Initial TBO & NEC

Federal Aviation Administration

Presented to: NEC NIWG

By: FAA

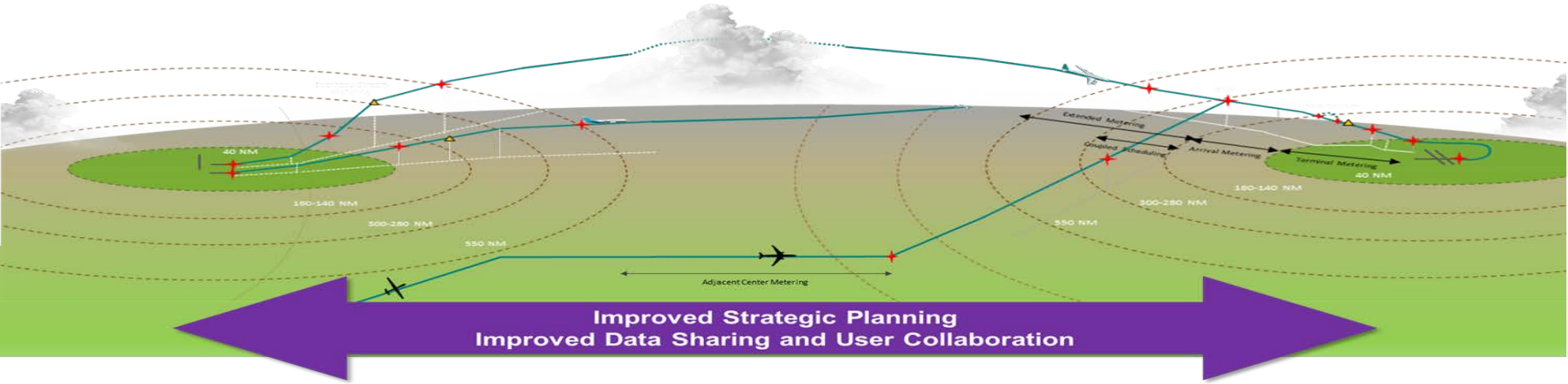
Date: April 2018

Initial TBO Overview

- **TBO Vision → Time-Based Management (TBM) + PBN**

  "TBO is an ATM method for strategically planning, managing, and optimizing flights throughout the operation by using TBM, information exchange between air and ground systems, and the aircraft's ability to fly precise paths in time and space." *-FAA Vision for TBO*

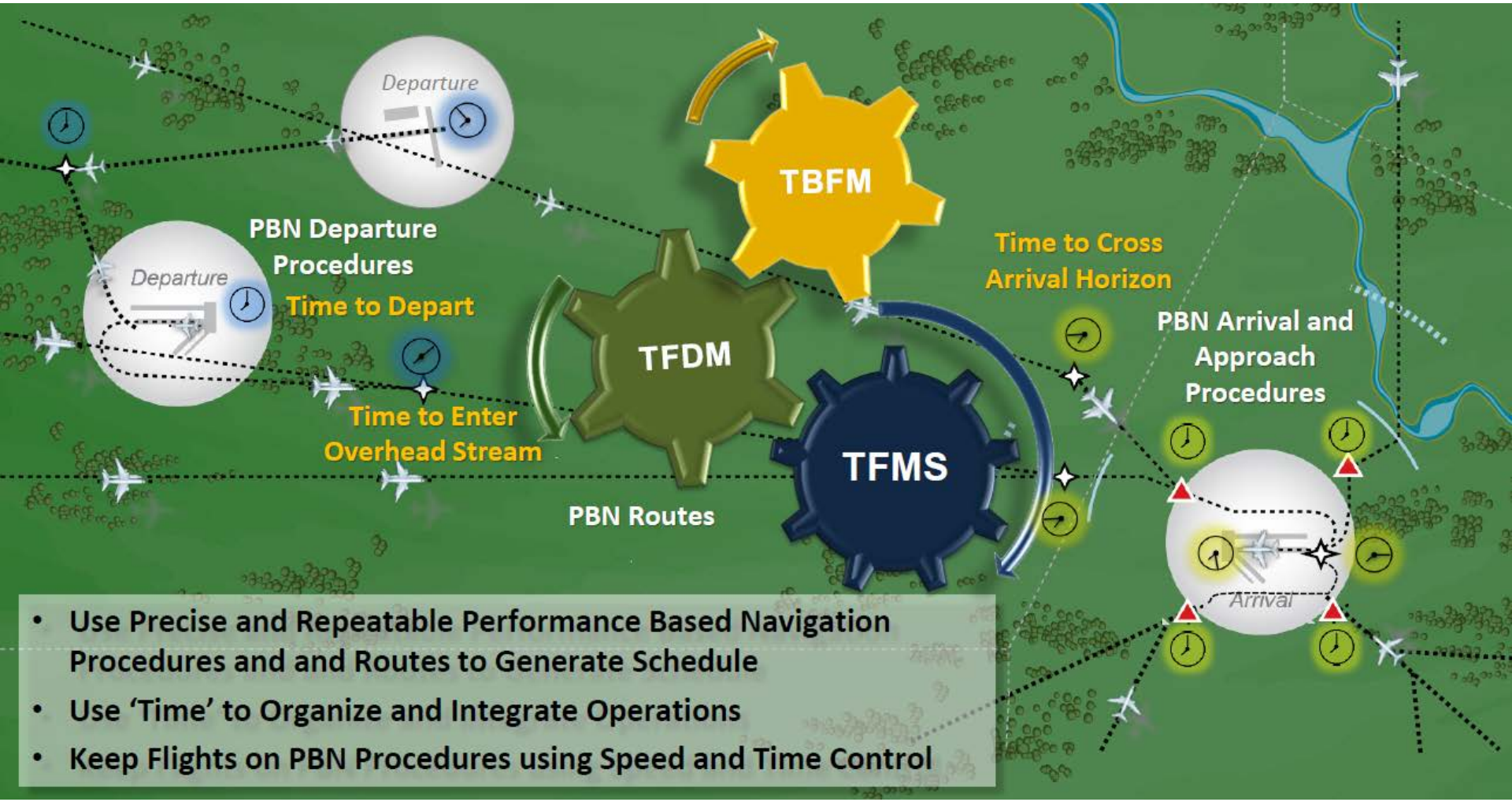
- **Focus on delivery of capabilities for approximately next 5 years (~2022)**
  - Accounts for budgeted implementation waterfalls of key capabilities
  - Initial set of capabilities enable the first comprehensive TBM environment phase
  - Interdependencies among initial set of capabilities are strongly coupled



