROPE

EFACA.EU

JETSCREEN

JET Fuel SCREENing and Optimazation

The purpose of JETSCREEN was to provide fuel producers, airframers, and aero-engine and fuel system OEMs with knowledge-based screening tools.

The goals of these tools were to:

- Streamline the alternative aviation fuel approval process.
- Assess the compatibility of fuel composition/properties with respect to the fuel system and the combustion system,
- Quantify the added value of alternative fuels.
- Optimize fuel formulation in order to attain the full environmental potential of synthetic and conventional fuels.

The objectives of JETSCREEN were to develop a screening and optimization platform/framework incorporating the distributed design tools and generic experiments to quantify the risks and benefits of alternative fuels, assess their compatibility with relevant aircraft sub-systems, optimize alternative and conventional fuels for maximum energy per kilogram of fuel, and a reduction of pollutants emissions.

Additionally, JETSCREEN aimed to develop advanced and reliable design tools capturing accurately fuel-related effects on airframe and aero-engine, delivered with low-cost small-scale experimental, and model-based testing to predict the impact of fuel on selected engine and fuel system components.

G.A. 7235251

7,4M BUDGET	**41** MONTHS DURATION
HORIZON 2020 | RIA	N/A

TAKE-OFF

Sustainable aviation fuel from CO_2

The TAKE-OFF project, funded by the Horizon 2020 EU program, will explore the development of a unique technology based on the conversion of CO2 and renewable hydrogen to dimethyl ether (DME) and light olefins, as part of the chain of going to SAF, from TRL 3 to TRL 5 and from TRL 3 to TRL 4 respectively.

This technology route aims to deliver a highly innovative process that produces SAF at lower costs and higher energy efficiency compared to other power-to-liquid alternatives currently available. The TAKE-OFF route consists of capturing CO2 from industrial flue gas or Direct Air Capture which reacts with hydrogen produced by renewable electricity to create light olefins. These light olefins are subsequently chemically upgraded into SAF. All innovative steps in upgrading CO2 will be demonstrated under industrially relevant conditions.

SAF produced through the TAKE-OFF technology could significantly support the aviation industry in reducing its carbon footprint and replace the utilisation of crude jet fuel products while proving: a 25% increase in carbon and hydrogen efficiency compared to other PtL alternatives; 100% reduction of sulfur compared to fossil aviation fuel; 20% reduction of total emissions compared to other PtL alternatives; 36% decrease of SAF production costs compared to other PtL alternatives.

The project will also quantify the economic and environmental performance of SAF produced from CO_2 and renewable H_2 via the light olefins route and competing production routes including:

- Economic evaluation and identified opportunities for the reduction of fuel costs.
- Environmental assessment and identify opportunities for the reduction of environmental impacts of jet fuel.
- Optimisation of the production of the SAF of the future by using cost and environmental performance data.

The achievement of the project objectives will contribute directly to the UN Sustainable Development Goals, European Green Deal, and the Renewable Energy Directive II.

G.A. 1010067991

5,3M
BUDGET

48
MONTHS DURATION

HORIZON 2020

TAKEOFF-PROJECT.EU

EASIER

Electric Aircraft System Integration Enabler

EASIER brings together leading research and industrial organisations in Europe and the US to demonstrate innovative concepts for ElectroMagnetic Interference (EMI) solutions and thermal management as key enabling technologies for hybrid/electric aircraft configurations

The challenges presented by aircraft electric propulsion require the development of new airborne technologies that enable expanding the electrification technology trend already impacting other areas, like ground transportation or the autonomous generation/usage of electricity from renewables, to efficient and economical air transportation. Those intended technologies must be capable of producing a highly efficient, lightweight, and compact aircraft electrical system that can supply the electric power for propulsion as well as for other aircraft uses while keeping electromagnetic emissions under safe limits compatible with airborne equipment operation and human safety. In addition, they shall control the heat up of the system by enhanced thermal dissipation through a proper thermal management system.

