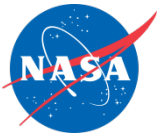


Human Factors of Conflict Detection Tool for Terminal Area

Savvy Verma, Huabin Tang, Debbi Ballinger, Fay Chinn, Thomas Kozon, Amir Farrahi, Estella Buchmann, John Walker, Darrell Wooten, Jacob Pfeiffer, Diane Carpenter, & Ron Lehmer





Outline

- Motivation
- Conflict Detection Tools
- Objective
- Experiment Details
- Results
- Conclusion



Motivation

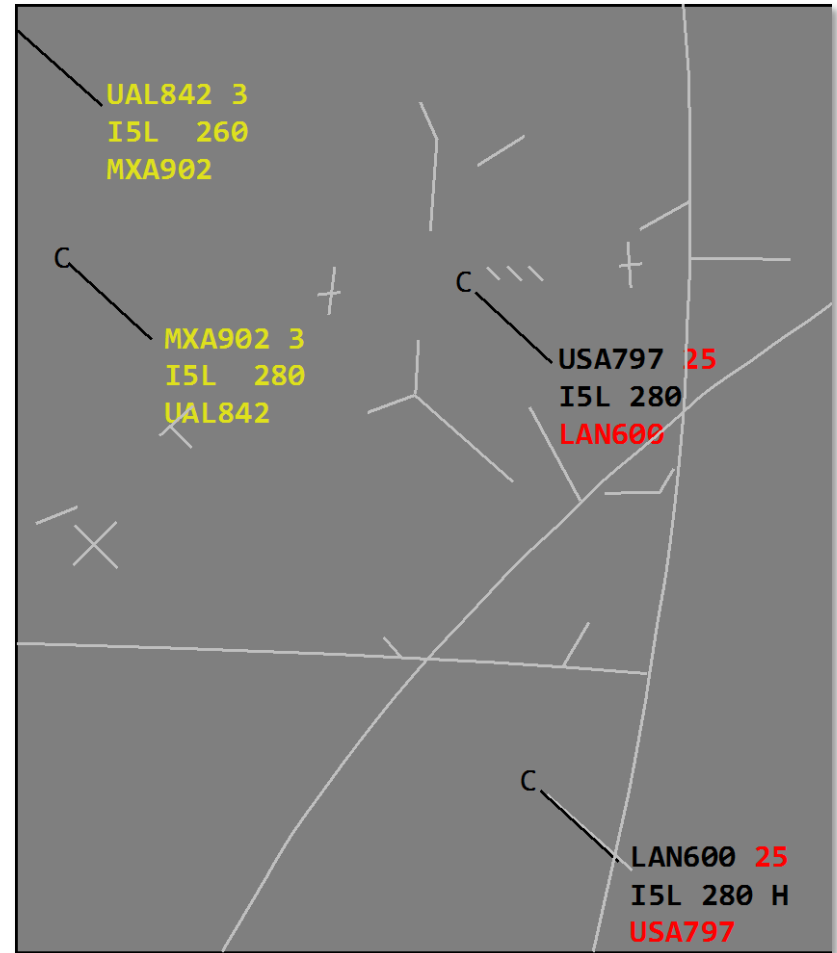
- Conflict Alert (CA) is inadequate (Friedman-Berg, 2008)
 - Controllers respond to CA only 56% of time
 - 81% of CA alerts are nuisance alerts
 - CA does not help with operational errors
 - CA uses dead reckoning only
- Several tools exist in U.S. terminal airspace
 - No exchange of inputs or outputs between such tools
 - An integrated tool in the terminal airspace is missing
- NextGen and SESAR have requirements for a conflict detection & resolution tool



Conflict Detection Tool

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

- Short-term conflict detection tool for terminal airspace alerts for potential loss of separation
- Based on similar principles as en route TSAFE (Erzberger & Paielli)
- Combines dead reckoning and flight intent information seamlessly





Eurocontrol Guidelines for Short Term Conflict Alert (STCA)

- Consider type of flight, wake category, Reduced Vertical Separation Minima (RVSM) status
- Use flight intent information
 - Airspace definitions including speed & altitude restrictions
 - RNAV departure routes
 - Controller entered flight levels
- Provide an alert with ample time for de-confliction
- User Interface that provide specific information about conflict



Previous Research

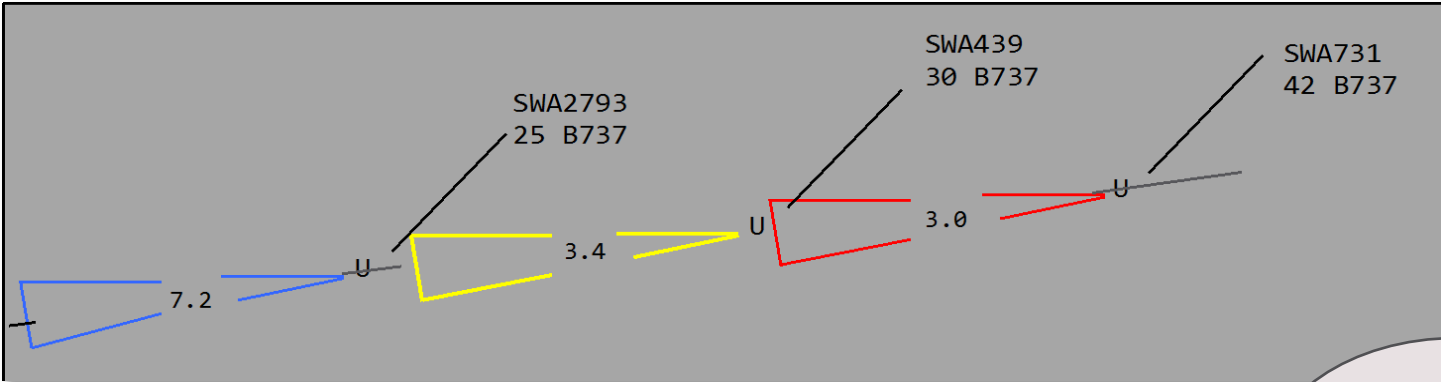
- Previous fast time simulation has shown (Tang et al.)
 - T-TSAFE had few false alerts when compared to CA
 - T-TSAFE provide a lead alert time of 38 sec
- Previous human-in-the-loop studies investigated
 - Terminal area under current day operations
 - Altitude entries
 - T-TSAFE in final approach
 - Altitude & speed resolutions



