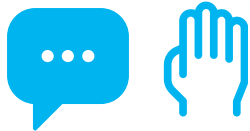# Audience Participation

Q&A sessions at the end of presentation and during Wrap Up

- Please ensure that your microphones are muted until you are called on during the designated time allotted for questions

- There are multiple ways to ask a question:
  - **Submit your question via email 9-AJT-TBO@faa.gov**
  - Submit your question via chat
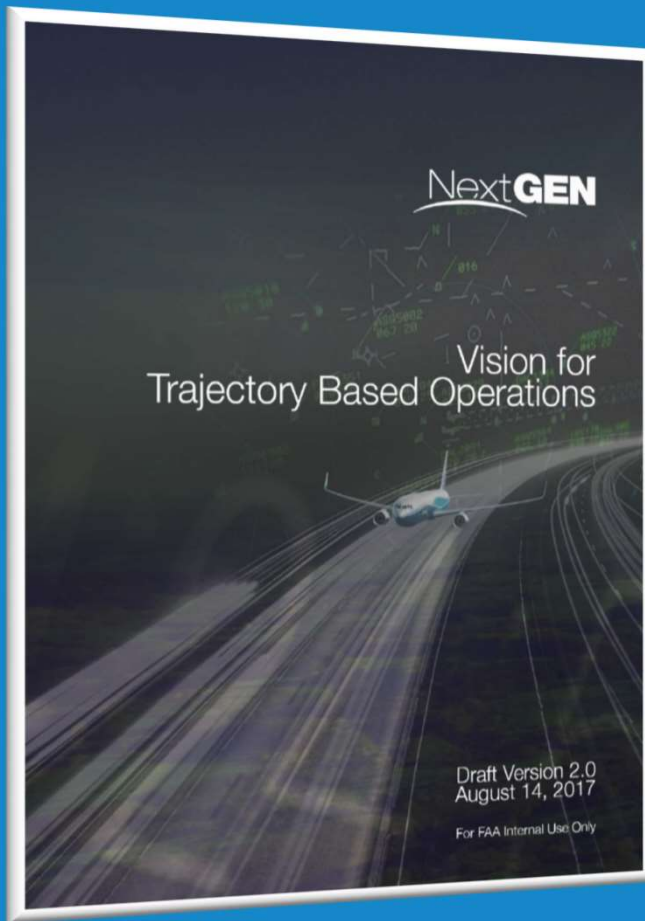 - Raise your hand to alert the moderator

Session One

Overview of Trajectory Based Operations

Michele Merkle, Air Traffic Services
Jeff Woods, National Air Traffic Controllers Association

What is TBO?

…an ATM method for strategically planning and managing flights throughout the operation by using time-based management (TBM), enhanced information exchange between air and ground systems, and advanced performance based navigation capabilities onboard aircraft.

What is the Scope of TBO?

**The FAA is fielding and integrating TBO technologies
to enhance strategic planning and management of NAS operations**
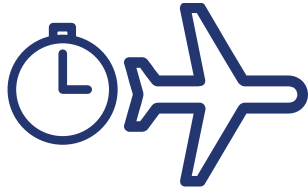
Time-Based Management (TBM)

Departure Scheduling
Arrival Metering
Terminal Metering
Surface Metering
… and more

*Helps Manage Trajectories by
Scheduling and Metering Aircraft
Through Constraint Points*

Performance Based Navigation (PBN)

Area Navigation (RNAV)
Required Navigation Performance (RNP)
STARs, SIDs, IAP and routes
…and more

*Enables Aircraft to More
Accurately Navigate Along
Their Trajectories*

Enabling Technologies

System-Wide Information Management (SWIM)
Enhanced Data Exchange
DataComm
Advanced Weather Products
Airborne Rerouting
…and more

*Expands and Automates
Sharing of Common Information
About Aircraft Trajectories*

- ✘ **A Single Program**
- ✘ **Full Automation**
- ✘ **Time-Based Separation**
- ✘ **Pilot-Controlled**
- ✘ **Rigid**

TBO is a collection of systems, capabilities, processes,
and people working together to achieve operational objectives

Why is the Trajectory Important?

TBO is about predicting and managing <u>where</u> a flight will be and at <u>what time</u>.

- A trajectory is defined in four dimensions: Latitude, Longitude, Altitude, and Time

- A planned aircraft trajectory is used as a reference for the flight and shared between systems and stakeholders

- The aircraft trajectory is updated as new information becomes available

- The aggregate set of aircraft trajectories defines demand, and informs traffic management actions and updates to the day-of operation plan

Synergy between TBM and PBN

TBM complements PBN by improving the predictability of where aircraft will be and at what time, resulting in reduced need for ATC intervention to assure safe merging and spacing, and in *increased utilization of PBN procedures and routes*.

TBM enables more accurate scheduling and metering of aircraft between their origin and destination airports.

PBN enables aircraft to more accurately navigate along their trajectories.

PBN complements TBM by providing a network of routes and procedures that helps create more feasible schedules for constraint points to which aircraft adhere with higher compliance, resulting in *improved predictability of operations*.

TBO works best when PBN and TBM complement each other. PBN aircraft equipage is encouraged but not required.

Key Elements of TBO

Trajectory Based Operations (TBO) provides a suite of capabilities which enhance strategic planning of traffic flows, and provides tools to traffic management personnel and air traffic controllers to improve management of flights via use of 4D trajectories

Increased Data Sharing and Collaboration

Ensures all systems and shareholders have a common understanding of trajectories and flight status information

Predominant Use of Time-Based Management (TBM)

Schedules and meters aircraft through key constraint points when needed. Integrates traffic management across systems, traffic flows, facilities, and domains.

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.

Complimentary Use of TBM and Conventional Traffic Management Initiatives (TMIs)

Addresses large imbalances between capacity and demand through flexible use of conventional TMIs

Improved Decision Support Tools

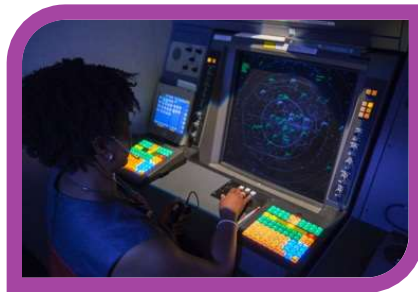Supports NAS-wide capacity-to-demand management with flexible adaptation and use based on the local needs and constraints

TBO will not change basic roles and responsibilities, but the way those jobs are done may change

Air Traffic Control ⟷ **Air Crews**
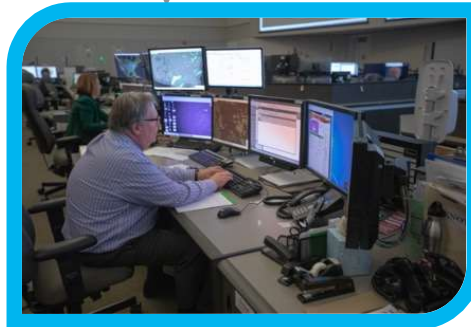
Traffic Flow Management ⟷ **Planning and Dispatch**

What are we trying to improve?

Throughput

Predictability

Flight Efficiency

Operator Flexibility
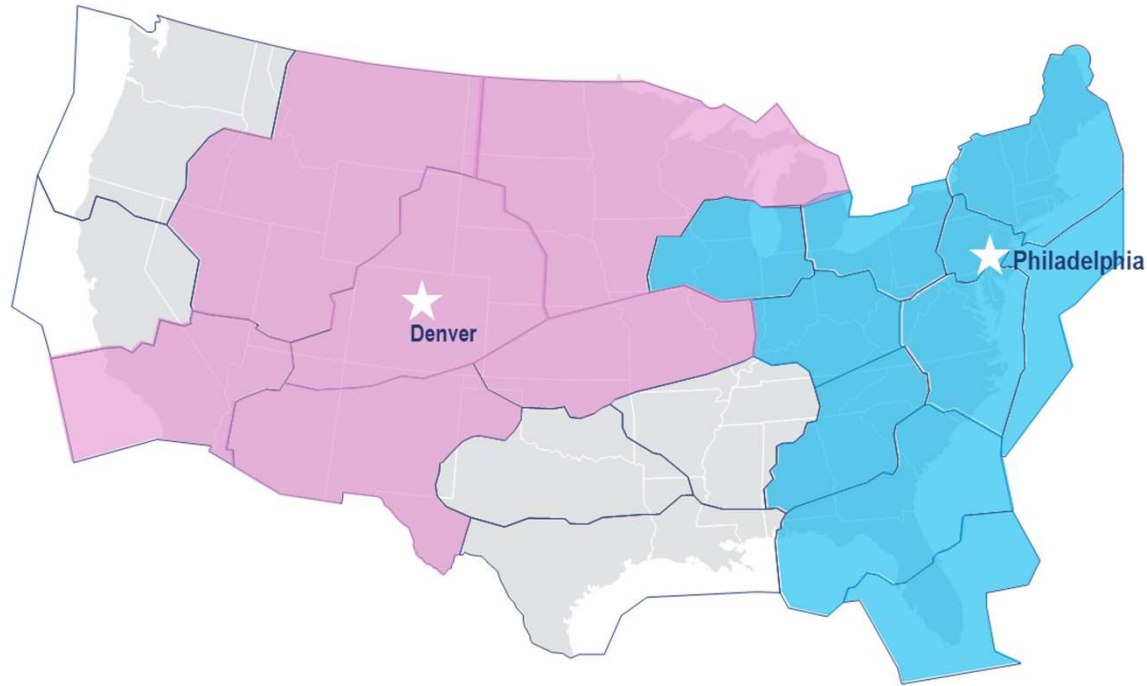
On-going Deployments and Planning Activities for Four Operating Areas

Far-reaching, Cross-facility and Multi-domain Integration

Right Tools at the Right Place Actively used at the Right Time

Transformation is already underway and affecting facilities beyond focal TRACONs for each operating area.

