EASA
European Union Aviation Safety Agency

EUROPEAN AVIATION ENVIRONMENTAL REPORT 2022

Executive Summary and Recommendations

European Environment Agency

EUROCONTROL

EXECUTIVE SUMMARY

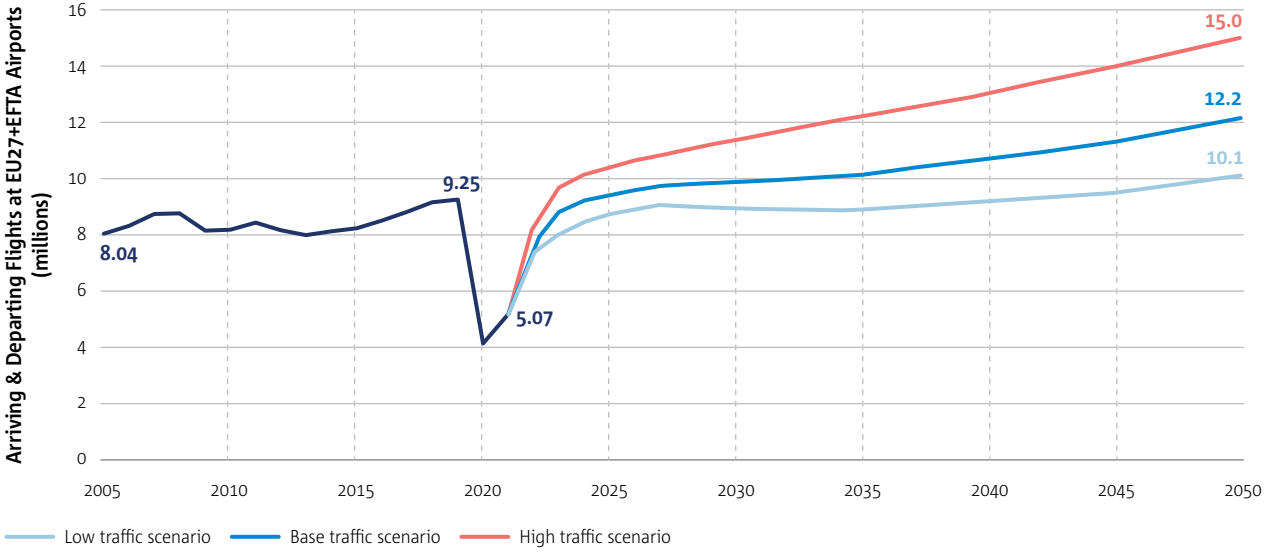
The last three years has seen a spotlight shone on the environmental performance of the aviation sector, and the future challenges that it faces to ensure a license to operate. The third European Aviation Environmental Report provides an objective overview of the significant developments that have taken place in response to this.

While the sector provides economic benefits, connectivity, and stimulates innovation, European citizens are becoming increasingly aware of the affect that aviation activities have on their quality of life through climate change, noise and air quality, and many are prepared to act on these concerns. This is especially so on climate change, which is considered by Europeans to be the single most serious problem facing the world. With these challenges also come opportunities for businesses to build their strategies and brand around this key priority of sustainability to reduce their environmental impact and attract a growing market share, talent and investment, as well as empower customers to join the fight against climate change in this decisive decade.

Scaled-up collaboration between public and private stakeholders will also be of the utmost importance to enhance existing measures, and identify new ones, that can deliver the European Green Deal objectives. This report provides a clear and accurate source of information to inform and inspire discussions and cooperation in Europe. The long-term future of the aviation sector will depend on the success of this effort.