Final Approach Tools in the Experiment

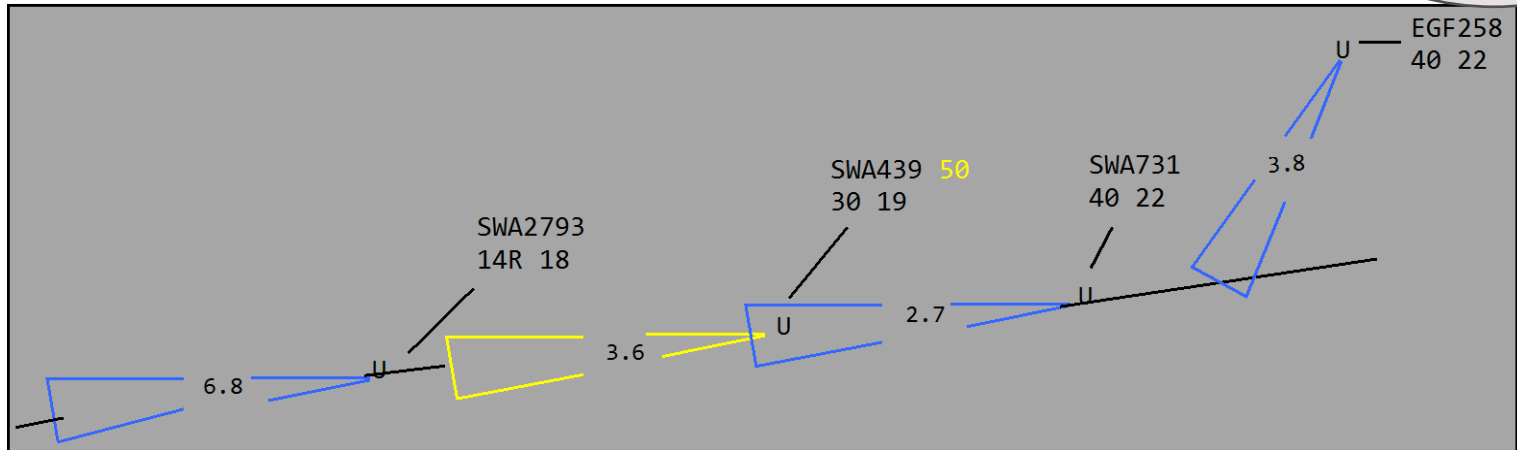


Final Approach Tools- ATPA Cones vs. T-TSAFE cones



Automated Terminal Proximity Alert - ATPA

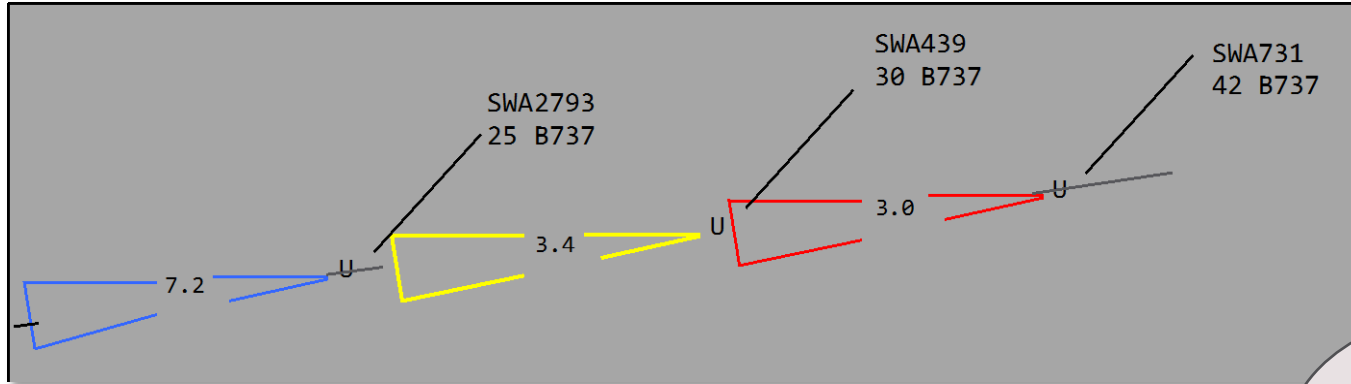
Appearance of cones



Terminal TSAFE cones

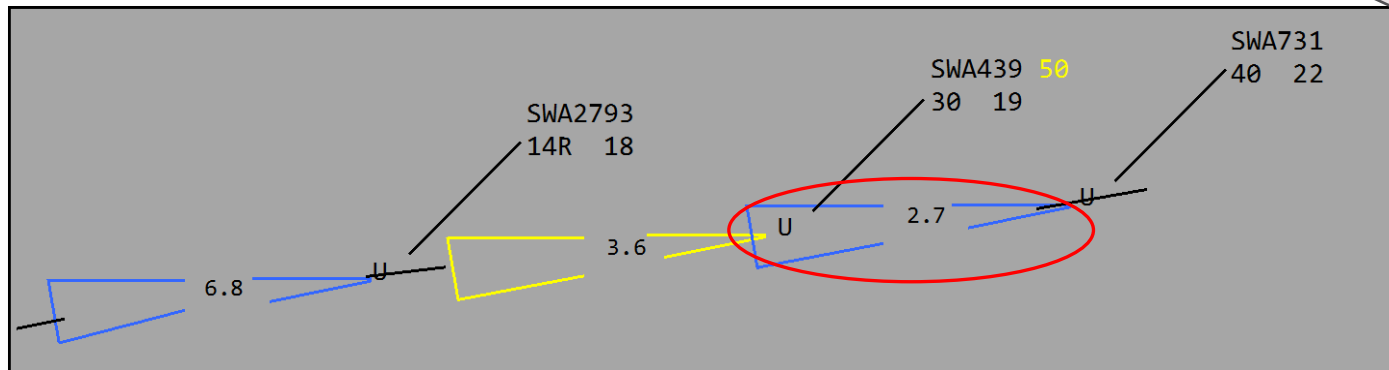


Final Approach Tools- ATPA Cones vs. T-TSAFE cones

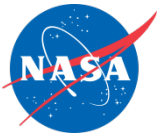


Automated Terminal Proximity Alert - ATPA

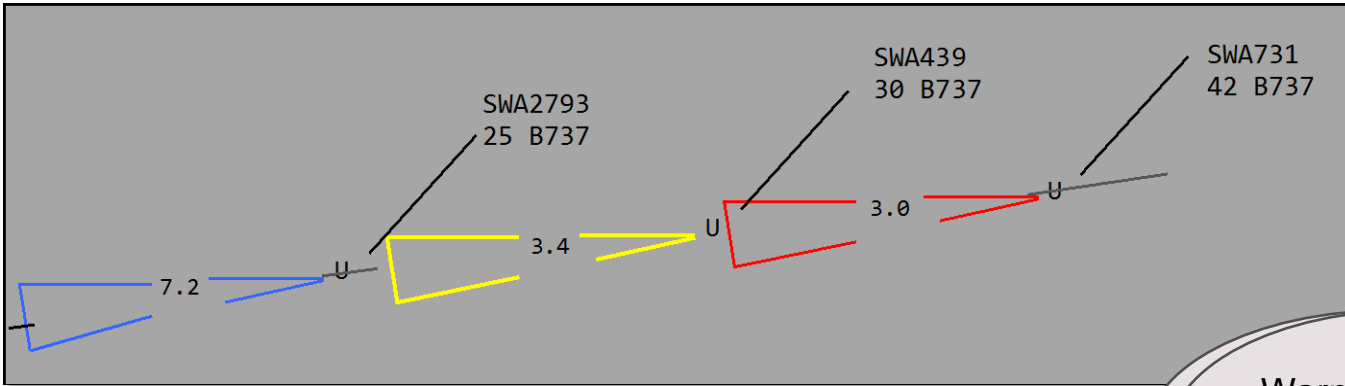
Compression error vs. Loss of Separation



Terminal TSAFE cones

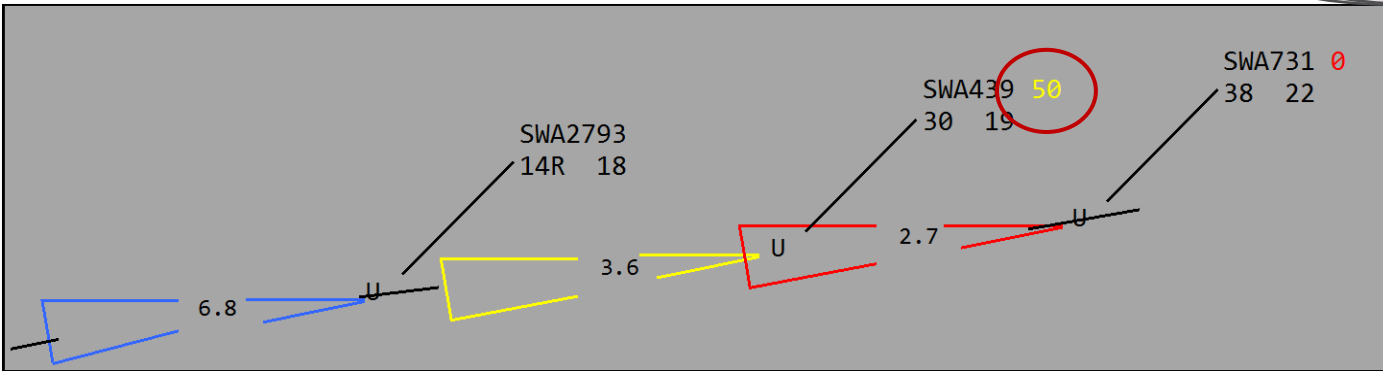


Final Approach Tools



ATPA Cones

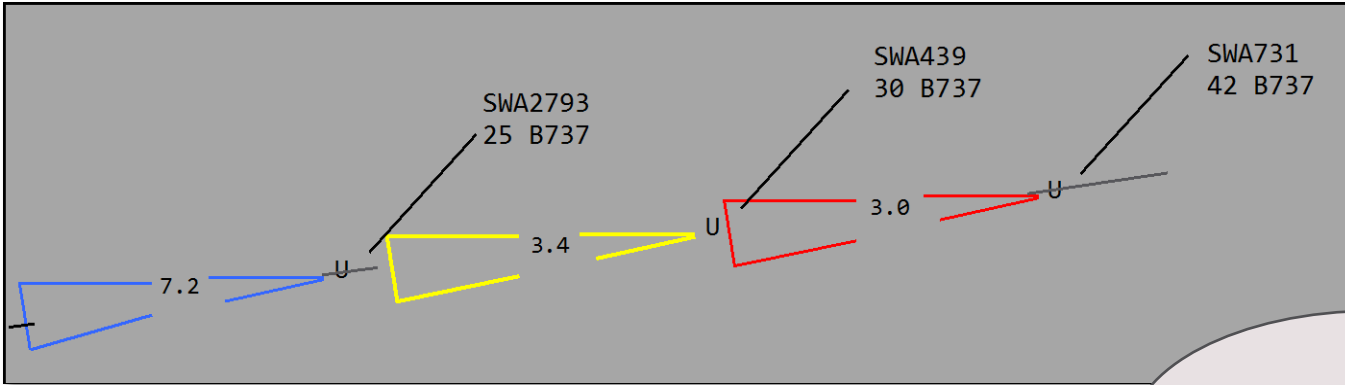
Warnings are hard coded vs. 45 sec boundary



