JPDO Paper

Flow Based Trajectory Management Research Transition Team Final Report

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Abstract

In 2007, the National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA), under the coordination of the Joint Planning and Development Office (JPDO), created a Research Transition Team (RTT) to help refine the Flow Based Trajectory Management (FBTM) concept. The primary technical challenge in implementing FBTM is developing an efficient process for managing trajectories of in-flight aircraft in a planning horizon that extends beyond the controller's field-of-view.

As part of this effort, researchers at NASA's Ames Research Center began conducting work in collaboration with the FAA's NextGen Office with funding from both agencies. Specifically, the researchers implemented two major human-in-the-loop simulations, which simulated operations at FAA en route centers with participation by air traffic controllers, traffic managers, and supervisors. Results showed that the FBTM is not only feasible, but it is also useful and beneficial. Most notably, it can support NextGen initiatives toward perspective "best-equipped, best-served" operations that would create incentives for operators to equip their aircraft to take advantage of NextGen capabilities.

The following paper outlines the methods of the RTT's research, its results, and lessons learned, all of which were discussed at a July 14, 2011 close-out meeting conducted by NASA, FAA, and JPDO executives.

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Flow Based Trajectory Management (FBTM) is a major component of the Next Generation Air Transportation System (NextGen) and part of a larger plan to integrate and facilitate seamless trajectory management among the major National Airspace System (NAS) automation functions. It is related to multiple Operational Improvements (OIs), which are increments for the NextGen Segment Implementation Plan (NSIP).

Current methods for traffic flow management (TFM) solutions are too cumbersome to be practical for in-flight trajectory changes within a 30- to 90-minute event horizon. Specifically, the sector controller's field-of-view is too limited to modify aircraft trajectories that satisfy all downstream constraints. FBTM, therefore, is designed to manage end-to-end trajectories from the early stages of flight planning until the time a flight reaches the gate at the destination airport. It bridges the gap between the strategic flow contingency management FBTM functions that manage demand for NAS resources and the tactical separation management functions. Additionally, FBTM is a process that uses tools and procedures to develop and coordinate trajectory clearances that span multiple sectors, meet traffic management objectives, and provide user benefits. In its simplest form, it modifies aircraft trajectories in flight to reduce airspace complexity and increase capacity.

The primary technical challenge in implementing FBTM is developing an efficient process for managing trajectories of in-flight aircraft in a planning horizon that extends beyond the controller's field-of-view. The concept has evolved through a series of studies beginning with a Multi-Sector Planner (MSP) position supporting radar controllers, to MSP operations for local-area flow management, to a FBTM concept now under review by the FAA. The ultimate objective is to create an efficient method for development, coordination, and execution of trajectory clearances that meet TFM objectives and provide user benefit in the NextGen mid-term timeframe.

MSP FBTM operations can be incorporated into existing air traffic team configurations with additional tools. Integrated capabilities for situation assessment, multi-trajectory planning, and coordination are key to successful planner and controller operations. In a mixed equipage environment, FBTM operations can provide a "best-equipped, best-served" policy, offering user benefits, increased throughput, and reduced controller workload.

Trajectory-Based Operations (TBO)—four-dimensional trajectories that enable controllers to know both current and future positions of an aircraft—are a major component of NextGen. For integrating TBO in the near-term, controllers can execute trajectory clearances sent from another station if coordination, evaluation decision-support tools, and clearances make sense from the controller's perspective. Reroute clearances may be sent directly to the aircraft if there is no impact on the current controller.

Simulations to Expand Airspace Capacity

For its research, the RTT team—a structure initiated by the National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA), under the auspices of the Joint Planning and Development Office (JPDO)—conducted a series of human-in-the-loop simulations to identify the actors, responsibilities, methods, and automation tools that would be required to best perform TBO. A method for in-flight FBTM was developed and tested in simulation. This method can be integrated successfully within today's facility team structure. With integrated tools and procedures, it will be possible to successfully manage traffic levels 30 percent greater than today. Procedures support a best-equipped, best-served policy that rewards early adopters with little–to-no impact on unequipped flights. Planned operations are suitable for data communications equipped and unequipped aircraft.

The MSP FBTM research incorporated a number of important features:

- Traffic managers, area supervisors, and air traffic controllers had access to integrated automation support and procedures to plan, coordinate, and enact new aircraft trajectories via automation for in-flight aircraft.
- A complexity-prediction metric was used, instead of simple aircraft count, to successfully predict and manage controller workload in real time.
- Traffic load predictions were integrated with multi-aircraft trajectory planning to support "what if" impact assessment.
- An interactive display with dynamic user-defined filters for traffic situation assessment in the context of weather and sector complexities was tested and improved in a series of simulations.
- Effective traffic management procedures were demonstrated to support a best-equipped, best-served policy that rewards early adopters with little-to-no impact on unequipped flights.
- Tools and procedures enabled controllers to easily issue reroutes for unequipped aircraft that were created on a different position (Traffic Management Unit, supervisor, or other controller).

Post-run and post-simulation data showed the mixed equipage concept to be acceptable, with tools for trajectory coordination effectively used by all positions.

Improvements in Traffic Flow Management

The simulations produced several notable improvements in TFM methods for addressing en-route issues related to congestion and severe weather in the NAS:

- Reductions in delay from removing the impacts of two Airspace Flow Programs (AFPs) on a severe weather day were on the order of 88 percent to 94 percent.
- Average delay to flights dropped from between 24 and 37 minutes per flight to between 2.2 and 2.8 minutes, respectively.
- Airborne reroutes with medium-term conflict detection (MTCD) resulted in 18 of the 20 upper airspace en route centers showing a net decrease in conflicts.
- Average conflict durations were lower in the MSP scenario.

- Allowing flights to depart as scheduled, then using the load balancing capabilities, reduced the number of overloaded periods.
- Approximately one-third of the 3,000 reroutes produced a solution with a shorter overall distance (averaging 11.2 nm in savings per flight).

Although more flights received path extensions due to reroutes, the cumulative increase in total distance flown for all rerouted flights represented less than 0.05 percent of the total distance flown for the entire flight set. Changes to airspace complexity scores demonstrated an increased ability to redistribute traffic while reducing the rigidity that is sometimes inherent within flight paths as part of a more strategic TFM plan.

The consensus of the July 14, 2011 meeting participants was that the FBTM RTT proved valuable in garnering joint agency management support for additional research, which will prioritize resources for the FAA and NASA.

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Document Revision History

VERSION	DATE	DESCRIPTION
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