Georgia Tech Research in Support of CDA at LAX

John-Paul Clarke
Associate Professor, School of Aerospace Engineering
Director, Air Transportation Laboratory
Georgia Institute of Technology

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Georgia Tech CDA Research Team

- Senior Research Scientist
  - James Brooks

- Research Engineers
  - Terran Melconian (MIT)
  - Sean Nolan

- Graduate Research Assistants
  - Liling Ren (MIT)
  - Heinrich Souza
  - Colin Whittaker (MIT)

- Undergraduate Research Assistants
  - Alexander Acierto
  - Stephanie Bills
  - Evan McClain
  - Gaurav Nagle
  - Rajiv Shenoy
  - Clayton Tino
  - Jebulan Watson
Design Methodology

• Determine lateral profile

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

• Use 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
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 noise, emissions, fuel burn and throughput
Wind Model

Mode decomposition and Auto-Regression modeling
• Monte Carlo Simulation-based Tool for the Analysis of Separation and Throughput (TASAT) where aircraft trajectory…
  – Lateral position
  – Altitude
  – Speed
  – Thrust setting
  – Speed brake setting
  – Flap setting
  – Landing gear position

• Computed versus time with uncertainties in…
  – Wind
  – Aircraft weight
  – Pilot behavior
TASAT

- Aircraft / Flap Schedule
- Procedure Definition
- Pilot Response
- Weight Distribution
- Local Wind Variation
- Monte-Carlo Engine
- Fast-Time Simulator
- Trajectories
- Convolution
- Target Separation & Expected Throughput
Throughput Analysis Methodology

- **Required separation at runway**
- **Expected “buffer” at runway**
- **Target separation at transition point**
- **Range of separations at runway with given target separation at transition point**
Separation Analysis Methodology

- **Required separation at runway**
- **Target separation at transition point**
- **Range of separations (at transition point) that can result in required separation at runway**
- **Desired confidence** e.g. 90th percentile
Benefit of Segmentation

Probability Density

Separation (nm)

Target Separation $S$
Benefit of Segmentation (cont’d)

Required separation at runway

Expected “buffer” at runway

Probability Density

Separation (nm)
Benefit of Segmentation (cont’d)

Target Separation $S_{AB}$
(Type A – Type B)

Target Separation $S_{BA}$
(Type B – Type A)

Separation (nm)

Probability Density
Benefit of Segmentation (cont’d)

Required separation at runway

Expected “buffer” at runway

Probability Density

Separation (nm)
CIVET Arrival

CIVET FIVE ARRIVAL
8/8/2005

Aircraft to proceed via RWY 25L unless otherwise instructed by ATC

NOTE: DME or RADAR required.
NOTE: Chart not to scale.
CIVET Analysis

• Transition point assumed to be GRAMM
  – Waypoint where Los Angeles Center “handoffs” aircraft to Southern California TRACON

• Wind model developed using ACARS data from LAX arrivals
  – Wind data separated into bins based on the magnitude and sign of the wind component along the runway axis
  – Separate model built for each 20 knot bin between -110 and +110 knots
### Separation & Throughput

**Separation Required at Threshold (nm)**

**Instrument Flight Rules (IFR)**

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Separation & Throughput

• Determined target separation at GRAMM as a function of
  – Desired confidence
    • Three confidence levels: 70%, 80%, 90%
    • Given: no wind, no restrictions and under IFR
  – Wind speeds
    • Three wind speeds: -100 (±10) knots, 0 (±10) knots, +60 (±10) knots
    • Given: 70% confidence, no restrictions and under IFR
Separation & Throughput (cont’d)
no wind, no restrictions, under IFR

Separation Required at GRAMM (nm) to be 70% Confident that Separation at Runway Greater Than Required Separation

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Separation & Throughput (cont’d)

no wind, no restrictions, under IFR

Separation Required at GRAMM (nm)
to be 80% Confident that Separation at Runway Greater Than Required Separation

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Separation & Throughput (cont’d)

Separation Required at GRAMM (nm) to be 90% Confident that Separation at Runway Greater Than Required Separation

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Separation & Throughput

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  – Wind speeds
    • Three wind speeds: -100 (±10) knots, 0 (±10) knots, +60 (±10) knots
    • Given: 70% confidence, no restrictions and under IFR
70% confidence, no restrictions, under IFR

Separation Required at GRAMM (nm)
when wind at 30,000 ft is \(-100 \pm 10\) knots

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Separation & Throughput (cont’d)

70% confidence, no restrictions, under IFR

Separation Required at GRAMM (nm)
when wind at 30,000 ft is 0 (±10) knots

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Separation & Throughput (cont’d)

70% confidence, no restrictions, under IFR

Separation Required at GRAMM (nm)
when wind at 30,000 ft is +60 (±10) knots

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Conclusions

• Required separations are similar in distance to current separations…
  – Currently aircraft are approximately 10 miles-in-trail at GRAMM until SCT begins to get overloaded and then 15 miles-in-trail thereafter

• Except that we apply separation on the basis of the pairing of the aircraft classes