TBO Objectives

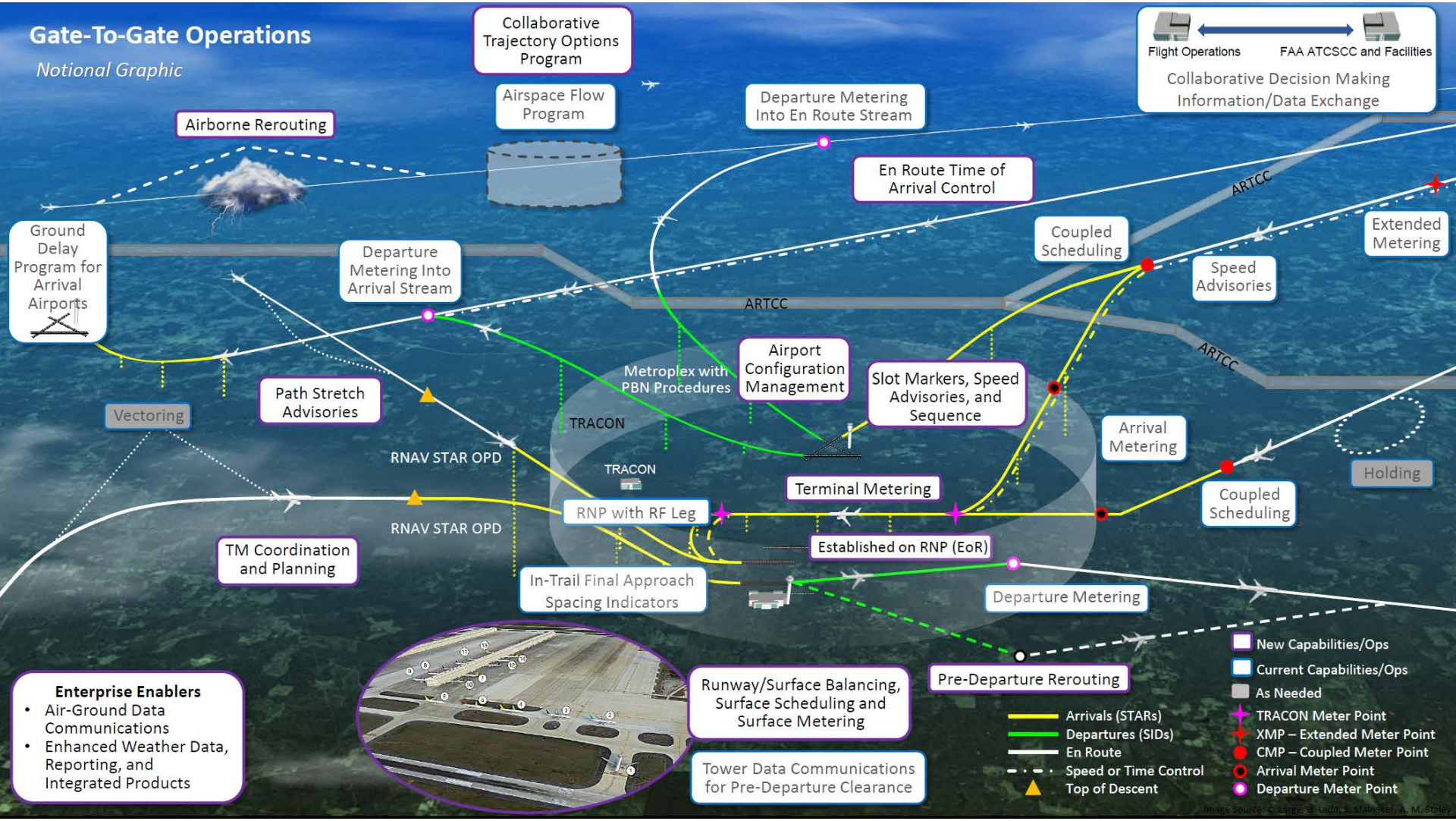
- More efficient use of system capacity by maximizing airspace and airport **throughput** using time-based management techniques and precise, repeatable PBN procedures
- Improved operational **predictability** through more accurate and efficient end-to-end strategic planning and scheduling
- Enhanced **flight efficiency** by delivering more efficient flows into and out of major metropolitan areas through integrated operations, including the continuous use of more PBN procedures
- Increased operational **flexibility** through increased user collaboration regarding preferred trajectories and priorities to support business objectives

TBO Objectives – Visualizing TBO



- Use Precise and Repeatable Performance Based Navigation Procedures and and Routes to Generate Schedule
- Use 'Time' to Organize and Integrate Operations
- Keep Flights on PBN Procedures using Speed and Time Control

iTBO – Scope


Gate-To-Gate Operations
Notional Graphic
Collaborative Trajectory Options Program
Airspace Flow Program
Departure Metering Into En Route Stream
Flight Operations
FAA ATCSCC and Facilities
Collaborative Decision Making Information/Data Exchange
Airborne Rerouting
En Route Time of Arrival Control
ARTCC
Ground Delay Program for Arrival Airports
Departure Metering Into Arrival Stream
Coupled Scheduling
Extended Metering
Speed Advisories
ARTCC
ARTCC
Airport Configuration Management
Metroplex with PBN Procedures
Slot Markers, Speed Advisories, and Sequence
Path Stretch Advisories
Vectoring
TRACON
Arrival Metering
RNAV STAR OPD
TRACON
Holding
Terminal Metering
Coupled Scheduling
RNP with RF Leg
RNAV STAR OPD
Established on RNP (EoR)
TM Coordination and Planning
In-Trail Final Approach Spacing Indicators
Departure Metering
Pre-Departure Rerouting
Enterprise Enablers
• Air-Ground Data Communications
• Enhanced Weather Data, Reporting, and Integrated Products
Runway/Surface Balancing, Surface Scheduling and Surface Metering
Tower Data Communications for Pre-Departure Clearance
Arrivals (STARs)
Departures (SIDs)
En Route
Speed or Time Control
Top of Descent
New Capabilities/Ops
Current Capabilities/Ops
As Needed
TRACON Meter Point
XMP – Extended Meter Point
CMP – Coupled Meter Point
Arrival Meter Point
Departure Meter Point

iTBO – Scope: Capability/Technology View

Function Category	Capabilities	Supporting Technologies
PBN	RNAV STAR Optimum Profile Descent (OPD) RNAV SIDs RNP / RNP with RF leg Established on RNP (EoR)*	FMS/ RNAV (LNAV/VNAV), RNP, RNP- AR, A-RNP
Strategic Planning / Flow Management	Airspace Flow Program (AFP), Ground Delay Program (GDP) Collaborative Trajectory Options Program (CTOP)* TM Coordination and Planning	TFMS/ FSM SWIM, TFMS, Operator Ground Automation TFMS/ FSM TBFM/ TM Ops Dashboard and Planning Tool
Route Management	Automated Reroutes Pre-Departure Rerouting Airborne Rerouting	TFMS/ ERAM PDRR ABRR
Time-Based Scheduling (Airborne and Surface)	Arrival Metering Coupled Scheduling/Extended Metering Collaborative Air Traffic Management Departure Metering (scheduling) into Arrival Stream Departure Metering (scheduling) into En Route Stream Terminal Metering Runway/Surface Balancing Surface Scheduling and Metering	TBFM/ GIM-S T-to-T, IDAC EDC, IDAC TSAS TFDM
En Route and Terminal Spacing Tools	Converging/Crossing Runway Operation Spacing Indicators In-Trail Final Approach Spacing Indicators Delay Countdown Timer Speed Advisories Path Stretch Advisories Slot Markers, Speed Advisories, and Sequence En Route Time of Arrival Control (TOAC)	STARS/ CRDA ATPA TBFM/ DCT/MRL GIM-S Path Stretch TSAS TBFM, FMS/ RTA
Surface Management	Tower Data Communications for Pre-Departure Clearance Electronic Flight Data* Airport Configuration Management	Controller Pilot Data Link for Tower TFDM
Enterprise Enablers	Information and Data Exchange Air-Ground Data Communication Enhanced Weather Data, Reporting, and Integrated Products	SWIM Controller Pilot Data Link for En Route (Initial Services) NWP, CSS-Wx