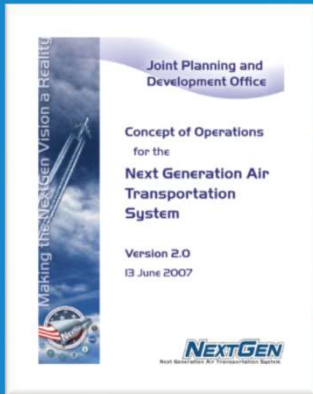| Air Traffic Operations				NextGen
Air Traffic Service (AJT)	**System Operations (AJR)**	**Program Management Organization (AJM)**	**Mission Support Services (AJV)**	**NAS Systems Engineering and Integration (ANG)**
• *Facilitates the integration of TBO capabilities and emerging technologies into the NAS*	• *Responsible for optimizing the overall efficiency of the NAS and coordinating NAS-wide operations on a day-to-day basis*	• *Maintains systems that support tactical operations and develops new automation capabilities*	• *Develops, revises, and implements procedures to improve ATC and airspace and efficiency* • *Oversees the alignment of new technological and operational efforts with current and anticipated operational needs*	• *Architects the evolution of the NAS and provides systems engineering leadership*

Session Two

TBO Evolution

Cynthia Morris, Office of NextGen

Trajectory Based Operations (TBO)

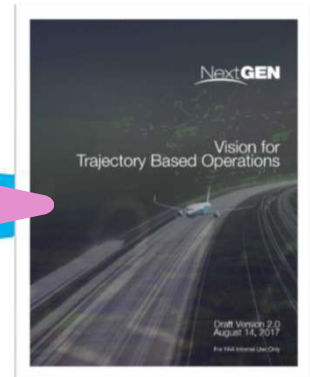Has Always Been The Target of NextGen

SOLUTION SPACE

RESEARCH

2007   2011   2016   2017

TBO Evolution

(We are Here)

Infrastructure	Initial	Full	Dynamic
Deployed the foundational automation, surveillance, weather, information and data exchange infrastructure to support TBO enabling capabilities and products	Initial TBO capabilities are being deployed for use domain by domain with integration of the capabilities left to the human operator	Full TBO capabilities delivered to all domains providing the ability to automate the integration of time-based management data and tools in order to greatly improve strategic planning and execution	Dynamic TBO capabilities will use advanced aircraft and ground automation to enable flight-specific time-based solutions for reroutes and aircraft sequencing and advanced aircraft-based pairwise trajectory solutions. Information will be integrated and shared to further improve NAS operations
Common Framework for Collaboration, Operations, and Performance Based Navigation	**Capabilities for integrated arrival and departure operations**	**Integrated Automation Capabilities for advanced trajectory management**	**Advancing Individual Aircraft Solutions**

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Note: Implementation timeframes are in flux due to COVID impacts. Deployment decisions on future capabilities will depend on research results, shortfalls that remain after initial implementation and other constraints such as budget, workforce training and sustainment needs.

Key Capabilities by Theme

Infrastructure	Integrated Arrivals	Integrated Departures	Advanced Trajectory Management	Dynamic Applications
✓ En Route & Terminal Automation ✓ TBFM ✓ TFMS ✓ SWIM ✓ AIMM ✓ Data Communications ✓ ADS-B ✓ PBN/Metroplex o TFDM o CSS-Wx/NWP	✓ Arrival Metering ✓ Extended Metering ✓ RNAV STARS ✓ RNP/RNP with RF ✓ Established on RNP o Terminal Metering ❖ Path Stretch ❖ Enhanced Time-Based Arrival Metering ❖ Improved Metering in Off-Nominal Conditions	✓ Time based Departure Management ✓ Departure Clearances Via Data Comm ✓ Pre-Departure Reroutes ✓ RNAV SIDs o Automated surface management including surface metering o Improved departure planning ❖ Improved Departure Operations Using Mobile Applications ❖ Multiple Airport Route Separation	✓ Controller Pilot Data Link Communications o Additional Data Comm Services ✓ Route Availability planning ❖ Improved Strategic Flight Planning ❖ Improved Strategic Flow Management ❖ Airborne Flight Negotiation	❖ ADS-B In enabled spacing applications ❖ Dynamic Wake Separation ❖ Dynamic RNP ❖ 4D Trajectory Management

✓ = Operationally Available in at least one location

o = In Acquisition

❖ = Planned or In Research

Note: Deployment decisions on future capabilities will be depend on research results, shortfalls that remain after initial implementation and other constraints such as budget, workforce training and sustainment needs.

Session Three

Implementation Strategy

Wendy O'Connor, Air Traffic Services
Phil Hargarten, National Air Traffic Controllers Association

What is Needed for TBO?

Integrated Use of new and existing capabilities on the ground and in the aircraft

Change Management effectively incorporating the people component

Integrated Approach to implementation

Results in

Flight Efficiency ✈ **Predictability** ✈ **Throughput** ✈ **Flexibility**

Synergy between TBM and PBN

TBM complements PBN by improving the predictability of where aircraft will be and at what time, resulting in reduced need for ATC intervention to assure safe merging and spacing, and in *increased utilization of PBN procedures and routes*.

TBM enables more accurate scheduling and metering of aircraft between their origin and destination airports.

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TBO works best when PBN and TBM complement each other. PBN aircraft equipage is encouraged but not required.

What is the Initial Geographic Scope of TBO?
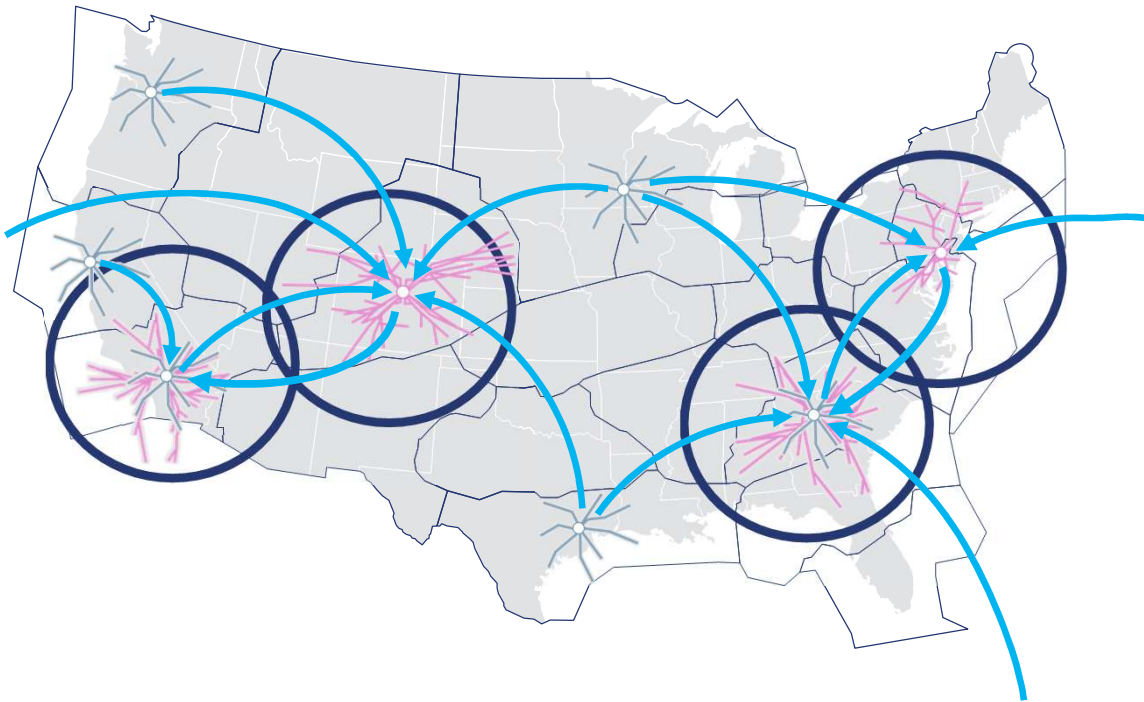
On-going Deployments and Planning Activities for Four Operating Areas

Far-reaching, Cross-facility and Multi-domain Integration

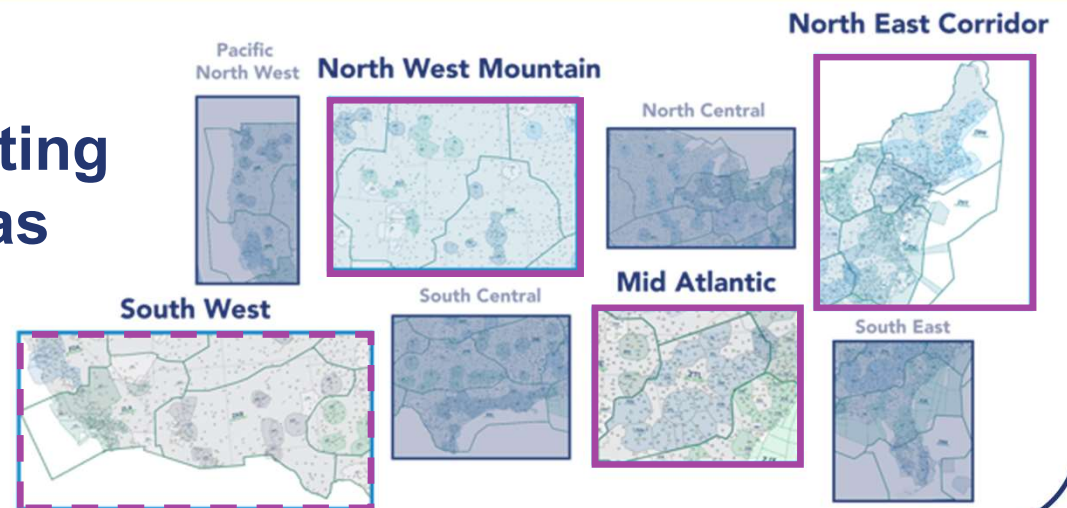**Right Tools at the Right Place**
Actively used at the Right Time

Geographically-based

- Areas reflect logical and inter-dependent TBM and PBN operational relationships
- Operational geographic scope is flexible and not necessarily aligned with existing airspace or organizational boundaries

Operating Areas

Pacific North West · North West Mountain · North Central · North East Corridor · South West · South Central · Mid Atlantic · South East

Holistic

- Cross-facility focused for NAS wide benefits
- Integrated, incremental and systematic deployment

Opportunity-driven

- Based on operational readiness, benefit opportunities, and anticipated costs and risks

Supportive

- Sustained communication, training, and technical support
- Planning and execution will be collaborative

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- *Aircraft Trajectory.* Defines *where* an aircraft is expected to be and *when*; it is defined in four dimensions: Latitude, Longitude, Altitude, and Time.
  - The trajectory is predicted using the flight plan and other operator provided information as well as navigation procedures and weather forecast information.
  - Some trajectory information is shared between systems and stakeholders to better align trajectory predictions across systems.

- *Constraint Point.* A NAS resource where demand may exceed capacity or where merging of traffic flows occurs. The resource may be a runway, a predetermined fix or arc, or airspace. The constraint can be managed by scheduling and metering of aircraft.

- *Meter Fix.* Constraint point on the TRACON boundary used for arrival metering.

- *Scheduling.* A function that creates a timed sequence of aircraft through a constraint point, with intervals between successive aircraft consistent with desired spacing and other parameters.

- *Metering.* A function that supports accurate execution of a time-based schedule. Controllers have decision support tools to help them manage aircraft trajectories to reliably execute time-based schedules.

