Boeing & LVNL

AAT: Advanced Arrival Techniques

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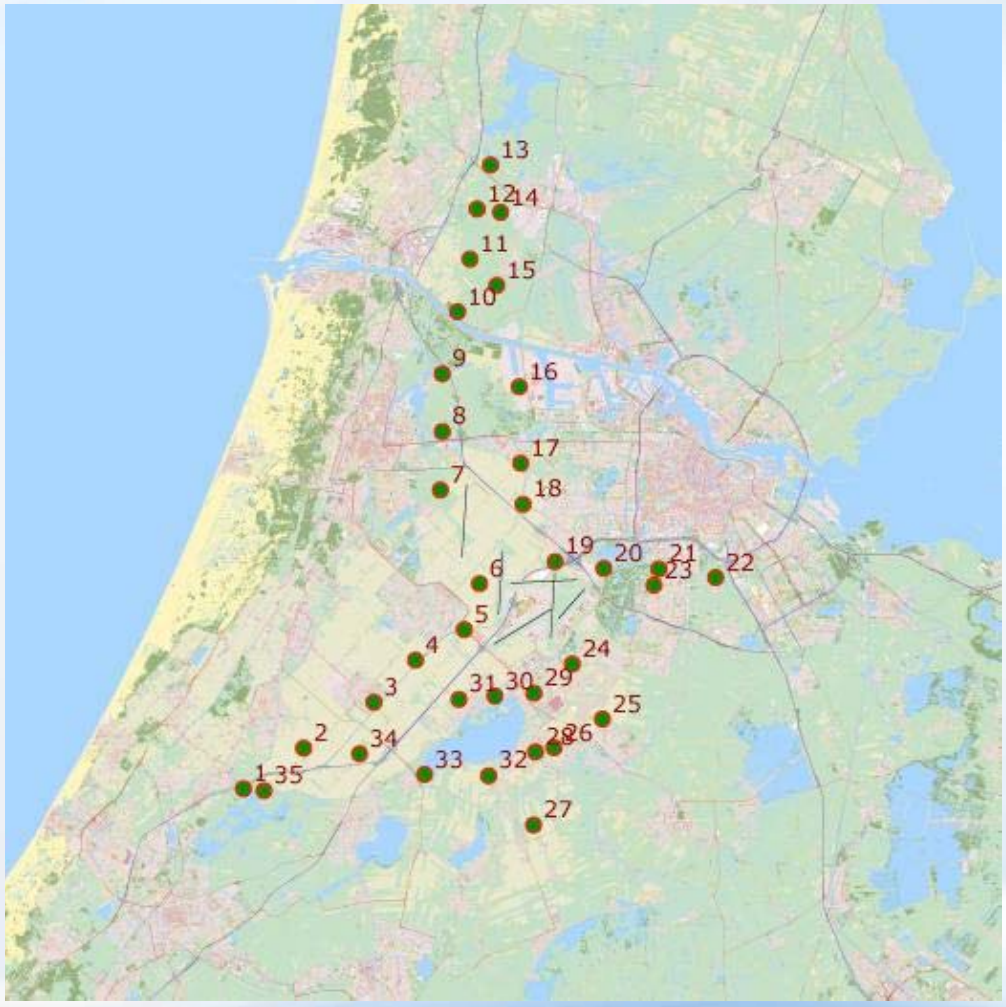
- *Boeing Commercial Airplanes*
- *Boeing Phantom Works – AATM*
- *LVNL - ATC the Netherlands*

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



NOMOS

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

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

Advanced Arrival Flight Demonstration

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**

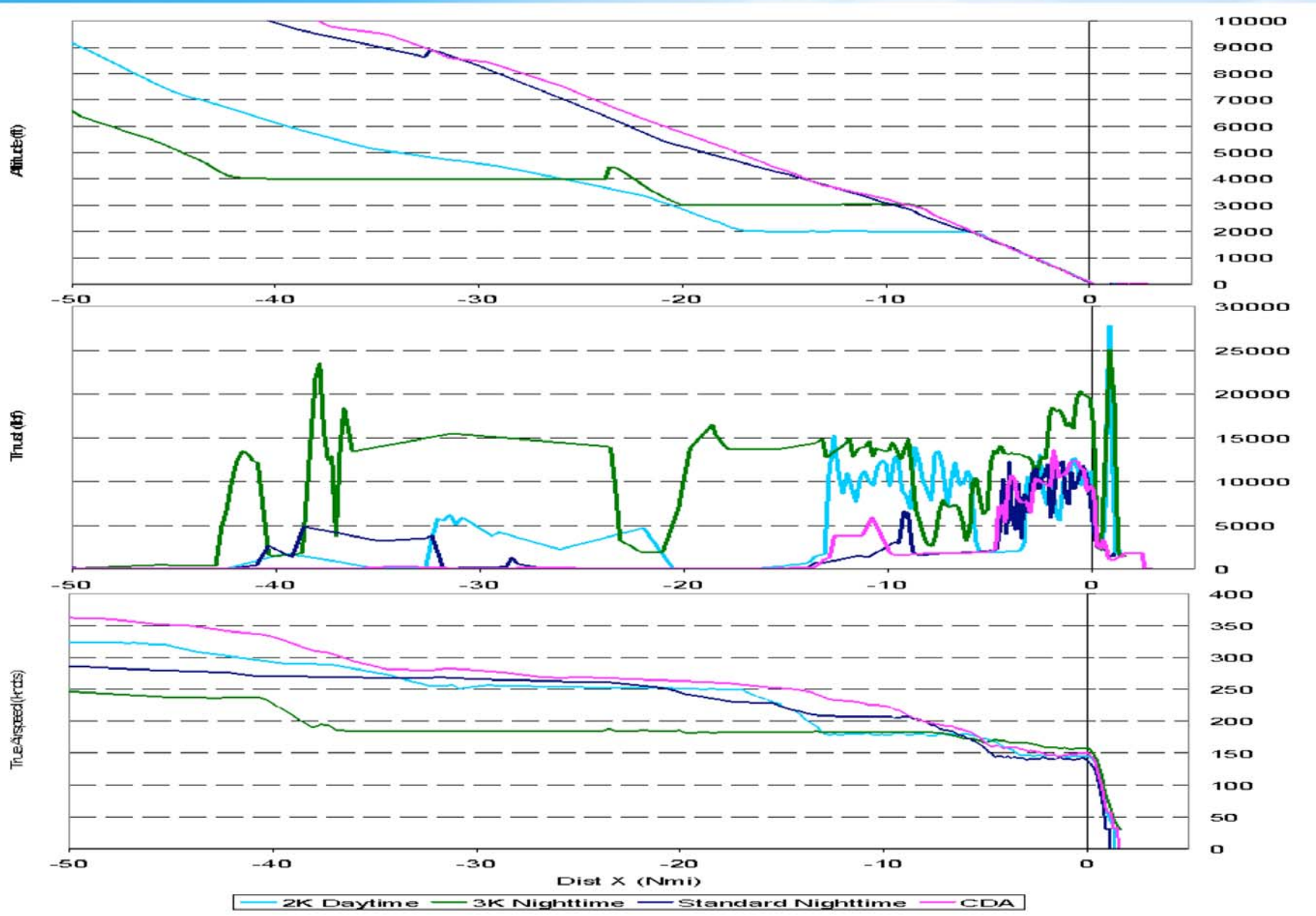
Trial Summary

- 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

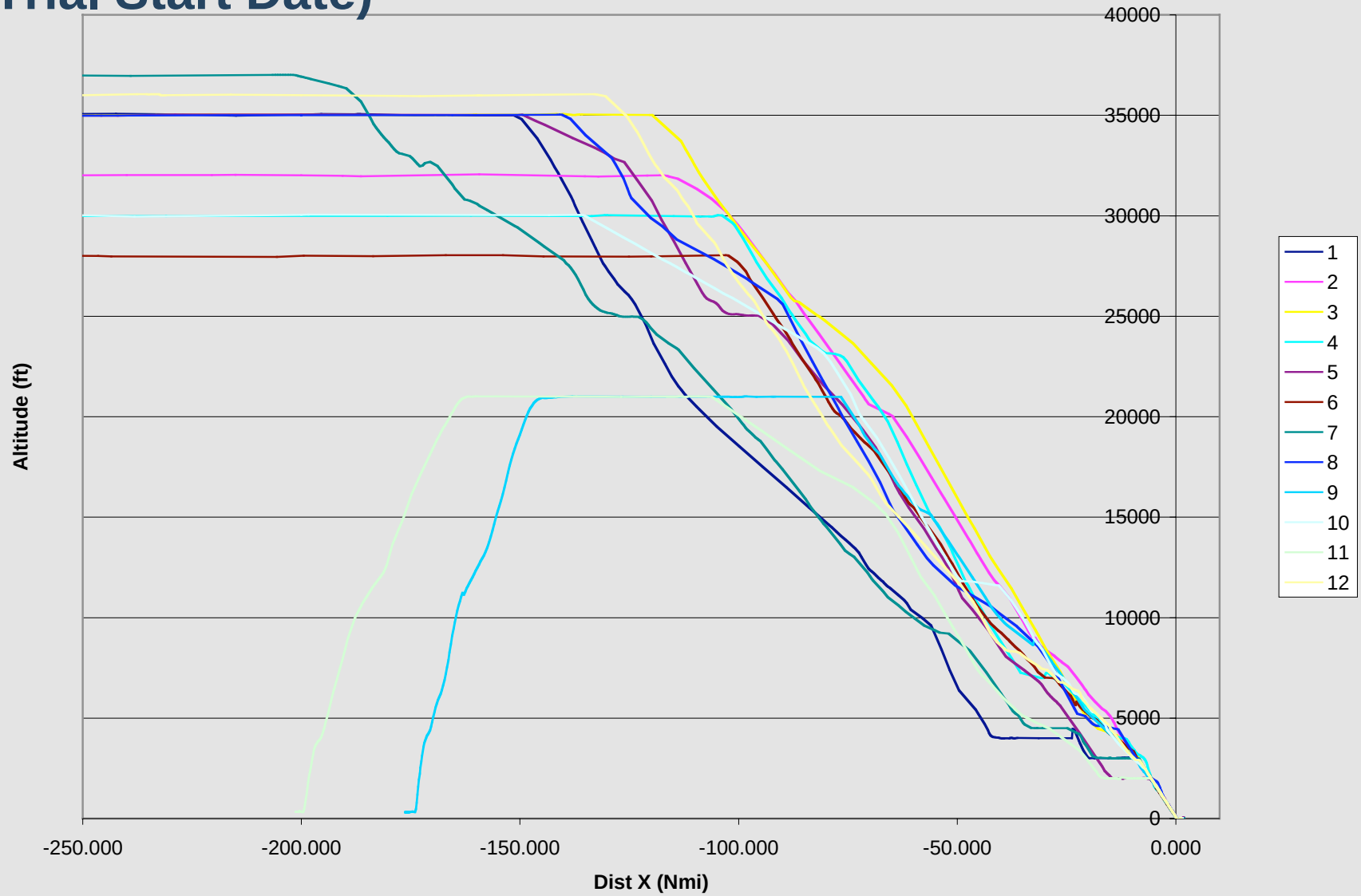
Candidate flights			Actual CDA flights		
Airline	actype	# flights	actype	# flights	%flights
MPH	A320	77	A320	44	**57%**
MPH	MD11	14	MD11	3	**21%**
TRA	B737/8	399	B737/8	145	**36%**
Total:		490		192	**39%**

