Coupling Aircraft Noise Prediction and Airport Noise Footprint Analyses for Enhanced Community Noise Prediction Capability

Nandita Bajaj, Tim Bilic
Bombardier Aerospace
Overview

- New analysis and design capabilities for external aircraft noise have been achieved via development and coupling of noise software.

- New capabilities allow for:
  - Design and analysis of enhanced aircraft operations
  - Conceptual design-change feedback

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Airport Noise Analysis + Aircraft Noise Prediction = New Analysis Capabilities
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Aircraft Community Noise

• What is it?
  – Noise received at ground-level resulting from aircraft operations
    • Significant to areas in the vicinity of airports

• Why does it matter?
  – Certification requirements
  – Airport-specific access
  – Basis for airport fees, restrictions, quota counts
Aircraft Community Noise Prediction

• Available Methodologies
  – Empirical models
  – Computational Aero Acoustics (CAA)

• Uses of Community Noise Prediction
  – Aircraft-Airport-specific noise assessments
  – Flightless Noise Certification of Derivative Aircraft
  – Analysis of proposed design changes
  – Noise Abatement Procedure Design
  – Preliminary analysis of Conceptual Aircraft

• Why not measure noise?
  – High cost: monetary, time, labour
  – Complex instrumentation
  – Meteorological uncertainty
INM – Integrated Noise Model

• The INM is an industry-standard computer program produced by the United States Federal Aviation Authority (FAA) to analyze aircraft noise levels in the vicinity of an airport.

• It is used by over 700 organizations in over 50 countries to assess changes in noise impact resulting from:
  – changes in runway configurations
  – new traffic demands and fleet mix
  – modifications to other operational procedures

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\text{Airport Noise Analysis} + \text{Aircraft Noise Prediction} = \text{New Analysis Capabilities}
\]
**INM – Integrated Noise Model**

**User-defined input parameters**

**PHYSICAL**
- Runway layouts, airfield altitude, atmospheric conditions, flight tracks

**OPERATIONAL**
- Aircraft types, numbers of aircraft, proportions by runway, proportions by flight track

**INM**

**AIRCRAFT INFORMATION**
- Noise data, Performance data

**INM Output**

**NOISE CONTOURS**
- For user defined noise metric(s) and observer location(s)

**DETAILED REPORTS**
- For user defined noise metric(s) and observer location(s)

Manufacturer-defined input parameters

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INM Input

- **Atmospheric Conditions**
  - Temperature (59F)
  - Pressure (29.92 in-Hg)
  - Relative Humidity (70%)
  - Headwind (8 kts)

- **Airport Characteristics**
  - Elevation
  - Runway altitude
  - Latitude and longitude
  - Atmospheric conditions over the course of the period being modelled

- **Flight Track Geometry**
  - All possible flight paths and operations that an aircraft may use can be depicted by sketching or entering flight track radar data.
INM Input

- Aircraft Selection
  - The model consists of more than 200 aircraft types in its database which are defined as a function of their performance, engine, and noise data.

- Aircraft definition
  - In addition to aircraft contained in the database, the user can conduct in-house analysis by defining own aircraft.

- Runway and flight track usage
  - The model allows users to specify usage percents of all the defined flight operations by aircraft, operation type, profile definition, runway, or track.
INM Database

- **Performance Data**
  - Altitude vs. distance
  - Power level vs. distance
  - Speed vs. distance

- **INM Profiles**
  - Procedural profiles → Dynamic
  - Fixed-point profiles → Static

- **Noise Power Distance data**
  - INM consists of sets of noise levels for various combinations of aircraft engine power states and distances from observer to aircraft.
Noise-Power-Distance (NPD) Data
INM Output
Aircraft Source Noise Prediction

- Bombardier has updated a public domain version of NASA’s Aircraft NOise Prediction (ANOP) computer program and has implemented additional features for in-house analyses.

- ANOP
  - Semi-empirical noise modeling of engine and airframe noise
  - Models sound propagation, ground effect, installation effects
  - Applies source noise predictions to specified flight profiles

Airport Noise Analysis + Aircraft Noise Prediction = New Analysis Capabilities
ANOP – Engine Noise Sources

- Fan
- Inlet
- Compressor
- Fan
- Exhaust
- Turbine
- Jet
- Mixing

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ANOP – Airframe Noise Sources

Main Element  Horizontal/Vertical Stabilizer

Landing Gear  Flaps + Aileron  Slats
ANOP – Physical Effects

- Engine Installation
- Propagation
- Ground Absorption/Reflection
- Flight Profile
ANOP – Input and Output

• Input
  – Simple geometry
  – Wing loading
  – Engine-deck
  – Atmospheric information
  – Ground surface
  – Flight profile
  – Aircraft configuration

• Output
  – 1/3rd Octave Band SPL
  – SPL-lin
  – SPL-A
  – SEL
  – PNL
  – PNLT
  – EPNL

• How does ANOP relate to INM?
  – INM input NPDs can be created from ANOP output
ANOP-INM Coupling

- New design features
- New configuration

GUI

ANOP Input Generator

Batch Processing

Data Import, Extraction and Formatting

ANOP

ANOP input files

ANOP output files

INM

INM NPD (.dbf-IV)

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Conclusion

- Noise prediction software has been developed and coupled to industry-standard noise analysis software, resulting in an Enhanced Community Noise Prediction tool.