EUROPEAN MODELS STRENGTHEN INTEROPERABILITY IN SUPPORT OF CAEP

BY DAVID MARSH (EUROCONTROL), IVAN DE LÉPINAY (EASA), LAURENT CAVADINI (EUROCONTROL) AND LAURENT BOX (EUROCONTROL)

In 2013, IMPACT and AAT were introduced as the new flagship tools within the European aviation environmental modelling tool suite. Both models are based on the experience gained during more than 15 years of environmental model development in support of European environmental assessments, and to support the ICAO Committee on Aviation Environmental Protection (CAEP) assessments.

Impact

AEM is a EUROCONTROL model that can determine the amount of fuel burned by a specific aircraft type equipped with a specific type of engine, flying a specific 4D trajectory. It can also determine the precise by-products of burning that fuel such as: carbon dioxide (CO_2), water vapour (H_2O), oxides of sulphur (SO_x), oxides of nitrogen (NO_x), unburnt hydrocarbons (HC), carbon monoxide (CO), particulate matter (PM), and some volatile organic compounds (VOCs) such as benzene and acetaldehyde.

STAPES is a multi-airport noise model that is the result of successful collaboration by the European Commission (EC), the European Aviation Safety Agency (EASA) and EUROCONTROL. STAPES consists of a noise modelling software, hosted and maintained by EUROCONTROL, which is compliant with the calculation method recommended in ICAO Doc 9911, combined with an airport database that provides information on runway and route layouts, along with statistics on their usage (i.e. distribution of aircraft operations). The STAPES airport database, jointly maintained by EASA and EUROCONTROL, covers 75 European airports that are representative in terms of their noise impact on the surrounding population (i.e. number of people within the L_{den} 55 dB noise contours). EASA and EUROCONTROL continue to work together to expand this database through the inclusion of additional airports, both within the European Union states and other European Civil Aviation Conference (ECAC) Member States. The ultimate goal is to cover 90% of the European population that is significantly exposed to aircraft noise. STAPES is a CAEP-approved noise model that has contributed to CAEP's noise trends assessment and future stringency analyses since 2009.

The introduction of IMPACT constitutes a significant improvement towards achieving robust trade-off assessments between noise and fuel burn and/or gaseous emissions. IMPACT integrates AEM and STAPES into a common modelling platform, with a goal to "feed" these environmental models with common input data in terms of aircraft trajectories (along with other flight parameters of relevance for environmental modelling purposes).

A key component of IMPACT is a new aircraft trajectory calculator, which computes complete aircraft trajectories from the departing airport to the destination point, along with engine thrust and fuel flow information. This common trajectory data is then exported to AEM and the core noise calculation module of STAPES to compute fuel consumption, emissions, and noise contours. With this modelling approach, consistent assessments of trade-offs between noise and fuel burn and/or gaseous emissions are enabled over the portion of the trajectories within the Terminal Manoeuvring Area (TMA). The IMPACT trajectory calculator relies on the Aircraft Noise and Performance (ANP) database and the latest release of EUROCONTROL's Base of Aircraft Data (BADA). The ANP database provides the noise and performance characteristics of a wide range of civil aircraft types, which are required to compute noise contours around civil airports using the calculation method described in ICAO Doc 9911. ANP datasets are supplied by aircraft manufacturers for specific airframe-engine combinations, in accordance with a specific ANP Data Request Form developed and maintained within ICAO. BADA (Base of Aircraft Data) is an aircraft performance model developed and maintained by EUROCONTROL, in cooperation with aircraft manufacturers and operating airlines. BADA is based on a kinetic approach to aircraft performance modelling, which enables the accurate prediction of aircraft trajectories and the associated fuel consumption.

The complete trajectory computed by the IMPACT aircraft trajectory calculator is illustrated in **Figure 1**.

Another key characteristic of IMPACT is that it is a web-based modelling platform remotely accessed by the users, via a dedicated and secured portal. All the calculations are performed on dedicated servers hosted by EUROCONTROL. In particular, users do not need to install any specific software on their machines; they only need a web browser to connect to the IMPACT web portal, upload their input data, launch calculations, visualise, and download the results. This web-based approach

