European Union Aviation Safety Agency

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AVIATION NON-CO_2 EXPERT NETWORK

NONCO2 RESEARCH PROJECT

Overview of historic and on-going work linked to the effects of aviation non-CO_2 emissions on climate change

Task 6 Report

October 2025

An Agency of the European Union

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For more information on non-CO_2 impacts of aviation and the ANCEN network, we invite you to visit https://www.easa.europa.eu/en/research-projects/ancen-nonco2.

Contents

1. Project context

The European Commission, under its Horizon Europe Cluster 5 work program on Climate, Energy, and Mobility, aims to accelerate the green and digital transition, and the associated transformation of the economy, industry, and society to achieve climate neutrality in Europe by 2050. As part of this initiative, a research action has been given to the European Union Aviation Safety Agency (EASA) to support the development, agreement, and implementation of effective policy responses to the climate impact of non-CO_2 emissions from the aviation sector. This includes a project aimed at establishing a non-CO_2 expert network to consolidate recent research project results, evaluate ongoing/planned projects and identify actions to address open issues and gaps, and propose technical guidance on future work to help move discussions forward, including enhanced impact assessment capabilities. This systematic consultation with a pool of experts will contribute further to non-CO_2 related decision-making in Europe as well as work at the international level.

2. Introduction

The impact of aviation on climate extends beyond carbon dioxide (CO_2) emissions, encompassing a variety of non-CO_2 factors such as nitrogen oxides (NOx), water vapour, particulate matter, and the formation of contrails and cirrus clouds. These factors collectively contribute to the atmospheric processes that affect the climate. This document aims to serve as a comprehensive resource, cataloguing both historic and ongoing efforts within Europe that address the broader climate impacts of aviation's non-CO_2 emissions. It provides a reference to help stakeholders navigate through the landscape of projects, research initiatives, and technological developments that aim to further understand and mitigate the non-CO_2 climate impacts.
This overview is designed to organize and present a wide array of initiatives, making it accessible for stakeholders within the Aviation Non-CO_2 Expert Network (ANCEN) and the broader community involved in climate impact research and regulation. The objectives are threefold:

- **Landscaping**: To map out the extensive body of work addressing the non-CO_2 climate impacts of aviation, including both past and current projects as well as policy measures.
- **Facilitating Collaboration**: To enhance collaborative efforts by connecting policymakers, researchers, industry stakeholders, and other relevant parties through a centralized resource that promotes shared understanding and joint initiatives.
- **Identifying Gaps**: To identify gaps in the existing research and policy measures, thereby directing future efforts towards areas where they are most needed and can be most effective.

This structured compilation provides direct access to detailed sources, documents, and further information that is intended to be updated on a regular basis. Any proposed additional input for this document should be sent to ancen@easa.europa.eu.

The report presents identified projects or research initiatives associated with the topics relevant to potential ANCEN working groups, including climate sciences, aircraft emissions, operational aspects, carbon market, economic impact, and fuel. Each topic can be defined as follows:

➡ **Table 2-1** Frequency and list of topics relevant to potential ANCEN working groups

Topic	*Sub-topic*	*Description*
1) Climate Sciences	**Modelling and process work**	Includes climate models, weather-dependent impact assessments, and understanding atmospheric processes.
	Research on Non-CO_2 effects	Studies on the impact of NOx, water vapor, particulates, contrails, and cirrus clouds on the climate.
	Impact assessments	Evaluating the overall climate impact of aviation, including both CO_2 and non-CO_2 emissions.
2) Aircraft Emissions	**Emission Measurement and Analysis**	Data collection and analysis of emissions from aircraft, including CO_2 and non-CO_2.
	Emission Reduction Technologies	Development and implementation of new technologies aimed at reducing aircraft emissions.
	Policy and Regulatory Frameworks	Policies aimed at controlling and reducing emissions from aviation.
3) Operational Aspects	**Flight Routing Optimization**	Strategies for optimizing flight paths to reduce fuel consumption and emissions, including climate-optimized routing.
	Air Traffic Management Improvements	Enhancements in air traffic management to minimize environmental impact.
	Operational Efficiencies	Measures to improve the efficiency of flight operations, such as optimizing flight altitudes and speeds.
4) Carbon Market	**Emissions Trading Systems (ETS)**	Integration of aviation emissions into carbon markets like the EU ETS and CORSIA.
	Market-Based Measures	Development and implementation of market-based measures to incentivize emission reductions.
	Economic Instruments	Use of taxes, fees, and subsidies to encourage lower emissions within the aviation sector.
5) Economic Impact	**Cost-Benefit Analysis**	Economic evaluations of different emission reduction strategies and technologies.
	Financial Implications	Impact of climate policies and regulations on the aviation industry's financial performance.
	Economic Incentives	Development of economic incentives to support the adoption of greener technologies and practices.
6) Fuel	**Sustainable Aviation Fuels (SAF)**	Research and development of alternative fuels that produce fewer emissions.
	Fuel Efficiency	Strategies and technologies to improve fuel efficiency in aircraft.
	Lifecycle Analysis	Assessment of the environmental impact of fuel production, distribution, and consumption.

ICAO maintains a similar tracker of non-CO_2 initiatives.

3. Overview of Projects and Research Initiatives

Table 3-1 Projects and research initiatives overview (indicated as historic "H" or ongoing "O"): *1) Climate Sciences ; 2) Aircraft emissions ; 3) Operational aspects ; 4) Carbon market ; 5) Economic impact; 6) Fuel*

Projects and Research Initiatives (starting date)		1	2	3	4	5	6
PACIFIC (2025) - Particle emissions, Air Quality and Climate Impact related to Fuel Composition and Engine Cycle	O	x	x				x
UNIC (2025) - Understanding Non-CO_2 Impact for deCarbonized aviation	O	x	x				x
A4CLIMATE (2025) - Advancing Aeronautics and Aerosol research to Accelerate Climate neutral aviation	O	x	x				x
PEACOCK (2024) - Predictable and Environmentally friendly operations of regional Airports with COnnectivity and Climate as Keyword	O	x					
COMPANION (2024) - COMmon Platform and Advanced INstrumentation ReadIness for ultra efficient propulsion demonstratiON	O		x				x
SAFice (2024) - The effect of transitioning to sustainable aviation fuels on contrails and climate	O	x	x				x
AEROSPACE TECHNOLOGY INSTITUTE (2024) – Non-CO_2 Programme	O	x	x	x	x		
CLAIM (2024) - Clean Aviation Support for Impact Monitoring	O	x		x			
STEPLESS (2024) - Stepless High-Lift Configurations for Optimised Aircraft Energy Management in the TMA	O			x			
F4ECLIM (2024) - Flying ATM for Environment Climate	O	x		x			
UPLIFT- CLIM0ART (2024) - inflight emission measurement campaign	O	x	x				x
ADVISAR (2023) - ADdressing feasibility studies towards cleaner aVIation and environmental impacts research with SAf on unRegulated engines	O		x				x
European body for jet fuel standards and safety certification (2023)	O						x
HOPE (2023) - Hydrogen Optimized multi-fuel Propulsion system for clean and silEnt aircraft	O	x	x				x
Faster-H2 (2023) - Fuselage, Rear Fuselage and Empannage with Cabin and Cargo Architecture Solution validation and Technologies for H2 integration	O		x				x
AEROPLANE (2023) – Advancing Measures to Reduce Aviation Impact on climate and enhance resilience to climate-change	O	X		x			
CICONIA (2023) – Climate effects reduced by Innovative Concept of Operations, Needs and Impacts Assessment	O	x		x			
REFMAP (2023) - Reducing Environmental Footprint through transformative Multi-scale Aviation Planning	O	x	x	x			
MEFKON (2023) - Measurement-Based Improvement of Humidity Forecasting for Contrail PreventionH2OPE (2023) - Hydrogen Optimized multi-fuel Propulsion system for clean and silEnt aircraft	O	x	x	x			
CONCERTO (2023) – dynamiC cOllaboratioN to generalize eCo-friEndly tRajecTOries	O		x	x			x
HYDEA (2023) - HYdrogen DEmonstrator for Aviation	O		x				x
PAREMPI (2023) - PARticle EMission Prevention and Impact	O	x	x			x	
SWITCH (2023) - Sustainable Water-Injecting Turbofan Comprising Hybrid-electrics	O		x				x

Projects and Research Initiatives (starting date)		1	2	3	4	5	6
E-CONTRAIL (2023) - Artificial Neural Networks for the Prediction of Contrails and Aviation Induced Cloudiness	O	x	x				
DYNMARS (2023) - Dynamic Management of Aircraft Configuration and Route Structures	O			x			
ECHOES (2023) - Extended Communications in vHf Over Enhanced Satellite segment	O			x			
GALAAD (2023) - Green Aviation – Lean Arrivals And Dynamicity	O			x			
GEESE (2023) - Gain Environmental Efficiency by Saving Energy	O			x			
GREENGEAR (2023) - Green operations with Geometric altitude, Advanced separation and Route charging Solutions	O			x			
ContrailNET (2023) – Sharing of data between contrail-related projects	O	x	x	x			
Blue Condor (2022)	O	x	x				x
BeCoM (2022) – Better Contrail Mitigation	O	x		x			
D-KULT (2022) - Demonstrator KLIMA- und Umweltfreundlicher Lufttransport demonstrator for climate and environmentally friendly air transport	O	x		x		x	
MINIMAL (2022) – Minimum environmental impact ultra-efficient cores for aircraft propulsion	O	x					x
STARGATE (2021) - SusTainable AiRports, the Green heArT of Europe	O			x	x	x	
CLIMAVIATION (2021) – Climate & Aviation	O	x					
MOREandLESS (2021) - MDO and REgulations for Low-boom and Environmentally Sustainable Supersonic aviation	H	x	x	x			x
SENECA (2021) - noiSe and EmissioNs of supErsoniC Aircraft	H	x	x	x			
ECLIF3 (2021) – Emission and Climate Impact of Alternative Fuels	O		x				x
MUAC (2021) – Contrails Avoidance project	H	x		x		x	
SAMPLE IV (2021) – Assessment of environmental impacts frameworks	H		x				x
LITECS (2020) - Laser Imaging of Turbine Engine Combustion Species	O		x				
ALIGHT (2020) - a Lighthouse for the introduction of sustainable aviation solutions for the future	O			x			x
ACACIA (2020) – Advancing the Science for Aviation and Climate	H	x					
ClimOP (2020) – Climate assessment of innovative mitigation strategies towards operational improvements in aviation	H	x		x			
CREATE (2020) – Climate and weather modEls to improve ATM resilience and reduce its impacts	H	x		x			
FlyATM4E (2020) – Flying Air Traffic Management for the benefit of environment and climate	H	x		x			
VOLCAN (2020) – VOL avec Carburants Alternatifs Nouveaux	O	x	x				x
ALTERNATE (2020) - Assessment on alternative aviation fuels development	H	x	x			x	x
ACCESSII (2019) – Alternative Fuel Effects on Contrails and Cruise Emissions	H	x	x				x
AVIATOR (2019) – Assessing aViation emission Impact on local Air quality at airports: Towards Regulation	H		x	x			x
GREAT (2019) - GREener Air Traffic operations	H	x	x	x			
GLOWOPT (2019) - Global-Warming-Optimized Aircraft Design	H	x	x	x			
RAPTOR (2018) – Research of Aviation PM Technologies, mOdelling and Regulation	H		x				x

