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
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

- Data Link
- Voice Link

- 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

Integration with SDO concept!
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.)

- **Average Alert Lead Time (in seconds)**
- **False Alert Rate (per hour)**

<table>
<thead>
<tr>
<th>Model</th>
<th>Average Alert Lead Time</th>
<th>False Alert Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conflict Alert Model</td>
<td>37.5</td>
<td>4.5</td>
</tr>
<tr>
<td>En Route TSAFE Model</td>
<td>45.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Terminal TSAFE</td>
<td>30.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
False Alerts (Results for lab analysis Tang et al.)

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>
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