EAER DASHBOARD

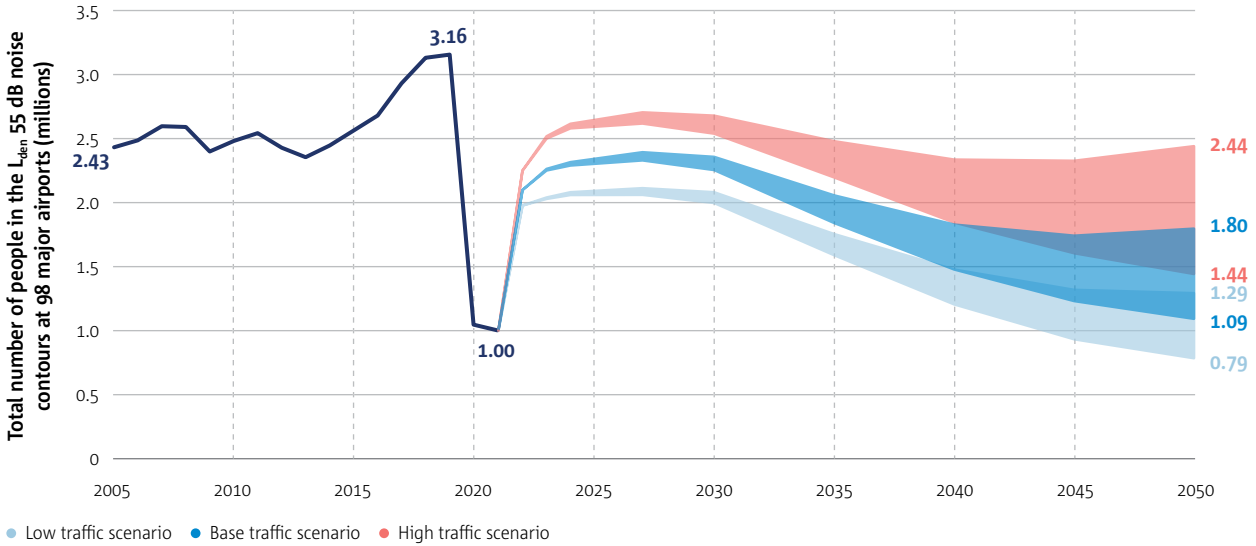
TRAFFIC



Indicator	Units	2005	2019	2020	2021
Number of flights[1]	million	8.04	9.25	4.12	5.07
Passenger kilometres[2]	billion	781	1484	389	509
Number of city pairs served most weeks by scheduled flights		5389	8161	N/A	6188

1 All departures and arrivals in EU27+EFTA.
2 All departures from EU27+EFTA.

NOISE



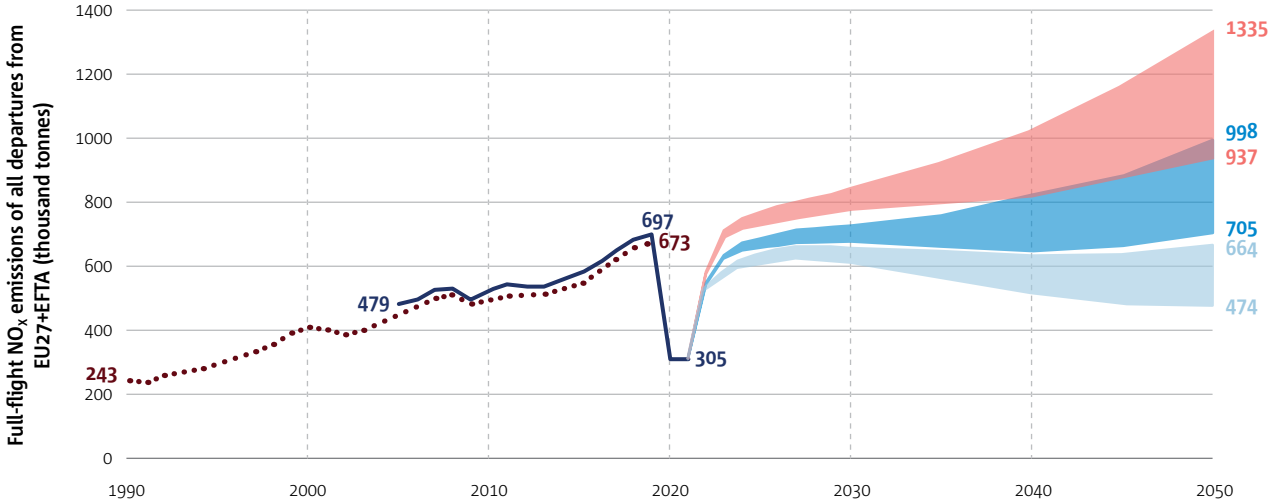
Assumptions:
- Infrastructure of each airport is unchanged (no new runway)
- Population distribution around airports is unchanged
- Local take-off & landing noise abatement procedures are not considered

For each traffic scenario, the upper bound of the range reflects fleet renewal with a 'frozen' technology scenario, and the lower bound reflects the 'advanced' technology scenario.

