Workshop on Aviation non-CO2 emissions

13-14 December 2023

European Commission, Brussels

BREY Auditorium - Avenue d'Auderghem 45

Background

For over 25 years, successive European aviation Strategic Research and Innovation Agendas set ambitious environmental and climate goals (i.e. ACARE Flightpath 2050[1]) and the achievements are very good. However, only last year, in the latest edition of Europe's Vision for Sustainable Aviation by ACARE, the importance of **all non-CO2 effects** was adequately recognised. The "**Fly the Green Deal**" came roughly at the same time as ICAO Assembly, at its 41st Session, adopted Resolution A41-21 which set the **long-term global aspirational goal for international aviation (LTAG) of net-zero CO2 emissions by 2050,** in support of the Paris Agreement's temperature goal.

Yet, for over 25 years, the European Commission together with Member States have invested heavily on atmospheric science as well as aviation research and technologies on "Aviation, Aerosols, Contrails and Cirrus Clouds" (A^2C^3). That was the name of the European Workshop that took place in Seeheim near Frankfurt, in 2000 (July 10-12). That was the result of another European workshop in Seeheim in July 1998, which was tasked to review the draft of the IPCC Special Report on Aviation "Aviation and the Global Atmosphere" (1999). Since then, more than 40 EU-funded research projects, many European workshops[2] on Aviation, Atmosphere and Climate (AAC), the successful actions of the Network of Excellence ECATS[3] and in-flight measurements have followed.

These European research efforts, at large, allow us today to estimate the climate impact of all non-CO2 aviation emissions, as well as the remaining uncertainties. The **Sixth IPCC report**[4] pays particular attention to **Short-Lived Climate Forcers (SLCF) from aviation** and transportation at large. It concludes that the largest SLCF effects are those from the formation of persistent condensation trails (contrails) and NOx emissions. Persistent contrails are ice-crystal clouds, formed around aircraft soot particles (and water vapour from the engine), injected in ambient cold and ice-supersaturated atmosphere, which can

[1] reduce CO2 emissions per passenger kilometre by 75%, NOx by 90% and perceived noise by 65% all relative to the year 2000.
[2] https://www.pa.op.dlr.de/aac/proceedings/AAC-proceedings-complete.pdf
[3] http://www.ecats-network.eu/about/background/more-background
[4] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter06.pdf

spread and form contrail cirrus clouds. The 'net NOx' effect arises from the formation of tropospheric ozone, counterbalanced by the destruction of ambient methane and associated cooling effects of reductions in stratospheric water vapour and background ozone. The IPCC reports suggests that the net temperature response from aviation emissions was determined by **similar contributions from contrails, contrail cirrus and CO_2 over a 20-year time horizon, and dominated by CO_2 in a 100-year perspective**.

Objectives

The workshop is organised jointly by the European Commission (DG-RTD, DG-MOVE, DG-CLIMA, DG-ENV), including the two aviation Horizon Europe Partnerships (Clean Aviation and SESAR) and the European Aviation Safety Agency. Given the many parallel initiatives in the last two years, it presents a great opportunity to work even closer together with the industry, airlines, research establishments and academia towards cost-optimum solutions for aviation and climate.

The objectives of the workshop are fourfold:

- To provide an overview of the **state-of-play of aviation non-CO_2 impacts**, notably:
    - Dependence of contrails on altitude and geographic region
    - Predictive accuracy of met conditions that promote persistent contrails
    - Sensors on-board
    - Satellite contrail detection & tracking - overestimation of persistent contrails
    - Percentage of flights that are really affected in Europe and globally
    - Expectations from hydrogen-powered aviation and water-enhanced turbofan
    - Impact of SAF on contrails
    - Can simplified calculation methods be trusted and verified?
    - Climate restricted airspaces
    - Metrics for CO2 and non-CO_2 aviation emissions – AGTP – ATR100 or what?
    - ATM trade-offs for CO_2, NOx and contrails
    - Can the complexity of non-CO2 emissions be represented by a CO_2 multiplier?
- To listen to all relevant stakeholders, identify research and policy gaps, and gather recommendations, that have the **potential to actually reduce the aviation non-CO_2 impacts**, mainly via new technologies and optimised operations, in the short- and medium-term.
- To contribute to a quantified and scientifically-agreed **roadmap** towards minimising all non-CO_2 aviation impacts towards 2050 (and 2070), considering all possible measures (i.e. new technologies, optimised operations, new fuel options, and market-