Constraint Points
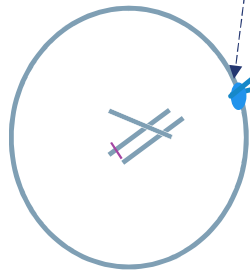
ARTCC 2

ARTCC 1

How it works

- Schedules departures into an en route or arrival flow
- Calculates departure release time for a time-based schedule
- Can be used with used airborne metering or MIT restrictions
- Can be coordinated between tower and ARTCC via voice or electronically with IDAC

Benefit Mechanism

- Improves merging of departures with airborne traffic
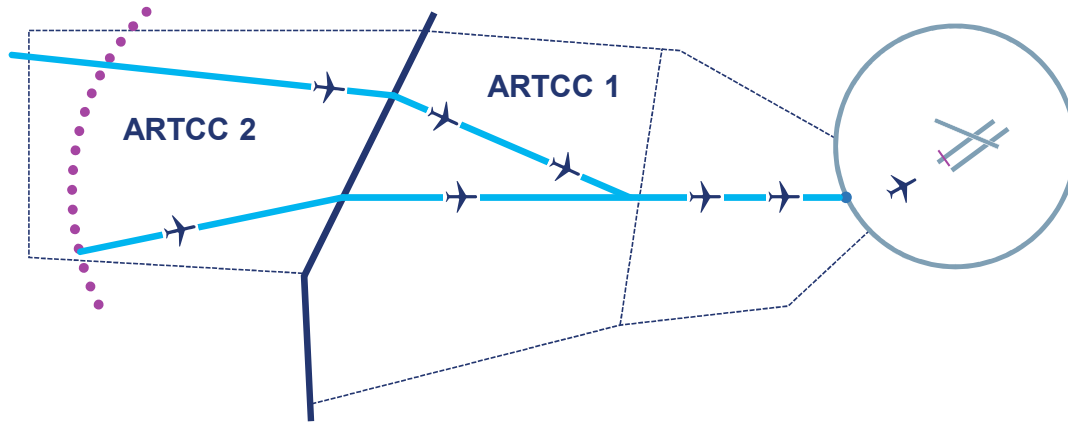- Reduces vectoring and other maneuvers
- Re-distributes delay to the ground

Currently in use in every ARTCC for constrained flows

TBFM: Arrival Metering

ARTCC 2

ARTCC 1

As of Feb 2020, in regular use for ATL, CLT, IAH, HOU, DFW, MSP, LAX, DEN, SEA, SAN, PHX, SFO and SLC. Planned PHL (2022), EWR (2023)

How it works

- Provides en route controllers decision support tools to manage time-based schedule for airborne flights destined to a specific arrival airport.

- Can be complimented by Adjacent Center Metering (ACM) which allows TBFM to exchange trajectory information with upstream automation

Benefit Mechanism

- Improves merging of traffic flows on entry to terminal area

- Re-distributes airborne delay over greater distances at higher altitudes

- Reduces holding at low altitude

- Reduces reliance on static MIT restrictions

All implementation dates subject to change due to COVID impacts, budget, sustainment needs, workforce training, and other constraints

How Arrival Metering Works

What the automation does

- Estimates the time of aircraft arrival to the meter arc based on the flight plan, aircraft performance characteristics, wind forecasts, and local adaption

- Determines the earliest time and position of this aircraft in the schedule at the constraint point on the TRACON boundary and at the runway

- Schedules the aircraft into metering line by accounting for the applicable spacing based on traffic manager inputs

- When the aircraft crosses the freeze horizon, determines any delays that may need to be absorbed en route to the TRACON

What the controller does

- Determines how to absorb any calculated delays and ensure that aircraft cross the constraint point at their scheduled time

- Traffic management personnel can manually adjust time-based schedules when needed

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TBFM: Extended Metering (XM)

LEGEND
- DEN MFs — 1st Tier XM Arc
- DEN MF FH — 1st Tier XM FH

ZLC will meter via XM

ZDV will meter over MFs

ZMP will meter via XM

ZKC will meter via XM

ZLA will schedule departures off LAS and SGU

ZAB will meter via XM into SE Gate; schedule departures into SW Gate

Currently in active use for DEN arrivals.
Planed for PHL (2022)
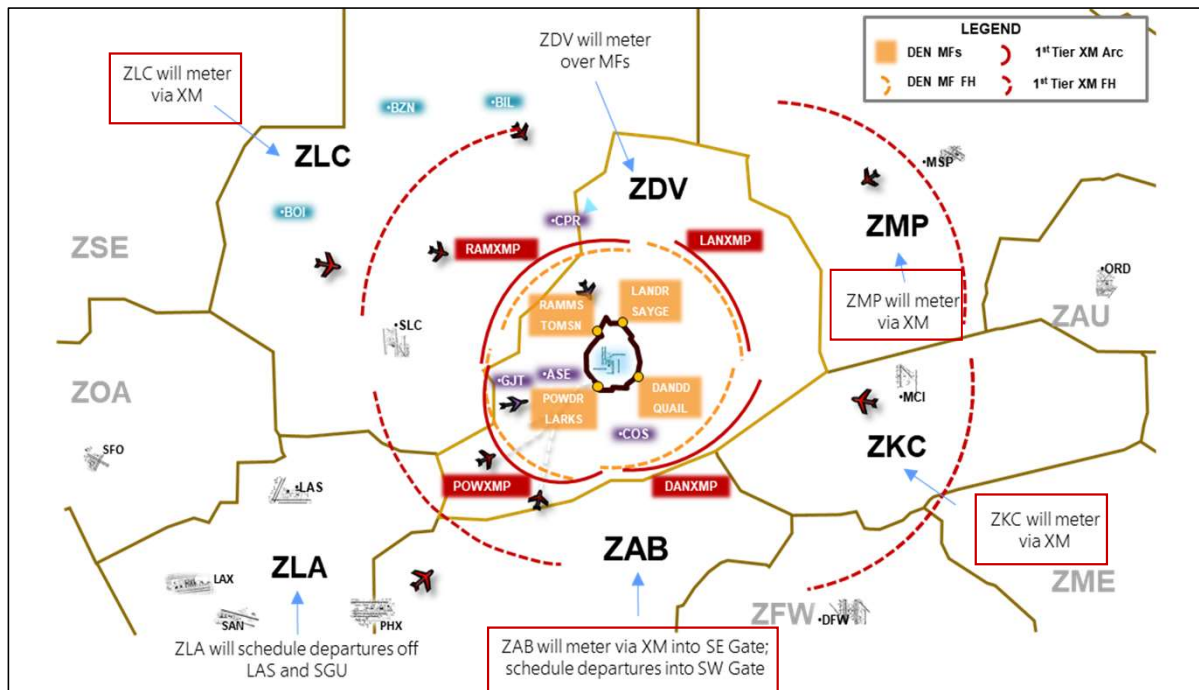
How it works

- Adds additional constraint points upstream from the meter fix

- Extends the distance over which TBFM delays can be managed

Benefit Mechanisms

- Improves merging of airborne traffic flows through a congested constraint point

- Improves stability of arrival meter list and predictability of operations

- Improves conformance with scheduled meter times

- Increases adherence to PBN STARs

All implementation dates subject to change due to COVID impacts, budget, sustainment needs, workforce training, and other constraints

TBFM: Terminal Sequencing and Spacing (TSAS)
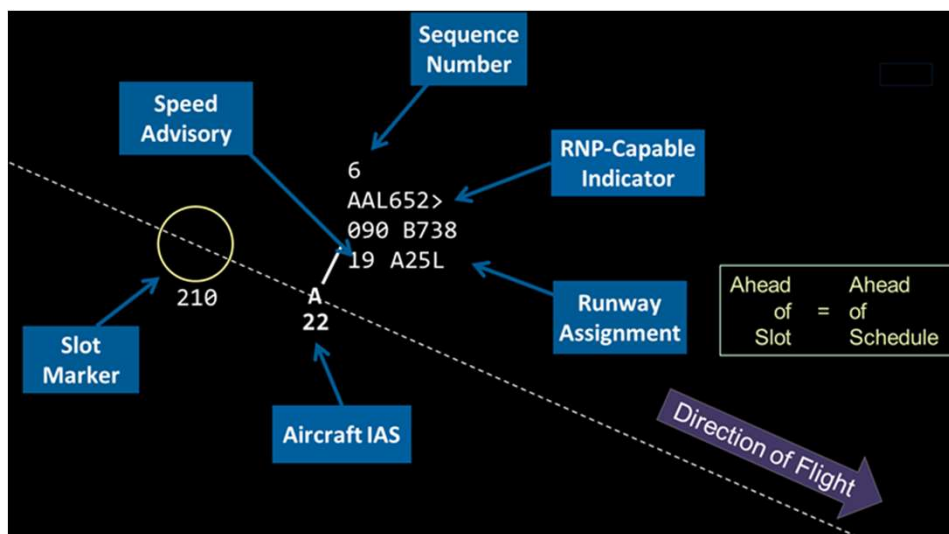
In development

Key Sites DEN (2022) and LAX (2023)

How it works

- Extends metering into the TRACON
- Adds constraint points inside the TRACON
- Provides more accurate TRACON trajectory modeling
- Considers aircraft equipage capabilities to establish the time-based schedule
- Provide tools that helps TRACON Controller maintain aircraft sequences, spacing and runway assignment

Benefit Mechanisms

- Improves merging of traffic flows inside terminal airspace
- Increases feasibility of the time-based runway schedule
- Reduces low altitude vectoring and holding
- Helps manage mixed equipage for arrivals in the terminal
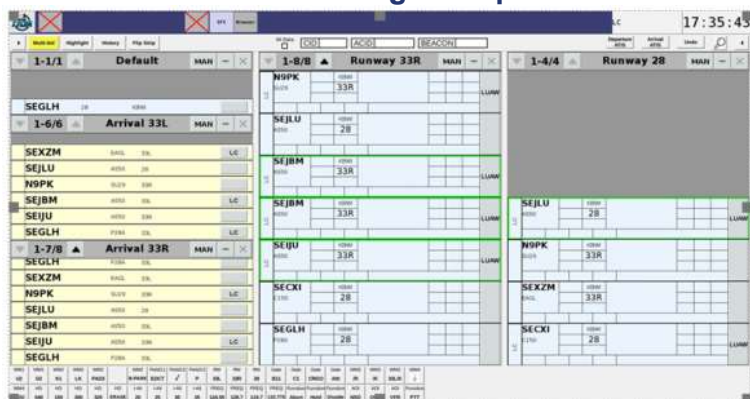- Increases use of RNP approaches

All implementation dates subject to change due to COVID impacts, budget, sustainment needs, workforce training, and other constraints

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TFDM: Surface Management

Surface Management Displays
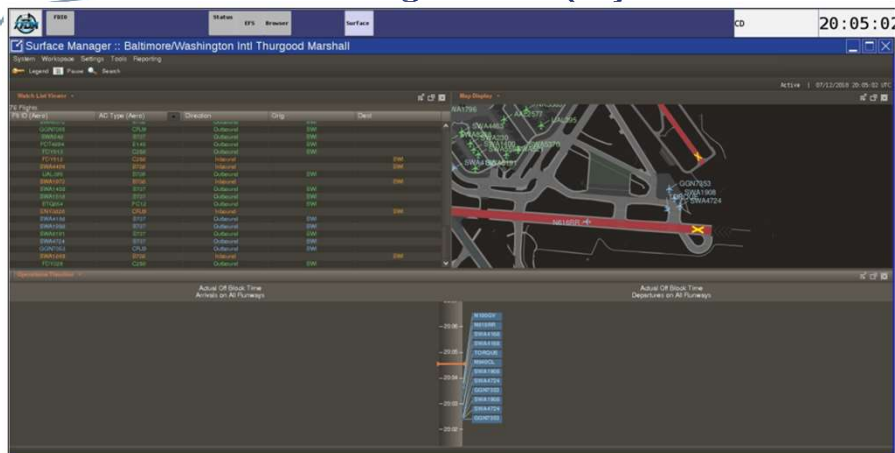
Electronic Flight Strips