Indicator	Units	2005	2019	2020	2021
Number of people inside L_{den} 55 dB airport noise contours[3]	million	2.43	3.16	1.05	1.00
Average noise energy per flight[4]	10^9 Joules	1.22	1.30	1.21	1.15

3 98 major European airports
4 All EU27+EFTA airports

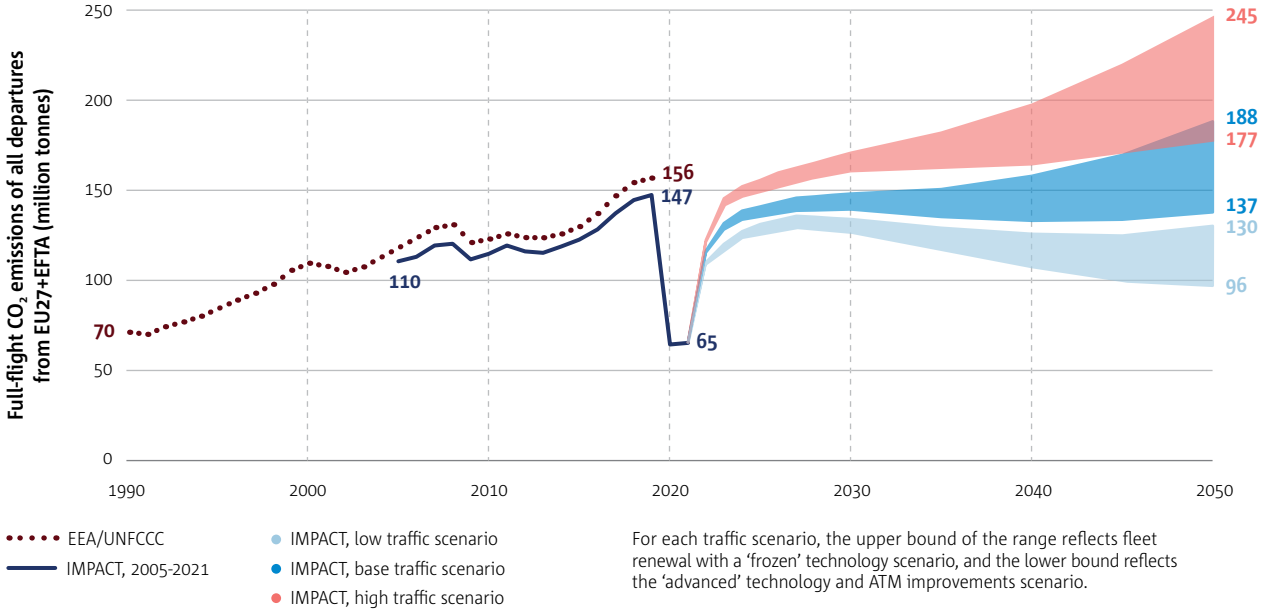
EMISSIONS



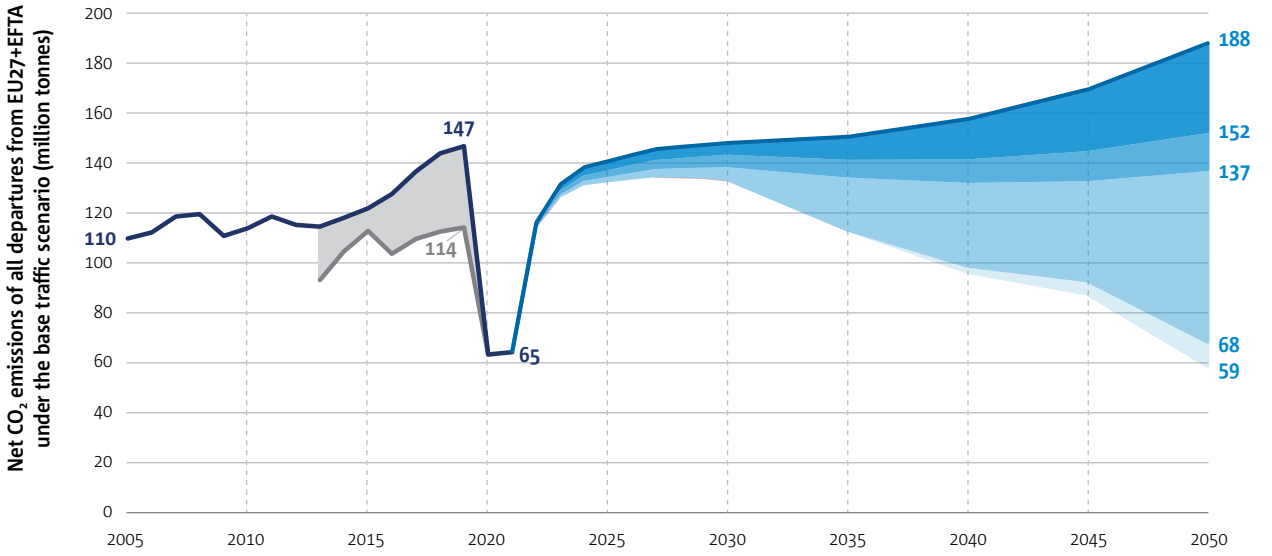
For each traffic scenario, the upper bound of the range reflects fleet renewal with a 'frozen' technology scenario, and the lower bound reflects the 'advanced' technology and ATM improvements scenario.

Indicator[5]	Units	2005	2019	2020	2021
Full-flight CO_2 emissions	million tonnes	110	147	64	65
Full-flight 'net' CO_2 emissions with ETS reductions	million tonnes	110	114	64	65
Full-flight NO_x emissions	thousand tonnes	479	697	306	305
Average fuel consumption	litres fuel per 100 passenger kilometre	4.8	3.5	4.8	N/A

5 All departures from EU27+EFTA



For each traffic scenario, the upper bound of the range reflects fleet renewal with a 'frozen' technology scenario, and the lower bound reflects the 'advanced' technology and ATM improvements scenario.



The net (i.e. lifecycle) CO_2 emissions reductions include the effect of the EU Emissions Trading System (ETS) for the period 2013-2020 and that of in-sector measures (technology, ATM, SAF, electric/hydrogen) under the base traffic scenario out to 2050. No forecast of emissions reductions from market-based measures have been made due to on-going discussions on ETS and CORSIA at the European and ICAO level.

Overview of Aviation Sector

- The number of flights at EU27+EFTA airports increased by 15% between 2005 and 2019 to 9.3 million, while passenger kilometres almost doubled (+90%). However, flights declined to just 5.1 million in 2021 due to the Covid-19 pandemic.
