RNAV/CDA Arrival Design
2004 Flight Test Trials
Louisville International Airport

Captain Jim Walton

JPDO EIPT Operations Panel

January 19, 2006

Overview

- Profile Design
- Pre-Test Simulator/Flight Testing
- Arrival Chart/Flight Crew Procedure Design
- Results
- Lessons Learned
- 2006 CDA Plan

Profile Design

Horizontal Profile

- Utilize existing arrival/waypoints
- Minimize flight distance
- Flyable by FMS/Auto flight system
- Stay outside of restricted area

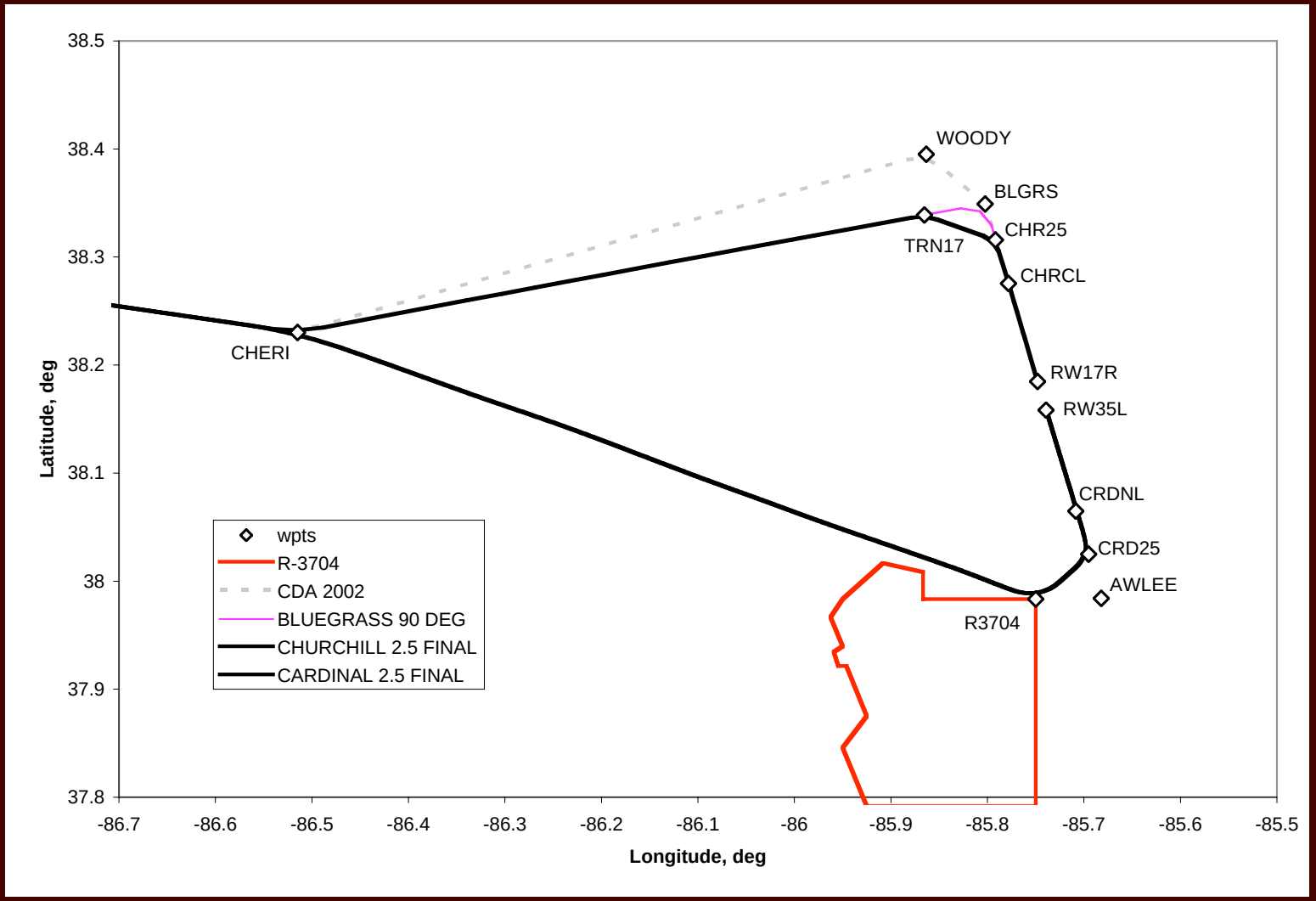
Vertical Profile

- FMS capabilities
- Usable by different FMSs
- Keep auto flight system in VNAV
- Minimize flight crew workload
- Minimize flight crew procedural changes

Air Traffic Coordination

- How to handle clearance-route and descent
- Minimize change to current procedures

CDA Flight Tracks



Simulator Testing

- B-757 FMS-200K Basic/B-767 FMS-Pegasus 2001
- Tested profiles up to 80 knot tailwinds
  - With and without pre-programming winds in FMS
- Route programming
  - Tests done without database
  - Required manual waypoint/constraint entry
- LNAV issues
  - When to select localizer and approach mode
- VNAV issues
  - Speed intervene use
  - When to configure aircraft
  - Making profile get underneath glide slope

Flight Testing

- Test flown in B-767-300
- ATC Coordination
- Manually loaded CDA waypoints/constraints
  - Lead to unexpected results with pre-loaded database
- Validated simulator testing
- Flight test results required altitude constraint modification

Air Traffic Coordination

Flight Plan Filing

- Flights filed for ‘non-CDA’ STAR
- Crews would load CDA STAR

Indianapolis Center

- Established a greater in-trail spacing
- Changed descent clearance at ‘CHERI’ waypoint
- Requested early frequency change to ‘Louisville Approach’

Louisville Approach Control

- Provides CDA clearance to 17R or 35L
- Provides pilot discretion descent clearance
- Cleared flight crew for ILS approach

Arrival Chart/Procedure Design and Implementation

Arrival plate design

- Displayed arrivals to both runways
- Standardize crew procedures
- Abbreviated flight crew procedures/techniques