With this aim, the EASIER project will bring together a multidisciplinary team in order to achieve the following objectives:

- Investigating EMI filtering solutions with less volume and weight.
- Investigating Electrical Wiring Interconnection System (EWIS) technologies with less radiated EMI, less volume, and lower weight.
- Improved heat transfer from electrical systems to the aircraft exterior.
- Optimization of the integration of electrical systems with significant mutual impact.
- Engagement with airframers and regulatory agencies.
- System trade-off analysis, technology identification, and road mapping.

G.A. 875504

3,5M

BUDGET

36

MONTHS DURATION

HORIZON 2020

EASIER-H2020.EU

HELENA

Halide solid state batteries for ELectric vEhicles aNd Aircrafts

To support the upcoming short-term needs of the battery industry, it is imperative to have new differentiating European battery technology for 4b generation batteries on the market from 2025.

HELENA responds to the need for the development of safe, novel high energy efficient, and power density solid-state battery (4b generation batteries) cells, based on high capacity Ni-rich cathode (NMC), high-energy Li metal (LiM) anode and Li-ion superionic halide solid electrolyte for application in electric vehicles and, especially in aircraft. HELENA will support Europe, in this sense, on its transition towards a climate-neutral continent since electric aviation is poised to take off within the next five to 10 years, with innovations already being pursued in electric vehicle batteries. Moreover, HELENA will avoid dependence on Asia for battery production.

HELENA, coordinated by CIC energiGUNE (the research center for electrochemical and thermal energy storage, a strategic initiative of the Basque Government), is built by a multidisciplinary and highly research-experienced consortium that covers the whole battery value chain and proposes a disruptive halide-based solid-state cell technology with the overall aim to significantly increase the adoption of these batteries on aircraft and Electric Vehicles (EVs). The technical challenges that are presented by current conventional battery technology and the consumer needs will be overcome - especially the reduction in costs of battery devices, enabling scalable and safe cell manufacturing, increasing their capabilities for long-distance traveling and fast charging, ensuring a high safety of the battery.

G.A. 101069681

8,3M

BUDGET

48

MONTHS DURATION

HORIZON 2020

HELENA PROJECT.EU

MATISSE

Multifunctional structures with quasi-solid-state Li-ion battery cells and sensors

MATISSE delivers improved aircraft technologies in the area of multifunctional structures capable of storing electrical energy for hybrid electric aircraft applications.

This consists in integrating Li-ion cells into aeronautical composite structures, sharing the load-bearing function with the structure, and achieving an aircraft structural element capable of functioning as a battery module.

To do so, MATISSE will:

- Advanced Li-ion battery cell technology, in a non-conventional formulation suitable for bearing structural loads: NMC811 (cathode), Si/C (anode), and bicontinuous polymer-ionic quasi-solid-state electrolyte (BCE), i.e. NMC811|BCE|Si/C, achieving 170-270 Wh/kg at the cell level.
- Enable the functional integration of Li-ion cells into solid laminate and sandwich composite structures.
- Make the structural battery smart, by equipping it with on-cell and in-structure sensors, connected to a chip-based CMU (Cell Monitoring Unit) and PLC (Power Line Communication).

MATISSE delivers a multifunctional structure demonstrator capable of power delivery, power management, and safety monitoring. This consists of a full-scale wing tip (1.42 m × 0.69 m) for use in place of the current wingtip assembly installed on Pipistrel Velis Electro, embedding a module of 40 battery cells at 72 VDC. This will undergo a comprehensive testing and characterisation campaign, qualifying the technology at TRL 4 at the end of the project (2025). MATISSE will also encompass aspects related to flight certification, life-cycle sustainability, and virtual scale-up, paving the way towards the application of structural batteries as an improved performance key enabling technology for next-generation commuter and regional hybrid-electric aircraft applications.