based measures) in combination as well as the trade-off between CO_2 and non-CO_2 emissions. The workshop is confined primarily to the climate effects of non-CO_2 aviation emissions, while Local Air Quality (and noise) will be the subject of an upcoming workshop in Q3 2024.

- To **communicate the findings** of the workshop and contribute towards clearing the fog that surrounds the issue, for the benefit of aviation and the climate.

Organisation

The workshop will take place in Brussels, Avenue d'Auderghem 45, 1000 (Building BREY[5]), on 13-14 December 2023, with maximum number of **150 in-person participants** and the **possibility of web-based connection**. There are no delegate fees or other charges. All confirmed in-person participants cover their own expenses. Register at:
https://research-innovation-community.ec.europa.eu/events/icGIke5cMVCM3scpfmT8d/overview

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[5] https://commission.europa.eu/about-european-commission/visit-european-commission/buildings-commission-and-executive-agencies-brussels_de?building=BREY

Workshop Programme

13-14 December 2023

Day 1

9h00 Registration and Welcome Coffee/Tea

9h30 Opening Address
DG RTD / Roselinde van der Vlies, DG CLIMA / Bea Yordi

9h45 Session 1 - Non-CO_2 Aviation Emissions/Impacts – State-of-the-art
Chair: Michael Kyriakopoulos (DG RTD)

- Keynote: 25 years of non-CO_2 aviation emissions research after Seeheim
  DLR & TU Delft / Volker Grewe
- Better contrail understanding and mitigation options
  DLR / Christiane Voigt
- Aircraft and engine influence on CO_2 and non-CO_2 emissions
  Airbus / *Charles Renard*
- Q&A (10 min)

11h30 Coffee Break

11h45 Session 1 - Continued

- Progressing toward a better estimate of the climate impact of aviation
  ISPL & ONERA / Nicolas Bellouin, Philippe Novelli
- Climate assessment of single flights
  DLR / Katrin Dahlmann, Sigrun Matthes
- Significant factors influencing the net effect of single contrail
  Technische Universität Dresden / Judith Rosenow, Hartmut Fricke
- Q&A (10 min)

13h00 Lunch Break

13h45 Session 2 – Innovative Technologies I
Chair: Niclas Dzikus (DG-RTD)

- Expectations from hydrogen-powered aviation
  Airbus / Glenn Llewellyn, Frédérique Rigal
- Challenges and non-CO_2 impact of hydrogen-burning engines
  Rolls-Royce / Paul Madden

- Multi MW fuel cell systems – challenges and potentials
  MTU / Dominik Wirth
- Current knowledge of the impacts of NOx
  IPSL & ONERA / Didier Hauglustaine and Etienne Terrenoire
- Q&A (10 min)

15h15 Coffee Break

15h30 Session 2: Innovative Technologies II

Chair: Jean-Francois Brouckaert (Horizon Europe Clean Aviation)

- A significant reduction in NOx emissions
  SAFRAN / Valérie Guenon, Nicolas Jeuland
- The Water-Enhanced Turbofan – A revolutionary gas turbine concept
  MTU / Christopher Pfennigs
- Low NOx Technologies
  GE Aerospace / Thomas Ripplinger
- CS2 Technology Evaluator and CA ACAP Impact Monitor
  Airbus / Matthias Meussen
- Q&A (10 min)

17h30 Discussion

18h00 Close Day 1

Day 2

9h00 Registration and Welcome Coffee/Tea

9h30 Opening Address
DG MOVE / Filip Cornelis

9h45 Session 3: Market-Based Measures – EU-ETS - MRV
Chair: Dimitar Nikov (DG-CLIMA)

