Third TBO Industry Day

Operational Analysis and Benefits

Reminders

TBO website:
https://www.faa.gov/air_traffic/technology/tbo/

- Please mute your microphones

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

Opening Remarks

Michele Merkle
Air Traffic Services

Dan Murphy
System Operations Services

Dan Hamilton
NATCA

Data-driven Operational Improvements

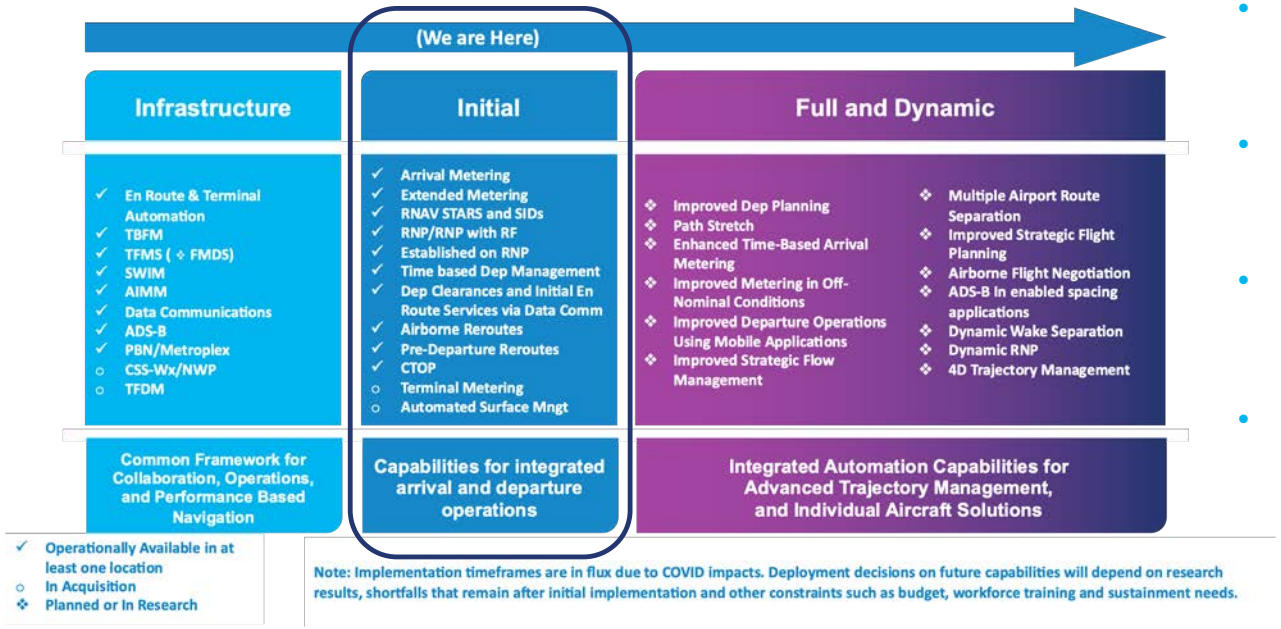
Almira Ramadani
Air Traffic Services

Data-Driven Operational Improvements

Analysis Supporting Lifecycle Management

- Shortfall analyses
- Analyses of alternative improvements
- Cost-Benefit analyses
  - Stakeholder views
  - Exogenous vs intended outcomes
  - Qualitative vs quantitative views
  - Monetization
- Post-implementation analyses
  - Technical (system performance)
  - Operational (use and outcomes)
  - Benefit achievement

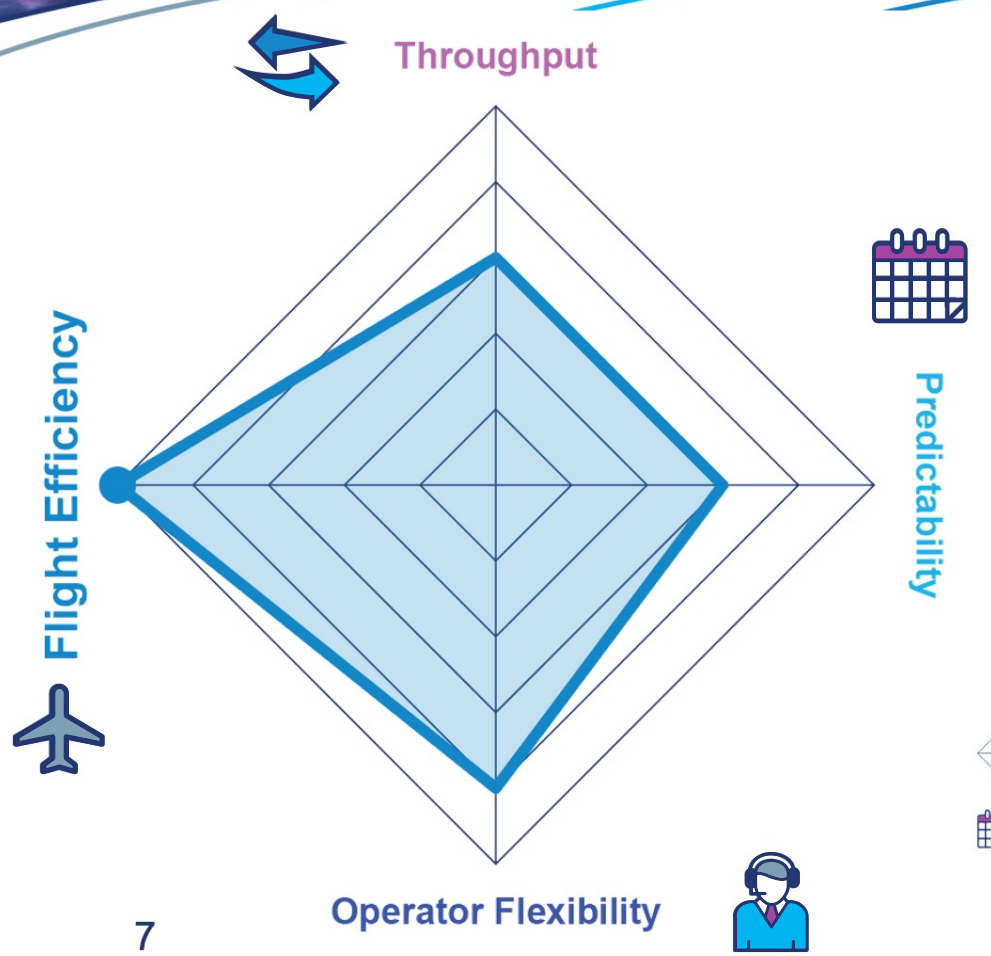
Data-Driven TBO Implementations



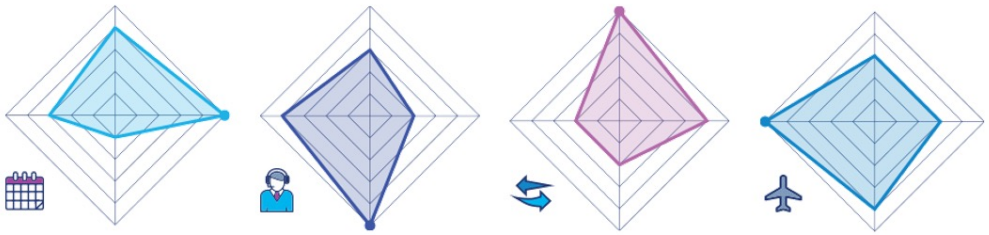
However…

- TBO is not a single program, and some of its components follow a different lifecycle management process
- TBO components vary in maturity, and span across <u>all</u> the stages of the lifecycle management process
- Use of operational TBO capabilities is being adjusted at many sites across the NAS (adaptation, training, etc.)
- There are many angles and considerations that may matter:
  - Deliver benefits vs. reduce risks/improve implementation process
  - Benefit opportunities vs. benefit expectations vs. achieved benefits
  - Exogenous vs. internal factors

TBO Objectives



- TBO touches on each objective
- Trade-offs between objectives exist, but are not well understood and difficult to quantify



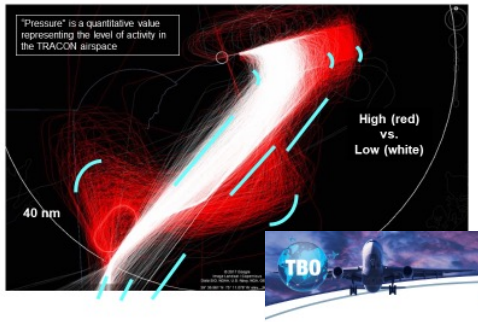
Opportunities

Dave Knorr

NextGen

Past Exchanges on Benefit Opportunities

Opportunity for Delay Redistribution



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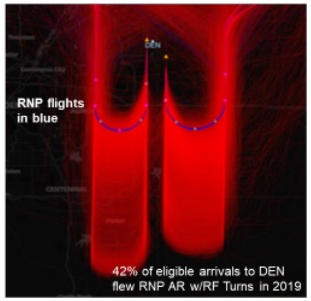
RNP Benefit Opportunity at DEN

- 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

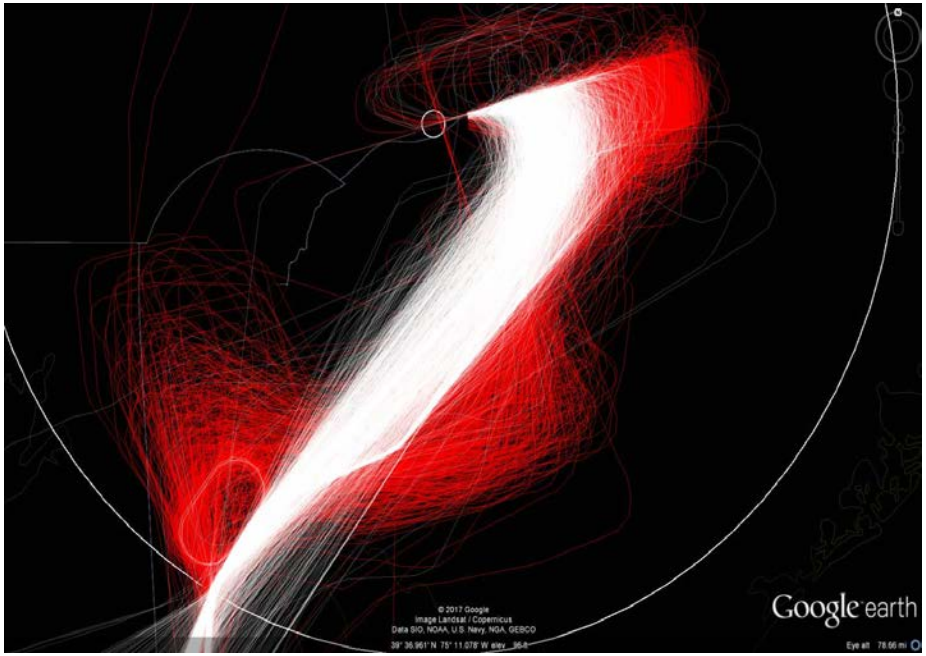


Necessary Delay by Airport

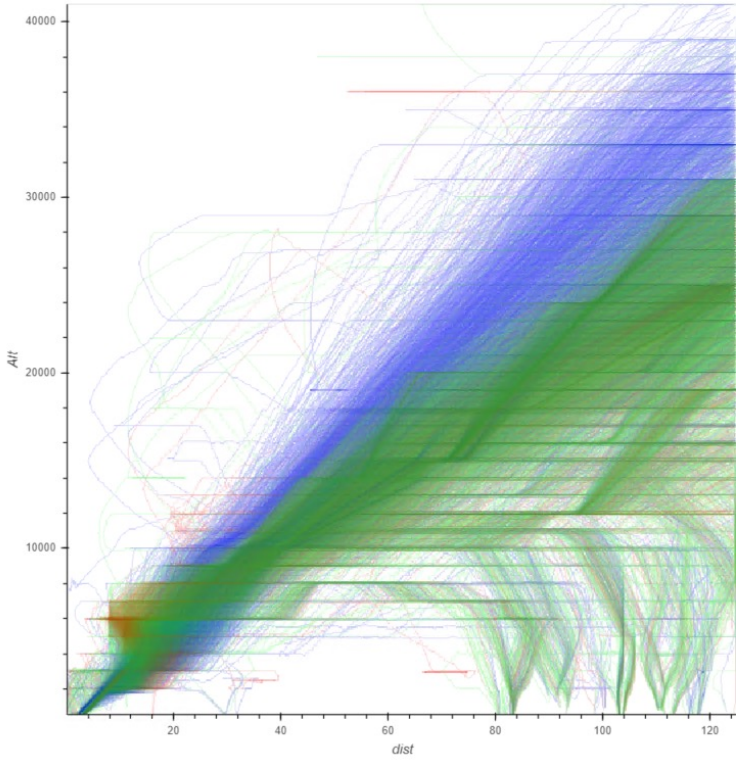
15


Opportunities:
Redistribution of Necessary Delay

Relationship between Demand and Performance

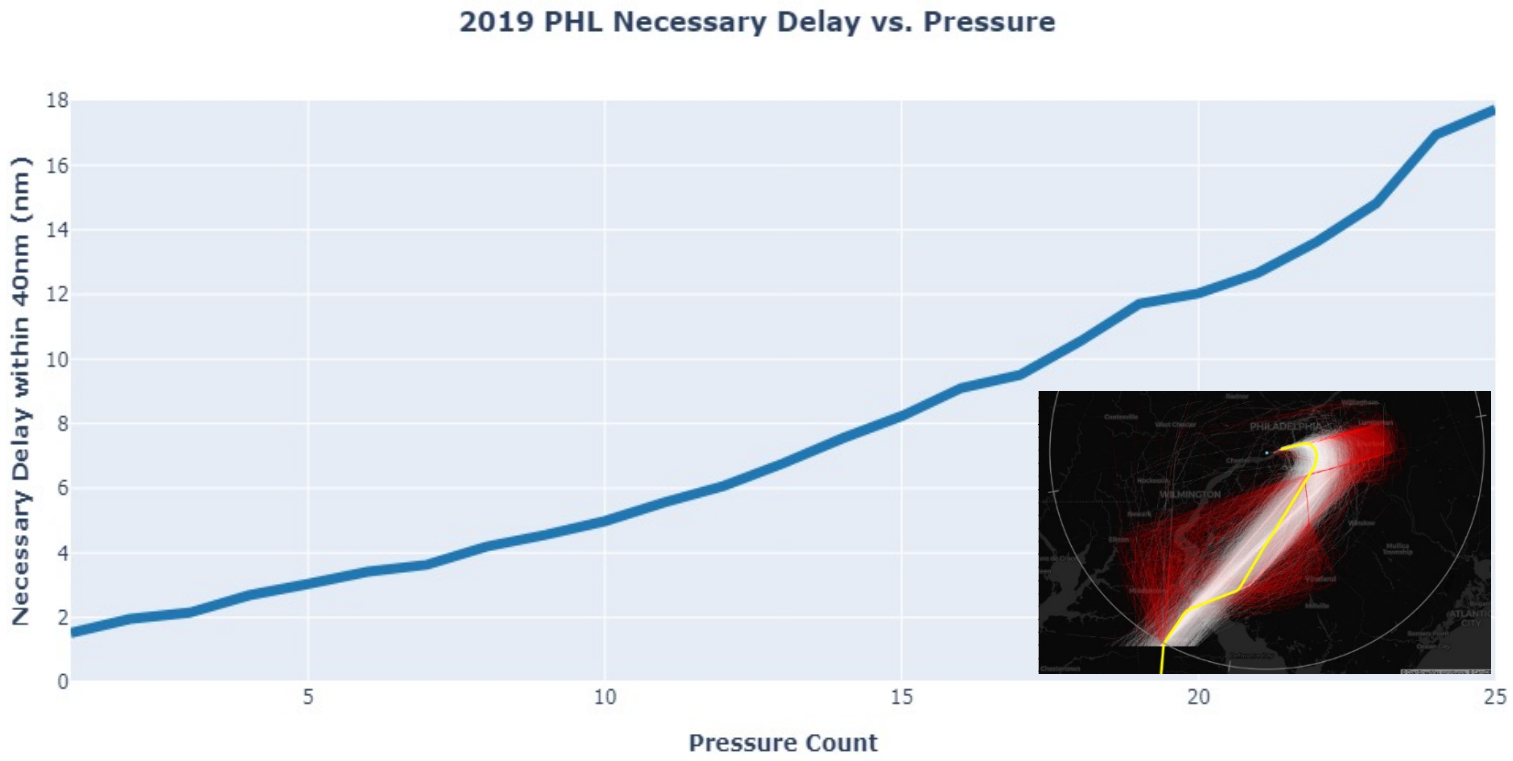


Red = High Demand/Pressure in TRACON



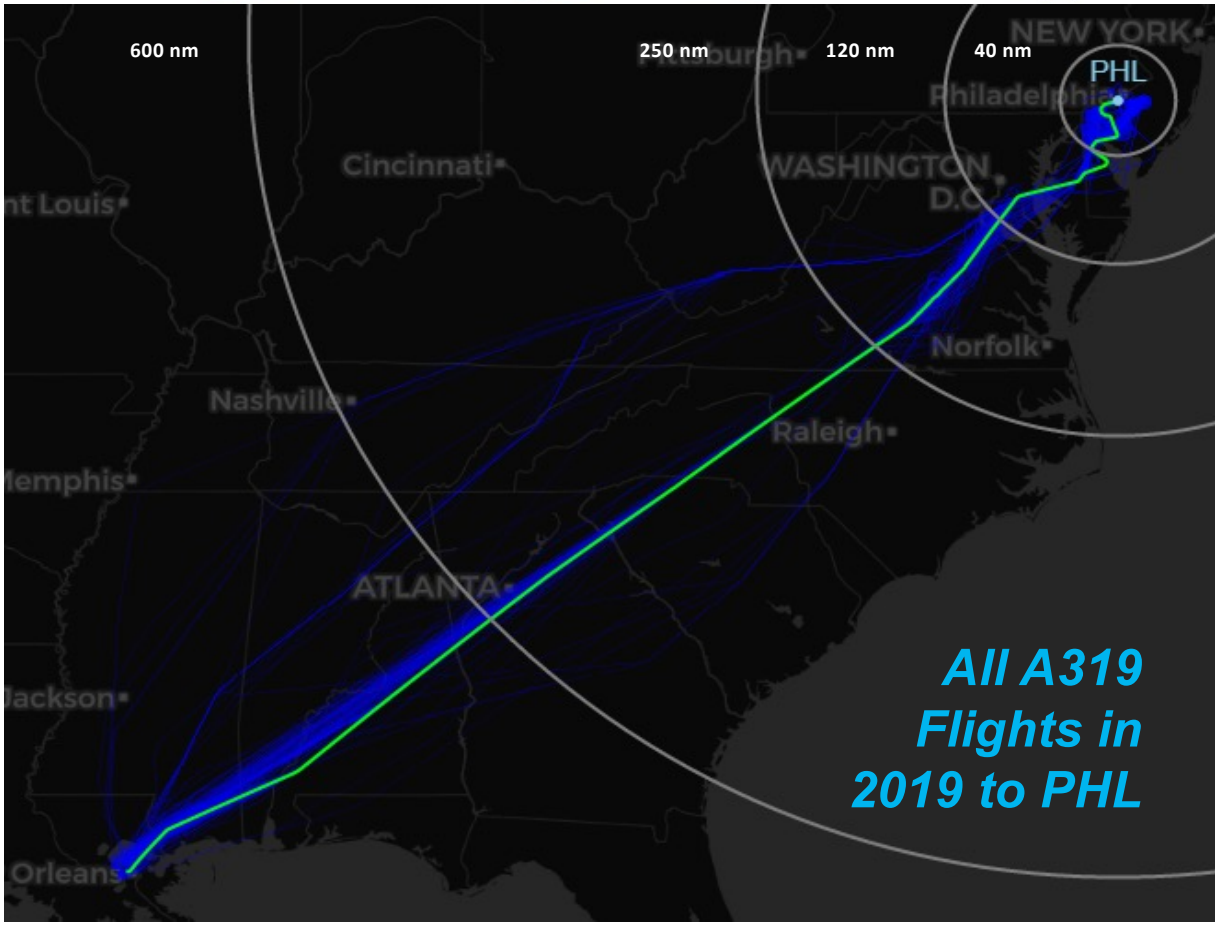
Blue = Low Demand/Pressure

TRACON Delay Increases with Demand/Pressure

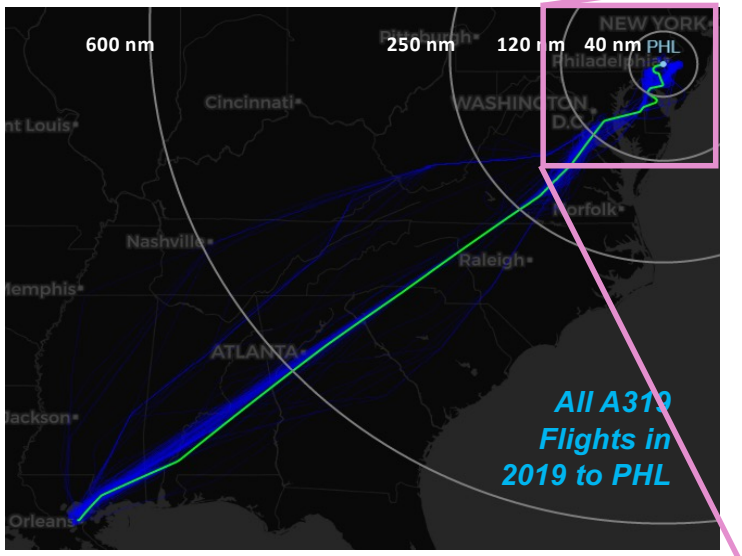


Pressure is defined as number of aircraft in the TRACON when measured flight enters