G.A. 101056674

3,4M BUDGET	36 MONTHS DURATION
HORIZON EUROPE	MATISSE - PROJECT.EU

Electric Propulsion

IMOTHEP

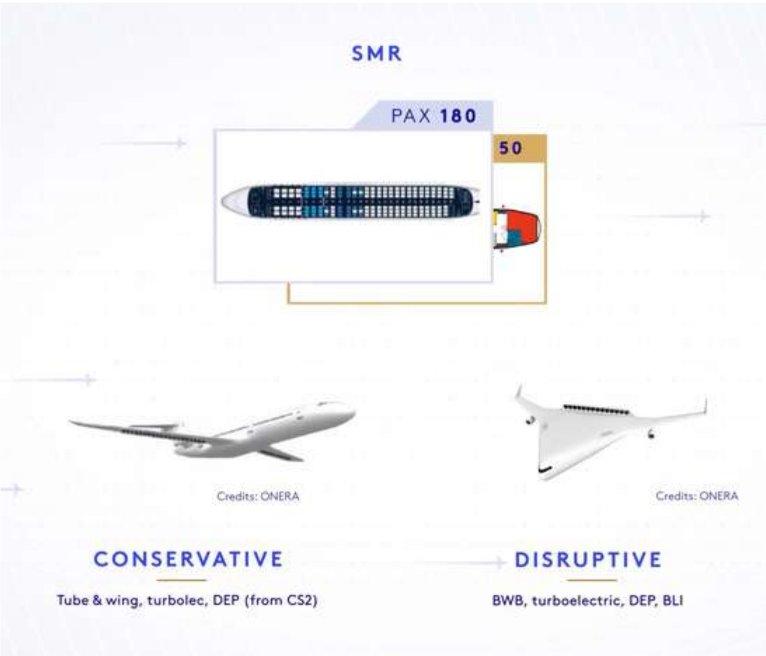
GETTING HYBRID ELECTRIC

Investigation and Maturation of Technologies for Hybrid Electric Propulsion

Commercial aviation is seeking new technologies to meet the goal of carbon-neutral growth. Accordingly, the top-level objective of IMOTHEP is to achieve a key step in assessing the potential offered by hybrid electric propulsion (HEP) and, ultimately, to build the correspondingng aviation sector-wide roadmap for the maturation of the technology.

The four-year project relies on R&D institutes, 11 industries (from aviation and electric systems), a service SME, and 7 universities from 9 EU countries.
The core of IMOTHEP is an integrated end-to-end investigation of hybrid-electric power trains for commercial aircraft, performed in close connection with the propulsion system and aircraft architecture. Aircraft configurations are selected based on their potential for fuel burn reduction and their representativeness of a variety of credible concepts, with a focus on regional and short-to-medium range missions. From the preliminary design of the aircraft, target specifications are defined for the architecture and components of the hybrid propulsion chain. Technological solutions and associated models are then investigated with a twenty-year timeframe perspective. In order to identify key technological enablers and technology gaps, the integrated performance of the electric components and power chain will be synthesized by assessing the fuel burn of the selected aircraft configurations, compared to conventional technologies extrapolated to 2035. The project will also address the infrastructures and tools required for HEP development, as well as the need for technology demonstrations or regulatory evolutions.

Eventually, all these elements will feed the research and technology roadmap of HEP, which will constitute the final synthesis of the project. In this respect, IMOTHEP builds on a strong team, associating major actors of aviation R&T in Europe, and proposes an ambitious program and a holistic approach to HEP, resulting in a sector-wide roadmap. In agreement with European Commission's policy to develop international cooperation with certain partner countries on low TRL research for future aircraft propulsion, IMOTHEP also involves international partners from Canada. This cooperation allows for increasing significantly the research effort and shares parts of the development roadmap beyond Europe. It also allows for increasing the environmental, economic, and societal impact of the intended HEP application in commercial aviation.



18M
BUDGET

48
MONTHS DURATION

HORIZON 2020 | SOCIETAL CHALLENGES

IMOTHEP - PROJECT.EU

G.A. 875006

The overall objective of MAHEPA was to bridge the gap between the research and product stage of a low-emission propulsion technology to meet the environmental goals for aviation towards the year 2050.