- At 98 major European airports during 2019, 3.2 million people were exposed to L_{den} 55 dB aircraft noise levels and 1.3 million people were exposed to more than 50 daily aircraft noise events above 70 dB. This is 30% and 71% more than in 2005 respectively.
- The top 10 airports in terms of L_{den} 55 dB population exposure in 2019 accounted for half of the total population exposure across the 98 major European airports.
- The CO_2 emissions of all flights departing from EU27+EFTA airports reached 147 million tonnes in 2019, which was 34% more than in 2005.
- Long-haul flights (above 4,000 km) represented approximately 6% of departures during 2019 and half of all CO_2 and NO_x emissions.
- Single-aisle jets had the larger share of flights and noise, but twin-aisle jets had the larger share of fuel burn and emissions.
- The average grams CO_2 emitted per passenger kilometre went down by an average 2.3% per annum to reach 89 grams in 2019, equivalent to 3.5 litres of fuel per 100 passenger kilometres.
- In 2020, due to the Covid-19 pandemic, emissions reduced by more than 50% and population exposure to noise fell by about 65%, while the average grams CO_2 emitted per passenger kilometre increased back to 2005 level.
- Fleet renewal could lead to reductions in total noise exposure at European airports as measured by the L_{den} and L_{night} indicators over the next twenty years.
- In 2050, it is predicted that in-sector measures could reduce CO_2 emissions by 69% to 59 million tonnes compared to a business-as-usual “technology freeze” scenario (19% from Technology/Design, 8% from ATM-Ops, 37% from SAF and 5% from electric/hydrogen aircraft).

