**Flight-Noise-II**

**Turboprop and Propfan-Equipped Aircraft Noise Emission Model**

**Funding:** European (7th RTD Framework Programme)  
**Duration:** Dec 2011 - Sep 2014  
**Status:** Complete with results  
**Total project cost:** €348,870  
**EU contribution:** €261,652

**Call for proposal:** SP1-JTI-CS-2010-04  
**CORDIS RCN:** 102316

**Objectives:**

This project aimed at delivering a multi-disciplinary computer program capable of simulating the noise emission and propagation of modern airplanes powered by turboshaft engines coupled to conventional propellers or advanced propellers (propfan). This document describes existing computer programs (FLIGHT and FLIGHT-NOISE) that comply substantially with the requirements of the Call for Proposals (Call). More specifically, the proposal has the following objectives:

- To produce state-of-the-art aircraft noise, emissions & propagation software.
- To validate the software with clear benchmark test cases.
- To provide support technical beyond the duration of the project.

The main project deliverables are:

1. The Software, including an "Airframe Module", a "Propulsion Module" and "Noise Propagation Module".
2. Database of turboprop engine performance (flight envelopes).
3. Validated prediction tools.
4. Software documentation, including user’s manuals (20 deliverables).

The project is expected to deliver benefits in other areas, such as:

1. Multi-disciplinary approach to aircraft noise and flight operations.
2. Flexibility in predicting sources of noise, noise perception, noise propagation.
3. Engineering advancements in the areas of advanced propeller noise.

This project proposed to compensate for the imbalance between the requirements of the aviation industry and the technology currently implemented in Aircraft Flight and Noise Prediction programs. In particular, noise propagation tools are currently unavailable to the industry.

**Parent Programmes:**  
FP7-JTI - Specific Programme "Cooperation": Joint Technology Initiatives

**Institute type:** Public institution  
**Institute name:** European Commission  
**Funding type:** Public (EU)
Executive Summary:

This project aimed at developing a computer code capable of predicting aircraft noise from a propeller-turboprop airplane. As part of the project, the partners were required to gather experimental data (noise measurements) and real-life trajectories, which was done by post-processing the Flight-Data-Recorder of a Bombardier Q400 airplane.

Project Context and Objectives:

The Clean Sky Call JTI-CS-2010-01-SGO-03-002 required the development of a computerised model for the simulation of turboprop-powered commercial airplanes and propfan-powered airplanes. The overall aim of this software was to demonstrate how it is possible to reduce perceived noise by optimization of the aircraft trajectory. To fulfil these aims, the software models the airplane, the engine, the propeller, the flight mechanics, the flight controls, the noise sources, the propagation effects and the conventional noise metrics and the overall systems integration.

Scope of Work

1. To identify the main parameters and propose the inputs/outputs parameters.
2. To adapt the turboprop and airframe model of noise emissions.
3. To provide evidence of model consistency through comparisons of estimated noise against experimental data.
4. To deliver turboprop & airframe software and its associated documentation.

Key Requirements

1. Ability to model turboprop commercial aircraft, engines and propellers.
2. Ability to model the effects of flight controls.
3. Ability to run off-line noise calculations.
4. Ability to model the effects of sound propagation through the atmosphere.
5. Ability to model the effects of the atmospheric winds.
6. Ability to model topographical details.

Model Requirements

1. Airplane Geometrical Model & Design Limitations.
2. Engine Model & Design Limitations.


4. Propeller Model, including geometry and limitations.

5. Databases for Noise Theories (experimental data).

**Project Results:**

Practical aircraft noise models have been proposed as far back as the 1970s at the Federal Aviation Authority in the USA. These models have then been taken up by NASA and other academic institutions and resulted in a noise model called ANOPP later into another code called FOOTPR and most recently (2011) into a brand new code, called ANOPP2. The last two computer codes are not fully documented in the literature, but we believe that a good portion of its models are based on ANOPP.

The most recent developments of ANOPP are unknown, but as far back as the mid 1990s this computer code did not have key components such atmospheric propagation models and their interaction with the ground. Unfortunately, many of its features are not disclosed. However, this code was a landmark example of how aircraft noise can be practically simulated and evaluated. In fact, it contained a fundamental feature: the independence of uncorrelated noise sources. Although this is generally still the case, more advanced models must consider the interference between acoustic signals and solid surfaces, which leads to some noise shielding effects. NASA, in cooperation with Boeing Commercial Airplanes continues to develop this software, which is continuously updated after 30 years of contributions.

Progress in aircraft noise simulation has been steady, but in some cases also uneven, in the sense that not all sub-models have been advanced in equal measure. However, thanks to the approach followed in the development of the Flight-Noise model, we will take full advantage of the modularity and will be able to establish a framework that will facilitate the implementation of alternative models in the future. In designing a noise simulation model, we have considered the following aspects:

- We wanted to have a simulation method that provides results in minutes, or seconds, rather than hours or days.
- We wanted to incorporate the aircraft noise model within the larger context of flight simulation and flight mechanics, which also provide engineering results in minutes rather than hours. This has resulted in a modular and multi-disciplinary code.
- We wanted a software package that runs on conventional hardware: single/dual processor desktop computers under Windows-XP and Linux.

During the design process, we considered other factors:

- We took into account uncertainty factors arising from the combination of noise sources and propagation effects, which cause the acoustic signal at the receiver to be considerably different from the source. Main causes include atmospheric propagation, shear winds and ground reflection.
- We took the view that inaccuracies at source level are inevitable, but in consideration of other factors, such as summation effects, there was some gain to be had with a low-order model.
- We realized that some noise sources could not be simulated realistically, due to lack of essential details. For example, in the case of turbofan engines it is impossible to gather data on the gas turbine and on basic geometrical characteristics of the compressors. As a result, any sophisticated computational model would fail, because the problem is ill-posed. Likewise, airframe details of components such as slats and flaps are unknown, although visual inspection of photographs can reveal key features.

The code has been built to be fully modular. Hence, changes in the model of a single component can be easily incorporated in the future, without affecting either the software architecture or the validity of the other sub-models. This structure has also a considerable advantage from the validation point of view. In fact, in the validation phase, we examine the role of each sub-model in isolation, and then we build a system of validated models. This is by itself no guarantee that the system is valid, but only that it has a strong theoretical background, upon which we can build knowledge and expertise.

Implementation of this software within the industrial context had to satisfy a number of important criteria:

- Capability of running with limited support from the developers.
- Clear and understandable input data.
• Clear and understandable output data structures.
• Self-contained modules that do not depend on external libraries and proprietary software.
• Self-contained software that does not depend of operating system.

**Potential Impact:**

Ability to predict aircraft noise can be used for:

- Aircraft trajectory optimization/minimum noise
- Aircraft trajectory optimization/minimum emission
- Aircraft noise mapping at airports
- Validation Standards & Certification Issues
- Advice on local community noise annoyance

List of Websites:

[www.flight.mace.manchester.ac.uk](http://www.flight.mace.manchester.ac.uk)

**STRIA Roadmaps:** Vehicle design and manufacturing  
**Transport mode:** Air transport  
**Transport sectors:** Passenger transport, Freight transport  
**Transport policies:** Environmental/Emissions aspects  
**Geo-spatial type:** Other