Airspace Technology Demonstration 2 (ATD-2)

Concept of Use (ConUse) Addendum for Phase 3

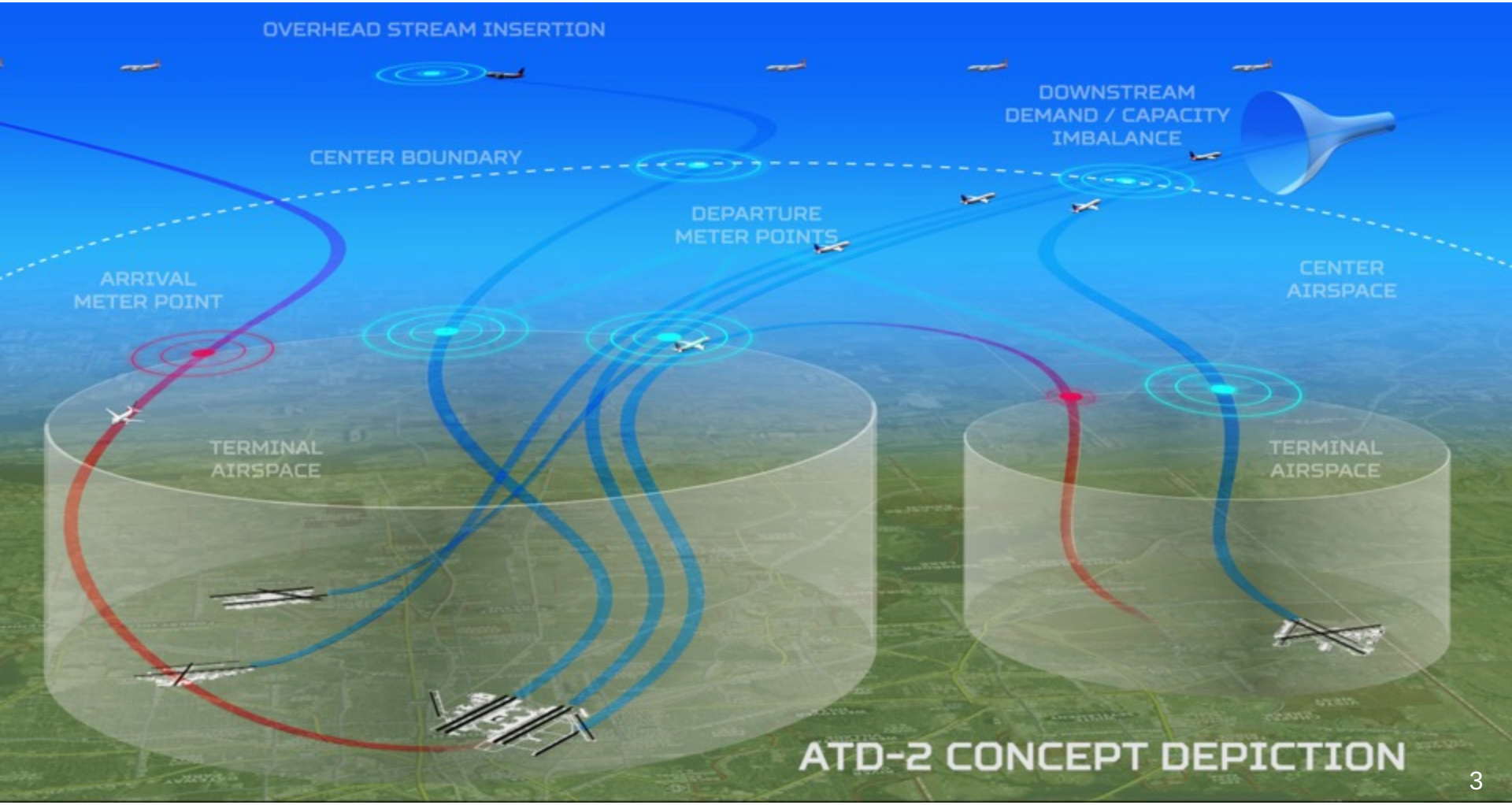
16 July 2020

Introduction: ATD-2 Phase 3 Metroplex Integrated Arrival, Departure, Surface (IADS) Demonstration