* Trial occurred between January 8 and March 15, 2006

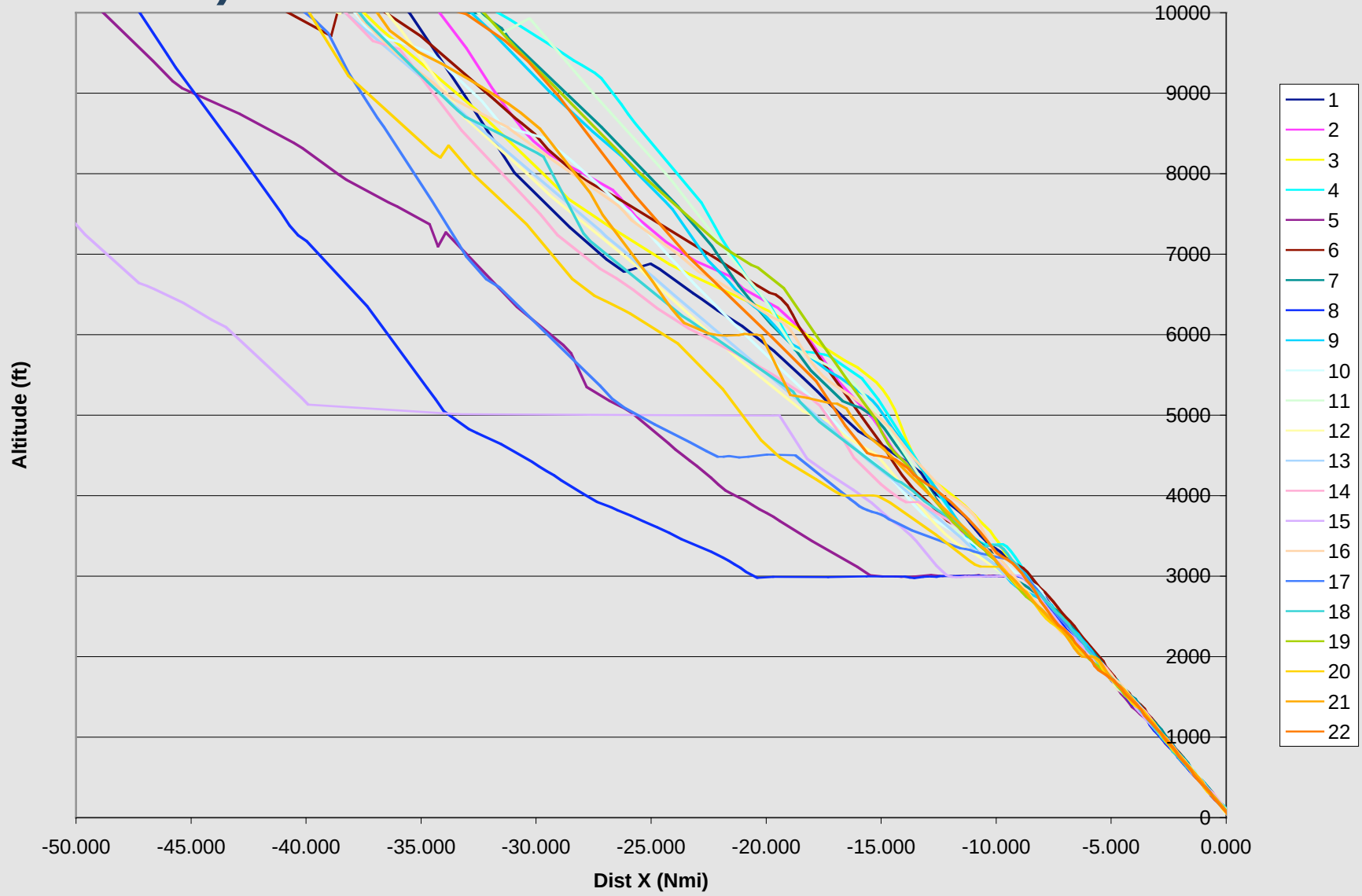
MD-11 Trial Profiles



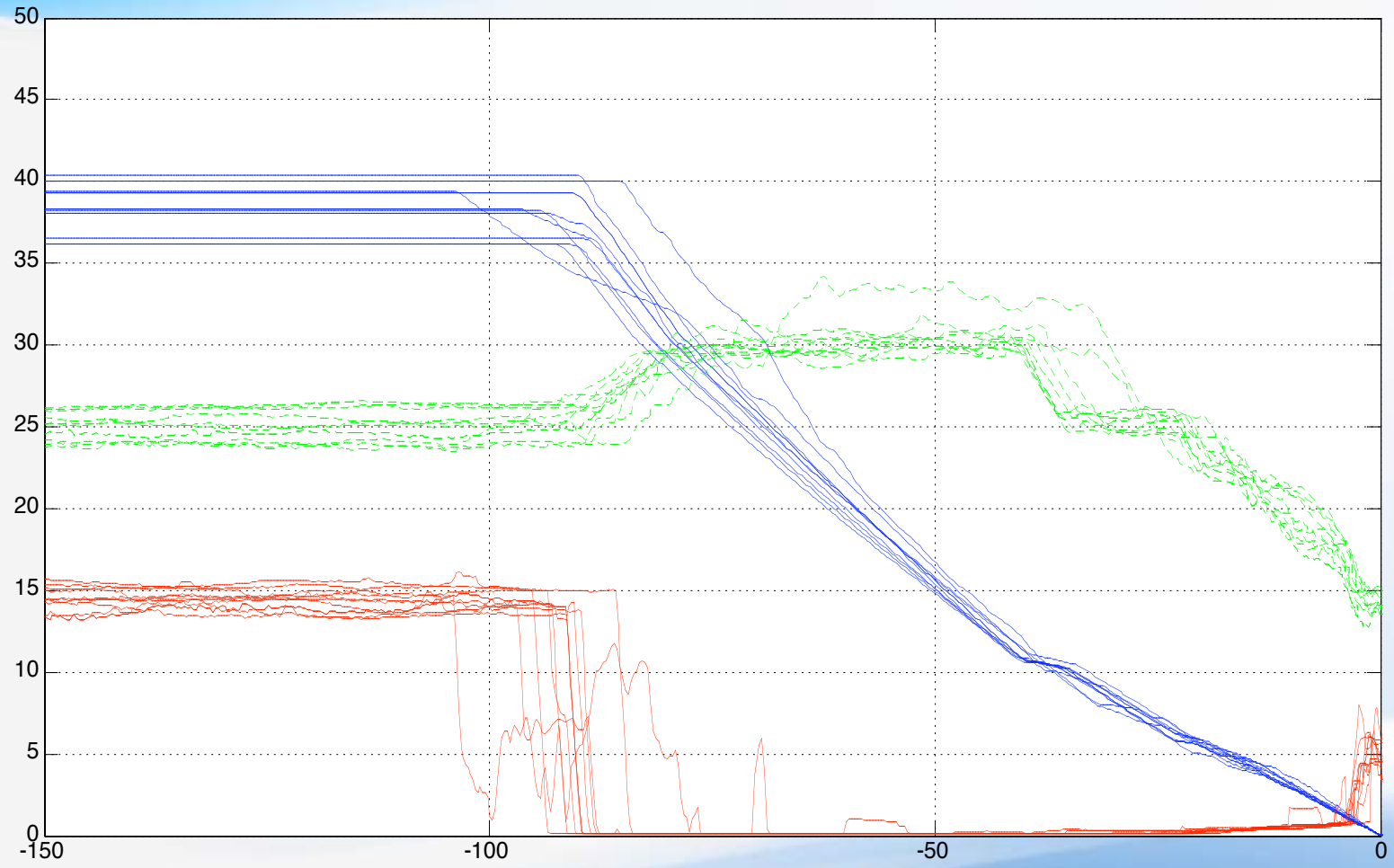
Baseline Altitude Profiles – MD11 (Prior to Trial Start Date)



CDA Altitude Profiles – MD11 (Prior to Trial Start Date)



CDA Nighttime Trial
Transavia 737NG
Schiphol Airport, Amsterdam



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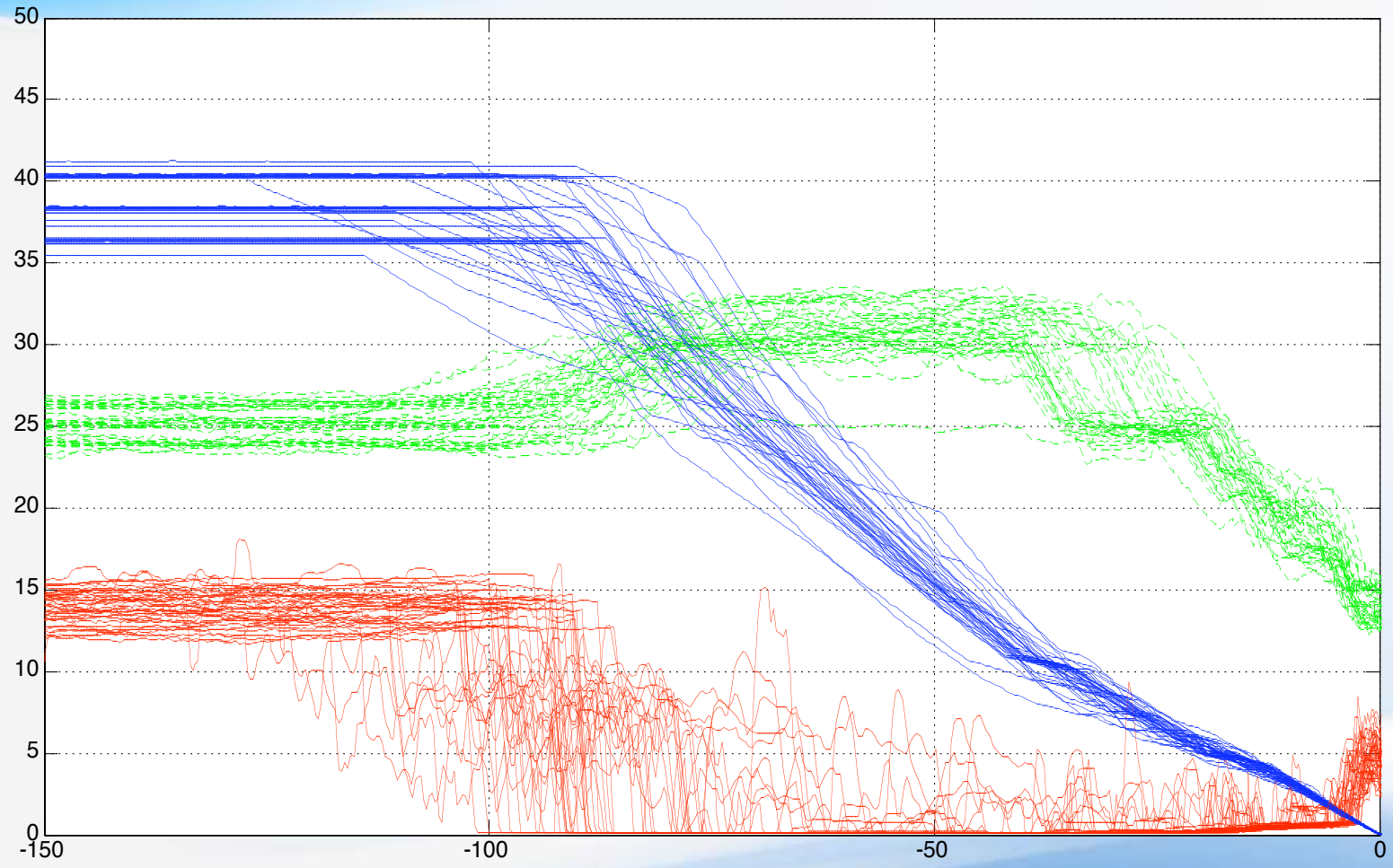

