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

Savvy Verma, Huabin Tang and Debbi Ballinger
NASA

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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 comparing Average Alert Lead Time and False Alert Rate for Conflict Alert Model, En Route TSAFE Model, and Terminal TSAFE.](chart.png)
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>

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
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!

Savvy Verma
savita.a.verma@nasa.gov

Huabin Tang
huabin.tang-1@nasa.gov
References