T-TSAFE Cones

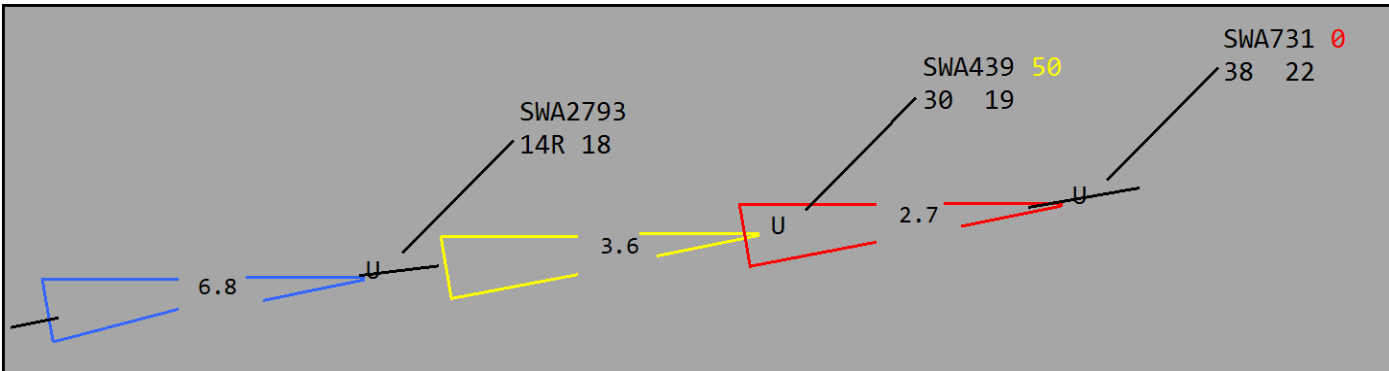


Final Approach Tools



ATPA Cones

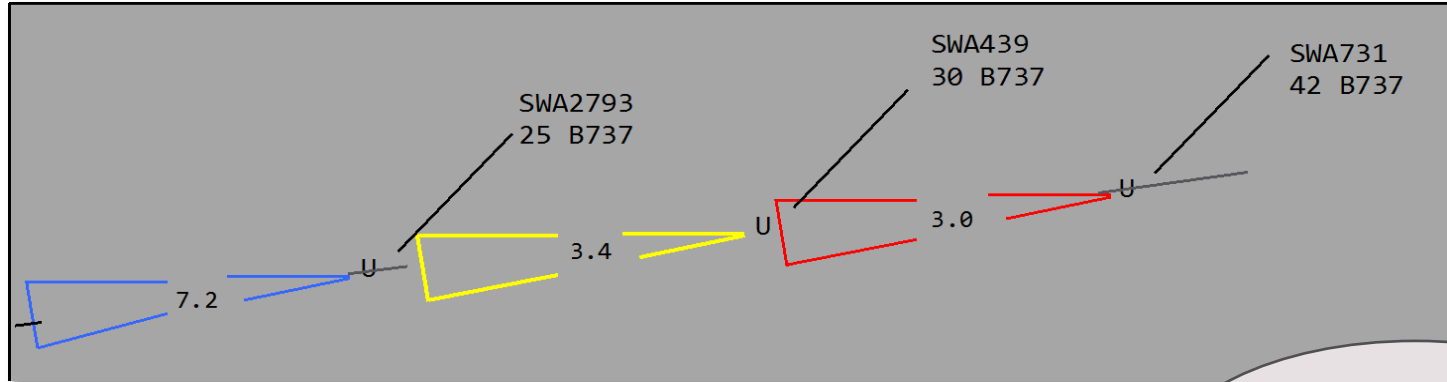
Altitude Entries by controller



T-TSAFE Cones

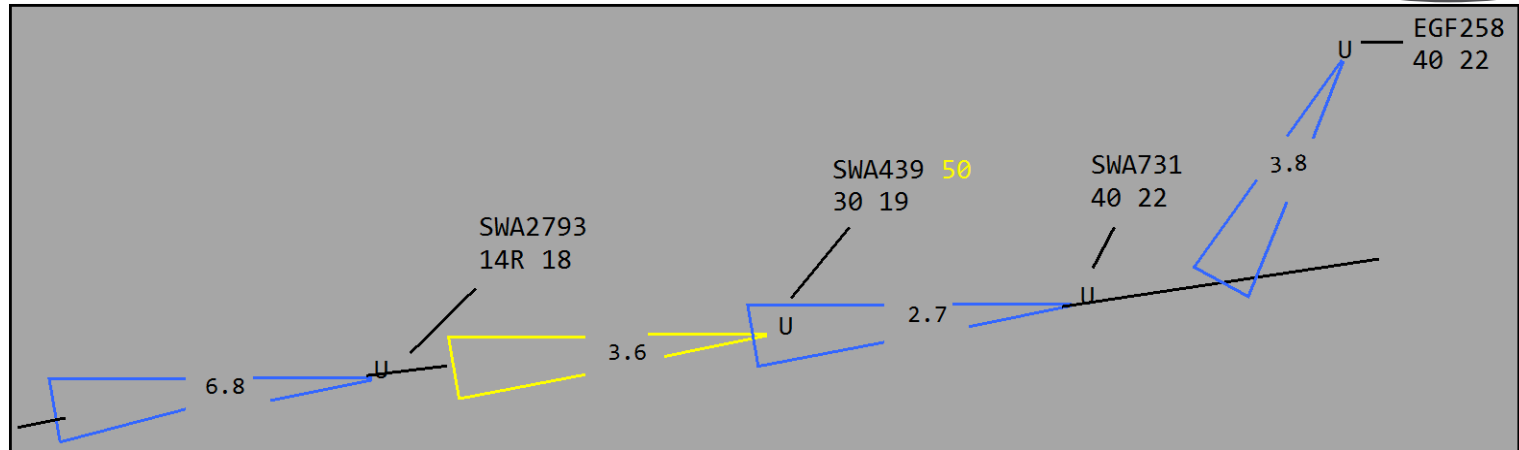


Final Approach Tools- ATPA Cones vs. T-TSAFE cones



Automated Terminal Proximity Alert - ATPA

Alerts on aircraft
physical vs.
schedule sequence



Terminal TSAFE cones

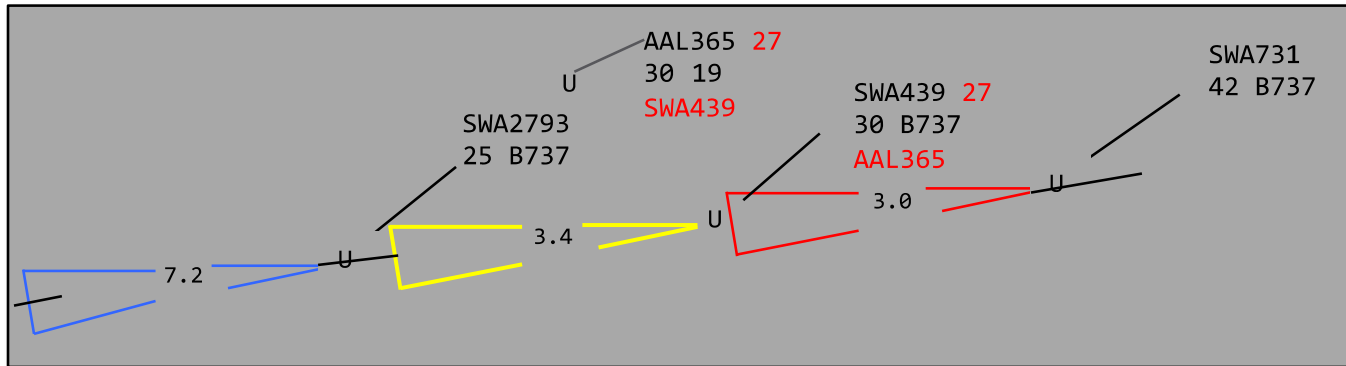


Objective

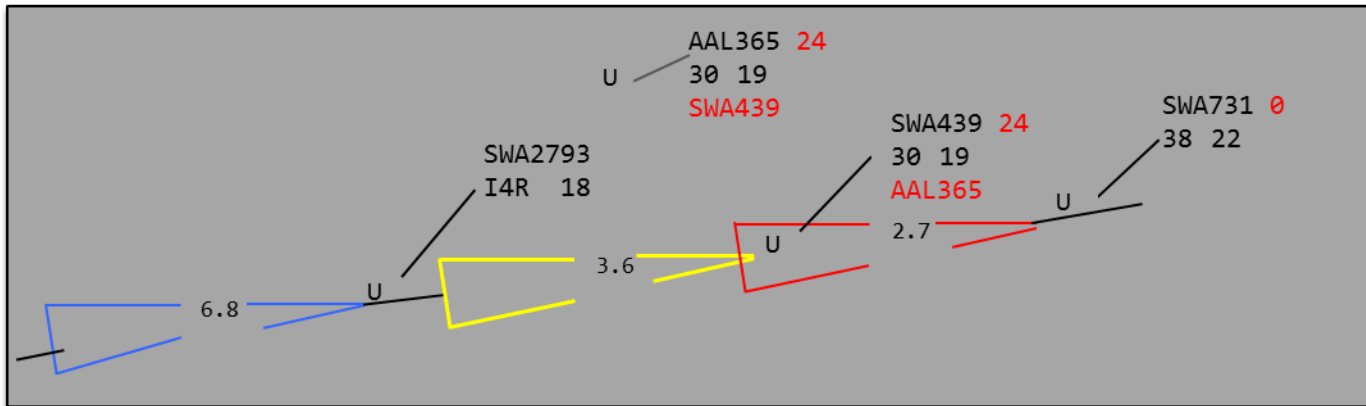
- Test one integrated tool in the terminal airspace and final approach (T-TSAFE alerts and T-TSAFE cones)
- Study the interaction of T-TSAFE alerts with ATPA cones
- Investigate robustness of T-TSAFE alerts under different operating conditions - Instrument and Mixed (mostly visual)



Interaction of ATPA with T-TSAFE vs. Integrated tool



Interaction between ATPA Cones & T-TSAFE Alerts



Integrated tool: T-TSAFE Cones & T-TSAFE Alerts



Experiment Details



Independent Variables

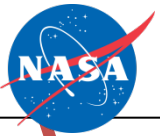
Cones(2) x Operating Conditions(2) within-subjects design