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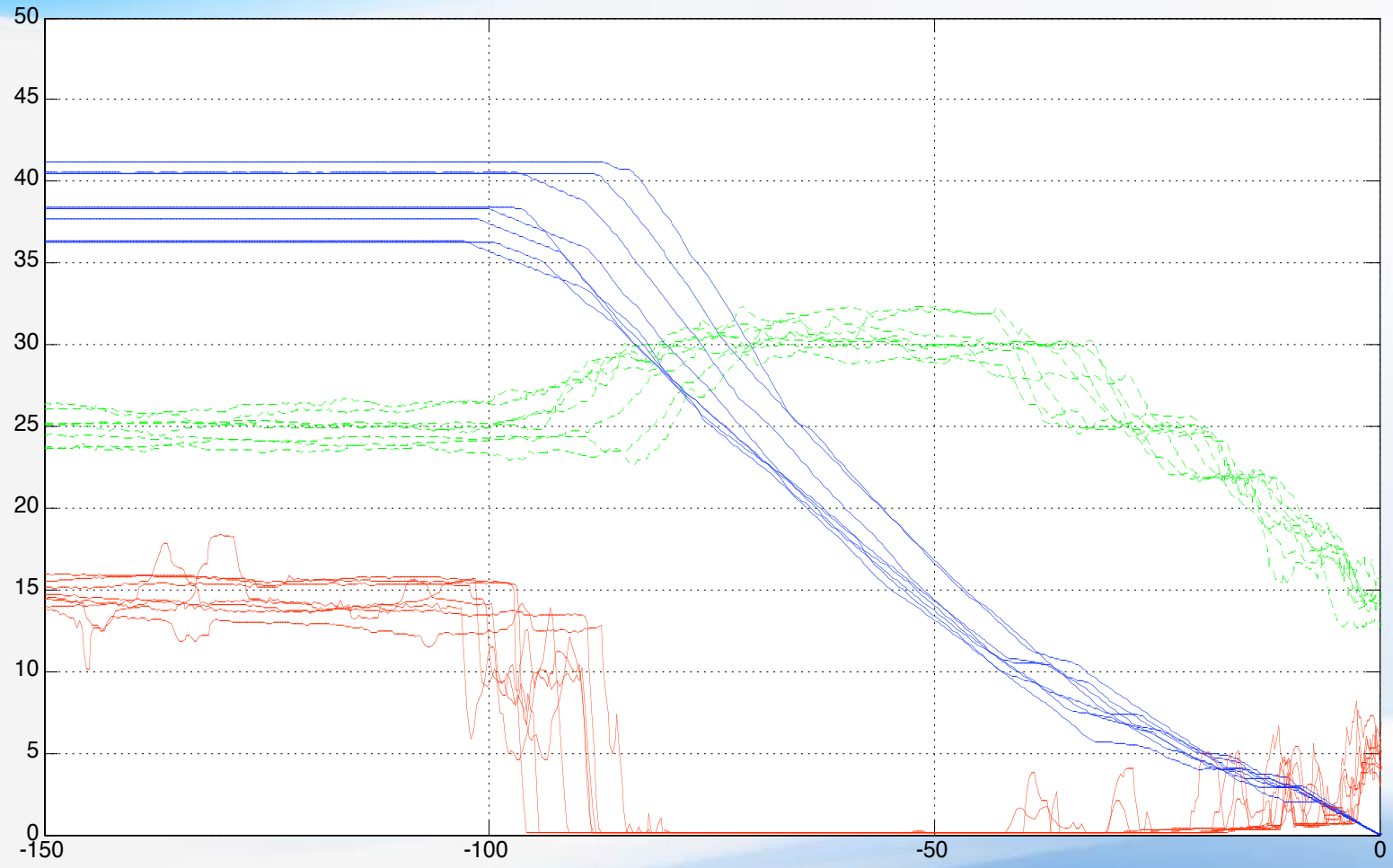

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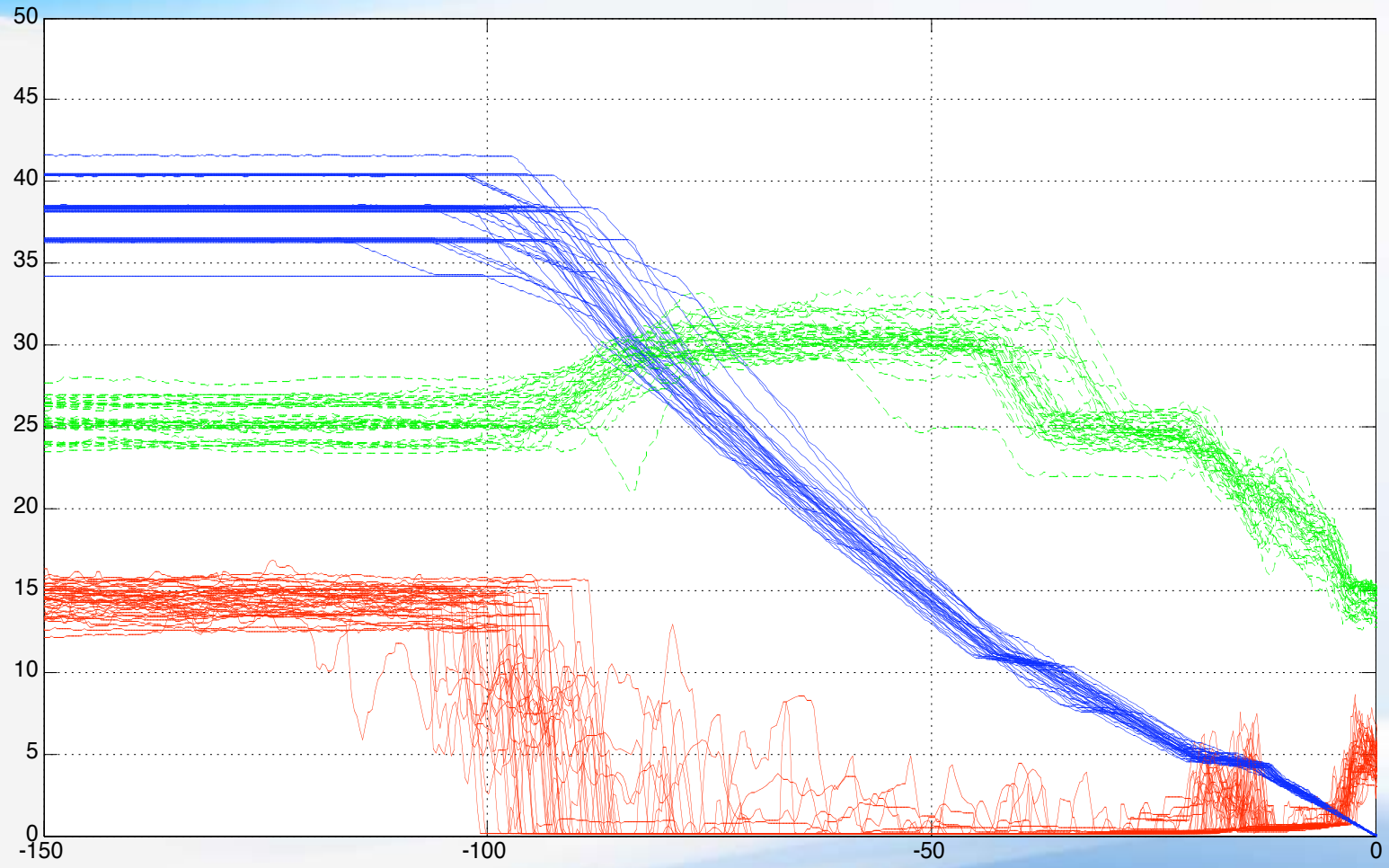

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CDA Nighttime Trial
Transavia 737NG
Schiphol Airport, Amsterdam

	Time from Top of Descent (Minutes)	Approximate Fuel Expended (lbm)	Approximate Fuel Expended (Gallons)
Conventional	23.4	760.5	108.6
Baseline Day	23.2	850.4	121.5
Baseline Night	23.6	809.8	115.7
Continuous Descent Arrival (CDA)	23.4	798.1	114.0
Savings from CDA	CDA Time Savings (Minutes)	CDA Fuel Savings (lbm)	Approximate Fuel Expended (Gallons)
Conventional	-0.2	89.9	12.8
Baseline Day	0.2	49.3	7.0
Baseline Night	0.0	37.7	5.4

