Boeing & LVNL

AAT: Advanced Arrival Techniques

- Jesse I Follet
- Joseph Wat
- Rob Mead
- Robert Kok

- Boeing Commercial Airplanes
- Boeing Phantom Works – AATM
- LVNL - ATC the Netherlands
The Amsterdam Schiphol Situation

- Legislation Drafted 2002 with the addition of 5th Runway
- Total noise load for day, night, and annual is limited
- Legislation gave control of noise mitigations to the LVNL (Dutch Air Traffic Control)
- As part of ATM/Aviation integration projects Boeing agreed to help with noise issues
What are we doing about the problem?

- Working Together with
  - LVNL Dutch Air Traffic Control
  - Phantom Work ATM and Technology Integration
  - Boeing Commercial Airplanes
  - Maastricht Upper Airspace Controllers
  - Partner Airlines – Transavia and Martinair
- Quiet operational procedures integration forming AADT
- Establishing relationships and long term partnerships

Sustainable Solutions

- Safe
- Environmentally beneficial
- Operationally feasible
- Capacity
- ANSP
- Air Traffic Mgmt.
- Boeing
- Community
- Regulators
- Pilots
- Airlines
Solutions for Today’s Fleet

- Tomorrow’s fleet will introduce lower noise aircraft into existing fleets of older aircraft
- Today’s fleet needs low noise solutions
- Airport noise is limiting factor in traffic growth
- Boeing needs solutions
- Integrating existing and new technologies into the total airspace environment is crucial to future growth of aviation
- Working with air navigation partners to improve airspace traffic and capacity will gain Boeing the knowledge and experience to introduce new products and solutions.
- Experience can be leveraged to improve the environment situation at airport community.
AADT – Advance Arrival and Departure Techniques

- Investigate the benefits of Low Noise Arrivals (CDA) and Optimized Departure procedures
- Goal Integrating Technologies for Air Traffic Growth while minimizing environmental loads
  - Aircraft Flight Management Systems (FMS) technology with Air Traffic Management (ATM) systems
- Conduct In-Service Demonstrations of procedures
  - Collect data!
  - Gain experience working with different ATC and Airplane systems in an operational environment
  - Leverage results and turn into real solutions
2005-2006 Team Objective:

Conduct in-service demonstration of CDA procedure to support the following analyses in order to provide recommendations for strategy development.

- Impact in environmental loads - fuel burn, noise and engine exhaust emissions
- Airline satisfaction with procedure and operating cost
- Flight Crew satisfaction with procedure and workload impact
- Controllers satisfaction with procedure and workload impact
- Use of aircraft derived data in enhancing the predictability of ATM system
**Trial Summary**

- Participating airlines: Transavia and MartinAir
- Aircraft types: B737/8, MD-11, and A320
- 192 flights performed CDA
- Demonstrated noise and emission reduction, fuel saving, and time reduction
- Demonstrated data downlink and ETO accuracy

<table>
<thead>
<tr>
<th>Candidate flights</th>
<th>Actual CDA flights</th>
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<tr>
<td><strong>Airline</strong></td>
<td><strong>actype</strong></td>
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<tr>
<td>MPH</td>
<td>A320</td>
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<tr>
<td>MPH</td>
<td>MD11</td>
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<tr>
<td>TRA</td>
<td>B737/8</td>
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<td><strong>Total:</strong></td>
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* Trial occurred between January 8 and March 15, 2006*
MD-11 Trial Profiles
Baseline Altitude Profiles – MD11 (Prior to Trial Start Date)
CDA Altitude Profiles – MD11 (Prior to Trial Start Date)
CDA Nighttime Trial
Transavia 737NG
Schiphol Airport, Amsterdam
CDA Nighttime Trial
Transavia 737NG
Schiphol Airport, Amsterdam
CDA Nighttime Trial
Transavia 737NG
Schiphol Airport, Amsterdam
## CDA Nighttime Trial
Transavia 737NG
Schiphol Airport, Amsterdam

<table>
<thead>
<tr>
<th></th>
<th>Time from Top of Descent (Minutes)</th>
<th>Approximate Fuel Expended (lbm)</th>
<th>Approximate Fuel Expended (Gallons)</th>
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<td>23.6</td>
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<tr>
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<tr>
<td>Baseline Night</td>
<td>0.0</td>
<td>37.7</td>
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## CDA Nighttime Trial
### Martinair MD-11
Schiphol Airport, Amsterdam

<table>
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<th>Approximate Fuel Expended (Ibm)</th>
<th>Approximate Fuel Expended (Gallons)</th>
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<th>CDA Fuel Savings (Ibm)</th>
<th>Approximate Fuel Expended (Gallons)</th>
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<tr>
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<tr>
<td>Baseline Night</td>
<td>8.2</td>
<td>1302.6</td>
<td>186.1</td>
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737 Noise Under the Flight Path

Peak dB vs Distance to Threshold (Nmi)

- CDA
- Baseline Night
- Baseline Day
- Conventional Runway
MD11 Noise Under the Flight Path