Aviation Environmental Impacts

- To mitigate adverse effects from aircraft noise on EU citizens' health, the World Health Organisation Europe recommends reducing aircraft noise levels below L_{den} 45dB and L_{night} 40dB.
- Air pollutant emissions from aviation have increased within the EU. Effective action requires better characterisation of aviation's specific contribution compared to other sources of emissions, especially on particulate matter.
- The growth in aviation CO_2 emissions was accelerating prior to Covid-19, with almost half of global CO_2 emissions between 1940 and 2019 having occurred since 2000.
- In 2018, the estimated Effective Radiative Forcing from non-CO_2 emissions accounted for more than half (66%) of the aviation net warming effect, although the level of uncertainty from the non-CO_2 effects is 8 times larger than that of CO_2.
- Environmental certification standards already exist for aircraft engine non-CO_2 emissions, including NO_X and nvPM, and further mitigation policy options are being considered.
- Where specific mitigation measures incur trade-offs between CO_2 and non-CO_2 emissions, a robust assessment methodology is essential to ensure an overall reduction in climate impact. In addition, 'win-win' options that reduce both simultaneously should be supported (e.g. appropriate sustainable aviation fuels).
- In 2022, the IPCC 6th Assessment Report noted that immediate, rapid and large-scale reductions in greenhouse gas emissions are needed to limit warming to 1.5°C and that the aviation sector is still in the earlier stages of adaptation to increased climate hazards.

Technology and Design

- New aircraft designs certified during the last 10 years (e.g. Airbus A320neo, A350 and Boeing 737MAX, 787) have a cumulative margin of 5 to 15 EPNdB below the latest Chapter 14 noise standard.
- While certification activities have recently reduced for conventional aircraft, they have increased in new market segments (e.g. Drones, Urban Air Mobility).
- EASA is developing dedicated noise certification standards for Drone and Urban Air Mobility aircraft that take into account their specific characteristics.
- In-production engine types were designed prior to the new non-volatile Particulate Matter (nvPM) standards and manufacturers are evaluating how to mitigate nvPM emissions in new engine designs.
- The engine NO_x/nvPM standards, and the aircraft noise/CO_2 standards, define the design space for products to simultaneously address noise, air quality and climate change issues.
- Pipistrel Velis Electro became the first fully electric general aviation aircraft to be certified by EASA in 2020 and is now being used by pilots to learn to fly.
- In 2021, the Airbus A330-900neo was the first aircraft to be approved worldwide against the new aeroplane CO_2 emissions standard, although certified aeroplane CO_2 data remains limited.

Sustainable Aviation Fuels

- Current SAF supply remains low at less than 0.05% of total EU aviation fuel use.
- The European Commission has proposed a SAF blending mandate for fuel supplied to EU airports, with minimum shares of SAF gradually increasing from 2% in 2025 to 63% in 2050, and a sub-mandate for Power-to-Liquid SAF.
- To achieve this mandate, approximately 2.3 million tonnes of SAF would be required by 2030, 14.8 million tonnes by 2040, and 28.6 million tonnes by 2050.
- Drop-in SAF will play a key part in decarbonising the aviation sector as they can be used within the existing global fleet and fuel supply infrastructure.
- Currently certified SAF are subject to a maximum blending ratio of 50% with fossil-based jet fuel depending on the feedstock-production pathway considered, but industry and fuel standard committees are looking into the future use of 100% SAF by 2030.
- SAF are certified by Sustainability Certification Schemes against criteria defined at EU level in the Renewable Energy Directive and at global level in the CORSIA framework.
- While SAF are currently more expensive than fossil-based jet fuel, cost savings are expected notably through future production economies of scale. SAF prices can vary depending on the production pathway, associated production costs and fluctuations in the energy market.