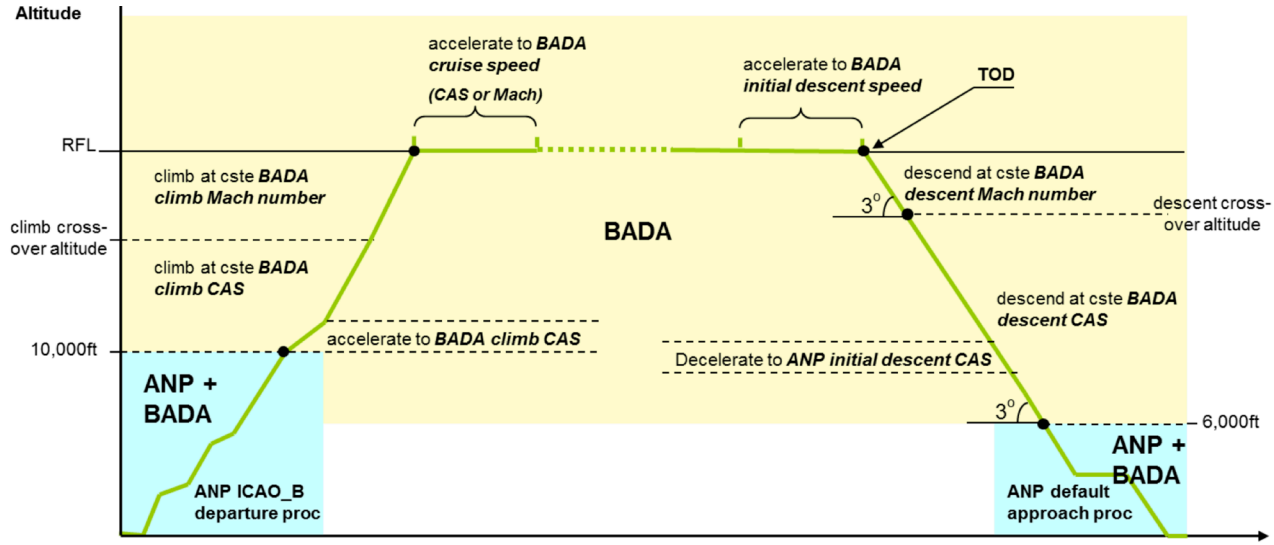


Figure 1. IMPACT full flight procedure used in CAEP[1].

enables easy update of the different databases used by IMPACT, without the need to redistribute a new software package, and provides the flexibility to select the database versions to be used in a study. Another major advantage is that it secures sensitive aircraft reference data such as the BADA data.

IMPACT supports different types of input data, which can be retrieved from various sources (i.e. real-time and arithmetic model-based simulations, real data, or more theoretical definitions of flight procedures). The main results produced by IMPACT include noise contour shapefiles, surface and population count using the European Environment Agency (EEA) population database, fuel burn and emissions of a wide range of pollutants, gridded (i.e. geo-referenced) emission inventories within the LTO portion; as an introduction to further – more detailed – Local Air Quality (LAQ) assessments.

During the CAEP/10 work programme, IMPACT was thoroughly reviewed against other CAEP-approved models and contributed to the CO_2 Standard analysis as well as the greenhouse gas and LAQ trends assessment.

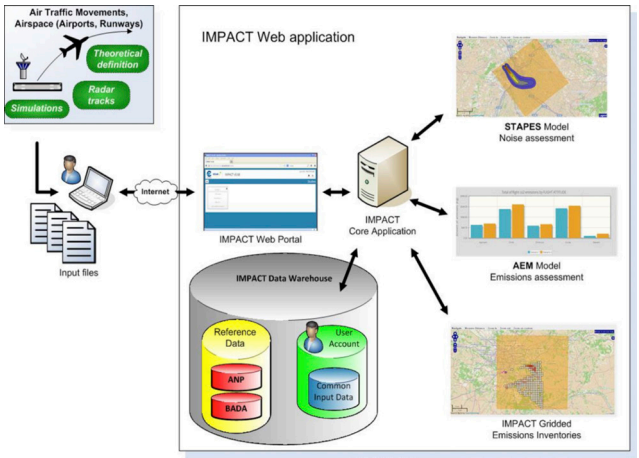


Figure 2. IMPACT Web-based Modelling Platform.

While meeting CAEP assessment needs, IMPACT was also developed to comply with the Single European Sky ATM Research (SESAR) environmental assessment requirements and is the recommended assessment tool for this European ATM research programme.

The Aircraft Assignment Tool (AAT)

To meet European needs and as part of their support of CAEP, the European Commission, EASA and EUROCONTROL have developed a fleet and operations forecasting capability called the Aircraft Assignment Tool (AAT). The AAT is a generic tool that takes as input an existing demand and fleet forecast, such as that from CAEP's Forecasting and Economic Analysis Support Group (FESG), and converts it into a forecast of movements by particular aircraft types on specific airport pairs. The geographical scope is dependent on the forecast, and can range from a single airport pair to full global operations. The output of the AAT can be used as input to environmental models such as IMPACT. Such information can also be used to assess the evolution of the aircraft fleet for future planning and policy purposes.

Aircraft types in AAT are typically grouped by user-defined categories based on their transport and range capability. Within a particular category, each aircraft type is assigned a specific market share. Market shares are specified by the user, which allows the application of various calculation methods including: equal market shares (all aircraft in a bin have the same share); market-driven market shares (shares are derived from the relative operating costs of each aircraft, e.g. using a multinomial logit); and historical market shares (shares are derived from past aircraft deliveries). If the demand forecast is expressed in available seat-kilometres (ASK) or available tonne-kilometres (ATK) for freighters, the AAT adjusts the number of movements on a given route to the size of the aircraft assigned to this route and their respective market shares.