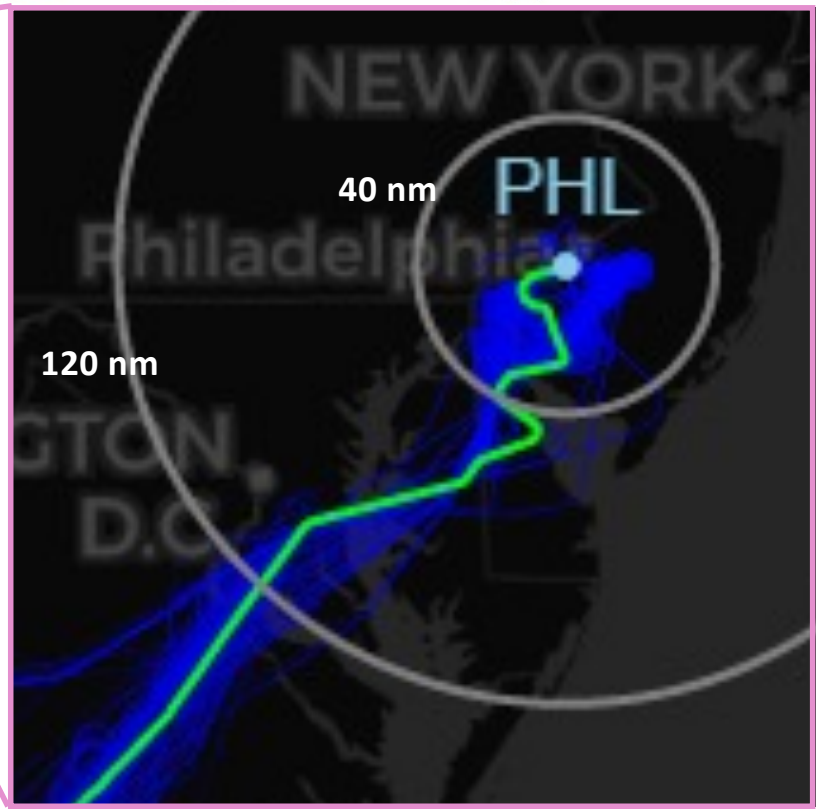
Example Flight – A319 MSY to PHL



Example Flight – A319 MSY to PHL

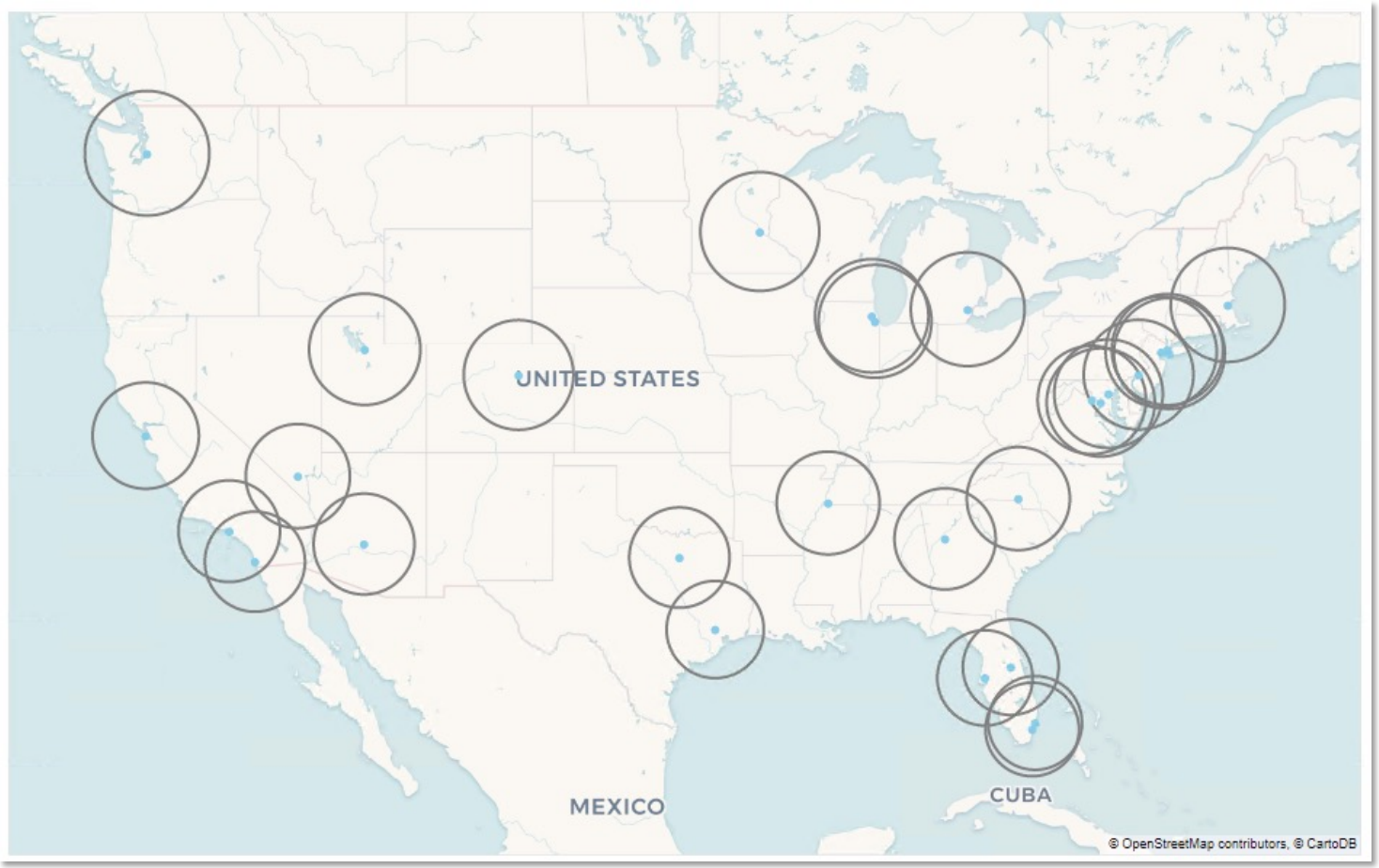


TBO will improve horizontal path

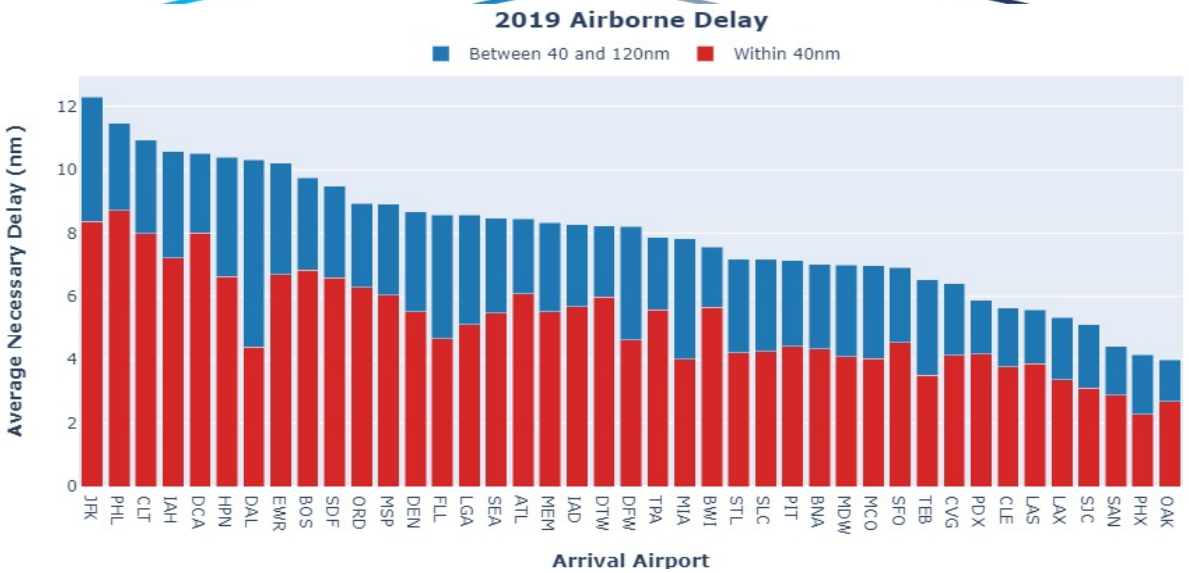


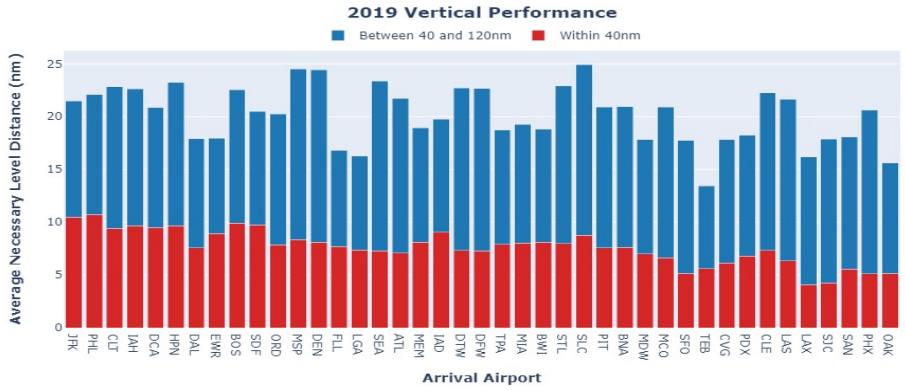
Redistribute necessary delay existing within 120 nm

Core 30 Airports with 120nm Circles



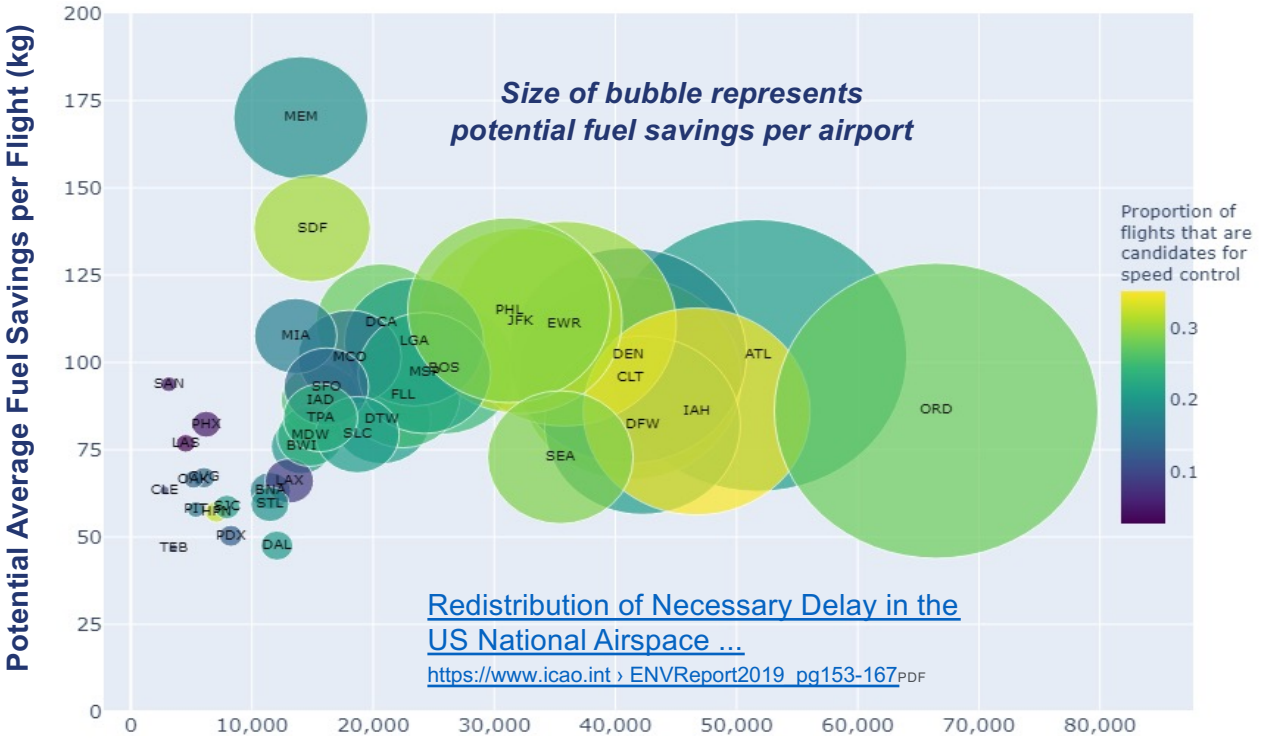
Necessary Delay by Airport





Key Airport Avg. Potential Fuel Burn Benefit Opportunity

Opportunities are not the sole driver of implementation decisions. Implementation decisions are driven by executability and risks, as well as on research results, shortfalls that remain after initial implementation and other constraints such as budget, workforce training and sustainment needs.



Redistribution of Necessary Delay in the US National Airspace ...
https://www.icao.int › ENVReport2019_pg153-167PDF


Opportunities:
TBO Improvement “Reduced Delay”

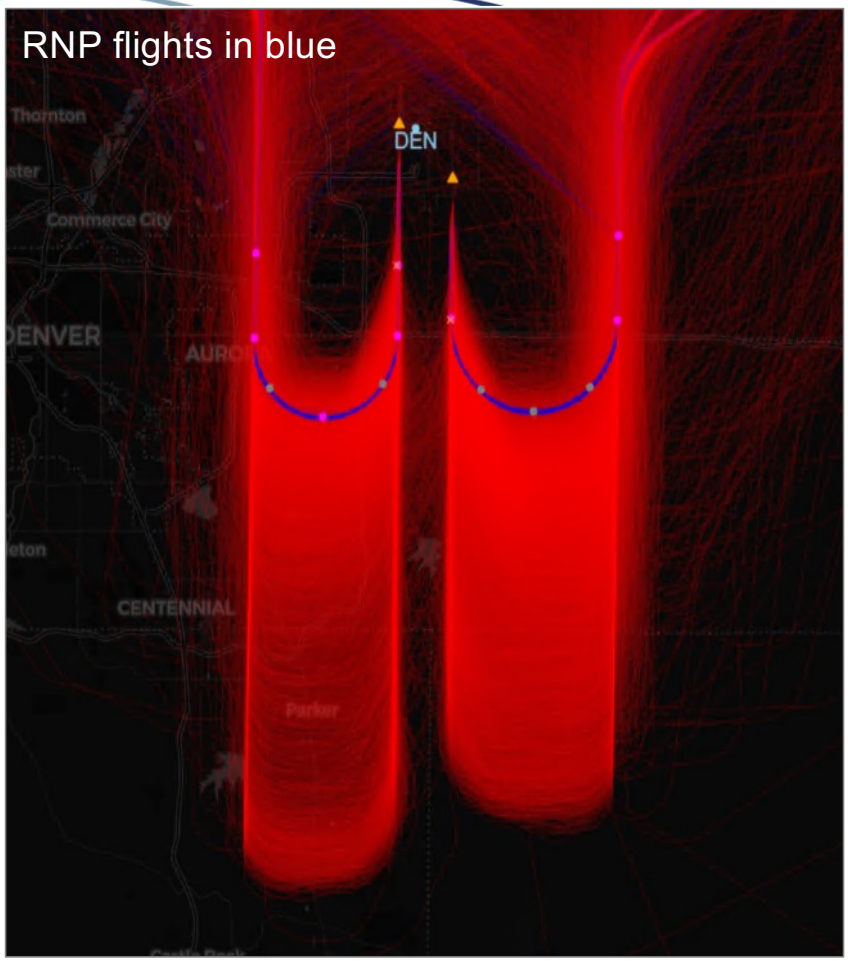
TBO Improvement Opportunities

How can we distinguish potential for:

“Delay Savings”
(distance/time with fuel/CO2)

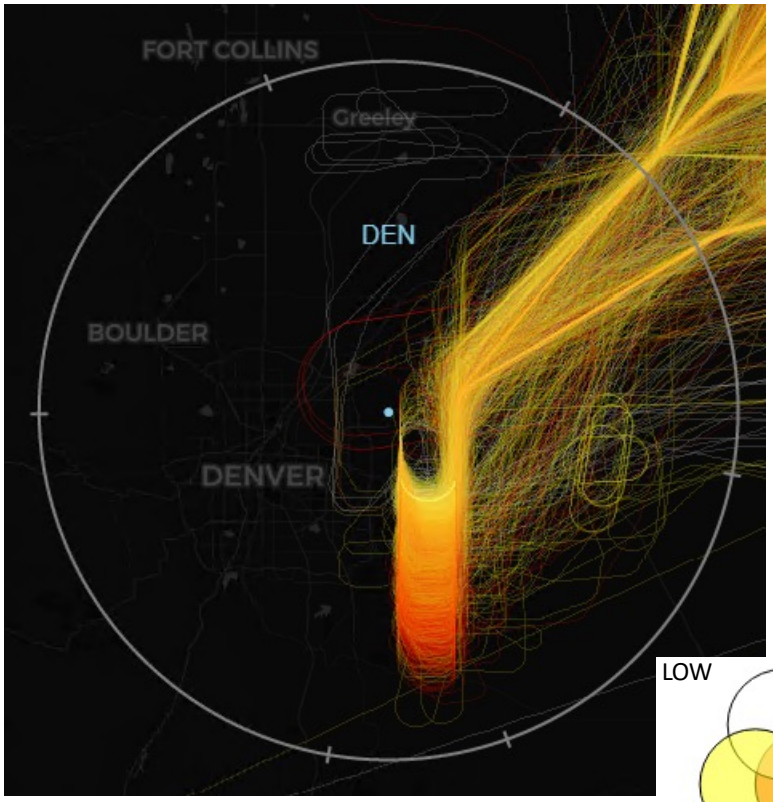
vs

“Necessary Delay Redistribution”
(efficiency/fuel/CO2)

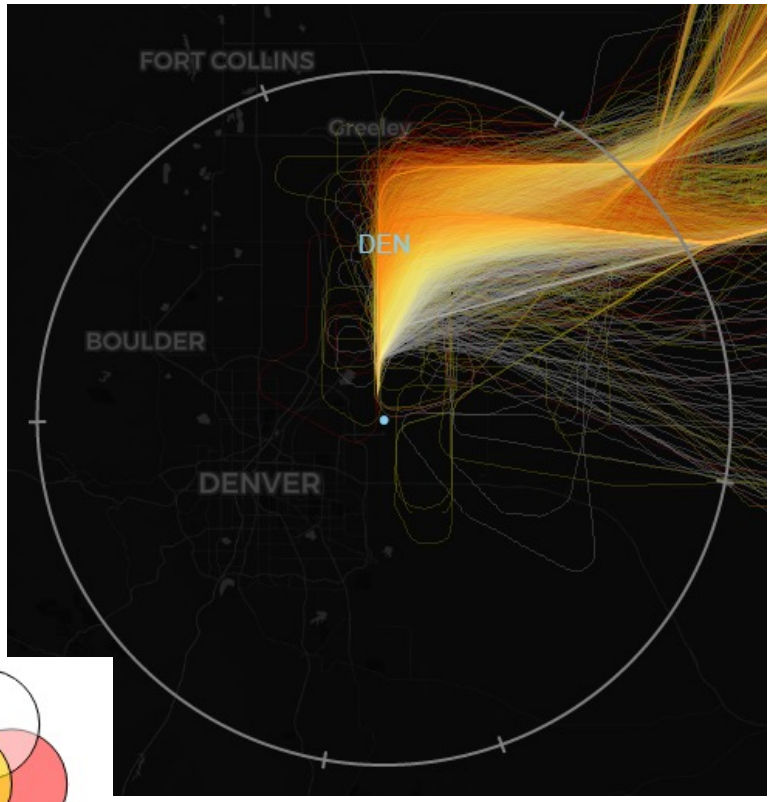


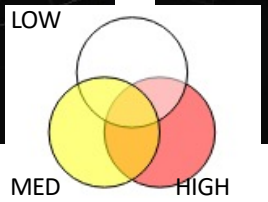
DEN Arrivals from NE Corner Post Pressure vs Route Length