Cones	Operating Condition
T-TSAFE	ILS
ATPA	Mixed

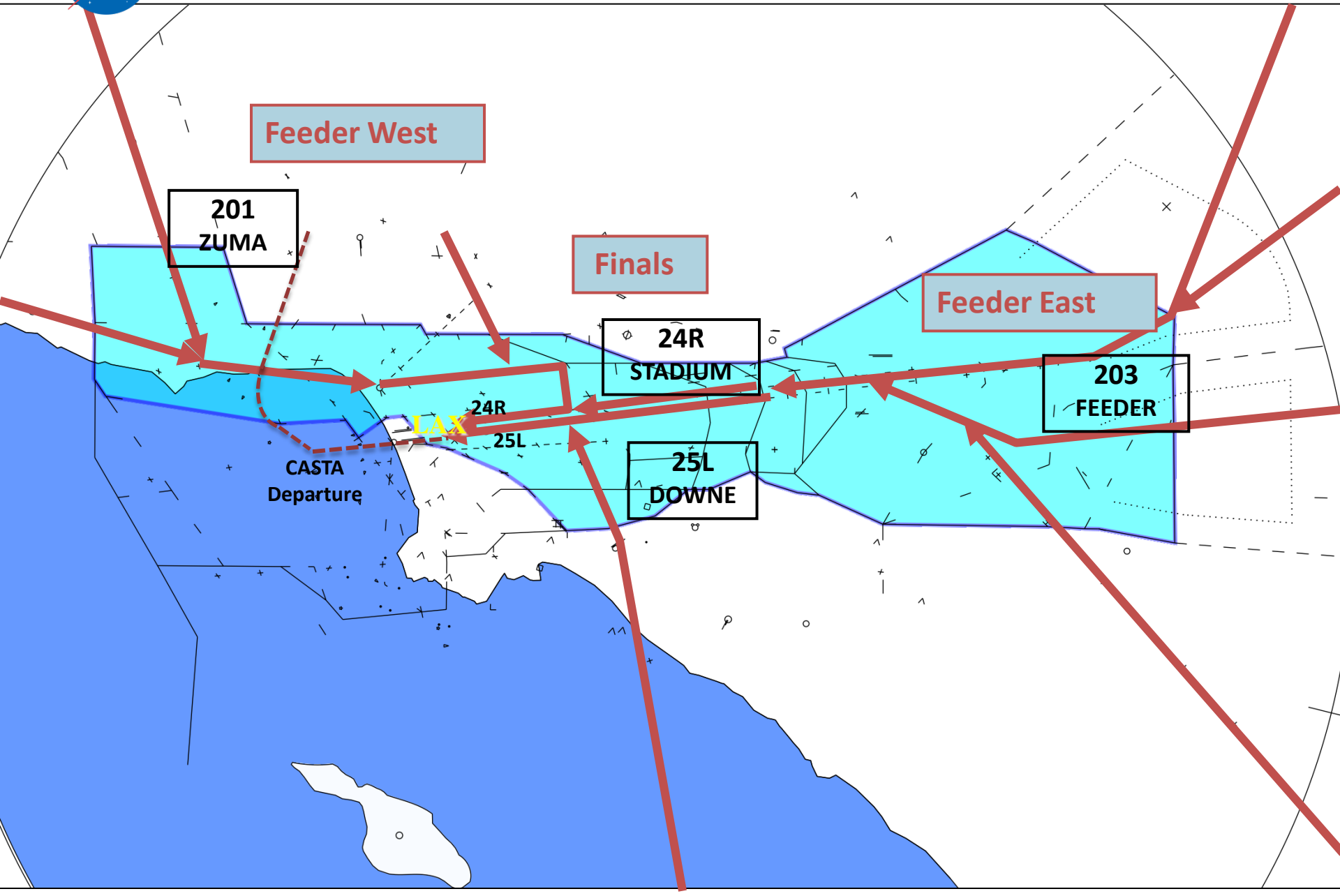


Method

- Number of weeks = 2
- Number of participants = 8 recently retired SoCal Terminal controllers
- Number of Pseudo Pilots = 12
- Confederates = 4
- Total Number of Scenarios = 4
- Total Number of runs = 16 per week
2 (cones) x 2 (operating conditions) x 4 (scenarios)
- Days of pseudo pilot training = 2
- Days of controller training = 2
- Days of data collection = 3



Los Angeles Airspace





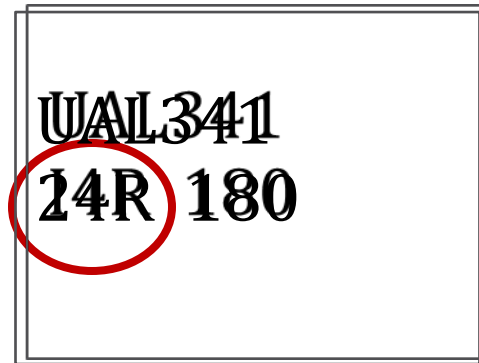
T-TSAFE Interface

AAL154 23
100 A250250
SWA987

Red Alert with time to Loss below 45 sec and altitude entry



T-TSAFE Interface (Visual approach entries)



Aircraft on ILS Approach to 24R
Aircraft on Visual Approach to 24R



Results

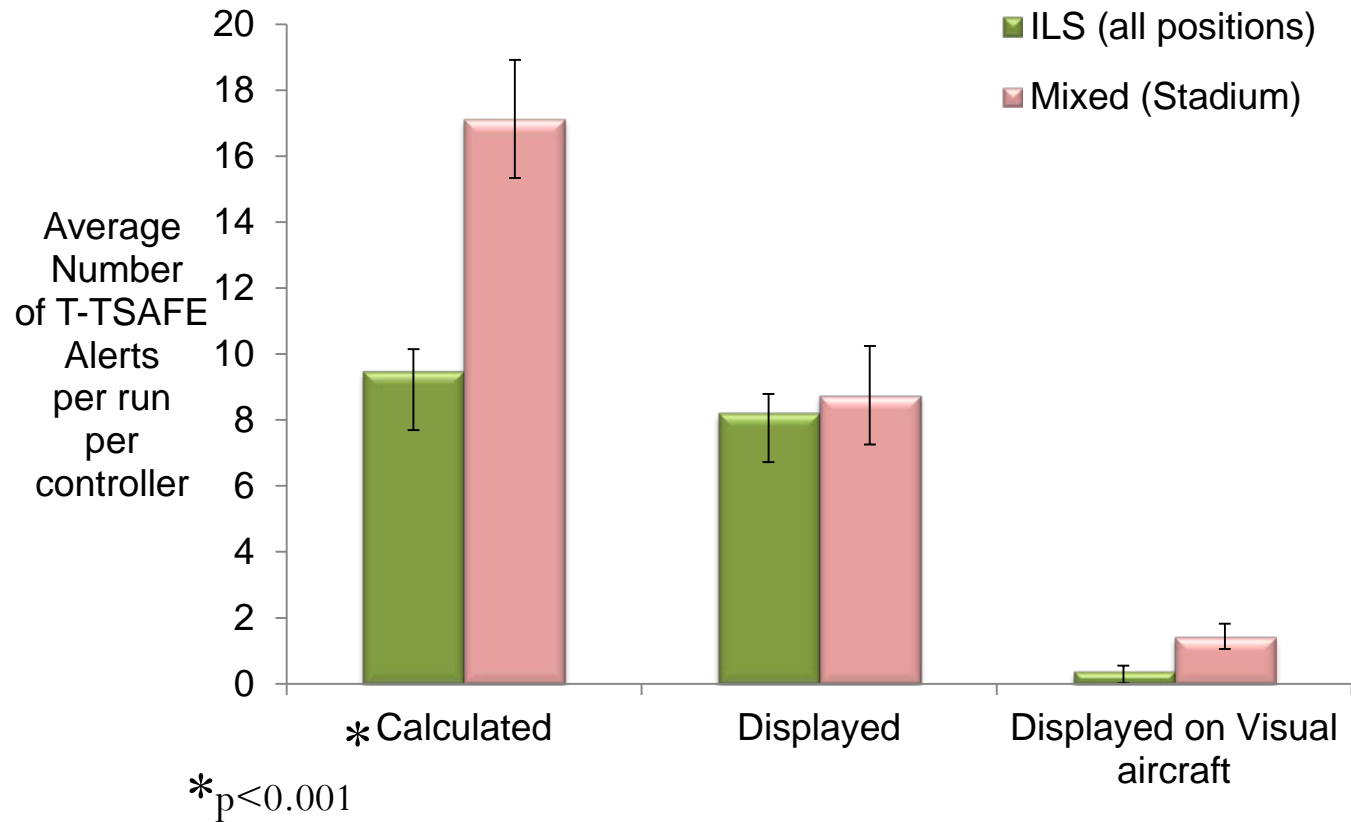


Dependent Variables

- Total alerts calculated vs. displayed
- Controller look-ahead time
- Duration of alerts
- Keyboard entries
- Controller preference for cone features
- Workload and Situational Awareness



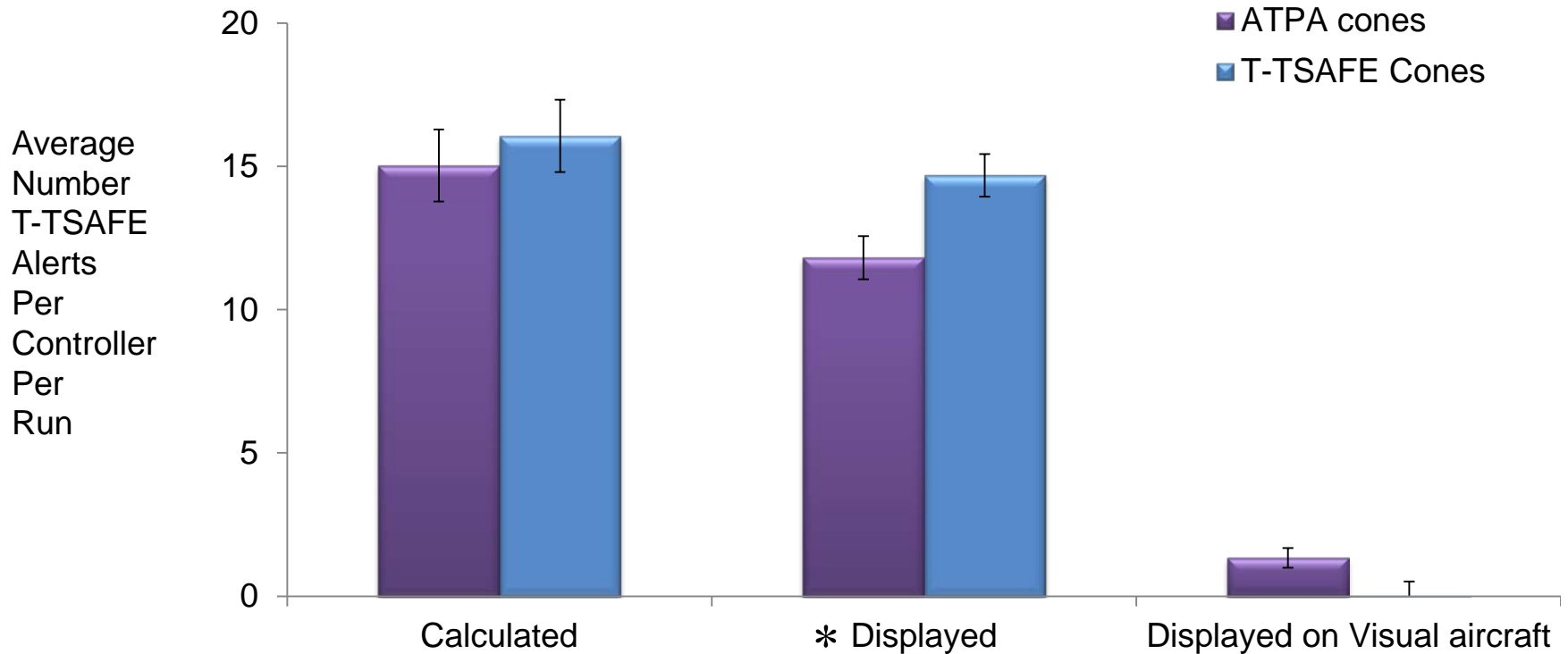
T-TSAFE Alerts Calculated vs. Displayed (ILS v. Mixed)