How it works

- Provides Electronic Flight Data to Tower Controllers
- Consolidates data and displays from several legacy systems
- Provides virtual runway queues and surface metering (TBM)
- Enables strategic runway balancing
- Integrates departure release time with TBFM and TFMS (when needed)

Benefit Mechanisms

- Improves surface management
- Improves management of runway queues
- Improves runway balancing for mixed operations

Key Sites: PHX 2021; CLT 2022
Expected at 89 sites by 2023
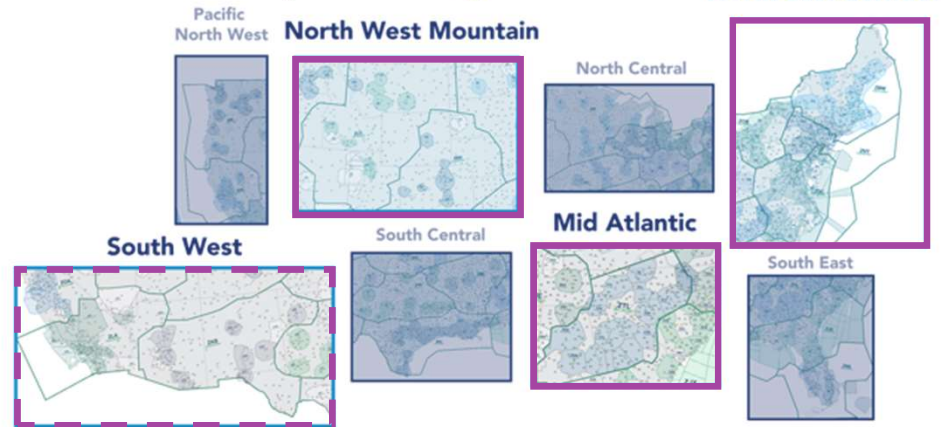**(27 of those sites with surface metering)**

Operating Areas

North West Mountain
- ✓ DEN Metroplex
- • Integrated Departure Arrival Capability (IDAC)
- ✓ Extended Metering to DEN
  - ✓ Infrastructure
  - ✓ Dep Scheduling
  - ✓ Arrival Metering
- • DEN Terminal Sequencing and Spacing (TSAS)

South West
- • LAS Metroplex
- • Update airspace/procedures infrastructure
- ✓ IDAC
- • Extended Metering for LAX
  - • Infrastructure
  - • Dep Scheduling
  - • Arrival Metering
- • LAX TSAS

NAS-Wide
- ✓ En Route Departure Capability (EDC)
- ✓ Pre-departure reroute & Airborne reroute (except ZNY)
- ✓ Tower CPDLC Services
- • Initial En Route CPDLC Services
- • Full En Route CPDLC services
- • TFDM (89 locations)

North East Corridor
- ✓ IDAC
- • Extended Metering to PHL, EWR
  - ✓ Infrastructure (PHL)
  - • Dep Scheduling
  - • Arrival Metering
- • Atlantic Coast Routes

Mid Atlantic
- ✓ Adjacent Metering for ATL
  - • Dep Scheduling
  - • Arrival Metering
- ✓ IDAC
- • Airspace/procedures infrastructure update
- • Evaluate extended metering for ATL
- • TFDM

- ✓ Operationally available
- • In deployment or development

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Key TBO Implementation Milestones

North West Mountain
- ✓ DEN Metroplex
- • Integrated Departure Arrival Capability (IDAC) - 2021
- ✓ Extended Metering to DEN
  - ✓ Infrastructure
  - ✓ Dep Scheduling
  - ✓ Arrival Metering
- • DEN Terminal Sequencing and Spacing (TSAS) - 2022

South West
- • LAS Metroplex - 2021
- • Update airspace/procedures infrastructure - 2021
- ✓ IDAC
- • Extended Metering for LAX - 2022
  - • Infrastructure
  - • Dep Scheduling
  - • Arrival Metering
- • LAX TSAS - 2023

Operating Areas

NAS-Wide
- ✓ En Route Departure Capability (EDC)
- ✓ Pre-departure reroute & Airborne reroute (except ZNY)
- ✓ Tower CPDLC Services
- • Initial En Route CPDLC Services – 2021
- • Full En Route CPDLC services – 2023
- • TFDM (89 locations) - 2023

All implementation dates subject to change due to COVID impacts, budget, sustainment needs, workforce training, and other constraints

North East Corridor
- ✓ IDAC
- • Extended Metering to PHL (2022), EWR (2023)
  - ✓ Infrastructure (PHL)
  - • Dep Scheduling
  - • Arrival Metering
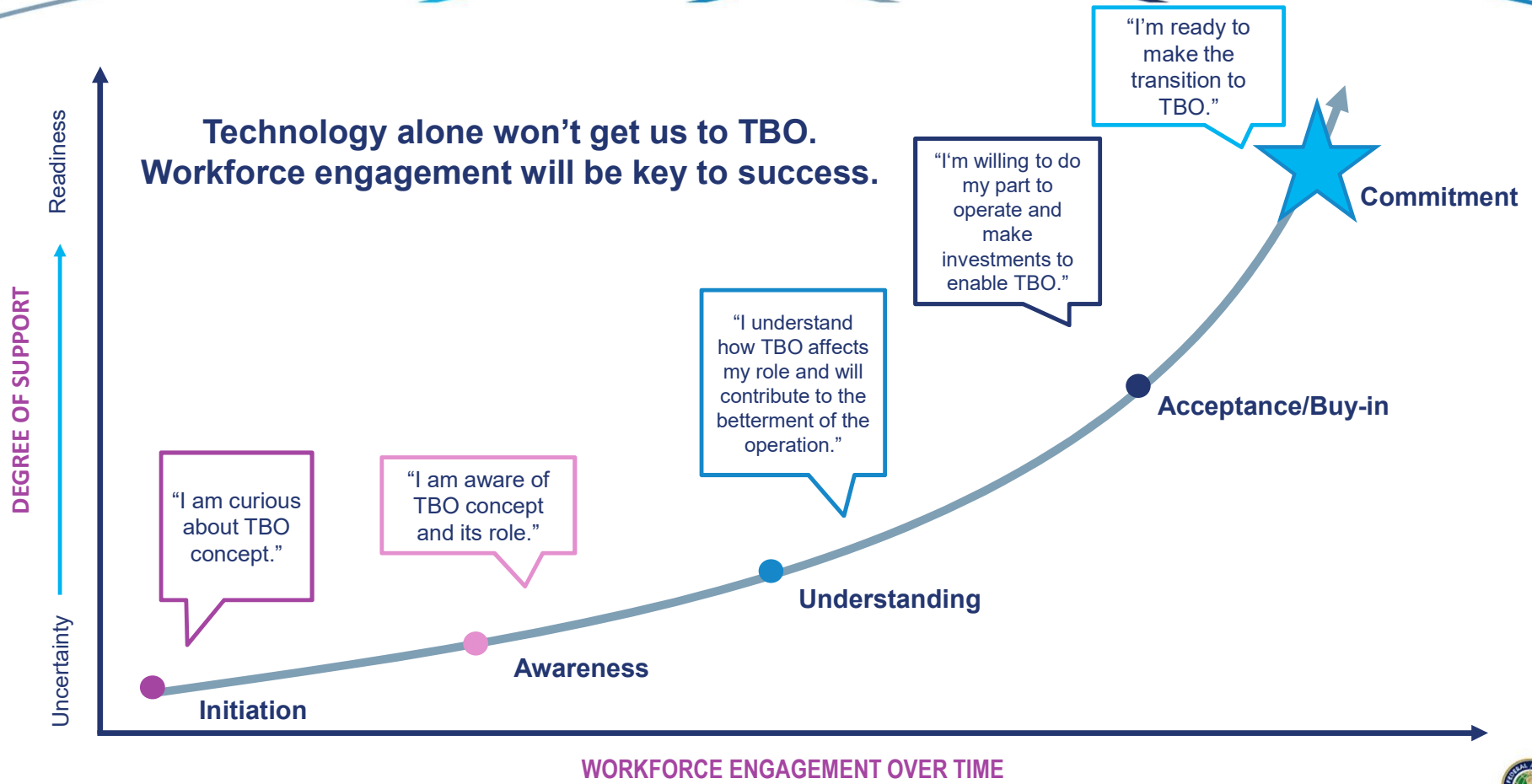- • Atlantic Coast Routes - 2021

Mid Atlantic
- ✓ Adjacent Metering for ATL
  - • Dep Scheduling
  - • Arrival Metering
- ✓ IDAC
- • Airspace/procedures infrastructure update
- • Evaluate extended metering for ATL
- • TFDM - 2022

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Key Elements of TBO Change Strategy

Intended Outcome: Preparing people to do business differently

Transition Approaches	
Leadership	*Leaders provide clear strategic direction and visibly support the change through meaningful action*
Stakeholder Engagement	*People affected by the change are actively involved. Their needs, concerns, and expectations drive the change process*
Communication	*People are well-informed through timely, relevant, and accurate information. Their feedback is incorporated into change strategies and messaging*
Evolution Planning	*Deployment plans are aligned to incrementally deliver an integrated set of capabilities to operating areas in a logical and manageable manner*
Training/ Education	*People are prepared and confident to implement a new way of doing work through effective training and education*
Organizational and Workforce Alignment	*The organization's structure, policies, reward systems, and roles and responsibilities align with the goals of the changes*

Change strategy is a systematic approach that aligns people to changes in strategy, process, and technology

Recent Accomplishments

Stakeholder Engagement
- Established Change Strategy Team
- Activated Field Implementation Teams in Denver

Communication
- Annual TBO Summit for FAA leadership

Training/ Education
- ZDV and Tier 1 Centers on Extended Metering operations
- TBFM Fundamentals Course for Controllers

Workforce Alignment
- Revision to ATC Orders submitted for Publication in June 2021;
- Updated Controller/Pilot Glossary

Still Moving Forward

- Looking for opportunities to engage **virtually**
- Continuing **coordination with facilities, contractors and industry**

Challenges

- Controller training and sustainment
- Access to facilities and personnel
- Evolving deconfliction across all operating areas and FAA projects
- TBO education and training for the workforce
- Budget constraints
- Evolving harmonization with industry

Session Four

Intro by Michele Merkle

TBO is a collection of systems, capabilities, processes, and people working together to achieve operational objectives

Time-Based Management (TBM)	Performance Based Navigation (PBN)	Enabling Technologies
Departure Scheduling Arrival Metering Terminal Metering Surface Metering … and more	Area Navigation (RNAV) Required Navigation Performance (RNP) STARs, SIDs, IAP and routes …and more	System-Wide Information Management (SWIM) Enhanced Data Exchange DataComm Advanced Weather Products Airborne Rerouting …and more
Helps Manage Trajectories by Scheduling and Metering Aircraft Through Constraint Points	*Enables Aircraft to More Accurately Navigate Along Their Trajectories*	*Expands and Automates Sharing of Common Information About Aircraft Trajectories*

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TBO Development and Deployment

The FAA is fielding and integrating TBO technologies to enhance strategic planning and management of NAS operations

Time-Based Management (TBM)

TBFM and TFDM
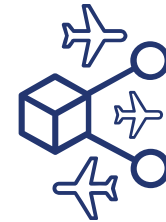Complemented by
TFMS

Helps Manage Trajectories by Scheduling and Metering Aircraft Through Constraint Points

Performance Based Navigation (PBN)

Metroplex
EOR / RNP w/RF Turns
Etc.