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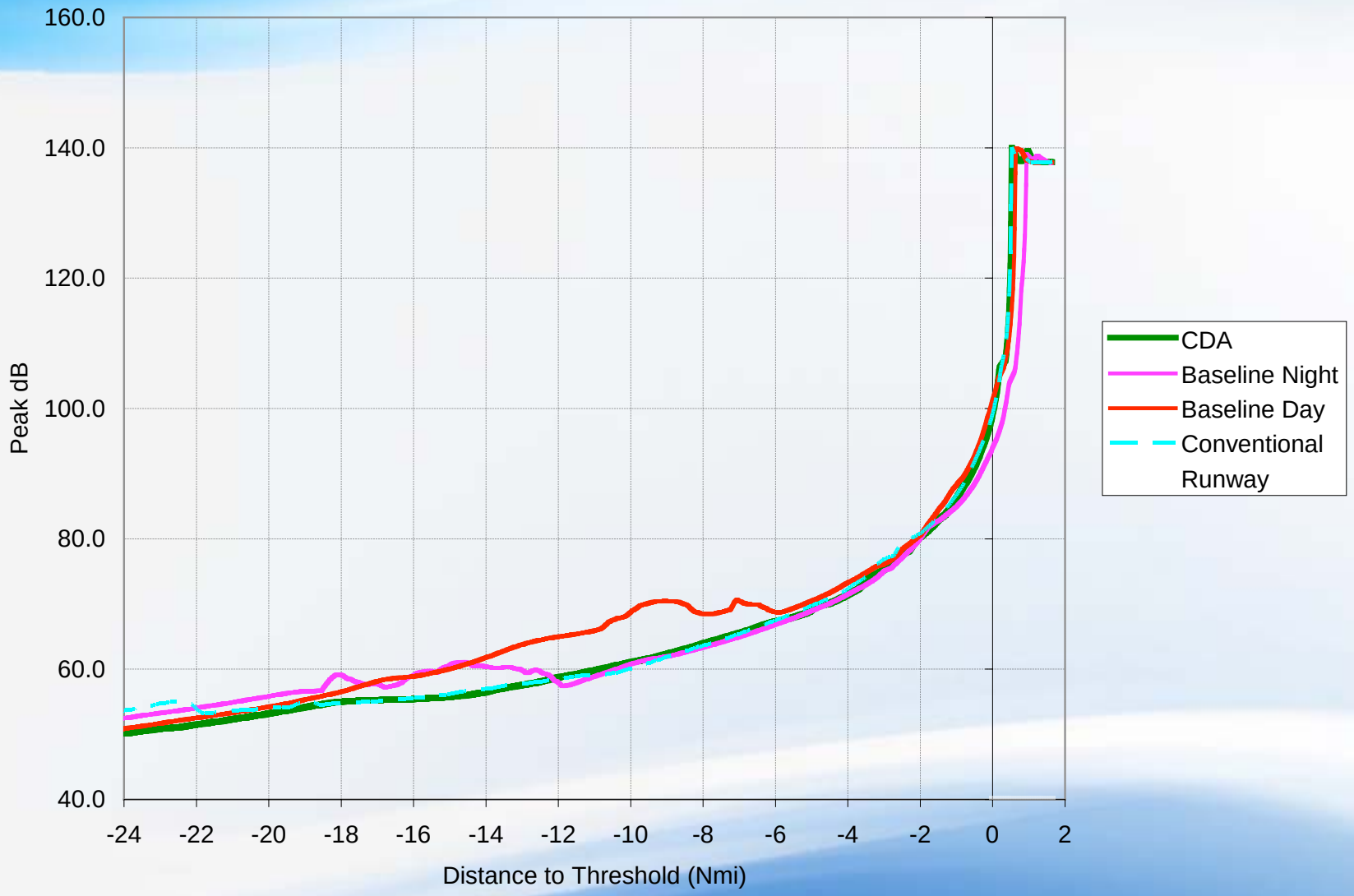
CDA Nighttime Trial

Martinair MD-11

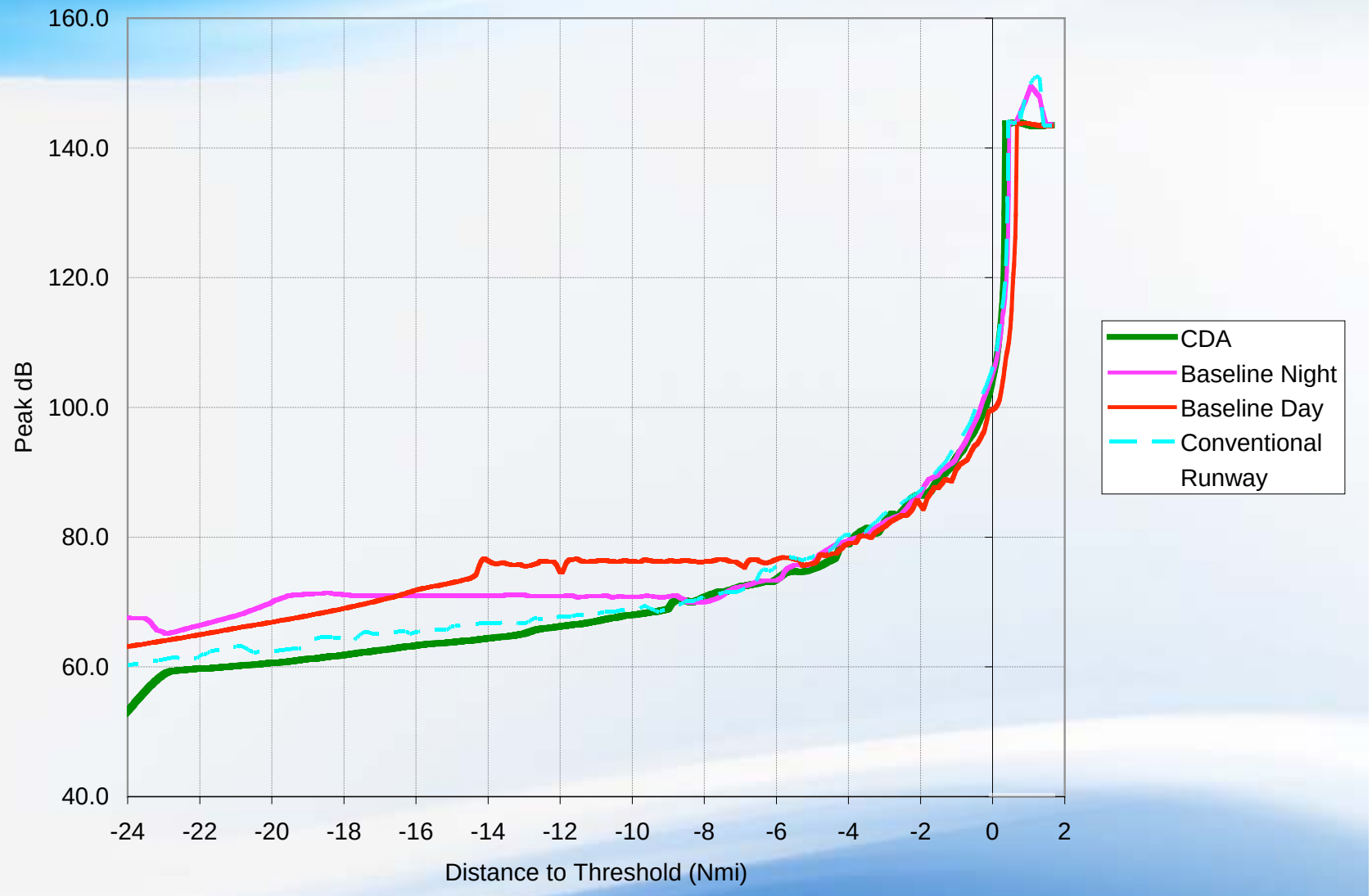
Schiphol Airport, Amsterdam

	Time from Top of Descent (Minutes)	Approximate Fuel Expended (lbm)	Approximate Fuel Expended (Gallons)
Conventional	33.9	2545.8	363.7
Baseline Day	32.9	3463.1	494.7
Baseline Night	40.8	3708.9	529.8
Continuous Descent Arrival (CDA)	32.5	2406.3	343.8
Savings from CDA	CDA Time Savings (Minutes)	CDA Fuel Savings (lbm)	Approximate Fuel Expended (Gallons)
Conventional	1.4	139.4	19.9
Baseline Day	0.4	1057.0	151.0
Baseline Night	8.2	1302.6	186.1

