Advanced Continuous Descent Approach Activities at Nottingham East Midlands Airport, UK

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The Silent Aircraft Initiative (SAI)

- Research project of Cambridge-MIT Institute
- Funded by Department for Trade and Industry

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

- 2025 timeframe
The Silent Aircraft Initiative (SAI)

- Five internal SAI teams:
  - Airframe
  - Engine
  - Integration
  - Operations
  - UK economy

- Over 30 researchers & over 20 partners, including:
  - Academia (Cranfield, GATech)
  - Government (CAA, DfT, NASA)
  - Manufacturers (Boeing, Rolls Royce, ITP, Messier Dowty)
  - Operators (Airports, Airlines, ATC)
  - Suppliers (B&K, Met Office, Wyle Labs)
Operations Team Goals

• Support development of Silent Aircraft
  - Operations-driven design requirements

• Simulation and analysis tool development
  - Flyability, Noise, Fuel burn, Emissions, Capacity

• Develop & analyze noise abatement approach procedures
  - Silent Aircraft (long term)
    - Steep, slow, displaced threshold, delayed gear deployment
  - Existing aircraft (short term)
Location for Short Term Operations Activities

• Assessment of numerous UK airports…
  - Gatwick
  - Heathrow
  - Luton
  - Manchester
  - Nottingham East Midlands Airport (NEMA)
  - Newcastle
  - Stansted

• …against key criteria
  - Airspace/ATC context
  - Other noise abatement activities
  - Potential benefits (local population, traffic, etc.)
  - Potential problems
  - Political context
  - Regulator advice

• Collaboration with NEMA resulted
NEMA Facts & Figures

- 11th biggest regional airport in UK
- Passenger flights to over 100 destinations in 2006
  - Catchment of 10.6 million people within a 90 min drive
- Largest “pure freight” airport in UK
  - UK center for Royal Mail, DHL, UPS
  - 89% mainland England & Wales within 4 hrs trucking time
- First UK airport to achieve ISO14001 accreditation (international environment management standard)

Source: NEMA Draft Master Plan, Feb. 2006
NEMA ATC Context

Manchester Area Control Centre (NATS)

NEMA airspace up to FL105

Restricted airspace

BIRMINGHAM (pop. 1m)

DERBY (pop. 220k)

NOTTINGHAM (pop. 270k)

LOUGHBOROUGH

LEICESTER (pop. 280k)

COVENTRY (pop. 300k)

London Area Control Centre (NATS)
NEMA Procedure Development/Trial Objectives

Develop approach procedures for reduced noise and fuel burn across range of aircraft types combining:

- Continuous Descent Approach (CDA)
  - Keep aircraft higher and lower thrust for longer
- Precision Area Navigation (P-RNAV)
  - Flight Management System control
- Low Power/Low Drag (LP/LD)
  - Clean aerodynamic configuration

“Flight Idle CDAs”

Flight trial procedures to examine:

- Achievement of LP/LD P-RNAV CDAs
- Environmental impacts (Noise, Fuel burn & Emissions)
- Operational impacts (Controller, Pilot, Aircraft)
Strong Collaboration
Multiple Aircraft Types & Technologies

- B757-200F, Honeywell Legacy FMS
- B767-300F, Honeywell Pegasus FMS
- MD11F, Honeywell Pegasus FMS
- A319, Thales/Honeywell Pegasus FMS
“NEMAX” Trial Procedures
NEMAX1A Detail

• Lateral profile for consultation zone compliance and low population exposure

• Vertical constraints for airspace compliance & assist CDA vertical profile

• Speed constraints to assist low power/low drag
Vertical Profile: Controlled Airspace Interactions

Latitude

Longitude

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Vertical Profiles: Airspace Challenges

Simulator data

NEMA terminal area airspace

GA/glider airspace
MIT Sim Results – NEMAX1A – Zero Wind

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Airline Simulator Studies

- A320 (easyJet) & 767 (UPS)
- 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 as AIP supplement March 2006
• Trials started May 2006, expected to continue for 6 mths
• Participation to 31 Aug: 67 flights

<table>
<thead>
<tr>
<th>Operator</th>
<th>Type</th>
<th>NEMAX1A</th>
<th>NEMAX1B</th>
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<tbody>
<tr>
<td>DHL</td>
<td>B757-200F</td>
<td>37</td>
<td>2</td>
</tr>
<tr>
<td>Lufthansa Cargo</td>
<td>MD11F</td>
<td>19</td>
<td>7</td>
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<tr>
<td>ups</td>
<td>B767-300F</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>easyJet</td>
<td>A319</td>
<td>0*</td>
<td>0*</td>
</tr>
</tbody>
</table>