Projects and Research Initiatives (starting date)		1	2	3	4	5	6
UNREAL (2019) - Unveiling nucleation mechanism in aircraft engine exhaust and its link with fuel composition	H		x				x
ND MAX/ECLIF 2 (2018) - Emission and Climate Impact of Alternative Fuels	H	x	x	x			x
JETSCREEN (2017) – JET Fuel SCREENing and Optimization	H		x				x
ATM4E (2016) – Air Traffic Management for Environment	H	x		x			
ECLIF I (2015) - Emission and Climate Impact of Alternative Fuels	H	x	x	x			x
FORUM-AE (2013) - FORUM on Aviation and Emissions	H	x	x	x	x		x
WeCare (2010)	H	x		x			
TEAM_PLAY (2010) - Tool Suite for Environmental and Economic Aviation Modelling for Policy Analysis)	H	x	x	x		x	
REACT4C (2010) – Reducing emissions from aviation by changing trajectories for the benefit of climate	H	x		x			

4. Summary of Projects and Research Initiatives

Project	PACIFIC – Particle emissions, Air Quality and Climate Impact related to Fuel Composition and Engine Cycle
Timeline	2025 - 2028
Funding	EU, Horizon Europe
Link	https://cordis.europa.eu/project/id/101192334
Partners	**Airbus**, DLR, Rolls-Royce Deutschland, Universitat Mainz, Erdyn Consultants, NESTE, Rolls-Royce PLC, HELSINGIN YLIOPISTO, MMU, University of Sheffield
Description	Among aviation's non-CO_2 impacts, the largest radiative forcing value is attributed to contrail cirrus. Recent tests have revealed an opportunity for lowering soot particles emissions and ice crystals - which play a pivotal role in contrail properties - through the use of SAF. However, substantial disparities remain among those test campaigns, involving a large variety of fuels, engine types and combustors. It is therefore not straightforward to compare and reconcile results. PACIFIC aims to bridge the gap: the project will test an unprecedented set of fuels from lab up to engine/aircraft level with a similarity of hardware and combustion parameters. It will translate the results into modelling efforts, to better correlate: (i) soot formation, based on an improved Yield Soot Index database and prediction model; (ii) particle emissions, depending on fuel composition for the whole engine thrust range via an upgraded ground-to-flight correlation methodology; (iii) the ice forming potential of engine emissions, using advanced measurement methods on ground; (iv) the non-CO_2 emission mitigation potential, through the impact assessment of fuel composition and engine cycle on contrail properties and radiative forcing, and longer-term climate impacts (including CO_2 emissions fuel production).

Project	UNIC - Understanding Non-CO_2 Impact for deCarbonized aviation
Timeline	2025-2028
Funding	EU, Horizon Europe
Link	https://cordis.europa.eu/project/id/101192598
Partners	**ONERA**, ENVISA, MMU, University of Reading, Cardiff University, Helsingin Yliopisto, Tambereen Korkeakoulusaatio SR, SMHI, NRC Canada, Pegasor OY
Description	UNIC will enhance scientific understanding and mitigate the impact of non-CO_2 aviation emissions which emanate from both combustor and oil lubrication vent. UNIC's objectives are to improve non-CO_2 emission measurements, including nitrogen oxides and volatile and non-volatile particulate matter, across all flight phases. This will improve the understanding of the impact of alternative fuels (SAF and H_2) on non-CO_2 aged emissions and refine aerosol-cloud interaction models whilst providing robust data to support future aviation policy decisions. UNIC will develop and enhance novel technologies including a cold oxidation flow reactor and an integrated on-board sensor for real-time CO_2 and non-CO_2 emission quantification across the entire flight envelope, including cruise.

Project	**A4CLIMATE - Advancing Aeronautics and Aerosol research to Accelerate Climate neutral aviation**
Timeline	2025-2028
Funding	EU, Horizon Europe
Link	https://cordis.europa.eu/project/id/101192301
Partners	**Deutscher Wetterdienst**, INCAS, Max Planck Society, Imperial College, Universitat Mainz, Universitaet frankfurt Am Main, University of Leeds, University of Reading, Flightkeys GMBH, TO70, Arttic innovation GMBH, Sopra Steria Group, TUIfly GMBH
Description	The mitigation of aviation non-CO_2 effects, in particular contrails, could cut the radiative forcing from aviation by half in the next decade. Furthermore, the European Commission requires the Monitoring, Reporting and Verification of non-CO_2 forcing agents by 2027. However, large uncertainties currently prevent the implementation of dedicated mitigation measures. A4Climate directly targets the complex challenge of reducing aviation non-CO_2 effects by advancing knowledge on engine particle emissions, contrails and their climate impact. A4Climate improves weather and contrail predictions and integrates new information on contrail predictability, accuracy, climate impact and cost in a real time software. The contrail prediction tool will be validated on 400 contrail avoidance flights, thereby leveraging the consortium's expertise in the air transport system, weather and climate research. A4Climate creates further knowledge on contrail formation in the "low-soot regime" through dedicated lab measurements and models, filling gaps towards the assessment of the climate impact of modern lean burn and future hydrogen-based propulsion systems. A4Climate will provide unique new atmospheric data on humidity, aerosols and contrails from an exceptional campaign with a research aircraft to improve process and climate models and to investigate fuel sulfur effects on contrails and low clouds.

Project	**PEACOCK - Predictable and Environmentally friendly operations of regional Airports with COnnectivity and Climate as Keyword**
Timeline	2024-2027
Funding	EU, SESAR
Link	https://www.sesarju.eu/projects/PEACOCK
Partners	**Swedavia**, Eurocontrol, ADP, Brussels Airport, Fraport Greece airport, Eindhoven airport, Gdansk airport, Bucharest airport, Wroclaw airport
Description	The PEACOCK project aims to enhance connectivity between regional airports and the Network Manager to improve flight predictability, fuel efficiency, and emission reductions. It achieves this through technological innovations and operational measures, such as automated time-stamp generation and improved data sharing between airspace users and ground handlers. Post-operational analysis assesses the impact of different configurations on noise and emissions. Results aims at demonstrating environmental benefits, including reduced holding times, lower fuel burn during taxiing, and increased network capacity due to more precise and predicted data. These improvements contribute to Europe's goal of having the most efficient and environmentally friendly airspace.

Project	COMPANION (COMmon Platform and Advanced INstrumentation ReadIness for ultra efficient propulsion demonstratiON)
Timeline	2024-206
Funding	EU, Clean Aviation
Link	https://clean-aviation.eu/companion
Partners	**Airbus operations**, DLR, EASN-TIS BVBA, Ecole centrale de Lyon, INSA Lyon, ONERA, DNW, NLR
Description	The COMPANION project aims at developing a flight test demonstrator platform using a modified Airbus A380 to validate ultra-efficient propulsion systems from Clean Aviation Call#01 projects. One of the A380's inboard engine pylons will be adapted to accommodate advanced propulsion technologies, including an Open Rotor test engine and a hybrid-electric Ultra High Bypass Turbofan. The aircraft will be equipped with extensive instrumentation to assess engine performance under real operational conditions. By June 2026, the platform will be ready for engine installation, with flight clearance processes initiated but finalized in follow-up projects. The demonstrator engines will be tested using both conventional kerosene and sustainable aviation fuel (SAF) at up to 100% blending. The results will provide crucial insights for achieving TRL 6 by 2030, supporting the transition to cleaner aviation technologies.

Project	SAFice (The effect of transitioning to sustainable aviation fuels on contrails and climate)
Timeline	2024-2026
Funding	NERC
Link	https://gtr.ukri.org/projects?ref=NE%2FZ503848%2F1
Partners	**University of Leeds**, Green Lizard Technologies
Description	The SAFice project aims to understand the impact of transitioning to sustainable aviation fuels (SAFs) on contrail formation and its resulting radiative effects. Contrail cirrus clouds, formed by aircraft exhaust, play a significant role in aviation's climate impact. SAFs are believed to not only reduce CO2 emissions but also produce shorter-lived contrails. The project focuses on improving the understanding of how different SAFs and SAF blends affect the number and size of ice crystals in contrails, which in turn influences their radiative properties and lifespan. To achieve this, SAFice employs a range of experimental methods, including aerosol chamber and ice nucleation measurements to examine the competition between different emission particles, and gas turbine experiments to explore the contrail-ice-forming potential of SAFs. Additionally, global contrail simulations will quantify the radiative effects of SAF use. The project is timely as SAFs are becoming more widely used, with significant milestones like the first 100% SAF trans-Atlantic flight. By integrating experimental data with advanced modeling tools, SAFice aims to provide a comprehensive understanding of how SAFs can reduce the climate impact of aviation contrails.