737 Noise Under the Flight Path

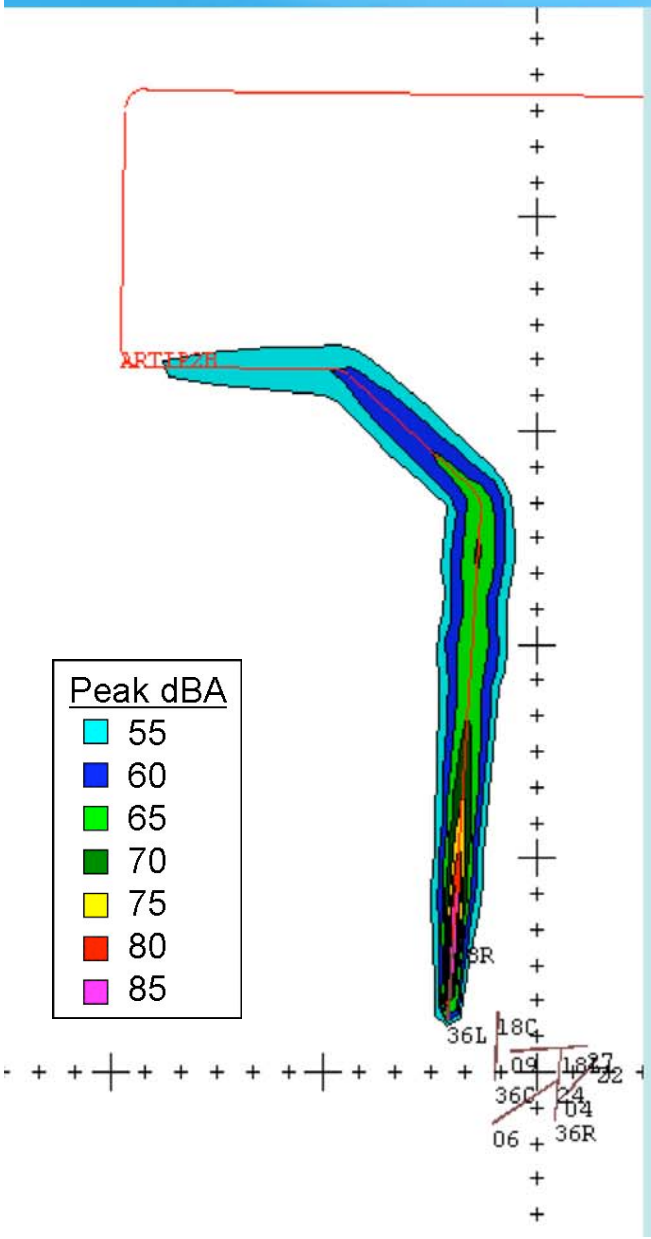


MD11 Noise Under the Flight Path

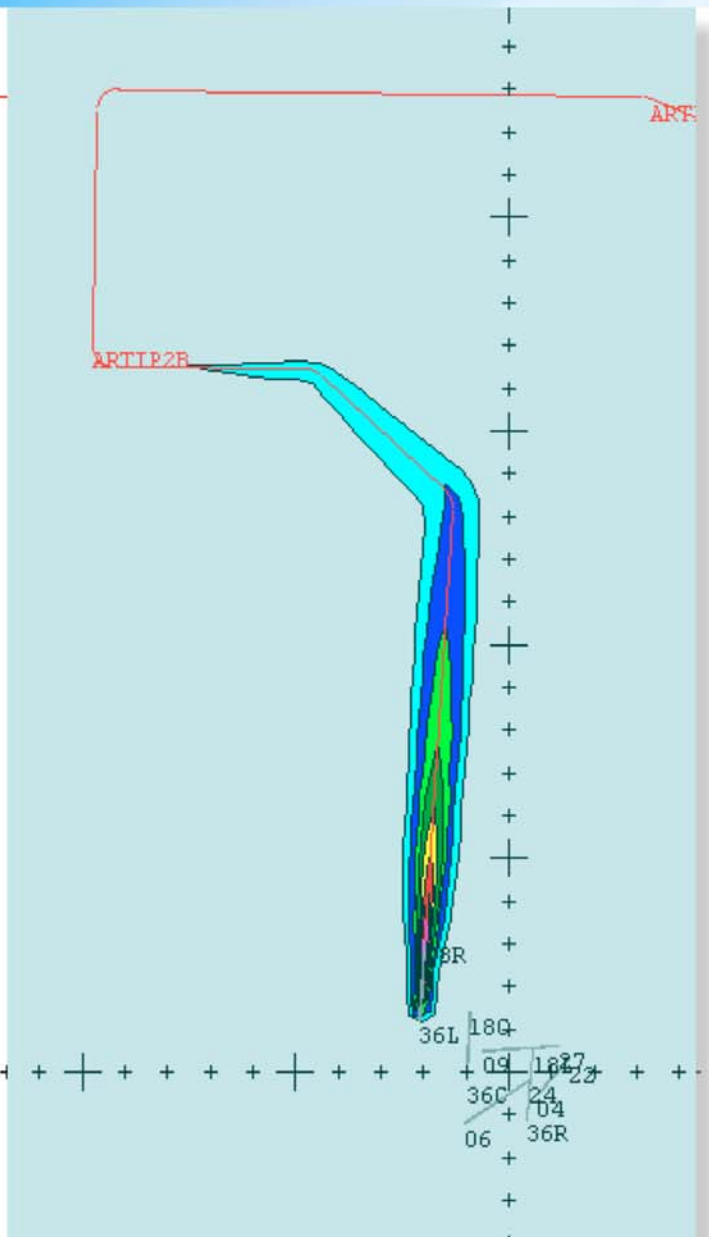


Continuous Descent Arrival

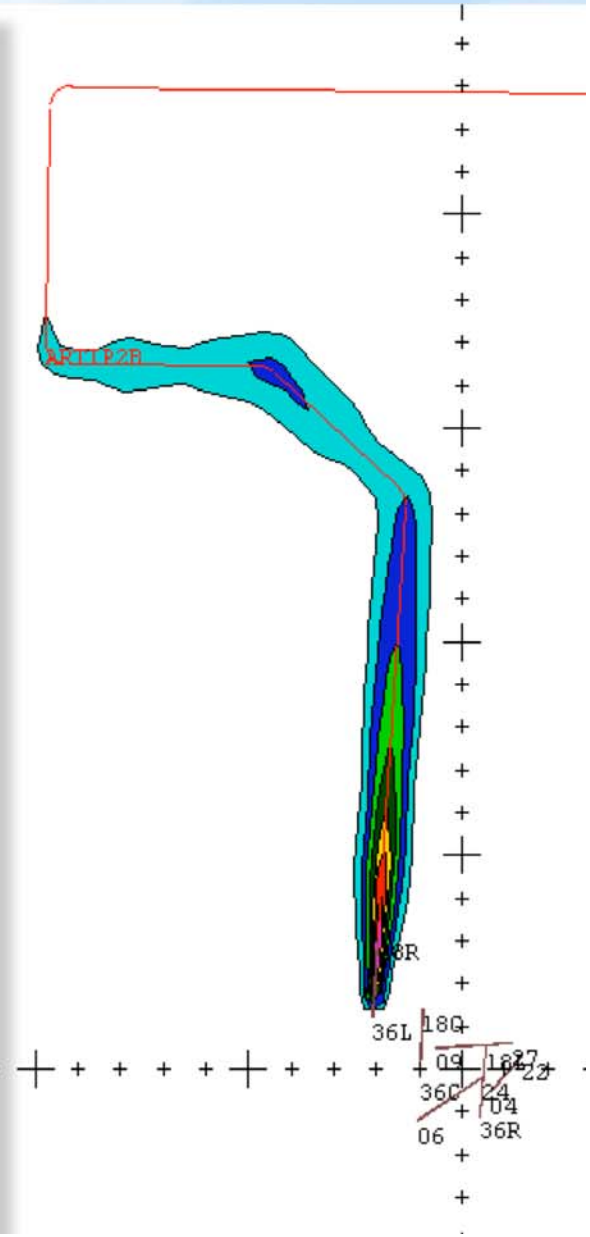
Standard Daytime Arrival
737NG - ARTIP2B



