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Executive summary

Aviation and Emissions Scenario and Policy Analysis Capabilities of AERO-MS

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Introduction and objective

Models are playing an increasing role in the assessment of aviation's environmental impact, as well as how this impact may evolve in the future according to different scenarios and the potential implementation of new environmental policy options.

Being able to anticipate the impact of such policies is indeed crucial given the long duration of R&D cycles and the lifetime of aircraft.

Description of work

The Aviation Emissions and evaluation of Reduction Options Modelling System (AERO-MS) was developed with this objective.

The development of AERO-MS was initiated by the Dutch Civil Aviation Authority in the early 1990s and went through several phases in the period 1992 to 2001.

EASA took over ownership of AERO-MS in 2009 and initiated a study on aviation economic modelling (SAVE) which involved an extensive update to the tool and its underlying databases from the original base year of 1992 to 2006.

In 2011 and beyond, further AERO-MS enhancements are covered in the framework of the part EC-funded TEAM_Play project. This involves, for instance, creating structural linkages between the AERO-MS and down-stream models for detailed computation of noise, emissions and environmental impacts.

This report is based on a presentation held at the 3rd Conference on Transport, Atmosphere and Climate, Prien am Chiemsee in Germany, June 25-28, 2012.

Results and conclusions
Since its creation, AERO-MS has formed a key part of over 25 international studies where the results have provided a quantified basis for policy judgement related to aviation environmental protection.

This paper provides an overview of the key features and capabilities of AERO-MS and explains the major developments the tool has gone through as part of the EU FP7 TEAM_Play project.

Applicability
AERO-MS is an advanced tool capable of analysing and assessing the impacts of different policies, including technological and operational measures and market-based options, aimed at the reduction of international and domestic aviation greenhouse gas emissions.

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This report is based on a presentation held at the Third Conference on Transport, Atmosphere and Climate (TAC-3), Prien am Chiemsee in Germany, June 25-28, 2012.

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Contents

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ABSTRACT: One of the key systems for future policy assessment studies in Europe is a Responsive Modelling System: this involves the existing Aviation Emissions and evaluation of Reduction Options Modelling System (AERO-MS). It is a policy analysis tool with the capability to assess economic and environmental impacts of measures to reduce global aviation emissions. Over the last 15 years, AERO-MS has been frequently used for ICAO-CAEP, the European Commission and other organisations such as UNFCCC and IATA.

In the AERO-MS, policy measures are evaluated in the context of alternative future "business-as-usual" economic and technological scenarios for the aviation sector. The AERO-MS comprehensively integrates the relevant economic, commercial and technological responses of alternative policy options within the scenario context considered. In this respect, the AERO-MS distinguishes between three different modelling situations:

1. Base situation, representing the best possible knowledge of the air transport system in today's world;
2. Projections of future scenarios containing alternative, autonomous economic and technological developments without policy options;
3. Projections of alternative (sets of) policy options within a specified scenario context.

In 2010, the EASA-commissioned project called SAVE (Study on Aviation Economic Modelling) updated the AERO-MS primary input data on world-wide aircraft movements, air-service demand and aircraft technology characteristics from the original Base Year 1992 to the new Base Year 2006. In 2011 and beyond, further AERO-MS enhancements are covered in the framework of the part EC-funded TEAM_Play project; e.g., creating structural linkages from the AERO-MS outputs to other models for detailed computation of noise, emissions and environmental impacts; for instance to climate models for full environmental impact assessment capabilities.

All these AERO-MS enhancements will further improve the quality of impact assessments and fulfil the broadening needs of policy-makers in the aviation & environment field.

1 Introduction

Models are playing an increasing role in the assessment of aviation's environmental impact, as well as how this impact may evolve in the future according to different scenarios and the potential implementation of new environmental policy options. Being able to anticipate the impact of such policies is indeed crucial given the long duration of R&D cycles and the lifetime of aircraft. The Aviation Emissions and evaluation of Reduction Options Modelling System (AERO-MS) was developed with this objective. AERO-MS is an advanced tool capable of analysing and assessing the impacts of different policies, including technological and operational measures and market-based options, aimed at the reduction of international and domestic aviation greenhouse gas emissions.
The development of AERO-MS was initiated by the Dutch Civil Aviation Authority in the early 1990s and went through several phases in the period 1992 to 2001. EASA took over ownership of AERO-MS in 2009 and initiated a study on aviation economic modelling (SAVE) which involved an extensive update to the tool and its underlying databases from the original base year of 1992 to 2006 (MVA, 2010). Since its creation, AERO-MS has formed a key part of over 25 international studies where the results have provided a quantified basis for policy judgement related to environmental protection, among which an analysis of Market-Based Options (MBO) for the reduction of global air transport related CO_2 emissions for CAEP's Forecast and Economic Support Group (Pulles et al, 2000). More examples of AERO-MS applications can be found on the EASA website (see the reference section for the link).
The following sections provide an overview of the key features and capabilities of AERO-MS and explain the major developments the tool has gone through as part of the FP7 TEAM_Play project.

