EASA
European Union Aviation Safety Agency

# Research project: Upgrade of the AERO-MS model (MbM)

## Webinar: final dissemination event
19/03/24, 15:00-17:00 CET

An Agency of the European Union

This project is funded by the European Union's Horizon 2020 Programme

# Disclaimer

This project is funded by the European Union under the Horizon 2020 Programme.

Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Union Aviation Safety Agency (EASA). Neither the European Union nor EASA can be held responsible for them.

This deliverable has been carried out for EASA by an external organisation and expresses the opinion of the organisation undertaking this deliverable. It is provided for information purposes. Consequently, it should not be relied upon as a statement, as any form of warranty, representation, undertaking, contractual, or other commitment binding in law upon the EASA.

# Welcome to this webinar!


This webinar is the final dissemination event of this research project

This project has received funding from the European Union’s Horizon 2020 research and innovation Programme

The EC delegated the contractual and technical management of this research action to EASA

EASA contracted NLR for the implementation of the research action following a public tender procedure

EASA-managed projects are addressing research needs of aviation authorities and are an important pillar of the EASA R&I portfolio

# The agenda

| TIME | TITLE, SPEAKER |
|---|---|
| 15:00 H – 15:05 H | **Welcome to the webinar**<br>Willy Sigl, EASA |
| 15:05 H – 15:15 H | **Research scope and objectives**<br>Joonas Laukia, EASA |
| 15:15 H – 16:15 H | **Research activities and results**<br>Jan Middel, NLR |
| 16:15 H – 16:25 H | **Benefits from the project**<br>Joonas Laukia, EASA |
| 16:25 H – 16:55 H | **Questions and answers**<br>Participants, EASA Project Team, and Contractor Project Team |
| 16:55 H – 17:00 H | **Concluding remarks**<br>Willy Sigl, EASA |

**Note:** this webinar will be recorded and made available at the EASA website after the event.

# Question and Answers

→ For sending questions and input, please use the slido app, which is also accessible through WebEx:

- www.slido.com
- event code: 4145899
- passcode: mfhvmw

# Research Scope and Objectives


This project is funded by the European Union's Horizon 2020 Programme

# Introduction

- AERO-MS Originally developed during the 1990s by the Dutch government. EASA took ownership of AERO-MS in 2010 after an extensive update.
- Used extensively by EU bodies, European Member States, ICAO Secretariat, Industry and NGOs to support policy/regulatory assessments which are primarily related to market based measures
- Back in 2020, EASA signed a Framework Contract with NLR (working with sub-contractors TAKS, DLR and Systra) to update the AERO-MS model in terms of its underlying databases, methodologies and capabilities
- Three Specific Contracts. Third SC includes 12 substantive Tasks. This event is part of the dissemination task.

# European model - Organisations for which AERO-MS has been used

ICAO

MOVE

EASA
European Aviation Safety Agency

Ministerie van Infrastructuur
en Waterstaat

WWF

IATA

www.VectorSeek.com

CLIMATE

Clean Sky 2

Umwelt Bundesamt

TRANSPORT & ENVIRONMENT

European Climate Foundation

TAXUD

UNFCCC

Energy

SEVENTH FRAMEWORK PROGRAMME

Department
for International
Development

CMW

EASA

# Specific Contract 1 - Scoping the needs

- Objective: enhance and validate European modelling capabilities
  - Costs and benefits for wide range of future policy assessments
  - Consequences for various types of stakeholders
  - Options to interface with other models and databases

- Review of state-of-art aviation environmental policy assessments, AERO-MS like tools and data sources
- Review of emerging environmental policy needs and challenges (EU and international)
- Review of user experiences, capability limitations, model requirements and potential improvements
- Review of model security, and needs

# Specific Contract 1 - Results

- Inventory of 33 potential improvements
- Ranking based on benefits and costs
  - Update the base year (2019) traffic, fleet, costs & calibration
  - 6 major ones
  - others minor
  - a few not achievable, e.g. H2

# Specific Contract 2

- Starting point SC 1: options and ranking
- For each SC 1 candidate improvement:
  - Identify data requirements
  - Inventory shortlist of data sources (coverage, granularity, overlap, complementary)
  - If missing information: identify options for synthesis
  - Estimate modelling & implementation efforts
  - Identify interdependencies between options and existing functionality
- Short list of improvements to be implemented: SC 3

# Specific Contract 3 - Selected Improvements & implementation

- → Task 1: Update the AERO-MS baseline
- → Task 2: Implementing baseline scenario and testing
- → Task 3: Update price elasticities of demand in AERO-MS
- → Task 4: Add nvPM and volPM to the AERO-MS emissions inventory
- → Task 5: Improve the AERO-MS function for data export
- → Task 6: Specify in AERO-MS detour factors by flight stage
- → Task 7: Better align AERO-MS with PRIMES-TREMOVE
- → Task 8: Promote assumption variables to scenario variables
- → Task 9: Include Impact of SAF (and alternative propulsion systems) and related policies in AERO-MS
- → Task 10: Improve AERO-MS model security
- → Task 11: Dissemination and communication
- → Task 12: Training

# Research activities and results

# Task 1 – Base year upgrade: input data sources

- AERO-MS Base Year updated to 2019: main data sources
  - Observed traffic: EUROCONTROL (to/from EEA airspace) and FlightRadar24 data
    - Airport pair, operator, aircraft type
  - Aircraft fleet and performance: Cirium, BADA4, ICAO-EMDB
    - Aircraft properties by tail number, e.g. operator, seats, production year, value
    - Detailed aircraft performance
    - Engine emissions database
  - Costs and operations: ICAO-datasets:
    - Traffic by Flight Stage
    - Air Carrier and Personnel & Fleet
    - Air Carrier Finances
  - (US Form41 data)

# Task 1 – Overview

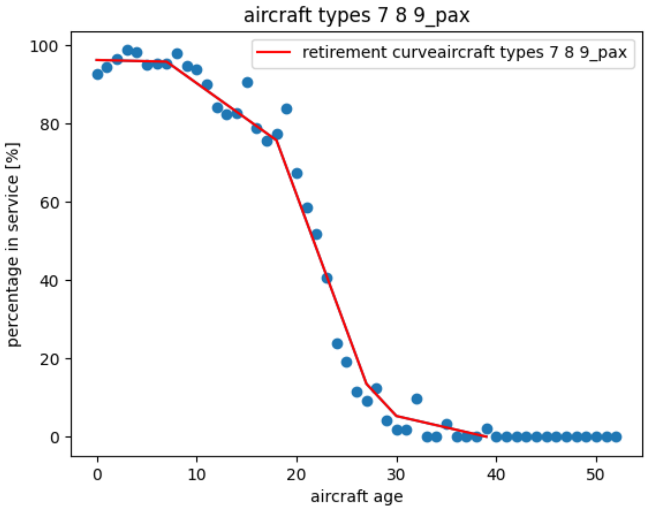
- Data availability: all necessary sources present
- Data processed and implemented:
  - ATEC: Fleet data, technology scenarios
  - ADEM: Operations and demand data
  - FLEM: Aircraft flight profiles and technology data
  - ACOS: Operating cost data
  - ADEM: Fare data
  - Framework/shell: AERO-MS dimension data
- Aircraft data, traffic data and costs data are processed and harmonized to fit AERO-MS
  - Calibration with external sources
- Data input protocol: steps from external data to calibrated AERO-MS