Arrivals to 35R

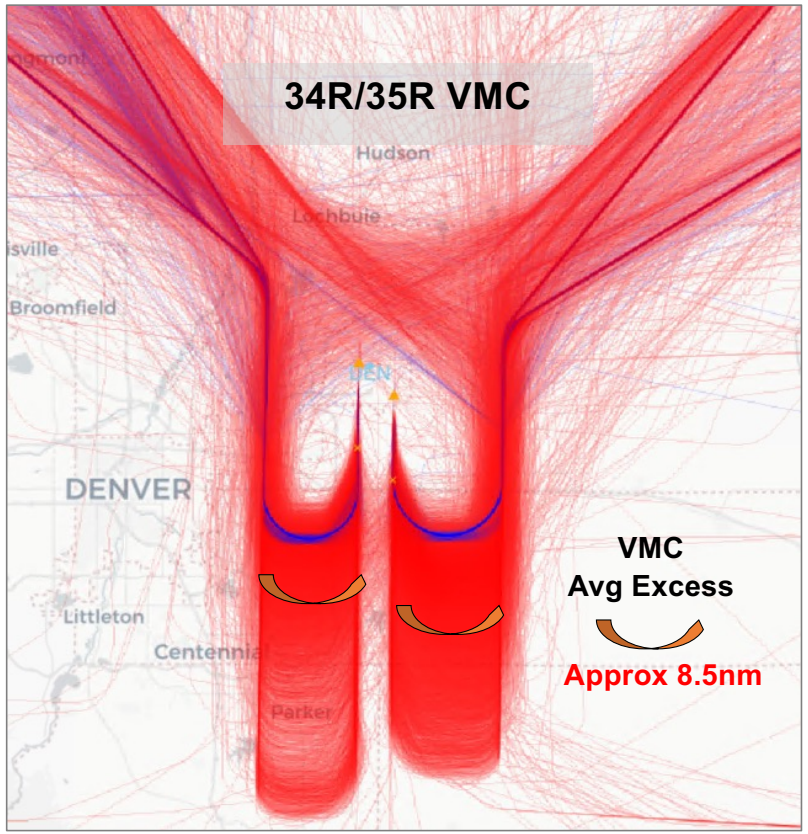


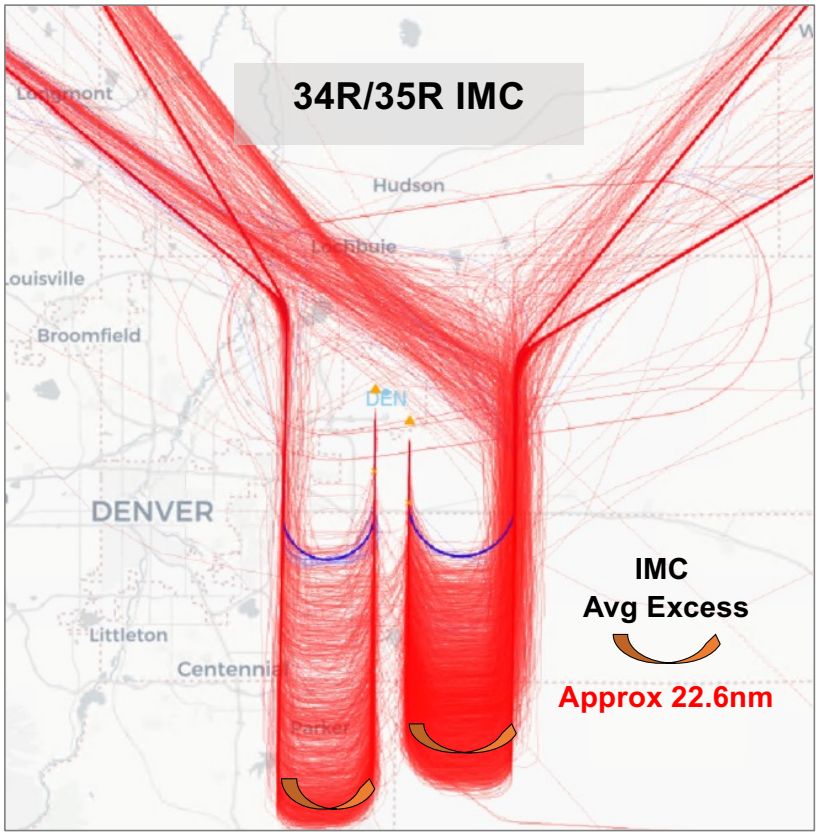
Arrivals to 16L





DEN Arrivals in North Flow - VMC vs IMC





DEN 2019 RNP Usage Shortfall

by Pressure and Meteorological Conditions

Pressure Category	Potential Change in Distance Flown Due To IMC-VMC and Pressure					
	VMC (89.6%)			IMC (10.4%)		
	Number of Flights	Prop. of Flights	Avg. Dist. Above RNP Pattern Dist. (nm)	Number of Flights	Prop. of Flights	Avg. Dist. Above RNP Pattern Dist. (nm)
High	26,892	37.3%	11.3	3,384	40.4%	27.6
Medium	36,737	51.0%	7.3	4,198	50.0%	20.5
Low	8,406	11.7%	4.4	805	9.6%	12.8
All	**72,035**	**100%**	**8.5**	**8,387**	**100.0%**	**22.6**

DEN 2019 RNP Usage Shortfall

by Pressure, Meteorological Conditions and Equipage Rate

Pressure Category	Potential Change in Distance Flown Due To IMC-VMC and Pressure					
	VMC (89.6%)			IMC (10.4%)		
	Number of Flights	Prop. of Flights	Avg. Dist. Above RNP Pattern Dist. (nm)	Number of Flights	Prop. of Flights	Avg. Dist. Above RNP Pattern Dist. (nm)
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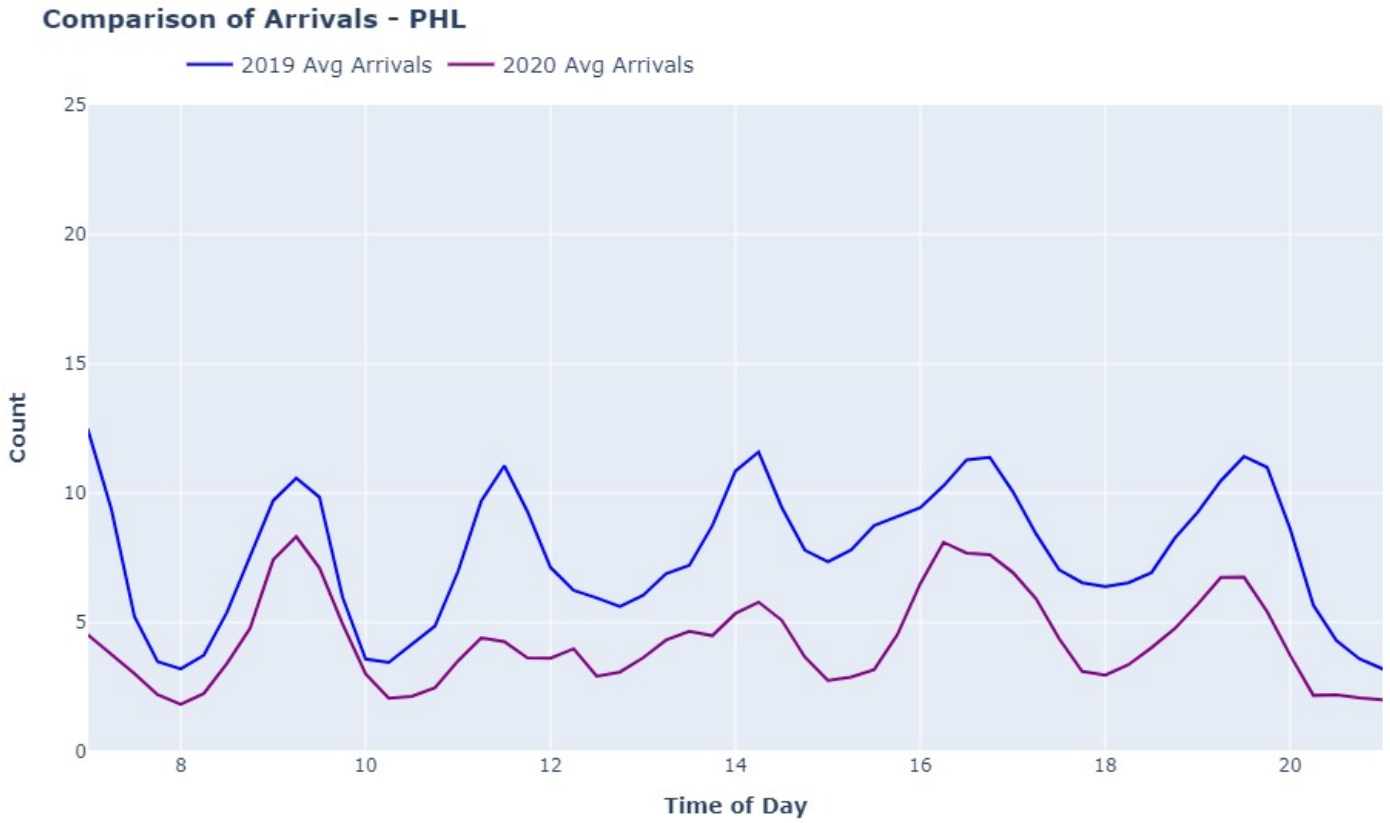
All	72,035	100%	**8.5**	8,387	100.0%	**22.6**

Carrier	Proportion RNP Equipped	# Downwind Flights with RNP Equipage	# Downwind Flights that Flew RNP Turn	RNP Success Rate for Downwind Flights			
				Overall	High	Medium	Low
100% Equipped Fleet	100%	31,066	14,625	47.1%	16.9%	47.6%	72.3%
Non-100% Equipped Fleet	54.8%	27,904	7,580	27.2%	10.4%	31.0%	47.5%


Opportunities:
Demand drives the size of the opportunity to improve

Philadelphia International Airport (PHL)

ASPM Qtr. Hr. Data for 2019 & 2020 (Reportable Hours – 0700 – 2159)



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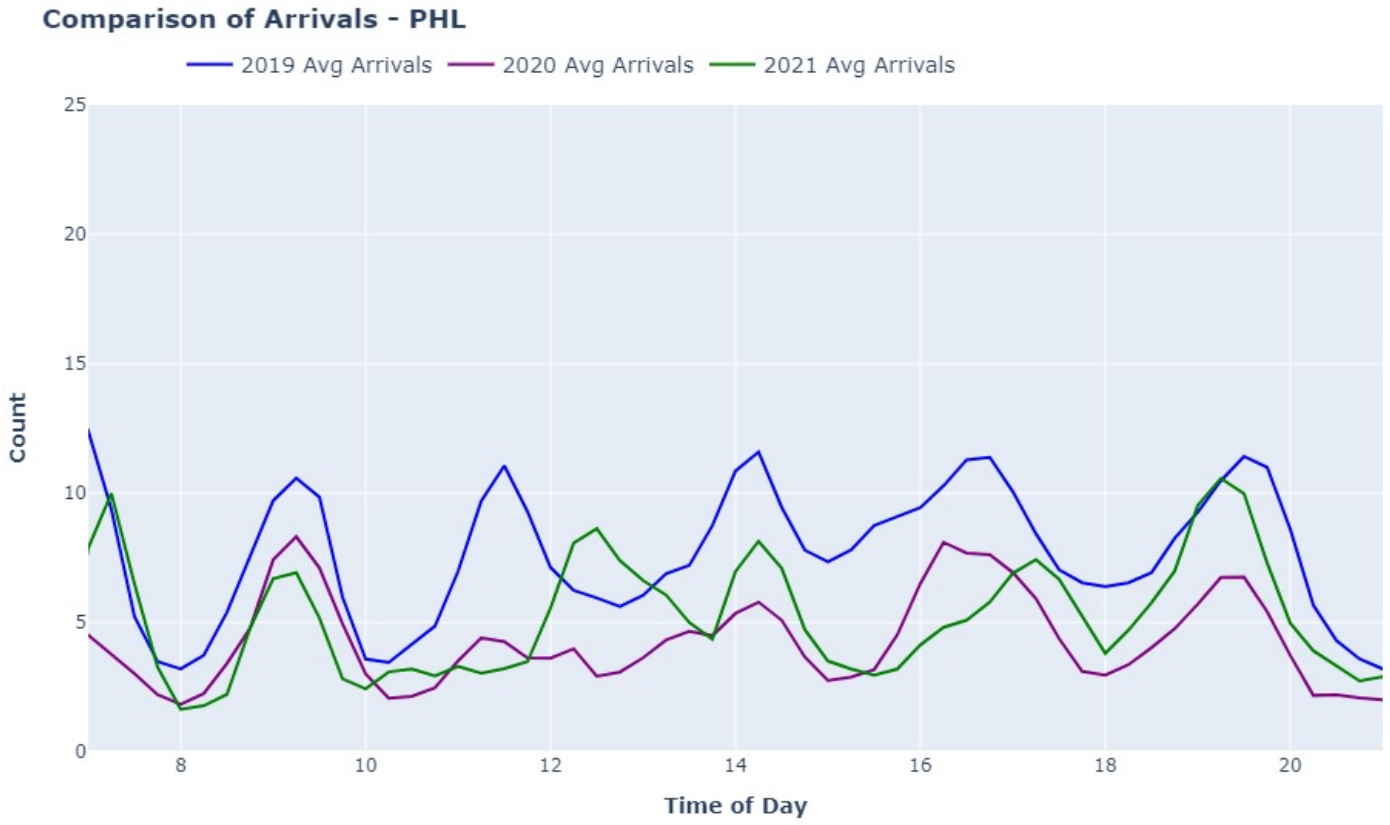
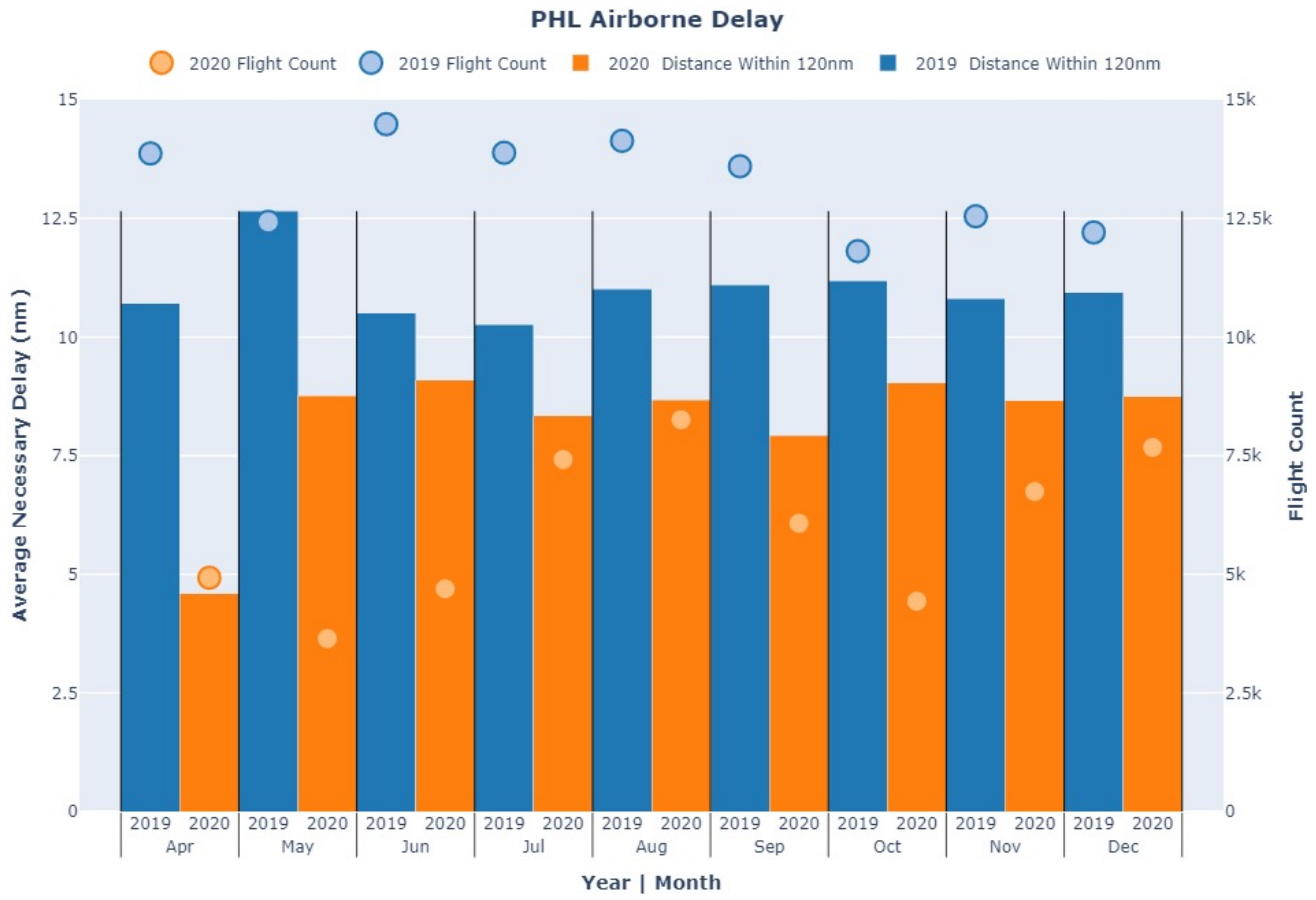
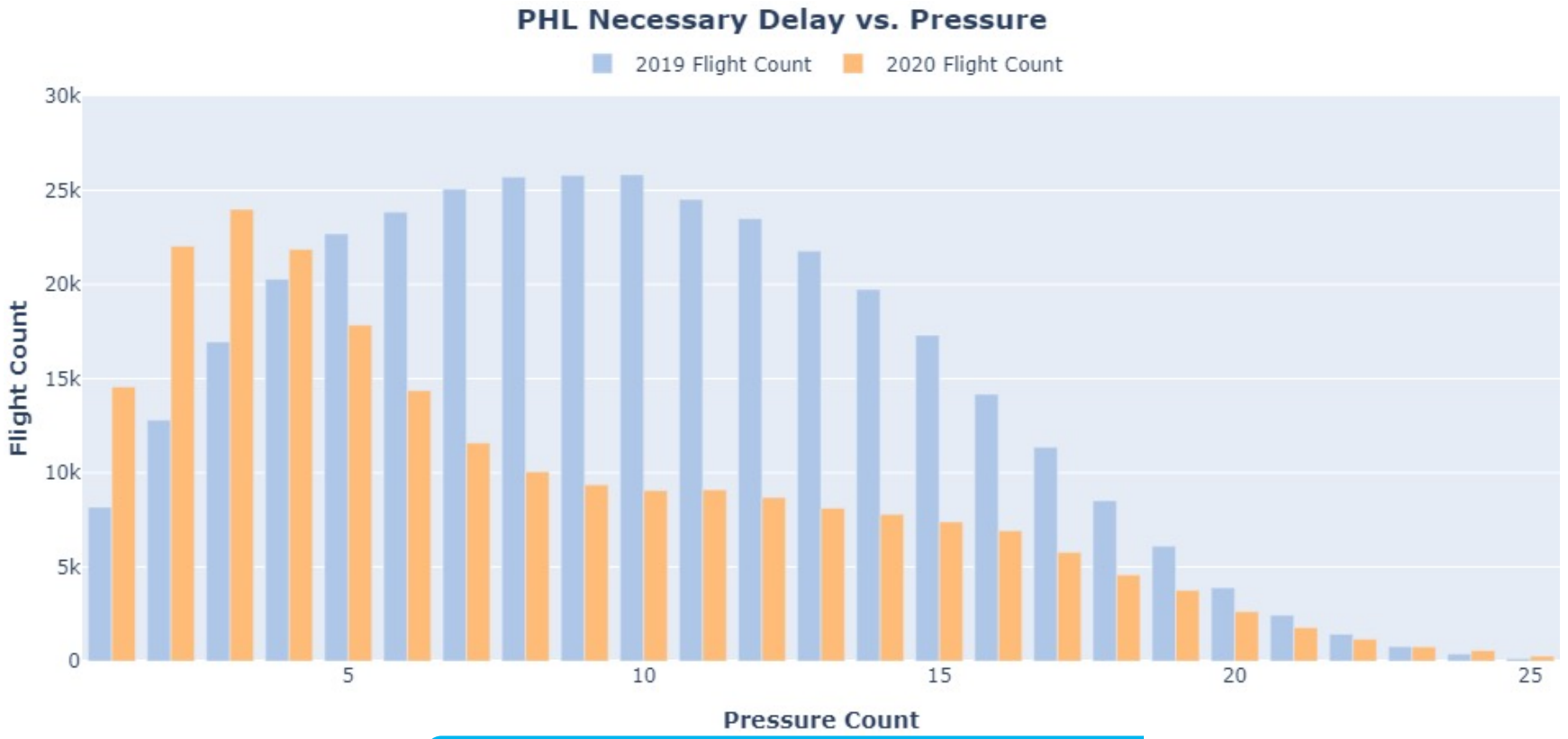