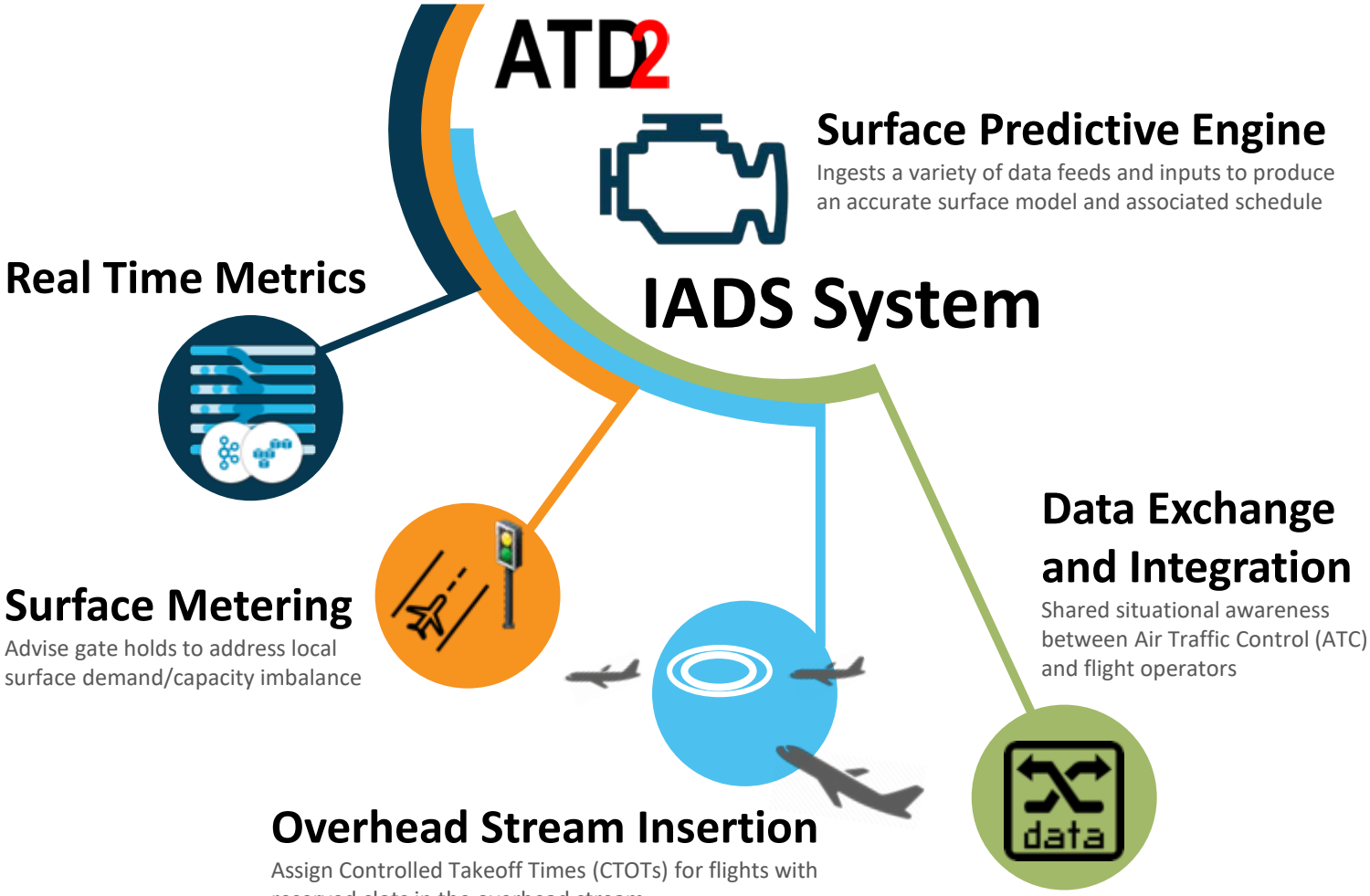
- Identification – Operational ConUse for ATD-2 Phase 3 Metroplex Integrated Arrival, Departure, Surface (IADS) Demonstration research
  - Add capabilities at Dallas/Fort Worth International Airport (DFW) and Dallas Love Field Airport (DAL) that build on the Phase 2 Fused IADS Demo at Charlotte Douglas International Airport (CLT)
    - ✓ **Trajectory Option Set (TOS) Service** – flight operator submitting requests to reroute flights on pre-coded routes
    - ✓ **Scheduling to the Terminal Boundary** – multi-airport scheduling via the DFW Terminal RADAR Approach Control (D10 TRACON)
    - ✓ **Traffic Management Initiative (TMI) Propagation** – restrictions entered by the Fort Worth Air Route Traffic Control Center (ZFW ARTCC) propagated via the National Traffic Management Log (NTML)
- Background – Planned evolution from Phase 2 Fused Demonstration
- Scope – Identify changes in ConUse relative to Phase 2 Fused Demo
- Organization of document
  - Introduction
  - ATD-2 IADS Overview & Early Phases
  - Phase 3 IADS System Concepts w/ Operational Scenarios/Use Cases (by technology area)
  - Operational Concepts and Impacts
  - Summary
  - References
  - Acronyms