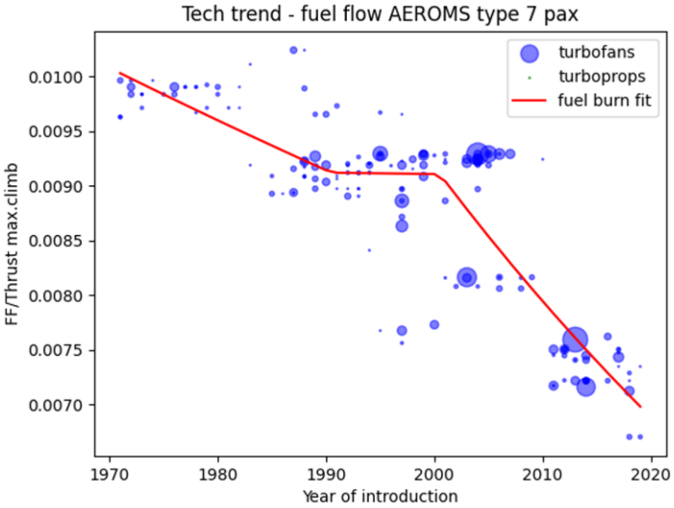
# Task 1 – ATEC fleet technology modelling

- Classify aircraft into: Purpose
  - Freighter, passenger
- Classify aircraft into: Seat bands
  - Aligned with ICAO
  - Historic sales trends
  - Retirement curves (proportion in service by production year)
  - Value, depreciation and new price (de-coupled tech trends)
  - Freight capacity, belly hold capacity
- Classify aircraft into: Technology levels
  - Old and current
  - Historic technology trends: fuel flow, noise, emissions
- Representative aircraft type selection
  - Link to FLEM performance, detailed flight trajectory, fuel burn and emissions modelling
  - Compared to average within group

| AERO-MS aircraft | AERO-MS generic aircraft type |
|---|---|
| 0 | less than 20 seats (short haul) |
| 1 | 20 to 50 seats (short haul) |
| 2 | 51 to 70 seats (short haul) |
| 3 | 71 to 100 seats (short haul) |
| 4 | 101 to 150 seats (medium haul) |
| 5 | 151 to 175 seats (medium haul) |
| 6 | 176 to 235 seats (medium haul) |
| 7 | 236 to 300 seats (long haul) |
| 8 | 301 to 500 seats (medium haul) |
| 9 | 501+ seats (medium haul) |

# Task 1 – ATEC fleet technology modelling

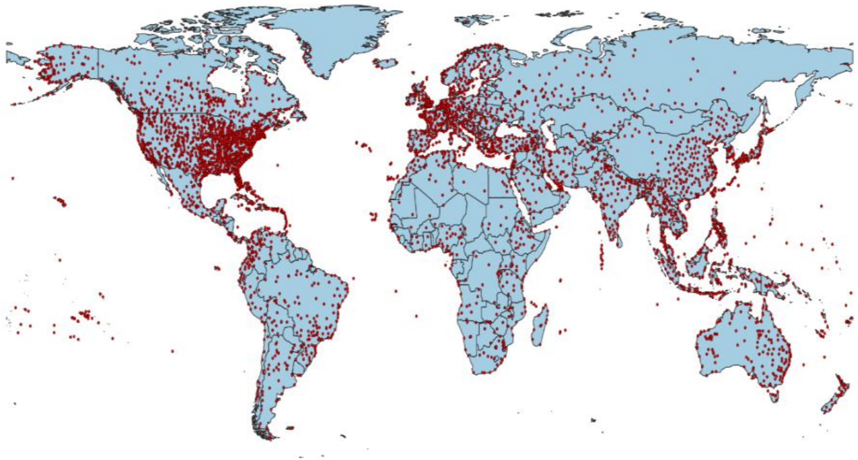


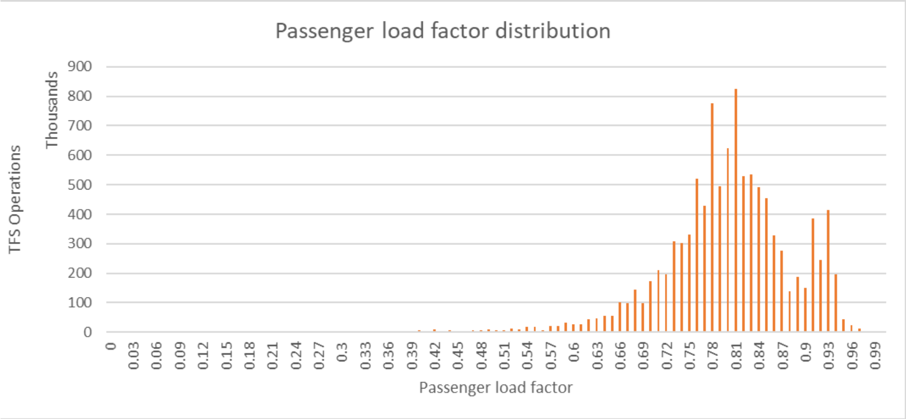




EASA

# Task 1 – ADEM traffic coverage

- Airport to airport
- Generic aircraft type, tech level
- Flights type
  - Scheduled pax - network carriers
  - Low costs carriers - charters
  - Scheduled freight
  - Chartered freight
  - Non-commercial
- Passenger flow converted into demand
  - Load factors, seats and freight capacities






EASA

# Task 1 – ADEM background data

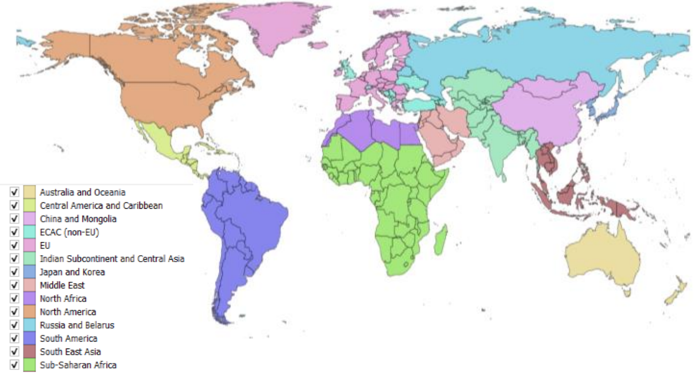
- Country attributes
  - GDP per capita
  - Population
  - Imports/Exports per capita
- Surface competition flag
  - High speed trains vs short distance flights