Project	AEROSPACE TECHNOLOGY INSTITUTE – Non-CO_2 Programme
Timeline	2024-2025
Funding	NERC
Link	Non-CO2 Programme - Aerospace Technology Institute (ati.org.uk)
Partners	University of Cambridge, University of Manchester, ICCT
Description	The joint Non-CO_2 Programme of NERC, ATI, DfT, DBT and IUK focuses on addressing challenges with reducing non-CO_2 emissions from aircraft, as outlined in the ATI Non-CO_2 Technologies Roadmap. The initial phase, which is due to report by end of 2024, includes research on (i) the implementation of contrail avoidance operational initiatives; (ii) collection of humidity data; (iii) Monitoring, Verification and Reporting of non-CO_2 emissions and (iv) uncertainties. A subsequent phase 2 of work is due to start later in 2024.

Project	CLAIM – Clean Aviation Support for Impact Monitoring
Timeline	2024-2025
Funding	EU, Clean Aviation
Link	https://cordis.europa.eu/project/id/101140632
Partners	**DLR**, NLR, ONERA, CIRA, EASN
Description	The CLAIM proposal aims to translate the Clean Aviation Programme's goal of reducing net greenhouse gas emissions by 30% into measurable engine tailpipe emissions metrics. This involves collecting and analyzing the current scientific understanding of aviation's climate impact, identifying research gaps, and aligning technology research streams towards green and zero-emission aircraft. Additionally, CLAIM will compile an inventory of advanced research activities and technologies from the aviation sector and beyond, reviewing literature on disruptive aircraft concepts and climate-neutral aviation. The proposal will categorize these concepts based on aerodynamics, structures, systems, and propulsion technologies, performing technology mapping and preliminary performance assessments. By achieving these objectives, CLAIM will assist Clean Aviation, the EC, and EASA in providing clarity and contributing to the expected outcomes of reducing aviation's environmental impact.

Project	STEPLESS - Stepless High-Lift Configurations for Optimised Aircraft Energy Management in the TMA
Timeline	2024-2027
Funding	EU, SESAR
Link	https://www.sesarju.eu/projects/STEPLESS
Partners	**DLR,** EMPA, NLR, Swiss Skylab Foundation, Thales Avs France, Universitat Politecnica De Catalunya, L - UP SAS
Description	The project aims to minimise the flight environmental footprint during final approach under operations with conventional and increased glideslope angles (IGS). IGS is intended to reduce the noise perception on ground by a higher flight altitude. Steeper approach angles however, also reduce the aircraft's capability to decelerate to final approach speed. Therefore, the risk occurs that pilots are forced to configure the aircraft too early, which can have deteriorating effects on noise and fuel consumption. The proposed solution enables the increase of the glideslope angle for the sake of the reduction of the noise perception on ground but by avoiding deteriorating effects on fuel consumption because of non-optimal high-lift configurations. It is predicted to bring operational improvements to the flow of arriving traffic as well as to provide greater fuel efficiency and environmental sustainability together with a further reduced noise perception on ground and even slight capacity gains through the avoidance of drawbacks in the energy management of approaching aircraft because of a steeper glidepath.

Project	F4ECLIM
Timeline	2024-2027
Funding	EU, SESAR
Link	https://www.sesarju.eu/projects/F4ECLIM
Partners	**DLR,** TU Delft, Universidad Carlos III de Madrid
Description	The scope of the project is to address uncertainties related to CO_2, contrails, ozone, methane, and water vapor climate effects. To achieve this objective, the project focuses on: • Improving algorithmic climate change functions (aCCFs) by integrating diverse weather patterns and seasonal variations, and incorporating various climate metrics. These advancements will support the development of a dedicated climate service for the aviation community. • Investigating aviation's potential to reduce its climate impact through the development of robust flight planning algorithms, which will identify eco-efficient aircraft trajectories, evaluating their potential to lower climate impact while assessing the associated costs.

Project	UPLIFT- CLIM0ART (inflight emission measurement campaign)
Timeline	2024-Ongoing
Funding	DLR / LuFo
Link	https://www.uplift-h2-aviation.de/uplift/
Partners	**Deutsche Aircraft**, Sasol, Pratt&Whitney Canada
Description	The UpLift project aims at accelerating the development of climate-neutral aviation technologies by providing a flying test platform (D328) and ground test facilities for industrial and research partners. Led by DLR, it focuses on electric flying, low-emission propulsion, and cryogenic techniques. In October 2024, UpLift conducted the world's first in-flight emission measurements using 100% synthetic, aromatics-free fuel to assess CO2 reduction, particle emissions, and contrail formation, paving the way for sustainable aviation.

Project	ADVISAR - ADdressing feasibility studies towards cleaner aVIation and environmental impacts research with SAf on unRegulated engines
Timeline	2023-Ongoing
Funding	Swiss Federal government
Link	https://www.zhaw.ch/en/research/project/75793
Partners	**ZHAW,** SR Technics, Universität Freiburg, Adolphe Merkle Institute, Paul Scherrer Institut PSI, Laboratory of Atmospheric Chemistry (LAC), Pilatus Flugzeugwerke AG, EMPA
Description	The ADVISAR project focuses on the environmental impact of aviation emissions, specifically from sustainable aviation fuels (SAF). It explores how SAF affects soot and combustion gases, with a particular focus on smaller aircraft engines (<26.7 kN thrust), which are under-researched in emissions certification. ZHAW researchers have conducted initial measurements on a Cessna 560 XL, showing that SAF components could reduce soot emissions. However, differences in emission behavior between high-performance and smaller engines need further study. The project also upgrades ZHAW's SMARTEMIS system and prepares for future fuel studies at SR Technics.

Project	European body for jet fuel standards and safety certification
Timeline	2023-2027
Funding	EU
Link	https://www.easa.europa.eu/en/newsroom-and-events/press-releases/easa-hosts-first-eu-aviation-fuel-stakeholder-forum
Partners	**EASA**, Envisa, Ricardo, DLR
Description	The project aims to evaluate the feasibility and requirements for establishing a European body responsible for the specification, standardisation and certification of aviation fuels. Its objective is to examine the necessary structures and processes that would enable the European Union to make decisions regarding aviation fuel standards and associated criteria. The pilot project covers the following points: • Conduct a feasibility study to set up an EU Aviation Fuel Standards Body; • Define and test several use cases for a European fuel standard regarding non-CO_2 emissions from aviation fuels; Assess possible actions to optimise the fuel content in aviation fuels according to the ReFuelEU Aviation regulation: • Technical assessment of effects of an amended/new fuel standard on the European Fuel Ecosystem • Quantifying the potential climate benefits both in reduction of emissions and environmental impact - in line with EU law and definitions. This quantification should be done for a systematic selection of fuel, considering stepwise (soot) aromatic, naphthalenes, and sulphur level reductions for conventional fuels, as well as potential disruptive fuel formulations (100% SAF). Climate benefits should be assessed against a European baseline and should include the estimated total climate impact, based on changes in CO_2 and non-CO_2 levels, including the level of confidence of any such quantification and the source of uncertainty. The project should be fed through the empirical data compiled through the MRV-non-CO_2. This assessment should also include air quality impact where possible to provide a comprehensive view on the environmental benefits. ANCEN should be regularly consulted and provide guidance on technical aspects of this project related to non-CO_2.

Project	HOPE (Hydrogen Optimized multi-fuel Propulsion system for clean and silEnt aircraft)
Timeline	2023-2027
Funding	Co-funded (Horizon Europe, UK Research and Innovation)
Link	https://hope-eu-project.eu/
Partners	**TU Delft**, Chalmers Teknisksa Hogskola AB, Bauhaus Luftfahrt EV, Ergon Research SRL, HIT09 SRL, MMU
Description	The HOPE project aims to delivering a cleaner and quieter aircraft propulsion system by integrating multi-fuel ultra-high bypass ratio (UHBR) turbofan engines, a fuel cell-based auxiliary unit (FC-APPU), and an aft boundary layer ingestion (BLI) propulsor. The system willminimise the combustion during the LTO cycle, hence reducing emissions during takeoff and landing, cutting NOx, CO, soot and noise, without the trade-off of cruise emissions. HOPE also focuses on retrofitting existing aircraft and safely integrating hydrogen into current designs. The project targets a 50% reduction in LTO NOx and CO, an 80% reduction in soot, and a 30% decrease in climate impact compared to 2020 technologies. Key innovations include testing multi-fuel combustion, zero-emission taxiing, and assessing the environmental and cost benefits of the system, along with providing policy recommendations for HOPE's adoption.

Project	Faster-H2 (Fuselage, Rear Fuselage and Empennage with Cabin and Cargo Architecture Solution validation and Technologies for H2 integration)
Timeline	2023-2026
Funding	EU, Clean Aviation
Link	https://clean-aviation.eu/faster-h2
Partners	**Airbus Operations,** Aernnova Aerospace, Alestis Aerospace, Albany Engineered Composites, Esploro Projects, Fundacion Gaiker, FUNDACION PARA LA INVESTIGACION, HONEYWELL INTERNATIONAL, Optics11, SOGECLAIR AEROSPACE, Econcore, Acciturri engineering, Leonardo, Airbus Atlantic
Description	The FASTER-H2 project focuses on validating and integrating hydrogen propulsion technologies into the airframe of ultra-efficient Short/Medium Range aircraft. Key areas include fuselage, empennage, fuel tank integration, and sustainable materials to achieve climate-neutral aviation. The project follows a phased approach, targeting TRL from 3/4 (2025) to 6 (2030), targeting an entry-into-service by 2035. Major milestones include defining H2 integration trade studies (Q1 2024), down-selecting key technologies for TRL3 (Q2 2024), and developing structural solutions for tank accessibility and crash safety (Q1 2025). A sustainability Life-Cycle Assessment (Q2 2025) will evaluate materials and eco-friendly design concepts. These efforts aim to enable safe, efficient, and scalable hydrogen-powered aircraft.

Project	AEROPLANE – Advancing Measure to Reduce Aviation Impact on climate and enhance resilience to climate-change
Timeline	2023-2026
Funding	EU, SESAR
Link	https://www.sesarju.eu/projects/AEROPLANE
Partners	**Deep Blue**, Amigo, Universitaet Leipzig, Eurocontrol, University of Reading
Description	The AEROPLANE project aims to tackle several key aspects of aviation's environmental impact and resilience to climate change through a multifaceted approach. Firstly, it seeks to quantify the impact of contrails on cirrus clouds and understand aviation's non-CO_2 effects on climate, alongside identifying relevant climate metrics for assessing emissions' aggregated impact. Additionally, it will evaluate how climate change affects aircraft performance during take-off due to higher temperatures. Through user-centric innovation and participatory processes, AEROPLANE aims to develop greener, more climate-resilient aviation services. Three specific case studies will validate these solutions: the first focusing on minimizing contrail formation and assessing their impact, the second on understanding the impact of heatwaves on take-off performance and noise distribution at airports, and the third on investigating climate change's effects on Urban Air Mobility operations using RPAS.