Frequency of alerts displayed in Mixed condition are nearly the same as those shown in ILS condition



T-TSAFE Alerts Calculated v. Displayed (ATPA v. T-TSAFE)

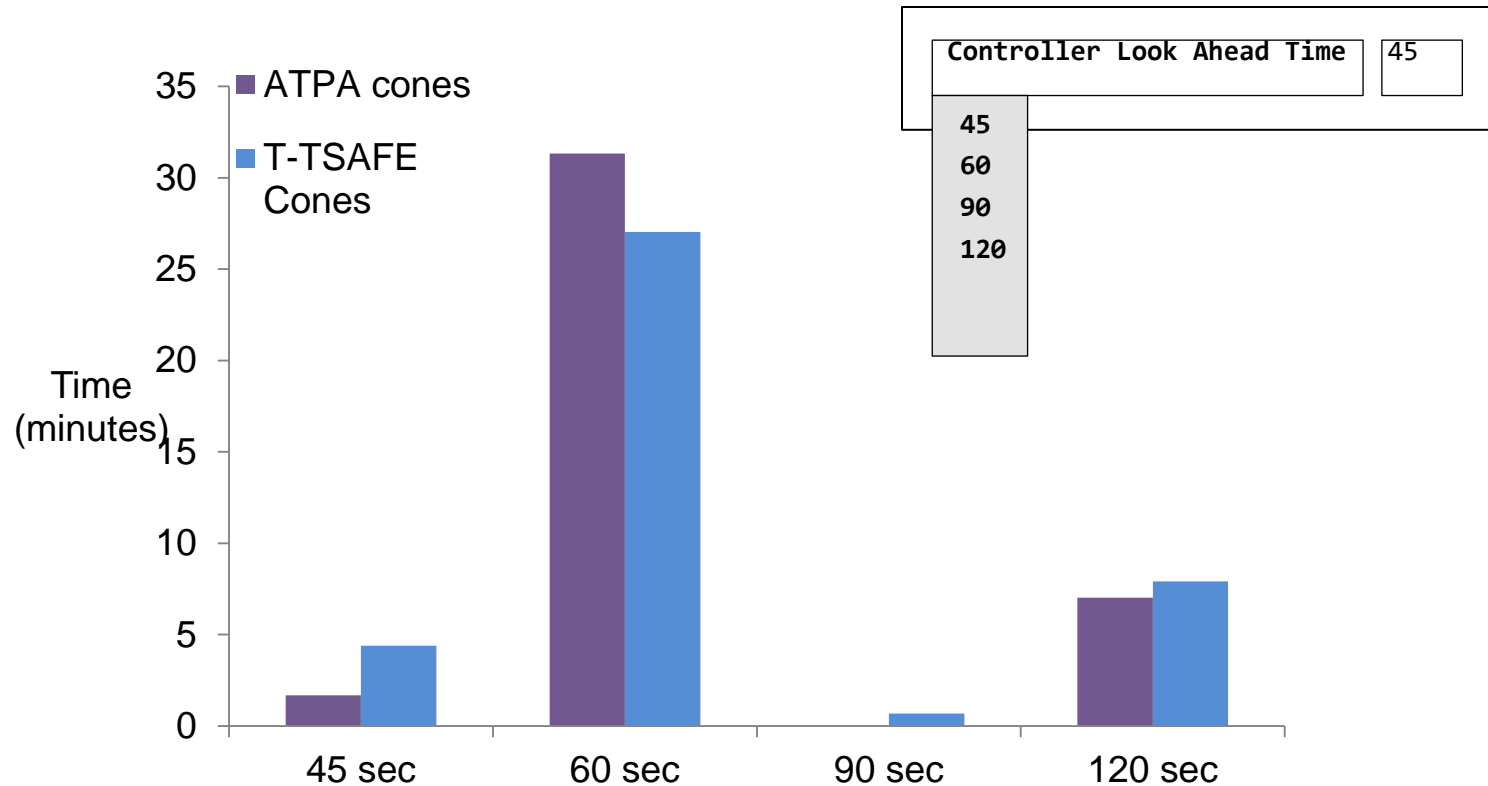


Marginal significance (* $p < 0.07$) for T-TSAFE alerts displayed

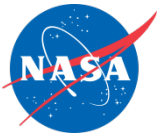
Fewer T-TSAFE alerts shown under ATPA condition since they are suppressed to prevent clutter



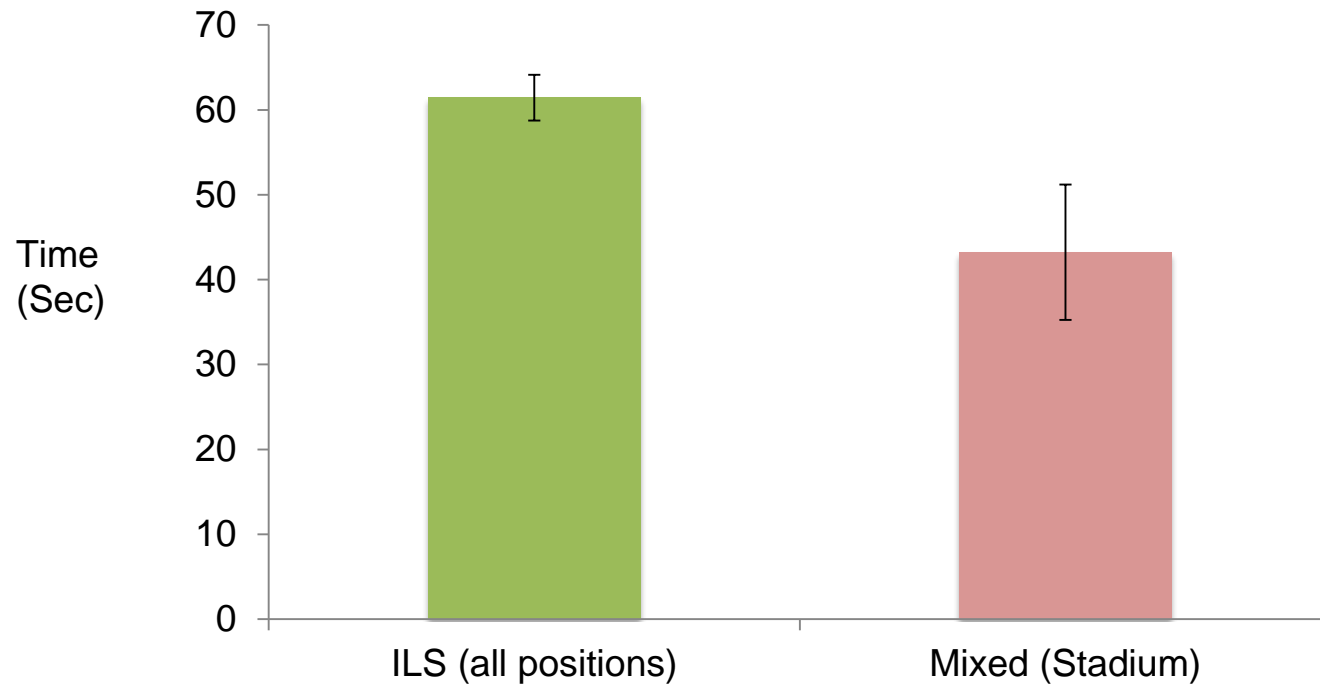
How long did controller select a look-ahead time? (ATPA vs. T-TSAFE)



Irrespective of position, type of cone, and type of operations controllers preferred to see T-TSAFE alerts within 60 sec



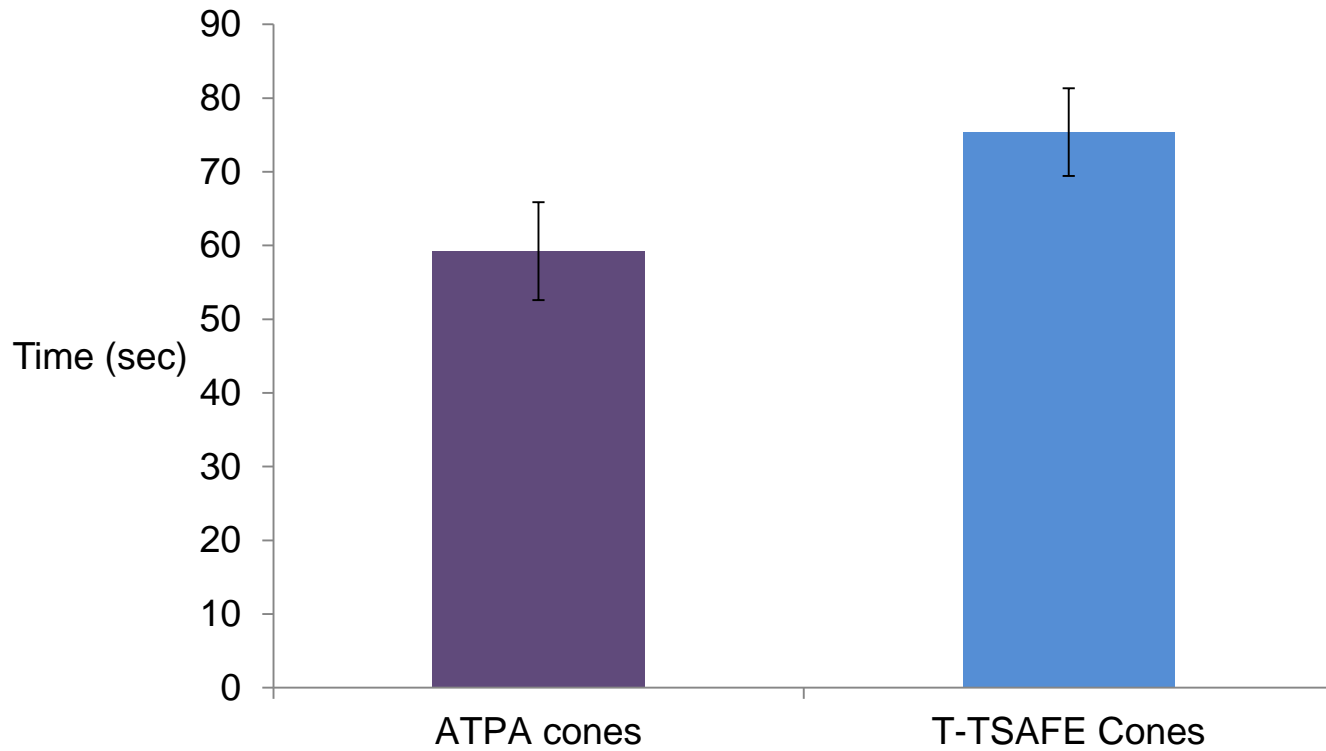
Duration of Alerts (ILS vs. Mixed)



