National Aeronautics and Space Administration

NASAfacts

Terminal TSAFE

Terminal Tactical Separation Assured Flight Environment

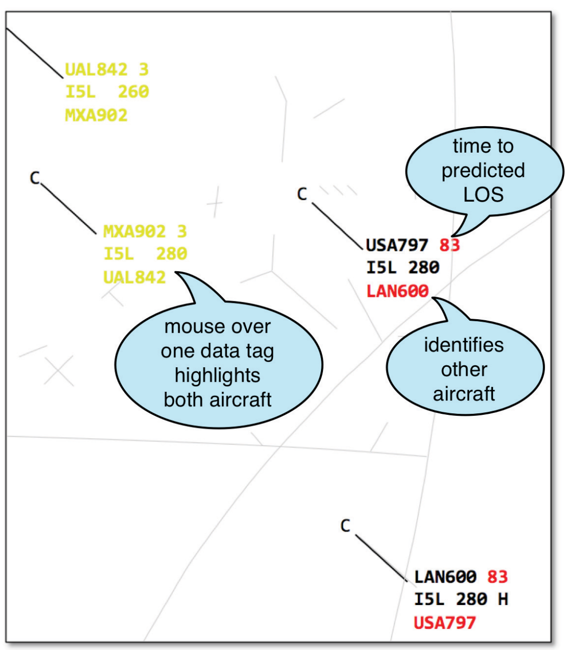
What is the problem?

Aircraft operating within the National Airspace System (NAS), whether carrying people or cargo, attempt to reach their destinations as safely and efficiently as possible. The NAS is controlled by approximately 14,000 air traffic controllers who monitor and detect conflicts and provide direction to pilots to maintain required separation. Separation standards are established to ensure that aircraft maintain a minimum distance from each other to reduce the risk of collision. If the minimum separation between two aircraft is lost, they are said to be in “conflict.” Periods of high traffic density create greater air traffic controller workload, and increase the likelihood that safe separation will not always be achieved. When a conflict occurs due to controller action or inaction, this event is known as an “operational error.” Federal Aviation Administration data have shown a correlation between operational errors and air traffic density. It is extremely rare for operational errors to lead to actual mid-air collisions, but they still pose a significant safety risk. Therefore, before air traffic density increases dramatically as predicted for the future, it is important to understand the nature of operational errors and prevent their occurrence.

Currently, in both en route and terminal airspace, a legacy system called Conflict Alert assists controllers by providing alerts when aircraft are too close to each other (usually much closer than the separation standard). To predict aircraft trajectories, Conflict Alert relies mainly on “dead reckoning,” which uses the current state of aircraft at a given point in time and assumes that it will continue to travel straight ahead and at constant velocity. However, Conflict Alert has some shortcomings: it may not provide enough lead time to enable controllers to resolve the conflict, fail to recognize an impending conflict, or provide a false alert by predicting a conflict that will not happen. False alerts are potentially dangerous because they divert controllers’ attention from other situations requiring their attention elsewhere in the airspace, and may reduce the controllers’ trust in the alerting system. One FAA study found that controllers attend to Conflict Alert only 56% of the time and found 80% of the alerts to be nuisance alerts.

What is the solution?

NASA is working to improve the safety of the nation’s air transportation system by developing new tools and procedures that are intended to replace Conflict Alert, the legacy conflict prediction tool in place today. A promising NASA technology, Tactical Separation Assured Flight Environment (TSAFE), works in the enroute airspace and uses both flight intent information and dead reckoning to calculate trajectories. Based on TSAFE, NASA has developed a tactical conflict detection and resolution tool specifically designed for the complexities of terminal airspace, called ***Terminal Tactical Separation Assured Flight Environment, or Terminal TSAFE (T-TSAFE)***.