Air Traffic Management and Operations

- The European Green Deal requires a more ambitious, comprehensive and holistic approach involving all stakeholders to accelerate solutions to enable greener operations in the short term.

- In 2019, excess fuel burn on an average flight by flight basis within the Network Manager area was estimated to be between 8.6% (XFB10)[6] to 11.2% (XFB5), with excess fuel burn decreasing as the flight distance increases.

- The European ATM Master Plan, managed by SESAR 3, defines a common vision and roadmap for ATM stakeholders to modernise and harmonise European ATM systems, including an aspirational goal to reduce average CO_2 emission per flight by 5-10% (0.8-1.6 tonnes) by 2035 through enhanced cooperation, compared to 2017.

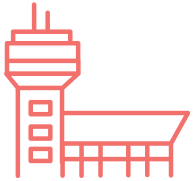
- Single European Sky (SES) union-wide environment targets were not reached during the entire RP2 period (2015-2019), with performance worsening in the second part of RP2. In 2020, whilst performance did improve, several Member States still did not achieve their environment targets despite the dramatic drop in traffic due to the pandemic.

- The KPI reflecting the relationship between flight routing and environmental impact is considered inadequate and needs to be re-evaluated, taking into account environmental indicators based on actual CO_2 emissions.

- As traffic returns to pre-Covid levels, efficiency improvements observed in 2020 should be maintained through 'green' recovery principles such as dynamic use of airspace constraints that are only applied when justified and the use of optimised flight planning by aircraft operators.

- It was estimated that, in 2018, 21% of ECAC flights performed fuel tankering, representing a net saving of €265 million per year for the airlines, but burning an unnecessary 286,000 tonnes of additional fuel (equivalent to 0.54% of ECAC jet fuel used).

6 The 10th percentile (XFB10) reference means in effect that for a city pair / aircraft type combination 90% of flights burnt more fuel than the reference and 10% of flights burnt the equivalent or less fuel.



Airports

- In 2020, EASA launched the Environmental Portal to facilitate sharing of Aircraft Noise Certificate information together with the ANP Database for sharing Aircraft Noise and Performance data.
- During 2020, approximately 50% of operations in Europe were by aircraft compliant with the latest Chapter 14 noise standard.
- There are significant delays in approving and implementing the Performance Based Navigation transition plans, which in turn delays the achievement of environmental benefits.
- As the aviation sector evolves to respond to environmental challenges, and new market segments are created, airport infrastructure also needs to adapt accordingly.
- By 2030, the European Green Deal's Zero Pollution Action Plan aims to reduce the share of people chronically disturbed by transport noise by 30% and improve air quality to reduce the number of premature deaths caused by air pollution by 55% (compared to 2017).
- In 2020, the Airport Carbon Accreditation Programme added Levels 4 (Transformation) and 4+ (Transition) to support airports in achieving net zero CO_2 emissions and to align it with the objectives of the Paris Agreement.

Market-Based Measures

- During 2013-2020, the EU Emissions Trading System led to a total reduction in aviation net CO_2 emissions of 159 Mt (approximately equivalent to the annual emissions of the Netherlands in 2018) through funding of emissions reductions in other sectors.

- Monitoring, reporting and verification of CO_2 emissions under the ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) began in 2019. 88 States volunteered to participate in the CORSIA offsetting pilot phase from 2021, including all EU and EFTA States. This has increased to 107 States in 2022 and represents a majority of ICAO Member States.

- The environmental integrity of offsets depends on their ability to demonstrate that the emissions reductions would not have occurred in the absence of the market mechanism that funds the offset.

- At COP26 in 2021, accounting rules under the Paris Agreement were agreed for international transfers of carbon market units, including the avoidance of double-counting of emission reductions in respect of CORSIA and nationally determined contributions by countries under the Climate Change Convention.

- International cooperation is key in building capacity to address the global environmental and sustainability challenges facing the aviation sector. EU funded action has enhanced the relationship with partner States on implementing CORSIA and other areas of environmental protection.

- Other measures linked to carbon pricing initiatives that are relevant for the aviation sector are being discussed in Europe.