Project	CICONIA – Climate effects reduced by Innovative Concept of Operations, Needs and Impacts Assessment
Timeline	2023-2026
Funding	EU, SESAR
Link	https://www.sesarju.eu/projects/CICONIA
Partners	**Airbus**, Meteo-France, Airbus Operations, Eurocontrol, NLR, Universitat Politecnica De Catalunya, DSNA, ONERA, ENAC, Forschungszentrum Jülich, Boeing Aerospace Spain, NATS, Swiss International Air Lines, MMU, DLR
Description	CICONIA, a SESAR industrial initiative, seeks to tackle aviation's climate impact by focusing on non-CO_2 emissions, particularly persistent contrails, which contribute significantly to net Effective Radiative Forcing. Operational mitigation measures, like trajectory optimization, hold promise, but their scalability and effectiveness are still being researched. CICONIA's objective, within SESAR3, is to unite key stakeholders to develop environmentally effective, economically balanced, and operationally viable mitigation strategies. The project faces challenges in developing reliable weather forecasts, modelling climate impact at the aircraft trajectory scale, and implementing operational measures without compromising safety. Building on previous SESAR projects, CICONIA aims to leverage expertise in defining climate-optimized aircraft trajectories and operational concepts. Expected outcomes include improved weather forecasting for contrail mitigation, standardized industry-wide climate impact models, and operational recommendations to balance environmental benefits, economic impacts, and safety considerations. These outcomes are envisioned to enhance climate mitigation efforts in aviation, potentially influencing future regulatory measures such as EU ETS or CORSIA.

Project	**REFMAP (Reducing Environmental Footprint through transformative Multi-scale Aviation Planning)**
Timeline	2023-2026
Funding	EU, Horizon
Link	https://www.refmap.eu/
Partners	**TU Delft**, AgentFly Technologies, Future Needs Management Consulting LTD, Universidad Carlos III de Madrid, Iscte - Instituto Universitário de Lisboa, Science and Technology BV, Institute of Communication & Computer Systems (ICCS)
Description	The REFMAP project is focused on quantifying the environmental footprints of air mobility, including both airliners and unmanned aircraft systems, across different scales. The goal is to optimize individual flight trajectories (micro level) and the flow of multiple aircraft (macro level) to minimize their environmental impact on various communities. The project will analyze how the availability of environmental data (e.g., wind, noise, emissions) will affect aviation business models. The project will develop the REFMAP analytics platform, which processes environmental and weather data, including CO_2 and non-CO_2 emissions, along with wind and noise levels. This platform will utilize a combination of numerical simulations, predictive models, and deep learning techniques, such as deep reinforcement learning, to optimize flight trajectories and improve overall environmental performance. Through this platform, REFMAP aims to align aviation business models with the EU's Green Agenda, contributing to evidence-based Green policymaking in the sector and ultimately reducing the aviation industry's carbon footprint.

Project	**MEFKON (Measurement-Based Improvement of Humidity Forecasting for Contrail Prevention)**
Timeline	2023-2026
Funding	German Federal Ministry of Economic Affairs and Climate Action
Link	https://www.dwd.de/EN/research/projects/mefkon/mefkon_node.html
Partners	**Deutscher Wetterdienst (DWD)**, Johannes Gutenberg University of Mainz
Description	The MEFKON project aims to reduce aviation's contribution to global warming by focusing on contrail prevention. Contrails, which are a significant non-CO2 emission source, could be reduced by adjusting flight paths in specific regions. This adjustment relies on accurately predicting Ice Supersaturated Regions (ISSR), where contrails form. In-situ humidity measurements at cruising altitude, collected from aircraft, are being assimilated into weather models by the German Weather Service (DWD) to improve weather forecasting accuracy. If these measurements can accurately predict ISSR, air traffic controllers and pilots will be able to avoid regions prone to contrail formation. The project's ultimate goal is to demonstrate the practical value of using aircraft-borne humidity data for contrail prevention and provide recommendations for its adoption by decision-makers.

Project	CONCERTO – dynamiC cOllaboratioN to generalize eCo-friEndly tRajecTOries
Timeline	2023-2026
Funding	EU, SESAR
Link	https://www.sesarju.eu/projects/CONCERTO
Partners	**Thales LAS**, Direction Des Services De La Navigation Aerienne (DSNA), Air France, Enav, Air Support, Deutscher Wetterdienst, Technische Universiteit Delft, Eurocontrol, Thales AVS , Thales Research & Technology, Ids Airnav, Deutsches Zentrum für Luft- und Raumfahrt, Udaras Eitliochta Na Heireann - The Irish Aviation Authority (IAA), Isavia ANS, Naviair, Luftfartsverket, Lennuliiklusteeninduse, Valsts Akciju Sabiedriba Latvijas Gaisa Satiksme, Deep Blue, Icelandair, Air Navigation Service Finland Oy, NATS
Description	The CONCERTO project aims to develop two solutions contributing to maximize the opportunities for CO_2 reduction and introducing non-CO_2 impact management in daily operations. CONCERTO gathers 23 partners and is part of the EU Aviation Green Deal Flag Ship. • Solution 0404: The Solution maximizes the opportunity for CO_2 reduction thanks to an innovative way to reduce operational constraints by detecting and operating eco-friendly timeslots in En-Route and Terminal Maneuvering Area (TMA). • Solution 0405: The Solution optimizes Traffic Flows based on CO_2, non-CO_2 & ATC capacity trade off thanks to an innovative way to forecast the climate sensitive areas and to implement new climate mitigation means in daily operations, with the ambition to make eco-friendly trajectories a well-automated, everyday task.

Project	HYDEA (HYdrogen DEmonstrator for Aviation)
Timeline	2023-2026
Funding	EU, Clean Aviation
Link	https://www.clean-aviation.eu/hydea
Partners	**GE AVIO SRL** + 29 other participants
Description	The HYDEA project is focused on developing a hydrogen combustion (H2C) propulsion system for aviation, aiming to support the European Green Deal and Clean Aviation Strategic Research and Innovation Agenda (SRIA) by 2035. The project will demonstrate the feasibility of hydrogen propulsion through ground testing from 2023 to 2026, addressing key challenges such as emission studies, NOx optimization, contrail emissions, and the integration of hydrogen technology with aircraft. HYDEA aims to lay the groundwork for the development and certification of hydrogen-powered aircraft, with its findings contributing to Airbus's ZEROe technology exploration initiative. The project's objective is to develop an H2 combustor and fuel system for aviation, focusing on their testing in real-world conditions and tackling essential questions about hydrogen as an aviation fuel. HYDEA will work closely with EASA to ensure regulatory alignment and drive the future of zero-emission aviation.

Project	PAREMPI (PARticle EMission Prevention and Impact)
Timeline	2023-2025
Funding	EU, Horizon
Link	https://parempi.eu/
Partners	**VTT Technical Research Centre of Finland**, Tampereen Yliopisto, Ilmatieteen Laitos, BOSMAL, Lund Universitet, OONERA, Institute of Experimental Medicine, Academy of Sciences of the Czech Republic, Magellan Circle – European Affairs Consultancy LDA, Magellan Circle Italy SRL
Description	The PAREMPI project aims to improve understanding of how transport sources contribute to ambient $PM_{2.5}$ levels, particularly focusing on secondary aerosols (SecA) formed through atmospheric reactions. Using a novel digital software (ePMI module), the project will analyze exhaust fumes, their chemical and physical characteristics, and their toxicity. This will help assess the health impacts of transport emissions and improve the quantification of transport-related externalities. The ultimate goal is to prevent smog episodes in Europe and inform policy measures to reduce harmful emissions. The project will focus on hard-to-decarbonize transport sectors, such as aviation and maritime, where combustion engines and turbines will remain in use for the foreseeable future. In addition to improving energy efficiency and using carbon-neutral fuels, solutions are needed to eliminate exhaust emissions, including secondary aerosols. PAREMPI brings together experts in transport emissions, aerosol formation, and health impacts to develop sound policy recommendations and help make European transportation systems cleaner and more sustainable.

Project	SWITCH (Sustainable Water-Injecting Turbofan Comprising Hybrid-electrics)
Timeline	2023-2025
Funding	EU, Clean Aviation
Link	https://www.clean-aviation.eu/switch
Partners	**MTU Aero Engines** + 15 other participants
Description	The SWITCH project focuses on developing a hybrid water-enhanced turbofan (hybrid WET) propulsion system for climate-neutral short-medium range air transport. This innovative system combines advanced technologies to achieve a 25% improvement in energy efficiency and a 75% reduction in climate impact compared to traditional engines. The hybrid WET system is unique in reducing all three major climate-warming effects: 1) CO_2 reduction through unmatched fuel efficiency. 2) NO_x reduction using water injection in the combustor. 3) Contrail reduction through particle removal and water recovery. Additionally, the system improves local air quality and noise levels around airports with the use of electric taxiing. It is compatible with SAF and could also be adapted for hydrogen fuel. The SWITCH project will mature the hybrid WET technology to TRL 4 by 2025, with the goal of achieving TRL 6 by 2030 and entering the market with a new short-medium range aircraft by 2035. This system will be crucial in helping the aviation sector reach the European Green Deal's goal of climate neutrality by 2050.

Project	E-CONTRAIL – Artificial Neural Networks for the Prediction of Contrails and Aviation Induced Cloudiness
Timeline	2023-2025
Funding	EU, Horizon
Link	https://www.econtrail.com/
Partners	**Universidad Carlos III de Madrid**, Royal Belgian Institute for Space Aeronomy, KTH Royal Institute of Technology, Royal Meteorological Institute of Belgium
Description	The overall purpose of the E-CONTRAIL project is to develop artificial neural networks (leveraging remote sensing detection methods) for the prediction of the climate impact derived from contrails and aviation-induced cloudiness, contributing, thus, to a better understanding of the non-CO_2 impact of aviation on global warming and reducing their associated uncertainties as essential steps towards green aviation. In particular, E-CONTRAIL will: • Leverage satellite data and artificial intelligence to improve understanding and prediction of contrail formation. • Develop remote sensing algorithms for contrail detection and quantify radiative forcing. • Create predictive AI models for high climatic impact areas. • Differentiate between natural clouds and contrails with advanced satellite data. • Provide actionable climate impact data to operators through a visualization platform.