- Regulatory/Certification issues related to EU-ETS Directive Art 30(4)
  EASA / Joonas Laukia
- Tender CLIMA/2023/OP/0005 - Support for establishing an MRV system for non-CO2 effects in aviation - revision of the ETS Directive
  To70 – DLR - AerLabs / Liam Megill
- Climate metrics for aviation CO_2 and non-CO_2 impacts: technical and policy implications
  Airbus / Philippe Mattei
- Aviation Impact Accelerator on fleet impact of new technologies
  University of Cambridge / Rob Miller
- Q&A (10 min)

11h15 Coffee Break

11h30 Session 4: Fuel Options
Chair: Andreas Busa (EASA)

- Unveiling nucleation mechanism in aircraft engine exhaust and its link with fuel composition options
  ONERA / Ismael Ortega
- Cleaner aviation fuels have the potential to reduce contrail cloudiness
  DLR / Patrick Le Clercq, Tina Jurkat-Witschas, Christiane Voigt
- A full environmental life cycle assessment (eLCA)
  BHL / Mirko Hornung, Andreas Sizmann, Valentin Batteiger
- Energy Transition in Aviation – future fuel options
  TU Delft / Arvind Gangoli Rao
- Q&A (10 min)

13h00 Lunch Break

13h45 Session 5: Optimised Operations I

Chair: Andrei Mungiu (DG-MOVE)

- Towards Climate-Optimized Operations
  THALES / Julien Lopez
- Mitigation strategies studied in the ClimOP project
  NLR / Elisabeth van der Sman
- Satellite and ATC data for contrail detection, tracking and matching
  Airbus/ Remi Chevallier
- Satellite detection of contrails using AI and changes COVID-19
  DLR / Luca Bugliaro
- Q&A (10 min)

15h15 Coffee Break

15h30 Session 5: Optimised Operations II

Chair: Olivia Nunez (Horizon Europe SESAR)

- CICONIA - Climate effects reduced by Innovative Concept of Operations
  Airbus / Philippe Mattei
- CONCERTO – Traffic Flow optimizations based on total climate impact
  THALES / David Antonello
- MUAC Contrails prevention – the global picture and main challenges
  EUROCONTROL / Ilona Sitova, Rüdiger Ehrmanntraut
  ContrailHub® - Sharing contrails data to facilitate research
  EUROCONTROL / Philippe Very, Gabriel Jarry
- Actual and Time-Optimized Flight Trajectories
  KLM – Air France / Lisanne van Wijngaarden
- Q&A (10 min)

17h00 Conclusions - Discussion Panel

Moderated: Michael Kyriakopoulos (DG RTD)