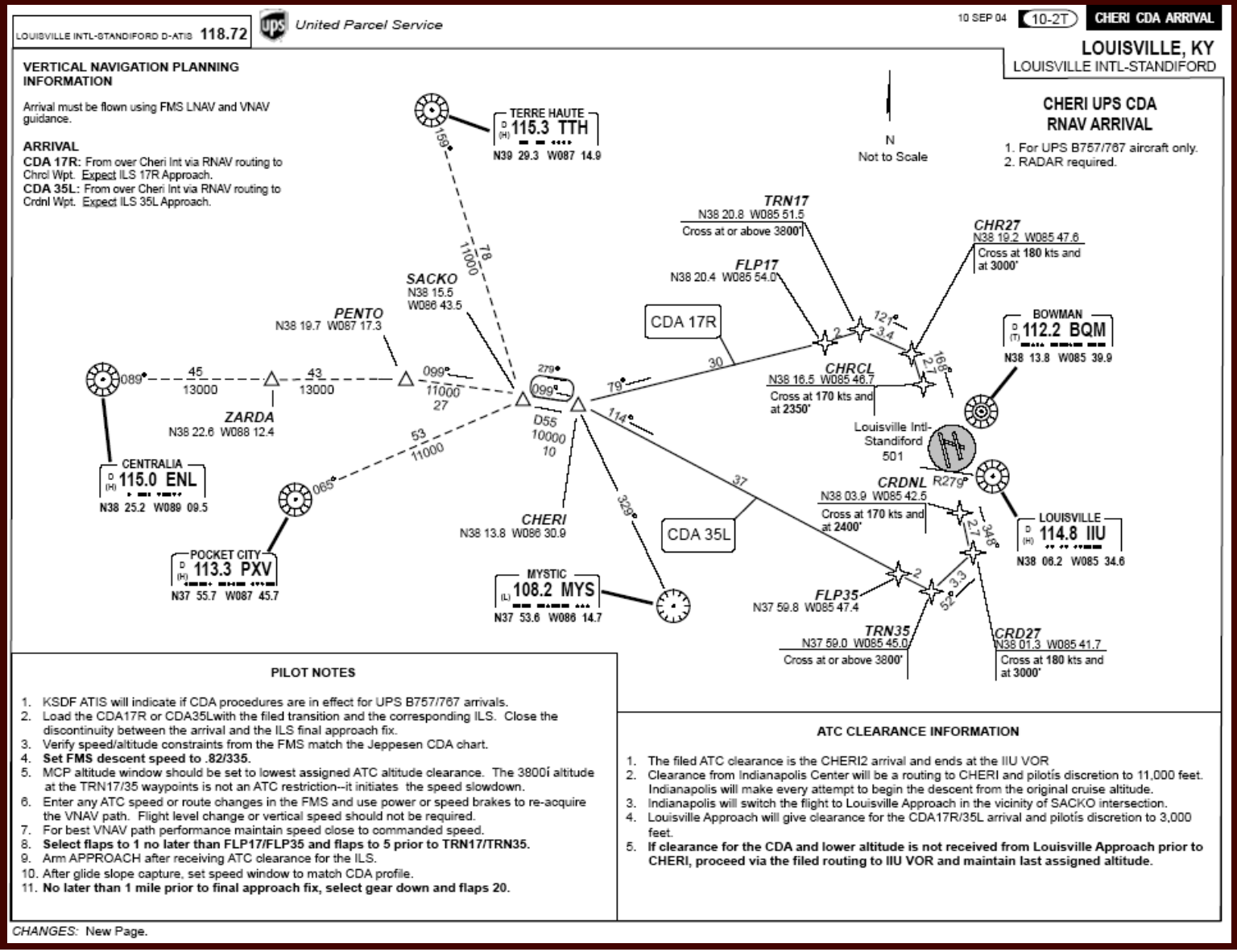
Flight crew procedures

- Arrival designed with FMS limitations in mind
- Limit speed brake use
- Approach intercept procedures easy to execute

Implementation

- Issued as a Jeppesen special plate
- Loaded in FMS navigation database

Jeppesen Arrival Chart



Results

FMS Issues

- Some crews had to manually load procedure
- Sequence of loading deleted altitude/airspeed constraints

Flight Issues

- Excessive use of speed brakes
- Intercept of glide slope prior to localizer capture
- Required attention to VNAV commanded speeds

ATC Issues

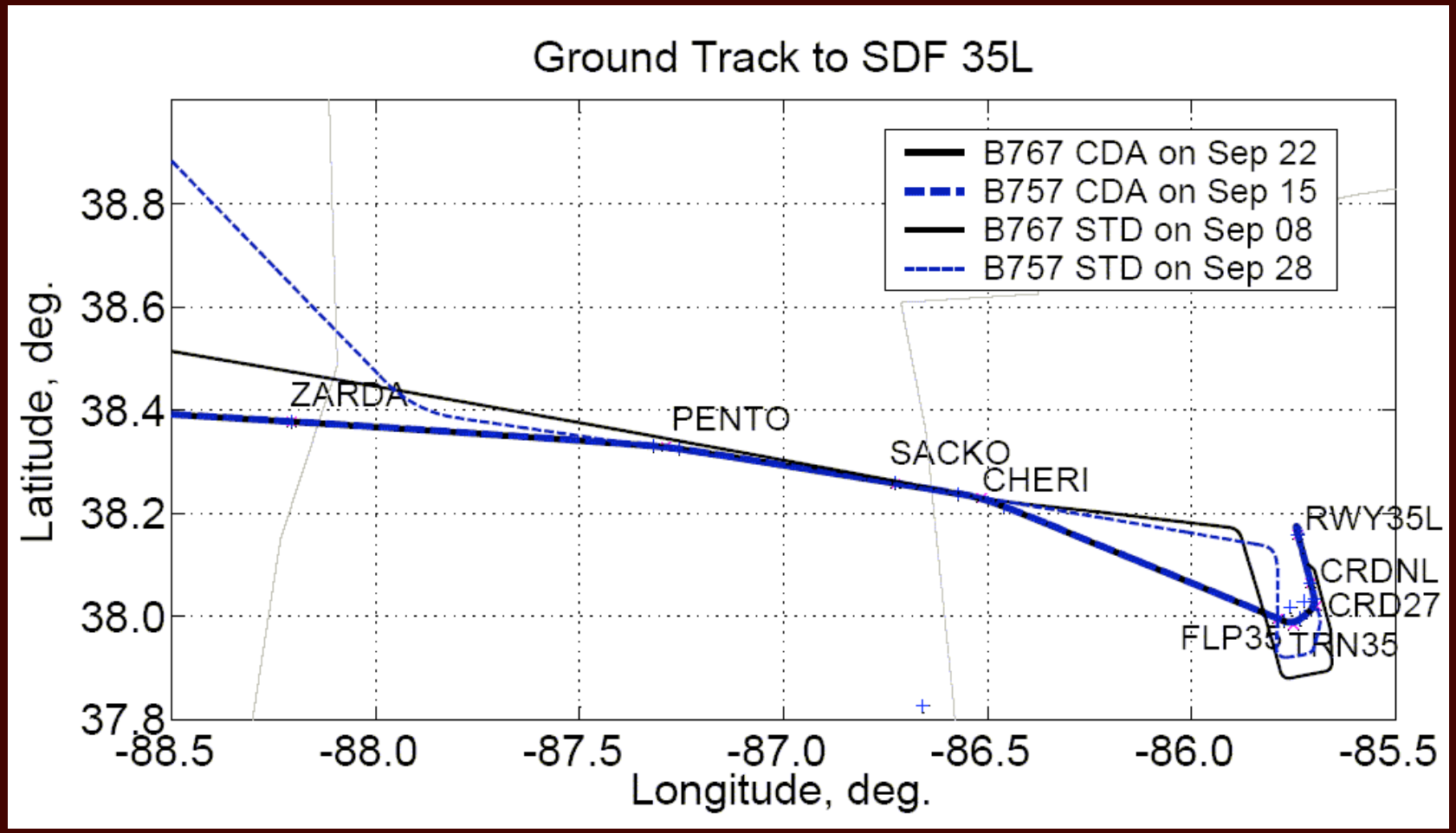
- Clearance for ILS occurred earlier than normal