Project	DYN-MARS
Timeline	2023-2026
Funding	EU, SESAR
Link	https://www.sesarju.eu/projects/DYN-MARS
Partners	**DLR,** Eurocontrol, Thales Avs France, NATS, EMPA, Swiss Skylab Foundation, Swiss International Air Lines
Description	The project aims to minimize aircraft exhaust emissions and noise pollution during climb, descent, and approach, by addressing the challenges of congested airports that limit optimal flight paths due to arrival sequencing and airspace capacity. To do so, it seeks to enhance coordination between pilots and air traffic control, while testing new avionics in the flight management system to better manage altitude and speed. The expected improvements include dynamic route assignments from ATC, precise flight planning, and better tactical speed reduction procedures. The benefits could be in the order of a 10% reduction in CO_2 emissions and fuel consumption, along with a decrease of at least 1 dB(A) in noise pollution during descent and approach.

Project	ECHOES
Timeline	2023-2026
Funding	EU, SESAR
Link	https://www.sesarju.eu/projects/ECHOES
Partners	**Startical,** Indra Sistemas Sa, Enaire, Nav Portugal, DLR, Mitiga Solutions
Description	The project aims to demonstrate the feasibility of space-based very high frequency (VHF) communications for air traffic management. Building on previous technical concepts, it will explore functionalities such as inter-satellite links, on-board data processing, and simultaneous VHF communication transmission and reception. The project will also address operational, regulatory, and standardization aspects of this technology. ECHOES will conduct use cases in the south Atlantic corridor and parts of European oceanic airspace, with a focus on environmental impact. This includes analyzing the potential for green procedures, such as permanent contrail avoidance and more efficient flight trajectories.

Project	GALAAD
Timeline	2023-2026
Funding	EU, SESAR
Link	https://sesarju.eu/projects/GALAAD
Partners	**Enav,** Honeywell International, Frequentis Orthogon, Eurocontrol, NAIS Solutions, Leonardo, Deep Blue, Airbus, Airbus Operations
Description	The project aims to develop and validate a concept for dynamic Required Navigation Performance (RNP) route allocation in the terminal area, enhancing the sustainability, resilience, and adaptability of air traffic control operations. This solution will address changes in operational conditions and traffic demand, incorporating decision-support tools and considering cross-border operations. The transition to dynamic routing is expected to improve fuel efficiency and environmental sustainability while maintaining capacity and enhancing safety and cost-effectiveness. In particular, GALAAD facilitates aircraft in flying closer to their most fuel-efficient 4D path, thereby optimising environmentally friendly flight routes while maintaining or even improving capacity, safety, and cost-effectiveness.

Project	GEESE
Timeline	2023-2026
Funding	EU, SESAR
Link	https://www.sesarju.eu/projects/GEESE
Partners	**Airbus,** Airbus Operations , Eurocontrol, DSNA, Air France, Oro Navigacija, Indra Sistemas Sa, Ecole Nationale De L' Aviation Civile (ENAC), Irish Aviation Authority (IAA), BULATSA, CIRA, Universitat Autonoma De Barcelona, Frequentis Comsoft, Boeing Aerospace Spain, NATS, Delta Air Lines
Description	The project aims to introduce the concept of wake energy retrieval (WER) into air traffic operations across Europe. It will elaborate an initial concept of operations (CONOPS) to facilitate WER implementation on Europe to North Atlantic routes, focusing on safety considerations and the impact on existing systems, and will provide operational solutions for the extension of WER operations within the European domestic airspace. It will also explore the potential non-CO_2 benefits of aircraft formations, as well as the CO_2 benefits.

Project	Green-GEAR
Timeline	2023-2026
Funding	EU, SESAR
Link	https://www.sesarju.eu/projects/GREEN-GEAR
Partners	**DLR**, Airbus, Airbus Operations, Eurocontrol, Università degli Studi Di Trieste, NLR, NATS, University of Westminster
Description	The project aims to enable optimum green flight trajectories to decrease both CO_2 and non-CO_2 climate impact at the network level. To do so, it proposes 3 solutions: • Examines the feasibility of switching from barometric to geometric altimetry, namely the use of satellite navigation altitude instead of air pressure measurement • Decrease existing vertical "**separation minima**" between aircraft • Incentivise environmentally friendly flight path choices by revolutionizing route charging

Project	ContrailNET
Operational date	2023
Funding	Eurocontrol
Link	https://www.eurocontrol.int/news/new-eurocontrol-contrail-observatory-our-innovation-hub-will-support-contrail-avoidance
Partners	Eurocontrol + partners of the different contrail-related projects tracked
Description	The ContrailNet initiative aimed to integrate the work of different contrail-related projects and share valuable, sometimes costly, data to avoid duplication of effort and to stimulate collaboration and research in the field of contrail science. Originally conceived for European projects, discussions with US partners broadened the scope to a global collaboration. The focus was on sharing high-quality labeled data sets, especially those that required manual validation. The initiative aimed to provide diverse data samples for building and comparing models. A key proposal was to collect data on contrail observations, which could help solve the difficult matching and tracking problem.

Project	Blue Condor
Timeline	2022-n/a
Funding	Airbus
Link	https://www.airbus.com/en/newsroom/stories/2022-07-how-blue-condor-will-accelerate-airbus-first-hydrogen-powered-test-flights
Partners	Airbus UpNext, Perlan Project
Description	The Blue Condor project, led by Airbus UpNext, involves modifying an Arcus-J glider to operate on hydrogen combustion and analyzing its emissions at high altitudes. One glider is retrofitted with a hydrogen-propulsion system, while another remains unmodified for comparative analysis. Flight tests, conducted in multiple phases, involve releasing the gliders at 33,000 feet and using a Grob Egrett aircraft equipped with emissions sensors to capture critical data. The focus is on evaluating hydrogen combustion's impact on contrails and non-CO2 emissions compared to traditional kerosene engines. Initial flight tests validate handling and configuration, while subsequent campaigns assess hydrogen-powered flight performance and emissions. The results will provide key insights into hydrogen's role in sustainable aviation, informing future developments of Airbus' ZEROe hydrogen aircraft program.

Project	BeCoM – Better Contrail Mitigation
Timeline	2022-2026
Funding	EU, Horizon
Link	https://www.becom-project.eu
Consortium	**TU Delft**, CNRS, DWD, DLR, Thales, ECATS, Envisa
Description	The BeCoM (Better Contrail Mitigation) project aims to enhance understanding and mitigation of contrails' climate impact. The project focuses on various aspects, including operational and new measurements, cloud physics, weather models, assimilation, data evaluation, model prediction, climate-optimized trajectories, and policy-driven flight planning. Objectives range from re-evaluating supersaturation degrees and compiling aircraft water humidity data to designing AI algorithms for contrail identification and evolving algorithmic cost functions for climate change. Led by different partners, each aspect contributes to a holistic approach to address contrails' environmental impact and develop effective mitigation strategies.

Project	**D-KULT – Demonstrator KLIMA- und Umweltfreundlicher Lufttransport demonstrator for climate and environmentally friendly air transport**
Timeline	2022-2025
Link	https://www.dwd.de/DE/fachnutzer/luftfahrt/download/produkte/luftfahrt_und_klima/d_kult_info.pdf
Consortium	**DLR**, DFS, Lufthansa, DWD, PACE, JEPPESEN, BDL, DHL, Airbus, MUAC, Eurocontrol
Description	A LuFO (Luftfahrtforschungsprogramm (aviation research program)) demonstrator - Climate and Environmental air transportation. Feasibility study of climate optimised flight trajectory planning due to avoidance of contrails/cirrus in ice-supersaturated areas. Tactical avoidance of ice supersaturated regions and evaluation of persistent contrail generation by satellite observation.

Project	**MINIMAL – Minimum environmental impact ultra-efficient cores for aircraft propulsion**
Timeline	2022-2026
Funding	EU, Horizon
Link	https://www.minimal-aviation.eu/
Partners	Charlmers University, Bauhaus Luftfarht, TU Delft, Cranfield University, Aristotle University of Thessaloniki, Reaction Engines, GKN Aerospace Sweden AB, Rolls-Royce, MTU Aeroengines
Description	The MINIMAL project aims to demonstrate the feasibility of achieving significant reductions in both non-CO_2 and CO_2 emissions by implementing intercooled composite cycle engine technology (CCE) to replace conventional constant pressure combustion cores. Building on technology developed in the H2020 ULTIMATE1 project, which showed substantial efficiency gains, MINIMAL seeks to advance CCE to TRL 3. It aims to prove that the altitude flexibility of CCE facilitates contrail mitigation measures, enhance efficiency through free-piston technology, and easily achieve necessary net-NOx reductions with proven NOx mitigation methods from heavy-duty vehicles. This project represents a critical step toward reducing emissions across the board in aviation.

Project	STARGATE (SusTainable AiRports, the Green heArT of Europe)
Timeline	2021-2026
Funding	EU, Horizon
Link	https://www.greendealstargate.eu/
Partners	**Brussels Airport Company** + 25 other participants
Description	The STARGATE project, supported by a consortium of 22 entities led by Brussels Airport, aims to create sustainable airports as multimodal hubs for smart mobility. It focuses on green solutions for European airports to improve day-to-day operations and overall sustainability. The project centers around five main pillars: 1. Digital Twin Ecosystem: Developing 3D models of airports to simulate operational processes, transport flows, energy supply, and emissions management, with a particular focus on Lighthouse Airports. 2. Multimodal, Sustainable, and Smart Mobility: Enhancing intermodal transport options through improved governance, digitalization, and decarbonization of both people and goods transport. 3. Optimization of Terminal Operations: Deploying a Terminal Command Centre, managing resources efficiently, minimizing waste, and implementing a circular resource management approach. 4. Energy and SAF (Sustainable Aviation Fuel): Focusing on energy production, consumption, and the integration of biofuels and SAF to reduce reliance on fossil fuels. 5. Cross-Cutting Aspects: Tackling noise reduction, emissions minimization, assessing non-technological framework conditions, and promoting new multi-actor governance models. STARGATE aims to be a benchmark for green airports worldwide, improving airport sustainability and creating a foundation for a greener future in the aviation sector.