Two variants of low emission, high efficiency, serial-hybrid-electric propulsion architecture were advanced to TRL 6: the first used a hydrocarbon-fuelled internal combustion engine and an electric generator as the primary power source, while in the second a hydrogen fuel cell was used to produce power showcasing the flexibility of the architecture. Common to both variants is the power control module, used to implement advanced power management methods to optimize mission, range, and emissions of hybrid electric aircraft, and the new power electronic devices namely a highly efficient, airborne qualified electric propulsion motor and next-generation inverter technology.

This modular approach was further demonstrated by the integration and flight testing of each variant on a different small aircraft to showcase the flexibility and scalability of the powertrain.

A visionary implementation study towards commercial/transport category aircraft rounded up the project. The core value of MAHEPA was to build up technological know-how and use flight test data to validate the performance, efficiency, and emission reduction capabilities of the above technologies. This allows to make conclusions about the suitability of these solutions for megawatt-scale hydrocarbon-driven hybrids and zero-emission hydrogen-powered solutions.
For small aircraft, this propulsion system development can be the door opener for a commercialized, new, low-emission, highly efficient airplane category.

G.A. 723368

8,9M

BUDGET

48

MONTHS DURATION

HORIZON 2020

MAHEPA.EU

ALIGHT

SUSTAINABLE AVIATION

A Lighthouse for the Introduction of Sustainable Aviation Solutions for the Future

ALIGHT is an EU Horizon2020 innovation partnership with the objective of showcasing the future of sustainable aviation.

In the project period from 2020-2024, ALIGHT will address the urgent global need to reduce greenhouse gas (GHG) and other air emissions in order to adapt to climate change and promote a sustainable future for all. This will be done with a focus on two separate workstreams) the supply, implementation, integration, and smart use of sustainable aviation fuel, and 2) the development and implementation of a smart energy system. ALIGHT will address the full value chain from system mapping and energy supply to passenger transport, as well as sustainable heating and cooling of airport buildings. The mission is to give best practice recommendations for fossil-free and energy-efficient aviation and airport operation, with the overall objective of paving the way for the green transition of European airports.

Led by Copenhagen Airport, the ALIGHT consortium consists of 17 partners who have jointly committed to address the challenges of creating a green transition in the aviation industry. Spread across 10 different European countries the ALIGHT partners range from European airports to technology providers and knowledge institutions. Most recently, AIRBUS joined the consortium in 2023 adding the unique expertise from the aircraft manufacturer side.

The composition of partners and the expertise each partner brings to the consortium is a prerequisite for creating sustainable and impactful change in the aviation sector. The committed ALIGHT partners are the following: CPH Airport (CPH), Aeroporti Di Roma (ADR), Vilnius Airport (LTOU), Centralny Port Komunikacyjny (CPK), Danish Technological Institute (DTI), Scandinavian Airlines System (SAS), Nordic Initiative for Sustainable Aviation (NISA), International Air Transport Association (IATA), Deutsches Zentrum Fuer Luft und Raumfahrt (DLR), Fuel Farm and Hydrant Operator (BKL), AIR BP Limited, RSB Roundtable om Sustainable Biomaterials Association (RSB), Hybrid Greentech (HG), BMGI Gindroz Bernard, University of Parma (UNIPR), Technical University of Hamburg (TUHH) and AIRBUS (A-CE).

G.A. 957824

15M
BUDGET

60
MONTHS DURATION

HORIZON 2020

ALIGHT-AVIATION.EU

OLGA
hOListic Green Airport

OLGA is an EU Green Deal project that aims to reduce the environmental impact of the aviation sector, based on a holistic approach.

It develops innovative and sustainable solutions to reduce airside and landside CO2 emissions, optimize energy efficiency, preserve biodiversity, and improve air quality and waste management while involving the entire aviation value chain. The project supports the European Union's (EU) carbon neutrality ambition and aims to improve quality of life. Focusing on boosting environmental performance at airports from flight operations, passenger and freight, and community perspectives, OLGA is uniquely positioned to showcase innovative sustainability measures and to prove scalability and EU-wide applicability.