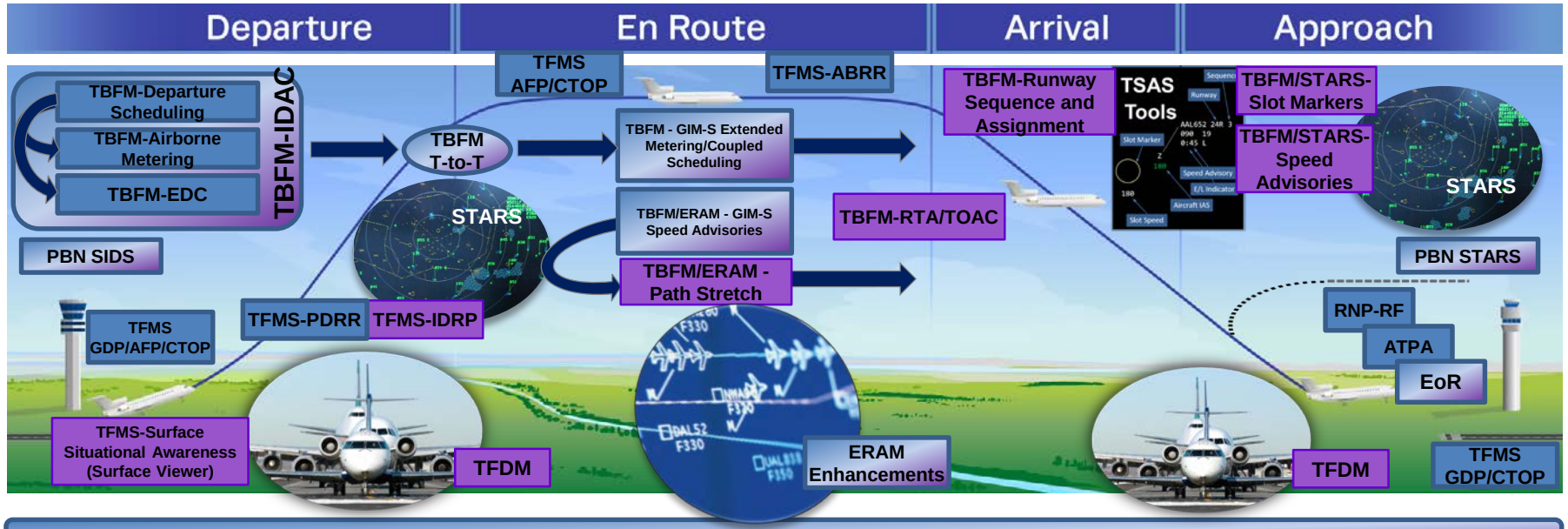
Currently Available Capabilities

Planned Capabilities

iTBO Capabilities Sequencing by Domain Operational Context

Existing Capability | *In-Process Deployment* | *2019+ Deployment*

PERTI Processes and Procedures



PBN Equipage

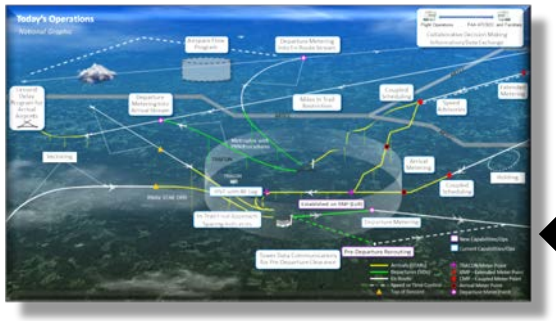
Data Communications

Weather Information – NextGen Weather Processor (NWP) /Common Support Services-Weather (CSS-Wx)

TFMS – Improved Demand Predictions (IDP)

Initial TBO Approach

As-Is State



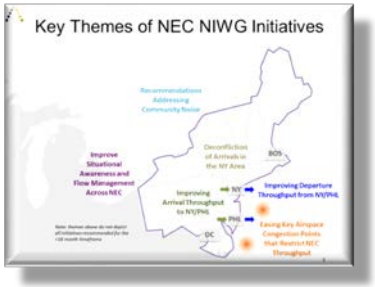
To-Be State

<TRANSITION ROADMAP>

Gap

Current Plans

New Commitments (e.g. NEC)



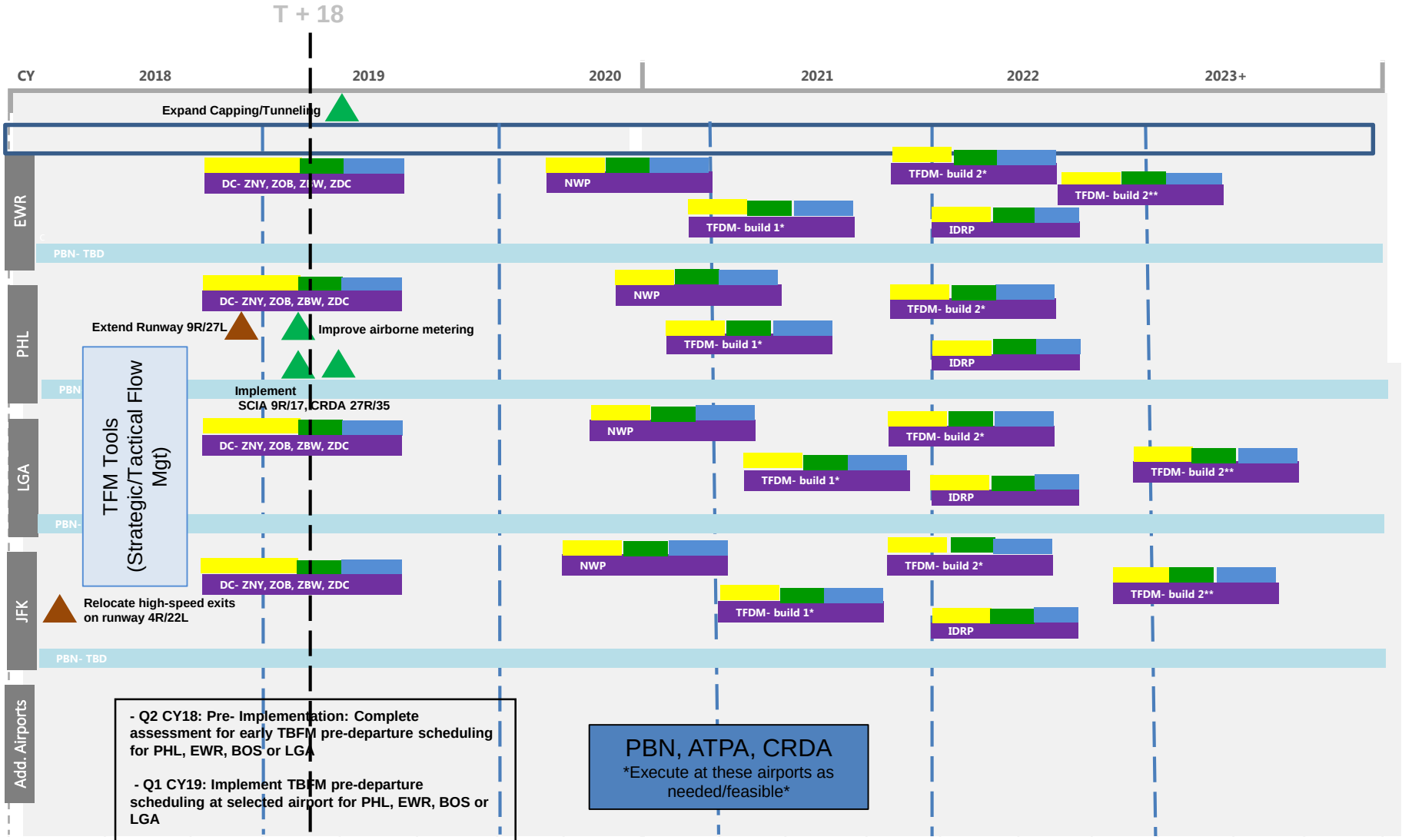
Evolution Plan Content

Target State	Plan Execution
Objective and Goals	Operating Area Change Increments
Operational Change - Scope - AS-IS vs. TO-BE	Implementation Approach
iTBO Success Criteria and Metrics	Stakeholder Groups and Roles
Assumptions	Integrated Schedule - Leadership Actions - Communications Activities - Organizational/facility Alignments - Training, Evaluation, and Development
Integration, Risks, Opportunities	
Dependencies, Risks, Mitigations, Opportunities	Post-Implementation Operations Sustainment
Impact – Procedures/Agreements	
Impact – Surrounding Operating Areas	

