Terminal – Tactical Separation
Assured Flight Environment
(T-TSAFE)

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Outline

• Objective
• Motivation
• Comparison with previous research and current operations
• Integration with SDO Concept
• T-TSAFE details
• Experiment Plan
• Summary
Objective

Conduct simulations of initial tactical conflict prediction and resolution advisory functions

- Develop, define and test controller procedures and roles and responsibilities
- Identify information requirements
- Evaluate and compare the tool with current day tools such as Conflict Alert

TSAFE = Tactical Separation Assured Flight Environment
Operational Errors and Deviations
(Selected TRACONs, 2009)

Roach (2011). North Texas Research Facility
Motivation

• Conflict Alert (CA) is inadequate
  – Insufficient flight plan detail to the runway
  – Complex separation standards

• Terminal airspace is challenging
  – Operational errors are high
  – Dense and complex airspace

• Previous research has clear gaps
### Background

#### Previous Research on TSAFE (Prevot et al.)
- En route HITL testing
- Automated conflict detection and resolution
- Management by exception
- All resolution trajectories are data linked

#### T-TSAFE & Current Operations
- Terminal area HITL testing
- Conflict detection is automated but resolution is manual
- Controllers responsible for separation assurance
- Voice commands
Integration with SDO concept

- Extended Terminal Area Resource Allocation (20 min. – 2 hr. time horizon)
- Precision Scheduling Along Routes (20 min. – 1 hr. time horizon)
- Merging and Spacing (2-20 min. time horizon)
- Tactical Separation (0-3 min. time horizon)
- Off-Nominal Recovery (2-10 min. time horizon)
- Trajectory Prediction
- Wake Prediction
- Weather Forecasts
What is T-TSAFE?

- Short-term conflict detection tool for terminal airspace
- Based on similar principles as en route TSAFE (Erzberger’s tool)
- Provides two-minute resolution trajectory without returning to flight plan route
- Uses dead reckoning and flight intent information separately or in combination when flight Intent is present
Algorithm Comparison
T-TSAFE vs. Conflict Alert (Tang et al.)

![Bar chart showing comparison between T-TSAFE and Conflict Alert models.](chart.png)

- **Average Alert Lead Time (in seconds):**
  - Conflict Alert Model: 38 seconds
  - En Route TSAFE Model: 45 seconds
  - Terminal TSAFE: 35 seconds

- **False Alert Rate (per hour):**
  - Conflict Alert Model: 10 alerts/hour
  - En Route TSAFE Model: 25 alerts/hour
  - Terminal TSAFE: 5 alerts/hour
False Alerts (Results for lab analysis Tang et al.)

False Alert Rate (per hour)

Without inferred altitude clearances

With inferred altitude clearances

False alerts further improved if altitude (flight intent) information is present
## Experiment Matrix

### March-April 2011

<table>
<thead>
<tr>
<th>Altitude Entries</th>
<th>Baseline (Conflict Alert and ATPA)</th>
<th>T-TSAFE (Conflict detection only) and ATPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Condition A</td>
<td>Condition B</td>
</tr>
<tr>
<td>Keyboard</td>
<td>NA</td>
<td>Condition C</td>
</tr>
<tr>
<td>ADS-B</td>
<td>NA</td>
<td>Condition D</td>
</tr>
</tbody>
</table>

Multi Aircraft Control System (MACS) used to integrate the T-TSAFE algorithms, ATPA, CA and develop user interfaces

ATPA = Automated Terminal Proximity Alert
Conflict Alert

- Conflict Alert is our adaptation to the one used in the field
- No audio alerts
- CA will be turned off when ATPA is turned on
Automated Terminal Proximity Alert

• Final approach tool
• Similar to the cones of TPA on the final approach
• The graphic cones depict the following:
  – Monitor Line (blue) (means no LOS)
  – Warning Line (yellow) (45 seconds look-ahead time to LOS)
  – Alert Line (orange) (24 seconds look-ahead time to LOS)
T-TSAFE Interfaces

Data Tags

T-TSAFE Conflict Table

<table>
<thead>
<tr>
<th>CONFLICT PAIR</th>
<th>LOS TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA5140</td>
<td>KAL7570</td>
</tr>
<tr>
<td>DAL2200</td>
<td>DAL4230</td>
</tr>
<tr>
<td>DAL4230</td>
<td>SWA3590</td>
</tr>
<tr>
<td>AAL1530</td>
<td>USA5140</td>
</tr>
<tr>
<td>AAL1530</td>
<td>KAL7570</td>
</tr>
</tbody>
</table>

Data Tags highlight on mouse-over
Research Questions

• Are conflicts better detected and solved by controllers in the T-TSAFE condition over Baseline (Conflict Alert)?

• How does altitude entry affect?
  – Number of losses of separation (LOS)
  – Number of false alerts
  – Time to potential loss of separation
  – Time when conflict is solved
  – T-TSAFE conflict detection ability
  – Vertical and horizontal distance between aircraft when conflict is solved
  – Workload, situation awareness, and trust in automation
Airspace Details

• Los Angeles International Airport (LAX)
• ILS simultaneous approaches (24R and 25L)
• Airport arrival rate of 68
• Controller Positions
  – Stadium and Downey (2 approach controllers)
  – East feeder and Zuma (2 feeder controllers)
• Departures scripted
• Six arrival routes simulated VFR traffic included
Airspace (LAX)
East Feeder Conflict: 2-way (@ Seavu) followed by 3-way (@ Luvyn) conflict
Zuma Conflict:
2-way (@ Sadde + Compression afterwards) followed by possible 3-way conflict with Casta Departure
Experimental Plan

- 4 controllers per week for two weeks
- 8 pseudo-pilots
- 4 confederates
- 4 scenarios
- 16 total runs
- 2 days of training, 3 days of data collection
Summary

- First HITL to test Terminal TSAFE using current day operations
- Controller procedures and information requirements for the tool will be identified
- Next Steps
  - HITL test to include conflict resolution
  - Integrate flight deck with the ground tool
Thank You!

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References