Continuous Descent Arrival
737NG - ARTIP2B



Standard Nighttime Arrival
737NG - ARTIP2B

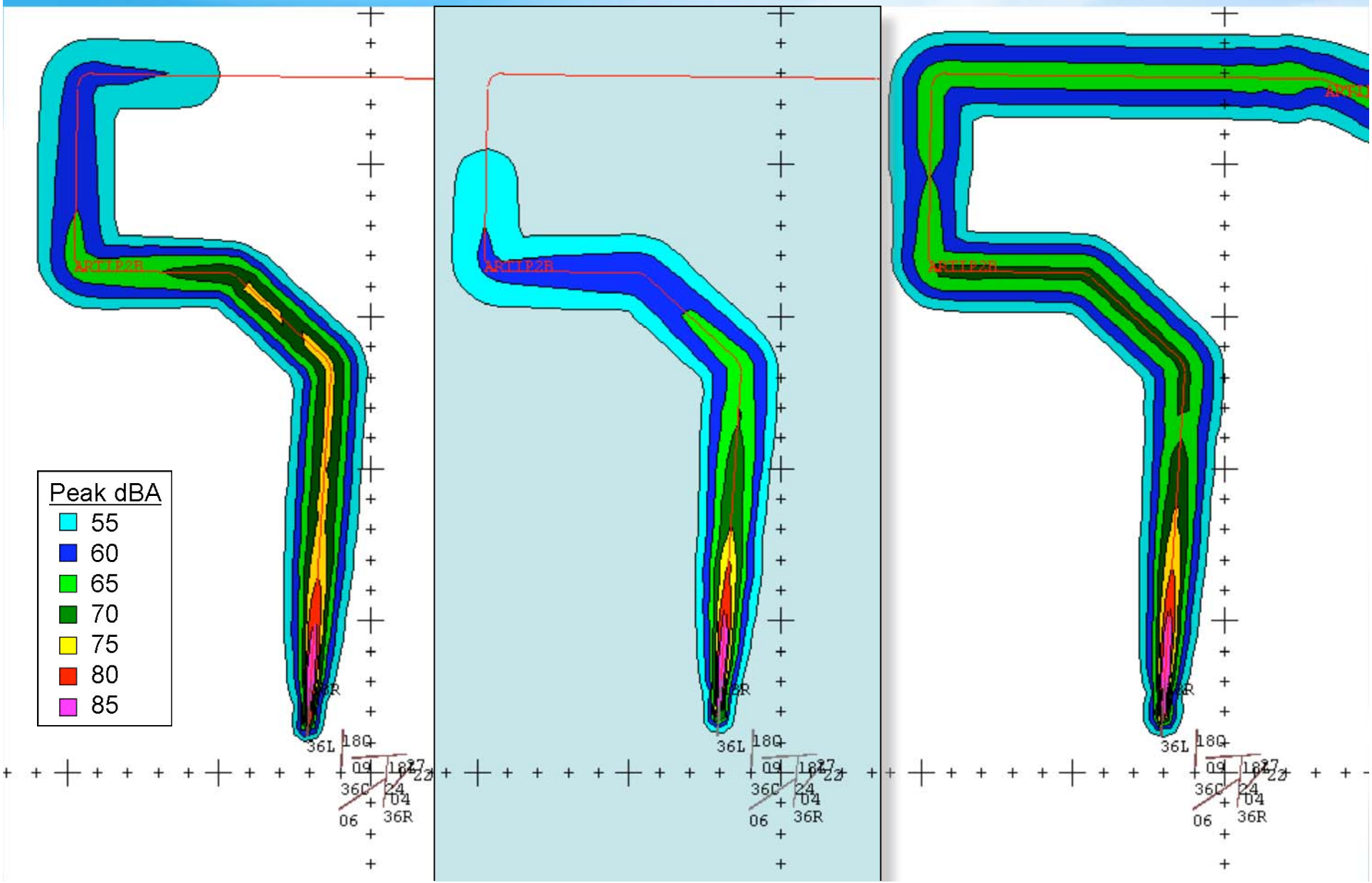


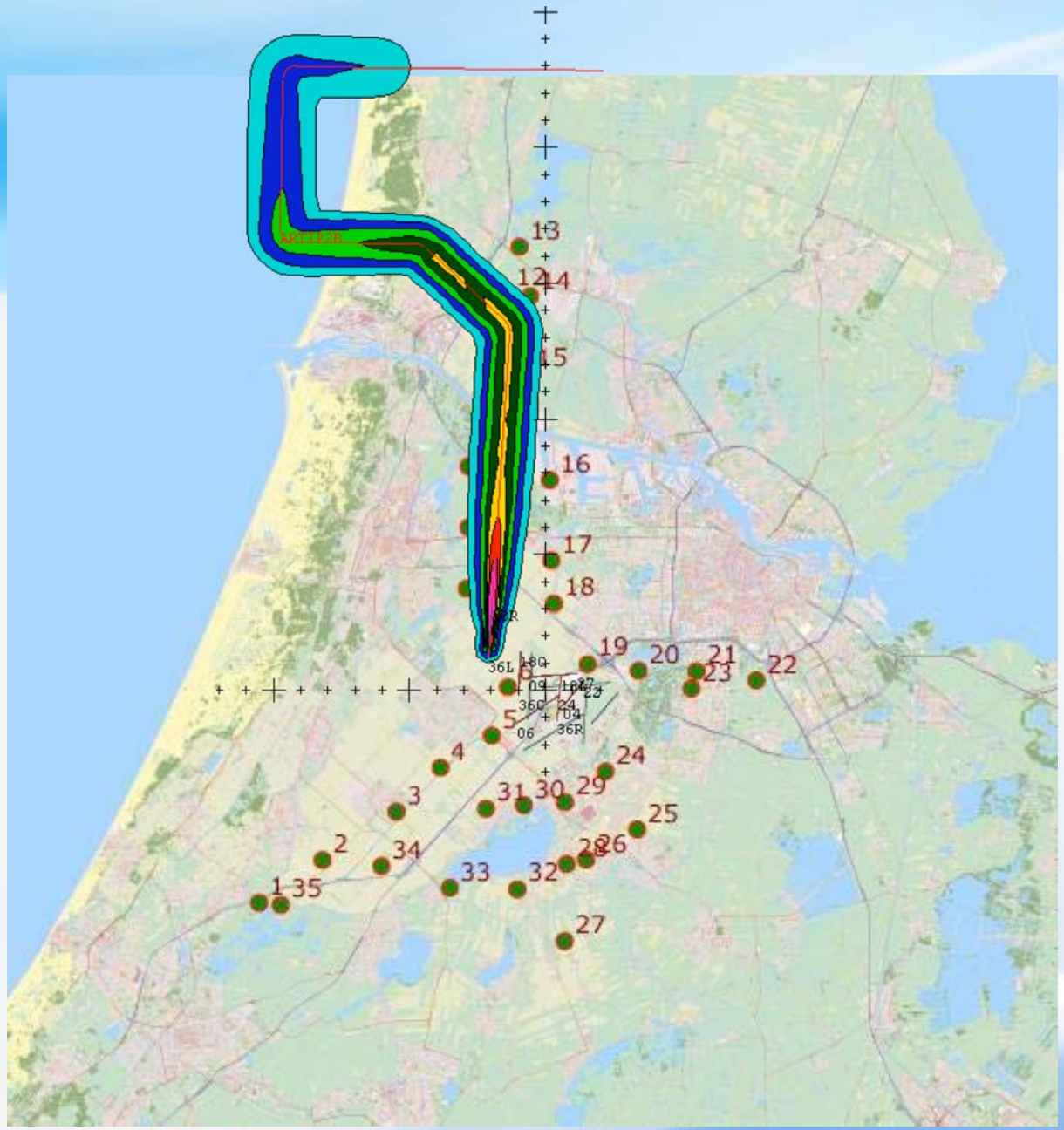
Continuous Descent Arrival

Standard Daytime Arrival
MD11 - ARTIP2B

MD11 - ARTIP2B

Standard Nighttime Arrival
MD11 - ARTIP2B

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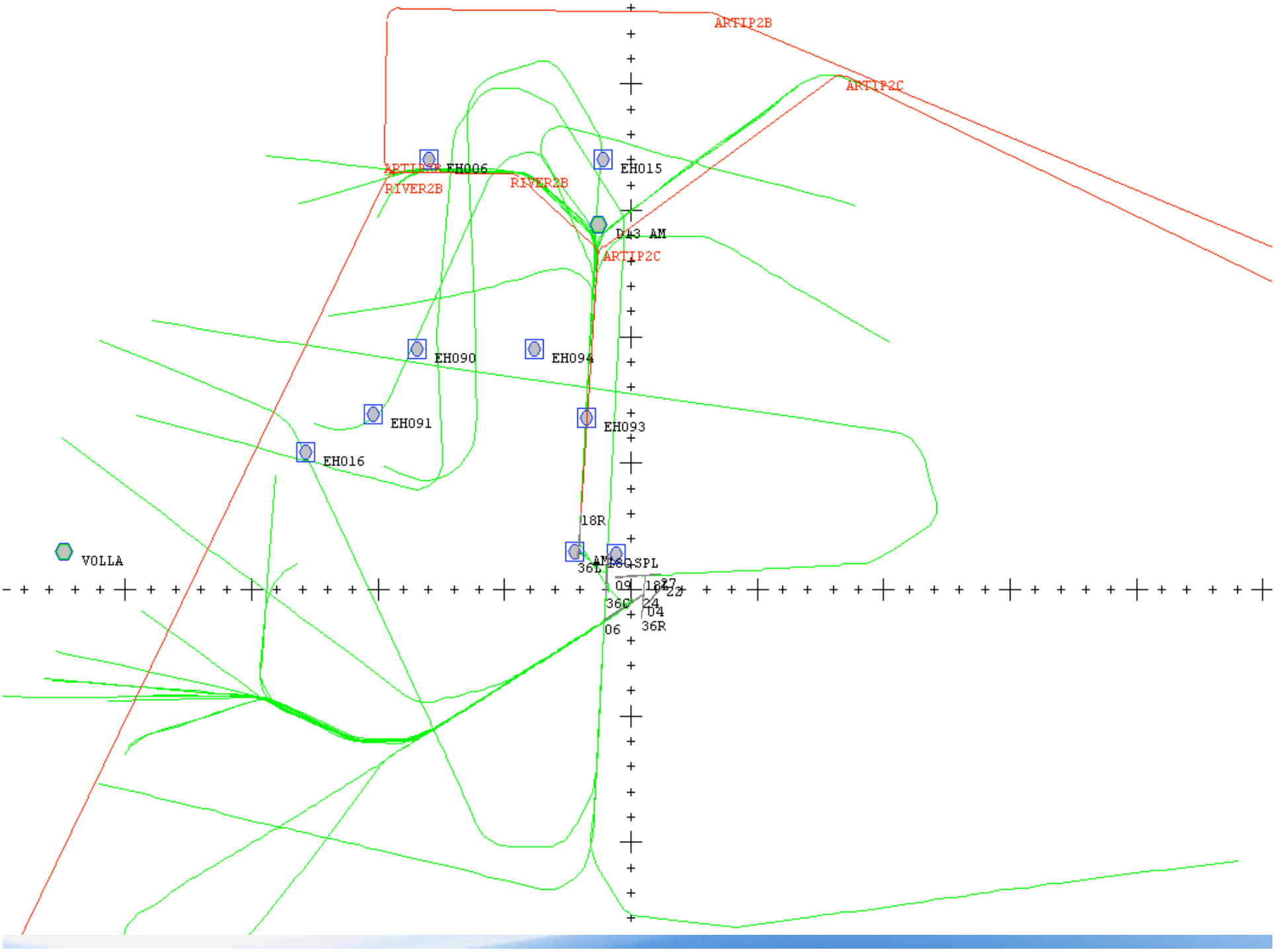
Preliminary Conclusions:

- Nighttime flights are cleared to fly their own procedure due to little to no traffic conflicts. Ie. 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?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EH015
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36R


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Forever New Frontiers

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

http://www.schiphol.nl/_nomos/portlet/NOMOS_online.jsp?PORTLET<>cnt_id=10134198673792117&FOLDER - Microsoft Internet Explorer

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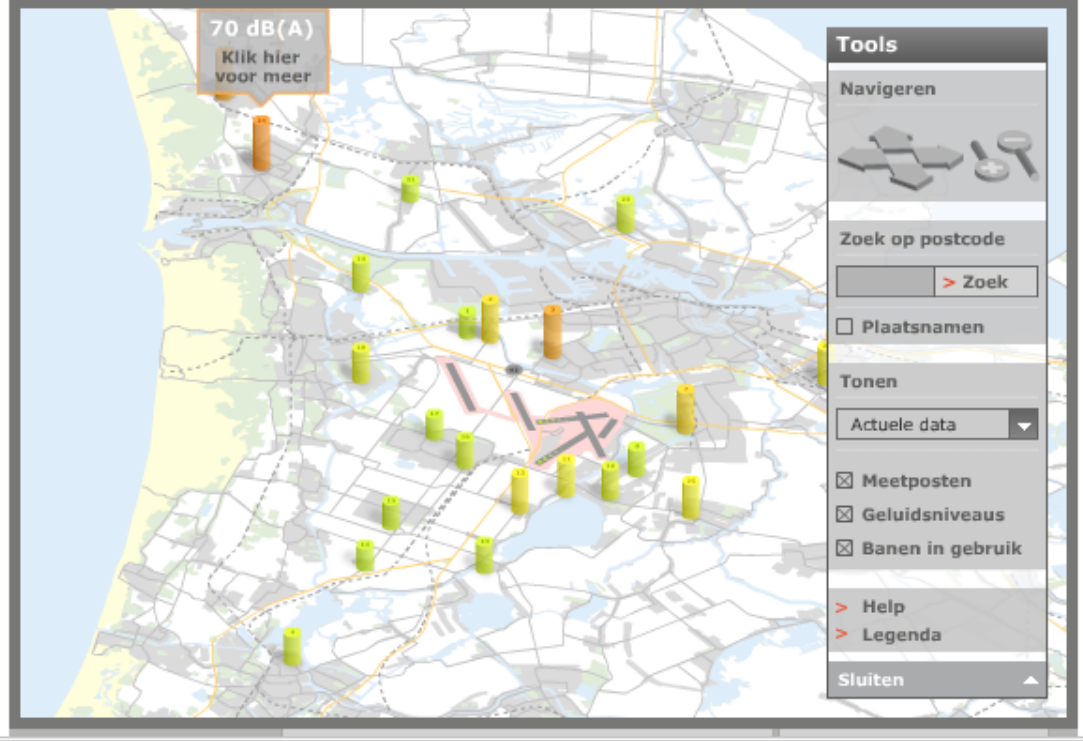
NOMOS online



Done Internet

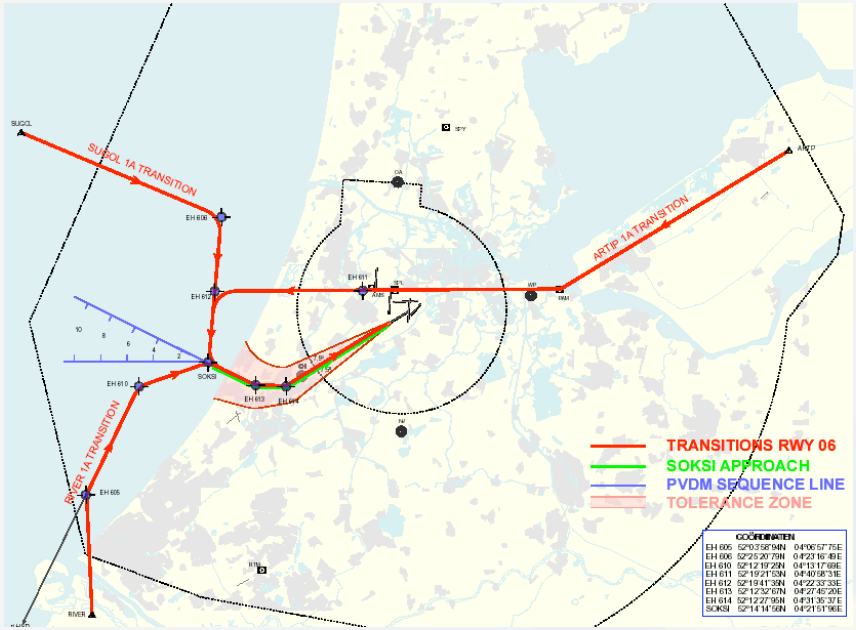
Start E:\CDA Workshop Atlanta Microsoft PowerPoint - [... PowerPoint Slide Show - ... My Yahoo! - Microsoft In... http://www.schiphol....