Average Arrival Performance to PHL

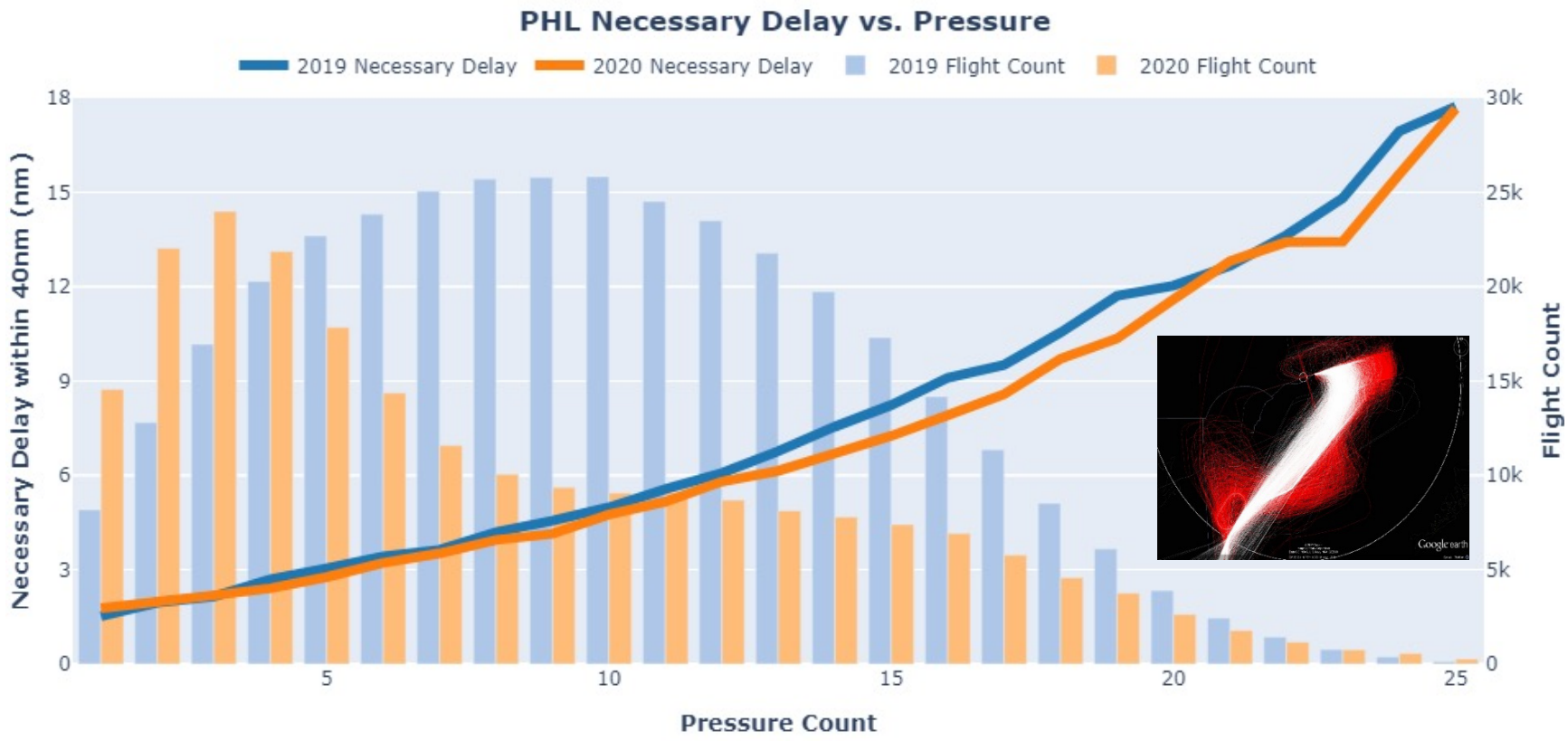


Demand-Induced Change in Pressure



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

TRACON Delay Increases with Demand/Pressure



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


Demand changes from COVID
also impact baselines for
future decision-making

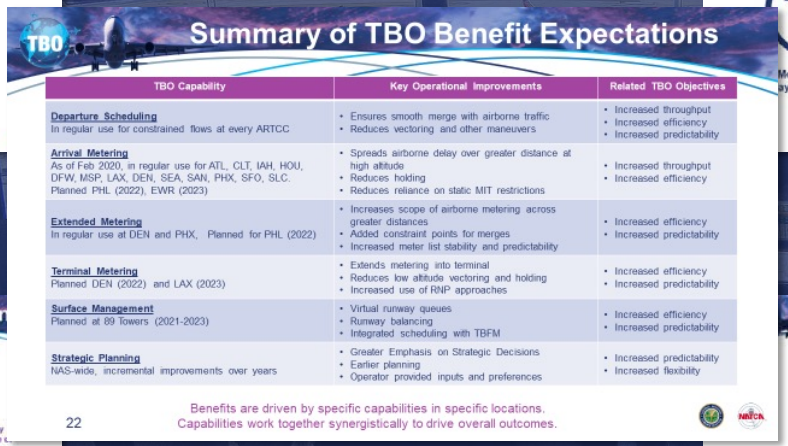

Questions
dave.knorr@faa.gov
martin.durbin@faa.gov

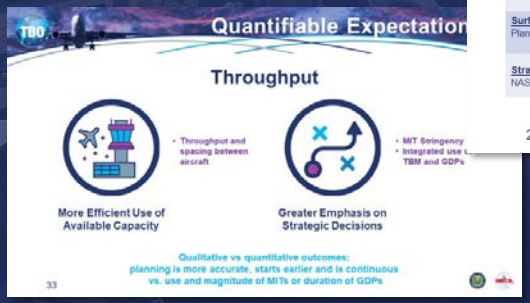
Expectations

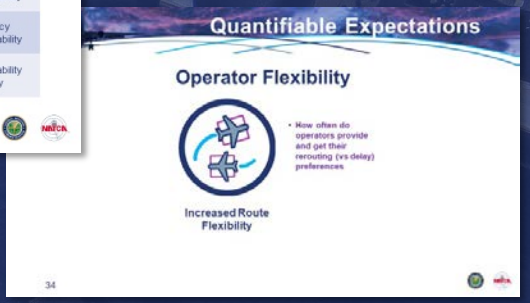
Aaron Wilkins, Doug Swol, Bob Tyo and **Danny Noh**

Program Management Office

Past Exchanges on Benefit Expectations





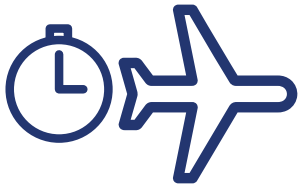


9-AJT-TBO@faa.gov

https://www.faa.gov/air_traffic/technology/tbo/

TBO Overview

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



Time-Based Management (TBM)

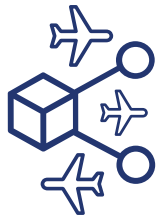
Dep Scheduling, Airborne Metering and Automated Surface Mngmt.
Complemented by Conventional TMIs as Needed

Helps manage trajectories by scheduling and metering aircraft through constraint points

Performance Based Navigation (PBN)

Metroplex
RNP w/RF Turns
Etc.

Enables aircraft to more accurately navigate along their trajectories



Enabling Technologies

SWIM
DataComm
Web-based Planning Tool
Etc.

Expands and automates sharing of common information about aircraft trajectories

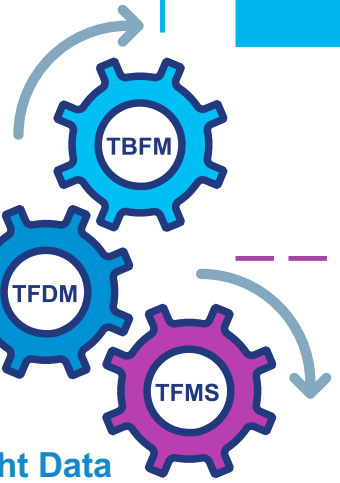
Decision Support Systems *(The 3 T's)*

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 NAS Constraint Points

Departure Scheduling
Extended Metering
Adjacent Center and Arrival Metering
TSAS
IDAC



In development

Pre-departure Rerouting
Airborne Rerouting
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

TFDM: Surface Management

Electronic Flight Data (EFD)

Replace paper flights strips and provides electronic data exchange with FAA systems and non-FAA stakeholders

Utilizes enhanced data exchange from operators (via TFMS)

Integrates:
- Flight data
- Surveillance data
- Traffic Flow data
- Clearance data

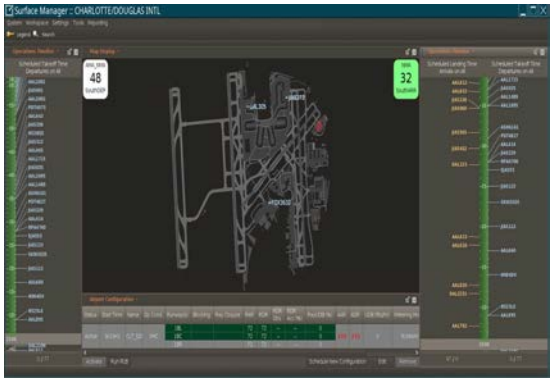
Collaborative Decision Making for the Surface (S-CDM) – Suite of Decision Support Tools

Surface Scheduling

Surface Metering

Runway Load Balancing

Airport Config Mgmt



Traffic Flow Management (TFM)

Integration with TFMS and TBFM to coordinate traffic manage constraints and create and support TBO.

Systems Consolidation

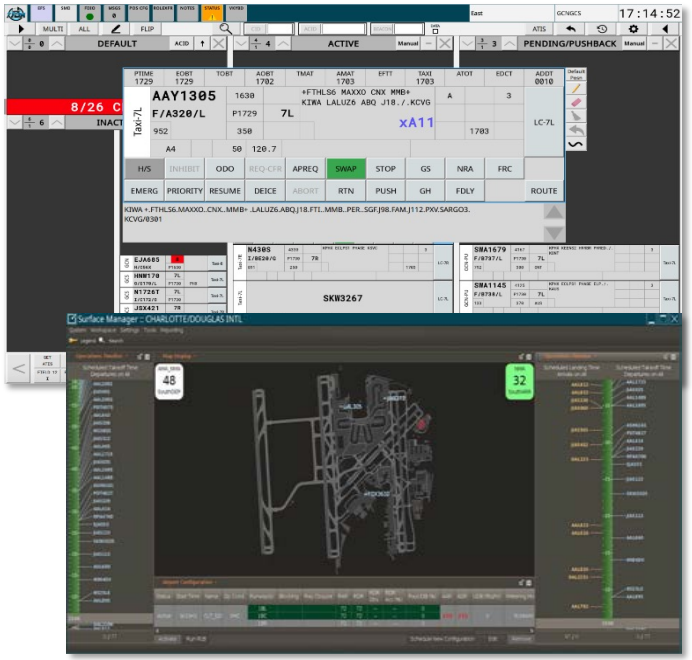
Systems to be consolidated include ARMT, DSP, EFSTS, AEFS.

Key Sites: PHX 2022; CLT 2023
Planned for 89 sites across the NAS
(27 of those sites with full Surface Management Suite)

TFDM: Key Benefits

TFDM Program benefits case established in 2016 as part of FAA Investment Decision

Benefit Mechanisms	Benefit Expectations
Surface queue management	Reduces fuel burn and emissions
Operators' ability to prioritize flights	Shift delay from higher priority flights to lower priority flights pre-departure
Shift call-for-release/en-route delay from taxiway to gate	Reduces fuel burn and emissions
Improved runway load balancing	Small increases in throughput by better balancing departure demand across departure runways
Improved data sharing	Improved predictability



TFDM EFS and Surface Management Displays

These benefits can only be fully realized via TBO where constraints from TBFM and TFMS are integrated with TFDM

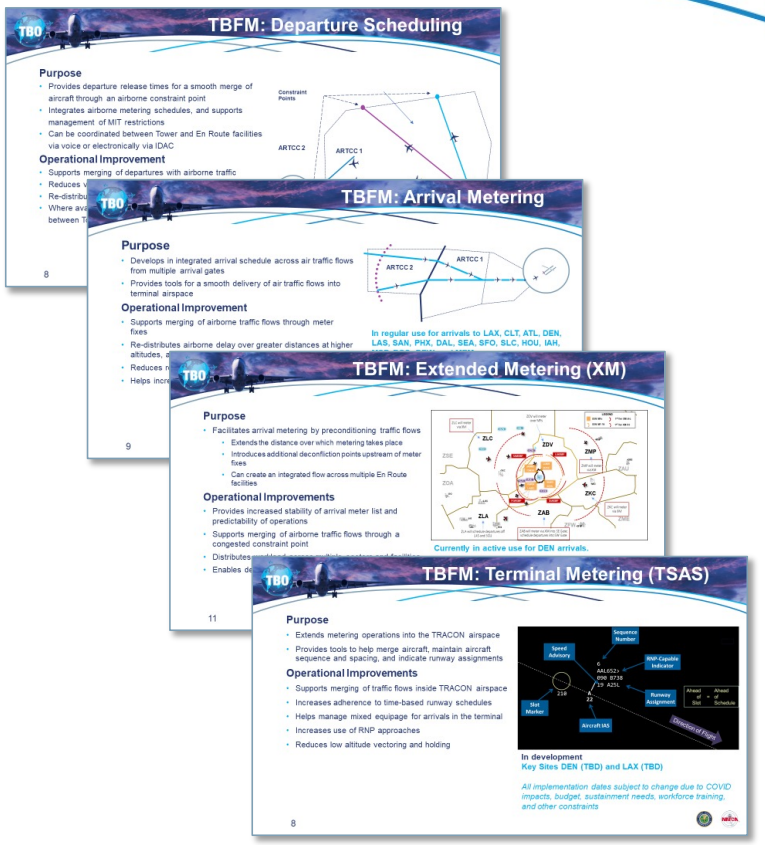
TBFM Overview

Purpose

- Helps manage air traffic flows by creating integrated time-based schedules through constraint points, and provides tools for smooth merging and sequencing of aircraft
- Applies additional spacing based on current and predicted traffic demand, aircraft trajectory and performance, winds, etc.
- TBFM capabilities are used to manage and coordinate anticipated delays through constraint points

Operational Improvement

- Provides integrated plan to facilities, and improves situational awareness for the management of flows
- Distributes workload across multiple facilities
- Supports the merging of departures with airborne traffic
- Re-distributes airborne delays over greater distances at higher altitudes, and reduces holding and vectoring
- Reduces reliance on static MIT restrictions
- Helps increase adherence to PBN procedures



TBFM: Terminal Metering

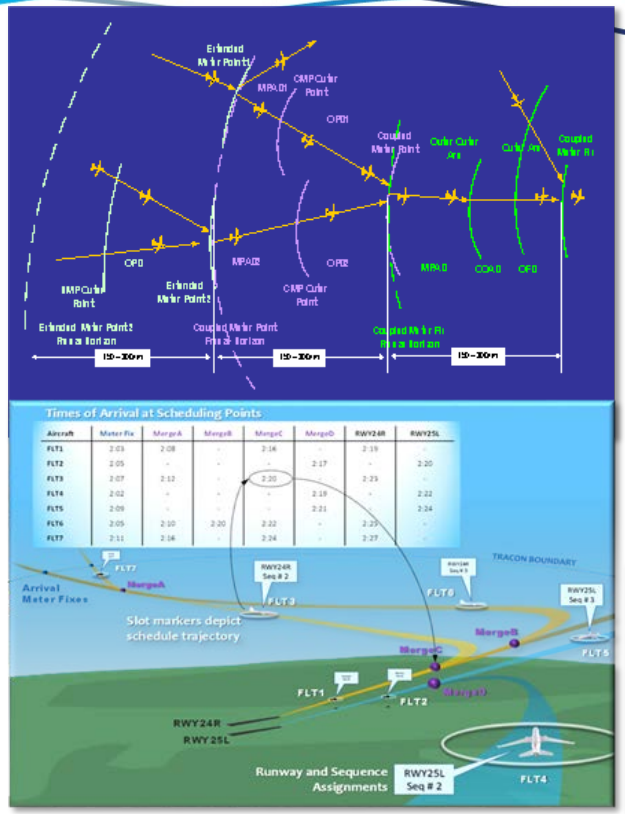
TSAS Program benefits case established in 2015 as part of FAA Investment Decision

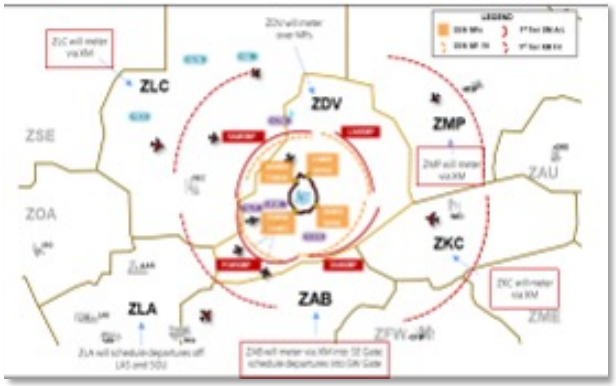
Extended Metering conditions air traffic flows for Terminal Metering

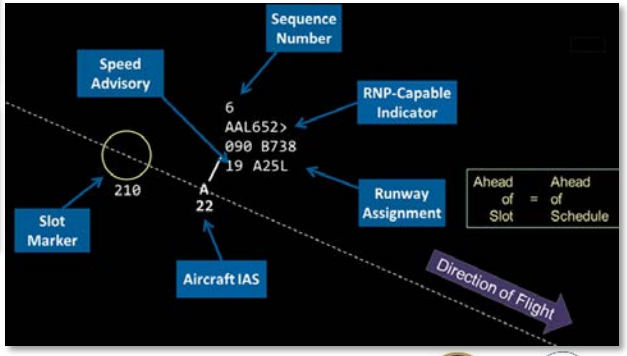
- Currently in use for arrivals into DEN

TSAS

- TBFM Release 4.15
- STARS Release 10
- Platform and capability testing on-going at WJHTC
- TSAS IOC TBD due to pandemic







TBFM: Key Benefits

Improvement	• Departure release times • IDAC electronic coordination between Tower and En Route	• Integrated arrival schedule • Extended Metering with additional deconfliction points	• Extend Metering into TRACON airspace
Benefit Mechanisms	• Smooths merges of departures with airborne traffic • Redistributes delay to the ground • Streamlines release process	• Redistributes delay at higher altitudes • Increases stability of arrival metering list and predictability of operations	• Helps manage mixed equipage for arrivals in the terminal • Increases use of RNP approaches
Benefit Expectation Examples	• Reduced taxi-out time	• Reduced vectoring and holding	• Reduced times in terminal airspace • Reduced low altitude vectoring and holding

These benefits are increased via TBO when metering tools are integrated and constraints integrated amongst TBFM, TFMS and TFDM!

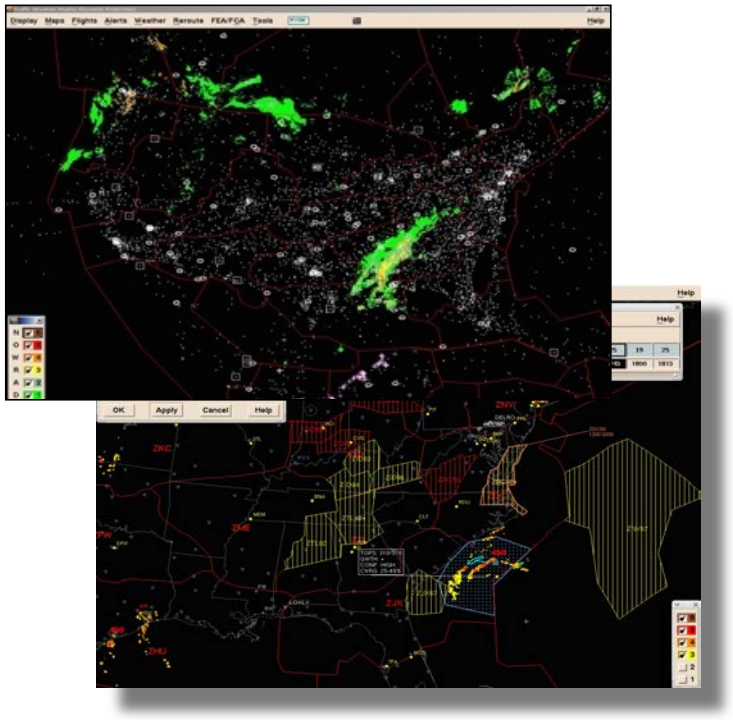
TFMS: NAS-Wide Flow Management

Purpose

- Creates demand predictions for airspace and airports
- Provides common situational awareness of current and forecasted weather impacts, SAA or other constraints
- Supports development of strategic TMIs to manage demand-capacity imbalances

Operational Improvements

- Enables pre-departure and airborne rerouting
- Provides visibility into surface operations through surface viewer
- Supports integrated traffic flow management by providing situational awareness of:
  - Demand
  - Delays for managing demand-to-capacity imbalances
  - Flight management options to users in conjunction with strategic TMIs



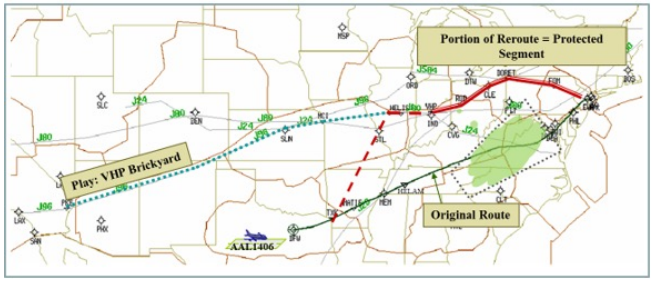
TFMS: R14 & R15 Key Benefits

TFMS Surface Viewer (R14)

- Real-time display of the airport surface movement and flight-specific data elements including
  - taxi times,
  - flight lists,
  - restriction and delay information,
  - runway configuration change alerts, and
  - surface aircraft Traffic Management Initiative (TMI) conformance

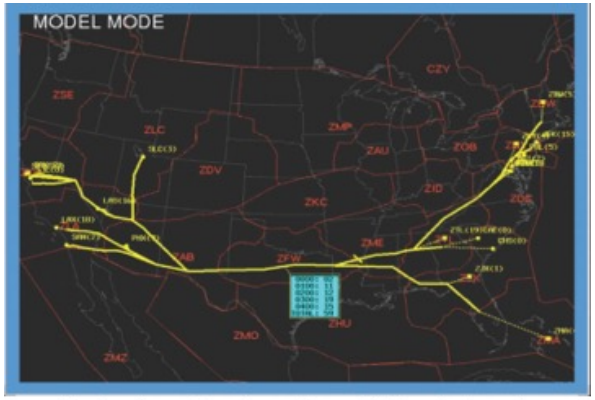
Airborne Reroute/Pre-Departure Reroute (ABRR/PDRR) (R14)

- Enhancements to the Route Amendment Dialog (RAD)
- Create reroute capability



Reroute Impact Assessments (RRIA) performance improvements (R15)

- Allows TMCs to see side-by-side comparison of multiple routes
- Allows operators to send the Coded Departure Route (CDR) code as part of the Trajectory Option Set (TOS) message



Display of reroute options with associated sector impacts

Release 14 (R14) Operational Date: 10/23/2021
Release 15 (R15) Operational Date: 10/15/2022

These benefits are increased via TBO when metering tools are integrated and constraints integrated amongst TBFM, TFMS and TFDM!