Four international airports and their local stakeholders are involved in OLGA: Paris-Charles de Gaulle as project coordinator and lighthouse airport, together with Milan Malpensa, Zagreb, and Cluj as fellow airports. The project aims to demonstrate the impact of the innovative and sustainable solutions presented at the lighthouse airport and replicated at fellow airports.

The solutions are scalable and generic, laying the foundations for greener airports throughout Europe. The OLGA results will generate positive societal, environmental, and economic impacts that will spread to the local, national, and European levels. OLGA has a total budget of €34 million, with €25 million in funding from the European Commission over a period of 60 months. The consortium is formed of 41 partners and 17 third parties, involving large and small airports, airlines and the aviation industry, public authorities, researchers, and innovative start-ups.

34M BUDGET	60 MONTHS DURATION
HORIZON 2020	OLGA - PROJECT.EU

G.A. 101036871

Airports

SusTainable AiRports, the Green heArT of Europe

Stargate is an ambitious project selected by the European Commission to prove that a more sustainable aviation is possible. Together with a diverse consortium of 21 partners, Brussels Airport takes the lead in the development of innovative solutions to create the green airports and aviation of the Future.

The programme includes over 30 specific projects focusing on three objectives: enhancing decarbonisation, improving local living quality, and stimulating the modal shift. In the area of decarbonisation, an increasing focus will be on electric taxing, electric ground handling material, and ground handling material fuelled by hydrogen. For the production of energy, Stargate looks into how to increase the supply of renewable energy and investigates the possibilities to cooperate with neighbouring municipalities. This could involve, for example, an additional solar panel park, and there will also be a feasibility study for the construction of a bio-digester at the airport.

Regarding the local environmental quality, the focus will be on refining existing techniques and on innovation. This includes improving flight efficiency and green landings, a landing technique that ensures lower fuel consumption, lower emissions and less noise.

Finally, Stargate also aims at improving mobility at and around airports and stimulating alternatives to the car, by, for example, investigating and testing solutions for the luggage of passengers arriving by train and by optimising the accessibility of the train station. There will also be a focus on digitisation and ways of making mobility information more centralised and fully accessible for passengers.

The consortium includes airports, airlines, mobility and knowledge institutes as well as local authorities. Stargate received a 24,5 million euro grant within the European Green Deal to research and demonstrate solutions before the end of 2026.

33M

BUDGET

60

MONTHS DURATION

HORIZON 2020

GREENDEAL STARGATE.EU

G.A. 101037053

TULIPS

DemonsTrating lower polIUting soLutions for
sustaInable airPorts acrosS Europe

Airports will play a major role in transition towards climate-neutral aviation. Sustainable energy production and use (both airside and landside) as well as a shift towards greener multi-modal transport options will reduce greenhouse gas emissions (GHG) and improve local air quality around airports.

Bringing together a highly competent and complementary consortium of 29 partners supported by an external advisory board, the EU Green Deal project TULIPS will accelerate the implementation of innovative and sustainable technologies toward lower emissions at airports.

17 real-life demonstrations of green airport innovations (technological, non-technological, and social) will be performed at the Lighthouse Schiphol, and some also at fellow Oslo, Turin, and Larnaca airports. Measuring and quantifying benefits and forecasting their impact on EU climate goals should they be implemented extensively across European airports, resulting in hands-on robust roadmaps which present how these technologies and concepts should be deployed to different sized airports (international hubs down to regional level) with consideration to economic, geographical, and political scenarios across Europe and beyond.

Topics covered include:

- Improved multi-modal shift for passengers and freight, reduce traffic congestion and offer seamless green travel options.
- Improved airside infrastructure for future electric/hybrid aircraft infrastructure.
- Smart energy solutions to manage airport operations.
- Integrating hydrogen fuel cell technology into current ground support equipment.
- Enabling large-scale supply of sustainable aviation fuel (SAF) along with the preparation of an EU clearing house.
- Circular economy.
- Ultrafine particle (UFP) mitigation.