Aircraft under ILS have alerts with longer duration than Mixed conditions, significant at $p < 0.05$



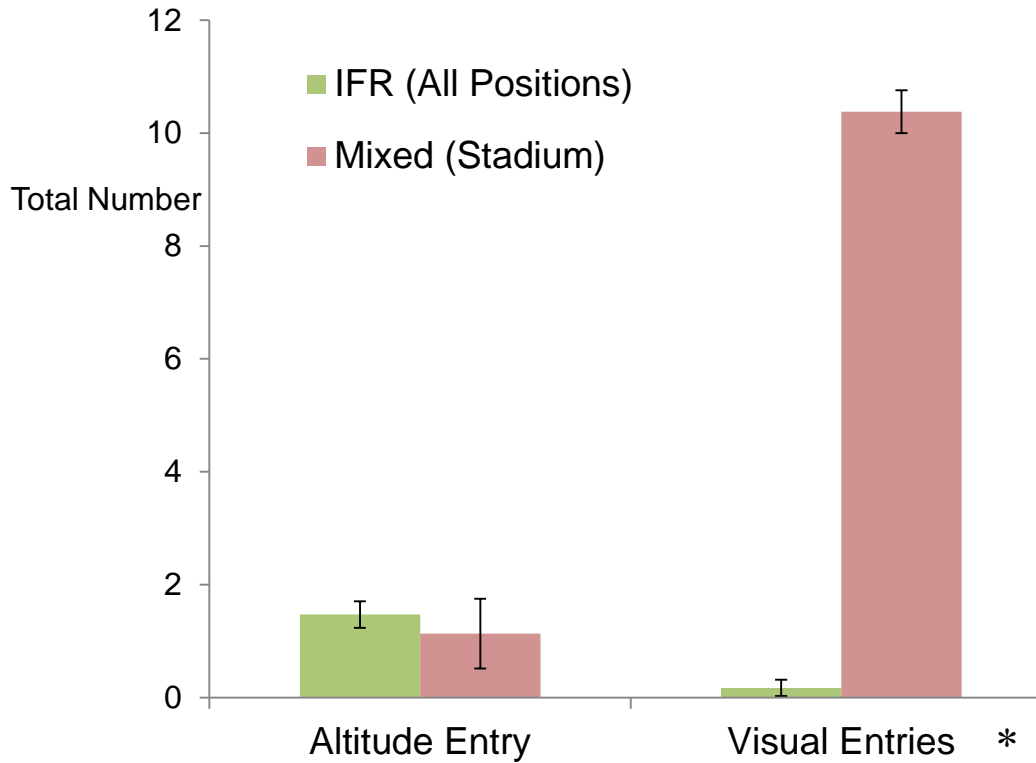
Duration of Alerts (ATPA vs. T-TSAFE)



T-TSAFE alerts under T-TSAFE cones have longer durations than T-TSAFE alerts when available with ATPA cones



Keyboard Entries

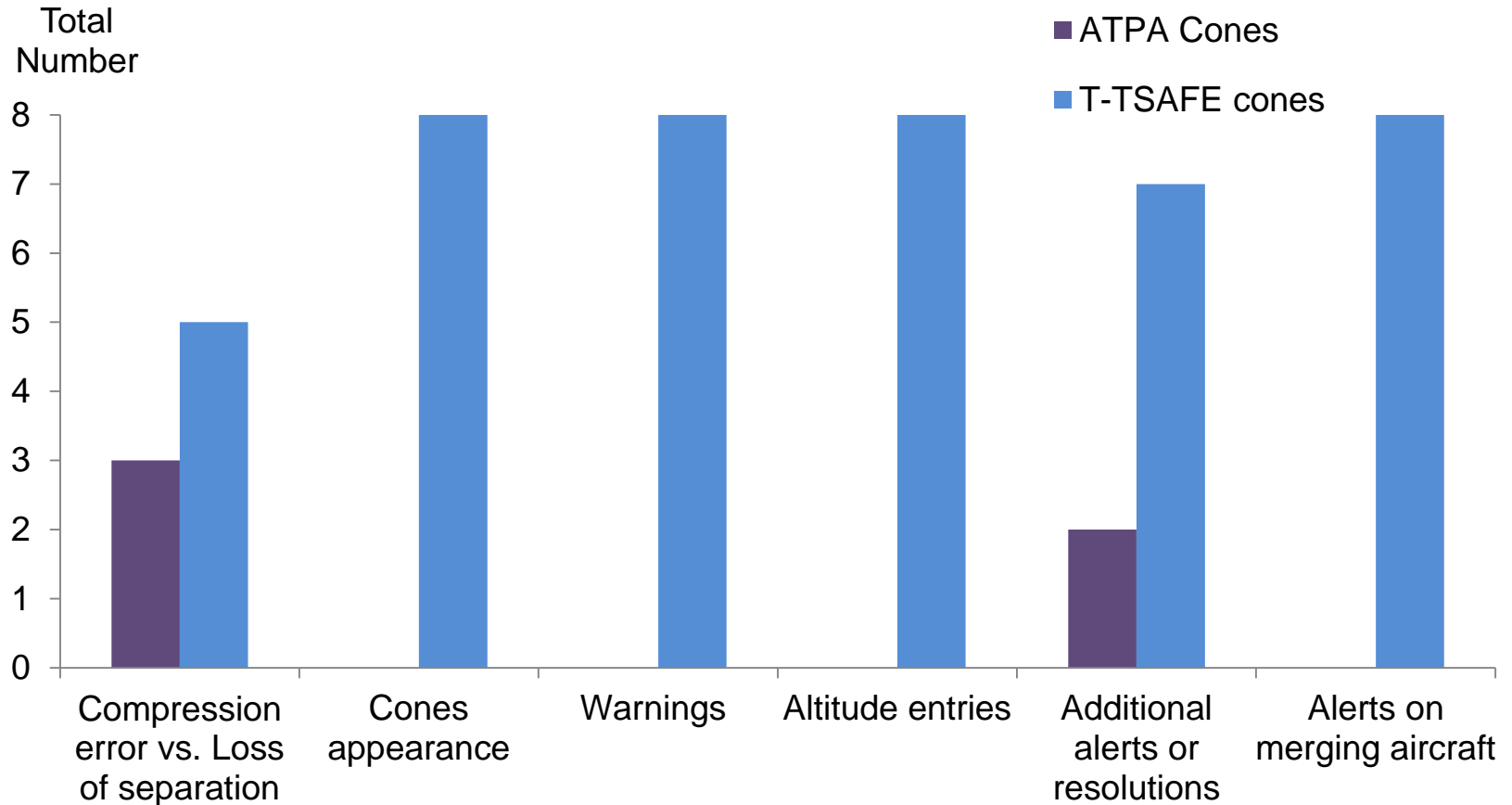


Statistical significance (* $p < 0.001$) for visual entries

Altitude entries are less likely to impact workload



Controller Preference for Cones



T-TSAFE Features are preferred over ATPA cone features by almost 100% participants except for the preference for compression error in ATPA vs. LoS in T-TSAFE cones



Results- Summary

Integrated Tool T-TSAFE cones & T-TSAFE alerts	Interaction between ATPA Cones & T-TSAFE alerts
Slightly higher number of alerts with time to LoS shown in data block	Slightly fewer number of alerts with time to LoS <i>not</i> shown in data block
Longer Duration	Shorter Duration
Altitude entries impact both cones and alerts	Altitude entries did not impact cones but did impact alerts
Controller selected Look-ahead time impacts (filters) cones and alerts	Controller selected Look-ahead time does not filter ATPA cones but does impact T-TSAFE alerts
60% preferred the depiction of loss of separation on cones	40% preferred the depiction of compression error
Similar level of Workload & Situational Awareness	Similar level of Workload & Situational Awareness



Conclusions & Future Work

- The integrated system would be the ideal system to implement
- Interaction between ATPA cones and T-TSAFE alerts can be improved by incorporating features of T-TSAFE cones
- Visual conditions provided similar levels of alerts as instrument conditions

Future Work

- Continue test T-TSAFE for robustness under different operating conditions (e.g. 4 runways and Visual Separation)
- Investigate high severity alerts on aircraft on visual approach



