National Aeronautics and Space Administration

NASAfacts

Trajectory-Based Automation System (TBAS)

Ensuring Safety for the Future Airspace System

The primary purposes of the air traffic control system are to keep aircraft safely separated and to minimize delay. This system includes approximately 14,000 air traffic controllers in 3,000 air traffic control facilities across the Nation who are responsible for getting each flight to its destination safely and on time.

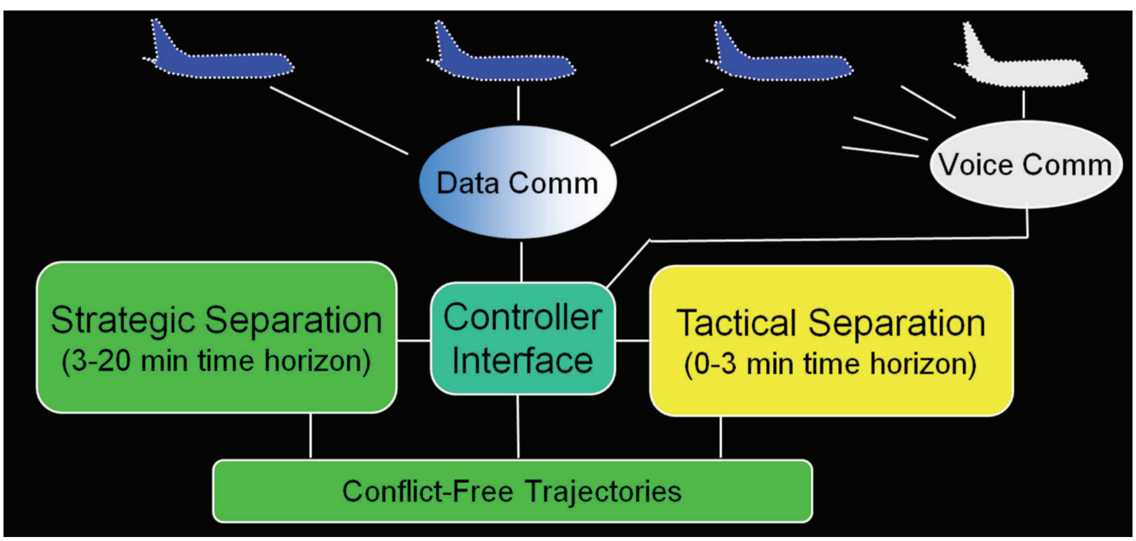
In today's air traffic control system, an air traffic controller maintains safe separation of aircraft in a single sector by visually scanning the controller radar display and looking for potential conflicts. A conflict is defined as a situation where two aircraft come close to violating safe separation criteria. In order to resolve a potential conflict, an air traffic controller provides clearance advisories to the pilot through radio communication.

What is the problem?

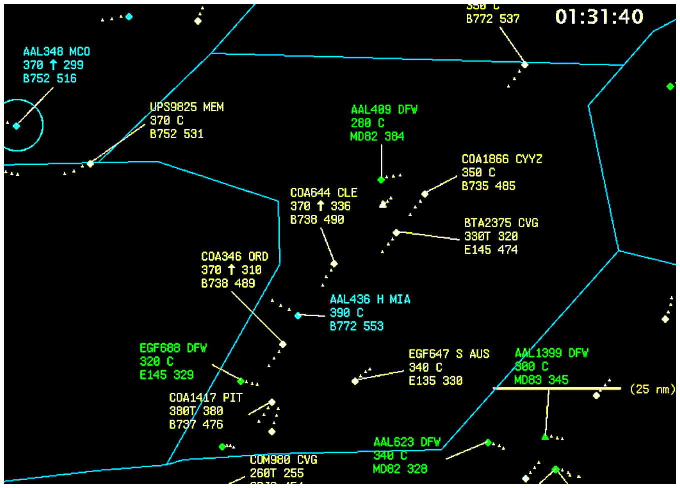
During a typical day, up to 5000 aircraft fly in the National Airspace System at any given time and that number is expected to increase. Air traffic demand is projected to double, or even triple, in the coming 20-25 years and experts don't believe that the current airspace system can support such a substantial increase in air traffic. Several factors limit airspace capacity, including severe weather and high demand at major airports, but overwhelming controller workload is a major concern when it comes to maintaining safety.

What is NASA's solution?