G.A. 101036996

25M
BUDGET

48
MONTHS DURATION

HORIZON 2020

TULIPS-GREEN AIRPORTS.EU

National projects

Efforts in shifting towards greener aviation do not end at EU-funded projects. Additionally, many member states take part in this initiative by supporting national environmental aviation projects.

Certain countries, particularly those with a sizeable aircraft industry, make larger investments in such projects. However, other nations also devote resources to research; for example, operations that optimize air traffic management around airports or the health impact of aviation.

Along with European Union projects, these national projects are involving a broad research community encompassing leading European companies, SMEs, dedicated research organisations or agencies as well as academia. This unique ecosystem, the associated wealth of expertise, and key research infrastructures are presently supporting the European leadership in the aircraft industry and the European will to spearhead research to make aviation more sustainable.

As examples of these endeavours, the following pages of this document showcase various national projects that are funded in France, Germany, and the Netherlands.

Action
de recherche
sur **Aviation** et **Climat**

Climaviation

Climaviation is an ambitious research action to understand and quantify the climate impacts of aviation.

Funded over the period 2021-2026 by the French Civil Aviation Authority (DGAC), this scientific research project brings together some thirty researchers from the Institute Pierre-Simon Laplace (IPSL) — represented in particular by its stakeholders Sorbonne University and the French National Centre for Scientific Research (CNRS) — and from the French Aerospace Lab (ONERA).

Facing the climate emergency, the aviation sector is now committed to a strategy of accelerated decarbonisation on a global scale, which sets targets for reducing CO2 emissions by 2050. This strategy is based on intensifying efforts to improve the energy efficiency of aircraft and their operations, but also on the use of alternative fuels with a low carbon footprint, and even new decarbonised energy carriers such as hydrogen.
However, CO2 is not the only contributor to the overall climate impact of aviation. Aircraft engines also emit nitrogen oxides (NOx), water vapour, and particles into the upper atmosphere. Through complex physical and chemical processes, these compounds also generate disturbances in the earth's radiation balance, referred to as «non-CO2 effects».

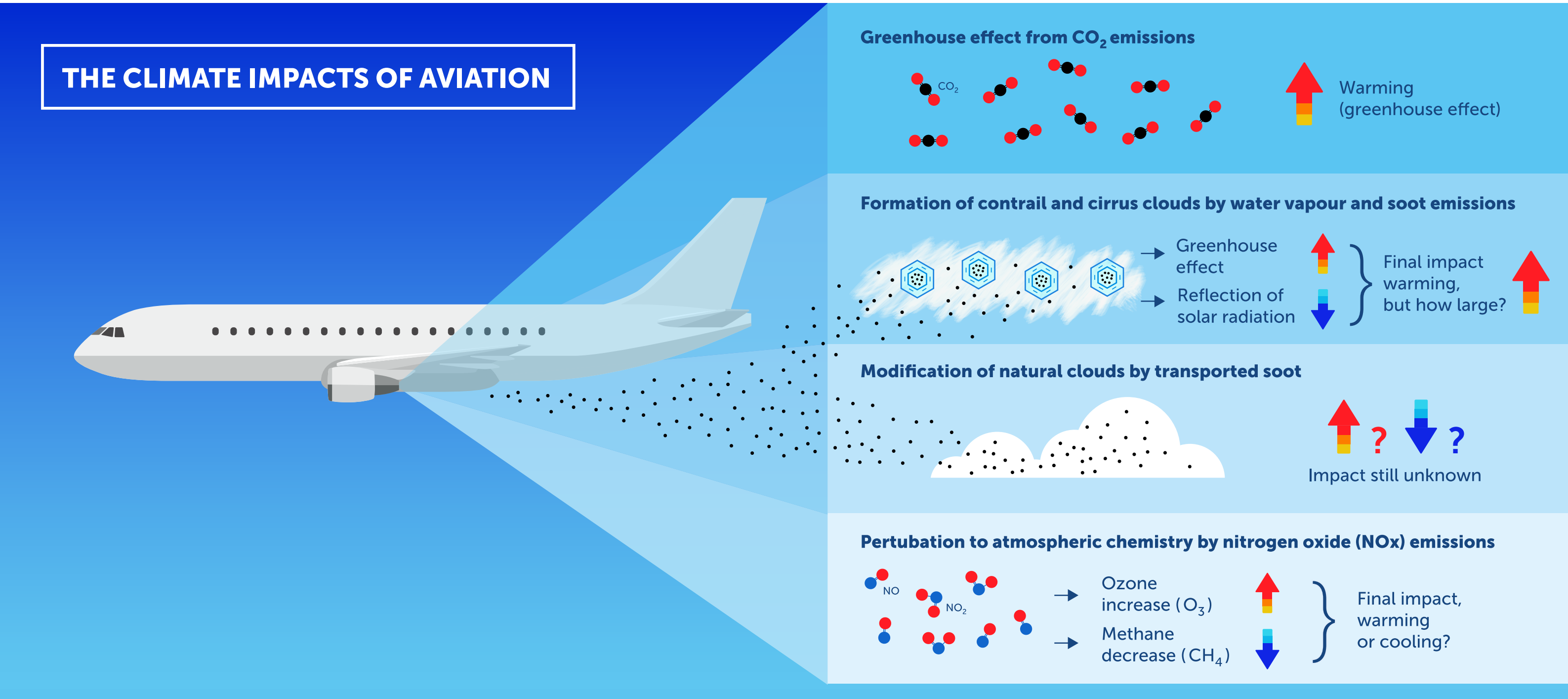
According to the most recent estimates, based on climate modeling, the impact of non-CO2 effects could be greater than that of CO2, at least in the short term, but the level of uncertainty in these estimates remains high due to the complexity of the mechanisms to be modeled and the many scales to represent in the simulations.