Questions

https://www.faa.gov/air_traffic/technology/tbo/

9-AJT-TBO@faa.gov

Expectations by Domain

Integrated TBO Benefit Mechanisms

Chad Wakefield, *System Operations Services*

Ayaz Kagzi, *Air Traffic Services*

David Leopold, *Air Traffic Services*

Past Exchanges on Benefit Mechanisms

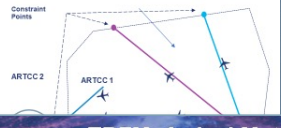
TBFM: Departure Scheduling

Purpose

- Provides departure release times for a smooth merge of aircraft through an airborne constraint point
- Integrates airborne metering schedules, and supports management of MIT restrictions
- Can be coordinated between Tower and En Route facilities via voice or electronically via IDAC

Operational Improvement

- Supports merging of departures with airborne traffic
- Reduces v
- Re-distribu
- Where ava
  between T



8

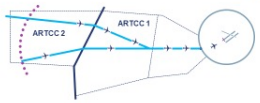
TBFM: Arrival Metering

Purpose

- Develops in integrated arrival schedule across air traffic flows from multiple arrival gates
- Provides tools for a smooth delivery of air traffic flows into terminal airspace

Operational Improvement

- Supports merging of airborne traffic flows through meter fixes
- Re-distributes airborne delay over greater distances at higher altitudes, a
- Reduces r
- Helps incre



In regular use for arrivals to LAX, CLT, ATL, DEN, LAS, SAN, PHX, DAL, SEA, SFO, SLC, HOU, IAH,

9

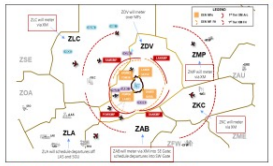
TBFM: Extended Metering (XM)

Purpose

- Facilitates arrival metering by preconditioning traffic flows
  - Extends the distance over which metering takes place
  - Introduces additional deconfliction points upstream of meter fixes
  - Can create an integrated flow across multiple En Route facilities

Operational Improvements

- Provides increased stability of arrival meter list and predictability of operations
- Supports merging of airborne traffic flows through a congested constraint point
- Distributes workload across multiple sectors and facilities
- Enables delay to be absorbed over longer distance



Currently in active use for DEN arrivals.

Planned for PHL and EWR (2022)

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

11

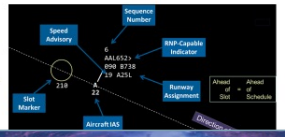
TBFM: Terminal Metering (TSAS)

Purpose

- Extends metering operations into the TRACON airspace
- Provides tools to help merge aircraft, maintain aircraft sequence and spacing, and indicate runway assignments

Operational Improvements

- Supports merging of traffic flows inside TRACON airspace
- Increases adherence to time-based runway schedules
- Helps manage mixed equipage for arrivals in the terminal
- Increases
- Reduces k



8

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 NAS Constraint Points

Departure Scheduling
Extended Metering
Adjacent Center and Arrival Metering
TSAS
IDAC

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

In development

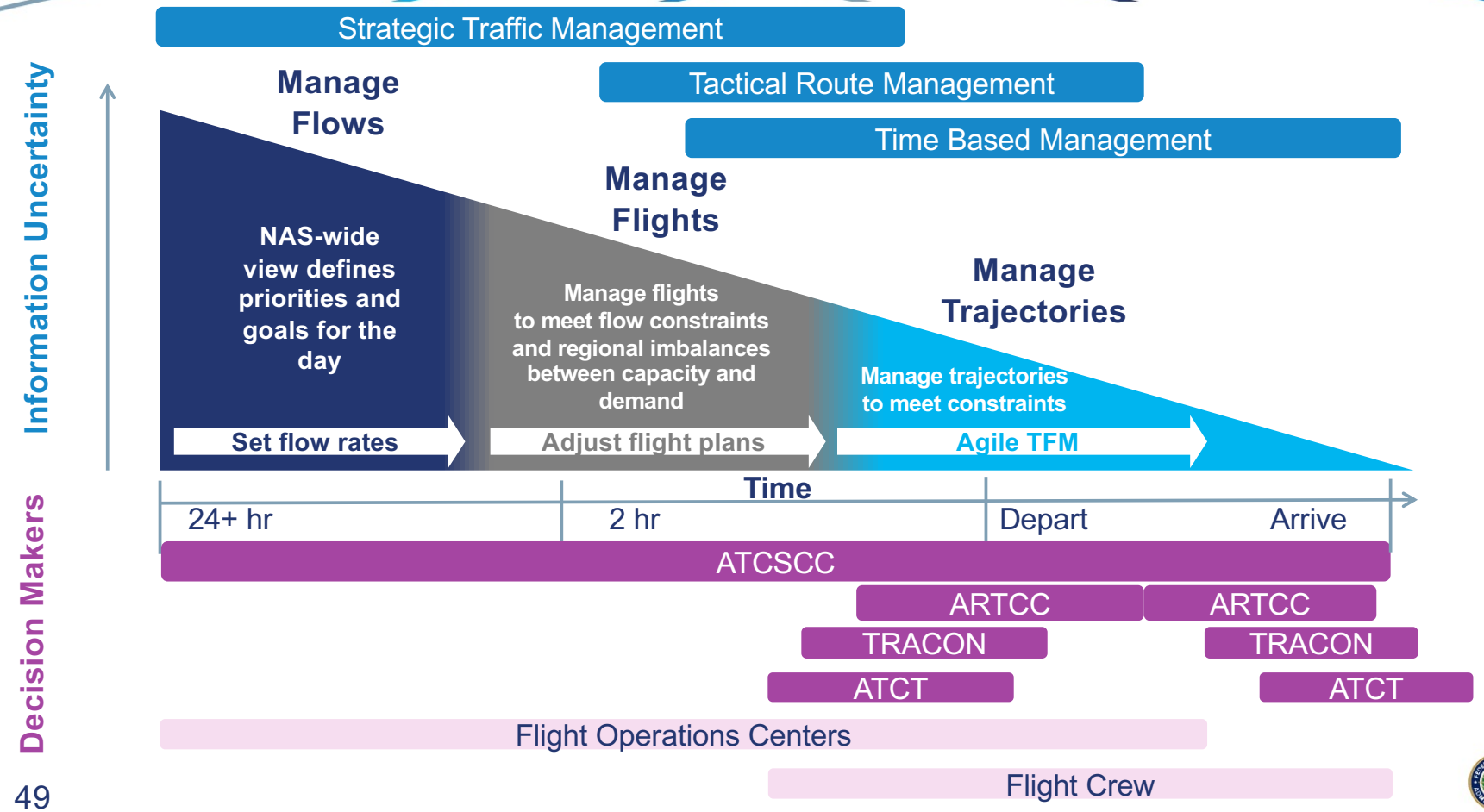
Terminal Flight Data Manager (TFDM)
Surface Management and Electronic Flight Data

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

23

Overview of TBO Across Different Planning Horizons

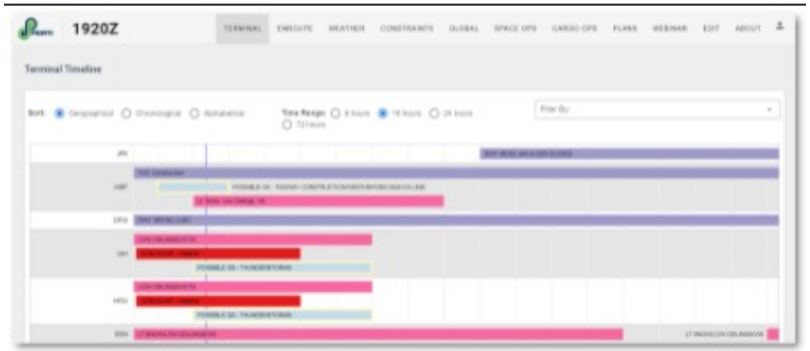


Improved Strategic Traffic Management

How it Works

- Strategic Traffic Management sets the stage for the day of operations, which begins before the day of operations, and includes on-going information exchange between the FAA and Flight Operators
- Continuous Strategic Planning is enhanced with Continuous Planner tool and the National Operations Dashboard (NOD), leading to improved situational awareness as well as improved strategic planning & decision making for the operators
- When needed, use of strategic TMIs such as GDPs, AFPs and CTOP helps pre-condition air traffic flows for TBM.
- During an active CTOP, automation assigns route options and ground delays based on program objectives and operator preferences as defined in TOS, which are submitted on a flight specific basis.

Continuous Planner



Updated System Status, Planned or Expected Traffic Management Initiatives

FAA **Operators**

Accurate and Timely Flight Specific Data

Expected Benefits:

- Improved demand predictions
- Improved schedule integrity on the day-of-operation
- Increased predictability on the day-of-operation
- More efficient use of available capacity
- Improved system efficiency
- Increased flexibility for flight operators

Enabling Capabilities:

- Continuous Planner Website
- Enhanced information sharing capabilities
- National Operations Dashboard (NOD)
- TFMS: TSD, GDP, AFP, CTOP, etc.

Increased Information Exchange

Enabling Capabilities

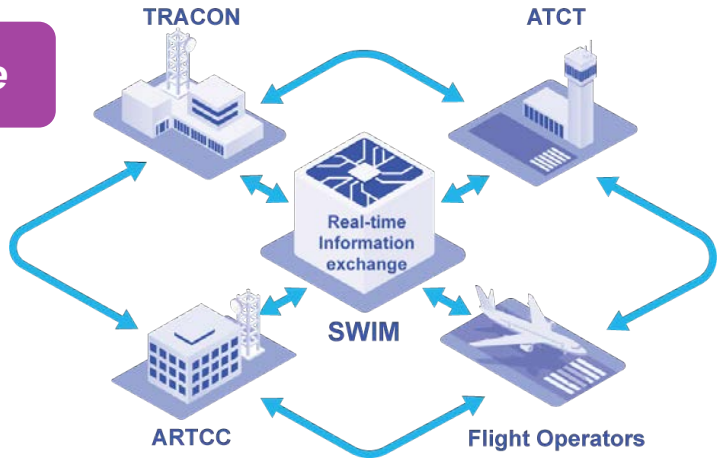
- System-Wide Information Management (SWIM)
- Controller Pilot Data Link Capability (CPDLC)
- Data-sharing between TFDM, TBFM and TFMS

Expected Benefits

- Accurate flight-specific information to support decision making
- Increased predictability
- Increased flexibility

Flight Operators *Provide*

- Planned & actual surface movement times
- Preferred runway
- Gate accessibility
- Ramp open/closed status
- Intent to hold on non movement/movement area



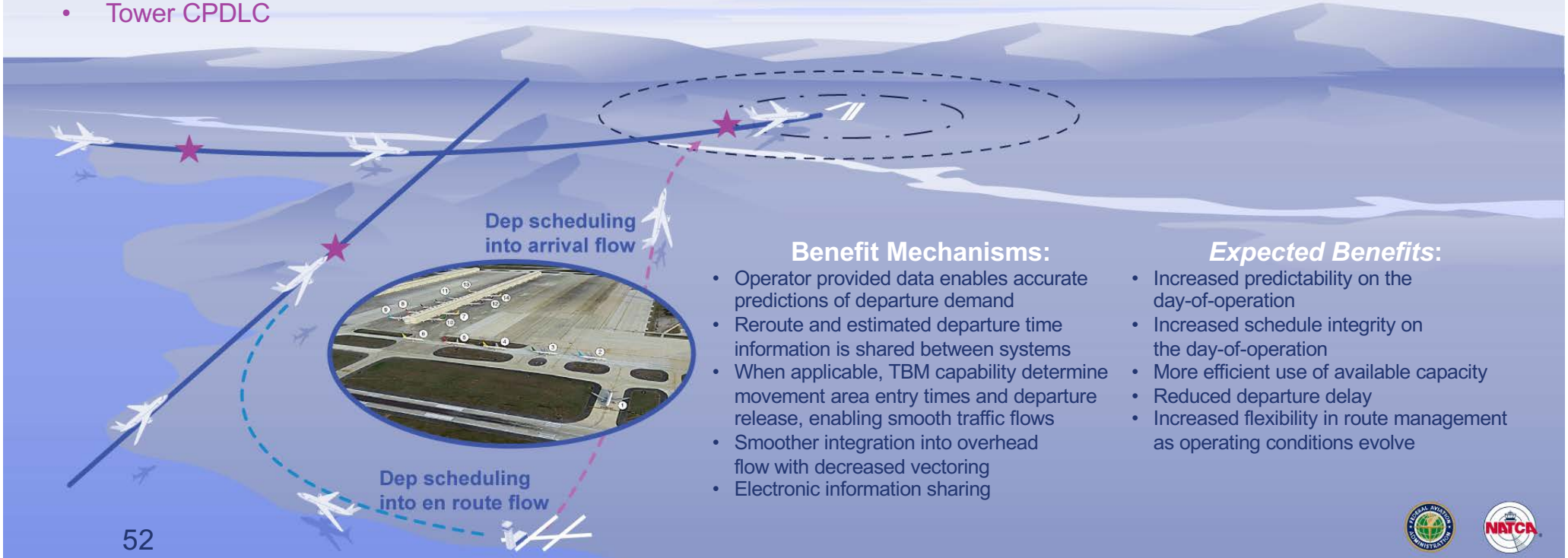
Flight Operators *Receive*

- Expected OFF times
- Airport configuration/rates
- Surface metering times
- Flight specific TMI status
- Surface substitution options
- Expected runway assignment

Integrated Departure Management

TBO Capabilities

- TFDM Automated Surface Management: Electronic Flight Strips, Runway Load Balancing and Surface Metering Program
- TBFM Departure scheduling and IDAC
- TFMS Pre-departure re-routes (PDRR)
- Improved departure release management: Integration of TFDM, TBFM and TFMS, and Increased Use of Operator Data
- Tower CPDLC



Benefit Mechanisms:

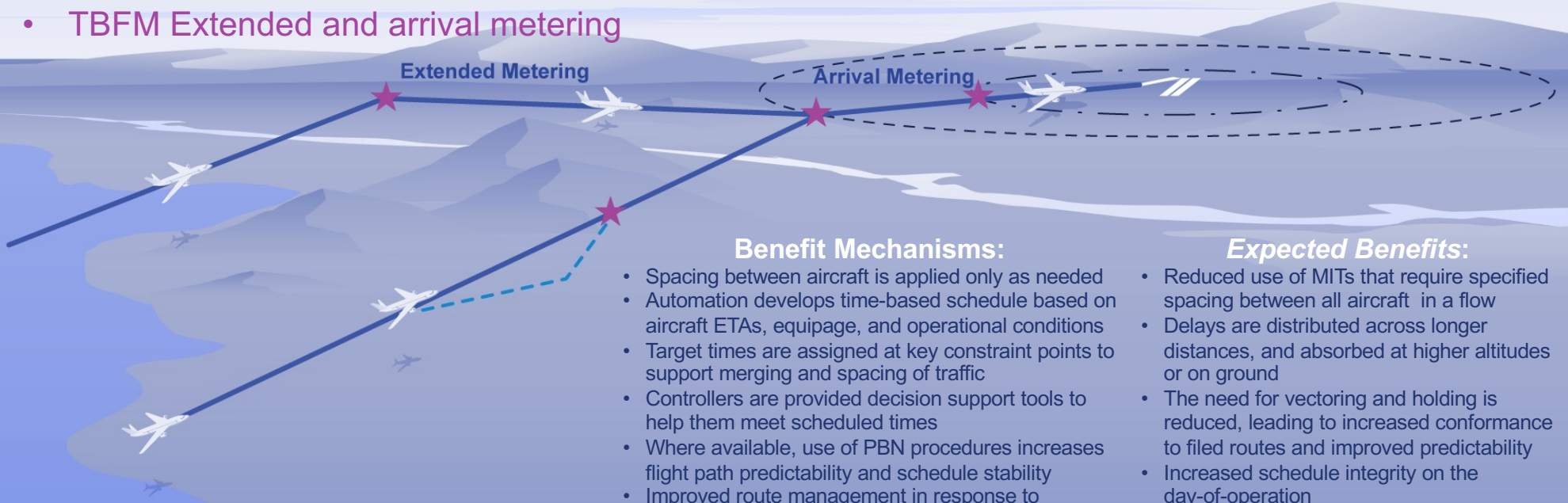
- Operator provided data enables accurate predictions of departure demand
- Reroute and estimated departure time information is shared between systems
- When applicable, TBM capability determine movement area entry times and departure release, enabling smooth traffic flows
- Smoother integration into overhead flow with decreased vectoring
- Electronic information sharing

Expected Benefits:

- Increased predictability on the day-of-operation
- Increased schedule integrity on the day-of-operation
- More efficient use of available capacity
- Reduced departure delay
- Increased flexibility in route management as operating conditions evolve

Integrated Airborne Operations

- TFMS Airborne Reroutes (ABRR)
- En Route CPDLC
- PBN Procedures
- TBFM Extended and arrival metering



Benefit Mechanisms:

- Spacing between aircraft is applied only as needed
- Automation develops time-based schedule based on aircraft ETAs, equipage, and operational conditions
- Target times are assigned at key constraint points to support merging and spacing of traffic
- Controllers are provided decision support tools to help them meet scheduled times
- Where available, use of PBN procedures increases flight path predictability and schedule stability
- Improved route management in response to evolving operating conditions
- Trajectory adjustments are communicated via voice or CPDLC
- Electronic information sharing

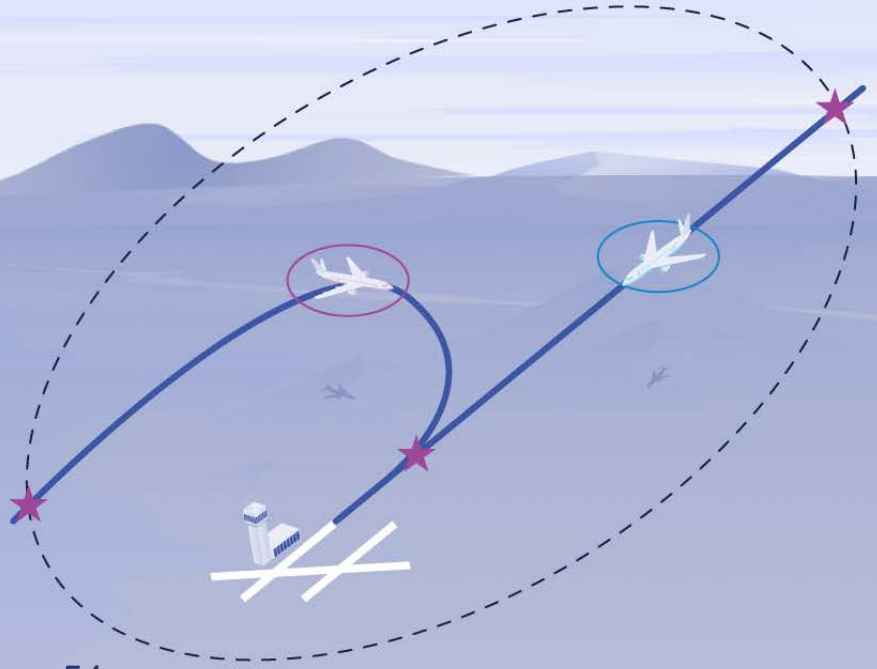
***Expected Benefits*:**

- Reduced use of MITs that require specified spacing between all aircraft in a flow
- Delays are distributed across longer distances, and absorbed at higher altitudes or on ground
- The need for vectoring and holding is reduced, leading to increased conformance to filed routes and improved predictability
- Increased schedule integrity on the day-of-operation
- Increased flexibility with tactical reroutes