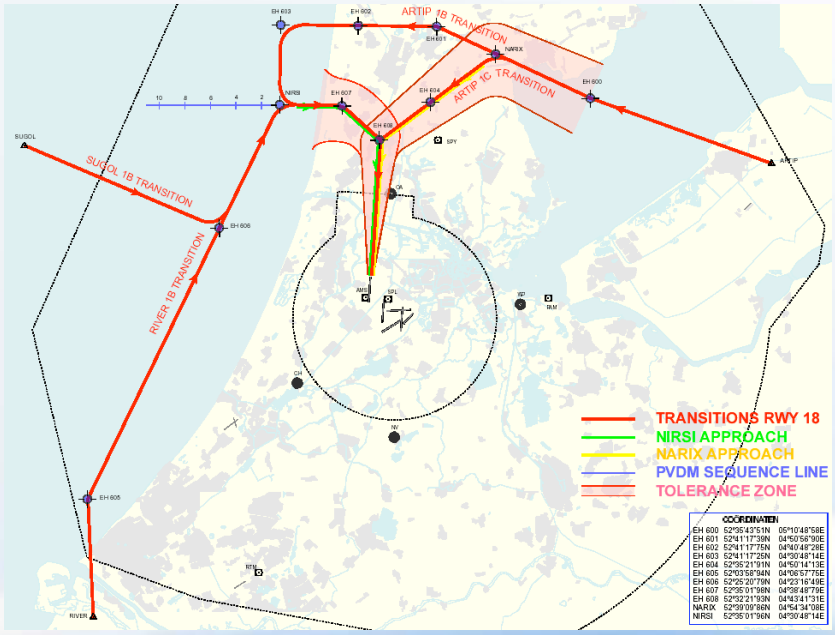
AADT – 2006 Plan of Action

- 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

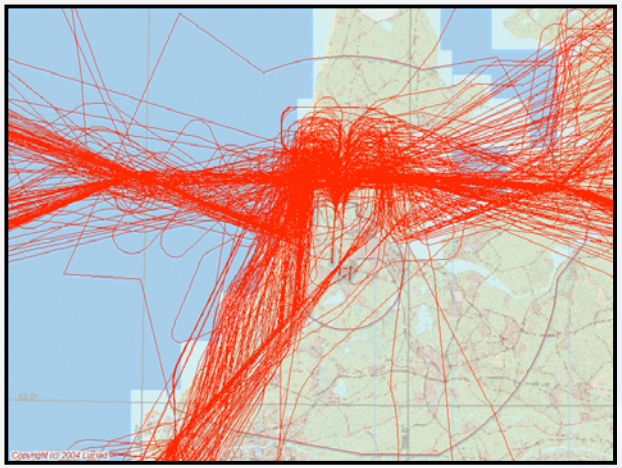
- New CDA procedures after the opration of the 5th RWY
- Single runway for departures and arrivals
- Arrival capacity 24 a/c per hour (Landing interval 2.5 min)
- CDA from 4000 ft via corridors





Schiphol Transition (CDA) Characteristics before 2006

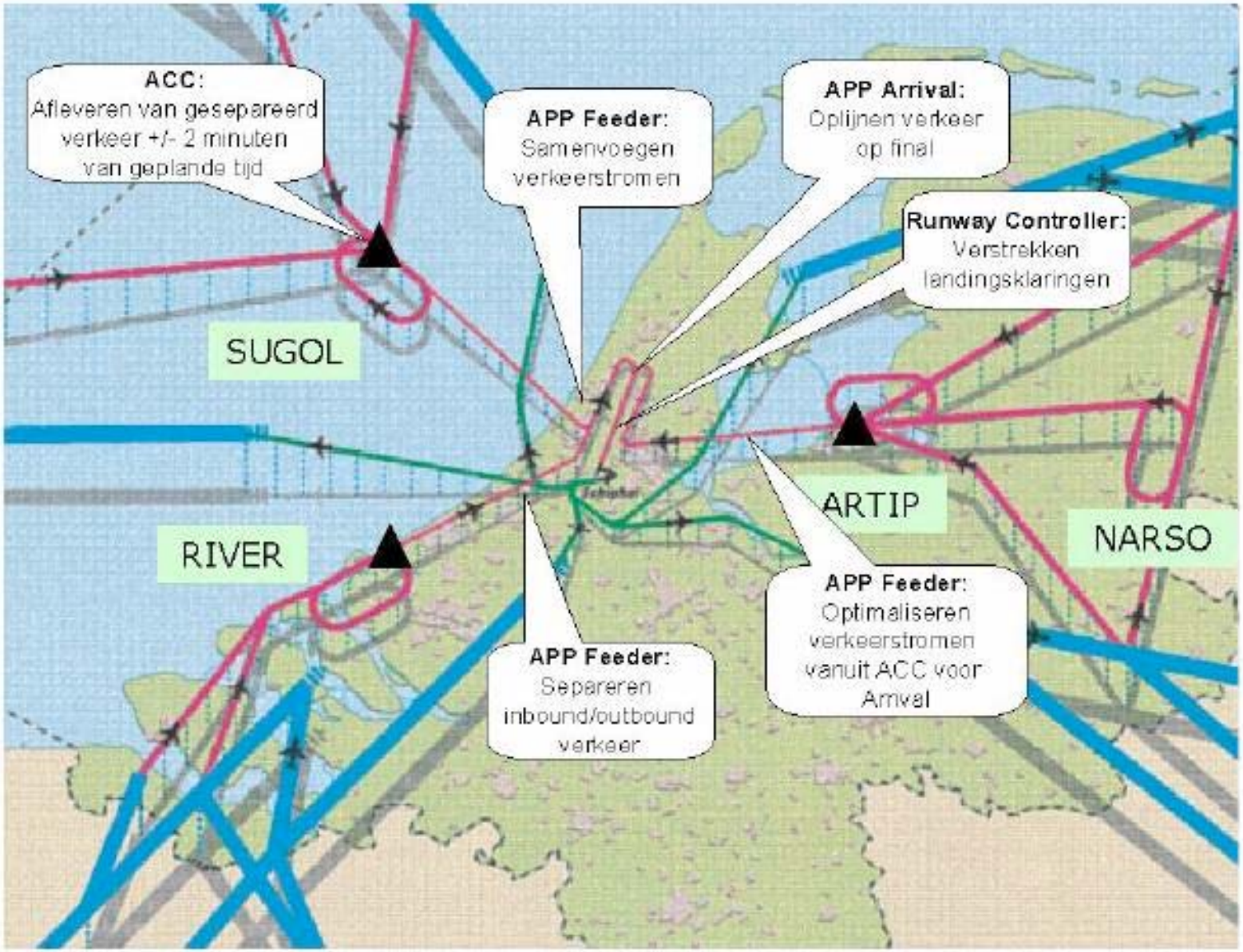
- Aircraft perform the approaches as expected
- Better vertical performance is desired
- Standardization of ATS procedures is required
  - Cleared for approach; or
  - Transition
- Critical aspect is controller training