Graph showing the peak dB levels at different distances to the threshold (Nmi). The graph compares different scenarios:
- CDA (green)
- Baseline Night (pink)
- Baseline Day (red)
- Conventional Runway (teal)

The x-axis represents the distance to the threshold in Nautical Miles, ranging from -24 to 2 Nmi. The y-axis represents the peak dB levels, ranging from 40 to 160 dB.
Continuous Descent Arrival
737NG - ARTIP2B

Peak dBA
- 55
- 60
- 65
- 70
- 75
- 80
- 85
Preliminary Conclusions:

- Nighttime flights are cleared to fly their own procedure due to little to no traffic conflicts. I.e. Few required level segments at night anyway.
- No appreciable fuel burn or time benefit for lighter airplanes that are allowed to fly pilot procedure and routing. Could be Transavia’s standard ops procedure.
- For optimal CDA, all airplanes must fly the published lateral routing for FMC to accurately predict waypoint speeds and altitude for ATC.
- Noise exposure areas are significantly reduced overall from a CDA.

In Work:

- Change in Engine Emissions levels?
- Importance of runway clearance?
- Consistency of CDA?
Results!!!!

- **Flight Crew Procedure Documents**
  - A320, MD-11, and 737-800 from Martinair and Transavia participating in CDA trial

- **ATM Procedures Documents**
  - Air Traffic Controller acceptance
  - Trial began January 9 and will run through March 15

- **Data!**
  - Require data for ATM predictability and environmental benefit assessment
  - FMC data for 737 and MD-11 (not A320) for environmental benefit assessment
  - ACARS data downlinks for ATM predictability assessment and systems improvement
Backups
AADT – 2006 Plan of Action

- Complete CDA trials
  - Assess environmental benefits
  - Assess aircraft position and time predictability
  - Assess air crew, controller and airline satisfaction
  - Final Report!!!

- R&D study of Advanced Departures
  - Spreading of flight tracks
  - Departure procedure development
  - Integration with Advanced Arrivals
  - Study multiple departure procedures on multi-operational metrics
Schiphol Night Operations - Transitions

- New CDA procedures after the operation of the 5th RWY
- Single runway for departures and arrivals
- Arrival capacity 24 a/c per hour (Landing interval 2.5 min)
- CDA from 4000 ft via corridors
Schiphol Transition (CDA) Characteristics before 2006

- Aircraft perform the approaches as expected
- Better vertical performance is desired
- Standardization of ATS procedures is required
  - Cleared for approach; or
  - Transition
- Critical aspect is controller training
With Such Obvious Benefits, What’s the Problem?

- More than one airplane in airspace!
  - Aircraft separations
  - Must be vectored to a particular STAR
  - Predictability of aircraft position by airplane and ground
  - Weather patterns
  - Airplane capabilities
  - Mixing inbound AND outbound traffic
  - Complexity of airspace (UAC, ATC, APP) and regional differences
- On and On and On...
Complexity of Airspace
CDA Procedure

- Requirements of individual flights for trial
  - Airplane must have RNAV and VNAV capabilities
  - Is on a Standard Arrival Route in the Amsterdam FIR
  - ETA is between 2330 and 0500 LT
- Flight Crews - Plan lateral route with the FMC
  - Program transitions
  - Delete published level and speed restrictions
  - Set Descent speed to 300 KIAS above FL100
  - Apply max speed of 250 KIAS below FL100
Continuous Descent Arrivals

- Designed for fuel efficiency
- Quieter farther from the airport

Standard Arrival
Continuous Descent Arrival

37% Reduction

747-400
65 dBA Contours

Distance along flight track (ft)
737 CDA Contour Area

Graph showing the ILS approach 2000ft Level, Glide Slope Intercept 2K ft, and Glide Slope Intercept 3K ft.
## 737-800 Fuel Burn and Time Comparisons

<table>
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<th>Fuel (kg)</th>
<th>Time (minutes)</th>
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<td>Daytime CDA Profile</td>
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<td>Nighttime Baseline Profile</td>
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<tr>
<td>Nighttime CDA Profile</td>
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<tr>
<td>Savings Attributed to Nighttime CDA</td>
<td>121</td>
<td>2.8</td>
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</table>
Current CDA Operation (2006 Trial) – Initial step of LVNL ATM CDA Strategy: One way communication from FMC to ATC
AMS CDA Procedure

5 minutes before TOD
Pilot manual selected FMC downlink through ACARS

“Request CDA for Schiphol Airport”

“Cleared for CDA” for Schiphol Airport

“On CDA”

Transfer to ATC

AMS Schiphol

LVNL ATC

Maastricht UAC

BOEING
Advanced Arrival Flight Demonstration
Boeing, ATM, The Netherlands ATC, Transavia, Martinair

2005 Flight Demonstration Schedule

- LVNL/Boeing Project Decision
- Flight Demo Plan
- Airline & Maastricht
- Final Documents
- Flight Demo Begins

Airline Agreement
PT 5 (AMS)
PT 6 (AMS)
PT 7 (AMS)
PT 8 (So Cal)
PT 9 (SEA)