Modifications to procedures

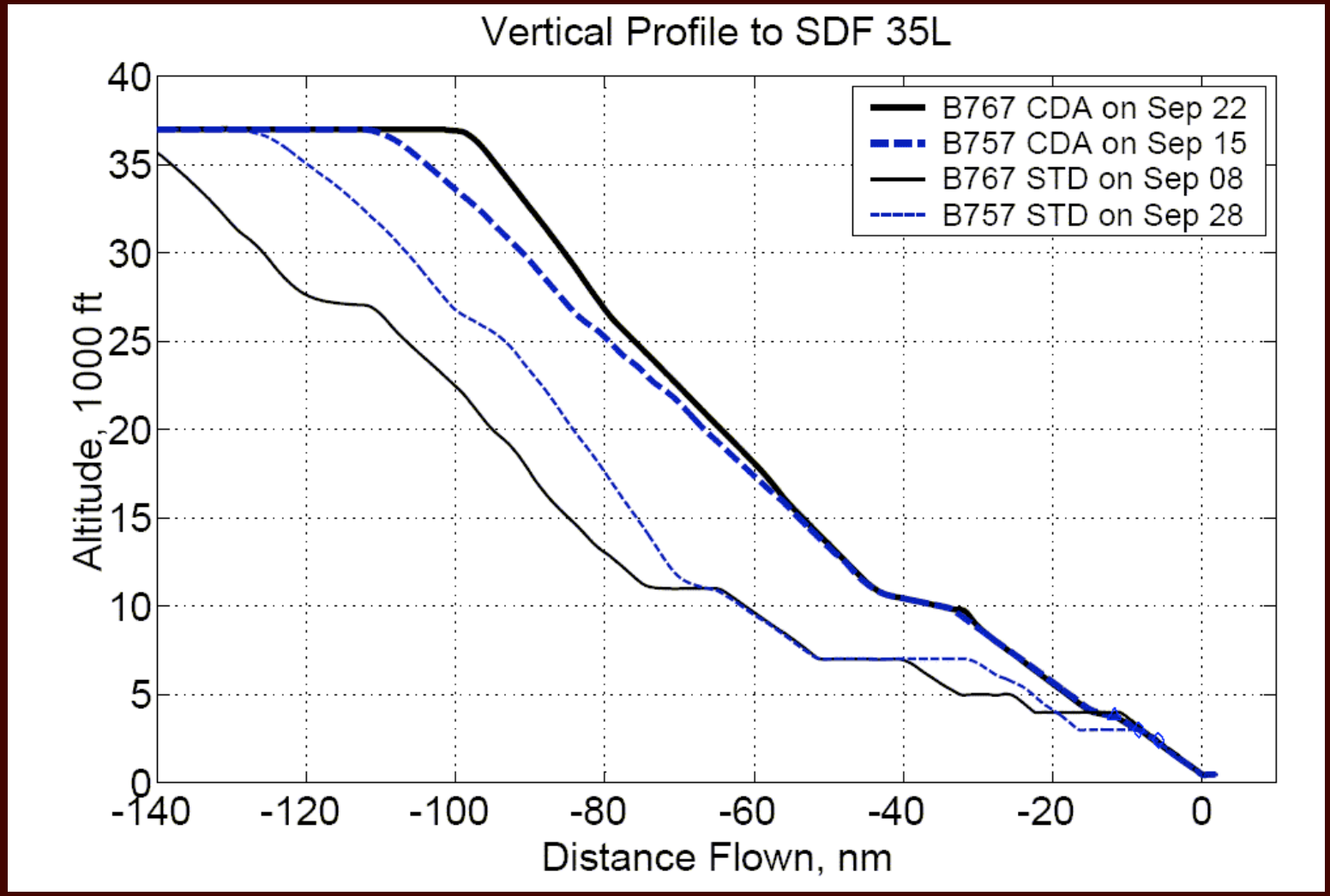
- Loading sequence
- Approach clearance
- Sent winds to aircraft

So! How did we do?

