Continuous Descent Arrivals

James Brooks
Georgia Institute of Technology

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What is CDA?

• Continuous descent arrival (CDA) is a procedure where aircraft descend from a relatively high altitude without leveling off
  – Also referred to as continuous decent approach

• CDAs being developed at Georgia Tech are Area Navigation (RNAV) procedures where…
  – Vertical profile (ideally between cruise altitude and the runway but at least between 10,000 ft and the runway) optimized to:
    • Eliminate level segments
    • Minimize emissions, flight time, fuel burn, noise
  – Inter-aircraft separations determined a priori:
    • Minimize need for controller intervention (vectoring) at low altitudes
CDA and the ATC Environment

- GNSS
- Weather Station
- False Glideslope
- ILS Glideslope
- Ground Track
- FAF
- Meter Fix
- Ground Track
- Low Noise Approach
- Conventional
- Voice
- Display
- Possible Datalink
- ATC Computer
- Controller
- Winds and Turbulence
What are the benefits of CDA?

• **Noise**
  - Up to 6 dBA reduction in peak level noise
  - Up to 30% reduction in noise contour area

• **Emissions (below 3,000 ft)**
  - Up to 20% reduction in CO
  - Up to 25% reduction in HC
  - Up to 35% reduction in NOx

• **Fuel**
  - 118 lb average reduction in B757 fuel burn
  - 364 lb average reduction in B767 fuel burn

• **Time**
  - 118 sec average reduction in B757 flight time
  - 147 sec average reduction in B767 flight time
Research Objectives

• Develop design framework, methodology, and tool to determine the set of waypoint restrictions and inter-aircraft separations that:
  – Eliminate level segments
  – Minimize vectoring at low altitudes
  – Minimize emissions, flight time, fuel burn, noise

• Given variability and uncertainties in…
  – Aircraft dynamics and weight
  – Flight management system (FMS) logic
  – Pilot response
  – Wind speed and direction

• And use framework, methodology, and tool to create…
  – CDA procedures throughout the US
  – Controller and pilot tools for heavy traffic scenarios
CDA Design Framework

- Controllers vector during descent from cruise altitude (top-of-descent) to transition altitude to establish separation and speed
- No planned vectoring during descent to runway i.e. below transition altitude
- Transition altitude dependent on traffic conditions
CDA Design Methodology

• Determine lateral profile
  – Set transition altitude based on air space segmentation and point where traffic merge

• Build wind model
  – Develop separate model for each definable subset of wind conditions

• Use Monte Carlo Simulation-based Tool for the Analysis of Separation and Throughput (TASAT) to determine:
  – Range of crossing altitudes (at each waypoint) for each aircraft type in “unrestricted” descent from cruise
  – Required separation at (or near) top-of-descent and at transition altitude for each pair of aircraft types in unrestricted descent from cruise
CDA Design Methodology (cont’d)

- Develop (if airspace is constrained) set of scenarios with different transition altitudes and waypoint (altitude and speed) restrictions

- Use TASAT to determine:
  - Required separation at (or near) top-of-descent and at transition altitude for each pair of aircraft types

- Determine “best” transition altitude, waypoint restrictions and required separations given:
  - Trade-off (if any) between emissions, fuel burn, noise, time, and throughput
Design Tool -- TASAT

Aircraft / Flap Schedule

| 45/270, 40000 |
| 30/256, 20000 |
| 21/252, 90000 |
| 10/249, 450 |

Wind Forecast

Pilot Response

Weight Distribution

Local Wind Variation

Trajectory

Convolution

Monte Carlo Tool

Separation and Throughput Analysis

Feasible Separation, $p_1$

AC Type A – Type B

Feasible Separation, $p_2$

AC Type B – Type A

A small slice of traffic at separation $s$

Actual Traffic Unadjusted, $p_A$

Actual Traffic Adjusted, $p_{A'}$

Target Separation $S_I$
Summary

- CDA is as cost effective means of achieving near-term reductions in noise and emissions
- Operators benefit from fuel and flight time savings
- Design framework, methodology, and tool has been developed and verified through flight test
- Positive feedback from controllers and pilot
- Framework, methodology, and tool being used to develop CDA procedures at US airports
  - e.g. ATL, LAX
Future Directions

• Fully automate design process
  – Automate the iterative use of TASAT
  – Formulate and implement non-linear optimization algorithm to drive iterations

• Study effects on noise, emissions, fuel, time (and the balance between them) of…
  – descent speed variation
  – altitude and speed constraints to allow for crossing traffic
  – multiple metering points

• Determine requirements and logic for controller and pilot decision support tools for higher traffic conditions