Integrated Terminal Operations

TBO Capabilities

- TBFM Terminal sequencing and spacing (TSAS)
- RNP AR approaches with RF legs
- Integration of TFDM and TBFM: Airport Surface Mngmt



Benefit Mechanisms:

- Flight operators ensure equipage is appropriately reflected in the flight plan
- Time-based schedule developed in en route is carried into the terminal
- Target times are assigned at key terminal constraint points to support merging and spacing of traffic
- Controllers are provided decision support tools to help them meet scheduled times, and manage mixed equipage
- Where available, use of PBN procedures increases flight path predictability and schedule stability
- Electronic information sharing

Expected Benefits:

- Delays are distributed across longer distances, and absorbed at higher altitudes or on ground
- The need for vectoring and extended downwinds is reduced, leading to increased conformance to filed procedures and improved predictability
- Better use of available runway capacity
- Increased schedule integrity on the day-of-operation

Questions

https://www.faa.gov/air_traffic/technology/tbo/

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Achievements

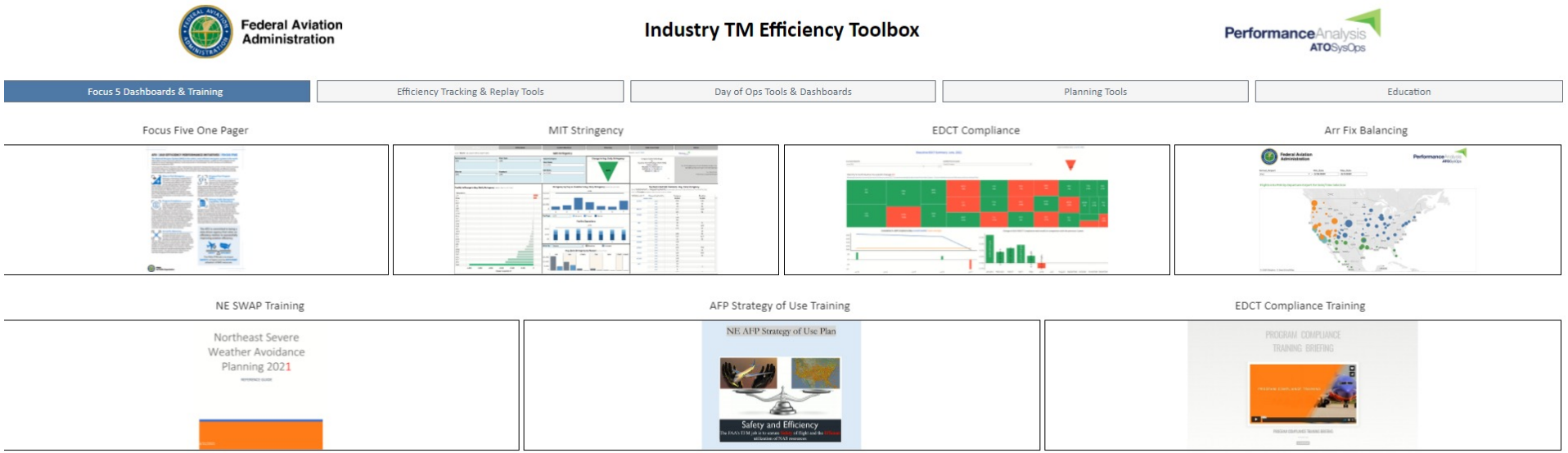
Curt Rademaker
System Operations Services

Almira Ramadani
Air Traffic Services

Achievements…

Industry TM Efficiency Toolbox

- One-stop-shop for all efficiency metrics
  - https://explore.dot.gov/views/IndustryTMEfficiencyToolbox/Links?:embed=y

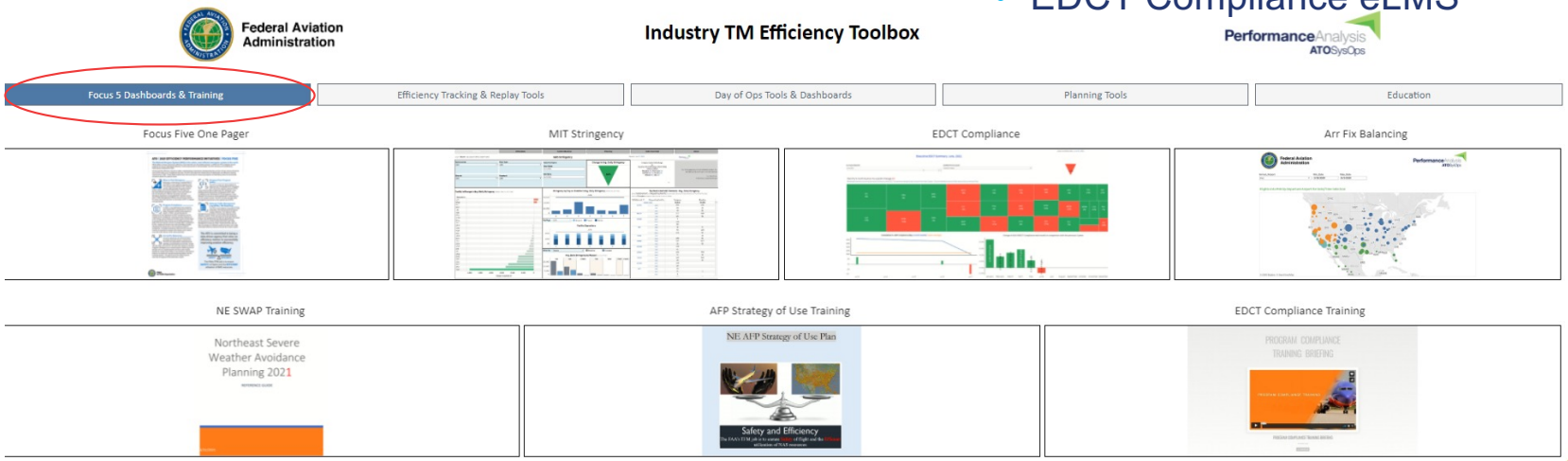


Achievements…

Focus 5 Dashboards and Training

- MIT Stringency
- EDCT Compliance
- Arrival Fix Balancing

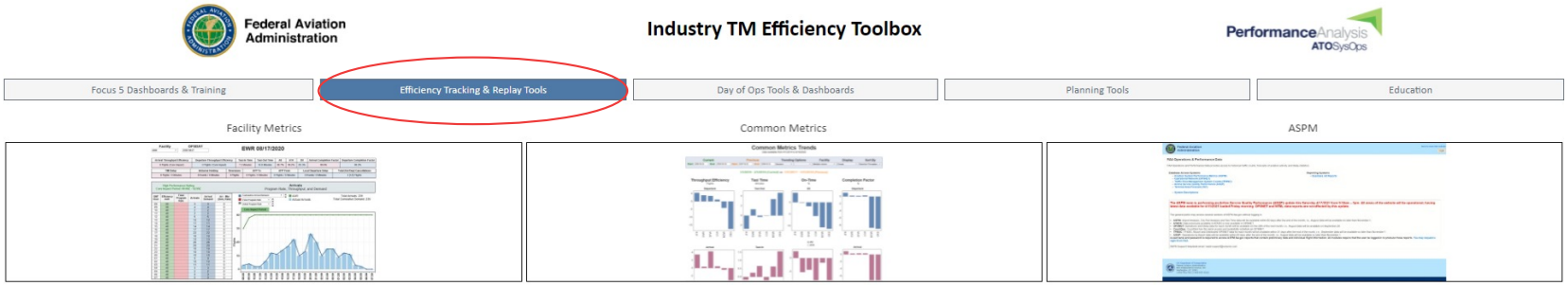
- Educational Material
  - The Focus Five Initiatives “One Pager”
  - NE SWAP
  - AFP Strategy of Use
  - EDCT Compliance eLMS



Achievements…

Efficiency Tracking and Replay Tools

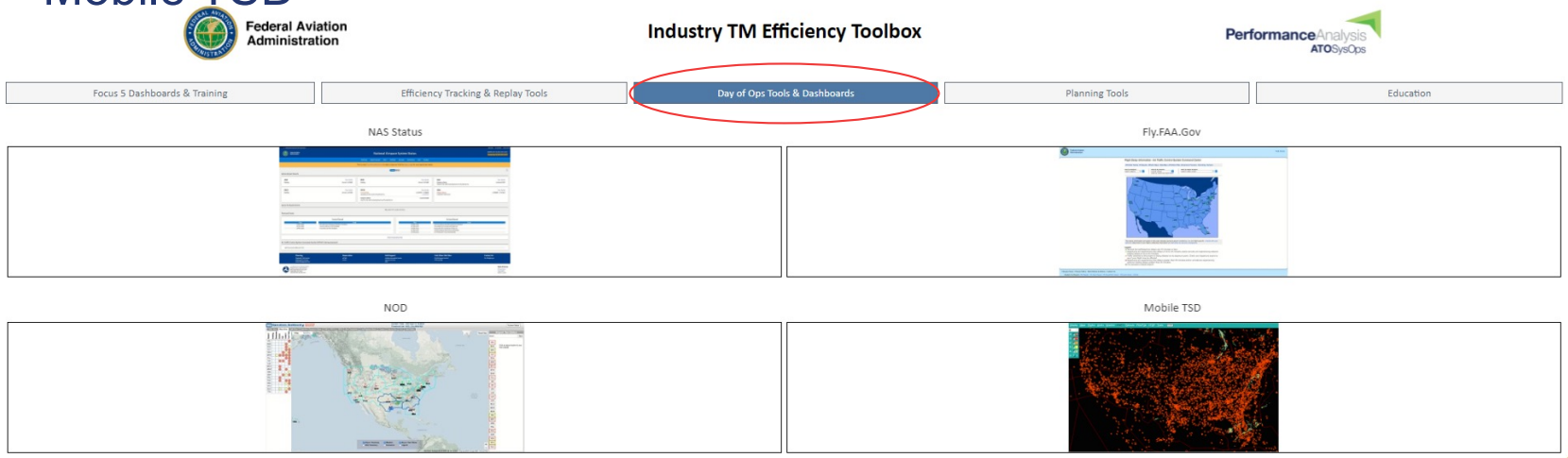
- Facility Metrics
- Common Metrics
- ASPM



Achievements…

Day of Ops Tool and Dashboards

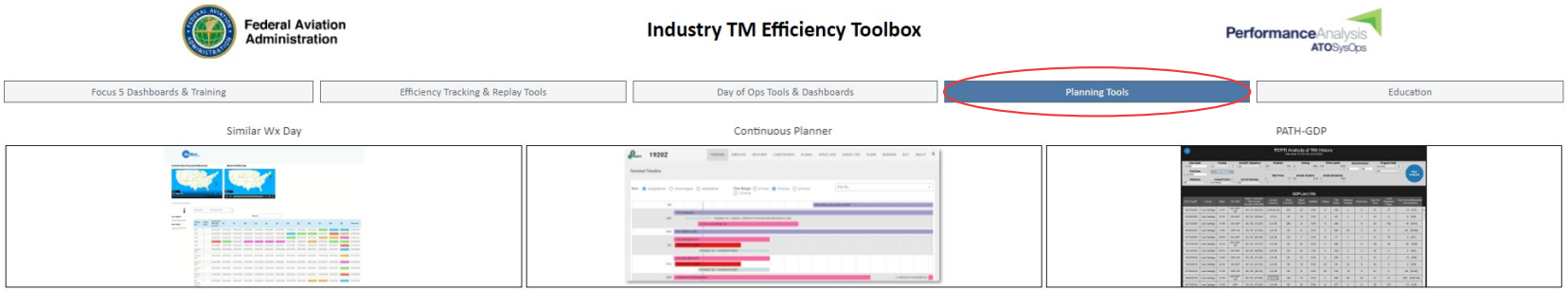
- NAS Status
- Fly.FAA.Gov
- NOD
- Mobile TSD



Achievements…

Planning Tools

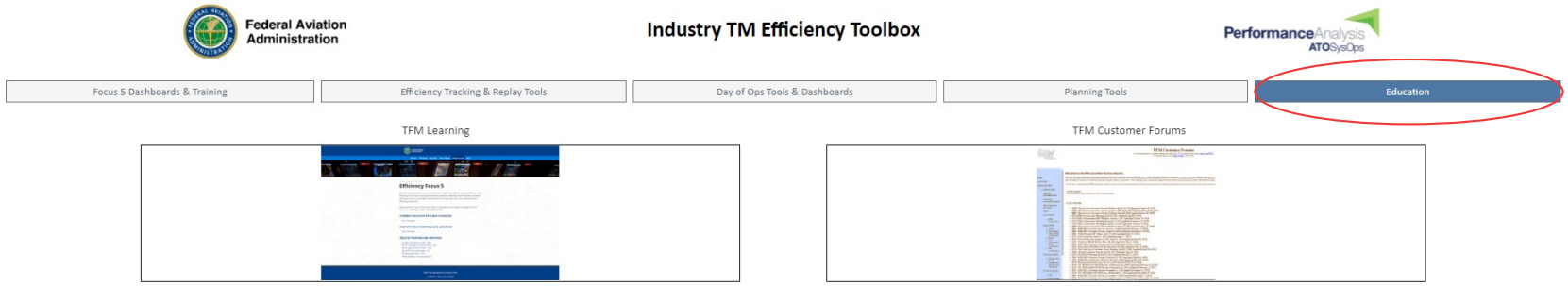
- Similar Wx Day
- Continuous Planner
- PATH-GDP



Achievements…

Education

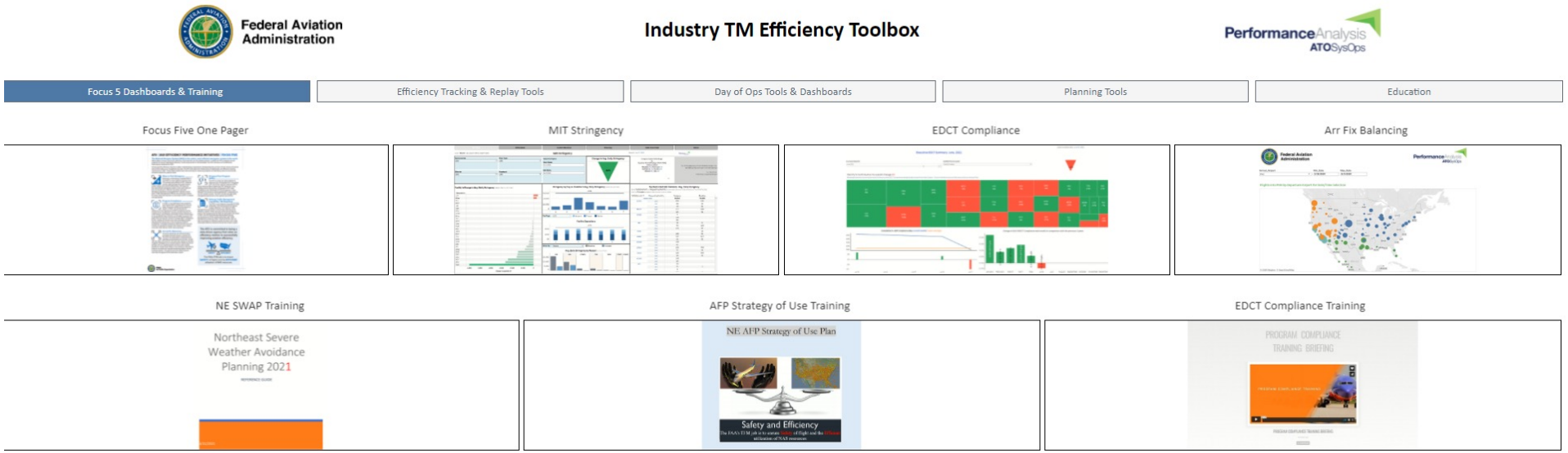
- TFM Learning
- TFM Customer Forums



Achievements…

Industry TM Efficiency Toolbox

- One-stop-shop for all efficiency metrics
  - https://explore.dot.gov/views/IndustryTMEfficiencyToolbox/Links?:embed=y