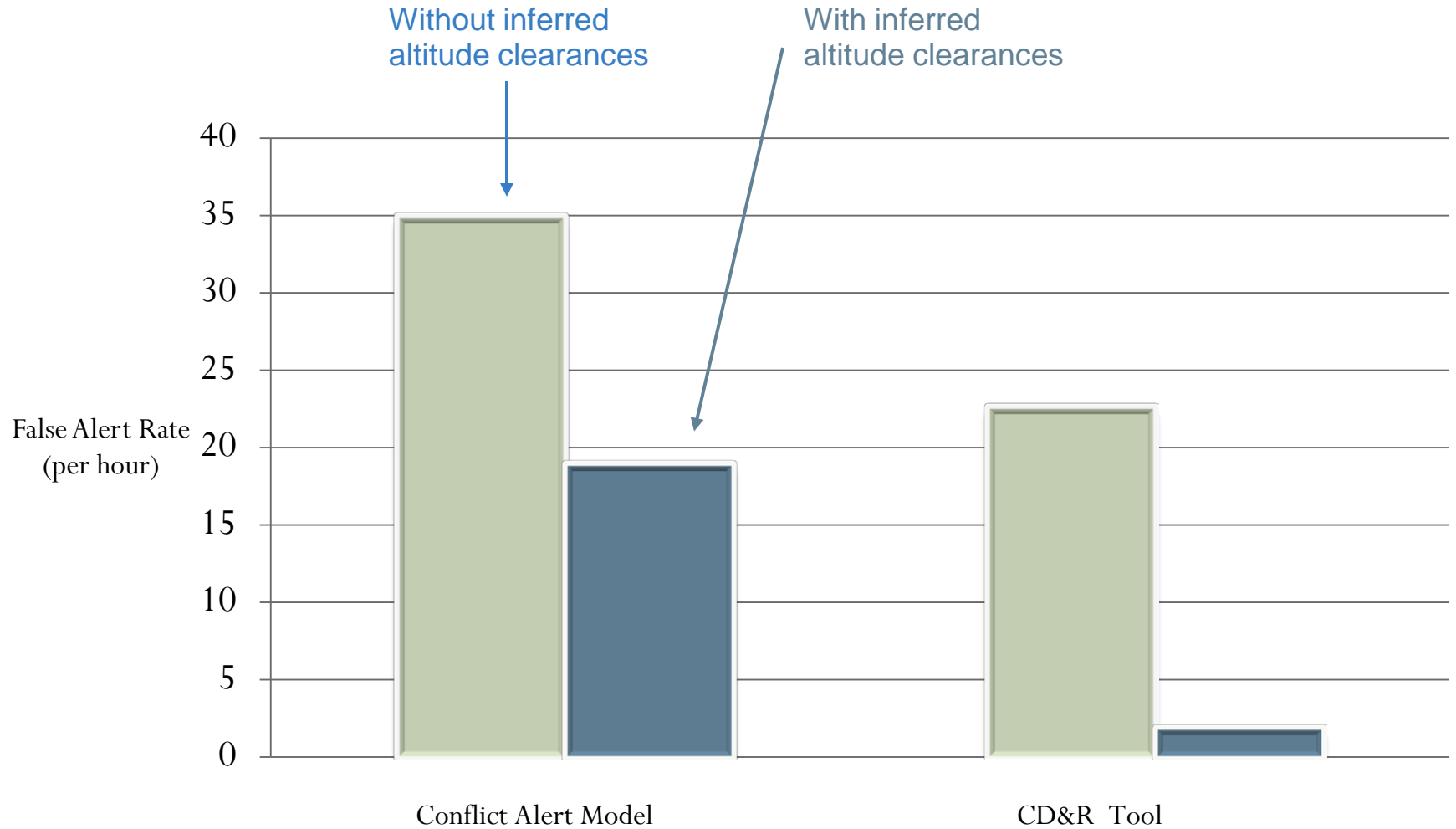
Thank you

savita.a.verma@nasa.gov



Back up slides

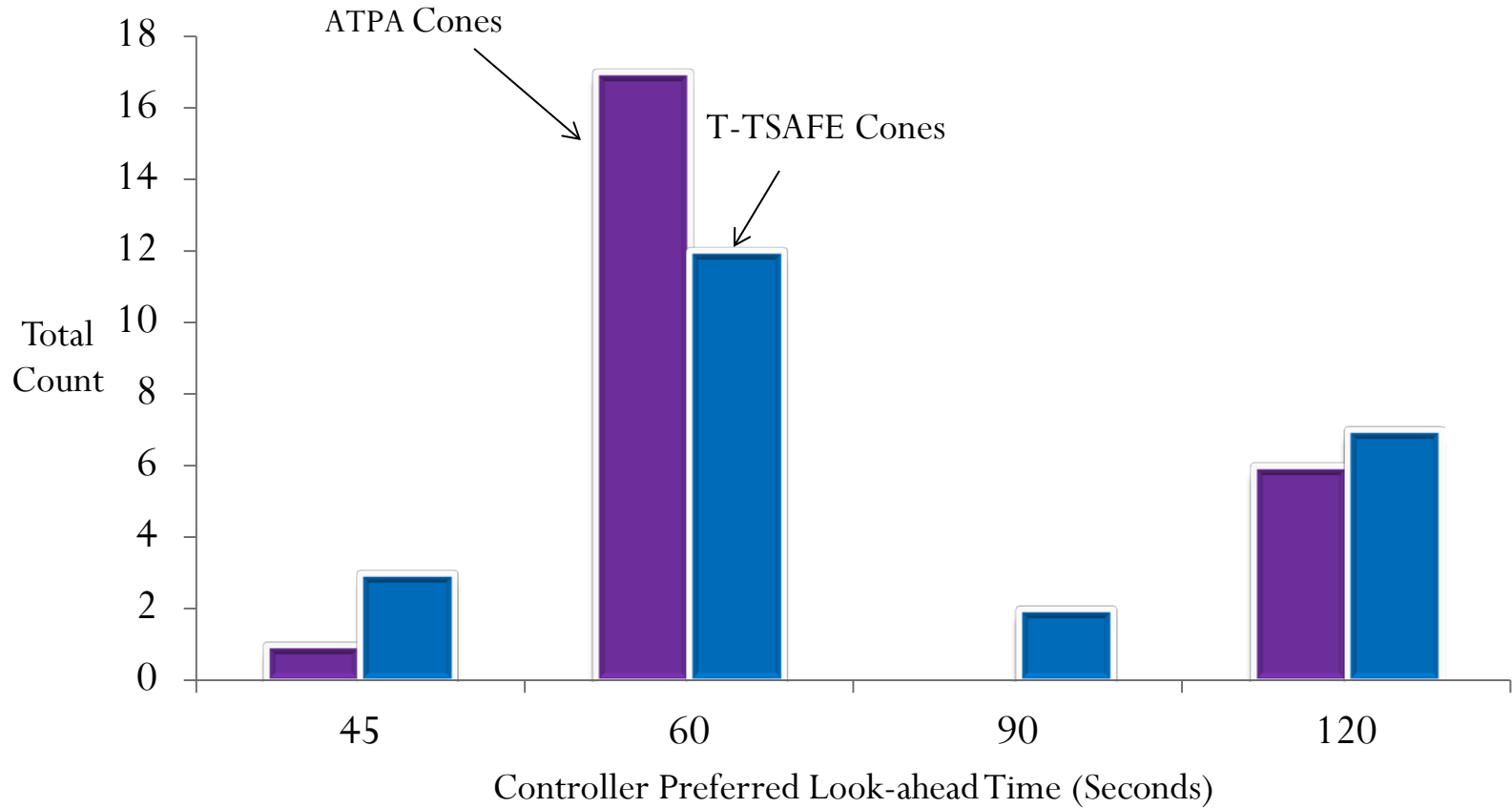
Previous Research (Fast-time analysis, Tang, et al.)



False Alerts further reduced when altitude (flight intent) information is present



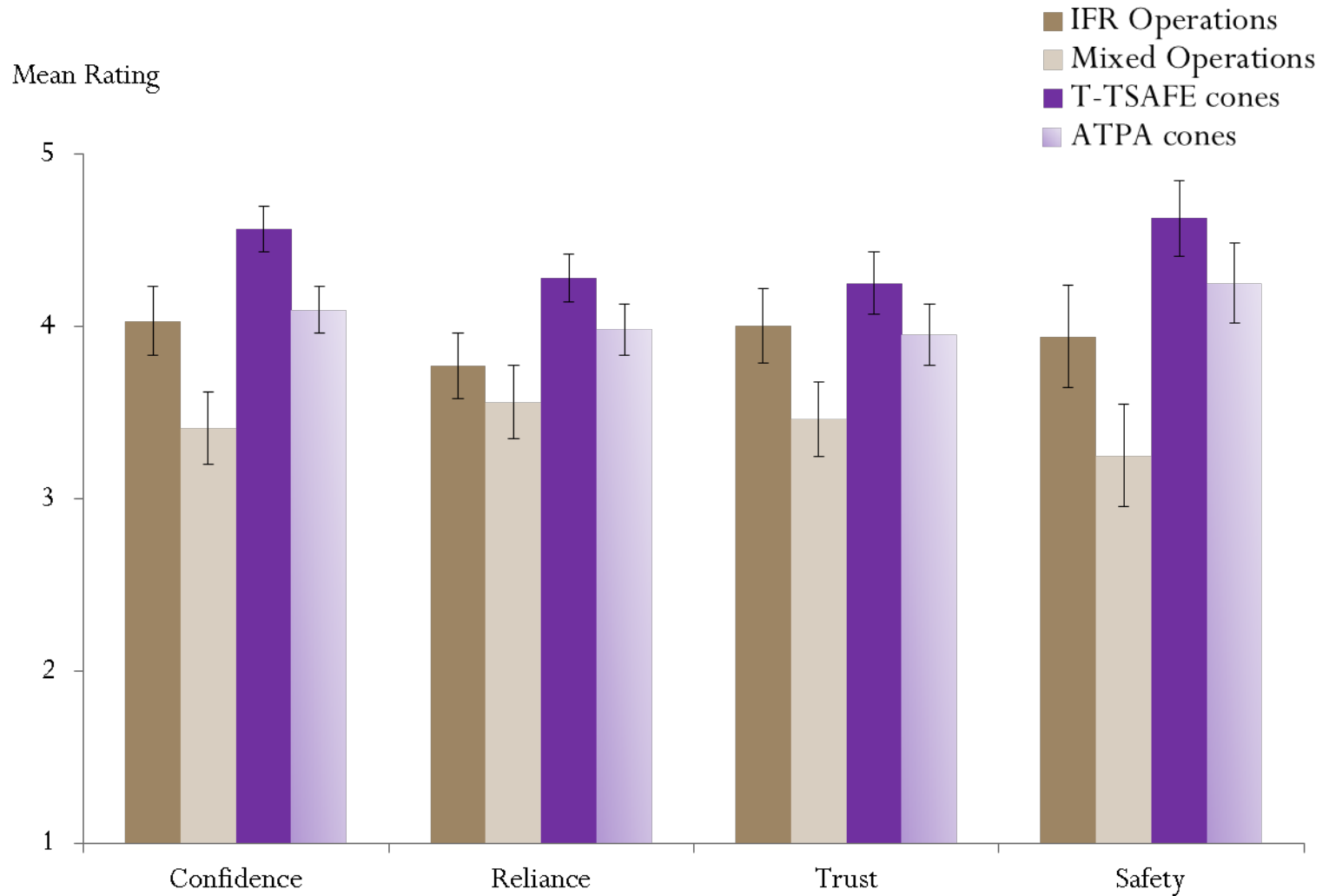
Controller Preferred Look-ahead Time



Irrespective of position, type of cone, and type of operations controllers preferred to see T-TSAFE alerts within 60 sec