Scandinavian
Airlines

Safety is a core element of the culture within the aviation sector and this commitment is reflected at all levels. The set of beliefs, values and rules, both formal and unspoken, on aviation safety is shared by all stakeholders and considered an essential prerequisite for a successful and effective business. The European Green Deal means that these same principles now need to be applied to the strategic issue of environmental protection to ensure the long-term viability of the industry.

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RECOMMENDATIONS

The following recommendations from EASA and EEA build on the information and analysis within the European Aviation Environmental Report (EAER) 2022. They aim to improve the level of environmental protection in the area of civil aviation and assist the European Union in ensuring that the aviation sector contributes to the objectives of the European Green Deal[7] through effective collaboration, commitment and verification.

Supporting the achievement of European environmental objectives

- To establish long-term noise and emissions reduction pathways and aspirational goals for European aviation in terms of in-sector (e.g. technology, operations, fuels) and out-of-sector (e.g. market-based) mitigation measures.
  - Support the European Green Deal objectives:
    - At least 55% reduction in economy-wide net greenhouse gas emissions by 2030, compared to 1990 levels, and a goal of climate neutrality by 2050.
    - 90% reduction in transport-related greenhouse gas emissions by 2050 compared to 1990 levels.
    - 30% reduction in the share of people chronically disturbed by transport noise by 2030 compared to 2017.
    - Improvement in air quality to achieve a 55% reduction in the number of premature deaths caused by air pollution by 2030 compared to 2005, including near airports by tackling the emissions of pollutants from aeroplanes and airport operations.
  - Strengthen the aviation sector's commitment in planning the necessary investments for the transition to a sustainable and climate-neutral economy.

7 The European Green Deal encompasses in particular the European Climate Law, the Sustainable and Smart Mobility Strategy and the Zero Pollution Action Plan.

- To enhance information underpinning the EAER and ensure a robust EU monitoring system on the environmental performance of the European aviation sector in support of the implementation of EU legislation and policy objectives, and to help verify the achievement of these objectives.
  - — Enhance datasets and analytical capabilities to provide an objective, comprehensive, transparent and accurate oversight of the historic and forecasted progress towards goals.

- To further explore economic incentives that encourage greater efficiency and improved environmental performance from airspace users, such as common unit rates and the modulation of Air Navigation Service charges.

- To develop environmental metrics that better reflect the environmental performance of ANSPs subject to the SES Performance Scheme, as well as other relevant stakeholders.

Integrating effective environmental measures into the European Air Traffic Management system

- To enhance implementation of the Single European Sky (SES) by the Network Manager, Air Navigation Service Providers (ANSPs), airports and other service providers[8], with a view to enable and incentivise airspace users to fly 'green' flight trajectories.
  - — Promote cross-border solutions and minimise network restrictions.

Scaling up the supply and use of Sustainable Aviation Fuels

- To explore the feasibility of putting in place a long-term coherent support structure to ensure the successful introduction of new SAF production pathways in Europe with high potential for emission reductions.
  - — Establish an EU Clearing House to support SAF producers through the fuel approval process and investigate an EU Fuel Standard to ensure robust certification processes that support environmental protection objectives.

8 For example, Providers of Data Services (PDS), European Satellite Service Providers (ESSP), European aeronautical information services database (EAD).

  - Advance approvals of higher SAF blends up to 100%, based on a diverse mix of feedstocks. Different types of SAF may support different aviation market segments in the medium term.

- To consider the use of the EU ETS Innovation Fund to support higher-risk SAF production investments, and other mechanisms that incentivise the uptake of SAF.

Promote research and identify solutions to address environment and climate impacts as well as build climate change resilience

- To respond to the IPCC 6th Assessment Report which states that aviation sector is a key vulnerable economic sector that is only in the early stage of adaptation to climate change.
  - Coordinate and enhance understanding on the hazards and risks to the aviation sector from climate impacts and extreme weather events.
  - Integrate climate adaptation and resilience considerations into planning processes, future investments and criteria applicable to the design of products and critical infrastructure.