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

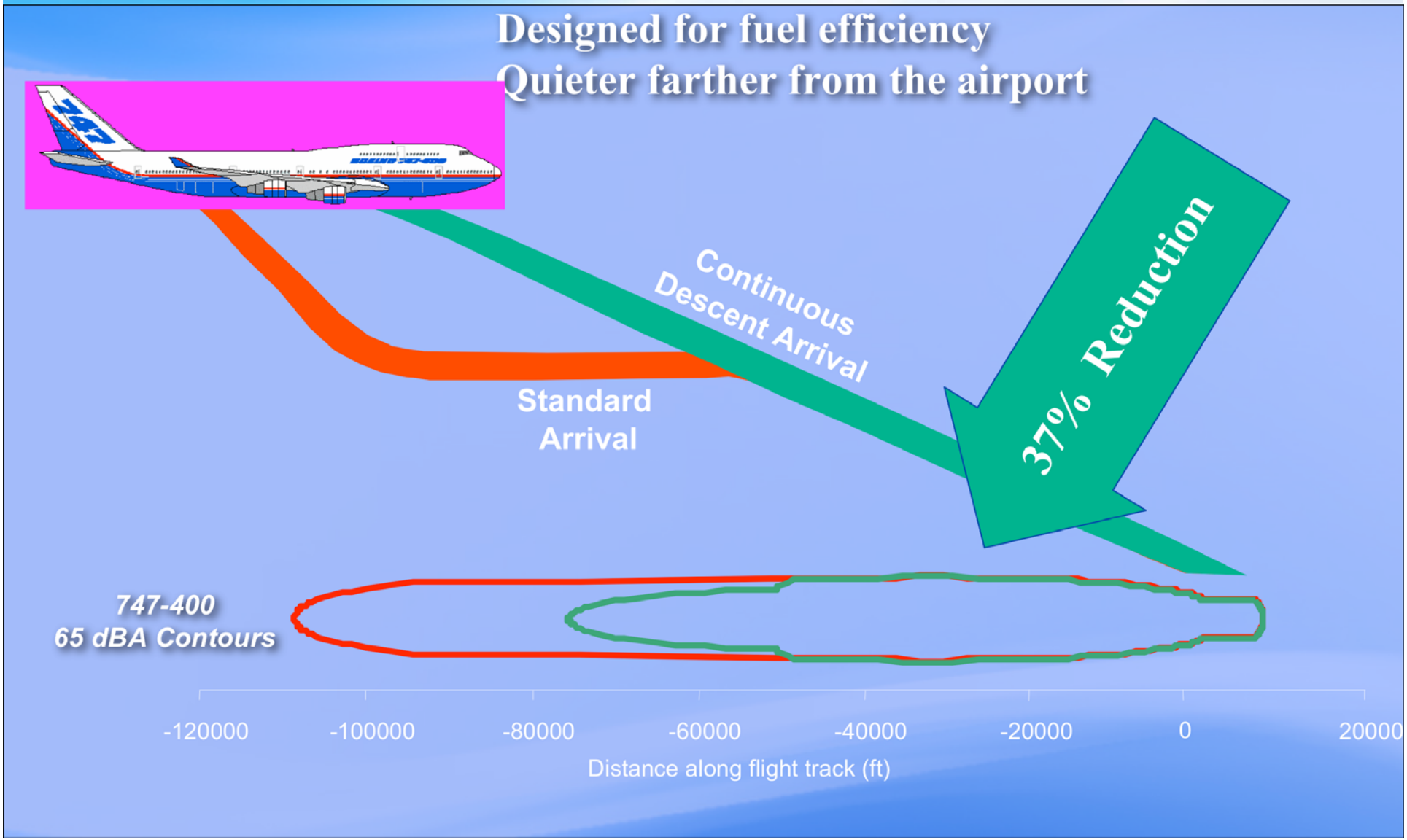


CDA Procedure

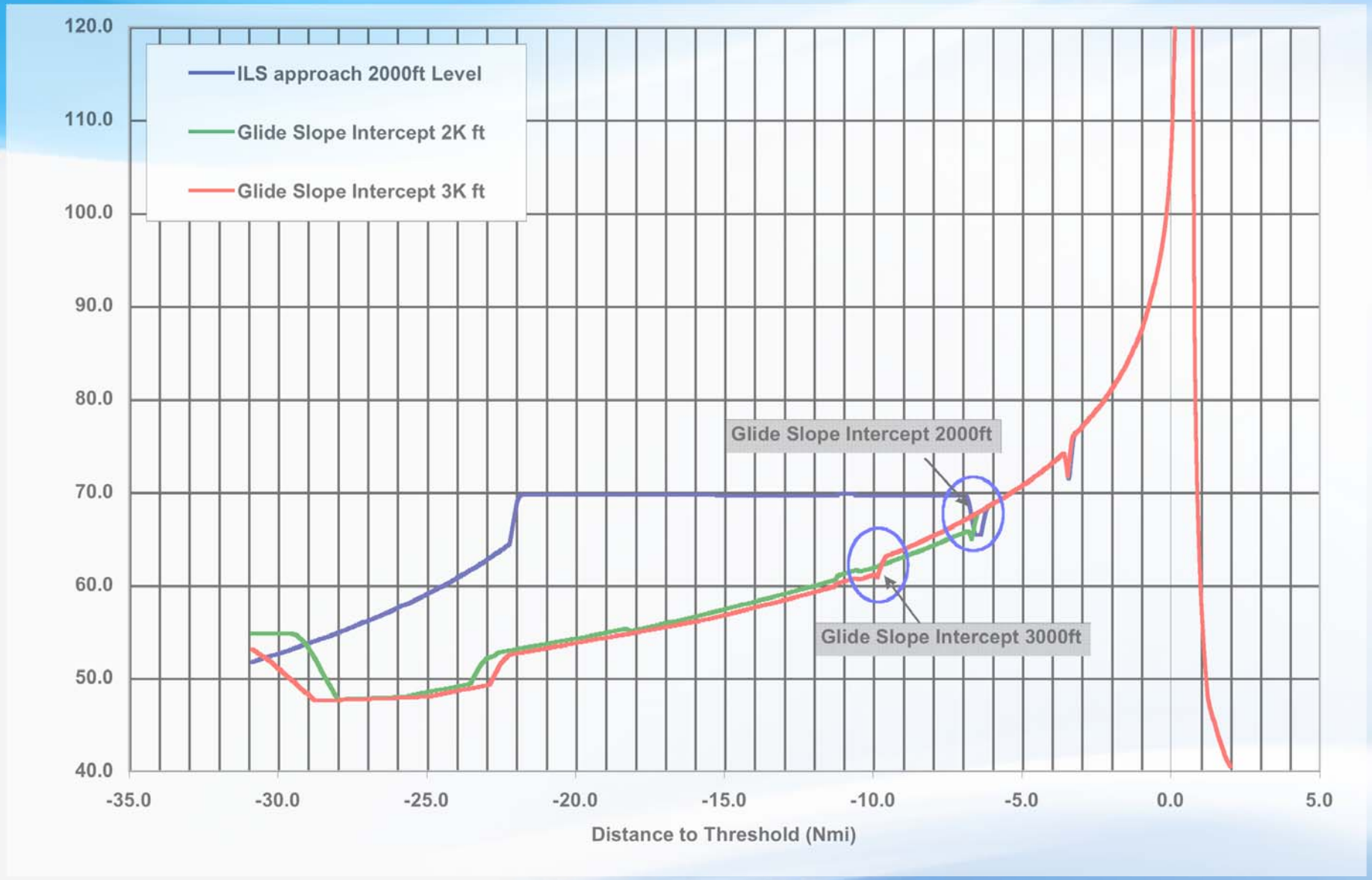
- Requirements of individual flights for trial
  - Airplane must have RNAV and VNAV capabilities
  - Is on a Standard Arrival Route in the Amsterdam FIR
  - ETA is between 2330 and 0500 LT
- Flight Crews - Plan lateral route with the FMC
  - Program transitions
  - Delete published level and speed restrictions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

FMC

Continuous Descent Arrivals



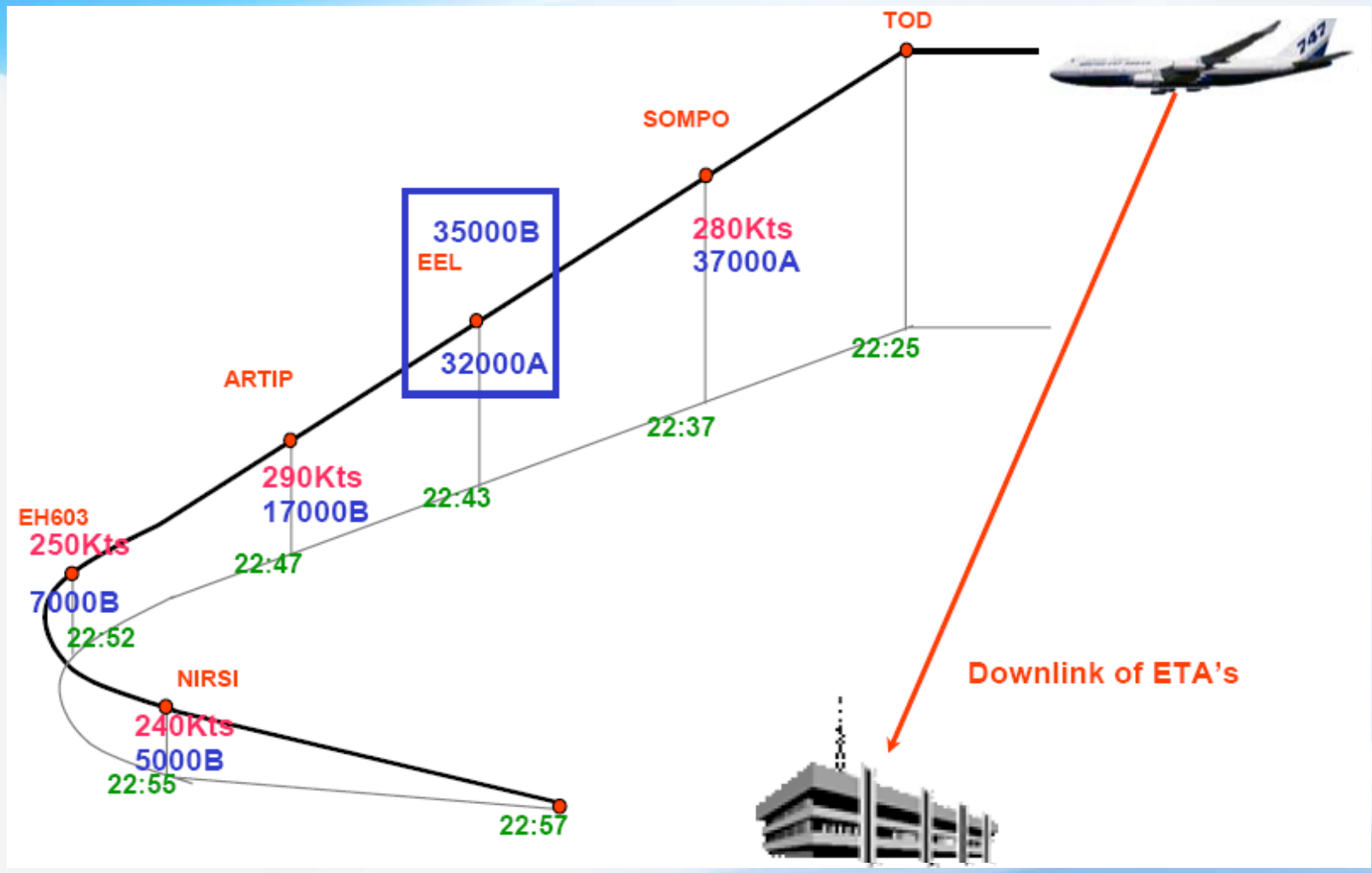
737 CDA Contour Area



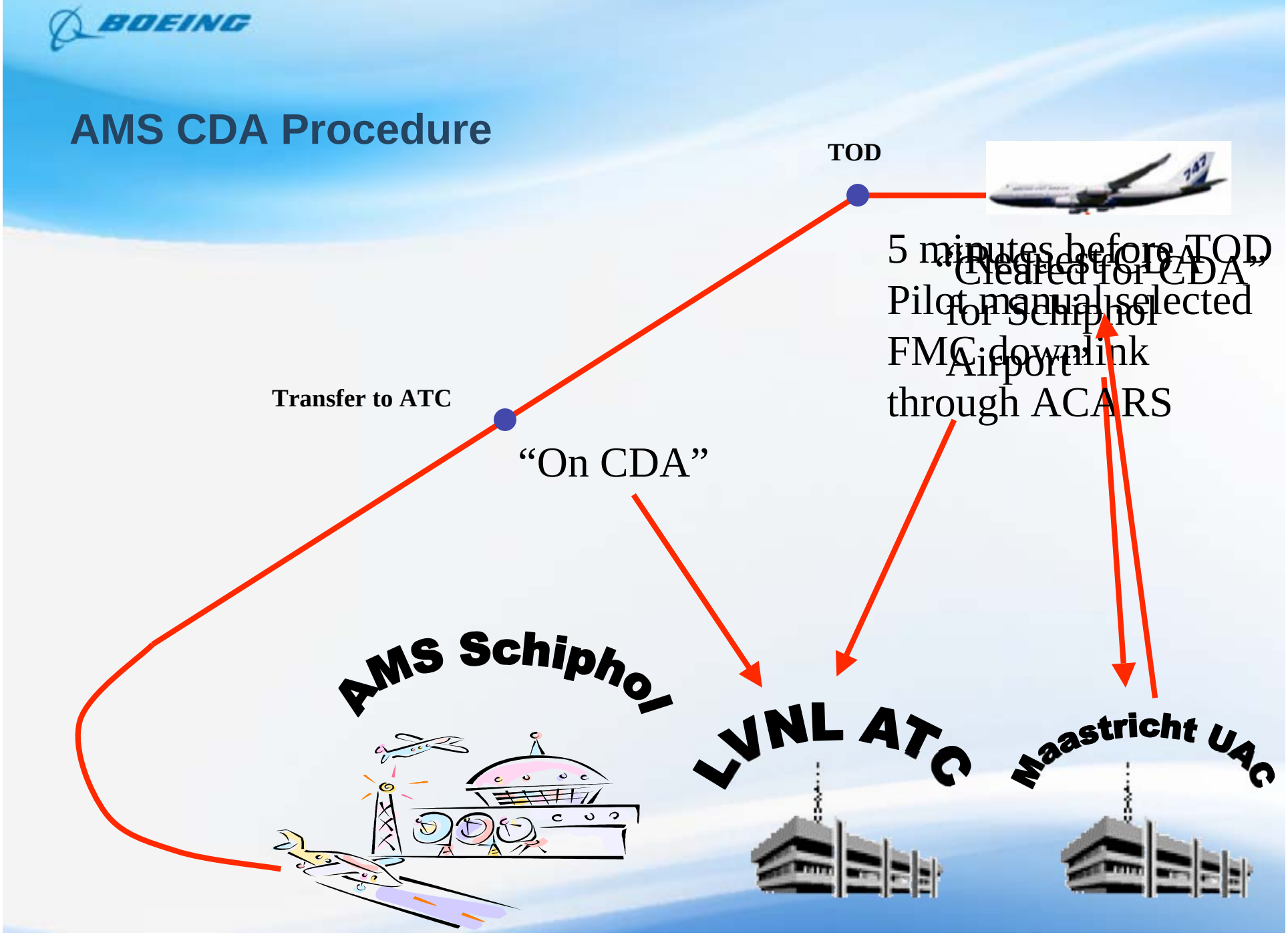
737-800 Fuel Burn and Time Comparisons

	Fuel (kg)	Time (minutes)	Distance (nm)
Daytime Baseline Profile	549	28.4	139.5
Daytime CDA Profile	440	25.9	139.5
Savings Attributed to Daytime CDA	109	2.5	0
Nighttime Baseline Profile	602	29.7	147
Nighttime CDA Profile	481	26.9	147
Savings Attributed to Nighttime CDA	121	2.8	0

Current CDA Operation (2006 Trial) – Initial step of LVNL ATM CDA Strategy:
One way communication from FMC to ATC



AMS CDA Procedure



Advanced Arrival Flight Demonstration

Boeing, ATM, The Netherlands ATC, Transavia, Martinair

2005 Flight Demonstration Schedule