ATD-2 IADS Overview: Overall Concept

ATD-2 is a field demonstration project of scheduling tools to efficiently manage traffic from the gate to the overhead stream merge. NASA is working in cooperation with the FAA and industry.



ATD-2 IADS Early Phases: Phase 1 Baseline IADS Capabilities



ATD-2 IADS Early Phases: Phase 1 Baseline IADS Micro-Phases Added Capabilities Incrementally

	ATC	Ramp	Flight Deck
Micro-Phase I	• Implement runway utilization strategies, departure fix closures, runway closures, and TMIs using Surface Trajectory Based Operations (STBO) as part of daily operations • System Wide Information Management (SWIM) Approval Required (APREQ) times and Expect Departure Clearance Times (EDCTs) available in STBO • STBO tools and Data Analysis and System Health (DASH) used to understand demand capacity imbalances	• During Bank 2, all ramp controllers and ramp manager use Ramp Traffic Console (RTC) • Inputs made by ATC will be seen on RTC regarding runway utilization strategies, departure fix closures, runway closures, and TMIs • Pushback advisories available for APREQ times and EDCTs • Ability to request runways for Operational Necessity (OpNec)	• During Bank 2, the flight deck receives changes to runway assignments and departure fixes from ramp control • Push back advisories given based on APREQ times and EDCTs

Micro-Phase II	• Time Based Flow Management (TBFM) Integrated Departure Arrival Capability (IDAC) style electronic negotiation with Washington ARTCC (ZDC) for APREQ times
	  • Use of red/green bar spacing to determine available slots
	  • Electronic requesting of slot
		• During additional banks, all ramp controllers and the ramp manager continue using RTC
		  • The manner in which Data Exchange and Integration (DE&I) is expanded is a ramp-based decision, but coordinated with ATC
			• During additional banks, the flight deck receives runway assignments and changes to departure fixes
			• Push back advisories given based on APREQ times and EDCTs

Micro-Phase III	• Procedures and coordination required for surface metering • Use of DASH to determine when to implement surface metering	• Daily operational use of RTC • Use of DASH to determine when to implement surface metering • During surface metering pushback advisories available and utilized	• During Bank 2, the flight deck receives a hold command for surface metering (e.g., “pushback hold due to metering”) from ramp control via voice communication