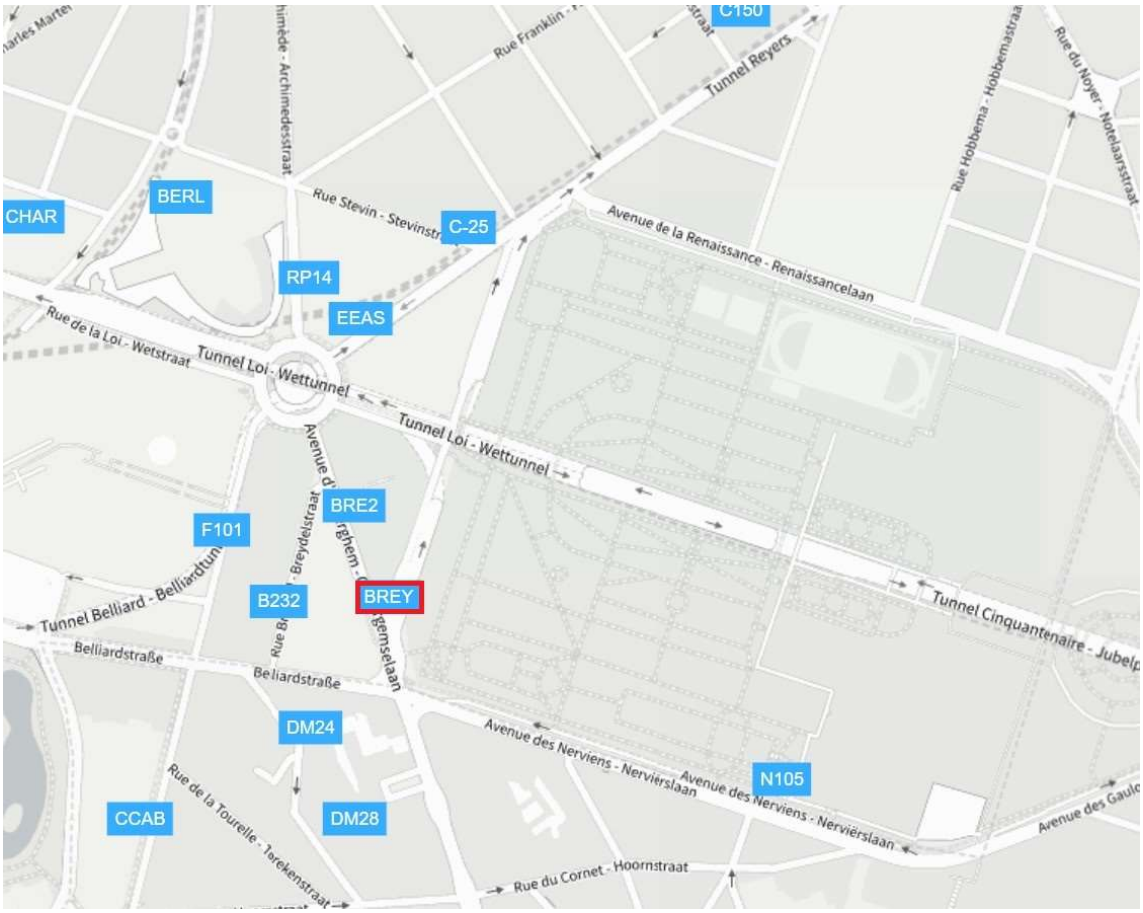
- DG RTD / JANE AMILHAT
- DG MOVE / Maria DE LAS FLORES DIAZ PULIDO
- DG CLIMA / POLONA GREGORIN
- DG ENV / FRANÇOIS WAKENHUT
- EASA / ALAIN LEROY