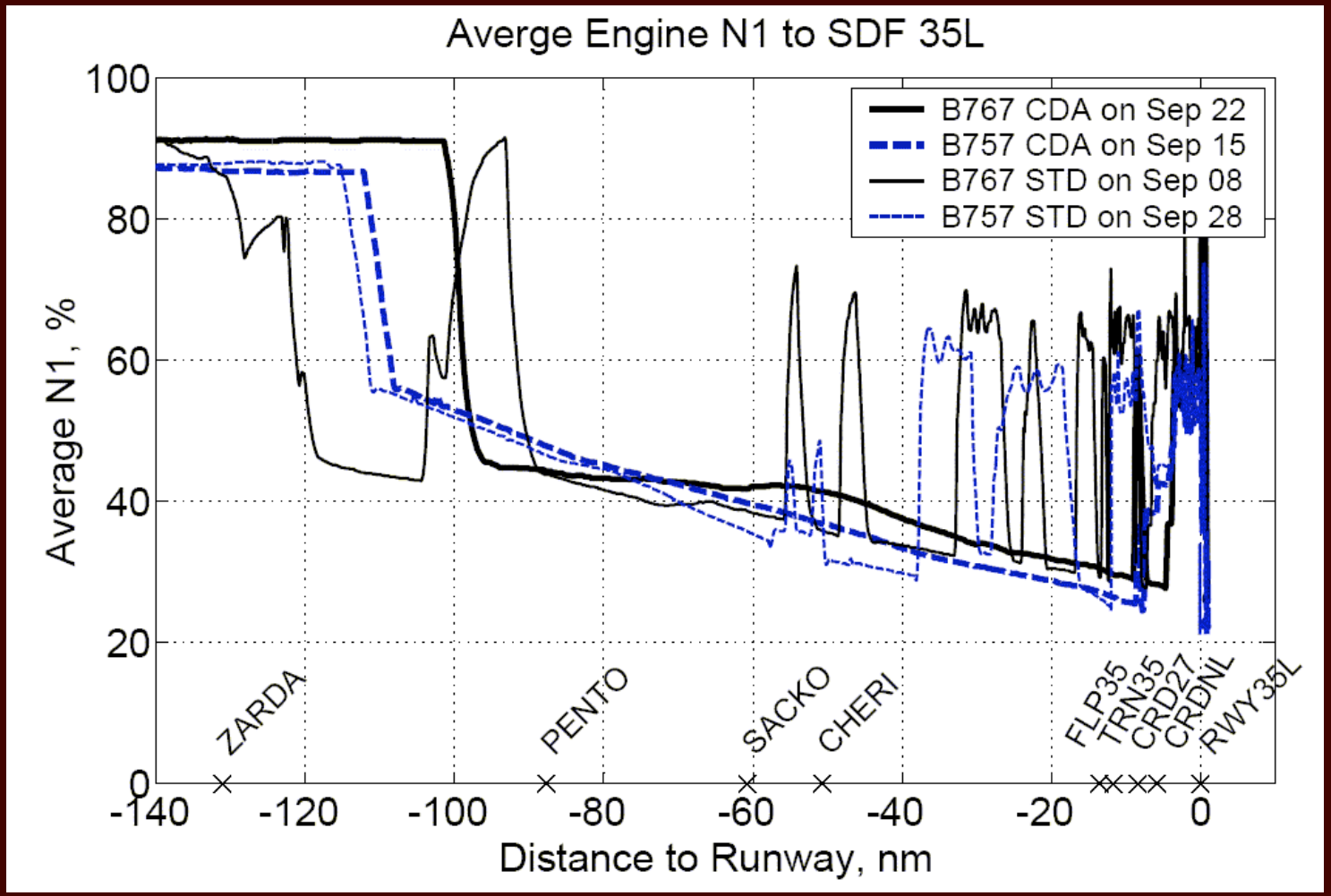
CDA Versus Standard Flight Tracks



CDA Versus Standard Vertical Profile

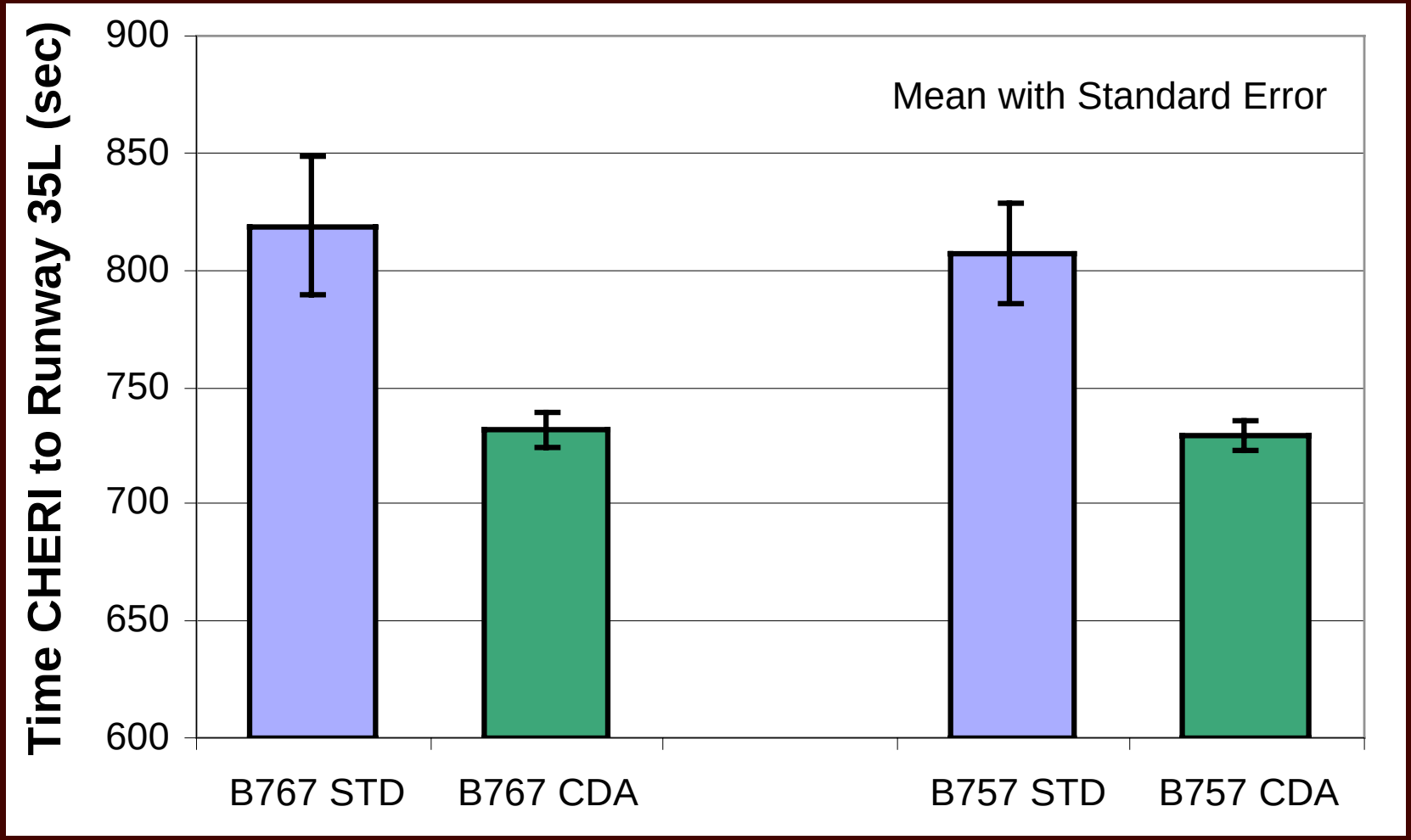


CDA Versus Standard Engine RPM



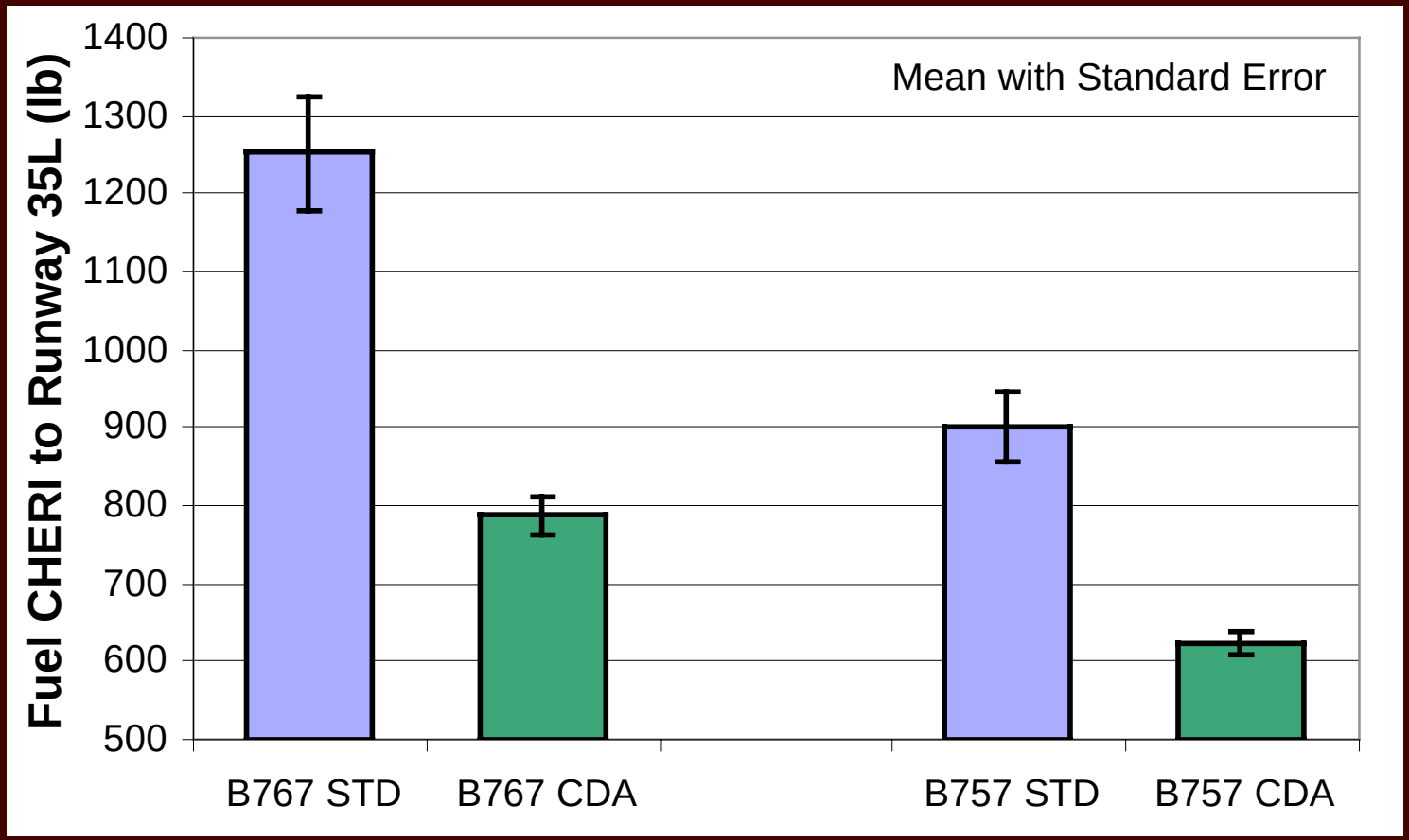
Time Comparison

104 / 90 sec reduction from CHERI



Fuel Usage Comparison

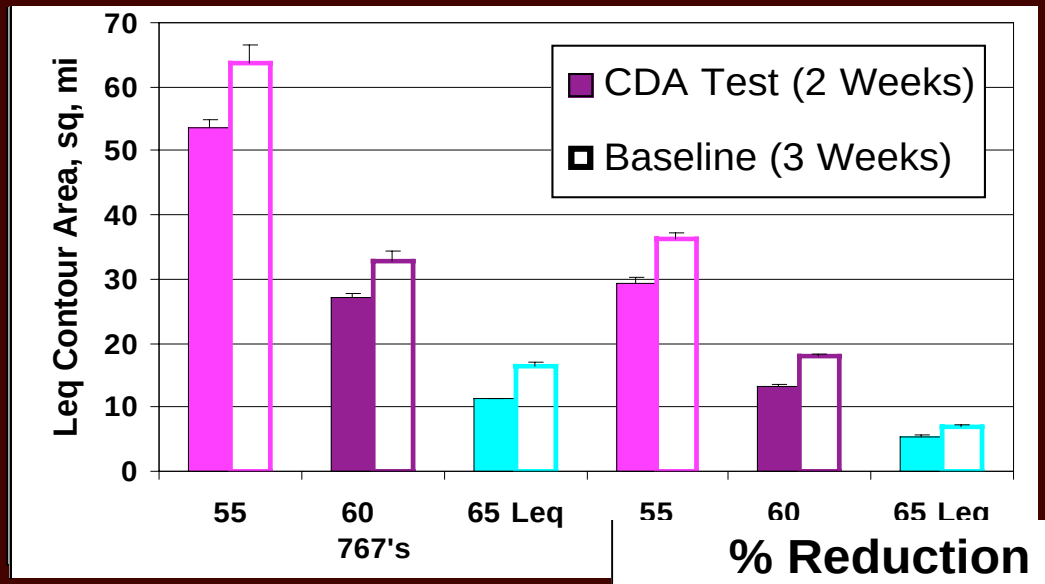
- 465 / 279 lb reduction from CHERI

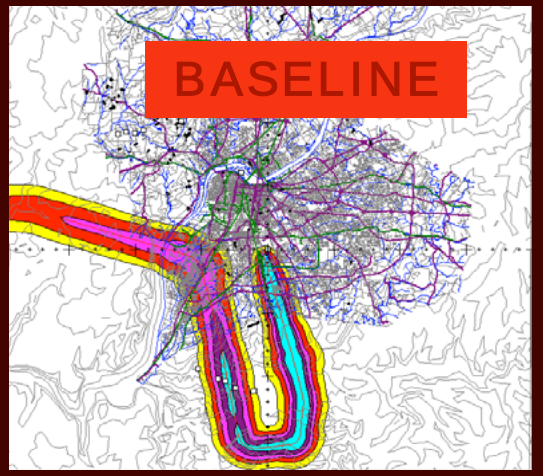


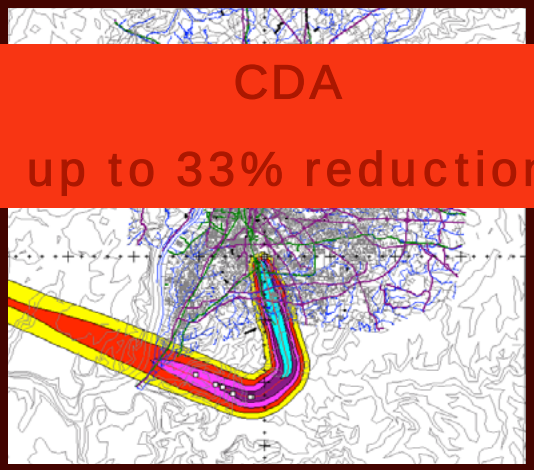