ATD-2 IADS Early Phases: Fused IADS Technology Enhancements

Phase 2 Development
Fused IADS Demonstration

Agile Deve
Continued eng

Foundatio
Leveraging IAD

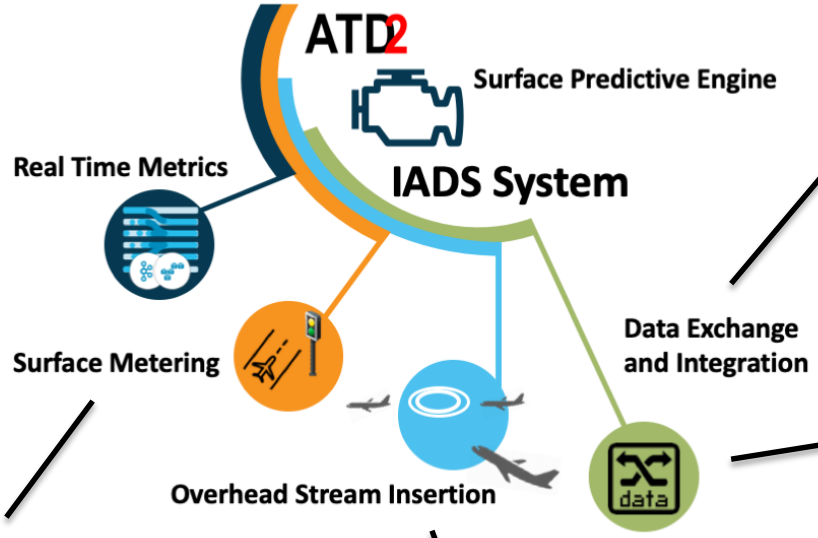
Leveragin
Iterating with F

Phase 2 (IADS Fusion, Sept 2018)

- **Strategic planning tools (strategic/tactical fusion)**
- **Atlanta ARTCC (ZTL) / Hartsfield-Jackson Atlanta International Airport (ATL) airspace tactical scheduling**
- **Electronic Flight Data (EFD) Integration**
- **Terminal Flight Data Manager (TFDM) Terminal Publication (TTP) prototype**
- **Mobile Application (App) for Earliest Off-Block Times (EOBTs) (General Aviation (GA) / Business Aviation (BA) community)**

ATD-2 IADS Early Phases: Fused IADS Introduces Five New Capabilities

Phase 2 capabilities built on Phase 1 IADS system in use at CLT since 29 Sep 2017



1. **Tactical-Strategic Fusion**: Extend metering horizon to strategic timeframes
Enables flight operators to make decisions earlier & more closely approximates TFDM