Enables Aircraft to More Accurately Navigate Along Their Trajectories

Enabling Technologies

SWIM
DataComm
Etc.

Expands and Automates Sharing of Common Information About Aircraft Trajectories

Deploying TBO Capabilities

Jere Hayslett, Program Management Organization
Aaron Wilkins, Program Management Organization
Jeff Woods, National Air Traffic Controllers Association

Program Management Organization (PMO)

Provides program and acquisition management for systems and capabilities that modernize and sustain the NAS. Created to successfully implement innovative technologies.

Integrated Services and Analysis

Develops effective, timely and innovative solutions to evolving business needs.

Integrated Resource Management

Acquisition Support & Analytics

Planning, Analysis & Integration

Technical Advisors

Air Traffic Systems

Maintains systems that support tactical operations today and executes new automation tools.

ERAM, STARS, 3 T's

Enterprise Services

Implements and executes technologies and services that connect ground systems and aircraft in the NAS.
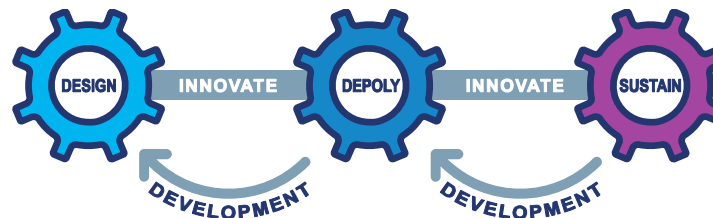
SWIM, DataComm, CSS-Wx

Surveillance Services

Implements systems and services that provide critical surveillance data, sustains systems that support tactical operations today and executes new surveillance technologies.

Radars, SENSR

ADS-B

ASSC, ASDE-X

DESIGN — INNOVATE — DEPOLY — INNOVATE — SUSTAIN

DEVELOPMENT   DEVELOPMENT

AJM-4

Surveillance Services

Implements systems and services that **provide surveillance data** that is critical to separate air traffic and provide situational awareness for airspace users.

AJM-1

PMO Integrated Services and Analysis

Provides **business management services**, acquisition support, program planning, and engineering analyses.

AJM-3

Enterprise Services

Manages systems and services that tie ground systems and aircraft together through **communications, navigation, weather, flight, and aeronautical** information

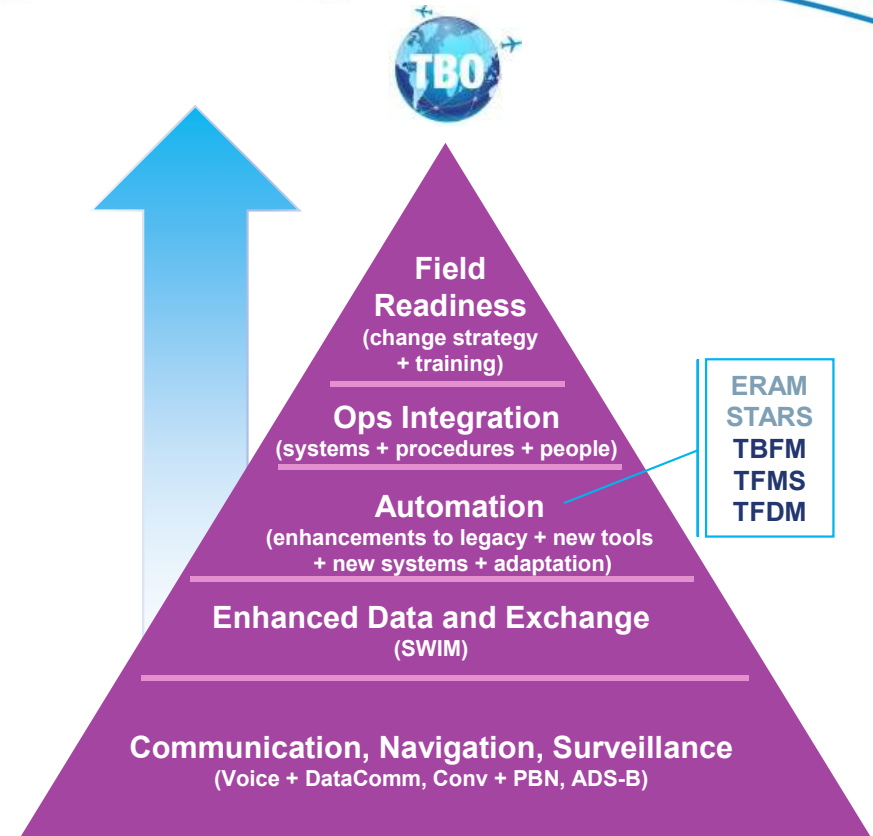**AJM-2**

Air Traffic Systems

Manages **systems that support aircraft separation services.** Oversees initial concepts through design and development and manages the deployment and sustainment of the systems.

TBO Implementation Management

TBO Is An Enterprise Operational Initiative Enabled By Many Programs and Investments

- *Current* congressional funding levels will allow the FAA to implement several TBO milestones over the next 3 years

- TBO is not a single program, it is enabled via integrated management and de-confliction of multiple programs and priorities

  - Sustainment of operations

  - Facility needs, including operational improvements, workforce staffing and training, etc.

  - Program needs, including budgets, system requirements, testing and validation, access to facilities, operational SMEs, etc.

  - Operators' recommendations and other inputs via NAC, CDM and other FAA/industry forums

Field Readiness
(change strategy + training)

Ops Integration
(systems + procedures + people)

Automation
(enhancements to legacy + new tools + new systems + adaptation)

Enhanced Data and Exchange
(SWIM)

Communication, Navigation, Surveillance
(Voice + DataComm, Conv + PBN, ADS-B)

ERAM
STARS
TBFM
TFMS
TFDM

Decision Support Systems *(The 3 T's)*

TBO functionality supported by Integration of 3 T's

- Enhance data-sharing across systems and stakeholders to increase situational awareness and improve data quality.

- Integrate management of local and NAS-wide traffic management activities.

- Redistribute delays and manage means of delay absorption (speed, vectoring, ground).

- Account for user preferences.

Time Based Flow Management (TBFM)
Scheduling and Metering through Congested NAS Resources

Departure Scheduling
Extended Metering
Adjacent Center
Arrival Metering
TSAS
IDAC

TBFM

TFDM

TFMS

In development

Pre-departure Rerouting
Airborne Re-routing
GDP, AFP, CTOP

Terminal Flight Data Manager (TFDM)
Surface Management and Electronic Flight Data

Electronic Flight Data
Rwy Queue Management
Strategic RWY Balancing
Arr/Dep Management Integration

Traffic Flow Management System (TFMS)
Demand and Capacity Management Across the NAS

Program Management Office Focus

Infrastructure

- ✓ ERAM
- ✓ TAMR
- ✓ SWIM
- ✓ AIMM
- ✓ Data Comm
- ✓ TBFM
- ✓ TFMS
- O TFDM

o = In Development
✓ = Operationally Available in at least one location

Integrated Arrivals

TBFM
- ✓ Arrival metering
- ✓ Extended metering
- o Terminal metering

Integrated Departures

TBFM Automation
- ✓ Time based departure management

TFMS
- ✓ Pre-departure reroutes

TFDM
- o Automated surface management including surface metering

Data Comm
- ✓ Tower Services

Advanced Trajectory Management

TFMS
- ✓ Route Availability Planning
- ✓ Airborne Reroutes

Data Comm
- ✓ Initial En Route Services
- o Additional Data Comm Services

- Integration issues remain open

- Risk to operational acceptance and use of to-be deployed iTBO and TBO capabilities

- Find issues before implementation to avoid cost and disruption to operations

Risk Analyses and Mitigation Development

Interoperability Assessments

1 Identify
2 Analyze & Assess
3 Develop RIO Plan
4 Execute RIO Plan
5 Track & Monitor

- Communicate
- Improve

Action Plans and Movement

- Status and priority assessments

- A sandbox to explore operations, systems, and adaptation

- Operational familiarity of change expectations and the collective use of capabilities

- Early identification and mitigation of issues

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Key TBO Implementation Milestones

Operating Areas

North West Mountain
- ✓ DEN Metroplex
- • Integrated Departure Arrival Capability (IDAC) - 2021
- ✓ Extended Metering to DEN
    - ✓ Infrastructure
    - ✓ Dep Scheduling
    - ✓ Arrival Metering
- • DEN Terminal Sequencing and Spacing (TSAS) - 2022

South West
- • LAS Metroplex - 2021
- • Update airspace/procedures infrastructure - 2021
- ✓ IDAC
- • Extended Metering for LAX - 2022
    - • Infrastructure
    - • Dep Scheduling
    - • Arrival Metering
- • LAX TSAS - 2023

NAS-Wide
- ✓ En Route Departure Capability (EDC)
- ✓ Pre-departure reroute & Airborne reroute (except ZNY)
- ✓ Tower CPDLC Services
- • Initial En Route CPDLC Services – 2021
- • Full En Route CPDLC services – 2023
- • TFDM (89 locations) - 2023

All implementation dates subject to change due to COVID impacts, budget, sustainment needs, workforce training, and other constraints

North East Corridor
- ✓ IDAC
- • Extended Metering to PHL (2022), EWR (2023)
    - ✓ Infrastructure (PHL)
    - • Dep Scheduling
    - • Arrival Metering
- • Atlantic Coast Routes - 2021

Mid Atlantic
- ✓ Adjacent Metering for ATL
    - ✓ Dep Scheduling
    - ✓ Arrival Metering
- ✓ IDAC
- • Airspace/procedures infrastructure update
- • Evaluate extended metering for ATL
- • TFDM - 2022

