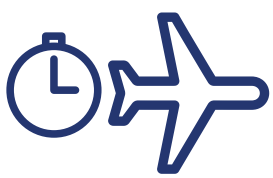
TBO Single Flight Perspective

Trajectory-Based Operations (TBO) is an air traffic management (ATM) concept that enhances strategic planning to reduce capacity-to-demand imbalances in the National Airspace System (NAS) and provides tools to air traffic management personnel and controllers to help expedite traffic flows. The core tenant of TBO is the aircraft trajectory, which is defined in four dimensions: Latitude, Longitude, Altitude and Time. The trajectory represents a common reference for where an aircraft is expected to be and when. The trajectory is defined prior to departure, updated in response to emerging conditions and operator inputs, and shared between stakeholders and systems. The aggregate set of aircraft trajectories on the day-of-operation defines demand and informs traffic management actions.

The key elements of TBO include:



Time Based Management (TBM), which helps manage traffic flows and trajectories by scheduling and metering aircraft through congested NAS resources or constraint points.

Performance Based Navigation (PBN), which enables aircraft to more accurately navigate along their trajectories and enables decision support tools to improve feasibility of schedules for constraint points as well as achieve greater compliance to schedules.

Enabling Technologies, which expand and automate sharing of common information about aircraft trajectories and include System-wide Information Management (SWIM), Data Communications, enhanced data exchange and many others.

The FAA is delivering decision support for TBO through evolving enhancements and integration of two legacy and one new automation platforms: Traffic Flow Management System (TFMS), Time-based Flow Management (TBFM), and Terminal Flow Data Management (TFDM). Also known as the three T's, these systems help strengthen strategic planning and resolution of capacity-to-demand imbalances throughout the day-of operation.

This handout will walk you through the phases of a single flight in the TBO environment.

TBO Environment from a Single Flight Perspective

Pre-departure Planning

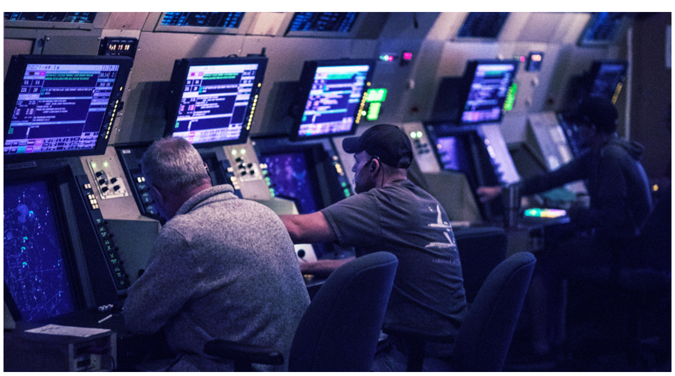
1. Long before a flight departs, the FAA flight operator begin a continuous exchange of real-time information establishing common situation awareness among stakeholders (webinars and telecons every two hours and web-based information exchange).

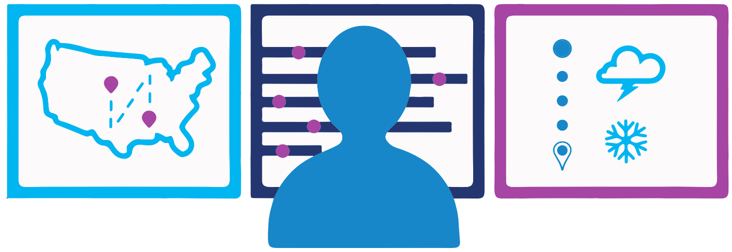
2. The FAA adjusts its traffic flow management strategies, and the operator adjusts the flight plan based on ever-changing conditions in the NAS (decision making process).

Departure Scheduling

1. Upon receipt of the flight plan from ERAM, TBFM becomes aware of the flight and places the aircraft on the departure timeline (between approximately two hours and thirty minutes before planned gate departure).

2. Shortly before the aircraft is ready to enter movement area, the pilot contacts the Air Traffic Control Tower. Based on the filed route and known constraints along that route, automation determines a departure release time that is synchronized with the time the aircraft is expected to fly through an applicable constraint point on its way to destination. When needed, the Tower controller manually adjusts this time.





3. In facilities without automated departure scheduling capabilities, the Tower controller coordinates with En Route traffic management personnel to determine departure release time based on manual, rough estimates of aircraft movement.

4. On demand and unscheduled business and recreational travel may experience additional departure delay until the flight can be absorbed into broader schedule of traffic operations.