- **Develop TBO Transition Roadmap & Evolution Plans to Close the Gap**

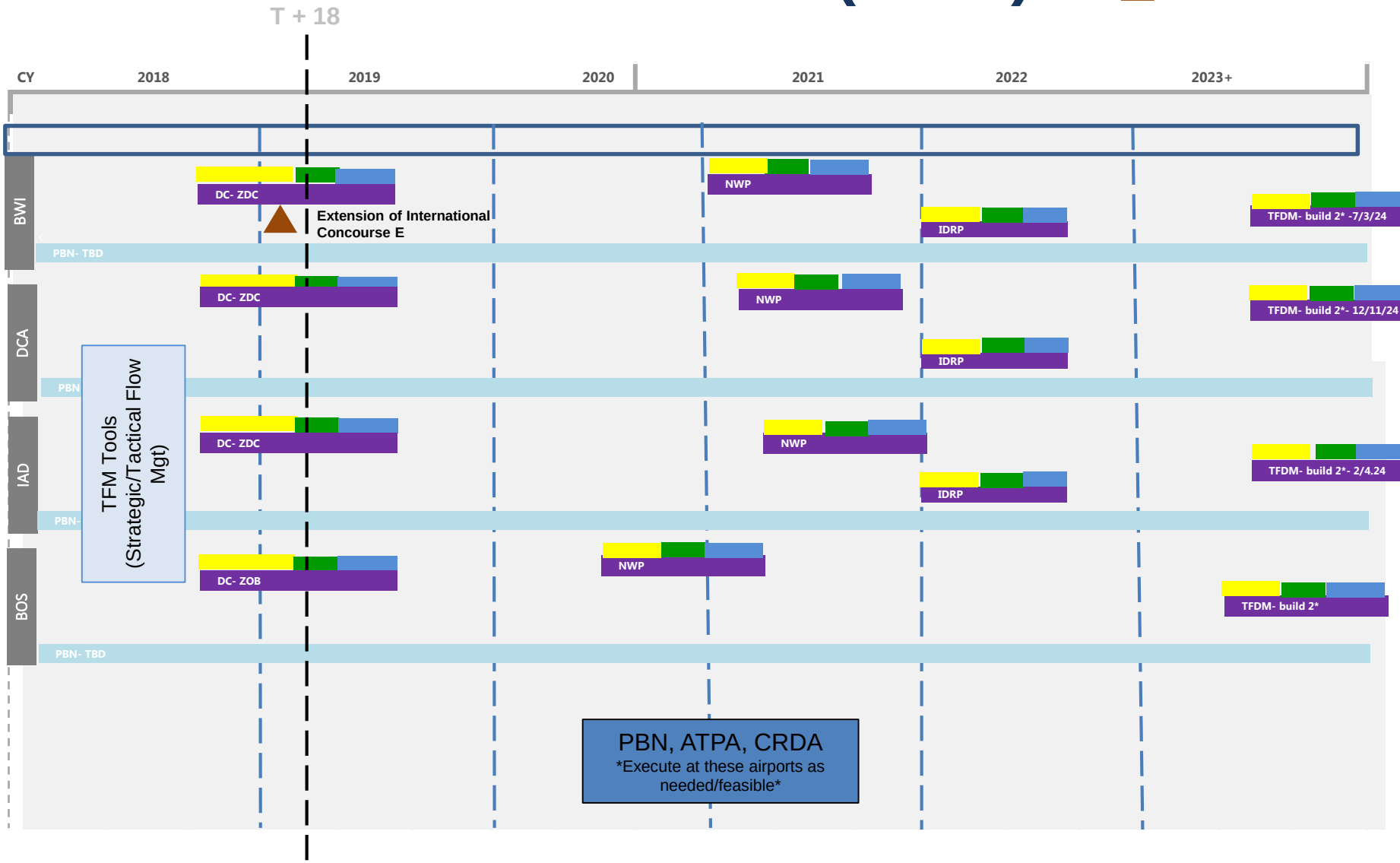
NEC: Current Plans

- Implementation Milestone
- Industry/Apt Milestone



NEC: Current Plans(cont.)

- Implementation Milestone
- Industry/Apt Milestone



ZNY Current and Planned TBO Capabilities

	TFM & Enterprise Enablers								Surface & Departure Management							Arrival Management					Arrival			Approach			
ARTCC	EDC	ACM	ABRR	CTOP	Data Comm Initial En Route	NWP	*NAV Group*	***Airports***	RNAV SID	TDLS	SVT at ZNY	IDAC (from)	PDRR	TFDM	IDRP	Departure scheduling (to)	Arrival metering	GIM-S	Path Stretch	RTA & TOAC	RNAV STAR	CRDA	TSAS	ATPA	RNP Approach	RNP RF	EOR
ZNY			TBD		2019	2020	1	**EWR**	1					A 2021	2022	*					2				4	2	
								JFK	2					A 2021	2022						1				5		*
								LGA	5					A 2021	2022	*					2019				2		
								PHL						A 2021	2022	*					4				2		
							2	HPN						B+ 2022	2022										2	2	
								TEB	1					B+ 2022	2022						2				2	1	

Legend						
Currently Available and in use	Not fully implemented or used	Planned	Pre-FID	NEC Commitment T+18	Not Planned or in use	* Pre-implementation milestone

Bold denotes CORE 30 airport

ZBW & ZDC Current and Planned TBO Capabilities

	TFM & Enterprise Enablers								Surface & Departure Management							En Route					Arrival			Approach			
ARTCC	EDC	ACM	ABRR	CTOP	Data Comm Initial En Route	NWP	***NAV Group***	***Airport***	RNAV SID	TDLS	SVT at ARTCC or TRACON	IDAC (from)	PDRR	TFDM	IDRP	Depar1ture scheduling (to)	Arrival metering	GIM-S	Path Stretch	RTA & TOAC	RNAV STAR	CRDA	TSAS	ATPA	RNP Approach	RNP RF	EOR
ZDC		CLT			2019	2021	**1**	**BWI**	3					A 2024	2022						4				4	2	
								DCA	9					A 2024	2022						7				2	1	
		EWR						**IAD**	9					A 2024	2022						6				4	2	
							2	RDU	7					B 2020							4	NA			4	4	
		PHL						RIC	2					B 2025	2022						3				4	4	
ZBW		EWR			2019	2020	2	BDL						B 2025											2	2	
		PHL						**BOS**	9					A 2021							3						

Legend

Available and in regular use	Not fully implemented or used	Planned 2019-2022	Pre-FID	NEC Commitment T+18	Not Planned or in Use

Bold denotes CORE 30 airport

ZID & ZOB Current and Planned TBO Capabilities

	TFM & Enterprise Enablers								Surface & Departure Management							En Route					Arrival			Approach			
ARTCC	EDC	ACM	ABRR	CTOP	Data Comm Initial En Route	NWP	NAV Group	***Airport***	RNAV SID	TDLS	SVT at ARTCC	IDAC (from)	PDRR	TFDM	IDRP	Departure scheduling (to)	Arrival metering	GIM-S	Path Stretch	RTA & TOAC	RNAV STAR	CRDA	TSAS	ATPA	RNP Approach	RNP RF	EOR
ZID		ATL			2018	2021	2	CHS	5			2018-2019		B 2025							8	NA			2	2	
								CMH						B 2022							1	NA			4		
		CLT						CVG	9					B 2024							5				8		
								IND						B 2020							5				6	6	
		MEM						SDF	4					B 2024							5				4	4	
ZOB		EWR			2019	2020		BUF						B 2025											2	2	
								CLE	1					B 2020													
		PHL						**DTW**						A 2024													
								PIT						B 2026							4				6		

