Advanced Noise Abatement Approach Activities at Nottingham East Midlands Airport, UK

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Silent Aircraft Initiative (SAI) Context

- **Goal:** Develop concept aircraft designs and procedures to reduce noise to below ambient levels at the perimeter of a typical urban airport

- Over 30 researchers from Cambridge and MIT plus over 20 partners from key stakeholder groups:
  - Airlines
  - Airports
  - Air Traffic Service Providers
  - Community groups
  - Manufacturers
  - Regulators, etc.

Steeper/slower approach: 3.9°/118 kts
Conventional approach: 3°/140 Kts

- 320 ft increase at perimeter = 7.8 dBA noise reduction
- 220 ft at perimeter
- 1 km from perimeter to runway
- 1.2 km landing threshold displacement
SAI Operations Focus

Utilise partnership and research tools available within SAI to develop and test advanced noise abatement approach procedures for a range of existing aircraft types combining:

• Continuous Descent Approach (CDA)

• Precision Area Navigation (P-RNAV)

• Low Power/Low Drag (LP/LD)
Strong Collaboration

Advanced Noise Abatement Procedures

SAI Ops

ATC

Regulators

Suppliers

Airlines

Airports

Nottingham East Midlands Airport

NATS

Civil Aviation Authority

wyle laboratories

CAE

STASYS

Met Office

DHL

Lufthansa Cargo

easyJet

Thomsonfly.com

Nottingham East Midlands Airport

The Cambridge-MIT Institute
Multiple Aircraft Types & Technologies

B757-200F, Honeywell Legacy FMS

MD11F, Honeywell Pegasus FMS

B767-300F, Honeywell Pegasus FMS

A319, Thales/Honeywell Pegasus FMS
“NEMAX” Trial Procedures

Longitude

53.1° N
53.0° N
52.9° N
52.8° N
52.7° N
52.6° N
52.5° N
52.4° N
52.3° N

5 nm

Approach zones

NEMAX1B

NEMAX1A

BIRMINGHAM
(pop. 1m)

COVENTRY
(pop. 300k)

LEICESTER
(pop. 280k)

LOUGHBOROUGH
(pop. 60k)

NXN31

NXN27

NEMAX

NXN13

NXN21

NXN10

NXN11

NXN19

NXN32

NXN22

NXN17

UPDUK

PIGOT

NEMAX1A

London
(pop. 3m)

NEMAX1B

NEMAX1A

Longitude
NEMAX1A Detail

- Lateral profile for:
  - Low population exposure
  - Approach zone compliance
  - Controlled airspace compliance

- Vertical constraints for:
  - CDA profile
  - Airspace compliance

- Speed constraints for:
  - Low power/low drag
Controlled Airspace Compliance

Manchester Area Control Centre

Military restricted airspace

NEMA terminal area airspace

London Area Control Centre

NEMAX1A

NEMAX1B

2500’ – FL105

2500’ – FL105

5 nm

Longitude

Latitude

53.1° N

53.0° N

52.9° N

52.8° N

52.7° N

52.6° N

52.5° N

52.4° N

52.3° N

2.1° W
2.0° W
1.9° W
1.8° W
1.7° W
1.6° W
1.5° W
1.4° W
1.3° W
1.2° W
1.1° W
1.0° W
0.9° W
0.8° W

5 nm
Controlled Airspace Effects on NEMAX Design

Simulator unconstrained trajectory

NEMA terminal area airspace

GA/glider airspace
TASAT Simulation Studies

A319  B752  B763  B744 (MD11)
Airline Simulator Studies

- Tested with A320 & 767
- Flew both procedures under variety of wind and pressure environments

- Performed well with largely idle thrust and no speedbrakes
- Minor tweaks resulted
NEMAX Flight Trials

- Procedures published March 2006
- Trials started June 2006
- Participation to date: 130 flights

<table>
<thead>
<tr>
<th>Type</th>
<th>NEMAX1A</th>
<th>NEMAX1B</th>
</tr>
</thead>
<tbody>
<tr>
<td>B757-200F</td>
<td>67</td>
<td>2</td>
</tr>
<tr>
<td>MD11F</td>
<td>42</td>
<td>12</td>
</tr>
<tr>
<td>B767-300F</td>
<td>7</td>
<td>0</td>
</tr>
</tbody>
</table>

A319 trials hopefully starting soon

- Data collection:
  - Radar data (lat/long/alt)
  - Pilot/controller reports
  - FDR data (20 states inc. engine N1/FF)
  - Noise monitors (3 sites)
NEMAX Radar Ground Tracks

- Lateral dispersions <0.5 nm, well within P-RNAV (RNP-1) limits
- Procedure commencement at intermediate points visible
B757 NEMAX1A/Baseline Ground Tracks

- **B757 NEMAX1A (n=23)**
- **B757 Baseline (n=20)**
B757 Actual Vertical Profiles

- Trial vertical profiles flown with V/S & VNAV
- Trial average level segments: 1.6 nm below 9000 ft
- Baseline average level segments: 6.0 nm below 9000 ft

**Legend:**
- B757 NEMAX1A (n=23)
- B757 Baseline (n=20)
B757 Average Vertical Profiles

- Trial average profile kept higher but with similar variability
- Trial average track distance: 34 nm below 9000 ft
- Baseline average track dist: 37 nm below 9000 ft
B757 & MD11 Actual Vertical Profiles