- Demand and traffic properties validated against
  - ICAO, Boeing
  - Pax, pax-km, (freigth) tonne-km,
  - Region level

| | AERO-MS | ICAO 2019 | % Diff |
|---|---|---|---|
| Operations | | | |
| All Flights (m) | 39.7 | | |
| Commercial operations (m) | 37.5 | 38.3 | -2% |
| Passengers | | | |
| Demand (m) | 4600 | 4486 | 3% |
| Passenger km (Bn) | 8608 | 8686 | -1% |
| RTK | | | |
| RTK Freighter (bn) | 112 | | |
| RTK Belly-hold (bn) | 131 | | |
| Total Freight RTK (bn) | 243 | 232 | 5% |
| Pax Tonne KM (bn) | 804 | 811 | -1% |
| Total RTK (bn) | 1,046 | 1,043 | 0% |
| ATK | | | |
| ATK Freighter (bn) | 165 | | |
| ATK belly (bn) | 333 | | |
| Total Freight ATK (bn) | 499 | | |
| ATK pax (bn) | 996 | | |
| Total ATK | 1,494 | 1,530 | -2% |
| Avg Load Factors | | | |
| Freighter | 68% | | |
| Belly-hold | 39% | | |
| Total freight | 49% | | |
| Passenger | 81% | 82% | -1% |
| Overall load factor | 70% | 68% | 2% |

# Task 1 – ACOS costs components in AERO-MS

- Costs differentiations:
  - AERO-MS generic aircraft type
  - Region
  - Flight type: LCC, FSC, shed/non-shed freight
- Costs components
  - Capital costs (depreciation, financing)
  - Operational costs
    - Fuel
    - ATM
    - Maintenance
    - Cockpit and cabin crew
    - Volume costs
- Revenues




- Calibration against:
  - IATA data
  - Missing details: use AERO-MS 2006

# Task 1 – Costs Calibration

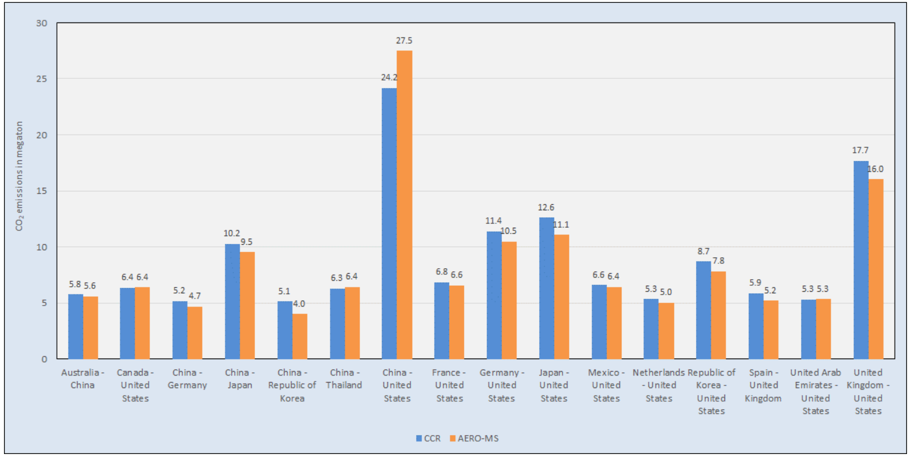
| Economic indicator | Unit | AERO-MS | IATA | % difference |
|---|---|---|---|---|
| Global airline revenues | billion US$ | 870 | 873 | -0.3% |
| Global airline expenses | billion US$ | 827 | 828 | -0.2% |
| Fuel costs | billion US$ | 189 | 188 | 0.7% |
| Labour costs | billion US$ | 186 | 188 | -1.0% |
| Gross Value Added (GVA) airline industry | billion US$ | 292 | 286 | 2.2% |
| Airline employment | million | 2.9 | 2.9 | 1.2% |
| GVA/employee | US$ | 99,477 | 98,483 | 1.0% |
| Operating profit | % of revenues | 5.0% | 5.1% | 0.1%* |

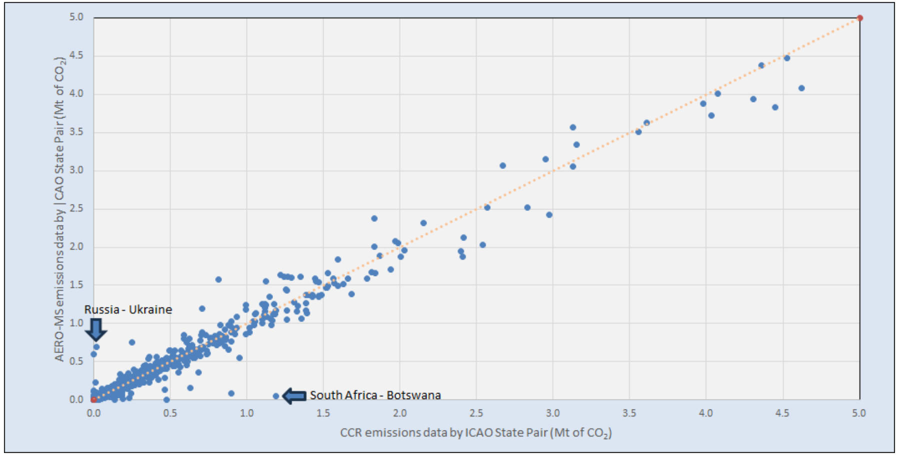
# Task 1 – FLEM performance model

- BADA 4, PEM style modelling of detail flight profiles, fuel burn, emissions
  - Weights, aerodynamics (lift, drag), propulsion (fuel flow incl emissions), operations (speeds, altitudes)
  - Confidential info: encryption
- Combine specific (representative) aircraft fuel and emissions characteristics with fleet level (old-current, seat-band average aircraft) technology properties: EMDB fuel burn and emissions.
  - Per technology level and seat-band
  - Produce flight trajectories and fuel burn and emissions along flight trajectories
  - Inventory emissions and fuel in 3D global grid
  - 2019 Base case
  - Embed fleet growth and technology scenarios for future fleet

# Task 1 – FLEM fuel burn calibration

- Fuel burn results compared to:
  - IATA, ATAG, ICCT (international + domestic commercial aviation)
  - CORSIA central registry (international aviation)
  - Small differences can be explained




EASA

# Task 2 – Implementing baseline scenario and policy testing

- → Baseline scenarios defined up to 2070 and tested for: 2028, 2038 and 2050 and 2070
- → Basis: the CAEP13 Mid Outlook growth in air transport passenger demand and cargo demand specified for 50 CAEP route groups.
- → Demand growth assumptions are supplemented with assumptions regarding: i) technology and operational improvements ; ii) load factors; and iii) crude oil price
- → All assumptions have been translated into AERO-MS scenario variables.
- → An output table with the main AERO-MS scenario results for the global aviation industry (international + domestic) is made. Results are also presented relative to the results of the Base Year 2019 run.
- → Scenario computation results, (incl. 2070), are as expected in light of the scenario assumptions. Hence, the time horizon for the updated AERO-MS has been successfully extended to the year 2070.