Legend

Available and in regular use	Not fully implemented or used	Planned 2019-2022	Pre-FID	NEC Commitment T+18	Not Planned or in Use

Bold denotes CORE 30 airport

Back-Up Materials

Current & Planned TBO – Candidate Op Areas

	TFM & Enterprise Enablers								Surface & Departure Management							En Route					Arrival			Approach			
ARTCC	EDC	ACM	ABRR	CTOP	Data Comm Initial En Route	NWP	NAV Group	Airport	RNAV SID	TDLS	SVT at ARTCC	IDAC (from)	PDRR	TFDM	IDRP	Departure scheduling (to)	Arrival metering	GIM-S	Path Stretch	RTA & TOAC	RNAV STAR	CRDA	TSAS	ATPA	RNP Approach	RNP RF	EOR
ZTL		ME M	2018		2019	2019	1	**ATL**	18			2018-2019		A 2022							16	NA	2020-2022		4	4	
								CLT	11			ATD-2		A 2021							7		2020-2022		4		
ZAB		DEN			2019	2021	2	**PHX**	**9**			**2018-2019**		**A 2020**							**8**	**NA**	**2020-2022**		**6**		
ZLA		PHX	2018		2019	2020	1	**LAX**	18					A 2022	2022						16		2020-2022		8	8	
							2	**LAS**	6					A 2021							5		2020-2022				
ZOA			2018		2019	2020	1	**SFO**	**10**			**2018**		**A 2021**							**7**		**2020-2022**		**2**	**1**	
ZSE			2018		2019	2020	2	**SEA**	4					A 2024							2		2019		6	4	
ZDV		PHX			2019	2021	1	**DEN**	16					**A 2023**							16		**2019**		12	**12**	
ZHU		ATL	2018		2019	2021	1	**IAH**	**13**		I90 / HOU (2018)			**A 2021**							**13**		**2020-2022**		**6**	**4**	

Legend

Currently Available and in use	Not fully implemented or used	Planned	Pre-FID	NEC Commitment T+18	Not in use or Planned

Federal Aviation Administration

High-level iTBO TFM Scenario Excerpts

High-level Scenario Steps

Required Steps
Conditional Steps

- Step 0: Day-Before TFM Planning
- Step 1: Day Of Traffic Management Planning for Eastbound Flows
- Step 2: Execute CTOP with Recommended Routes for Route Outs
- Step 3: ATCSCC Severe Weather Specialist Monitors Flows Resulting from CTOP
- Step 4: ARTCC TMU Develops Plan to Use TOSs for Westbound Flows Predicted to be Impacted
- Step 5a: Strategic and Tactical Actions Applied to Manage Impacted Eastbound Flows
- Step 5b: Strategic and Tactical Actions Applied to Selectively Reroute Impacted Westbound Departures
- Step 6: All TMs Monitor and Evaluate Need for Updates to the Departure Plan
- Step 7: Weather Dissipates and TMIs are Reduced and Then Discontinued
- Step 8: Post-Event Analysis is Conducted and Reviewed with ATM Stakeholders

DRAFT

Federal Aviation Administration

Step 0: Day-Before TFM Planning

- **Initial planning began at least two days in advance of day-of operations**
- **Early in the afternoon the day before operations, the National Weather Forecasters give a briefing to the National Operations Manager (NOM) and the National Traffic Management Officers (NTMOs)**
- **The ATCSCC advanced planner (and supporting team) develops plans based on Ohio Valley forecast**
  - Use weather forecast and modeling to assess demand and impacts
  - Determine need for / identify playbook reroutes
  - Determine likely need for CTOP for eastbound flows, the definition of the FCAs, the parameters, and the applicable time periods
  - Determines likely need to reroute NY/PHL westbound departures which could include the use of TOS
  - Identify preliminary goals for next day operations
  - Develop draft plan based on all of the analysis
- **ATCSCC holds webinar that includes discussion of Advanced plan**
  - Participants include TMs from FAA ARTCCs, TRACONs, DDSO (Deputy Directors of Sys Ops), and flight operators
  - Flight operator and facility feedback is captured
- **End of afternoon, the Advanced Plan is finalized**
  - Advanced Plan released as part of 20:00 Ops Plan advisory (see figure)
- **Field Facilities and flight operators plan resources using Advanced Plan**

ATCSCC ADZSY 001 DCC 08/20/2022 OPERATION PLAN
RAW TEXT: EVENT TIME: 20/0100 – AND LATER

******ADVANCED PLAN FOR August 21, 2022******
Summary: Low IFR conditions and light rain forecast in EWR/LGA/PHL through mid-morning. If IFR conditions develop as forecast, GS and/or GDPs will be necessary to manage demand.

Thunderstorms forecast for Ohio Valley in mid-afternoon. Expect reroutes/CTOP to eastbound flows. Potential need for GDPs at NY Metros. Expect CDR usage for NY and PHL departures.
. . .
Preliminary Goals:
- Manage EWR/LGA/JFK maximum departure delays to less than 90 minutes due to SWAP. Document actions taken.
- Manage any en route TRANSCON structure to balance demand thru effected facilities. Document actions taken.
- Utilize CTOP for eastbound flows to the maximum extent possible
- Utilize TOS to reroute NY/PHL departures
- Maintain metering operations

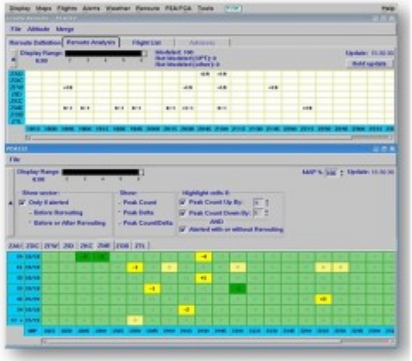
NEXT PLANNING WEBINAR: 1215Z
EFFECTIVE TIME: 20/0030 – 20/1359
20/08/22 00:30 DCCOPS.lxstn35

DRAFT

Federal Aviation Administration

Step 3: ATCSCC Severe Weather Specialist Monitors Flows Resulting from CTOP

- **Flights that 'route out' are identified**
- **ATCSCC Severe Weather Specialist evaluates airspace north and south of the CTOP FCA to identify secondary impacts of CTOP (i.e. demand/capacity imbalances) which may require further actions**
- **If imbalance is identified, the ATCSCC Severe Weather Specialist and impacted ARTCC TMCs would coordinate to develop TMIs to mitigate the imbalance**
- **Resulting TMIs are issued**



TFMS NAS Monitor

DRAFT

Federal Aviation Administration

Step 5b: Strategic and Tactical Actions Applied to Selectively Reroute Impacted Westbound Departures

- **ZOB TMC coordinates verbally with ZNY TMC to manage storm impact on westbound departures**
- **ZNY TMC uses TFMS (e.g., Departure Viewer, Integrated Departure Route Planning tool, Create Reroute tool, Reroute Monitor, Traffic Situation Display) to assess the impact of weather constraints on departure fixes and routes, and which flights are predicted to be impacted so they can be rerouted**
- **ZNY TMC uses TFMS to identify route options (including available TOSs to account for user preferences in the reroute process) and *checks operational suitability of route and estimates potential impact to flight's departure time*, if route option is subject to TBFM metering**
  - If no acceptable TOS is available (i.e., does not fit the constraints) then 1) flight operators can resubmit a new TOS or 2) a coded departure route (CDR) is assigned
- **ZNY TMC amends the flight's filed route to the new route with TFMS**
  - TFMS submits the amendment to ERAM (e.g., Pre-departure Reroutes [PDRR]) and ERAM distributes the route amendment to TFDM and TBFM (IDAC)
  - TBFM unschedules the flight
    - If the new route is subject to metering, TBFM displays the flight on the new estimated timeline and TBFM (IDAC) displays the flight in the unscheduled bin
- **ZNY TMC updates TBFM scheduling parameters and coordinates with Tower TMCs to appropriately adjust pre-departure scheduling of flights**