Complacency Potential



ILS conditions have higher potential for complacency than Visual conditions (Significant)

T-TSAFE cones have higher potential for complacency than ATPA (Marginally Significant)



Complacency Potential (continued)

Construct	F statistic (df values)	Significance
Confidence	F(1,7)= 15.91	Significant for operation type at p<0.005
Confidence	F(1,7) = 4.82	Marginally Significant for cone type at p<0.06
Reliance	F(1,7) = 5.90	Significant for operation type at p<0.05
Trust	F(1,7) = 14.97	Significant for operation type at p<0.05
Trust	F(1,7) = 3.94	Marginally Significant for cone type at p<0.08
Safety	F(1,7) = 6.67	Significant for operation type at p<0.05

ATPA vs. T-TSAFE Cones

ATPA cones

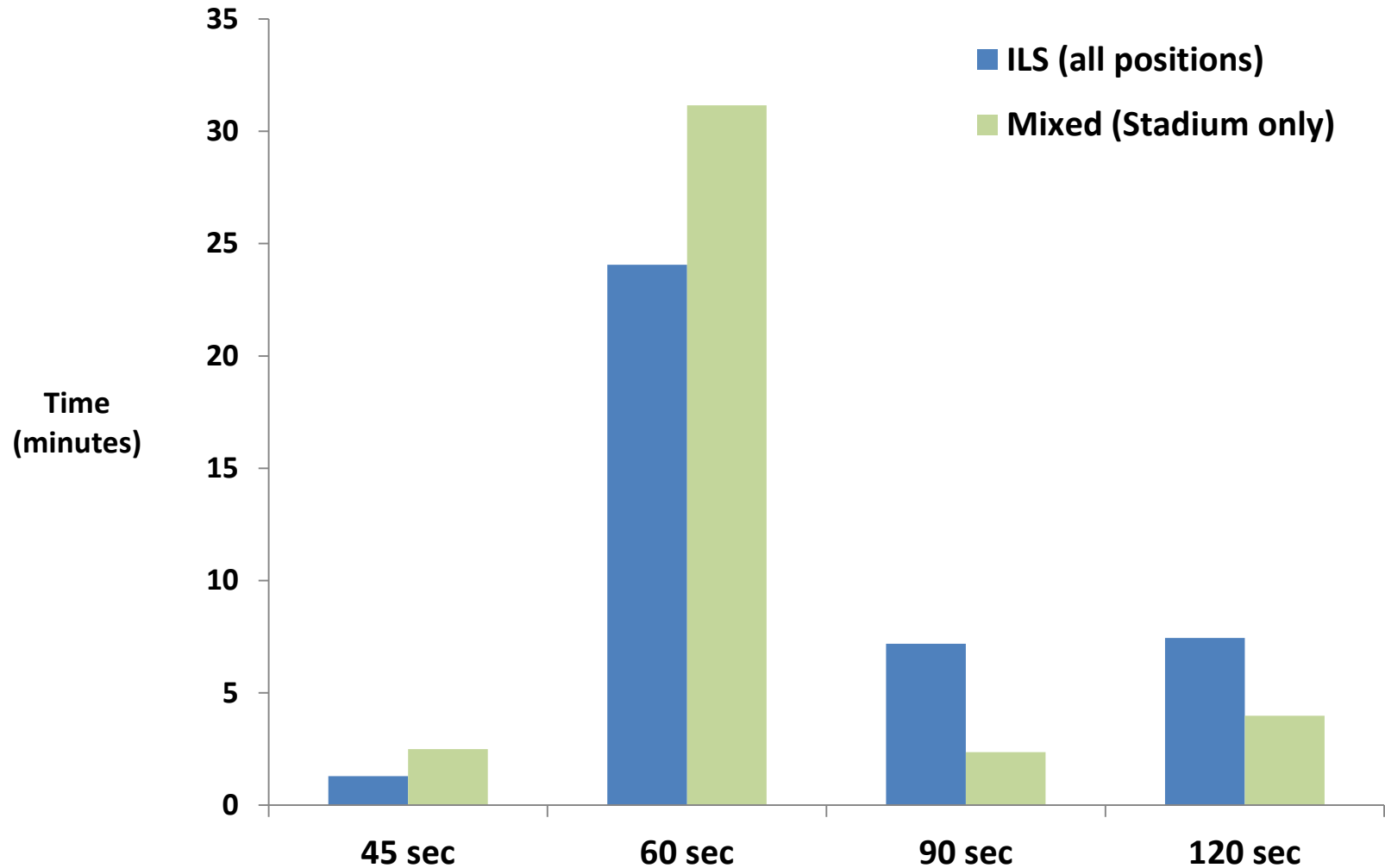
- Compression error
- Cones appear after established on localizer
- Altitude intent has no impact
- Warnings are hard coded at 45 sec and 24 sec to predicted time to LoS
- T-TSAFE compression alerts are suppressed
- Alerts shown for aircraft physically ahead

T-TSAFE Cones

- Loss of Separation
- Cones appear 30 sec before established on localizer
- Altitude entry reduces false alerts
- Warnings are coded as yellow above 45 sec and red below 45 sec as predicted time to LoS
- Only time to LoS is shown in data block
- Alerts are shown for aircraft ahead in the schedule

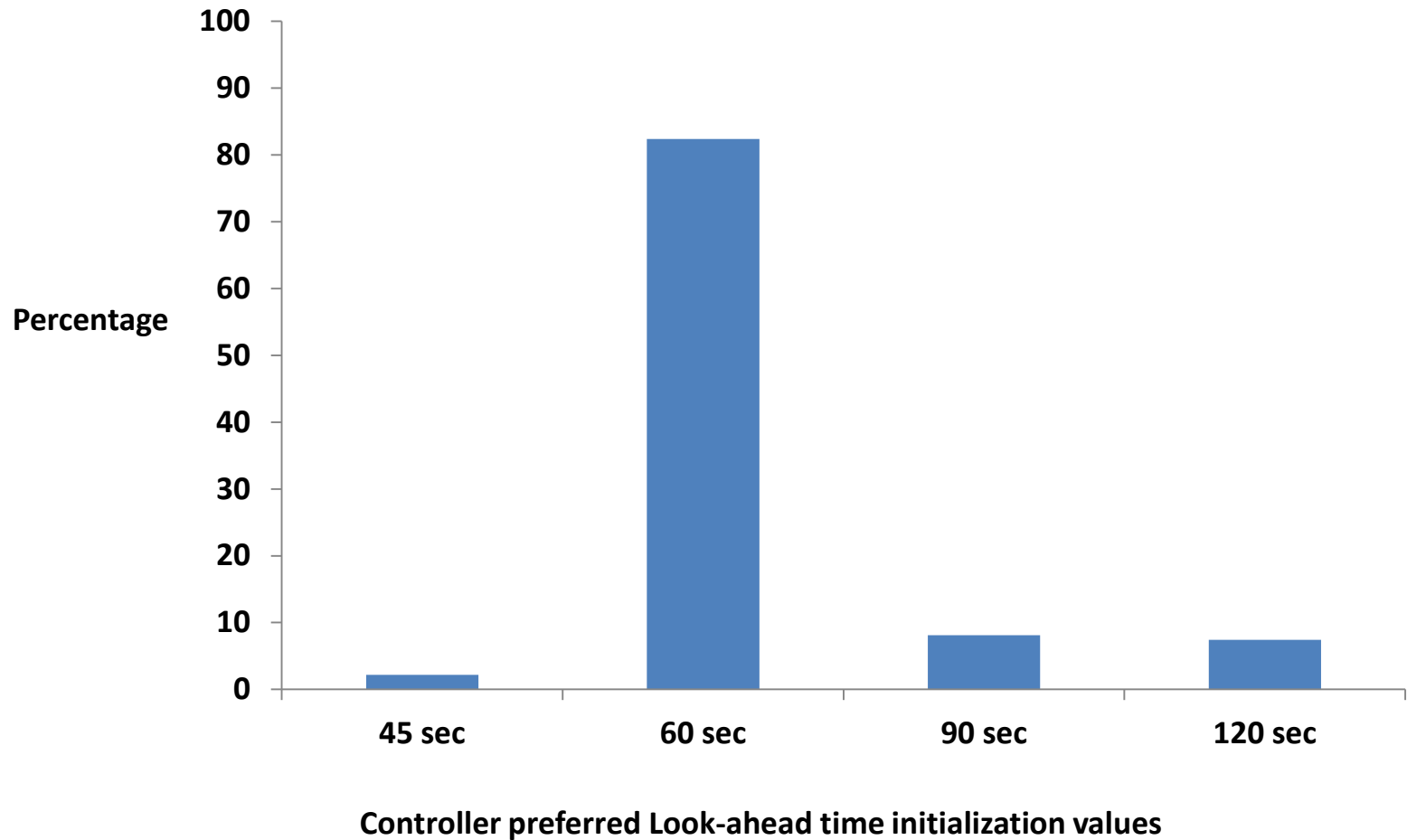


How long did controller select a look-ahead time? (ILS vs. Mixed)





Initial values for look-ahead time



These are usually 60 but sometimes changed by controllers to different values