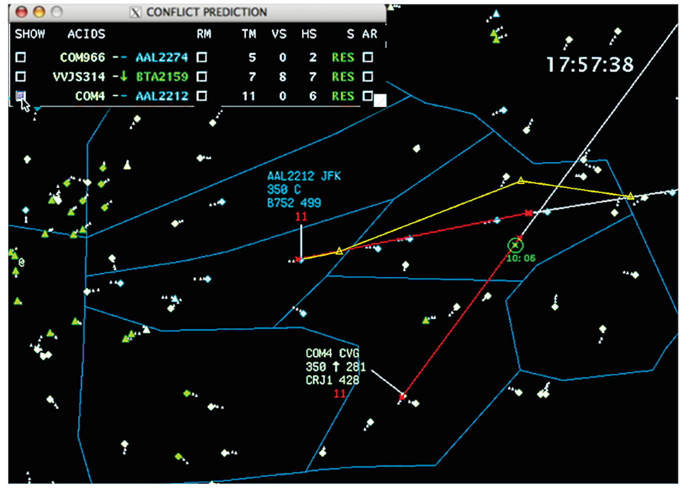
The capacity limitations of today's air traffic control operations and the expected increase in air traffic demand are the primary motivation for NASA's research in trajectory-based automation. NASA is currently developing the ***Trajectory-Based Automation System (or TBAS)***, which will enable an increase in the number of aircraft a controller can safely manage. In addition to visually scanning a radar display for potential conflicts, an air traffic controller will be assisted by TBAS in automatically monitoring the traffic in the area. TBAS detects traffic conflicts and displays them to the controller. Because TBAS supports multiple levels of automation, conflict resolutions may be generated manually by the controller or automatically by the system, and then transmitted to the aircraft using data-link communications. By eliminating some of the manual work that a controller traditionally



The Trajectory-Based Automation System consists of two independent aircraft separation algorithms, strategic and tactical, to ensure safety. Both algorithms depend on a database of conflict-free aircraft trajectories that are communicated to advanced aircraft by data-link communications and to legacy aircraft using radio-based voice communications; the controller coordinates all of this activity.



This screenshot represents a controller radar display very similar to those currently in use by air traffic controllers. Each target on the display represents an aircraft and its flight data block. Under today's system, an air traffic controller is responsible for the aircraft within a single airspace sector's boundary, outlined here in blue. An air traffic controller maintains safe separation by visually scanning the sector looking for potential conflicts.



This screenshot represents a controller radar display using TBAS. Here, TBAS automatically monitors the traffic in a multi-sector area and displays potential conflicts to the controller in a conflict list; the geometry of one of those conflicts is shown in red The automation suggests a resolution of the conflict to the controller, shown as a "trial plan" (in yellow) that the controller can modify if necessary by clicking and dragging the triangular waypoints. The final trajectory change is automatically composed as a data-link message and transmitted to the aircraft for execution with a press of a button by the controller. The reduced workload required to detect, analyze, resolve and communicate the trajectory change increases both airspace capacity and safety.

performs, TBAS allows the controller to manage a larger volume of airspace containing higher densities of aircraft. In addition to identifying and resolving conflicts, TBAS responds to pilot requests for preferred routes and provides support to air traffic controllers for off-nominal situations.

TBAS analyzes the four-dimensional (or 4D) trajectories of aircraft in order to track their flight paths. A 4D trajectory is a prediction of an aircraft's latitude, longitude, and altitude as a function of time. Four key pieces of information are combined in order to generate a 4D flight trajectory for all aircraft in the sky:

- Position and velocity data from radar or GPS
- Filed flight plan information and flight plan updates
- Wind and weather predictions from the National Weather Service
- Aircraft performance models

Once 4D trajectories for all of the aircraft in the airspace have been determined, TBAS can compare the trajectories against each other to identify potential conflicts. When a conflict is detected, it needs to be solved without creating other new conflicts. TBAS dynamically generates a new horizontal or vertical trajectory for one of the conflicting aircraft, tests the new trajectory for conflicts with all other aircraft and repeats the process until an efficient, conflict-free trajectory is found.

NASA conducts human-in-the-loop simulations to test the performance of TBAS in real-world traffic conditions. Various scenarios are tested using actual traffic and flight plan data from the Federal Aviation Administration (FAA). Traffic flow and aircraft separation characteristics are measured during the runs, and then compared to those of today's operations. Past simulation runs included conditions where a single controller maintained safe separation and improved flying time efficiency by up to 5.2% for the combined traffic of five Fort Worth Center sectors under normal traffic levels. Under these simulation conditions, the controller performed the safe separation functions usually performed by 4-10 controllers under today's operations. Simulation results show that the use of TBAS has the potential to help accommodate the growing demand of the air traffic system without sacrificing safety.

For more information on the Trajectory-Based Automation System (TBAS), please visit:

www.aviationsystems.arc.nasa.gov.

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Ames Research Center
Moffett Field, CA 94035
www.aviationsystems.arc.nasa.gov

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