Project	CLIMAVIATION – Climate & Aviation
Timeline	2021-2026
Funding	National, FR DGAC
Link	https://climaviation.fr
Partners	IPSL, CNRS, ONERA
Description	Climaviation, a research initiative merging "Climate" and "Aviation," endeavors to understand and quantify aviation's climate impacts. Funded from 2021 to 2026 by the French Directorate General of Civil Aviation (DGAC) as part of the national Recovery and Resilience Plan and NextGenerationEU, it brings together researchers from the Pierre-Simon Laplace Institute (IPSL) and the French Aerospace Research and Study Center (ONERA). Amidst climate urgency, aviation aims for accelerated decarbonization globally by 2050, emphasizing efficiency improvements, alternative low-carbon fuels, and potentially hydrogen. However, besides CO_2, aircraft engines emit nitrogen oxides (NOx), water vapor, and particles, contributing to complex atmospheric interactions termed "non-CO_2 effects." Climaviation aims to better understand and quantify these effects, evaluate new fuel impacts, and propose strategies based on CO_2 and non-CO_2 effects synergies or compromises. These impacts include NOx contributing to ozone formation and indirect warming, while also cooling by methane destruction, water vapor forming contrails and induced cirrus clouds with radiative effects, and combustion particles acting as condensation nuclei for clouds. The project seeks to address these challenges and uncertainties to minimize aviation's total climate impact effectively.

Project	MOREandLESS (MDO and REgulations for Low-boom and Environmentally Sustainable Supersonic aviation)
Timeline	2021-2025
Funding	EU, Horizon
Link	https://h2020moreandless.polito.it
Partners	**Politecnico Di Torino** + 15 other participants
Description	The MOREandLESS project examined the environmental impact of supersonic aviation by developing a multidisciplinary framework that assesses aircraft technologies, flight trajectories, and alternative fuels. Researchers enhanced existing modeling tools and conducted test campaigns to evaluate noise, emissions, and overall environmental impact. The study covered the full supersonic speed range and explors the most promising aircraft designs, propulsion systems, and sustainable fuel options like biofuels and hydrogen. The aim of the project was to help shape future regulations for supersonic travel, ensuring high environmental standards while maintaining global connectivity. By providing solid technical data, MOREandLESS supported the development of sustainable supersonic aviation and fosters international cooperation in setting global environmental policies.

Project	**SENECA (noiSe and EmissioNs of supErsoniC Aircraft)**
Timeline	2021-2024
Funding	EU, Horizon
Link	https://seneca-project.eu/
Partners	**DLR**, Rolls Royce Deutschland, Rolls Royce PLC, ONERA, MMU, MTU AERO ENGINES AG, NLR, Cranfield University, University of Southampton, National Aviation University, AEDS SARL, NLR, CIRA
Description	The SENECA project, which brought together 11 academic and industrial aerospace partners across Europe, addressed the environmental challenges posed by the new generation of supersonic aircraft. The project developed advanced models to assess the carbon emissions and landing and take-off (LTO) noise from supersonic aircraft, particularly in the vicinity of airports. It focused on aircraft that would fly supersonic over water and subsonic over land, addressing the unresolved issue of the sonic boom. Researchers also examined the global climate impact of these aircraft. SENECA successfully deepened the understanding of emissions and noise from supersonic aviation and worked on technologies to reduce its environmental footprint. The project's results contributed to international regulatory discussions and strengthened Europe's perspective within ICAO, aiming to influence global environmental standards for supersonic aviation.

Project	**ECLIF3 – Emission and Climate Impact of Alternative Fuels**
Timeline	2021-2024
Funding	Industry, Ind&Res
Link	https://www.airbus.com/sites/g/files/jlcbta136/files/2021-11/EN-ECLIF3-study.pdf
Partners	**Airbus**, Rolls-Royce, DLR, NESTE, NRC
Description	ECLIF3 marks the first in-flight examination of 100% SAF on both engines of a commercial Airbus A350 aircraft, powered by Rolls-Royce Trent XWB engines. The study aims to support Airbus and Rolls-Royce's efforts in certifying 100% SAF use, crucial for the aviation sector's decarbonization. Findings indicate that SAF emits fewer particulates than conventional kerosene, potentially reducing climate impact and improving air quality around airports. Moreover, SAF's lower density and higher energy content offer fuel-efficiency advantages.

Project	MUAC Contrails Avoidance project
Timeline	2021
Funding	Eurocontro, DLR
Link	https://www.eurocontrol.int/article/reducing-impact-non-co2-climate-impact-eurocontrol-muac-and-dlr-partnering-contrail
Partners	**EUROCONTROL**, DLR
Description	The trial aimed to demonstrate the feasibility of avoiding persistent contrails through slight re- routing measures. The weather service provided forecasts for ice-supersaturation and the decision to avoid contrails was also based on cloudiness. The trial was planned on odd days, with even days serving as reference, and the results showed that contrail avoidance was effective on average. However, the accuracy of the forecast for ice-supersaturation needs improvement as there were more false alarms and false positives than correctly predicted persistent contrails. MUAC continues to explore ways to improve its prediction for future trials.

Project	SAMPLE IV – Assessment of environmental impacts frameworks
Timeline	2021-2024
Funding	EU, Horizon
Link	https://www.easa.europa.eu/en/research-projects/environmental-research-engine-emissions-sample-iv
Partners	**EASA**, INTA, Rolls-Royce, University of Manchester, Cardiff University, Zurich University, Universidad Politécnica de Madrid
Description	The SAMPLE IV project focused on the impact assessment of non-volatile particulate matter (nvPM) emissions from non-regulated engines. The project aimed to assess the environmental impacts of nvPM emissions from non-regulated engines, particularly focusing on the estimation of nvPM emissions and selecting specific engines for further testing. The project was structured into specific contracts (SC01 and SC02) to carry out detailed analyses and evaluations. The deliverables of the project provide insights into the characteristics of aircraft engine emissions and contribute to the overall understanding of environmental impacts in aviation, as well as recommendations based on the research conducted by the consortium partners. The project emphasizes the importance of sustainable aviation practices, including the use of Sustainable Aviation Fuel (SAF) and the consideration of emission indices (EI) in assessing environmental impacts.

Project	LITECS (Laser Imaging of Turbine Engine Combustion Species)
Timeline	2020-2025
Funding	UK Research and Innovation
Link	https://gtr.ukri.org/projects?ref=EP%2FT012595%2F1
Partners	**University of Strathclyde**, Loughborough University, National Physical Laboratory, Rolls Royce Group Plc, University of Manchester, University of Edinburgh, Siemens AG, M Squared Lasers Ltd, Optosci Ltd, University of Sheffield, University of Southampton, Tracerco Ltd, Siemens plc (UK)
Description	This program aims to reduce the environmental impact of aviation and power-generating gas turbine engines (GTEs) by improving the understanding and modeling of combustion and emissions processes. To achieve this, innovative measurement techniques will be developed to analyze combustion zones and exhaust emissions, providing new insights into emissions formation and fuel behavior. These advancements will support the development of cleaner engine and fuel technologies. The project's impact extends to both industry and academia. Collaborating with Rolls-Royce and Siemens, the research will help the UK's GTE industry meet stricter emissions targets, enhancing competitiveness and economic growth. New measurement systems at the National Centre for Combustion Aero-thermal Technologies and the Low Carbon Combustion Centre will contribute to fundamental combustion research, with findings submitted to international databases like HITRAN. Additionally, the project will train a new generation of experts in advanced instrumentation and combustion systems, fostering long-term innovation in sustainable aviation and energy.

Project	ALIGHT (a Lighthouse for the introduction of sustainable aviation solutions for the future)
Timeline	2020-2025
Funding	EU, Horizon
Link	https://www.alight-aviation.eu/
Partners	**Copenhagen Airport** + 17 other participants
Description	The ALIGHT project aims to facilitate the transition to zero-emission aviation and airport operations by developing innovative solutions, including IT platforms, smart energy management, SAF logistics, remote quality control, and emissions measurement. It will create a replication toolbox, best practice handbooks, and sustainability guidelines to support widespread adoption across European airports. By aligning with international climate targets and collaborating with stakeholders, ALIGHT seeks to establish a scalable model for smart, sustainable airports by 2050.

Project	ACACIA – Advancing the Science for Aviation and Climate
Timeline	2020-2024
Funding	EU, H2020
Link	https://www.acacia-project.eu
Partners	**DLR**, CICERO, MMU, University of Reading, Universität Wien, ETH Zürich, Universität Leipzig, TU Delft, Jülich, CNRS, ZHAW
Description	The EU-H2020 project ACACIA sought to address the significant impact of aviation's non-CO2 emissions on climate, which rivaled the effects of carbon dioxide emissions but were associated with larger uncertainties. With four overarching aims, ACACIA aimed to enhance scientific understanding of these impacts, identify the need for international measurement campaigns, standardize aviation effects for updated climate impact assessments, and provide strategic guidance for implementing mitigation options. This collaborative effort involved 11 participants from 7 European countries, organized into 6 work packages and aimed to host an international conference, thus bridging research across various scales and disciplines to offer recommendations for policy, regulatory bodies, and stakeholders in the aviation industry.

Project	ClimOP – Climate assessment of innovative mitigation strategies towards operational improvements in aviation
Timeline	2020-2023
Funding	EU, Horizon
Link	https://climop-h2020.eu/
Partners	**Deep Blue**, NLR, TU Delft, DLR, Amigo, ITU, IATA, SEA
Description	Aviation is one of Europe's strongest economic sectors, with the aeroplane being the most convenient and preferred means of transport. However, air travel also accounts for 5 % of global carbon emissions and flying is responsible for several negative external effects that are not neutral to the environment. Experts suggest that aviation's share of the entire anthropogenic climate impact will increase exponentially in the coming years. As a result, intergovernmental and scientific institutions as well as the aviation industry are seeking new technologies and operational improvements to reduce these negative effects. The EU-funded ClimOP project aimed to detect, evaluate, develop, and propose to aviation stakeholders and policymakers a set of the most promising and integrated mitigation strategies to restrict the aviation sector's climate impact.