Theoretical Fuel and Cost Savings-Annual

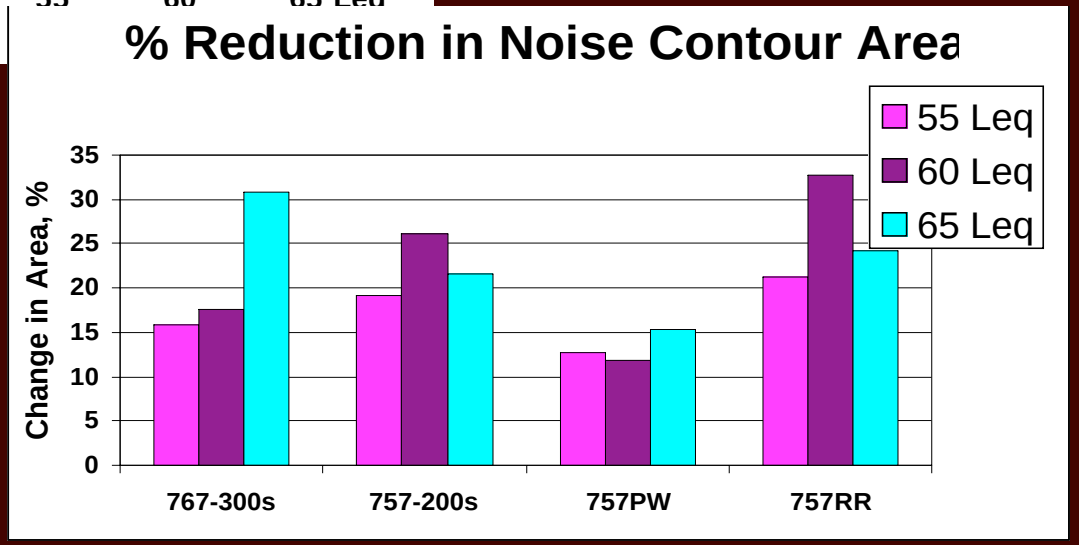
	B-757 279 lbs/flt*	B-767 465 lbs/flt*	Total		
			Fuel Savings	Annual Dollar Savings	
				$1.00/ gallon	$1.50/ gallon
West Coast Arrivals 12-13 Aircraft/Night	49,800 Gallons	111,740 Gallons	161,540 Gallons	$161,540	$242,310
Next Day Air Outbounds 80%	201,250 Gallons	186,444 Gallons	387,694 Gallons	$387,694	$581,541
Total	251050 Gallons	298,184 Gallons	549,234 Gallons	$549,234	$823,851

