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

- 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)
- Off-Nominal Recovery (2-10 min. time horizon)
- Tactical Separation (0-3 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.)

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

### Graph Details:
- **X-axis:** Conflict Alert Model, En Route TSAFE Model, Terminal TSAFE
- **Y-axis:**
  - Range: 0 to 50
  - Markers: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

#### Data Points:
- **Conflict Alert Model**
  - Average Alert Lead Time: Approximately 35 seconds
  - False Alert Rate: Approximately 30 per hour
- **En Route TSAFE Model**
  - Average Alert Lead Time: Approximately 45 seconds
  - False Alert Rate: Approximately 25 per hour
- **Terminal TSAFE**
  - Average Alert Lead Time: Approximately 40 seconds
  - False Alert Rate: Approximately 4 per hour
False Alerts (Results for lab analysis Tang et al.)

- False Alert Rate (per hour)

- Without inferred altitude clearances
  - En Route TSAFE Model: 60
  - Conflict Alert Model: 30
  - Terminal TSAFE: 20

- 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