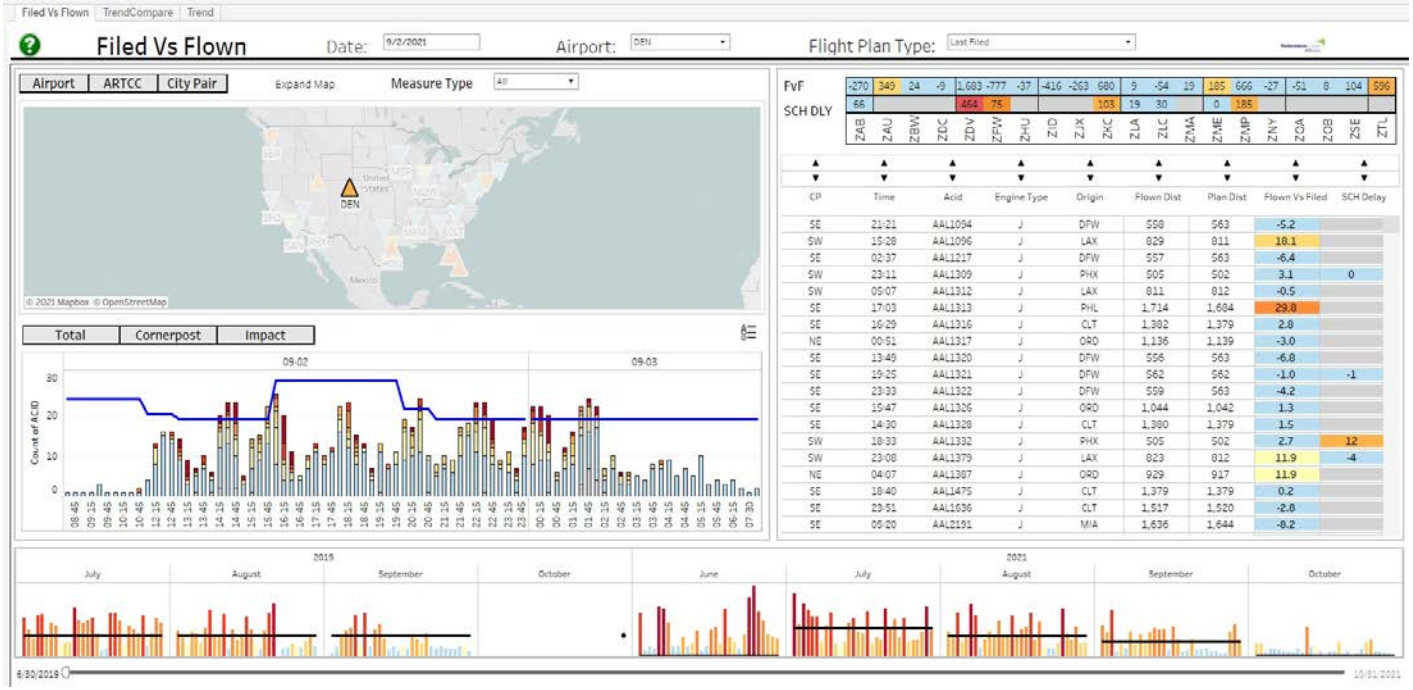


Achievements…

Industry TM Efficiency Toolbox

- Future Additions

File vs Flown



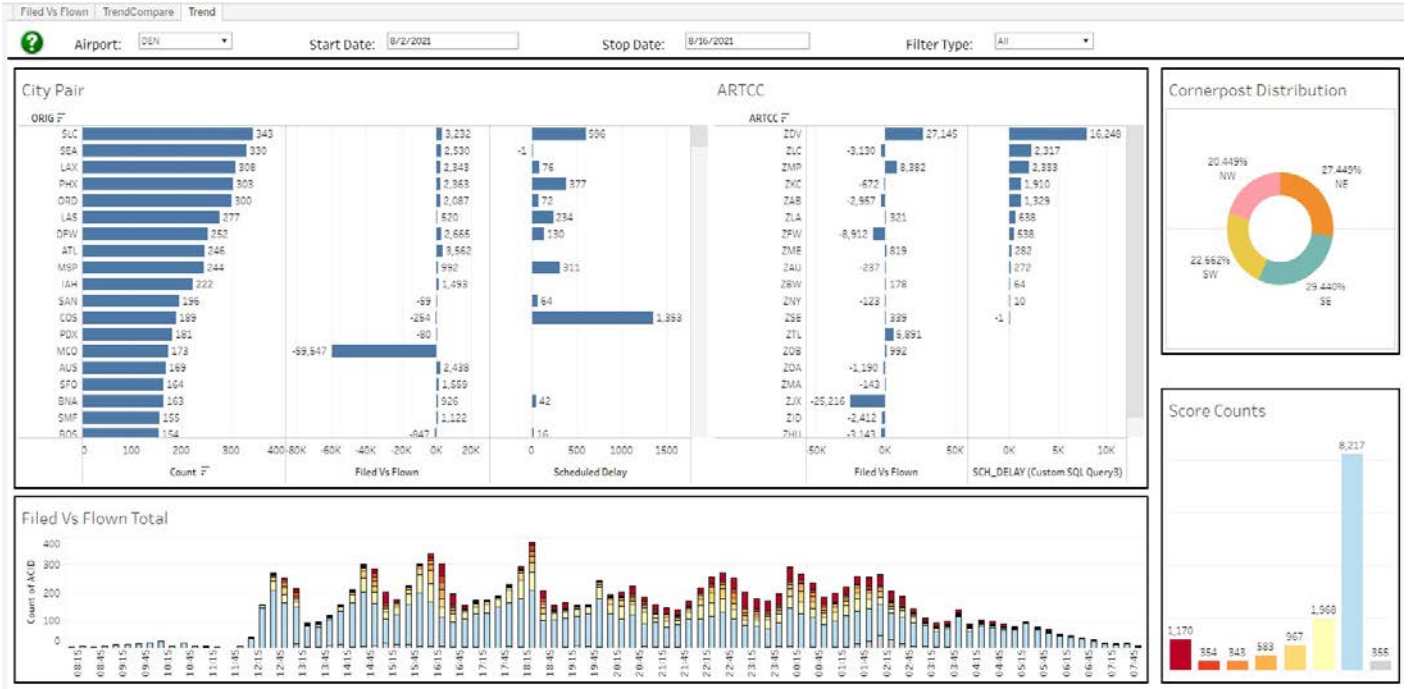
Achievements…

Industry TM Efficiency Toolbox

- Future Additions

File vs Flown

- Trending Data

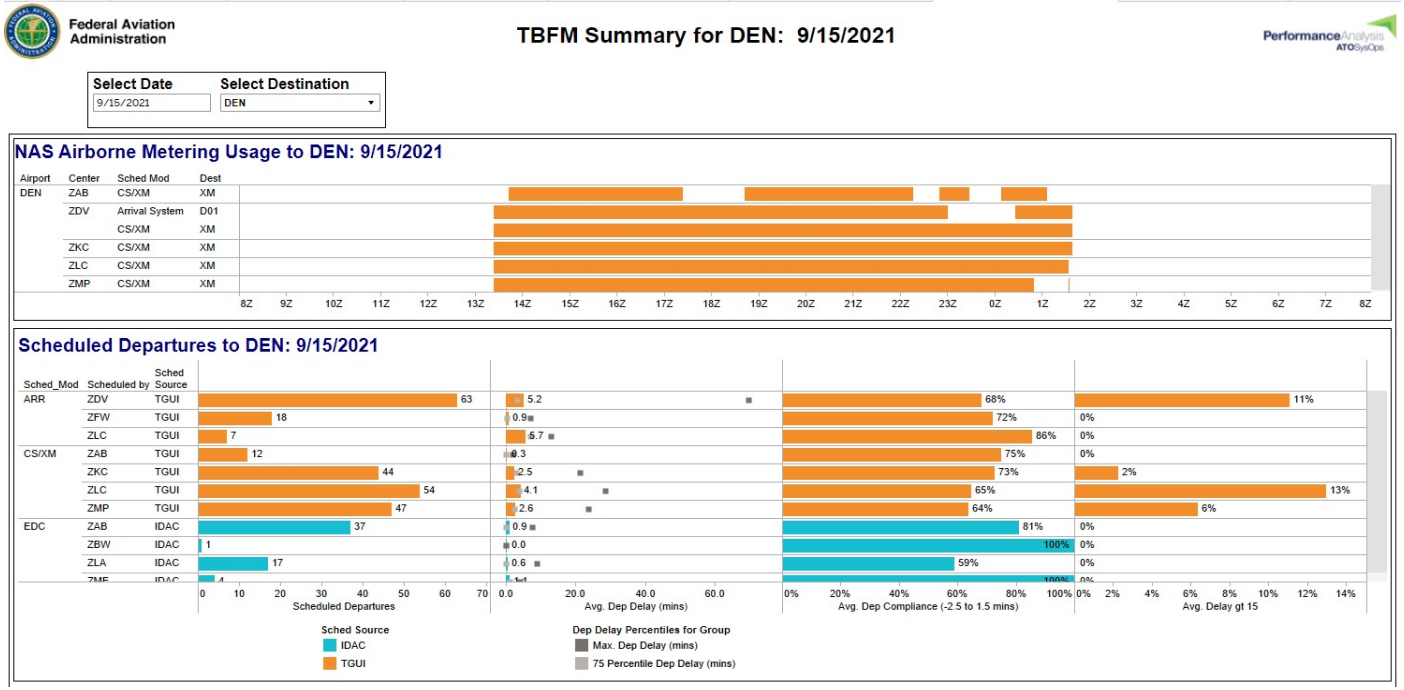


Achievements…

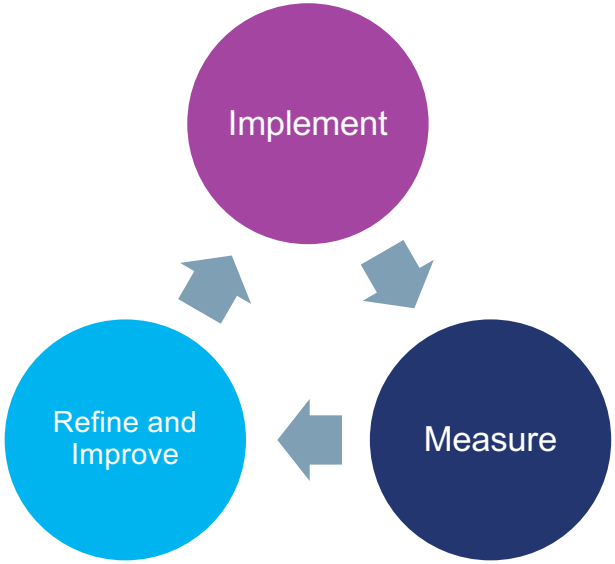
Industry TM Efficiency Toolbox

- Future Additions

TBFM



Challenges with TBO Analysis



Why is TBO Analysis Important?

- Supports continuous adjustments throughout TBO "lifecycle"
- Provides feedback to operational personnel on what may and may not be working
- Helps identify new or additional opportunities for improvement
- Helps us communicate our successes and failures to the workforce, senior leadership, and external stakeholders

Why are the existing tools and dashboards inadequate for TBO analysis?

- Outcomes from TBO implementation and use have a *broad* reach on operations
- Existing analysis tools are geared towards specific audiences and needs
- Data is generated by different systems in different time frames
- Integration of data and analytical methods remains resource-intensive

Key Metrics of Value

TBO Objective	Outcomes	Key Metric of Value
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 incremental delays
Increased Efficiency	• More efficient delay redistribution	• Distance over nominal in terminal airspace during periods of high-demand • Ground delays during nominal operations
	• Additional 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 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 Flexibility	• Increased route flexibility	• How often do operators provide and get their rerouting (vs delay) preferences

TBO Dashboard Prototype Overview

TBO Dashboard aims to evaluate outcomes from *TBO deployment and use*

- **Airports**

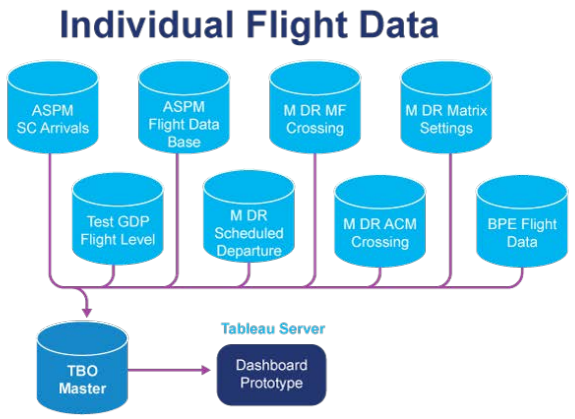
  ATL, DEN, EWR, PHL, LAX

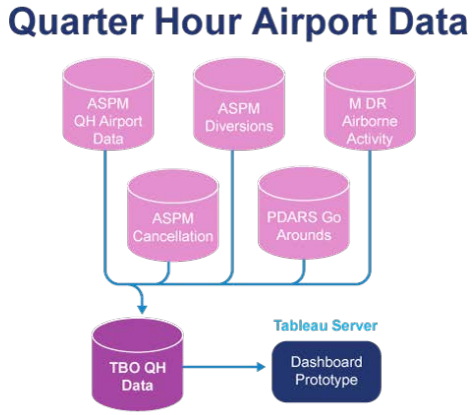
- **Data Range**

  1/1/2019 – 9/14/2021

- **Data Sources**
  - FAA ASPM: Flight and airport performance
  - CAASD TBFM Data Acquisition System: Flight performance and active use
- **"Living Tool"**

  Enhancements will be prioritized and implemented based on user-feedback

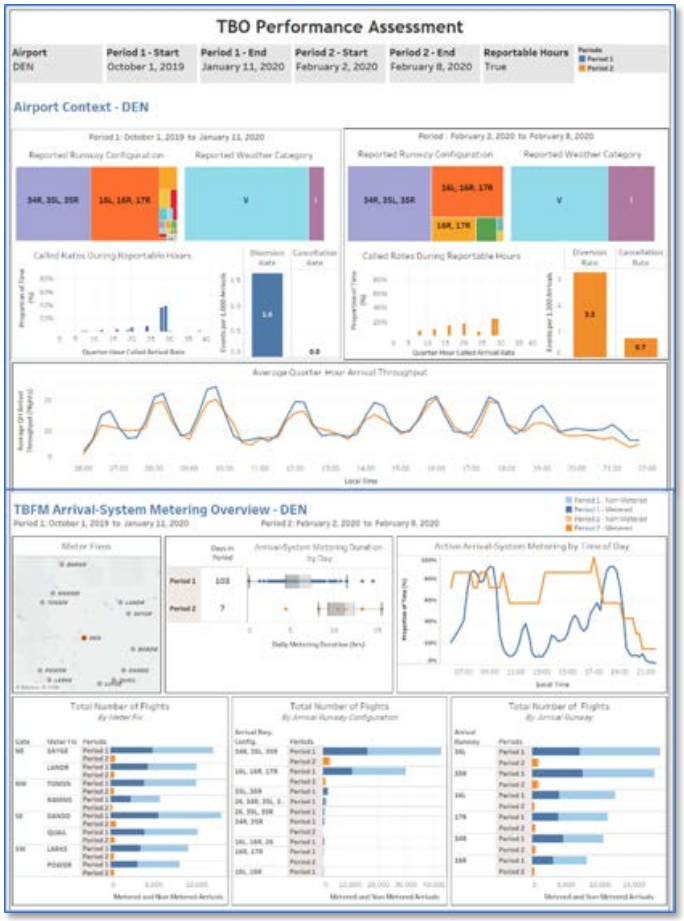




TBO Dashboard: Key Sections

TBO Dashboard aims to evaluate outcomes from *TBO deployment and use*

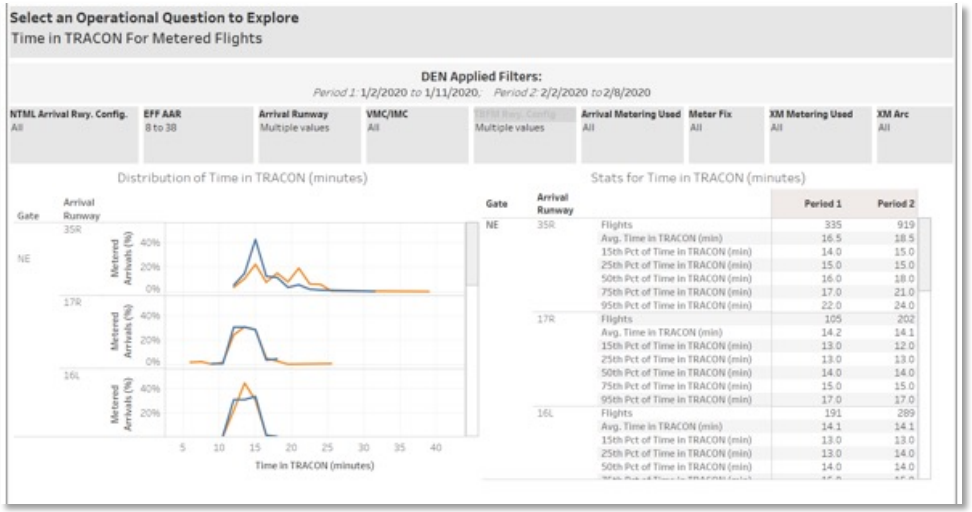
- Available within the AJR-G Analytical Suite
- Three key sections displayed on one page
  - **Airport Context:** high level information for the airport during each time range
  - **Arrival Metering System Overview:** high level metering overview at the airport during each time range
  - **Operational Topics of Interests:** deeper dive into topics and conditions of interest



TBO Dashboard: Example #1

Operational Topics of Interests

- TBFM Arrival System Metering Delay and Compliance
- TBFM Extended Metering Delay and Compliance
- TBFM Departure Scheduling Delay and Compliance
- ***Time in TRACON For Metered Flights***
- Runway Inter-Arrival Times and Quarter Hour Throughput
- Time Between Aircraft Through the Meter Fix
- Taxi Out and Departure Times at Origin Airports
- Go-Arounds
- TBFM Assigned Runway Compared to Arrival Runway Used

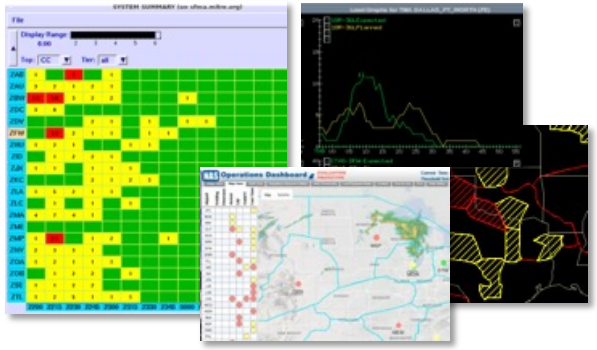


TBO Dashboard: Example #2

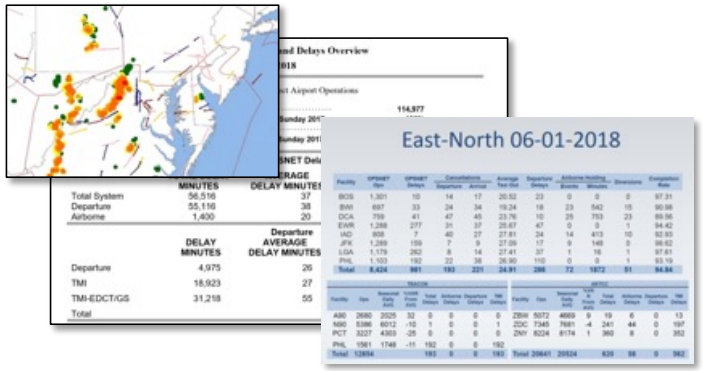
Operational Topics of Interests

- TBFM Arrival System Metering Delay and Compliance
- TBFM Extended Metering Delay and Compliance
- TBFM Departure Scheduling Delay and Compliance
- Time in TRACON For Metered Flights
- ***Runway Inter-Arrival Times and Quarter Hour Throughput***
- Time Between Aircraft Through the Meter Fix
- Taxi Out and Departure Times at Origin Airports
- Go-Arounds
- TBFM Assigned Runway Compared to Arrival Runway Used

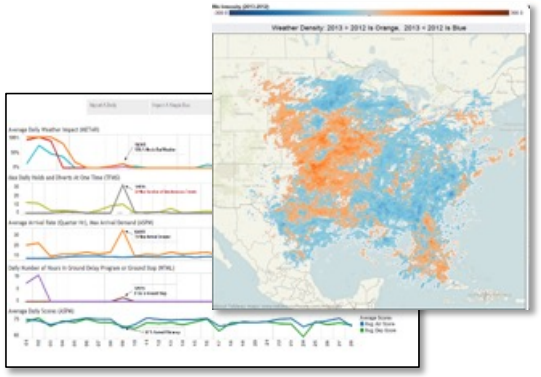
Data Collection and Analysis Timeframes



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

Real-time performance monitoring of current operations and TFM Strategy

Next Day

Use previous day performance analysis to improve the current day operations

Monthly/Seasonal

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

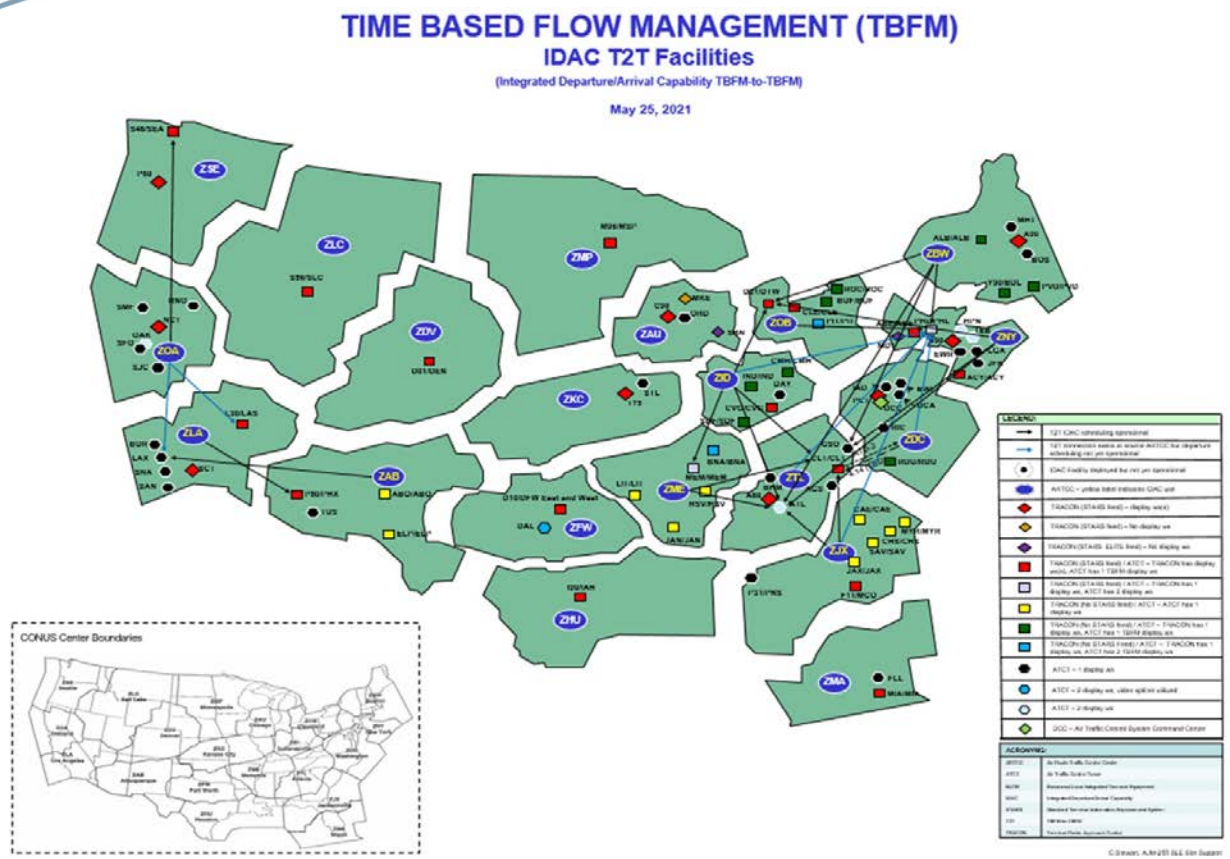
Expanded Departure Scheduling and T2T

Blake Locke, *NATCA*

Rob Goldman, *Delta Air Lines*

Almira Ramadani, *Air Traffic Services*

TBFM-to-TBFM (T2T) Functionality

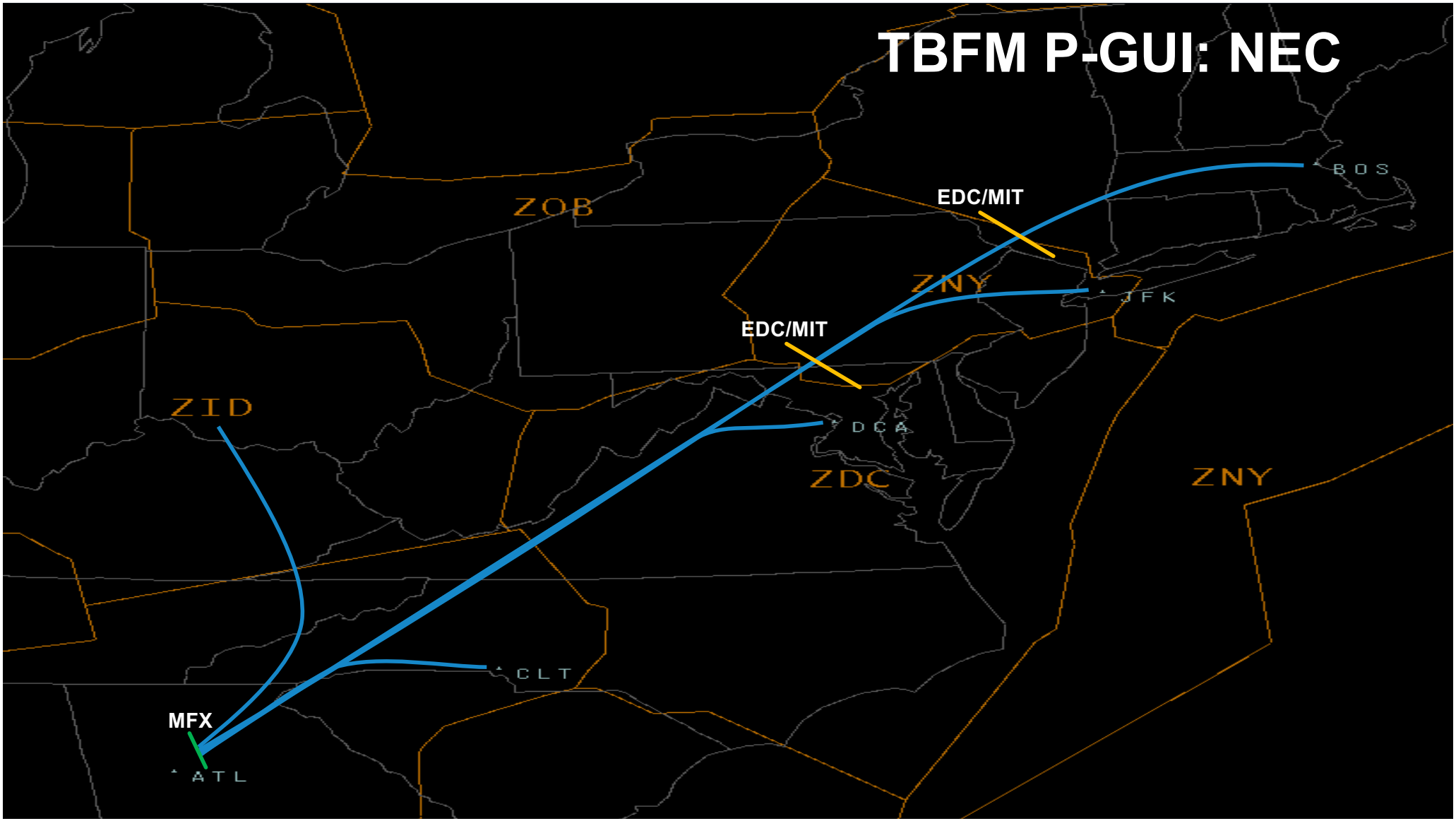


Incremental Improvements

- Expanded T2T functionality in NEC
- Expanded departure scheduling capability for ZNY and ZBW departures to ATL and CLT metering systems