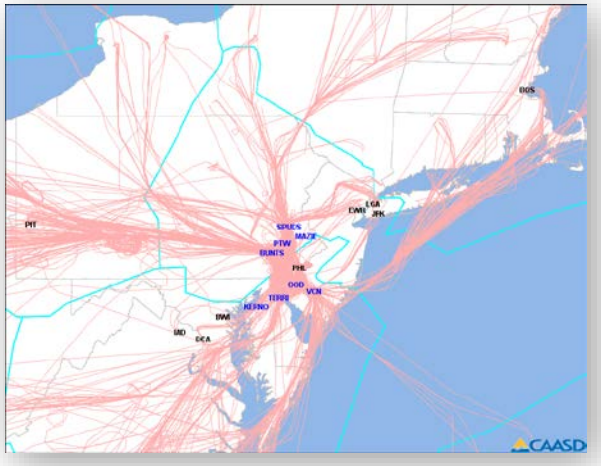
Situation: Storm is impacting NY/PHL westbound departures headed to ZOB airspace

DRAFT

Federal Aviation Administration

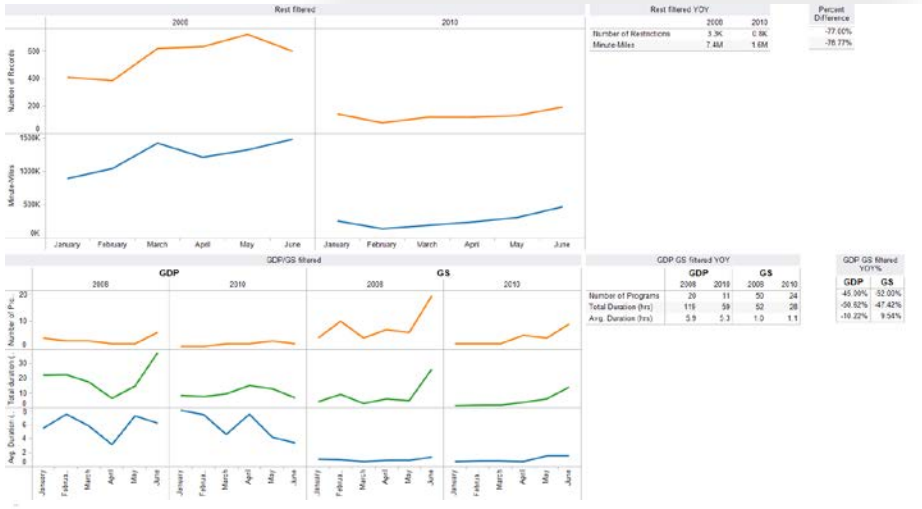
Why Should We Use Time-based Management?

A Measure of Success: Metering to PHL



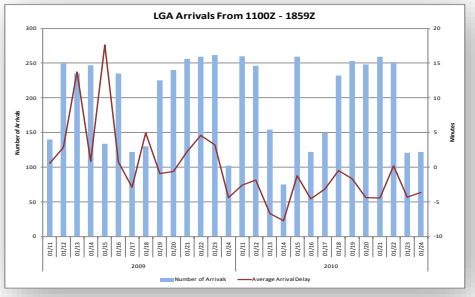
- **Post-Implementation Analysis to Evaluate Operational impact of Metering to PHL**
  - Jan-June 2008 (pre-TMA) vs Jan-June 2010 (post-TMA)

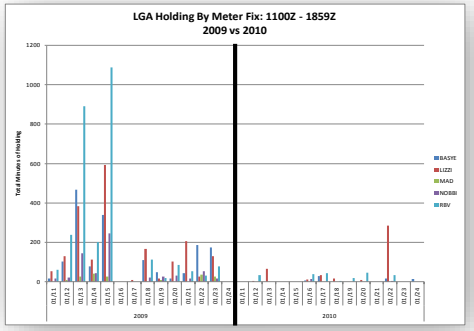
- **Findings showed significant Decrease in Holding** (number of flights held and total duration), **MIT Restrictions** (number and total minute-miles), and the number and duration of both **GDPs and grounds stops**
  - Average peak throughput at PHL increased ~ 3%
  - Holding reduced by ~ 50%



A Measure of Success: Metering to LGA

- **Post-Implementation Analysis to Evaluate Operational impact of Metering to LGA**
  - Comparison of operations (2 week period) in 2009 (before TMA) to 2010 (with TMA)
- **Findings showed Significant Benefits**
  - Arrival Delays
    - Average arrival delay vs flight plan **Decreased** from 2009 to 2010
  - Holding
    - Total minutes of holding **Reduced** in 2010 versus 2009
    - 2009—flights over RBV had greatest amount of holding. 2010—holding more **evenly distributed** across all fixes
  - MIT Usage
    - Number of MIT restrictions issued were ~ 25% *higher* in 2010 than 2009
    - Number of Minute-Miles (measure of MIT severity) were ~40% *Lower* in 2010 than 2009
  - Internal Departures
    - Average internal departure delays were under 5 minutes





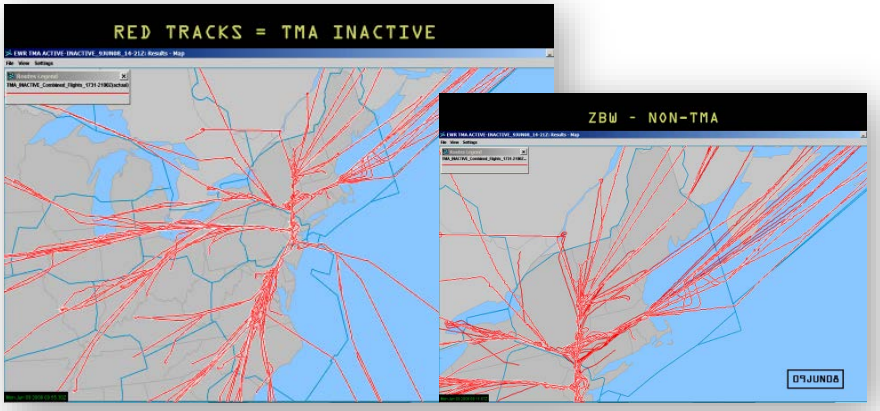
A Measure of Success: Metering to EWR

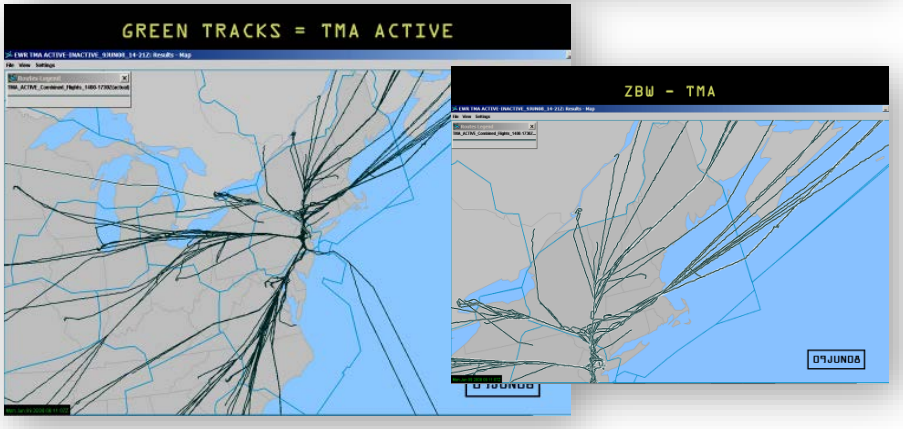
- **Performance Analysis Conducted by Continental Airlines Show Benefits of Metering**