Noise Footprint

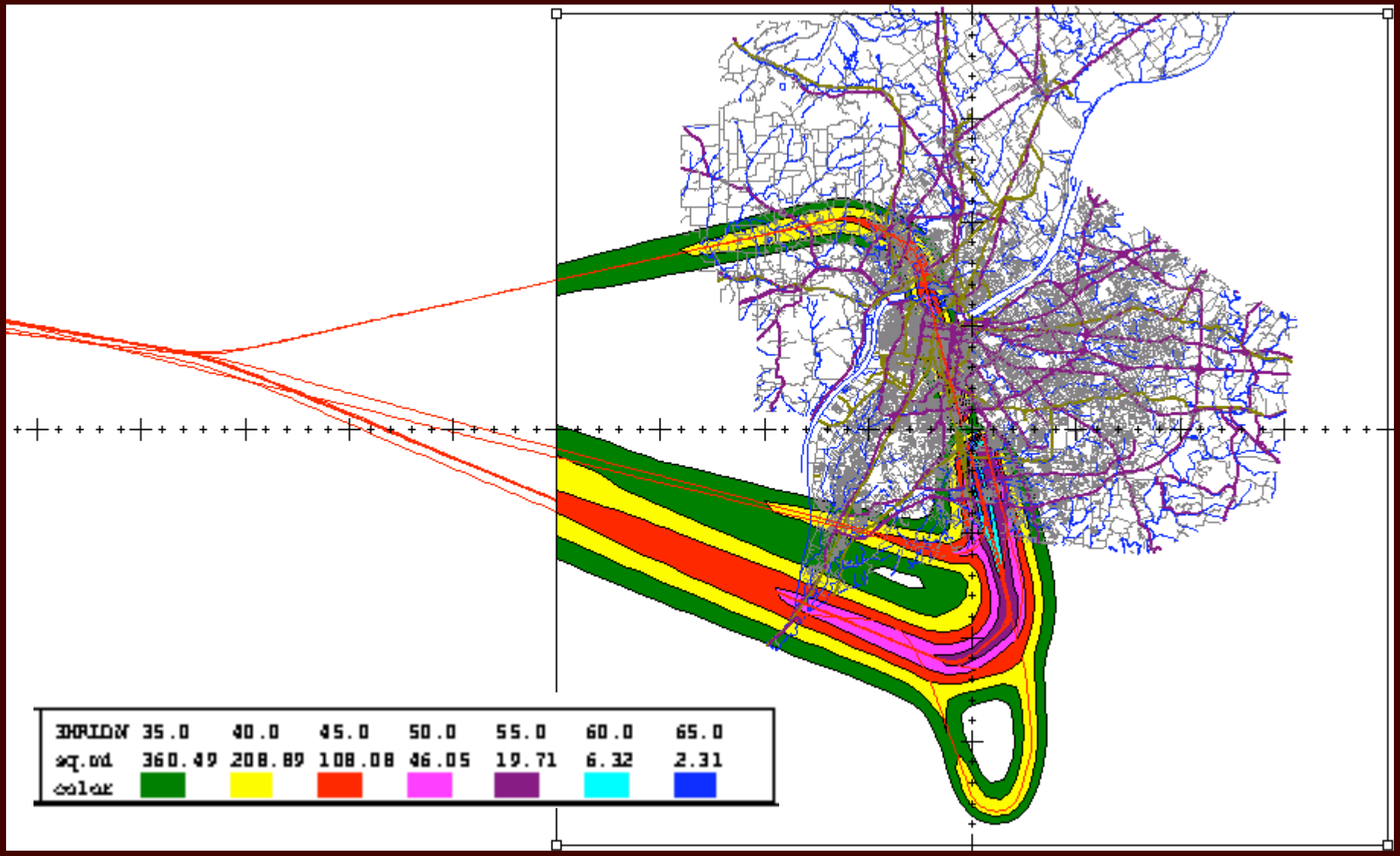




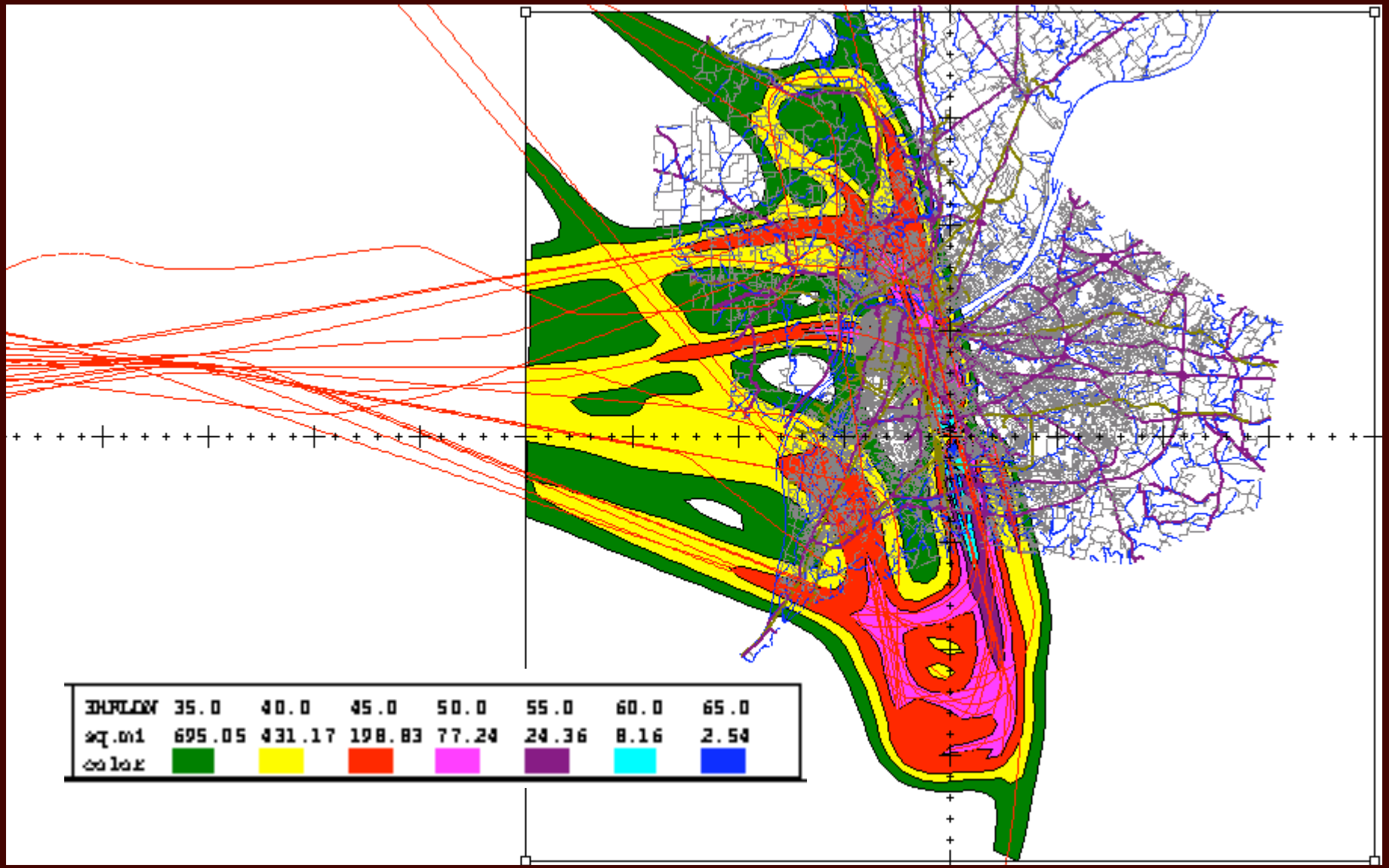




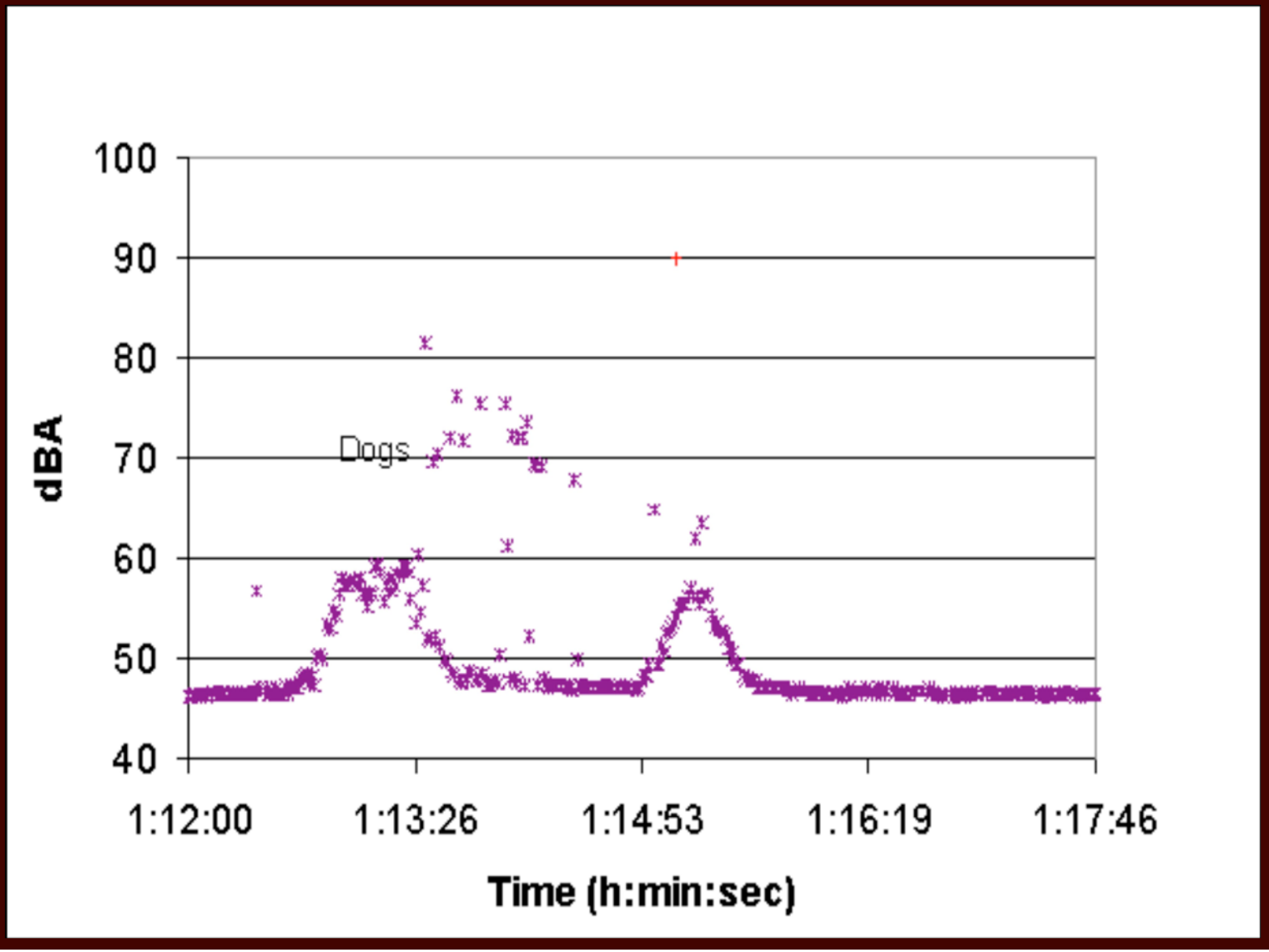