# Task 2 – Baseline scenario results

| Effect | Unit | Base Year 2019 | Baseline scenario results (absolute) | | | | Average annual % change | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | CAEP13 Mid 2028 | CAEP13 Mid 2038 | CAEP13 Mid 2050 | CAEP13 Mid 2070 | 2019-2028 | 2028-2038 | 2038-2050 | 2050-2070 |
| **Air transport and aircraft operations** | | | | | | | | | | |
| Passenger demand - scheduled network carriers | | | | | | | | | | |
| a. First/business | billion pax-km pa | 627 | 764 | 1,123 | 1,803 | 3,347 | 2.2% | 3.9% | 4.0% | 3.1% |
| b. Economy | billion pax-km pa | 5,599 | 6,794 | 10,017 | 15,954 | 29,673 | 2.2% | 4.0% | 4.0% | 3.2% |
| c. Total scheduled network carriers | billion pax-km pa | 6,226 | 7,558 | 11,140 | 17,757 | 33,020 | 2.2% | 4.0% | 4.0% | 3.2% |
| Passenger demand - LCC and non-scheduled | billion pax-km pa | 2,382 | 2,841 | 4,168 | 6,680 | 12,574 | 2.0% | 3.9% | 4.0% | 3.2% |
| Total passenger demand | billion pax-km pa | 8,608 | 10,399 | 15,307 | 24,436 | 45,594 | 2.1% | 3.9% | 4.0% | 3.2% |
| Cargo demand | billion tonne-km pa | 243 | 320 | 453 | 628 | 1,204 | 3.1% | 3.5% | 2.8% | 3.3% |
| Revenue tonne-Km (RTK) | billion RTK pa | 1,047 | 1,291 | 1,883 | 2,911 | 5,462 | 2.4% | 3.8% | 3.7% | 3.2% |
| Available tonne-Km (ATK) | billion ATK pa | 1,494 | 1,833 | 2,657 | 4,171 | 7,654 | 2.3% | 3.8% | 3.8% | 3.1% |
| Flights | million | 38 | 46 | 64 | 96 | 169 | 2.4% | 3.3% | 3.5% | 2.8% |
| Aircraft km | billion ac-km pa | 60 | 72 | 99 | 151 | 266 | 2.1% | 3.3% | 3.6% | 2.9% |
| **Effects on airlines** | | | | | | | | | | |
| Direct operating costs | billion 2019 US $ | 436 | 577 | 759 | 1,138 | 1,926 | 3.2% | 2.8% | 3.4% | 2.7% |
| Total operating costs | billion 2019 US $ | 827 | 1,098 | 1,463 | 2,259 | 4,085 | 3.2% | 2.9% | 3.7% | 3.0% |
| Total operating revenues | billion 2019 US $ | 870 | 1,138 | 1,524 | 2,353 | 4,284 | 3.0% | 3.0% | 3.7% | 3.0% |
| Total operating result* | % of revenues | 5.0% | 3.5% | 4.0% | 4.0% | 4.7% | n.a. | n.a. | n.a. | n.a. |
| Contribution to gross value added | billion 2019 US $ | 292 | 402 | 559 | 906 | 1,662 | 3.6% | 3.4% | 4.1% | 3.1% |
| Airlines related employment | 1000 employees | 2,935 | 3,471 | 4,752 | 7,477 | 14,211 | 1.9% | 3.2% | 3.8% | 3.3% |
| **Economic effects for other actors** | | | | | | | | | | |
| Commercial fleet | number of aircraft | 25,822 | 31,605 | 42,425 | 61,684 | 106,788 | 2.3% | 3.0% | 3.2% | 2.8% |
| **Fuel consumption and emissions commercial aviation** | | | | | | | | | | |
| Fuel use | billion kg pa | 293 | 321 | 395 | 526 | 827 | 1.0% | 2.1% | 2.4% | 2.3% |
| $CO_2$ emissions | billion kg pa | 925 | 1,012 | 1,247 | 1,662 | 2,610 | 1.0% | 2.1% | 2.4% | 2.3% |
| **Operating efficiency commercial aviation** | | | | | | | | | | |
| Direct operating costs / RTK | US$/tonne-km | 0.42 | 0.45 | 0.40 | 0.39 | 0.35 | 0.8% | -1.0% | -0.3% | -0.5% |
| Total oparting cost / RTK | US$/tonne-km | 0.79 | 0.85 | 0.78 | 0.78 | 0.75 | 0.8% | -0.9% | 0.0% | -0.2% |
| Fuel / RTK | kg/tonne-km | 0.28 | 0.25 | 0.21 | 0.18 | 0.15 | -1.3% | -1.7% | -1.2% | -0.9% |
| Fuel / ATK | kg/tonne-km | 0.20 | 0.17 | 0.15 | 0.13 | 0.11 | -1.3% | -1.6% | -1.4% | -0.8% |
| RTK / ATK | factor | 0.70 | 0.70 | 0.71 | 0.70 | 0.71 | 0.1% | 0.1% | -0.1% | 0.1% |
| RTK / aircraft-km | tonne-km/ac-km | 17.58 | 17.97 | 18.97 | 19.26 | 20.54 | 0.2% | 0.5% | 0.1% | 0.3% |
| Revenues / RTK | US$/tonne-km | 0.83 | 0.88 | 0.81 | 0.81 | 0.78 | 0.6% | -0.8% | 0.0% | -0.2% |
| Fuel / aircraft-km | kg/ac-km | 4.92 | 4.46 | 3.98 | 3.48 | 3.11 | -1.1% | -1.1% | -1.1% | -0.6% |

* Total operating result is presented as a % of operating revenues for the base year and the baseline scenarios.