2 Overview of AERO-MS

2.1 A system of interacting models

The economic and technical modelling of air transport within the AERO-MS consists of five interacting core models, namely: the aircraft technology model (ATEC) to determine aircraft technology characteristics based on fleet development; the air transport demand model (ADEM) to forecast demand for air services and aircraft flights; the aviation cost model (ACOS) to estimate the overall aircraft operating costs; the flights and emissions model (FLEM) to calculate aircraft fuel use and engine emissions; the direct economic impacts model (DECI) to provide a comprehensive overview of the cost and revenues of air transport and a number of other economic impacts.

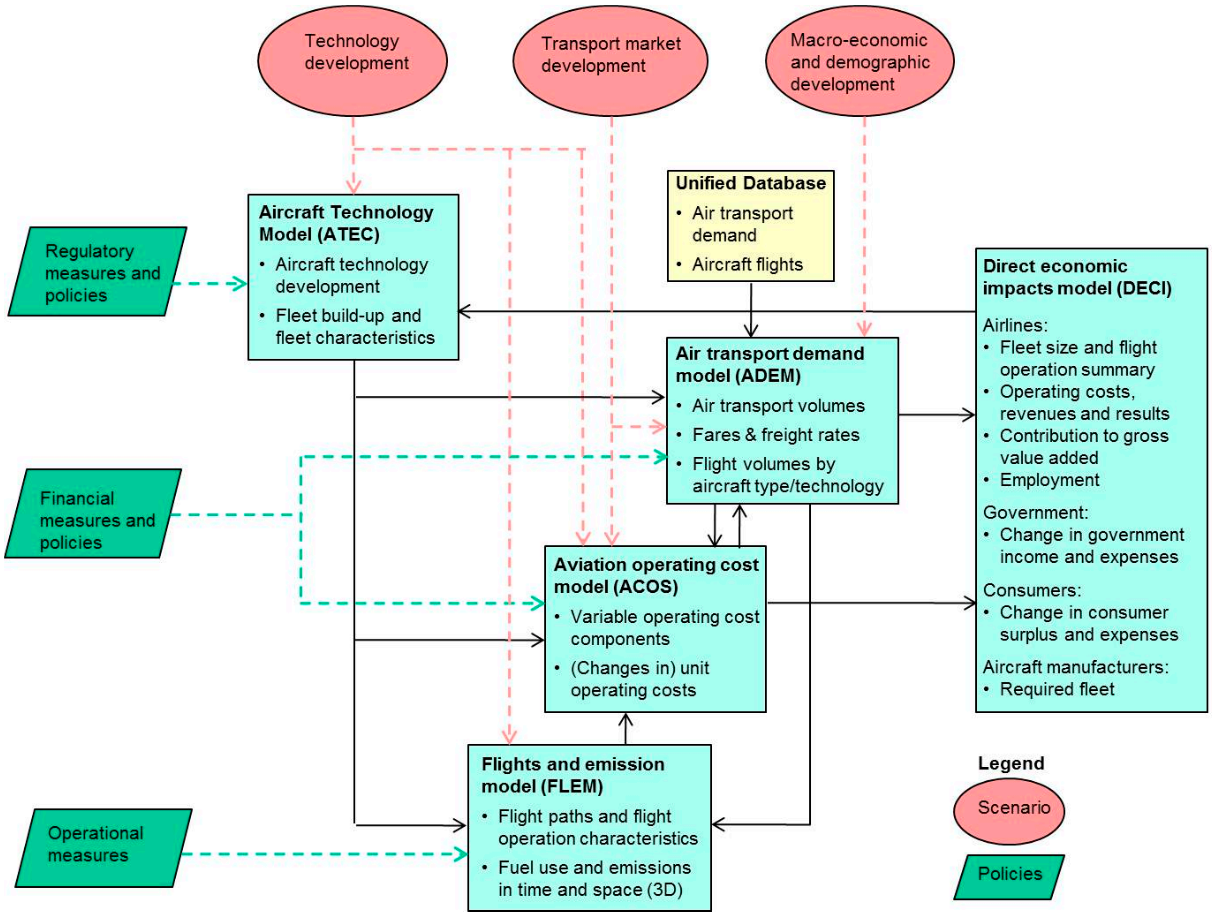

Figure 1. The AERO-MS core models and interactions

The key strength of AERO-MS relies in the interaction between the above models: e.g. the information on fuel-burn resulting from FLEM computations is used in ACOS to allow for the computation of fuel cost. Policy measures can indeed affect the supply side costs of the industry, which may lead to air operators increasing the prices for their customers. Through the multiple interactions between the core models, AERO-MS can assess the effect of price variations on air travel demand, as well as the changes in the global fleet with respect to fuel efficient technology.

2.2 Underlying data

The starting point for the modelling of air transport demand and aircraft flights is provided by the Unified Database, which is a computerised description of the volume and pattern of global air transport activity in the base year (presently 2006). The current Unified Database was compiled using a number of input data sources, including: EUROCONTROL's 2006 WISDOM Operations Database of aircraft movement data; the 2006 ICAO Traffic by Flight Stage (TFS) scheduled air movement and demand data; the 2006 U.S. Department of Transport (DOT)

T-100 scheduled air movement and demand data; and the 2006 IATA Route Tracker passenger class split data.