Project	CREATE – Climate and weather modEls to improve ATM resilience and reduce its impacts
Timeline	2020-2022
Funding	EU, SESAR
Link	https://create-project.eu/
Partners	**Università degli Studi di Napoli PArthenope**, Arianet, CIRA, FMI, NLR, Universitat Politècnica de Catalunya
Description	Aviation's role in mitigating climate impact is vital within global climate change mitigation efforts. CREATE addressed this by developing climate and weather-aware operational concepts, optimizing aircraft trajectories in space and time to enhance resilience to disruptive weather events. By incorporating an environmental scoring module (ESM), CREATE evaluated trajectory "greenness," considering CO_2, non-CO_2 emissions, contrail probability, and air quality impacts. Tested in the North Atlantic and Mediterranean regions, the framework proved adaptable for resolving network hotspots and air quality-sensitive areas, showcasing its potential to minimize climate impact while ensuring operational efficiency.

Project	FlyATM4E – Flying Air Traffic Management for the benefit of environment and climate
Timeline	2020-2022
Funding	EU, SESAR
Link	https://flyatm4e.eu/
Partners	**DLR**, TUHH, TU Delft, UC3M
Description	The FlyATM4E project aimed to enhance climate-assessment methods and optimize aircraft trajectories to identify effective mitigation strategies for reducing the overall climate impact of aircraft operations. It assessed the feasibility of an environmental assessment concept for ATM operations, developing climate-optimized aircraft trajectories to minimize aviation's climate impact. These trajectories considered both CO_2 and non-CO_2 effects, such as contrails, water vapor, NOx, and particulate emissions. By identifying weather situations and trajectories conducive to robust climate impact reduction, despite atmospheric science uncertainties, the project aimed to enhance aviation's climate impact assessment. It also pinpointed scenarios where climate impact reduction can be achieved at minimal or no additional cost where both climate impact and costs can be reduced. Ultimately, FlyATM4E provided recommendations for implementing these strategies in meteorological products, facilitating eco-efficient routing in ATM operations. Drawing on expertise across atmospheric science, climate research, aviation operations, and aircraft trajectory optimization, the consortium aimed to advance understanding and implementation of eco-efficient routing in aviation.

Project	VOLCAN – VOL avec Carburants Alternatifs Nouveaux
Timeline	2020-2024
Funding	National, FR DGAC
Link	https://www.dlr.de/en/latest/news/2023/01/emissions-and-contrail-study-with-100-percent-sustainable-aviation-fuel
Partners	**Airbus**, Safran, Dassault, ONERA
Description	The VOLCAN project (Flight with New Alternative Fuels), is a joint research initiative led by DLR and Airbus. It focuses on conducting flight tests using SAFs to reduce the climate impact of air transport. In these tests, an Airbus A321neo is powered by pure SAF in both engines, with emissions and ice crystal formation in the exhaust plumes being measured by DLR's Falcon 20E research aircraft. The project aims to understand how ice crystals form when significantly fewer soot particles are emitted from the aircraft engines. Various variants of sustainable fuel are tested, including HEFA, which are derived from used cooking oil and other waste fats. The project builds on previous flight test campaigns conducted by DLR to characterize emissions from synthetic fuels and SAFs. The ultimate goal is to achieve climate-neutral air transport through the development of highly efficient aircraft and the use of sustainable fuels.

Project	ALTERNATE - Assessment on alternative aviation fuels development
Timeline	2020-2022
Funding	EU, Horizon
Link	https://alternate.cimne.com/
Partners	**Universidad Politecnica De Madrid**, CIMNE, Safran Sa, Zodiac Aerotechnics Sas, ONERA, IATA Espana, Universiteit Hasselt, IIASA
Description	The ALTERNATE project was a European initiative focused on aviation sustainability, in collaboration with Chinese partners. Its goal was to comprehensively study the use of Aviation Alternative Fuels (AAF), including their impact on feedstocks, life cycle assessment (LCA), aircraft and engine performance, and business models for airlines. Running from 2020 to 2022, the project brought together research and industry institutions to ensure the viability of Sustainable Aviation Fuels (SAF) and promote the sustainability of air transport. ALTERNATE was one of four European-funded projects under the ACGA cluster, which also included ACACIA, CLIMOP, and GREAT. The project had four main objectives: improving physical and climate models for alternative aviation fuel use; developing a reliable, globally harmonized LCA approach for SAF supply chains; reducing fuel and certification costs for drop-in jet fuels; and creating protocols to support the introduction of alternative fuels in aviation. The project involved global experts from both Europe and China to advance climate change mitigation strategies through alternative fuel pathways, aiming for a Technology Readiness Level (TRL) of 3 to 4 across various developments.

Project	ACCESSII – Alternative Fuel Effects on Contrails and Cruise Emissions
Timeline	2014
Link	https://www.nasa.gov/image-article/access-ii-team-effort/
Partners	**NASA**, NRC, DLR
Description	ACCESS II focused on studying the emissions and contrail characteristics of aircraft exhaust, particularly in relation to the turbulent air streams behind aircraft wingtips. ACCESS II aimed to fly research aircraft into the turbulent wake vortices created by the DC-8 aircraft's wingtips. Detailed studies and simulations were conducted to ensure the safety of flying through these vortices, with a goal of collecting data on exhaust composition and contrail characteristics. The project involved multiple aircraft equipped with instruments to measure various aspects of chemistry, aerodynamics, and physics related to the wingtip wake vortices. Flights were primarily staged from NASA's Armstrong Aircraft Operations Facility in California, and measurements were taken in restricted airspace near Edwards Air Force Base. The research supported NASA's strategic vision for transitioning the aviation industry to low-carbon fuels and alternative propulsion systems, with findings shared internationally through organizations like the International Forum for Aviation Research.

Project	AVIATOR – Assessing aViation emission Impact on local Air quality at airports: Towards Regulation
Timeline	2019-2022
Funding	EU, Horizon
Link	https://aviatorproject.eu
Partners	**INTA**, NRC, ETS, IBERIA, AENA, CIEMAT, RAMEM, Rolls-Royce, MMU, Cardiff University, DLR, CPH, ONERA, Janicke Consulting, FZAG, IA, UoM
Description	The AVIATOR PROJECT, which aimed to assess aviation emissions' impact on local air quality and advance regulatory standards, collaborated with industry stakeholders to develop tools and regulations while linking with the health community. It encompassed four main objectives: enhancing measurement systems for aircraft engine emissions, advancing aircraft plume and airport modeling, bridging the gap between aircraft engine certification and air quality regulation, and providing protocols and guidance for air quality and health impact assessment. These aims included developing measurement protocols, investigating pollutant dynamics, understanding regulatory constraints, and disseminating outcomes to stakeholders.

Project	**GREAT (Greener Air Traffic Operations)**
Timeline	2019-2020
Funding	EU, Horizon
Link	https://www.project-great.eu/
Partners	**DLR** L - Up Sas, Hungarocontrol, CIRA, Pildo Consulting Sl, Universidad Politecnica De Madrid, KLM, Cetc Avionics Co. Ltd., Nanjing Research Institute Of Electronics Engineering, Civil Aviation University Of China, China Aeronautical Radio Electronics Research Institute, Nanjing University Of Aeronautics And Astronautics, Technical Center Or Air Traffic Management Bureau Of Caac
Description	The GREAT project focused on reducing aviation's environmental impact by optimizing gate-to-gate flight trajectories and air traffic management (ATM) operations. By minimizing fuel consumption, CO2, NOx, and contrail formation, the project aimed to make flights more efficient while maintaining mobility. GREAT developed green air traffic operational concepts, adaptive airspace configurations, and trajectory optimization technologies, ensuring that planned eco-friendly flight paths remain viable under real traffic conditions. A collaboration between European and Chinese partners, the project conducted evaluation campaigns to validate its approach and demonstrate significant climate benefits.

Project	**GLOWOPT (Global-Warming-Optimized Aircraft Design)**
Timeline	2019-2022
Funding	EU, Horizon
Link	https://cordis.europa.eu/project/id/865300
Partners	**TUHH**, TU Delft
Description	The GLOWOPT project aimed to reduce aviation's climate impact by developing Climate Cost Functions (CCFs) for optimizing next-generation aircraft design. It analyzed global aircraft fleet data to establish payload and range requirements, integrate emissions and contrail effects into aircraft design optimization, and apply Multidisciplinary Design Optimization (MDO) to minimize climate impact. The project also evaluated aircraft designs for emissions, noise, and cost efficiency using high-fidelity simulations.

Project	RAPTOR – Research of Aviation PM Technologies, mOdelling and Regulation
Timeline	2018-2022
Funding	EU, Horizon
Link	https://aviation-pm.eu/
Partners	**Envisa**, MMU, Cardiff University, TNO, RIVN, ONERA, Janicke Consulting, UoM, ZHAW
Description	Climate change and environmental concerns, highlighted by the Intergovernmental Panel on Climate Change (IPCC), are pressing global issues. Aviation's environmental impact, though relatively small, is steadily increasing, driven by long-term CO_2 emissions and shorter-term non-CO_2 emissions such as water vapor, particles, and nitrogen oxides. Particulate matter emissions from aircraft operations, especially during taxing, take-off, and landing, pose health risks to communities near airports and can alter atmospheric composition at cruising altitudes. This Cleansky research project aimed to consolidate European research efforts to understand aircraft particulate matter formation and develop tools for effective regulations, fostering collaboration among industry, academia, and research institutes to address these critical issues.