EASA

# Task 2 – Implementing baseline policies

- Policy tests: (not necessarily reflecting current ambitions)
  - A global fuel taxation of 0.50 US$ per kg of fuel (FuelTax 0.50US$ / kg);
  - A global $CO_2$ taxation of 50 US$ per ton of $CO_2$ ($CO_2$Tax 50US$ / tonne);
  - A global passenger ticket and cargo taxation of 10% (Ticket + CargoTax 10%).
- The impacts of the policy tests are presented relative to the (baseline) scenario and can be explained given the policy specifications and some of the updates made as part of SC3 (e.g. updated elasticity values).
- The scenario and policy test specifications are included in the updated AERO-MS. Hence users can reproduce the results which will be presented in D1.

# Task 2 – Baseline policy results

| Effect | Unit | Baseline scenario: CAEP13 Mid 2038 | Policy tests results (absolute) | | | Policy tests impacts (% change relative to baseline scenario) | | |
|---|---|---|---|---|---|---|---|---|
| | | | FuelTax 0.50US$_pkg | CO2Tax 50US$_pt | Ticket+CargoTax 10% | FuelTax 0.50US$_pkg | CO2Tax 50US$_pt | Ticket+CargoTax 10% |
| **Air transport and aircraft operations** | | | | | | | | |
| Passenger demand - scheduled network carriers | | | | | | | | |
| a. First/business | billion pax-km pa | 1,123 | 1,095 | 1,114 | 1,104 | -2.5% | -0.8% | -1.7% |
| b. Economy | billion pax-km pa | 10,017 | 9,257 | 9,758 | 9,442 | -7.6% | -2.6% | -5.7% |
| c. Total scheduled network carriers | billion pax-km pa | 11,140 | 10,352 | 10,871 | 10,547 | -7.1% | -2.4% | -5.3% |
| Passenger demand - LCC and non-scheduled | billion pax-km pa | 4,168 | 3,544 | 3,938 | 3,849 | -15.0% | -5.5% | -7.6% |
| Total passenger demand | billion pax-km pa | 15,307 | 13,896 | 14,809 | 14,396 | -9.2% | -3.3% | -6.0% |
| Cargo demand | billion tonne-km pa | 453 | 416 | 440 | 433 | -8.2% | -2.8% | -4.5% |
| Revenue tonne-Km (RTK) | billion RTK pa | 1,883 | 1,714 | 1,823 | 1,777 | -9.0% | -3.2% | -5.6% |
| Available tonne-Km (ATK) | billion ATK pa | 2,657 | 2,427 | 2,576 | 2,518 | -8.7% | -3.1% | -5.2% |
| Flights | million | 64 | 58 | 62 | 60 | -8.5% | -2.9% | -6.1% |
| Aircraft km | billion ac-km pa | 99 | 91 | 96 | 94 | -8.3% | -2.9% | -5.7% |
| **Effects on airlines** | | | | | | | | |
| Direct operating costs | billion 2019 US $ | 759 | 867 | 794 | 841 | 14.2% | 4.6% | 10.9% |
| Total operating costs | billion 2019 US $ | 1,463 | 1,526 | 1,483 | 1,507 | 4.3% | 1.3% | 3.0% |
| Total operating revenues | billion 2019 US $ | 1,524 | 1,579 | 1,542 | 1,560 | 3.6% | 1.2% | 2.3% |
| Total operating result* | % of revenues | 4.0% | 3.3% | 3.8% | 3.4% | n.a. | n.a. | n.a. |
| Contribution to gross value added | billion 2019 US $ | 559 | 515 | 545 | 523 | -7.8% | -2.6% | -6.5% |
| Airlines related employment | 1000 employees | 4,752 | 4,390 | 4,626 | 4,485 | -7.6% | -2.6% | -5.6% |
| **Economic effects for other actors** | | | | | | | | |
| Commercial fleet | number of aircraft | 42,425 | 38,925 | 41,168 | 39,998 | -8.2% | -3.0% | -5.7% |
| Revenue from taxation** | billion 2019 US $ | n.a. | 176 | 60 | 142 | n.a. | n.a. | n.a. |
| **Fuel consumption and emissions aviation sector** | | | | | | | | |
| Fuel use | billion kg pa | 395 | 353 | 380 | 373 | -10.6% | -3.8% | -5.5% |
| $CO_2$ emissions | billion kg pa | 1,247 | 1,114 | 1,199 | 1,178 | -10.6% | -3.8% | -5.5% |
| **Operating efficiency commercial aviation** | | | | | | | | |
| Direct operating costs / RTK | US$/tonne-km | 0.40 | 0.51 | 0.44 | 0.47 | 25.5% | 8.0% | 17.4% |
| Total oparting cost / RTK | US$/tonne-km | 0.78 | 0.89 | 0.81 | 0.85 | 14.6% | 4.6% | 9.1% |
| Fuel / RTK | kg/tonne-km | 0.21 | 0.21 | 0.21 | 0.21 | -1.8% | -0.7% | 0.1% |
| Fuel / ATK | kg/tonne-km | 0.15 | 0.15 | 0.15 | 0.15 | -2.1% | -0.8% | -0.3% |
| RTK / ATK | factor | 0.71 | 0.71 | 0.71 | 0.71 | -0.3% | -0.1% | -0.4% |
| RTK / aircraft-km | tonne-km/ac-km | 18.97 | 18.82 | 18.92 | 18.99 | -0.8% | -0.2% | 0.1% |
| Revenues / RTK | US$/tonne-km | 0.81 | 0.92 | 0.85 | 0.88 | 13.8% | 4.5% | 8.4% |
| Fuel / aircraft-km | kg/ac-km | 3.98 | 3.88 | 3.94 | 3.99 | -2.5% | -0.9% | 0.2% |

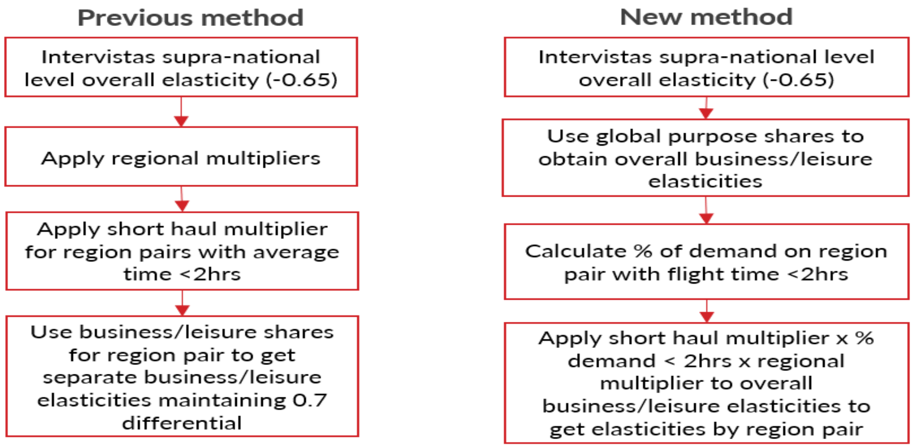
* Total operating result is presented as a % of operating revenues for the baseline scenario and the policy cases.