Continental

EWR TMA vs NON-TMA DIFFERENCES
June 9, 12, 25, 2008

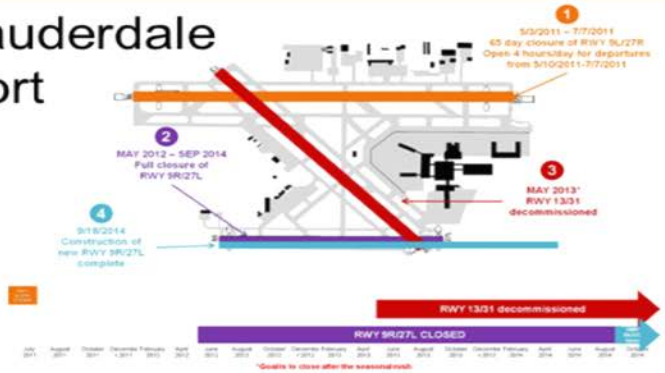
- AVG NON-TMA AIRTIME DIFFERENCE:
  - PLANNED vs ACTUAL AIRTIME = +7.4 MINUTES
  - PLANNED vs ACTUAL AIRTIME PERCENT = +5.3%
- AVERAGE TMA AIRTIME DIFFERENCE:
  - PLANNED vs ACTUAL AIRTIME = +3.4 MINUTES
  - PLANNED vs ACTUAL AIRTIME PERCENT = +3.1%
- SUMMARY:
  - TMA USAGE SAVED AN AVERGE OF 4.0 MINUTES OR 2.2% AIRTIME OVER NON-TMA FLIGHTS

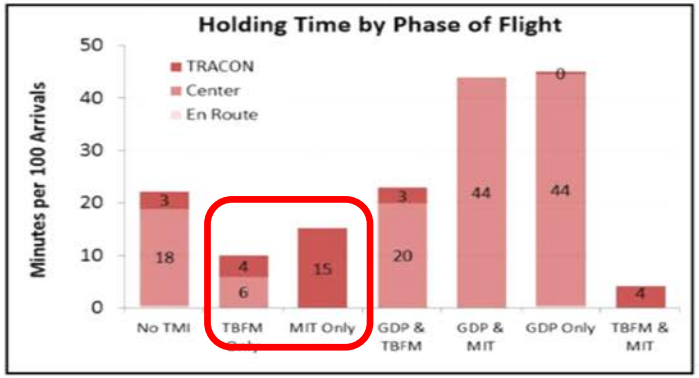




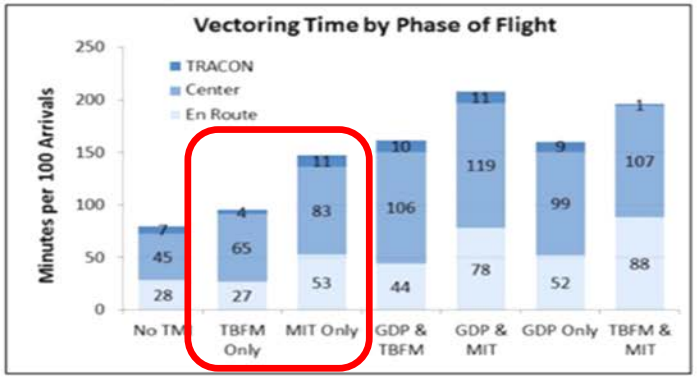
A Measure of Success: Metering to FLL

Ft Lauderdale Airport





- 3 year construction project reduces airport to single runway operation
- 2 years of pre-planning to minimize delays through traffic management initiatives
- Time Based Flow Metering (TBFM) improves efficiency for the capacity constrained airport
- TBFM results in reduced holding and vectoring



A Measure of Success: Metering over MIT

- **2014 TBFM NextGen Operational Performance Assessment**
  - Empirical Analysis of current operations to understand NAS-wide and Local use of TBFM

- **Findings Support Time-Based Metering as More Effective TMI over Miles-In-Trail**
  - **Use of Departure Scheduling**
    - Led to less arrival delay and arrival delay variability
    - Led to less variability of airborne delay
  - **Use of Airborne Metering**
    - Led to decrease in average holding and vectoring delays
    - Led to reduction in variability of holding and vectoring delays
    - Upstream center share of holding/vectoring drops most

Terminal TBM Benefit Areas

Types of Benefit	Benefit	Source
Trajectory Efficiency	Decrease in delays through reduced flight time	TSS2 HITL, 2013
	Savings due to greater use of optimal trajectories and reduced ground tracks	TSS2 HITL, 2013
Throughput*	Increase throughput due to the ability to realize more efficient arrival spacing	TSS2 HITL, 2013; TBFM WP3 Shortfalls, 2013
Safety	Decreased probability of loss of separation due to TSAS spacing assurance	SME input based on reduced route deviations
	Reduced controller workload due to improved capability to maintain the queuing flights on their published routes & STA with less control actions	Various HITLs 2013-2014
	Decreased deviations from published routes	Application of ASIAS study, 2012
Environmental	Reduction in CO_2 emissions and noise level	TSS2 HITL, 2013
TBFM Schedule Improvements	Improved scheduling allows better merging of flows to the runways allowing En Route and TRACON controllers to work toward common plan that includes appropriate spacing at all merge points	SME input based on HITL experience

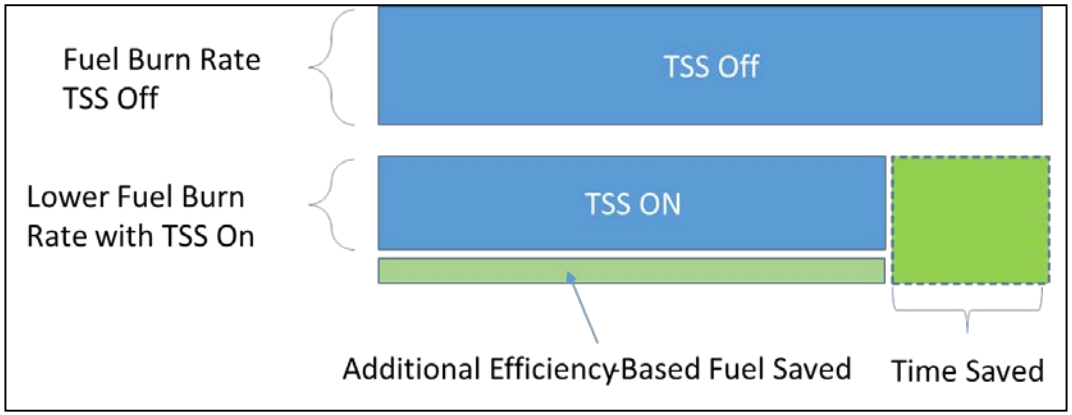
* Not part of economic analysis

ASIAS: Aviation Safety Information Analysis and Sharing
STA: Schedule Time of Arrival