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TBO Milestones

	2020	2021	2022	2023	2024
North East Corridor			**Improve Airborne Metering to PHL** (Implement TMA's Adjacent Center Metering Capability at Additional Locations) **Implement Eastern Seaboard High Altitude PBN Routes** (Transition to PBN Routing for Cruise Operations) **DSP Enhancements** (Non-NextGen Tool) **PDRR/ABRR Enhancements** (Airborne Rerouting) (Delivery of Pre-Departure Reroutes to Controllers)	**IDAC** (Integrated Departure/Arrival Capability)	
		Data Comm Initial En Route Services (Initial En Route Data Comm Services)			
NW Mountain		**Metroplex** (Expansion of Metroplex PBN Procedures)	**Data Comm Initial En Route Services** (Initial En Route Data Comm Services) **IDAC** (Integrated Departure/ Arrival Capability)	**TSAS (DEN)** (Time-Based Metering in the Terminal Environment) **TFDM Surface Metering** (TFDM Scheduler/Sequencer) (Surface Metering Operations)	
Mid-Atlantic	**IDAC (ATL)** (Integrated Departure/Arrival Capability)		**Data Comm Initial En Route Services** (Initial En Route Data Comm Services)	**TFDM (CLT, ATL)** (TFDM Scheduler/Sequencer) (Surface Metering Operations)	
South West		**LAS Metroplex** (Expansion of Metroplex PBN Procedures)	**TFDM (PHX)** (Improved Electronic Flight Data Exchange) (TFDM Scheduler/Sequencer) (Surface Metering Operations)	**TSAS (LAX)** (Time-Based Metering in the Terminal Environment)	

NOTE: Reassessing all activities due to COVID-19 impacts

◆ - ARTCC iTBO Initiative   ◆ - TRACON iTBO Initiative   ◆ - ATCT/Airport iTBO Initiative   ◇ (Blue Border) - NAC Commitment

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Deployed Tech refreshes
- Foundational infrastructure: ERAM and STARS
- Legacy decision support systems for traffic flow management: TFMS and TBFM

Deployed New tools and functions in legacy DSS
- TBFM: Extended Metering in ZDV and Tier 1 ARTCCs
- TBFM: IDAC deployed to12 ARTCCs and 60 ATC Towers
- TFMS: Pre-departure and Airborne Reroutes (PDRR/ABRR)

Improved TBFM Infrastructure and Adaptation at NEC
- To support departure scheduling from ZBW and ZNY for ATL and CLT
- To support XM Infrastructure for PHL and EWR Arrivals

Data Communications Services (CPDLC)
- Tower Services at 74 Towers (currently working on three more sites)
- Initial En Route Services at 3 ARTCCs

Preparing for Deployment of a new decision support automation: TFDM

Safety critical and sustainment initiatives remain our top priority

Progress During Pandemic

- Continued software development and limited developmental testing
- Prioritized activities that can be accomplished safely and with limited travel or access to FAA facilities
  - Delayed Operational Testing of Systems, and Integration Testing between FAA Systems
  - Unable to Achieve Operational Suitability or In-Service Decision Milestones

We continue to address risks and adjust to constraints

- Budget, program dependences, need for SMEs, sustainment needs, facility needs, workforce training, etc.
- Other constraints such as research results and remaining shortfalls
- Unknown when travel and access to facilities will resume

On-going focus on re-planning activities

- PMO integrates system requirements, and manages programmatic dependences and execution
- AJT/Ops manages operational dependences and facility coordination, and leads the implementation at service delivery points

Operator Roles in TBO

Dan Murphy, Systems Operations Services
Michele Merkle, Air Traffic Services

TBO Operational Roles Overview

ATCSCC

Monitor and manage a safe, orderly, and efficient air traffic flow

Multi-directional communications is critical

Operators

Collectively convey needs and allow the FAA to derive solutions

TBO will not change basic roles and responsibilities. It may change the way roles and responsibilities are executed.

Facilities

Ensure safe, orderly and expeditious flow of air traffic

Develop Plan

Execute Plan

Provide Data

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Overview of TBO Across Different Planning Horizons
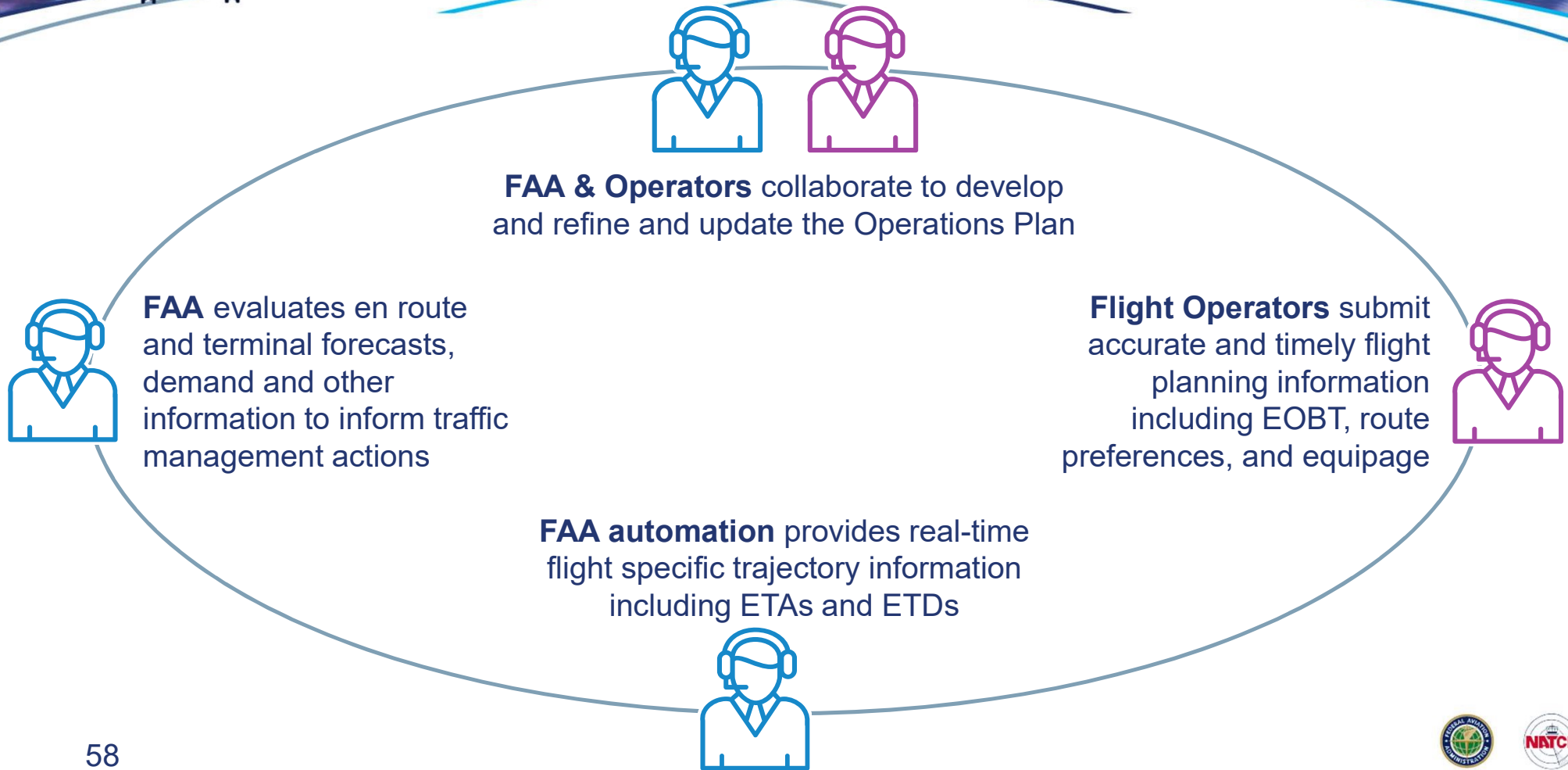
Information Uncertainty

Strategic Traffic Management

Time Based Management

Manage Flows

Pre-departure reroutes

Airborne re-routes

Manage Flights

Manage Trajectories

NAS-wide view defines priorities and goals for the day

Manage flights to meet flow constraints and regional imbalances

Manage trajectories to meet constraints

Set flow rates

Adjust flight plans

Agile TFM

Time

| 24+ hr | 2 hr | Depart | Arrive |

Decision Makers

ATCSCC

TRACON

TRACON

ATCT

ATCT

Flight Operations Centers

Flight Crew

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How TBO Impacts Strategic Planning

FAA & Operators collaborate to develop and refine and update the Operations Plan

FAA evaluates en route and terminal forecasts, demand and other information to inform traffic management actions

Flight Operators submit accurate and timely flight planning information including EOBT, route preferences, and equipage

FAA automation provides real-time flight specific trajectory information including ETAs and ETDs

How TBO Impacts Strategic Planning

FAA & Operators collaborate to develop and refine and update the Operations Plan

FAA evaluates en route and terminal forecasts, demand and other information to inform traffic management actions

Daily Operations Plan
• Active Metering and Dep Scheduling
• Strategic TMIs (GDP, AFP, CTOP)
• Route Management
• Surface Management

Flight Operators submit accurate and timely flight planning information including EOBT, route preferences, and equipage

FAA automation provides real-time flight specific trajectory information including ETAs and ETDs

How TBO Impacts Strategic Planning

Shift towards earlier planning ✓

Shift towards electronic real-time collaboration ✓

FAA & Operators collaborate to develop and refine and update the Operations Plan

FAA evaluates en route and terminal forecasts, demand and other information to inform traffic management actions

Daily Operations Plan
- Active Metering and Dep Scheduling
- Strategic TMIs (GDP, AFP, CTOP)
- Route Management
- Surface Management

Flight Operators submit accurate and timely flight planning information including EOBT, route preferences, and equipage

FAA automation provides real-time flight specific trajectory information including ETAs and ETDs

Improved information sharing ✓

Improved information content ✓

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How Can Operators Enhance TBO?

Strategy & Planning

- Understand the TBO Vision and Implementation Strategy
- Train and Educate Your Workforce on TBO Capabilities
- Equip Aircraft as Described in the Minimum Capability List (MCL)
- Provide Timely & Accurate Data to Support TBO Capabilities
  - TFMS Data Elements
  - Flight Planning Info (Route/Speed; Equipage/Crew Qualifications)
  - Operator preferences (e.g., TOS)
- Develop Ground Automation to Leverage TBO Data via SWIM

Operational Execution

- Collaborate & Maintain Situation Awareness through PERTI Process, Advanced Planning, and Planning Telcons
- Execute Operations Consistent with Plans and TBO Vision

Flight Status
Actual Off-Block Time (AOBT)
Actual Takeoff Time (ATOT)
Actual Landing Time (ALDT)
Actual In-Bock Time (AIBT)
Aircraft Tail/Registration Number
Earliest Off-Block Time (EOBT)
Flight Cancellation
Flight Intent
Gate Assignment
Initial Off-Block Time (IOBT)
Earliest Runway Time of Departure (ERDT)
Operator Preferences
Program Slot Swapping
Multi-Option TOS

Investment into better data and data-sharing is encouraged and not required, but does increase benefits for everyone.

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More information: www.faa.gov/air_traffic/technology/tbo/
Questions: 9-AJT-TBO@faa.gov

Session Six

TBO Performance Assessment

Almira Ramadani, Air Traffic Services
Dave Knorr, Office of Next Gen
Dave Raymond, Systems Operations Services

What are we trying to improve?