** For policy cases this impact is presented in absolute terms (and thus not as a % change relative to the scenario case).

EASA

# Task 3 – Passenger fare elasticities

- Intervistas report remains the most recent source of elasticities with adequate coverage
- Method of converting Intervistas values to appropriate values for AERO-MS has been reviewed and updated
- Previous method produced values which varied too much for a particular purpose, and placed a lot of weight on the region specific purpose shares
- New method gives more consistent values for each journey purpose and an overall smaller elasticity
- Intra Europe values validated against values used in UK National Air Passenger Model
- Passenger ticket class to journey purpose proportions are under review as part of this task



# Task 4 – Particulate Matter (PM) implementation

- Approach (ATEC, FLEM)
  - FLEM implementation as other engine type and operations related emissions: CxHy, CO, NOx
    - Follows ICAO Doc. 8998 volatile (CxHy related) & non-volatile (Sulphur related)
    - Boeing-2 fuel flow approach for operations (speed, altitude)
    - PM emissions certification values available for reference aircraft (ICAO-EMDB)
  - Implementation of PM technology scenario in ATEC (fleet evolution)

- Steps taken
  - Software adjustments in ATEC (include PM in timeline scenario) and FLEM (emission calculations)
  - Data gathering and implementation (FLEM, ATEC variables related to emissions)
  - Calibration and checks on visibility in AERO-MS user-interface

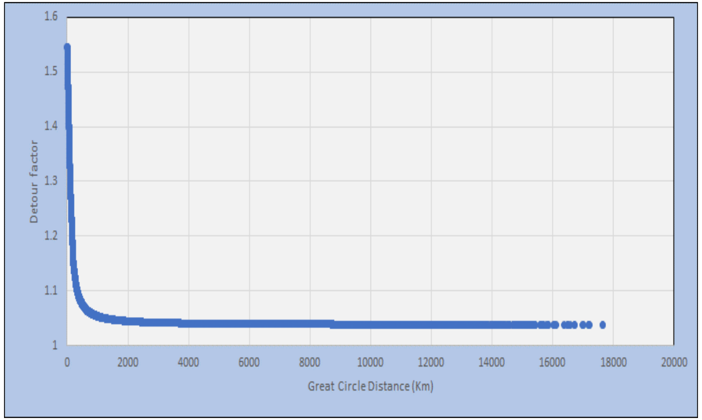
- Optional future work
  - Possible adjustment to comply with ongoing insights in PM calculation methodology

# Task 5 – Improve the AERO-MS function for data export

- Task 5 has been completed and embedded in AERO-MS and consist of two improvements:
  - Improve the AERO-MS export function with variables that have a dimension “Flight Stage” including options to aggregate over (other) dimensions. The actual implementation has been achieved by improving the capabilities of the reporting functionality. The reports are to an Excel workbook, which can then be converted to *.csv or some other convenient format. A few sample export templates (that export variables with dimension “flight stage”) have been added to the reporting facility of AERO-MS.
  - Compute the available tonne kilometers (ATK) by “Flight Stage” allowing to combine with revenue tonne kilometer (RTK) to show load factors at country level.

# Task 6 – Specify in AERO-MS detour factors by flight stage

- Detour factors reflect the relative difference between great circle distances and actual flight distances.
- Detour factors were dimensioned by region pair. In the new AERO-MS by flight stage (i.e. airport pair)
  - Code changes were made in FLEM and DECI to change dimension of detour factor variable. Also changes in ACOS code to be able to use the detour factors by flight stage in a loop over region pairs.
- Detour factors by flight stage provide improved analysis opportunities, e.g.:
  - Analysis of environmental benefits of ban of short flights (i.e. emissions on short flights computed more accurately in updated version AERO-MS).
  - Analysis of environmental benefits of ATM improvements in specific parts of European airspace.
  - Impact on fuel use / CO2 emissions of measures to address non-CO2 impacts which affect flight trajectories for a specific subset of airport pairs.



# Task 7 – AERO-MS alignment with PRIMES-TREMOVE

- AERO-MS and PRIMES-TREMOVE widely in use within EU.
- AERO-MS focus on aviation, PRIMES-TREMOVE multi-modal transport modes
- Potential linkages/alignment: EU reference scenario's
  - EU-ETS, ticket pricing and demand response
  - Interviews with end-users and developers
  - Overlap and differences: difference in granularity
  - PRIMES-TREMOVE outputs can help to guide AERO-MS scenario development:
    - Crude oil prices, EU-ETS prices, demand changes,

# Task 8 – Promote assumption variables to scenario variables

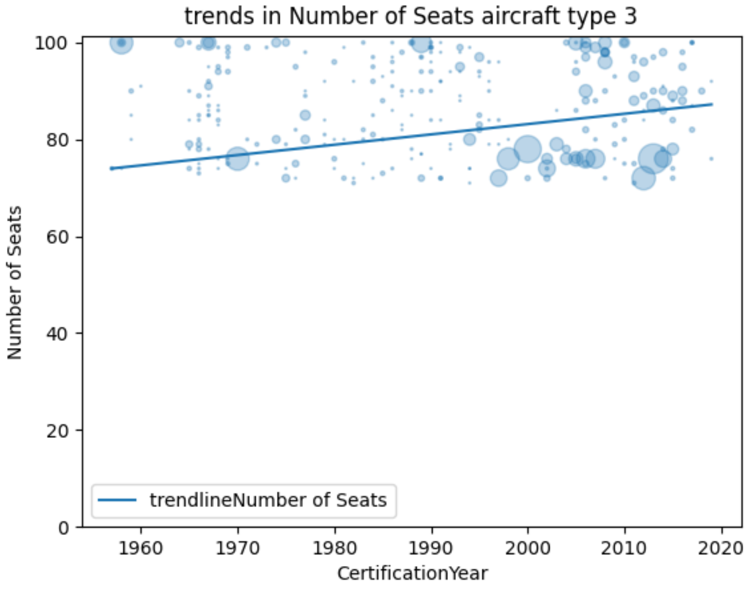
- Observations
  - Some (constant) assumption variables might change with time
  - Usually relevant for fleet properties