Project	UNREAL (Unveiling Nucleation mechanism in aiRcraft Engine exhAust and its Link with fuel composition)
Timeline	2018-2020
Funding	Agence Nationale de la recherce (ANR)
Link	https://anr.fr/Project-ANR-18-CE22-0019
Partners	**ONERA**, LSCE Laboratoire des Sciences du Climat et de l'Environnement, INSTITUT UTINAM Sylvain PICAUD, LISA Laboratoire inter-universitaire des systèmes atmosphèriques, Département Sciences de l'Atmosphère et Génie de l'Environnement (SAGE) ARMINES, INTA Instituto Nacional de Tecnología Aeroespacial, TUT Tampere University of Technology, ONERA Office National d'Etudes et de Recherches Aérospatiales, PhLAM Physique des lasers, atomes et molécules
Description	The UNREAL project studied new particle formation (vPM) in aircraft engine exhaust using different fuels to reduce aviation's environmental impact. Using advanced experimental setups like the CAST generator, CESAM atmospheric chamber, and PAM reactor, alongside molecular simulations, the project investigated how fuel composition influences vPM formation. Initial findings showed that higher hydrogen content fuels emit less black carbon, with alternative fuels like ATJ SPK reducing emissions by up to 89%. Surprisingly, 100% alternative fuels, despite lacking sulphur and aromatics, exhibited the highest new particle formation rates, prompting further research.

Project	ND MAX/ECLIF 2 (NASA/DLR Multidisciplinary Airborne eXperiments/Emission and Climate Impact of alternative Fuel 2)
Timeline	2018
Funding	NASA / DLR
Link	https://halo-db.pa.op.dlr.de/mission/108
Partners	Aerodyne, Boeing, FAA
Description	The ECLIF/NDMAX campaign focused on investigating the climate impact of aviation fuels, particularly biofuels like HEFA (Hydro processed Esters and Fatty Acids) biofuel blends. The ECLIF (Emission and Climate Impact of Alternative Fuels) project, a collaborative effort between NASA and DLR, aimed to assess how alternative fuels affect contrail formation, emissions, and their overall climate impact. In January 2018, the NASA DC-8 research aircraft conducted in-situ measurements on the exhaust emissions of an ATRA Airbus A320, which was burning both conventional Jet-A1 fuels and blends of HEFA biofuels. These measurements were taken in flight traffic-restricted areas above Germany, and the goal was to explore how different fuel types influenced contrail cirrus formation, which has a major contribution to aviation's climate impact, sometimes even exceeding the effects of CO2 emissions. The flight experiments were supplemented with ground-based measurements to assess engine emissions from the different fuels and to understand their contribution to climate change. The findings could potentially lead to more sustainable aviation practices by optimizing fuel use to reduce contrail formation and overall climate impact.

Project	JETSCREEN – JET Fuel SCREENing and Optimization
Timeline	2017-2020
Funding	EU, Horizon
Link	JET Fuel SCREENing and Optimization | JETSCREEN | Project | Fact sheet | H2020 | CORDIS | European Commission
Partners	**DLR**, ARTTIC, Airbus, CERFACS, IFP EN, MMU, MTU Aeroengines, ONERA, Politecnico di Milano, SAFRAN, SAFRAN AE, The University of Sheffield, SAFRAN Aerosystems, Rolls-Royce, Airbus Operations
Description	The JETSCREEN project aimed to support the EU's goal of achieving 10% renewable energy in the transport sector by 2020 and a 40% share of low-carbon fuels in aviation by 2050. It provided screening tools for alternative fuel producers, air framers, and aero-engine OEMs to assess fuel compatibility with fuel and combustion systems. The project's objectives included developing a platform that integrated design tools and experiments to evaluate the risks and benefits of alternative fuels, optimizing them for maximum energy per kilogram and reduced emissions. JETSCREEN focused on using low-cost, small-scale experimental and model-based testing to predict the impact of fuels on engine and fuel system components, forming a preliminary step before the lengthy and expensive approval process. The methodology involved creating predictive tools that captured the effects of fuel composition on performance and emissions. This allowed for the optimization of fuel formulations to achieve targeted performance or emission reductions. The project's ambition was to deliver a certificate of analysis for candidate fuels, summarizing key results from the ASTM D4054 approval process, based solely on detailed fuel composition and simulation results. This innovation streamlined the approval process, relying on models and simulations to predict fuel performance.

Project	ATM4E – Air Traffic Management for Environment
Timeline	2016-2018
Funding	EU, SESAR
Link	https://www.atm4e.eu
Partners	**DLR**, University of Reading, Envisa, MMU, TUD, TUHH
Description	The European project ATM4E, part of the SESAR2020 Exploratory Research initiative, aimed to assess the feasibility of a concept for environmental evaluation of ATM operations, with the goal of optimizing air traffic operations in European airspace. This two-year research endeavor, launched in May 2016 and concluded in April 2018, focused on integrating existing methodologies to assess the environmental impact of aviation, considering climate, air quality, and noise. Coordinated by the DLR-Institute of Atmospheric Physics, the Consortium comprised six partners. ATM4E's scope aligned with the Trajectory Management Framework within the SESAR Operational Concept, focusing on optimized 2D/3D routes and processing business and mission trajectories for civil aviation, particularly commercial air transport. Funded by the SESAR Joint Undertaking under Horizon 2020, ATM4E contributed to advancing environmental optimization strategies for air traffic management.

Project	ECLIF I (Emission and CLimate Impact of alternative Fuels)
Timeline	2015
Funding	NASA Aeronautics Research Mission Directorate – Aeronautics Field Projects
Link	https://science-data.larc.nasa.gov/large/aeronautics-eclif.html
Partners	NASA, DLR
Description	The ECLIF project aimed to evaluate the combustion performance, emissions, and contrail characteristics of alternative jet fuels. The study involved burning two standard jet fuels and four alternative fuel blends with varying aromatic hydrocarbon and sulfur content in a DLR Airbus A320 ATRA. Emissions and contrails were measured using an instrumented DLR Falcon 20 during nine 2.5-hour flights, as well as in extensive ground-based engine tests. Preliminary results indicate that fuels with lower aromatic and sulfur content produce fewer particle emissions, aligning with findings from previous studies like ACCESS-II. These insights contribute to understanding the climate benefits of alternative fuels and their potential to reduce aviation's environmental impact.

Project	FORUM-AE (FORUM on Aviation and Emissions)
Timeline	2013-2017
Funding	Specific Programme "Cooperation": Transport (including Aeronautics)
Link	https://cordis.europa.eu/project/id/605506
Partners	**SAFRAN Aircraft Engines**, Airbus, DLR, Lufthansa, ECATS, Flughafen Zurich Ag, Ifp Energies Nouvelles, MMU, NLR, ONERA, Rolls-Royce Plc, Rolls-Royce Deutschland Ltd & Co Kg, SENASA
Description	The FORUM-AE project was a European initiative focused on addressing environmental concerns related to aviation emissions. It served as a technical and scientific forum that promoted awareness, research, and innovation to tackle aviation's impact on air quality, climate change, and regulations. The project organized focused workshops to better understand these impacts, explore potential technological solutions, and assess regulatory challenges. It also monitored and compiled information from various EU and national research projects to ensure alignment with the ACARE environmental goals. Over its course, FORUM-AE held several workshops on key topics such as air quality, climate change, fuel burn, alternative fuels, and market-based measures, with strong participation from experts and stakeholders. The project contributed to raising awareness of crucial environmental issues and has provided recommendations for research priorities in areas like mitigation solutions and regulatory issues. Its findings have been shared with ACARE, the European Commission, and other organizations, aiming to improve the sustainability and environmental performance of the aviation industry.

Project	WeCare
Timeline	2013-2017
Funding	DLR
Link	https://www.dlr.de/en/pa/latest/news/2013/new-concepts-to-reduce-climate-effects-of-aviation-dlr-project-wecare-started
Partners	**DLR**
Description	Air traffic is a fast growing business which currently contributes by about 5 percent to the global climate change, mainly by non-CO_2 effects. Non-CO_2 effects (the formation of cirrus clouds originating from condensation trails and ozone for instance) have a strong spatial variability caused by meteorological processes. In WeCare, this relationship was determined and utilized in the optimization of flight paths to realize an eco-efficient air traffic. The resulting cost-benefit analysis was compared with alternative conceptions of aircraft design and flight guidance to assess the potentials of reducing climate effects. The efforts were accompanied by flight experiments to verify the relevant process chain from the emission to changes in climate-active trace substances and cloud properties.

Project	**TEAM_PLAY (Tool Suite for Environmental and Economic Aviation Modelling for Policy Analysis)**
Timeline	2010-2013
Funding	EU, Horizon
Link	https://cordis.europa.eu/project/id/266465
Partners	**DLR** + 17 other participants
Description	The TEAM_PLAY project developed a state-of-the-art modelling tool suite to assess the economic and environmental impacts of aviation policies. It harmonized data using common interfaces, data formats, and a central database, enabling comparison and scenario assessments for informed policymaking. For the first time, Europe had a comprehensive framework to measure the effects of aviation policies on the economy, transport system, and environment, with customizable scenarios for ongoing and future research. The project's success led to plans for a European modelling strategy, ensuring long-term sustainability and enhancing Europe's influence in international aviation policy, particularly within ICAO-CAEP.

Project	**REACT4C – Reducing emissions from aviation by changing trajectories for the benefit of climate**
Timeline	2010-2014
Funding	EU, Horizon
Link	https://www.react4c.eu/
Partners	**DLR**, ULAQ, Airbus, EEC, CICERO, UKMO, University of Reading, MMU
Description	Project REACT4C aimed to investigate climate-optimized flight routing's potential to mitigate aviation's atmospheric impact. The project involved eight partners. REACT4C sought to evaluate altered flight altitudes and routes for reduced fuel consumption and emissions, considering the global effect on climate change. The project introduced a modeling chain to optimize aircraft trajectories based on weather-dependent climate impacts, including CO_2 and non-CO_2 emissions, like NOx, H_2O, and contrail cirrus. Through weather classification and 4-dimensional climate cost functions, the project identified climate-optimized routes, showing significant impact reduction with moderate cost increases. It proposed integrating this method with emission trading systems to convert costs into gains for airlines. Uncertainty studies confirmed the robustness of the findings, advocating for weather-dependent routing over simplified mitigation procedures, with flexibility for incorporating new climate impact findings into future studies.

EASA

European Union Aviation Safety Agency

European Union Aviation Safety Agency

Konrad-Adenauer-Ufer 3
50668 Cologne
Germany

https://www.easa.europa.eu/ANCEN

Mail ANCEN@easa.europa.eu
Web www.easa.europa.eu

An Agency of the European Union