Noise Exposure - CDA (Sep 14-Sep 18)



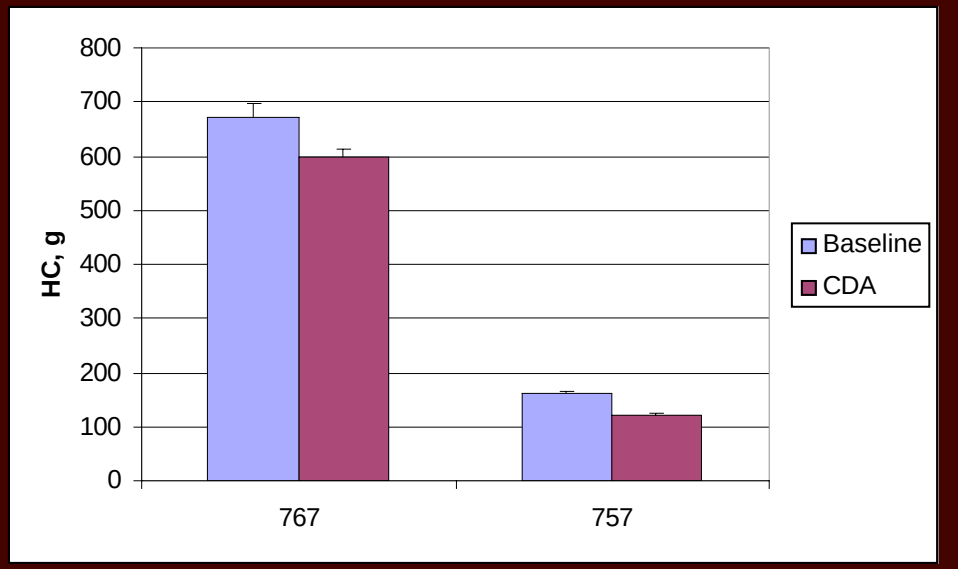
Noise Exposure - Baseline (Sep 28-Oct 2)