To minimise the total climate impact of aviation, it is therefore essential to better understand and quantify the non-CO2 effects in order to take them into account in the strategies to reduce this impact.

48

MONTHS DURATION

CLIM AVIATION.FR



“Luchtvaart in Transitie” (Aviation in Transition) is the Dutch research programme for sustainable aviation. Funded by the National Growth Fund, it brings together tens of organisations.

The group spans the entire Dutch aviation ecosystem, ranging from internationally renowned companies such as GKN Fokker and KLM to SMEs, and from universities and research institutes such as Delft University of Technology and Royal NLR to innovative start-ups.

The aim of the project is to structurally increase the earning capacity of the Dutch economy by making aviation more sustainable at an accelerated pace. To achieve this, Luchtvaart in Transitie aims to position the Netherlands as a sustainability pioneer in Europe, in order to gain a leading position in selected innovations and to be able to market the innovations internationally.

In terms of content, the project is focused on three key areas: sustainable aircraft technology, sustainable knowledge, and a sustainable ecosystem. The first, sustainable aircraft technology, includes two hydrogen-powered aircraft demonstrators and furthermore looks at materials, production technology, and structures. As part of the sustainable knowledge area, a Dutch Aviation Systems Analysis Lab (DASAL) is developed, creating a 'digital twin' of the aviation ecosystem. The third effort aims to strengthen the ecosystem through international cooperation and aims to bring forward the human capital agenda.

96

MONTHS DURATION

LUCHTVAARTINTRANSITIE.NL

Bundesministerium
für Wirtschaft
und Klimaschutz

The national civil aviation research programme (LuFo) of the Federal Ministry for Economic and Affairs and Climate Action (BMWK) will in the future give even more of a boost to climate-neutral aviation.

The latest call for applications for funding will prioritise R&D projects that contribute significantly to reducing aviation's impact on the environment.

In order to aid the process of transition in the aviation industry and further enhance the technological competitiveness of the German aviation industry, the support is based on three pillars:

1. Alternative climate-neutral propulsion systems.
2. Reduction of primary energy needs and resource consumption by cutting weight and improving the efficiency of propulsion systems, other systems, and aerodynamics.
3. Reduction of manufacturing times and costs primarily through closed material cycles.