- To coordinate and perform further research on the overall climate impact of aviation, including non-CO_2 emissions and contrail-cirrus cloud formation, that reduces scientific uncertainties and informs cost-effective actions.
  - Identify and apply 'win-win' solutions that reduce both CO_2 and non-CO_2 emissions and, where necessary, assess trade-offs from mitigation measures using a robust assessment methodology to ensure an overall reduction in climate and air quality impacts from aviation (e.g. changes to fuel specifications such as lower aromatics and/or sulphur, 'green' flight trajectories and use of Sustainable Aviation Fuels).

- To accelerate the development and deployment of technological and ATM solutions, in collaboration with key partners, to improve the environmental performance of the European and global fleet.

Incentivise technological innovation through continued international cooperation on regulatory standards

- To assess the environmental impact from new market segments (e.g. drones, urban air mobility, supersonic), and develop certification standards that ensure a high and uniform level of environmental protection which facilitates their integration into the aviation system.

- To develop, based on latest data, more stringent regulatory limits for existing ICAO environmental certification standards that are technologically feasible, economically reasonable and environmentally beneficial.

Fostering green airport operations and infrastructure

- To keep Performance-Based Navigation (PBN) transition plans up-to-date and fully implement them in line with the applicability dates of EU Regulation 2018/1048 on airspace usage requirements and operating procedures.
  - Assess and optimise the environmental benefits (noise and emissions) from PBN implementation when preparing transition plans.

- To incentivise and enable the development and implementation of necessary green airport infrastructure and operations (e.g. standards on supply of SAF / hydrogen / electrification).

- To promote Airport Noise Action Plans that mitigate adverse effects from aircraft noise on citizens' health by moving towards aircraft noise levels recommended by the World Health Organisation for the European Region.

Promoting investments and Market Based Measures to enhance the sustainability of aviation

- To ensure the environmental credibility of voluntary and compliance-based carbon credits used in offsetting or reducing emissions within the aviation sector.
- To continue the progressive inclusion of the costs from aviation environmental and climate impacts within market prices.
- To encourage the use of the EU Taxonomy system to incentivise sustainable investment within the aviation sector.

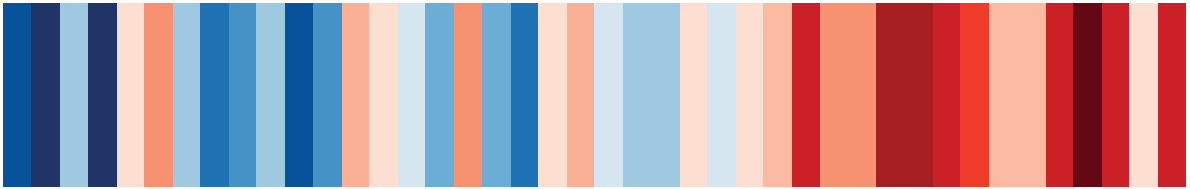
ISBN: 978-92-9210-277-7 (BOOK) | 978-92-9210-266-1 (PDF) **Catalogue Number:** TO-05-22-042-EN-C (BOOK) | TO-05-22-042-EN-N (PDF)
Doi: 10.2822432163 (BOOK) | 10.2822/455210 (PDF) **Photo credits:** Sylvain Ramadier, istock.com

Cover Pages

The aviation warming stripes were developed in collaboration with the University of Oxford, Manchester Metropolitan University, and the NERC National Centre for Earth Observation.

Aviation Warming Stripes

Based on a recent study that quantified aviation's contribution to global warming[9], the below aviation 'warming stripes' have been developed with the aim of communicating a complex message in a visually simple and memorable way that people can relate to. Warming stripes typically communicate on the impact of global warming in terms of changes in average surface temperature over time at the global or national level[10]. In comparison, the colours of the aviation warming stripes below represent the modelled % contribution of aviation emissions to overall global warming (temperature increase against a pre-industrial baseline) on an annual basis between 1980 (1.9% on left) and 2021 (3.7% on right).



9 Klöwer, M., Allen, M. R., Lee, D.S., Proud, S.R., Gallagher, L. and Skowron A. (2021) Quantifying aviation's contribution to global warming. Environmental Research Letters, Volume 16, Number 10.

10 University of Reading (2018), Warming Stripes.

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