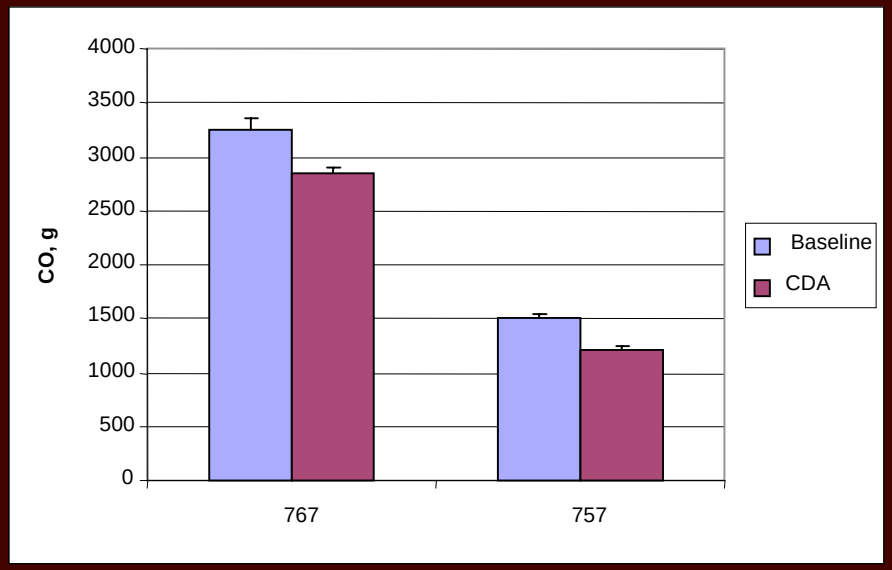


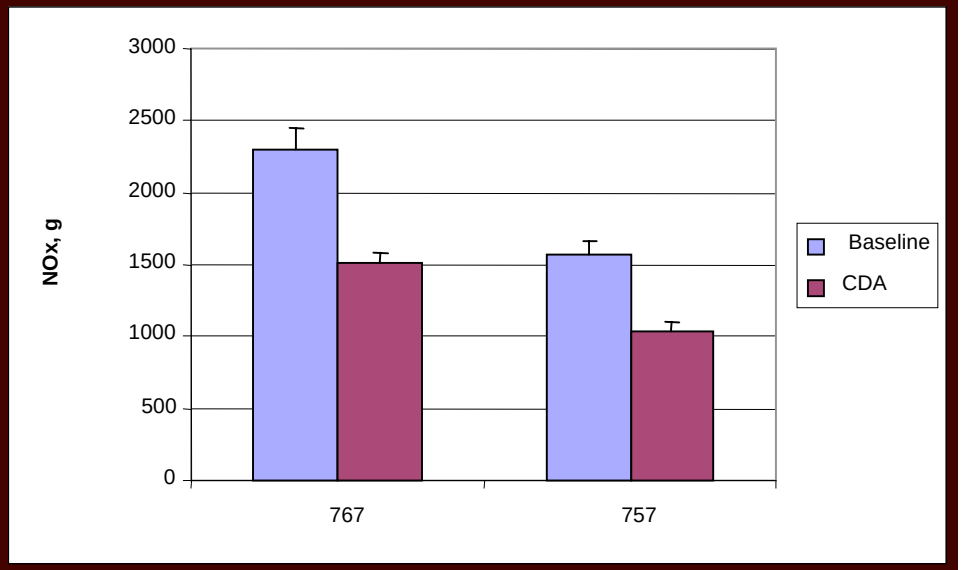
Noise Levels



Emissions


800
700
600
500
400
300
200
100
0
HC, g
767
757
Baseline
CDA


4000
3500
3000
2500
2000
1500
1000
500
0
CO, g
767
757
Baseline
CDA


3000
2500
2000
1500
1000
500
0
NOx, g
767
757
Baseline
CDA

Lessons Learned

We have to do this

- **Saves fuel and time**
- **Reduces noise and emissions**
- **Win-win**

Arrival plate design

- **Applicable to all fleets**
- **Minimize pilot notes, if any**
- **Simplify**

FMS procedures

- **Design arrival with FMS limitations in mind**
- **Limit speed brake use**
- **Intercept procedures easy to execute**
- **Simplify/standardize wind uplink**

Air Traffic Control

- **Vectors occurred further west**
- **Reduced controller workload at Indy Center and Louisville Approach**
- **Traffic flow is manageable at West Coast inbound rates**
- **Mixed equipage may cause less than optimum CDA**
- **FAA approval process can be slow**

2006 Plan

Implement CDA arrivals for West Coast inbounds

- May be applicable to all aircraft types
- Dual stream arrivals to airport

Implement CDA arrivals to Next Day Air outbounds

- Target low density traffic gateways

Prerequisites To Implement

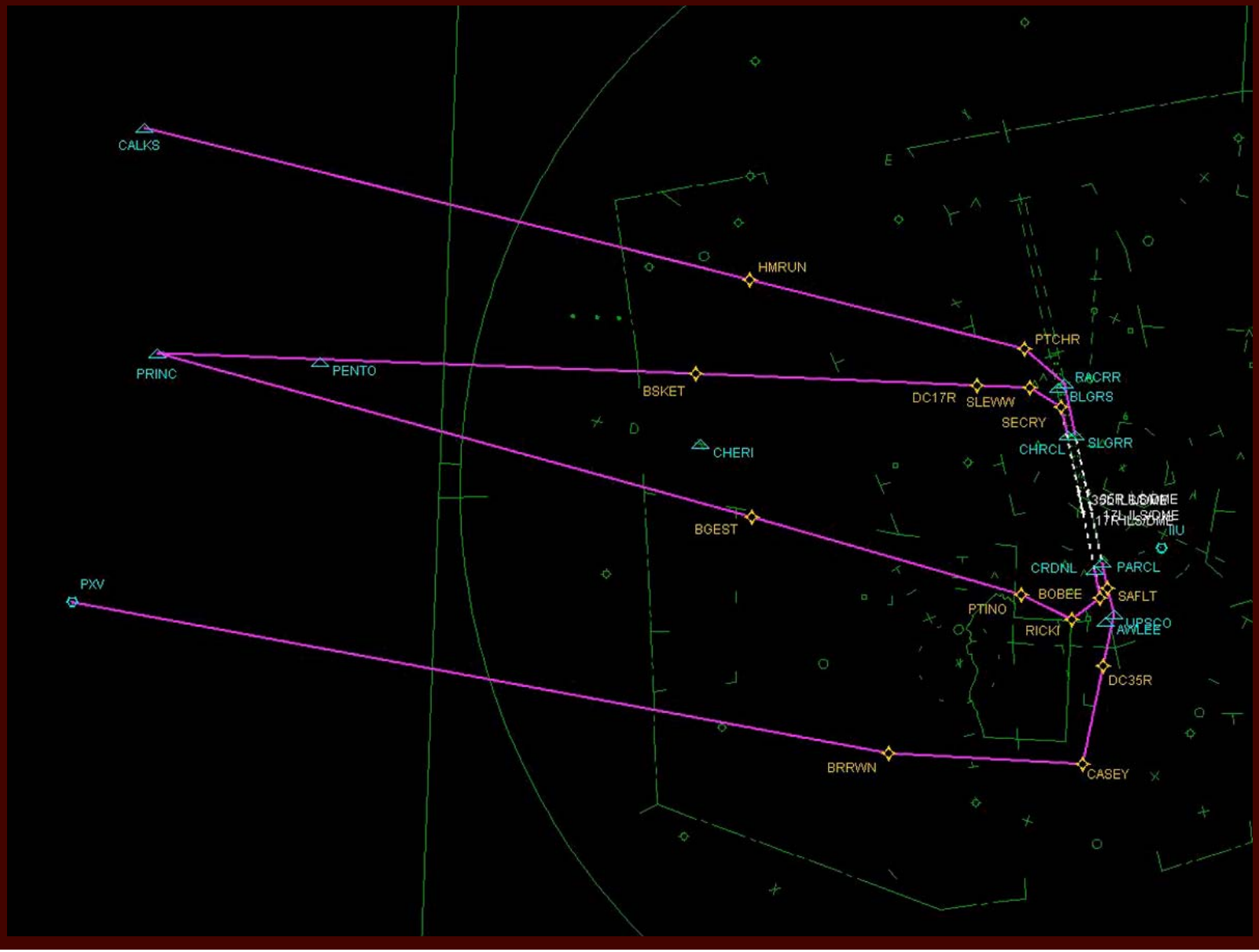
Arrival Design

- Requires additional simulator testing
- Requires lateral/vertical analysis for different aircraft types
  - NASA Langley

Approval Process

- UPS is lead for all coordination
- Must be submitted to POI for approval
  - 18 step FAA process recommended
  - Must be coordinated with FAA ATC
  - Could be lengthy
- Special UPS arrival
- May require training and/or operations bulletins

2006 CDA Design-Louisville



Questions?