Source: derived from TBFM WP3 BBOE

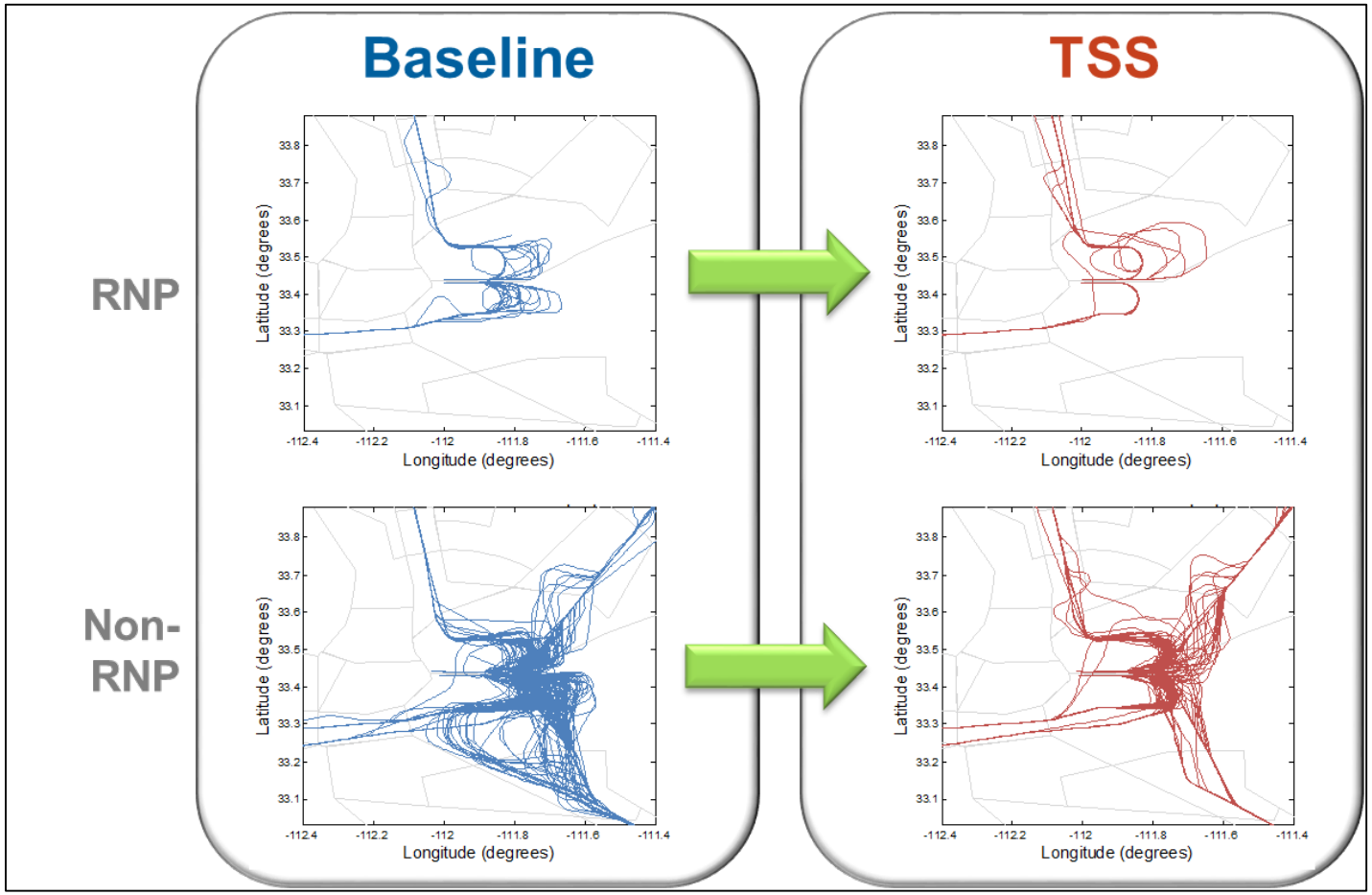
Terminal TBM Enables Reduced Flight Time and Fuel Burn

- **TSAS shortens flying time in TRACON**
  - More RNP approaches with RF-leg (curved)
  - Less vectoring
- **TSAS promotes more efficient trajectories in TRACON**



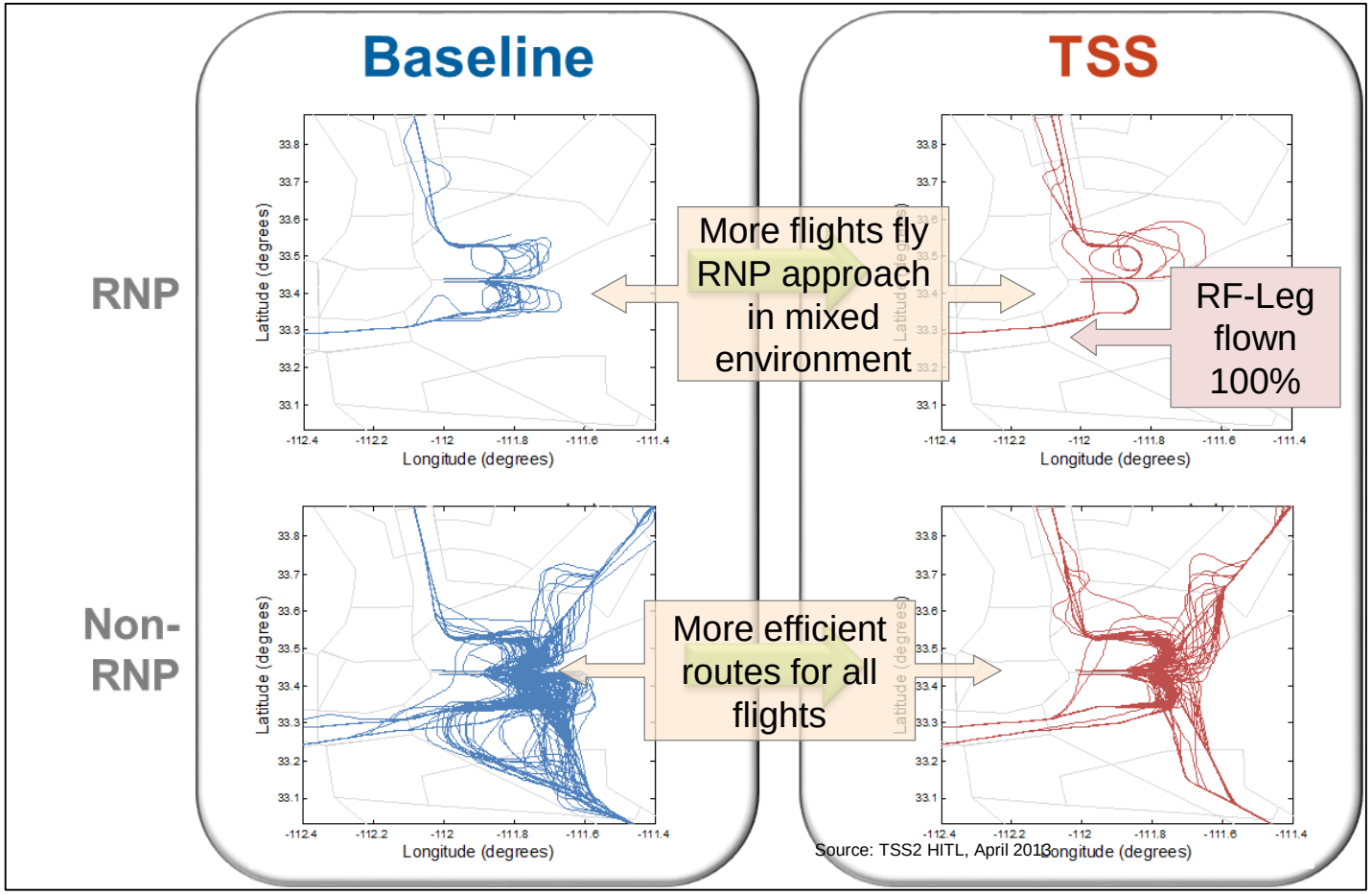
Source: TBFM WP3 BBOE

Terminal TBM: TSAS HITL Simulation Results



Source: TSS2 HITL, April 2013

Terminal TBM: TSAS HITL Simulation Results



Source: TSS2 HITL, April 2013