5. Short flights and aircraft that depart from airports close to center boundaries can be difficult to integrate into already established busy overhead streams. Current uncertainties in their readiness to depart at a planned time creates significant challenges in balancing airport demand and capacity. The FAA is aware of the challenge and looking for additional support opportunities.

6. TDFM deployment provides more proactive approach because the earliest off-block time will be available to automatically schedule the departure release time prior to push-back. The resulting departure release and movement area entry times will be shared via System Wide Information Management (SWIM) along with the ETAs to the destination airport.

Surface Management

1. After confirming departure release time, the ATC can issue clearances to guide the aircraft from its gate to its take-off runway in a timely manner.

2. Through deployment of TFDM at the nation's busiest airports, new tools will be available to ATC Tower personnel to help with management of airport resources, including gates, runway queues, and runways. In response to expected demand and operating conditions, these tools will support departure queue management concurrently with proactive balancing of runway use for departures, arrivals, or mixed operations.

3. Airports without new TFDM tools and services will continue the same practices as done today.

4. Operators who invested in enhanced information sharing and electronic coordination will be able to proactively participate in decision-making that affects their responses to unanticipated events, fuel-loading, gate management, and arrival/departure coordination.

5. At airports providing Tower Controller-Pilot Data Link Communications (CPDLC), operators of aircraft equipped with CPDLC have an important advantage in situations when rerouting and taxi clearances need to be issued prior to take-off. Not only are such complex clearances easier to deliver in digital form, but they are delivered faster and with fewer misunderstandings compared to the same instruction issued via voice, leading to a reduction in voice-frequency congestion and pilot and controller workload. Prior to departure, CPDLC equipped aircraft can get an earlier start than its non-equipped contemporaries and may even be able to assume an earlier spot in departure queue. Non-CPDLC equipped aircraft will continue the same practices as done today.

Airborne metering

1. As aircraft takes-off and progresses on its route to the destination, it is actively monitored by the ATC of the facility it is traversing, as well as supervised by traffic management and ATCSCC personnel. Operators who invested in enhanced data exchange with the FAA can also monitor flights from their flight operations center (FOC), as well as weather development and the status of NAS resources of relevance to their flights.

2. TBFM automation monitors the flight and calculates whether any adjustments in the aircraft's trajectory need to be enforced in the current facility for the flight to arrive at the next constraint point at its scheduled time. In facilities with active metering, controllers can see aircraft sequence through the constraint points they manage on their scopes; if the active controller modifies aircraft trajectory, automation updates the flight's data-block accordingly, ERAM forwards the update to TBFM and other automation systems, and stakeholders receive it via SWIM.

3. Arrival metering is used within the arrival center to sequence aircraft into destination terminal airspace according to the applicable operating conditions, arrival runway capacity and spacing requirements. More advanced airborne metering tools expand the distance from destination over which aircraft are actively metered to enable improved compliance through arrival meter fixes and arcs. With adjacent center metering capability, the TBFM system becomes aware of the aircraft before it enters the arrival center, which enables metering to start in the adjacent centers. With the advanced Extended Metering (XM) capability, airborne metering can be expanded even further away from the destination and divided between multiple subsequent facilities too.

4. Terminal Sequencing and Spacing (TSAS) algorithms estimate aircraft times to the arrival runway based on adapted route and aircraft capabilities as reflected in the flight plan. They also account for differences between conventional and PBN approach procedures to the same runway.

5. TSAS displays runway assignment for the individual aircraft and flight sequence to that runway, leading to a shared understanding of TBFM schedules for En Route and TRACON controllers. To preserve overall efficiency however, opportunities to make tactical adjustments for individual flights will be reduced.

6. Terminal areas without TSAS will continue the same practices as done today.

Summary

A. **Synergy between TBM and PBN creates more feasible time-based schedules to which aircraft adhere with higher compliance, and increases utilization of PBN procedures and routes.**

B. **The TBO environment provides a strategic plan for the single flights from the time its flight plan is filed all the way to the arrival runway and relative to other aircraft through the same constraint points on its route to destination.**

C. **TBO improves predictability, but does not remove all uncertainties**

D. **TBO is deployed through a gradual increase in capabilities and integration over time, and as needed to address both local and NAS traffic flow management needs**

E. **TBO requires significant improvements in infrastructure and automation, including integration across systems, domains and stakeholders**

F. **Aircraft equipage is not required, but will increase benefit opportunities**

TBO facilitates strategic and collaborative approaches to managing demand-to-capacity imbalances in the National Airspace System, allowing for more predictable, efficient and flexible operations for its users.

To find out more contact **9-AJT-TBO@faa.org**

FAA Air Traffic Organization