The typical AAT input data consists of: a demand forecast; a set of base year operations (e.g. the Common Operations

Database for CAEP applications); aircraft retirement curves; a set of in-production aircraft over the forecast period (future fleet) along with their respective transport capability (seats/tonnes), maximum range and their market shares in the group they belong to (shares may vary in time). The AAT can also handle user-defined phase-out functions for specific aircraft types.

The AAT was developed following four key non-functional requirements:

Flexibility: With a variety of possible uses, the AAT is flexible enough to process input data from different sources and deliver output data fit for various modelling tools.

Speed: To allow regular updates within strict deadlines and with limited resources (e.g. EUROCONTROL forecasting process), the AAT architecture allows relatively easy operation and fast run-times.

Openness: In order to be transparent, the AAT does not develop its own assumptions (based on historical data patterns or the like). Instead the assumptions are formulated, and the input data constructed, by the user outside the AAT. This allows the AAT to be used for analysis of scenarios and "what-ifs" following different "stories" as defined and specified in the inputs by the user.

Accessibility: The AAT is accessible via a web portal and therefore only requires a web browser and an internet connection to be run.

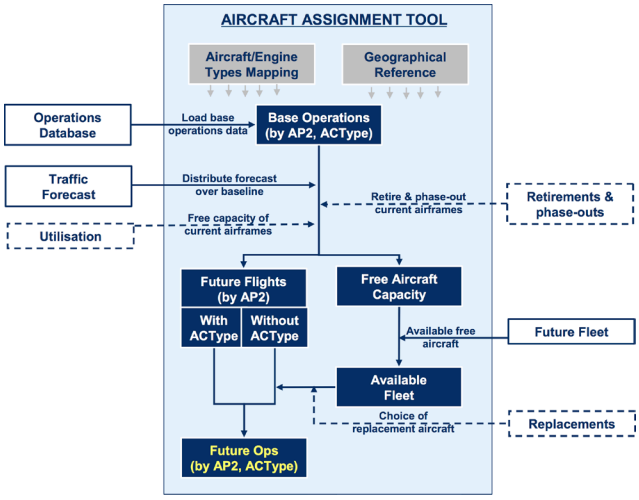
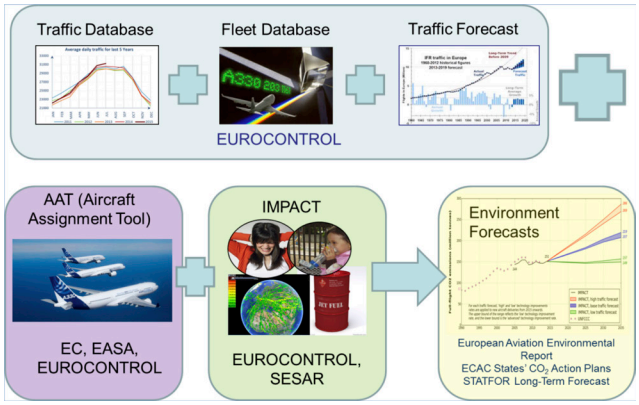


Figure 3. Aircraft Assignment Tool (AAT) design. (AP2 = Airport pair; ACType = Aircraft type)

During the CAEP/10 cycle, the AAT was reviewed by the FESG and was used in the CO_2 standard's cost-effectiveness analysis. During 2015, the focus of work on AAT was on European applications. The tool was integrated into the EUROCONTROL/ STATFOR 20-year forecast toolset for the passenger market segment. Combined with IMPACT, it made it possible to estimate the evolution of noise and emissions in Europe until 2035 under various traffic forecasts and aircraft technology scenarios.

Examples of IMPACT and AAT Benefits:



The combination of AAT and IMPACT enabled to estimate the evolution of noise and emissions in Europe until 2035 under various traffic forecast and aircraft technology scenarios to feed the European Aviation Environmental Report 2016[2].

Future Developments

IMPACT and AAT will continue to be developed in order to meet CAEP/11 and European modelling needs. In particular:

- Additional comparisons between IMPACT and other CAEP models have been initiated, which focus on the calculation of other pollutants such as Particulate Matter (PM), in preparation for the CAEP/11 analyses of the PM Standard.

- The integration of AAT with STATFOR will be completed in 2016 with the addition of the business aviation and all-cargo market segments. Begun in late 2015, and continuing into 2016, a number of improvements are being made to this interface, designed to reduce the manual effort required to prepare the inputs, and to analyse the outputs, including a new module to derive year-on-year aircraft deliveries.

References

1. TOD= Top Of Descent ; CAS=Calibrated airspeed ; RFL= Requested Flight Level
2. http://easa.europa.eu/eaer