SCT Trajectory & Separation Optimization

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Objective

- Enable Continuous Descent Approaches to all airports in the Southern California TRACON by:
  - Determining trade-off between throughput, noise, emissions and fuel burn as a function of initiation altitude and stringency of waypoint altitude crossing restrictions
  - Setting initiation altitude, initial separation and stringency of waypoint altitude crossing restrictions to meet desired throughput for each runway
Research Approach

• For a given lateral profile
  – Determine range of crossing altitudes (at each waypoint) for each aircraft type in unrestricted descent using Monte-Carlo simulation tool
  – Develop set of scenarios with different initial altitudes and waypoint altitude crossing restrictions
  – Determine required initial separation and throughput for each scenario using Monte-Carlo simulation tool
  – Determine fuel burn, emission and noise impact for each scenario
  – Establish trade-off between throughput, noise, emissions and fuel burn as a function of initiation altitude and stringency of waypoint altitude crossing restrictions
Monte Carlo Simulation

• Flight path is computed as a function of time…
  – Lateral position
  – Altitude
  – Speed
  – Thrust setting
  – Speed brake setting
  – Flap setting
  – Landing gear position

• Given uncertainties in…
  – Pilot behaviour
  – Aircraft weight
  – Wind
Monte Carlo Simulation

Aircraft / Flap Schedule

Procedure Definition

Fast-Time Simulator Core

Pilot Response

Weight Distribution

Local Wind Variation

Trajectory

Post Processing

Batch Execution

Required separation at metering point
Single runway throughput
Monte Carlo Simulation

• No interaction between consecutive flights
  – Each flight simulated separately
  – Controller intervention not simulated (contingency)

• Wind variations handled through convolution
  – Leading flights
    • An ensemble of flights simulated with wind fixed to the nominal wind condition while retaining other factors such as pilot response and weight as random
  – Trailing flights
    • Another ensemble of flights simulated with wind that is equal to the nominal wind condition plus inter-flight wind variation, in addition to random factors such as pilot response and weight
  – Flights from leading ensemble and trailing ensemble convoluted to form probability density functions
Separation Analysis Methodology

Required Initial Separation, $p_1$
AC Type A – Type B

Selected Threshold $S_{i1}$

Required Initial Separation, $p_2$
AC Type B – Type A

Selected Threshold $S_{i2}$
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.

LOCALIZER 119.9 I-LAX

LOCALIZER 111.1 I-CFN

PALAC  Cross at or above 7,000'

BREEA  Cross at or above 8,000'

DECOR  Cross at or below 9,800'  Cross at or above 9,000'

SKOLL  Cross at or above 10,000'

CAMDI  Cross at or above 12,000'

MINZA

ROWLIA  Cross at or above 12,000'

PFILA  Cross at or above 10,000'

SHURL  Cross at or above 12,000'

SALVA  Cross at or below 9,800'  Cross at or above 9,000'

WNLIT  Cross at or above 8,000'

HURLR  Cross at or above 7,000'

LOCALIZER 118.5 I-GSS

LOCALIZER 111.1 I-CFN

MD  257'

MUSHI  Cross at or above 7,000'

DYMNO  Cross at or above 8,000'

TAROC  Cross at or below 9,700'  Cross at or above 9,500'

KRAIN  Cross at or above 10,000'

EDOSO  Cross at or above 12,600'

LOS ANGELES 113.9 LAX

HECTOR 112.7 FEC

PEACH SPRINGS 112.9 PSG

DYPESO  48.1'

HETTE  46.5'

ETINE

DIKES

BUGGA

EMMEY

RUSTT  Cross at or above 15,000'

GRAMM  Cross at or below FL190

Cross at or above 17,000'

Cross at 290K

PARADISE 112.2 PD2

Chase 59
CIVET Altitude Analysis

• Initiation point assumed to be GRAMM where the control handoff takes place

• Mean wind and wind variation calculated using ACARS data from LAX arrivals
  – Eastern Portion of the Airport (for Civet Arrival Path)
  – Wind divided into “bins” of 20 knots depending on the strength of the wind the direction of the runway
  – Winds tested range from -110 to +110
### CIVET Altitude Analysis

**With Mean Wind of Zero**

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<th>HIGH[ft]</th>
<th>LOW[ft]</th>
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CIVET Separation Analysis

• 100 leading flights and 100 trailing flights simulated for each aircraft type

• Aircraft descent simulated from cruise altitude
  – No level segment at the initiation altitude

• Initial separation values dependent on:
  – Leading aircraft type and weight
  – Trailing aircraft type and weight
  – Mean wind and wind variation
  – Pilot response
767 Leading 747

Initial Separation Required [nm]

Probability Density

-110_-90
-10_10
50_70
Status/Future SCT-PARTNER

• Analysis procedure up and running

• CIVET and SEAVU analysis near complete
  – LAX wind model for wide range of days and hours
  – Altitude and separation analysis to be completed for wider range of aircraft types

• Passive test of “TMA type implementation” in FY06

• Other runways/airports to be taken in rank order (based on needs of Walter et al.)