Throughput

Predictability

Flight Efficiency

Operator Flexibility

TBO Benefits Recap

TBO Capability	Key Benefit Mechanism	Related TBO Objectives
Departure Scheduling In regular use for constrained flows at every ARTCC	• Ensures smooth merge with airborne traffic • Reduces vectoring and other maneuvers	• Increased throughput • Increased efficiency • Increased predictability
Arrival Metering As of Feb 2020, in regular use for ATL, CLT, IAH, HOU, DFW, MSP, LAX, DEN, SEA, SAN, PHX, SFO, SLC. Planned PHL (2022), EWR (2023)	• Spreads airborne delay over greater distance at high altitude • Reduces holding • Reduces reliance on static MIT restrictions	• Increased throughput • Increased efficiency
Extended Metering In regular use at DEN, Planned for PHL (2022)	• Increase scope of airborne metering across greater distances • Added constraint points for merges • Increased meter list stability and predictability	• Increased efficiency • Increased predictability
Terminal Metering Planned DEN (2022) and LAX (2023)	• Extends metering into terminal • Reduce low altitude vectoring and holding • Increased use of RNP approaches	• Increased efficiency • Increased predictability
Surface Management Planned at 89 Towers (2021-2023)	• Virtual runway queues • Runway balancing • Integrated scheduling with TBFM	• Increased efficiency • Increased predictability
Strategic Planning NAS-wide, incremental improvements over years	• Greater Emphasis on Strategic Decisions • Earlier planning • Operator Provided inputs and preferences	• Increased predictability • Increased flexibility

Benefits are driven by specific capabilities in specific locations.
Capabilities work together synergistically to drive overall outcomes.

Key Metrics of Value

TBO Objective	Outcomes	Key Metric of Value
Increased Throughput	• More Efficient Use of Available Capacity	• Throughput and spacing between aircraft during periods of high-demand
	• Increased Capacity in Certain ops conditions	• AARs under the same operating conditions
Increased Efficiency	• More Efficient Delay Redistribution	• Distance over nominal in terminal airspace during periods of high-demand • Ground delays during nominal operations
	• Add' Efficiency Gains	• Descent efficiency: time and distance in level-flight at low altitude • Distance in Terminal Airspace (reduction via use of RNP IAP w/RF)
Increased Predictability	• Increased Day-of-Operation Schedule Integrity	• Proportion of "on-time" arrivals relative to ETAs on the day-of-operation • Proportion of cancellations and diversions on the day-of-operation
	• Increased Flight Path Confidence	• Use of RNP IAP w/RF • Procedure Conformance • Filed vs. flown
	• Reduced End-to-End Variability	• Variance in end-to-end times • Distribution of flights (by magnitude of delay) • Occurrences and the amount of "double" delays
Increased Flexibility	• Increased Route Flexibility	• How often do operators provide and get their rerouting (vs delay) preferences

Quantifiable Expectations

Throughput

More Efficient Use of Available Capacity

- Throughput and spacing between aircraft
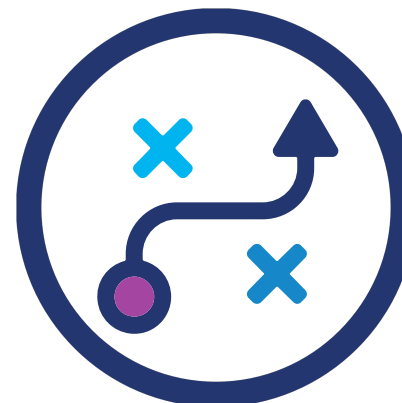
Greater Emphasis on Strategic Decisions

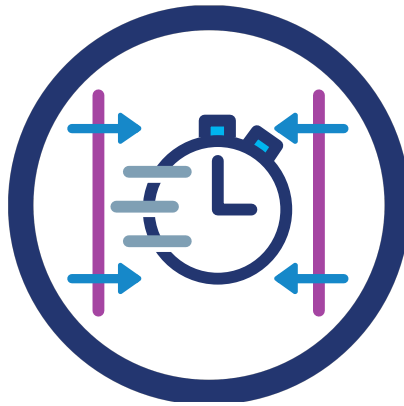- MIT Stringency
- Integrated use of TBM and GDPs

Qualitative vs quantitative outcomes:
planning is more accurate, starts earlier and is continuous
vs. use and magnitude of MITs or duration of GDPs

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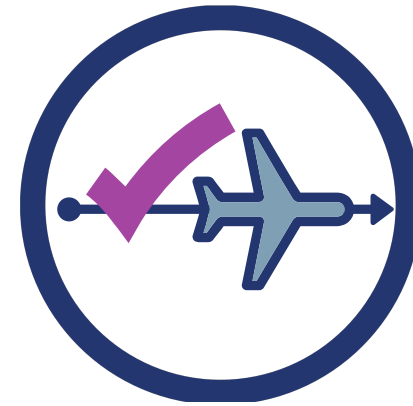# Quantifiable Expectations

Predictability

Reduced End-to-End Variability

- Variance in end-to-end times?
- Distribution of flights (by magnitude of delay)?

Increased Day of Operation Schedule Integrity

- Proportion of "on-time" arrivals relative to ETAs on the day-of-operation?
- Proportion of cancellations and diversions on the day-of-operation

Increased Flight Path Confidence

- Procedure Conformance
- Filed vs. flown?

Flight Efficiency

**More Efficient
Delay Redistribution**

- Distance over nominal in terminal airspace
- Ground delays
- "Double" delays

**Add' Efficiency
Gains**

- Descent efficiency: time and distance in level-flight at low altitude
- Use of RNP IAP w/RF
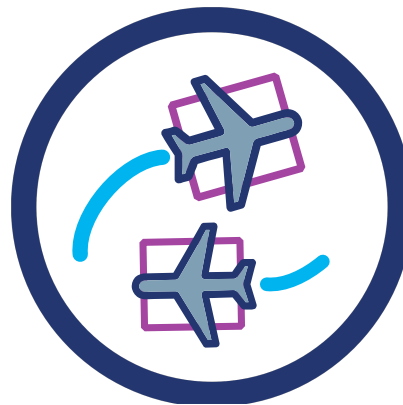
Operator Flexibility

Increased Route Flexibility

- **How often do operators provide and get their rerouting (vs delay) preferences**
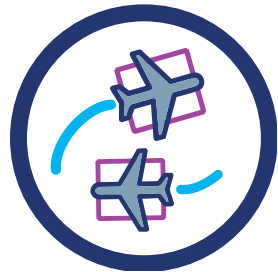
- Metrics can't be viewed in isolation
  - Incremental deployments ➔ incremental benefits
  - What capabilities are available and in use?
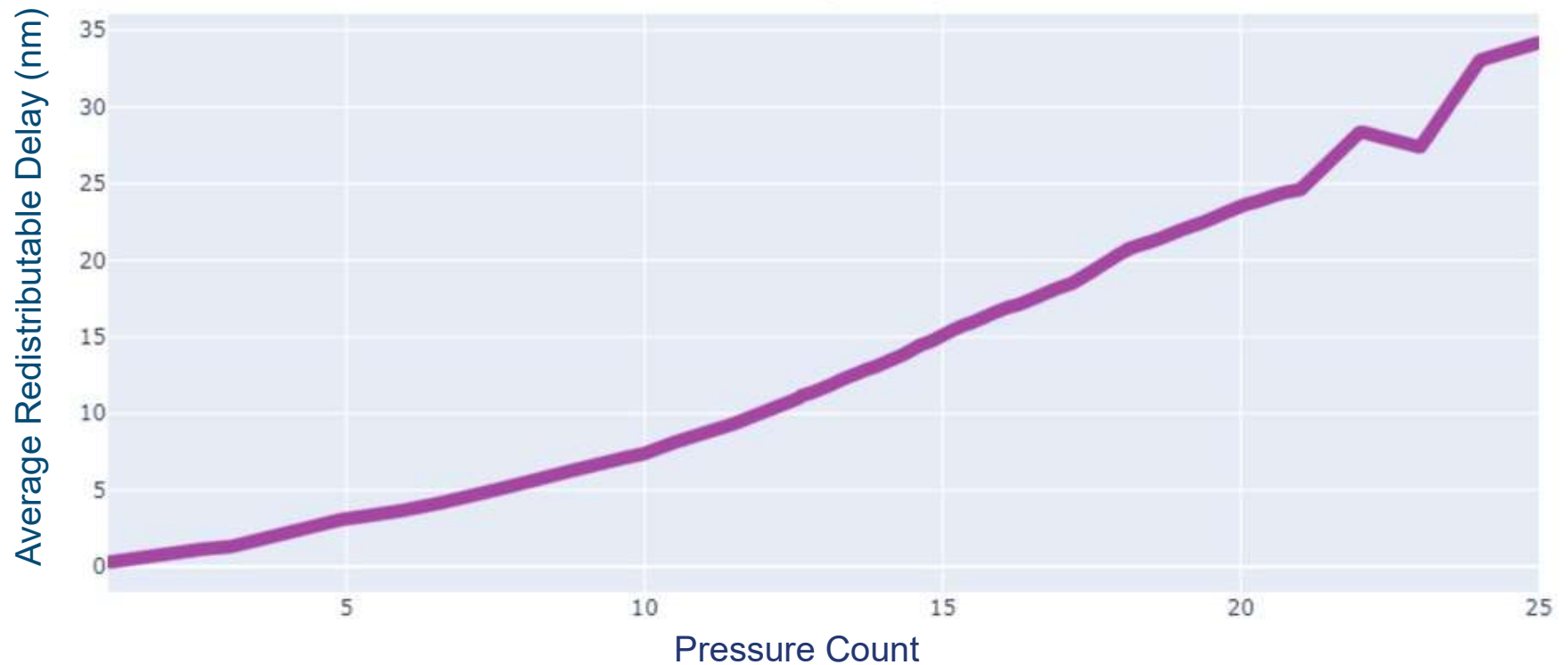 - Operational conditions: demand profile, weather, etc.
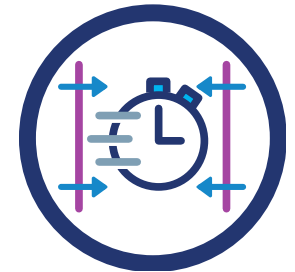
"Pressure" is a quantitative value representing the level of activity in the TRACON airspace

High (red)
vs.
Low (white)