18h00 Workshop closure

Annex 1 – Links to representative EU-funded projects

Acronym	Title	web-link
QUANTIFY	Quantifying the Climate Impact of Global and European Transport System	https://cordis.europa.eu/project/id/3893
ATTICA	European Assessment of Transport Impacts on Climate Change and Ozone Depletion - Metrics & Aviation	https://www.pa.op.dlr.de/attica/
MOZAIC	Measurement of Ozone on Airbus In-Service Aircraft	https://cordis.europa.eu/project/id/AER30052
FLAME	Future laser atmospheric measurement equipment	https://cordis.europa.eu/project/id/AER20045
AERONOX	The impact of NOx emissions from aircraft upon the atmosphere at flight altitude 8-15 km	https://cordis.europa.eu/project/id/EV5V0044
LOWNOX II	Low emission combustor technology - Phase II	https://cordis.europa.eu/project/id/AER20036
LOWNOX III	Low Emission Combustor Technology - Phase III	https://cordis.europa.eu/project/id/BRPR950122
CYPRESS	Future Engine Cycle Prediction and Emissions Study	https://cordis.europa.eu/project/id/G4RD-CT-2000-00383
AERO2K	Global aircraft emissions data project for climate impacts evaluation	https://cordis.europa.eu/project/id/G4RD-CT-2000-00382
MENELAS	Minority Exhaust Measurements of Aircraft Engine Emissions by Infrared Laser Spectroscopy	https://cordis.europa.eu/project/id/G4RD-CT-2002-00645
PARTEMIS	Measurement and Predictions of the Emission of Aerosols and Gaseous Precursors from Gas Turbine Engines	https://cordis.europa.eu/project/id/G4RD-CT-2000-00207
TRADEOFF	Aircraft emissions: contribution of different climate components to changes in RF–tradeoff to reduce atmospheric impact	https://cordis.europa.eu/project/id/EVK2-CT-1999-00030
AERONET III	Aircraft Emissions and Reduction Technologies	https://cordis.europa.eu/project/id/502882
NEPAIR	Development of the technical basis for a new emissions parameter covering the whole aircraft operation	https://cordis.europa.eu/project/id/G4RD-CT-2000-00182
SCENIC	Scenarios of aircraft emissions and impact studies on chemistry and climate	https://cordis.europa.eu/project/id/EVK2-CT-2001-00103
IMPACT2C	Quantifying projected impacts under 2°C warming	https://cordis.europa.eu/project/id/282746
CLIMATECOST	Full Costs of Climate Change	https://cordis.europa.eu/project/id/212774
ALTERNATE	ASSESSMENT ON ALTERNATIVE AVIATION FUELS DEVELOPMENT	https://cordis.europa.eu/project/id/875538
REACT4C	Reducing Emissions from Aviation by Changing Trajectories for the benefit of Climate	https://cordis.europa.eu/project/id/233772
ATM4E	Exploratory Research project demonstrated the integration of environmental change functions	https://cordis.europa.eu/project/id/699395
TEAM_PLAY	Tool Suite for Environmental and Economic Aviation Modelling for Policy Analysis	https://cordis.europa.eu/project/id/266465
ACACIA	Understanding non-CO2 effects and aviation climate impact	https://cordis.europa.eu/project/id/875036
ClimOP	Assessment of improved ground and air operations for aviation emissions mitigation	https://cordis.europa.eu/project/id/875503
GREAT	Greener Air Traffic Operations	https://cordis.europa.eu/project/id/875154
FlyATM4E	Flying Air Traffic Management for the benefit of environment and climate	https://cordis.europa.eu/project/id/891317
BeCom	Better Contrails Mitigation	https://cordis.europa.eu/project/id/101056885
SENECA	(LTO) noiSe and EmissioNs of supErsoniC Aircraft	https://cordis.europa.eu/project/id/101006742
More & Less	MDO and Regulations for Low-boom and Environmentally Sustainable Supersonic aviation	https://cordis.europa.eu/project/id/101006856
CONCERTO	Dynamic Collaboration to Generalize Eco-friendly Trajectories	https://www.sesarju.eu/projects/concerto
CICONIA	Climate effects reduced by Innovative Concept of Operations - Needs and Impacts Assessment	https://www.sesarju.eu/projects/CICONIA
REIVON	Reduction of the Environmental Impact of aviation via Optimisation of aircraft size/range and flight Network	https://cordis.europa.eu/project/id/101007659
MINIMAL	Minimum environmental impact ultra-efficient cores for aircraft propulsion	https://cordis.europa.eu/project/id/101056863
NEEDED	Next generation models and methods for aircraft pollutants and noise estimation	https://cordis.europa.eu/project/id/101095754
RAPTOR	Research of Aviation PM Technologies, mOdelling and Regulation	https://cordis.europa.eu/project/id/863969
AVIATOR	Assessing aViation emission Impact on local Air quality at airports: TOwards Regulation	https://cordis.europa.eu/project/id/814801
REFMAP	Reducing Environmental Footprint through transformative Multi-scale Aviation Planning	https://cordis.europa.eu/project/id/101096698
GLIMPSE2050	Quantifying the environmental impact of global air transport	https://cordis.europa.eu/project/id/865118
GLOWOPT	Global-Warming-Optimized Aircraft Design	https://cordis.europa.eu/project/id/865300
EFACA	Environmentally Friendly Aviation for all Classes of Aircraft	https://cordis.europa.eu/project/id/101056866
AHEAD	Advanced Hybrid Engines for Aircraft Development	https://cordis.europa.eu/project/id/284636
COST 723	Data Exploitation and Modeling for the Upper Troposphere and Lower Stratosphere	https://www.cost.eu/actions/723/

Annex 2 - Address: Avenue d'Auderghem 45, 1000 Bruxelles / Brussel, Belgium



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