Benefit Mechanisms

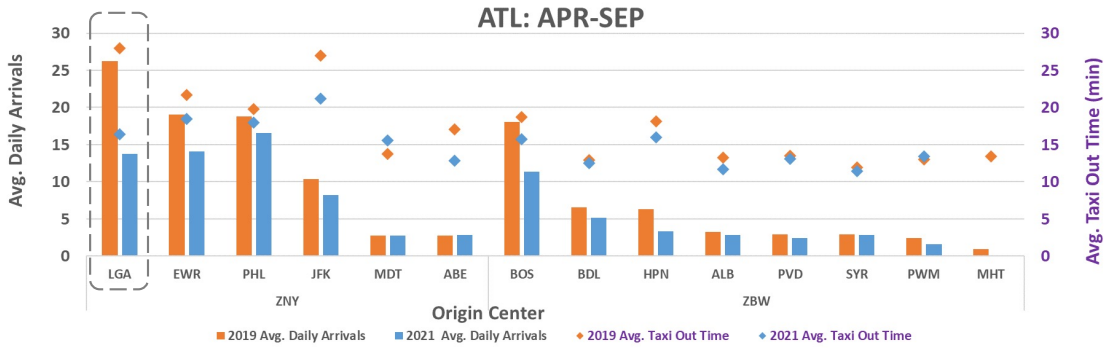
- Reduces use of pass-back MIT restrictions
- Improves reliability and stability of metering schedules
- Achieves departure release times that are integrated with the overall end-to-end TBM operation

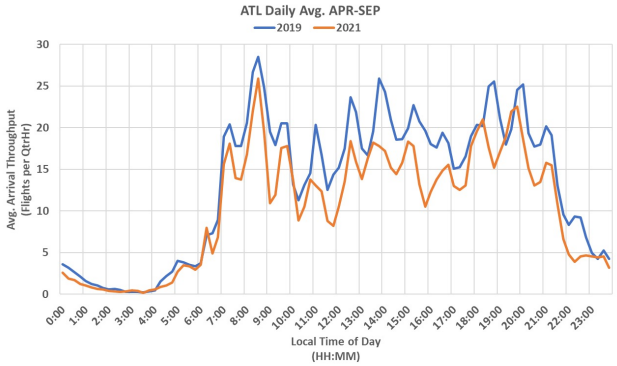

TBFM P-GUI: NEC
ZOB
ZNY
ZID
ZDC
ZNY
BOS
JFK
DCA
CLT
ATL
EDC/MIT
EDC/MIT
MFX

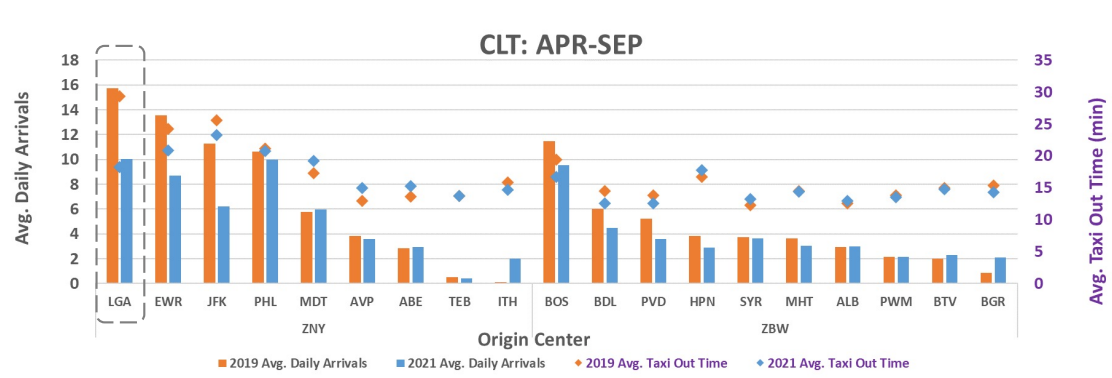
Delta Noticed Improved Performance…

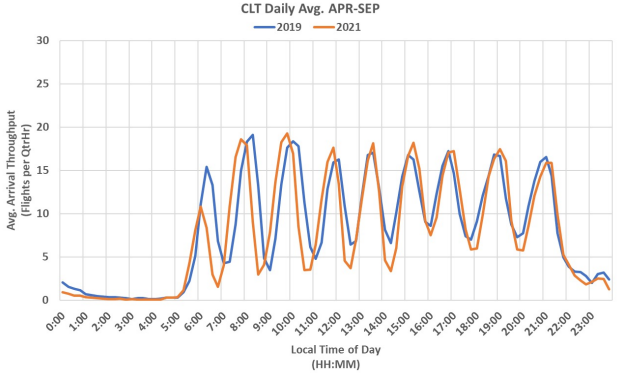
- Observed decrease in taxi-out times at LGA and JFK, as well as improvement in A0 for arrivals to ATL
  - Approximately 1,000 flights before and after implementation
  - Historic comparison unavailable due to COVID
    - LGA traffic expected to be back at ~85% of 2019 levels after Nov 1 of this year
- Release Times produced by TBFM, distributed via SWIM and ingested in Delta's automation tools is far better than an airplane sitting and waiting for a MIT restriction

Avg. Daily Arrivals and Taxi-out by Origin

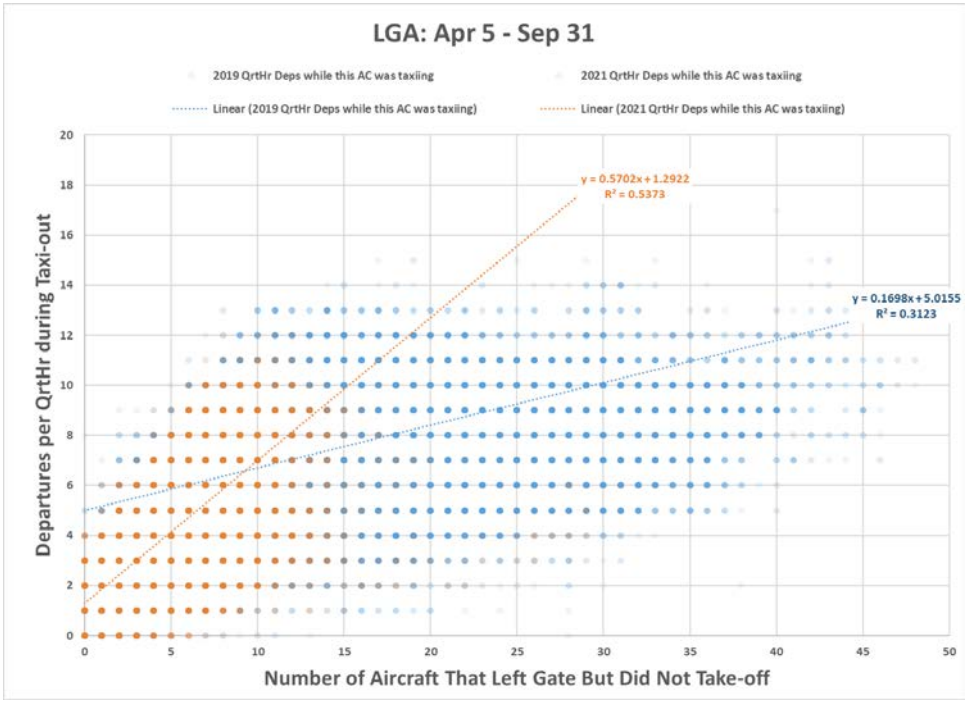


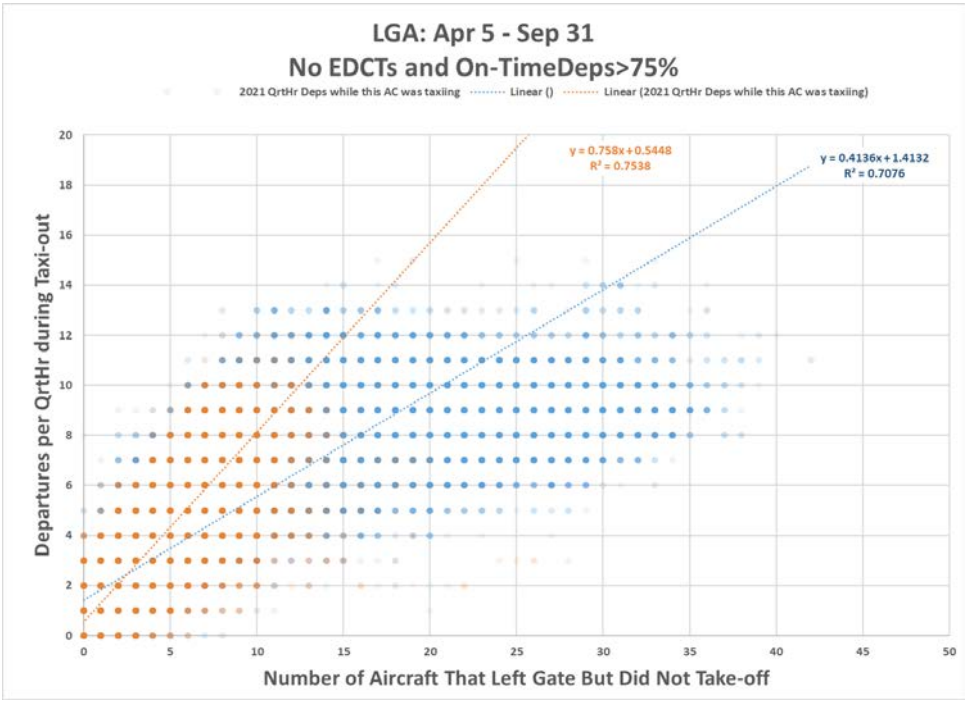




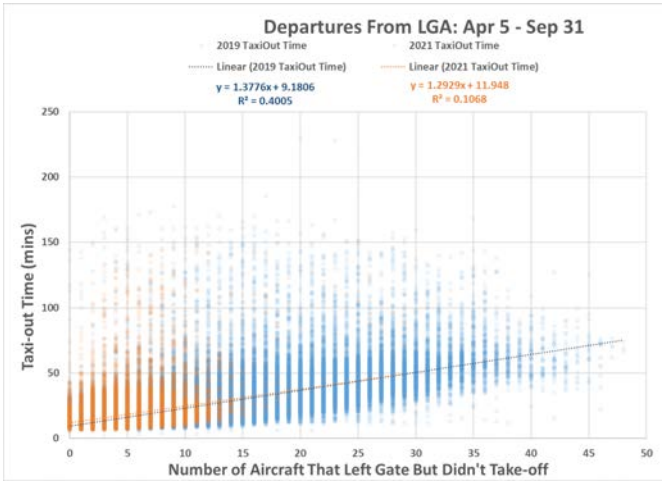


Departure Throughput vs Airport Congestion

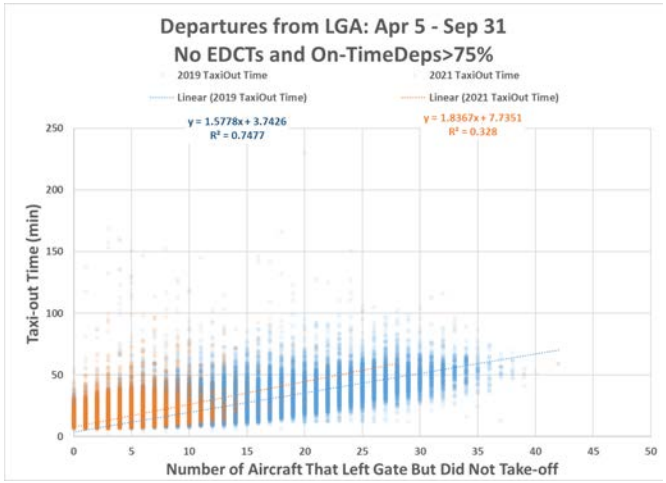




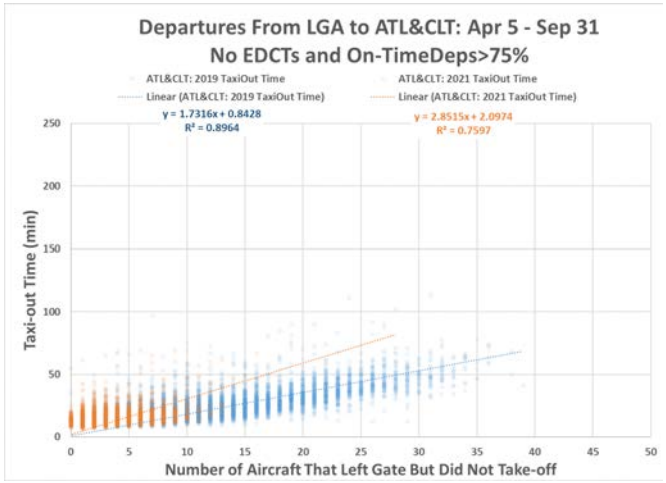
Taxi-out Times vs. Congestion



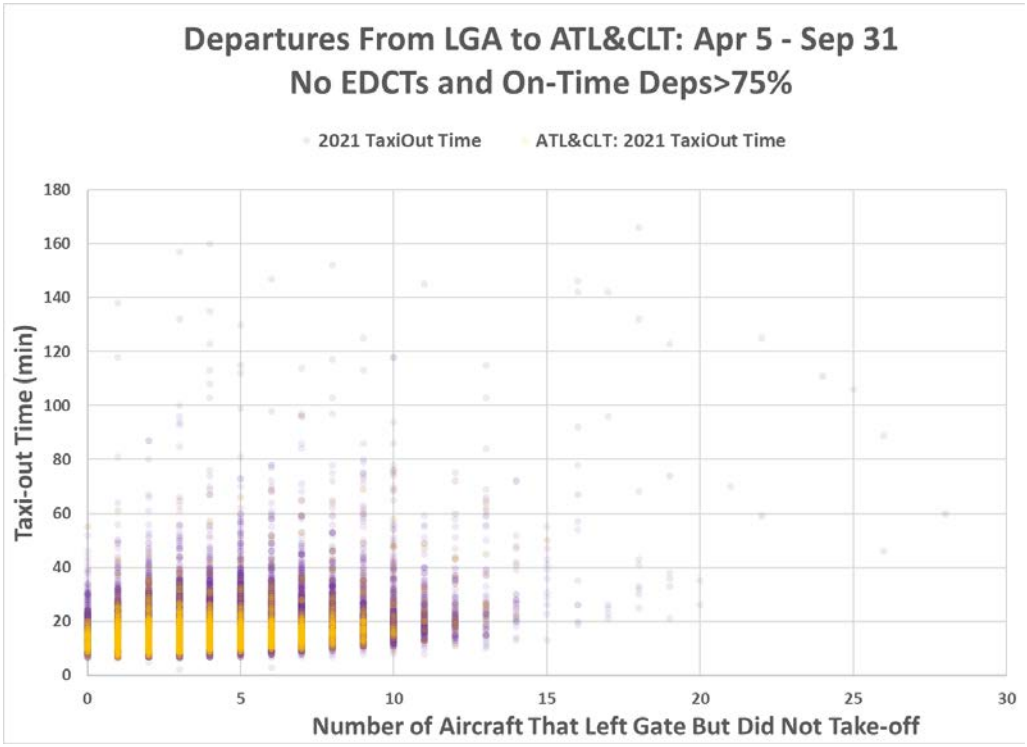
Avg. Taxi-out Time in 2019: 17.7 mins
Avg. Taxi-out Time in 2021: 14.4 mins
Normalized Diff in Taxi-out: 43 secs



Avg. Taxi-out Time in 2019: 17.6 mins
Avg. Taxi-out Time in 2021: 14.0 mins
Normalized Diff in Taxi-out: 47 secs



Avg. Taxi-out Time in 2019: 14.9 mins
Avg. Taxi-out Time in 2021: 13.7 mins
Normalized Diff in Taxi-out: 66 secs



Avg. Taxi-out Time for Deps to ATL or CLT: *13.7 mins*

Avg. Taxi-out Time for Deps to other Destinations: *14.0 mins*

Diff in Taxi-out Times: *17.5 secs*

Summary of Findings

- Small but important step towards TBO
- Definitely a positive outcome, but the signal is hidden by demand-driven impacts
- This example illustrates complexities we face with in post-implementation assessments
- We didn't want to jump to a conclusion we would like to see
  - Opposite example: NTX Metroplex

Joint Analysis Team (JAT)

Industry Role in Measuring Outcomes

Joint Analysis Team (JAT)

An FAA / industry collaboration forum established to reach a consensus on methodologies and results regarding NAS performance changes resulting from NextGen implementations

Focused on measuring performance impacts in key metrics

- Throughput
- Block time, including variability
  - Taxi-out time
- Arrival performance (A0)
- Fuel burn
- Gate departure delay
- Completion factor (added by NEC)

Additional metrics and normalization applied as appropriate

Sample JAT Taskings

Previous JAT analyses

- ✓ 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)
- ✓ Northeast Corridor
  - ✓ En Route Departure Capability/ Integrated Departure Capability
  - ✓ Simultaneous Converging Instrument Approaches (SCIA)
  - ✓ Escape Routes from NEC airports

Future Analyses

- Trajectory Based Flow Management – PHL (Future)
- Atlantic Coast Routes (Future)

Wrap-up and Questions

https://www.faa.gov/air_traffic/technology/tbo/

9-AJT-TBO@faa.gov

We Hear You

"We want to know specifics about when and where specific TBO capabilities will be available."	At TBO Industry Days and on the TBO website, we have been providing updated timelines for individual capabilities by operating area.
"How does TBO and its many capabilities work together?"	At TBO Industry Days and on the TBO website, we provided detailed information about specific capabilities and programs through which they are being implemented, how they work individually and how they work together across domains to enable TBO.
"What benefits does TBO bring to aircraft operators?"	Today we've provided explanations about the opportunity space that TBO is focused on, specific benefits expectations associated with TBO capabilities, and the specific benefit outcome anticipated for operators.
"How will we measure success?"	Today we showed you some of the tools and capabilities we've been developing for performance monitoring and reporting. We will continue to work with you through the JAT to assess progress towards TBO objectives.

https://www.faa.gov/air_traffic/technology/tbo/

email: 9-AJT-TBO@faa.gov