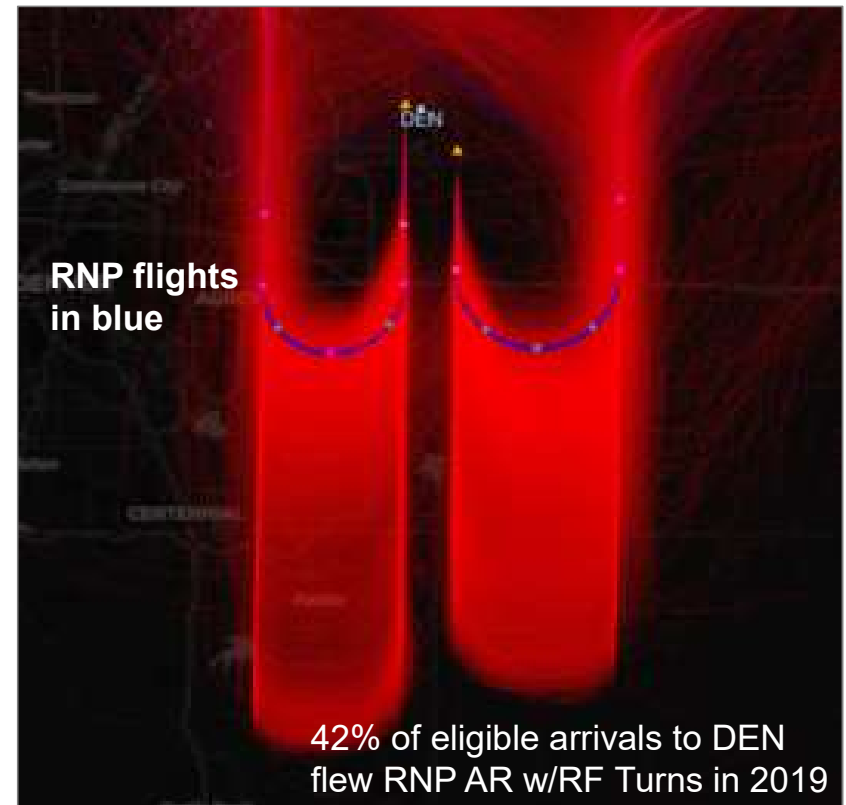40 nm
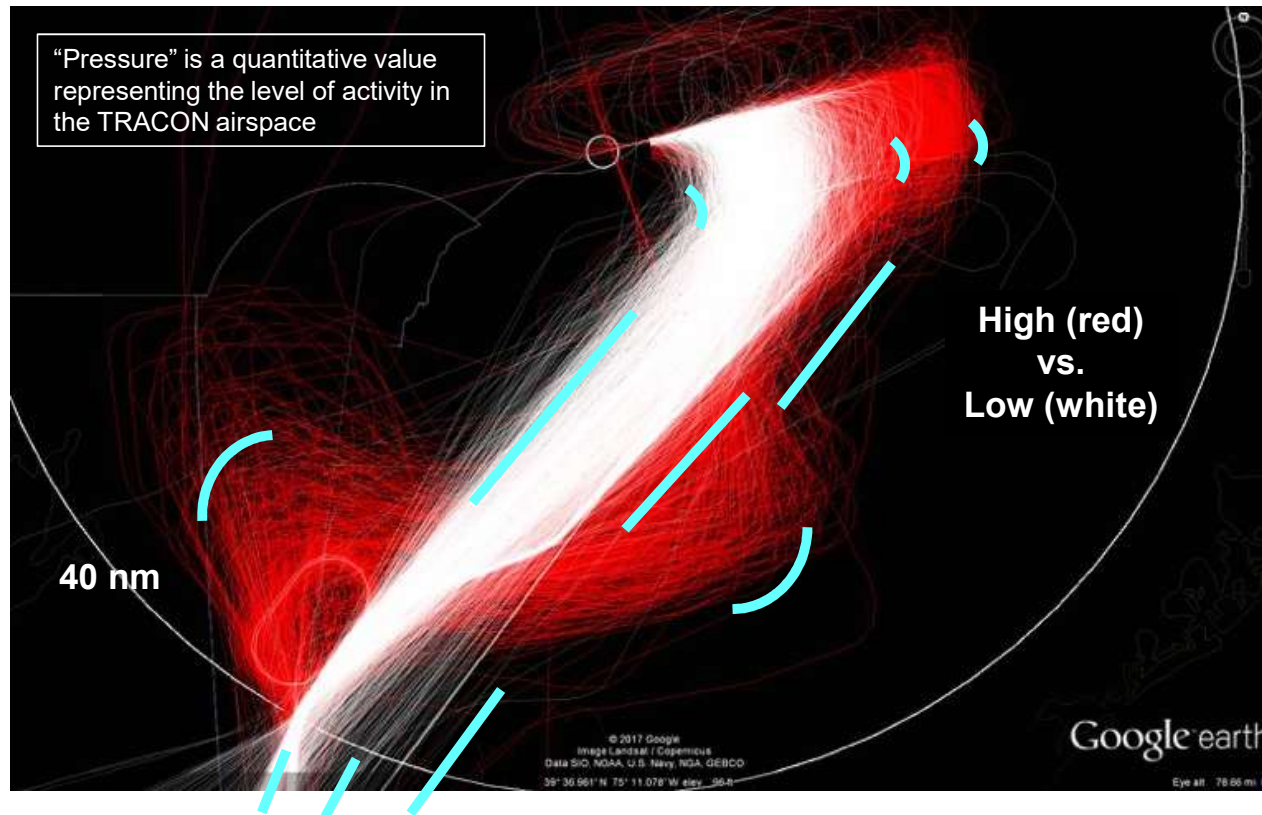
2019 PHL Redistributable Delay vs Pressure

Pressure is defined as number of aircraft in the TRACON when measured flight enters

RNP Benefit Opportunity at DEN

- RNP supports reduced distance flown at DEN

- The proportion of arrivals that fly RNP approaches decreases as the terminal area gets busier

- Airlines that are fully RNP equipped see a higher percent of RNP usage than airlines with mixed equipage

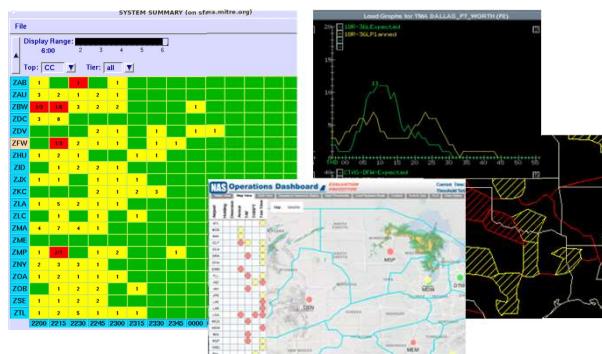- With TSAS, more RNP routes can be flown for eligible aircraft

RNP flights in blue

42% of eligible arrivals to DEN flew RNP AR w/RF Turns in 2019

Necessary Delay by Airport

2019 Airborne Delay

Legend: Between 40 and 120nm — Within 40nm

Y-axis: Average Necessary Delay (nm)

X-axis: Arrival Airport — JFK, PHL, CLT, IAH, DCA, HPN, DAL, EWR, BOS, SDF, ORD, MSP, DEN, FLL, LGA, SEA, ATL, MEM, IAD, DTW, DFW, TPA, MIA, BWI, STL, SLC, PIT, BNA, MDW, MCO, SFO, TEB, CVG, PDX, CLE, LAS, LAX, SJC, SAN, PHX, OAK
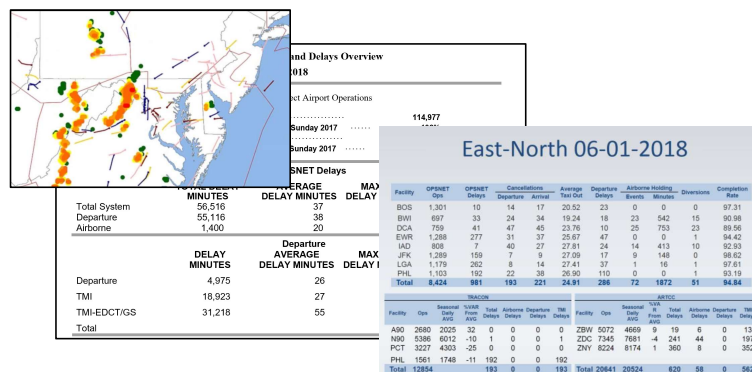
Traffic Managers, Airline Operators,
Area Supervisors

Traffic Managers, Airline Operators,
Quality Assurance Specialists
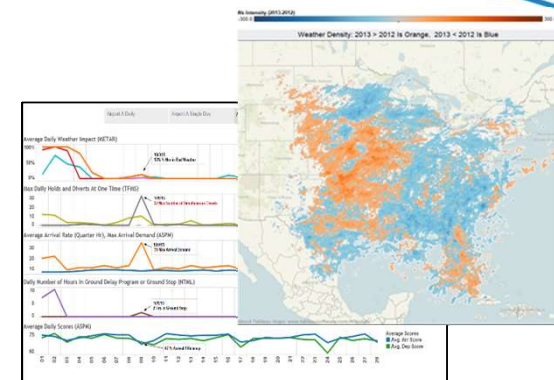
Traffic Managers, Airspace
Managers, Analysts, Quality
Assurance, Safety, Airlines,
Research Organizations

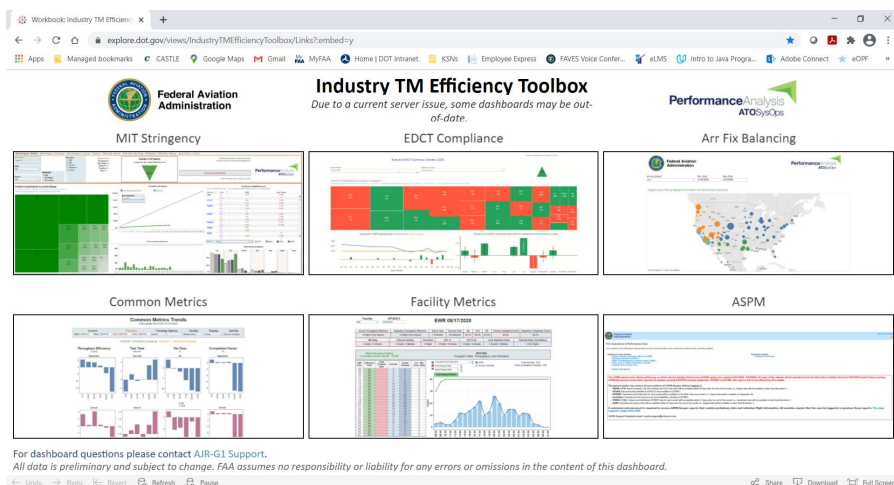| Real-Time	Next Day	Monthly/Seasonal

Real-time Performance monitoring of
current operations and ATFM Strategy

Use previous day performance
analysis to improve the current day
operations

Long term trends to improve
airspace design and procedures,
review ATFM actions and results

TM Efficiency Toolbox
- MIT Stringency
- EDCT Compliance
- Arrival Fix Balancing
- others

National Collaboration Forum
- 2nd Wednesday of every month
- NAS Performance Review
- Traffic Management Initiatives

National Collaboration Forum
Wednesday, January 13, 2021
8:00AM –12:00PM

An FAA / industry collaboration forum established to reach a common statement of fact regarding NAS performance changes resulting from NextGen implementation

Completed Tasks include:
- Multiple Runway Operations (RECAT at 5 sites)
- Performance Based Navigation
- North Texas Metroplex
- Established on RNP (EOR) at Denver
- Optimized Profile Descents (OPD) at BOS and GYY
- Data Communications (tower services)
- North East Corridor (EDC/IDAC, SCIA @ PHL, Escape Routes)

Future Tasks:
- More NEC (PBRR, Atlantic Coast Routes, TBFM @ PHL)

Wrap-up and Questions