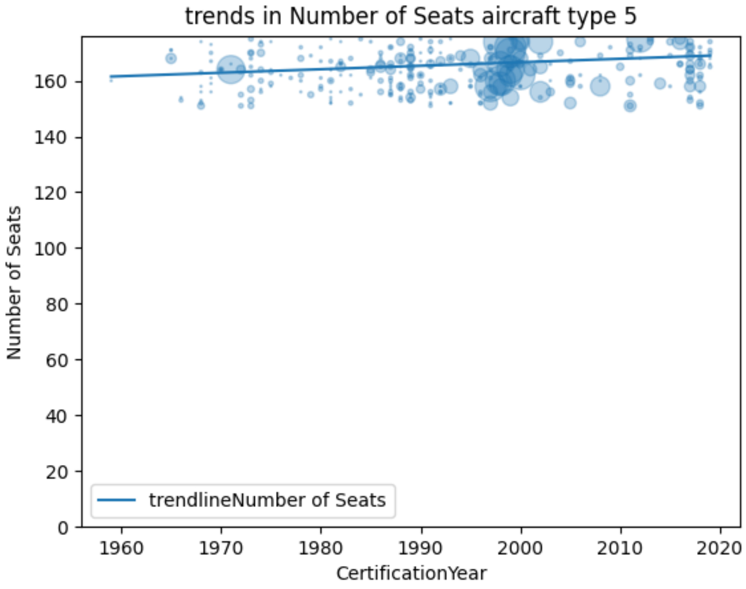
- Process
  - Development of tooling to retrieve trendlines from Cirium fleet properties
  - Selection of candidate Cirium data / AERO-MS variables
    - Assumption variables are fixed, independent on time
    - Scenario policy variables vary with time
    - Criterion: promotion should be meaningful for results
      - Note: some assumptions are already (implicitly) supported by scenario variables, e.g. weight impact on fuel burn

EASA

# Task 8 - Promote assumption variables to scenario variables

- Selected variables:
  - Seat growth within a generic aircraft type seat-band
  - Belly hold cargo on passenger aircraft




EASA

# Task 9 – Sustainable Alternative Fuels: Drop-in fuels

- Modelling approach: two main impacts of SAF which AERO-MS:
  - Reduction in CO2 emissions due to demand impact of higher SAF prices
  - Reduction of CO2 emissions due to SAF properties: Emission Reduction Factor (ERF)

- Implementation
  - Scenario/Policy variable:  (SAF) fuel price increase per flight stage (as a fuel tax)
  - Scenario/Policy variable: ERF per flight stage (airport pair)
    - (mandatory) blend of fossil fuel and SAF: input
  - Results:  Life Cycle CO2 emissions per flight stage, fuel costs changes.
  - (can be aggregated into country, region, world, region pair etc.)

# Task 9 – Sustainable Alternative Fuels: Drop-in fuels

- NOTES on implementation
  - $CO_2$ reduction at (production) source (dimension airport, region) not along a flight trajectory
  - SAF/fossil fuel blending possible
  - Reduction in demand follows from input of higher fuel prices (through fuel tax) in a policy run. The higher fuel price can be based on the proportion of SAF to be blended and the SAF price. No model changes required in this respect
  - Not accounting for minor differences in chemical composition: emissions & fuel burn changes
  - Other (minor) impacts follow automatically e.g. fleet renewal through costs impacts

# Task 9 – SAF sample case inputs

- ReFuelEU In October 2023, the ReFuelEU Aviation initiative was adopted by the EU Council. For flights departing from airports in the EEA fuel suppliers will have to incorporate 2% SAF in 2025, 6% in 2030, 20% in 2035, 34% in 2040, 42% in 2045 and 70% in 2050.
- Assumptions adopted in the test-case:
  - Mix of different types of SAFs from the impact assessment study for ReFuelEU Aviation initiative;
  - Emission Reduction Factors for different types of SAF from CORSIA eligible fuel documents;
  - Price trajectories for different types of SAFs in case of the ReFuelEU Aviation policy scenario from a PwC report.
  - The costs of EU ETS allowances (for intra EEA traffic) and CORSIA offsets (extra EEA traffic) which reduce the additional SAF related costs because of reduced obligations to surrender allowances or offsets.
- Impacts of ReFuelEU Aviation are presented for all EEA related routes. This includes:
  - Intra EEA routes (subject to the SAF blending mandate in 2 directions);
  - Extra EEA routes departing from the EEA (subject to the SAF blending mandate);
  - Extra EEA routes arriving in the EEA (not subject to the SAF blending mandate, but demand is affected because price increases are assessed based on a return ticket basis).

# Task 9 – SAF sample case outputs

| | Unit | Baseline scenario: CAEP13 Mid 2038 | ReFuelEU Aviation 2038 | % change relative to baseline scenario<br>ReFuelEU Aviation 2038 |
|---|---|---|---|---|
| **Aircraft operations** | | | | |
| Flights | million | 12.3 | 12.0 | -2.8% |
| Aircraft km | billion ac-km pa | 20.8 | 20.2 | -2.9% |
| **Passenger and cargo demand** | | | | |
| Passenger-km - scheduled network carriers | billion pax-km | 2,182 | 2,138 | -2.0% |
| Passenger-km - LCC and non-scheduled | billion pax-km | 1,315 | 1,243 | -5.5% |
| Total passenger demand | billion pax-km | 3,497 | 3,381 | -3.3% |
| Cargo tonne-km | billion tonne-km | 99 | 97 | -2.3% |
| Revenue tonne-Km (RTK) | billion RTK pa | 426 | 413 | -3.1% |
| Available tonne-Km (ATK) | billion ATK pa | 585 | 567 | -3.0% |
| **Fuel consumption and emissions** | | | | |
| Fuel use (fossil fuel plus SAF) | billion kg pa | 88 | 84 | -3.9% |
| Use of SAF | billion kg pa | 0 | 15 | n.a. |
| $CO_2$ emissions (direct emissions) | billion kg pa | 277 | 266 | -3.9% |
| SAF Life Cycle $CO_2$ emissions reduction | billion kg pa | 0 | 38 | n.a. |
| $CO_2$ emissions (net emissions) | billion kg pa | 277 | 228 | -17.7% |
| **$CO_2$ emission reduction** | | | | |
| Contribution of lower SAF Life Cycle $CO_2$ emissions | % | n.a. | 78% | n.a. |
| Contribution of reduction within aviation sector | % | n.a. | 22% | n.a. |

→ Because of the increased stringency of the blending mandate over time, the impact of the ReFuelEU Aviation policy also increases over time. CO2 emissions on routes from/to the EAA decrease by 17.7% compared to 2.6% in 2028.

→ The total demand for SAF resulting from ReFuelEU Aviation is 15 Mt in 2038 (up from 2 Mt in 2028).

→ The relative contribution of the reduction within the aviation sector is expected to decrease over time (from 30% in 2028 to 22% in 2038). This is because of the increased ERF of SAFs over time but also because of expected unit cost reduction of SAFs over time.