The programme creates strong incentives to develop new climate technologies. For the first time, LuFo contains specific, ambitious targets against which new projects have to be judged. Moreover, the environmental and climate-related assessment criteria for the independent evaluation of the project outlines submitted will be further tightened.

N.A

MONTHS DURATION

BMWK.DE

National Projects

Bundesministerium für Wirtschaft und Klimaschutz

D-KULT

The joint project D-KULT aims at demonstrating the feasibility of eco-efficient flight trajectories considering the climate effect of non-CO2 aircraft emissions through extensive simulations and their possible application in operational use in European and especially German airspace.

D-KULT is a concerted German cooperation of meteorological services, science, air traffic control, and airlines funded over the period 2022-2025 by the German Federal Ministry of Economics and Climate Protection within the framework of the sixth civil aviation research program.

Global aviation impacts climate through CO2- and non-CO2 emissions. The climate effects of non-CO2 emissions include water vapor, NOx-induced changes in ozone and methane, contrails, and contrail cirrus. These non-CO2 effects depend strongly on the geographic location, altitude, time of emission, local sun position, and weather conditions. This dependency facilitates reducing the climate effect of air traffic through appropriate choice of flight routes and altitudes (climate-optimized flight trajectories). D-KULT investigates whether such climate-optimized flight trajectories can be implemented into operational tools and processes for flight trajectory planning. In particular, long-lived contrails are to be avoided by intervening in-flight guidance and extending current methods for flight trajectory planning to include climate optimization. Contributions of CO2 and non-CO2 effects to climate need to be available in suitable metrics to be incorporated into the flight planning system. A number of constraints, regulatory limitations, and capacities of airspace and airports need to be considered in terms of real-world application.

The main focus of D-KULT is to investigate whether climate-optimized flight trajectories can be implemented in practical operations and which methods and tools are required therefore. In particular, the following will be demonstrated and tested:

- Long-lived contrails are to be avoided by intervening in-flight guidance.
- Current methods for flight trajectory planning are to be extended to include climate optimization.

36

MONTHS DURATION

SIGRUN.
MATTHES
@DLR.DE

The Aeronautical Technological Program (PTA) is a multiannual programme included in the State Plan for Scientific and Technical Research and Innovation 2021-2023.

Its main objective is to finance intensive strategic initiatives focused on reducing the environmental impact of aeronautical technologies, increasing the efficiency of future aircraft, and reducing polluting emissions from air transport; without forgetting other strategic technological challenges such as systems, UAS, onboard systems, or intelligent and advanced manufacturing.

The PTA has allocated 190M€ in subsidies distributed over three years: 40M€ in 2021, 80M€ in 2022, and 70M€ in 2023, with the aim to mobilize more than 300M€ in R&D projects for the industry in the aeronautic sector.

The PTA is focused on four main challenges which are divided into several sub-challenges:

- Emissions reduction: zero-emission aircraft

Development of technologies-focused solutions in the medium-long term that provide a considerable or total reduction of polluting emissions from air traffic.

- UAs

Development of a technological base in the field of unmanned, intelligent aircraft and connected systems.

- Onboard Systems

Develop and implement systems that serve to maintain national capacities in the design, development, production, and certification of a complete aircraft.

- Smart and advanced manufacturing

Development of advanced manufacturing technologies with high added value.

36

MONTHS DURATION

PT_AERO@CDTI.ES

AIRPORT REGIONS COUNCIL

This brochure was produced within the framework of the EU-funded project PULSAR, with the support of the European Climate, Infrastructure and Environment Executive Agency (CINEA) and the other EU-funded projects mentioned in the publication. The editing, review, and design were done by the Airport Regions Council, PULSAR's communication partner. The Airport Regions Council (ARC) is the association of regional and local authorities with an airport situated within or near their territories. More information: www.airportregions.org.

PULSAR has received funding from the European Union's Horizon Europe Research and Innovation programme under grant agreement No 101095395. Views and opinions expressed are, however, those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting authority (CINEA) can be held responsible for them.