*Awaiting P-RNAV approval

• Data collection:
  - Radar data (lat/long/alt)
  - Pilot/controller report forms
  - FDR data (20 states inc. N1 & FF)
  - Noise monitors (3 sites)
Flight Trial Ground Tracks

• Lateral dispersions well within P-RNAV (RNP-1) limits
• Procedure commencement at intermediate points points visible
B752F NEMAX1A/Baseline Ground Tracks

- **B752F NEMAX1A (n=15)**
- **B752F Baseline (n=12)**

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B752F Actual Vertical Profiles

- Trial lateral paths flown with LNAV, vertical profiles flown with V/S & speedbrake
- Trial average level segments: 1.3 nm/flight below 9000 ft
- Baseline average level segments: 5.9 nm/flight below 9000 ft
B752F Average Vertical Profiles

- Trial average profile kept higher but with similar variability
- Trial average track distance: 33 nm below 9000 ft
- Baseline average track dist: 39 nm below 9000 ft
- Trial fewer/smaller level-offs AND higher altitude targets

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B752F/MD11F Actual Vertical Profiles

- MD11F trials flown in full LNAV/VNAV
- B752F trial average level segments:
  - 1.3 nm/flight below 9000 ft
- MD11F trial average level segments:
  - 0.8 nm/flight below 9000 ft,
  - 0 nm/flight below 8000 ft
B752F/MD11F Average Vertical Profiles

- Average profiles very similar indicating B752F pilots flying close to MD11F LNAV path via V/S
- MD11F variability much lower

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**B752F Average Speed Profiles**

- Trial average speed profile slightly lower 20-5 nm to runway
- Baseline variability slightly higher >20nm to runway

**Graph Details:**
- **B752F NEMAX1A av ±2sd (n=15)**
- **B752F Baseline av ±2sd (n=12)**
B752F/MD11 Average Speed Profiles

- 250 kts speed constraint visible
- B752F speed higher for longer
- MD11F variability generally lower
B752F Average N1 Profiles

- High variability >20 nm to rwy
- Trial average N1 profile lower >30 nm to rwy
- Similar variabilities
B752F/MD11 Average N1 Profiles

- Average profiles largely flight idle
- MD11F variability lower 23-17 nm to runway

B752F NEMAX1A av ±2sd (n=15)
MD11F NEMAX1A av ±2sd (n=6)
NEMAX1A Noise Monitoring

Baseline

NEMAX1A

A319
Zero wind
Simulator trajectories

NXS11
NXS17
NXS22

LMax
AWgt

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Preliminary NMSim Analysis @ NXS11

[Graph showing sound level over time for A319 and NEMAX1A with a baseline and 6 dBA difference marked.]
NEMAX1A Fuel Burn

*Preliminary data based on small sample sizes

-35 kg (-9%)

-150 kg* (-20%)

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Preliminary Conclusions

• NEMA P-RNAV noise abatement approach procedures successfully developed & introduced

• Lateral path concentration as expected

• Vertical path keeps aircraft higher & reduces level flight
  - Performance dependent on aircraft type/equipage

• Overall impacts on noise, fuel burn & emissions ongoing but initial results look promising
  - Lateral concentration reduces no. of people exposed to noise
  - Higher altitudes should reduce noise impacts on ground
  - LP/LD and flight idle metrics need more data & analysis

• Capacity: up to 30% of traffic could use trial approach
Need for Definition of Advanced CDA

- Current UK industry standard criteria for CDA compliance:
  - “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”
  - Level flight = any flight segment with an altitude change of not more than 50 ft over 2 nm as measured in the NTK system

- Propose need for modified 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”

<table>
<thead>
<tr>
<th></th>
<th>Average level segments below 9000 ft</th>
<th>Current CDA definition compliance</th>
<th>Proposed new CDA definition compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>B752F base</td>
<td>5.9 nm/flight</td>
<td>67%</td>
<td>8%</td>
</tr>
<tr>
<td>B752F trial</td>
<td>1.3 nm/flight</td>
<td>93%</td>
<td>60%</td>
</tr>
<tr>
<td>MD11F trial</td>
<td>0.8 nm/flight</td>
<td>100%</td>
<td>83%</td>
</tr>
</tbody>
</table>
Institute for Aviation and the Environment (IAE)

- New inter-disciplinary institute at University of Cambridge
  - Involving 7 depts/centres

- “Fosters a close alliance between academia, industry and government to facilitate the transfer of knowledge by aligning world-leading research with end-user needs”

- Aviation Integrated Modelling (AIM)
  - Integrate economics, technology and atmospheric science (on both local and global scales) into a single model system

- Opportunities for Meeting Envtl Challenges of Growth in Aviation (OMEGA)
  - Combine academic capability with knowledge exchange between academia, industry & policymakers to develop future strategies for sustainable aviation

http://www.iae.damtp.cam.ac.uk/