- MD11 trials flown in full VNAV
- B757 trial average level segments:
  1.6 nm below 9000 ft
- MD11 trial average level segments:
  0.3 nm below 9000 ft
B757 & MD11 Average Vertical Profiles

- Average profiles similar indicating B757 pilots flying with mixed V/S & VNAV achieve profile close to MD11 VNAV path
- MD11 variability much lower
NEMAX1A Noise Monitoring

• Used to validate noise model predictions

<table>
<thead>
<tr>
<th>Location</th>
<th>B757 (n=12)</th>
<th>MD11 (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NXS11</td>
<td>61.8</td>
<td>67.3</td>
</tr>
<tr>
<td>NXS17</td>
<td>56.0 (n=11)</td>
<td>59.8 (n=9)</td>
</tr>
<tr>
<td>NXS22</td>
<td>No data</td>
<td>No data</td>
</tr>
</tbody>
</table>
NEMAX1A Estimated Noise Reductions (NMSim)

Distance to Runway (nm)

Estimated Noise Change with NEMAX1A compared to Baseline (Peak dBA)

-7 -6 -5 -4 -3 -2 -1 0

B757
MD11

11 17 22 26

Distance to Runway (nm)
Noise Contour Analysis (INM)

B757 BASELINE

- 55 km² area
  - 9,700 people

- 139 km² area
  - 16,700 people

- 308 km² area
  - 20,300 people

- 683 km² area
  - 30,000 people

B757 NEMAX1A

- 27 km² area
  - 9,300 people

- 51 km² area
  - 11,600 people

- 97 km² area
  - 13,200 people

- 181 km² area
  - 16,500 people

<table>
<thead>
<tr>
<th>Peak dBA</th>
<th>80</th>
<th>75</th>
<th>70</th>
<th>65</th>
<th>60</th>
<th>55</th>
<th>50</th>
</tr>
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Average Fuel Burn

- B757 BASELINE (n=20)
- B757 NEMAX1A (n=23)
- MD11 BASELINE (n=21)
- MD11 NEMAX1A (n=10)

-30 kg (-8%)
-73 kg (-11%)
NEMAX1A Improved CDA Performance

Average Level Segments Below 9000 ft (nm)

- B757 BASELINE (n=20)
- B757 NEMAX1A (n=23)
- MD11 BASELINE (n=21)
- MD11 NEMAX1A (n=10)
Need for Definition of Advanced CDA

- **CDA definition at London airports** (becoming industry standard?)
  - “An arrival is classified as a CDA if it contains, at or below **6000 ft**, no level flight OR one phase of level flight not longer than **2.5 nm**”

- **Propose need for additional definition for advanced CDAs:**
  - “An arrival is an advanced CDA if it contains, at or below **9000 ft**, no level flight OR one phase of level flight not longer than **1 nm**”

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<thead>
<tr>
<th></th>
<th>Average level segments below 9000 ft</th>
<th>London CDA definition compliance</th>
<th>Proposed new CDA definition compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>B757 Baseline</td>
<td>6.0 nm/flight</td>
<td>65%</td>
<td>10%</td>
</tr>
<tr>
<td>B757 NEMAX1A</td>
<td>1.6 nm/flight</td>
<td>87%</td>
<td>52%</td>
</tr>
<tr>
<td>MD11 Baseline</td>
<td>3.9 nm/flight</td>
<td>81%</td>
<td>23%</td>
</tr>
<tr>
<td>MD11 NEMAX1A</td>
<td>0.3 nm/flight</td>
<td>100%</td>
<td>90%</td>
</tr>
</tbody>
</table>
Sample Pilot/Controller Report Comments

• The good…
  - “…procedure performed very smoothly, no problems at all…”
  - “…procedure worked out nicely! Idle most of the time…”
  - “Procedure worked perfect for the entire time”

• …and the pointers for improvement
  - “…although workable, can place a higher workload on the pilot…” => Airspace design/aircraft vertical automation issues
  - “…very easy to fly…[but] Area Control Centre should have cleared us earlier…” => ATC coordination issues
  - “…trying to sequence a non-participating a/c behind was hard…”
    => Ground automation implications
    => Overall environmental affect of trial flights on non-trial flights
Conclusions

• Noise abatement procedures successfully developed & introduced as part of Silent Aircraft Initiative
  - True collaborative exercise between academia and stakeholders
  - Research tools integral to the process

• Flight trials show environmental benefits across types
  - Aircraft kept higher with better CDA performance (less level flight)
  - Lower noise (peak noise and contour areas)
  - Lower fuel burn (and mostly lower emissions)

• Interesting pointers for further work
  - Aircraft automation, airspace constraints & proc. design interactions
  - Need for enhanced ATC coordination/automation for max. benefits
  - Need for effective individual & aggregate environmental metrics
Acknowledgements

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Aviation Integrated Modelling (AIM)

- **Project goal:** Develop policy assessment tool for aviation, environment & economic interactions at local & global levels
  - Assess policies to strike appropriate balances between economic benefits and environmental impact mitigation
  - Independent & transparent tool for mediating between stakeholders
AIM Architecture

Aircraft Movement

Global Climate

Local Air Quality & Noise

Regional Economics

Air Transport Demand

Sample policy: ATC evolution

Sample policy: Regulation

Sample policy: Airport capacity

Sample policy: Economic instruments

See www.AIMproject.aero for more information

Institute for Aviation and the Environment