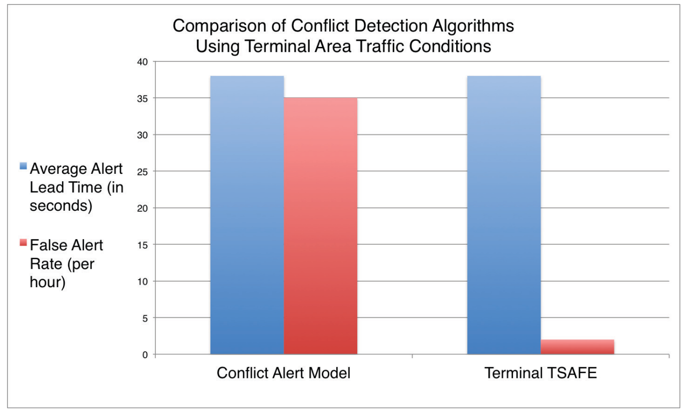
Data tags for T-TSAFE

Terminal airspace surrounds airports within a radius of about 40 miles. Terminal area air traffic controllers guide aircraft as they approach or depart the airport, and must maintain complex legal separation standards, which change based on aircraft weight class, type of approach, visual vs. instrument flight rules, and whether the aircraft is transitioning to or from en route airspace.

Unlike Conflict Alert and En Route TSAFE, Terminal TSAFE uses a single trajectory algorithm based on available flight intent information that includes flight plans, area navigation departure routes, site-specific nominal arrival routes, speed restrictions, and altitude clearances. Terminal TSAFE also includes a refined set of current, dynamic separation standards for terminal airspace to define losses of separation. By combining all of these variables, Terminal TSAFE is able to predict the future positions of aircraft and check them for possible conflicts with significantly fewer false alerts.

A prototype Terminal TSAFE system has been developed that sets up a framework to incorporate different conflict detection and resolution algorithms in a fast-time simulation of aircraft traffic data. The prototype system was used to evaluate the alert lead time and false alert rate performance of the Terminal TSAFE algorithm and a dead reckoning algorithm that models Conflict Alert. Analysis of real-world track data of arrival and departure operations at the Dallas/Fort Worth TRACON (Terminal Radar Approach Control) facility from January 2007 to April 2009 showed that while Terminal TSAFE performs similarly to the Conflict Alert model in terms of alert lead time, it shows significant reduction in the number of false alerts. The new Terminal TSAFE algorithm yielded a false alert rate of two per hour, representing a 94% improvement over the Conflict Alert model.

After substantial fast time analysis and refinement of the conflict prediction and resolution algorithms, the Terminal TSAFE project began a series of human-in-the-loop (HITL) experiments to develop the controller interface, further refine the algorithm, and test the tool with retired controllers from Southern California TRACON. The Phase 1 HITL experiments helped NASA researchers understand how controllers used information supplied by T-TSAFE to prioritize their tasks and easily locate and focus on problem areas. Controllers provided additional intent information to T-TSAFE by entering the altitude commands



Recent studies using real-world track data of arrival and departure operations at the Dallas/Fort Worth terminal approach control facility show that while Terminal TSAFE performs similarly to the Conflict Alert model in terms of alert lead time (blue bars), it shows significant reduction in the number of false alerts (red bars).

via the keyboard. The participants felt T-TSAFE was highly acceptable, easy to use, and ***did not increase workload***. Phase 2 integrated T-TSAFE with Automated Terminal Proximity Alert (ATPA), a tool recently introduced into the field to assist controllers with spacing on final approach. Controllers liked the combined tool set, demonstrating that ***T-TSAFE integrates well with other tools***. The acceptability of controller-entered altitude commands and the usability of T-TSAFE resolutions were improved. Phase 3 used the T-TSAFE algorithm to provide all of the conflict detection, and was used to drive the controller interface usually provided by ATPA. T-TSAFE predicts more types of loss of separation than available with ATPA and its predictions are depicted earlier than ATPA on the controller's screen. This configuration was preferred over the integration of two separate tools (T-TSAFE with ATPA). Visual separation clearances were included in these scenarios, and the applicable rules were added to T-TSAFE. Overall, controllers felt that the tool had great promise.

Future Terminal TSAFE research will involve more extensive testing under different operations such as four parallel runways and will also include detection of conflicts with Mode C Intruder (MCI), which constitute about 60% of alerts with the legacy system, Conflict Alert.

For more information on the Terminal Tactical Separation Assured Flight Environment (Terminal TSAFE), please visit:

www.aviationsystems.arc.nasa.gov.

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