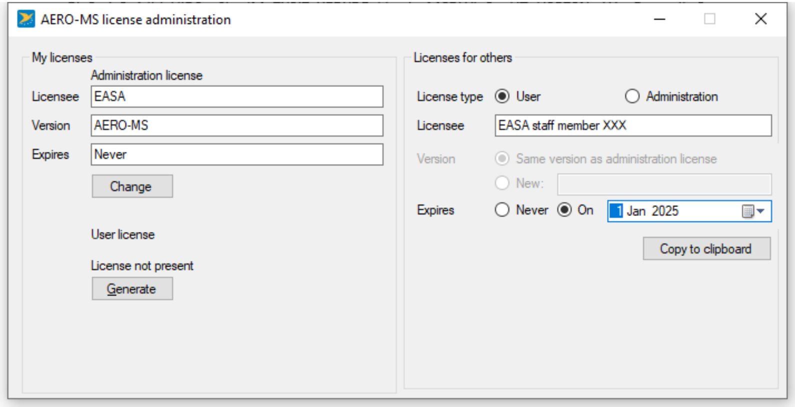
EASA

# Task 9 – SAF sample case conclusions

- Latest version of AERO-MS can be used to assess the impacts of SAF policies.
- The AERO-MS is able to assess the combined impact on CO2 emission resulting from the lower Life Cycle CO2 emissions of SAFs and the reduction within the aviation sector. The latter is often not assessed in analyses, but the analysis of ReFuelEU Aviation shows it is not insignificant.
- The AERO-MS can be used to forecast the demand for SAFs resulting from ReFuelEU Aviation.
- The ReFuelEU Aviation test-case shows the ability of the updated AERO-MS to assess the impact of regional policies in addition to the ability to analyse global policies.
- In a more elaborate analysis of ReFuelEU Aviation, impacts could be split out between intra and extra EEA routes. Also the AERO-MS allows impacts to be shown per EEA Member State.
- In this test-case the impacts of ReFuelEU Aviation are presented relative to the CAEP13 mid growth scenario. Similarly, the impacts could be shown relative to a European baseline scenario (e.g. EU Reference scenario).
- **There are relations of SAF policies with other policies like EU ETS and CORSIA. The AERO-MS can also be used to assess the impact on demand (and the resulting reduction of emissions within the aviation sector) of a package of policies.**

# Task 10 – Improve AERO-MS model security

- AERO-MS security:
  - New license manager: authorized and temporarily access
  - License (keys) to be obtained from EASA
  - Encrypted data, sensitive input data not accessible by end-users
    - Not visible in user interface
    - Encrypted data in files



# Task 11 – Communications

- Project webpage updated: [https://www.easa.europa.eu/en/research-projects/environmental-research-market-based-measures](https://www.easa.europa.eu/en/research-projects/environmental-research-market-based-measures)

- Final Dissemination Event, project end meeting and AERO-MS Training: March 2024

## Environmental Research - Market-based Measures

Show internal statistics

PROJECT - OPEN | HORIZON 2020 | EASA participation: Contract and technical management | Research Domain: Environment

### Context

The Aviation Emissions and evaluation of Reduction Options Modelling System (AERO-MS) is a bespoke software developed to examine the environmental and economic impacts of a wide range of policies intended to reduce greenhouse-gas emissions from international and domestic aviation. The types of policies AERO-MS can model include technological, operational and market-based measures. Since EASA obtained the Intellectual Property Rights for AERO-MS in 2009, the tool has been applied for policy-impact assessments in about 35 studies and research projects.

### Overall objective and expected outcome

The objective of this framework contract is to update and enhance AERO-MS and thereby increase the European modelling capability for a wide range of future aviation policy assessments.
The extended and updated capabilities of AERO-MS will be used for policy decisions at European level as well as at the ICAO level.
The main users of the upgraded AERO-MS tool will be the European Commission, EASA, Member States and research centres.

# Task 12 – Training

- Training on the updated AERO-MS model

- Set up of the training
  - General introduction AERO-MS
  - Presentation of AERO-MS Interface
  - First example cases to be explored by trainees
  - Feed-back on first user experiences
  - Second example cases to be explored by trainees
  - Final feed-back and closure

EASA

EASA
European Union Aviation Safety Agency

# Benefits from the project


This project is funded by the European Union's Horizon 2020 Programme

# Updated AERO-MS Ready for Applications

- Intended usage of the model:
  - Use the updated AERO-MS for a wide range of future **aviation policy impact assessments** (e.g., on CORSIA, ETS, ReFuelEU)
  - Modelling of Market-based measure impacts for the **2025 European Aviation Environmental Report (EAER)** and subsequent EAER versions
  - Use the updated AERO-MS to support ICAO Council in conducting the 2025 (and subsequent) **periodic reviews on CORSIA**
  - Use the updated AERO-MS to support the revision of the **EU ETS Directive** in 2027
  - Use the updated AERO-MS to support any additional policy impact assessments related to, e.g., **fuel and ticket taxation** initiatives, **green investment taxonomy** or economic and environmental impacts of **Sustainable Aviation Fuels**

# Questions and answers

# Question and Answers

→ For sending questions and input, please use the slido app, which is also accessible through WebEx:

- www.slido.com
- event code: 4145899
- passcode: mfhvmw

# Concluding Remarks

# Recent and upcoming EASA research & innovation events

March 12th
Integrity improvement of rotorcraft main gear boxes (**MGB**)
Final dissemination event (webinar)

March 13th
Assessment of environmental impacts – rotorcraft (**NOISE**)
Final dissemination event (webinar, training for users)

March 19th
Market-based Measures – AERO-MS (**MbM**)
Final dissemination event (webinar); Training event on 20 March

April 23rd
New standards for drones and U-Space (**SHEPHERD**)
Final dissemination event (webinar)

April 23-24
Mental Health of Pilots and ATCOs (**MESAFE**)
Final dissemination event during EASA Mental Health Conference

April 25th
Helicopter underwater escape #2 (**HUE2**)
Final dissemination event (webinar)


EASA

# Aviation Authorities Research Agenda – topics

**Environment**

- New SAF production pathways

**Artificial intelligence**

- Human factors

**Security impacting safety**

- AI aspects, conflict zones

**Health / medical**

- Obstructive sleep apnea, high air space operations

**Automation**

- Impact on responsibilities of flight crews and air traffic controllers

**Air operations**

- Flight time limitations for EMCO

**ATM / ANS**

- Performance of ground equipment, airspace classifications

**Drones**

- BVLOS operations

**Data for Safety**

- Research on future uses cases

**PNT**

**Icing**


EASA
MAB RESEARCH Group
Proposed research topics for
Horizon Europe Work Programme(s) 2025-2027
Aviation authority needs – proposed as indirect managed topics
EASA
MAB RESEARCH Group
Proposed research topics for
Horizon Europe Work Programme(s) 2025-2027
Aviation

# Thank you for joining this webinar!

[Environmental Research – Market-based Measures | EASA (europa.eu)]

AEROMS@easa.europa.eu