For 2006, the Unified Database records 123,025 airport-pairs, 33.1 million civil flights, 2.6 billion passenger trips, 4,658 billion passenger-km, 44.8 million tonnes of cargo transported and 158 billion cargo tonne-km.

Lastly, the FLEM module uses EUROCONTROL's Base of Aircraft Data (BADA) combined with the ICAO Aircraft Engine Emissions Databank to generate fuel burn and emissions.

2.3 AERO-MS outputs

The AERO-MS outputs are presented in the form of a standard *scorecard* which allows the comparison of model runs reflecting different scenario and/or policy situations. The main categories of outputs in the scorecard representation are:

- Air transport and aircraft operations: passenger and cargo demand by type; revenue ton-km; number of flights; aircraft-km.
- Effects on airlines: operating costs, revenues and results; contribution to gross value added; airlines related employment.
- Economic effects on other actors: (change in) government income/expenses; consumer surplus and expenses; required fleet.
- Fuel consumption and emissions (CO_2, NO_x, SO_2, C_xH_y, CO and H_2O). Emissions can be computed using either the Boeing Fuel Flow Method 2 (BFFM2) or the P_3T_3 method, and presented in the form of 3D grids potentially reusable in a climate model.

Policy options are evaluated in the context of alternative future "business-as-usual" economic and technological scenarios for the aviation sector. In this respect, the AERO-MS distinguishes between three different modelling situations: the *Base* situation representing the best possible knowledge of the air transport system in today's world; projections of future scenario's containing alternative, autonomous economic and technological developments without policy options (referred to as the *Datum* situation); projections of alternative (sets of) policy options within a specified scenario context (referred to as the *Forecast* situation). The effects of alternative policy options are quantified in relation to a common benchmark represented by the selected *Datum* situation. This produces a snapshot of each policy option against the same scenario in the same year, allowing a comparative evaluation of policy options on a consistent basis.

3 TEAM_Play enhancements

The earlier-mentioned SAVE study (MVA, 2010) also identified and proposed further improvements to the AERO-MS. Selections from these proposals are currently addressed in the EU FP7 project TEAM_Play – Tool Suite for Environmental and Economic Aviation Modelling for Policy Analysis. TEAM_Play (www.teamplay-project.eu) is a collaborative project co-funded by the European Commission. It is aimed at setting up an effective and efficiently working Tool Suite to provide powerful tools to conduct policy assessment studies within ICAO-CAEP and on European, national and local levels.
The enhancements made to the AERO-MS in the framework of TEAM_Play are:

- Software-technical, data structure and user interface enhancements, which resulted in a completely renewed and modernised AERO-MS framework. The revised system is referred to as "AERO-MS vNext". As part of the development of AERO-MS vNext, changes have been made to programs, data manager and models.
- Improvements in representation of aircraft types and enhancements in flight, emissions and noise modelling, all with the aim to improve the modelling of the aviation environmental system and to enhance interdependency modelling and analysis. The specific enhancements of AERO-MS (elements) are:
    - Update of the Unified Database (air traffic in Base Year 2006)
    - Revision of utilisation rates and further specification of retirement curves
    - Modifications to the aircraft demand model (ADEM) and aircraft technology model (ATEC)
    - Definition and implementation of a technology restriction measure
    - Floating Attributes Tool introducing the (cap)ability to investigate and analyse a range of aircraft and engine technology characteristics in a finer detail
    - Improved representation of aircraft technology and performance using BADA
    - New features in the Flight and Emissions Model (FLEM), including aircraft noise indicators for enhanced interdependency modelling and policy analysis.
- Integration and interfaces with higher-precision, pre-processing ("up-stream") and post-processing ("down-stream") models; for instance, creating structural linkages from the AERO-MS outputs to a range of downstream environmental models for detailed computation of noise, emissions and environmental impacts (the AERO-MS is now linked to climate response models for environmental impact assessment and policy

analysis concerning the reduction of NO_x emissions and or the reduction of contrails and cirrus). Other linkages involve those with technology response, energy, macro-economic, interdependency metrics and impact monetisation tools.

The calibration, validation and testing of the enhanced AERO-MS will be finished and reported in the final quarter of 2012.

4 Future developments

Further enhancement of the AERO-MS is needed, for instance, to address remaining SAVE-proposed improvements, but also to be able in the future to fulfil the broadening needs of policy-makers in the aviation & environment field. For the time being, there is no program, project or study planned to further develop the AERO-MS. Opportunities will however come up when considering, for instance, a TEAM_Play follow-up project in the EU research framework programme and or other relevant European programmes like Clean Sky and SESAR which involve evaluation, assessment and interdependency modelling activities.

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EU FP7 TEAM_Play project website: www.teamplay-project.eu

Further information on AERO-MS, including applications of the modelling system in policy assessments for EC/ICAO/UNFCCC/IATA, can be found at the following website: http://www.easa.europa.eu/environment/aero-ms.php