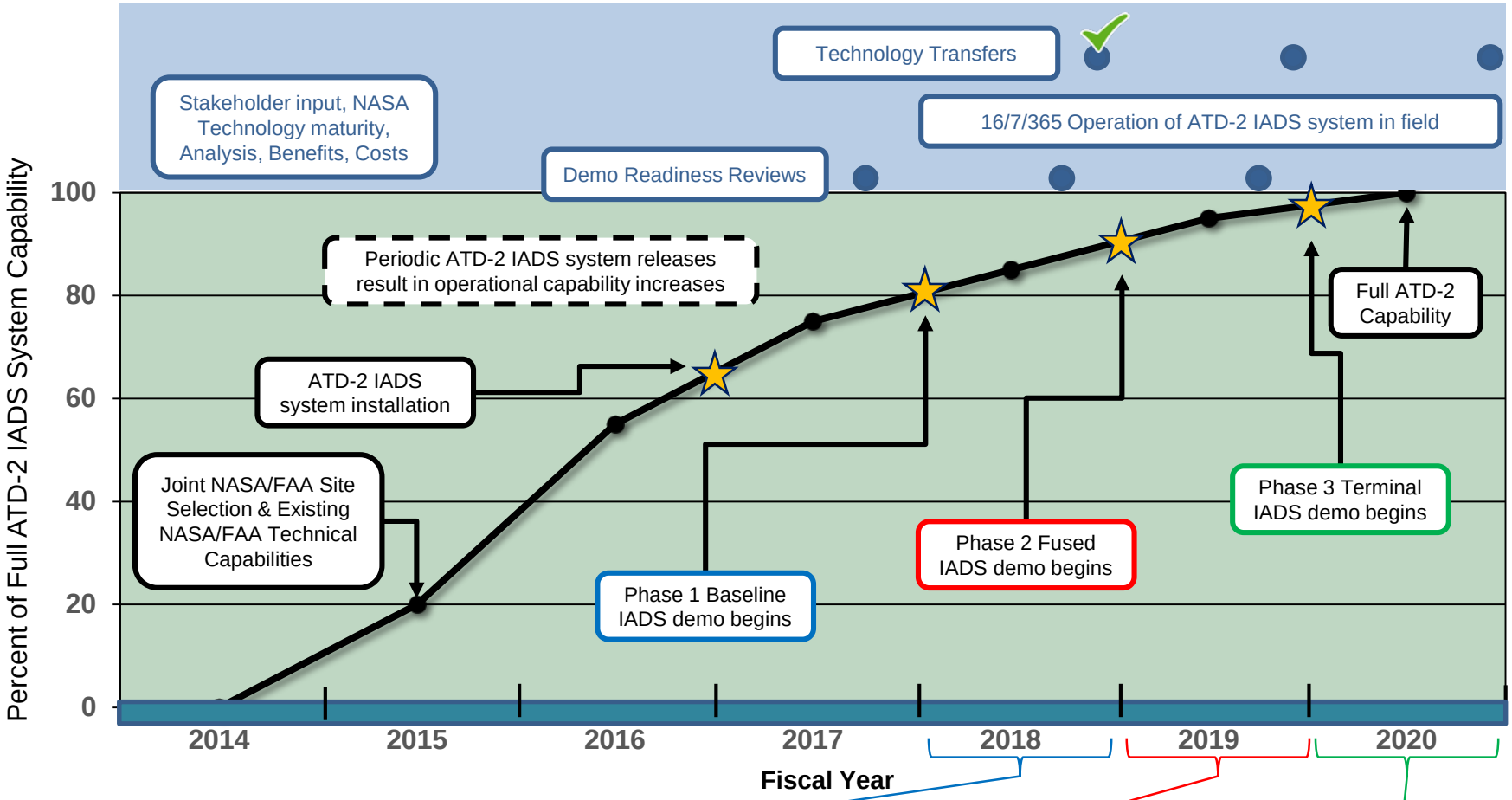
2. **TMI Evolution**: Interface with ZTL arrival metering TBFM system
Enables evaluation of pre-scheduling into overhead stream

3. **Advanced Electronic Flight Strips (AEFS) Integration:** Interface with FAA prototype Tower controller electronic flight strips system
Enables more precise management of controlled takeoff times & more closely approximates TFDM

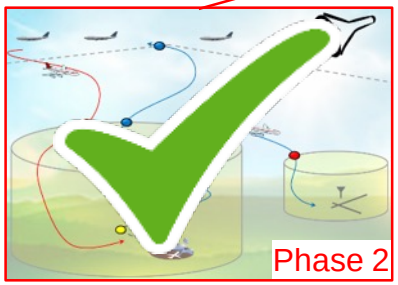
4. **TFDM Terminal Publication (TTP):** Deliver IADS data as TTP service via FAA SWIM
Enables all flight operators to participate in ATD-2 Field Demo & more closely approximates TFDM

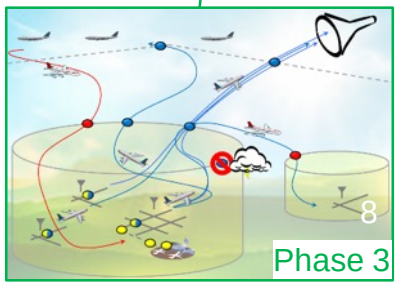
5. **Mobile App**: Ingest data from TTP-connected Mobile App into IADS scheduling system
Enables GA/BA flight operators to participate in ATD-2 Field Demo

ATD-2 IADS Early Phases: Buildup and Progress



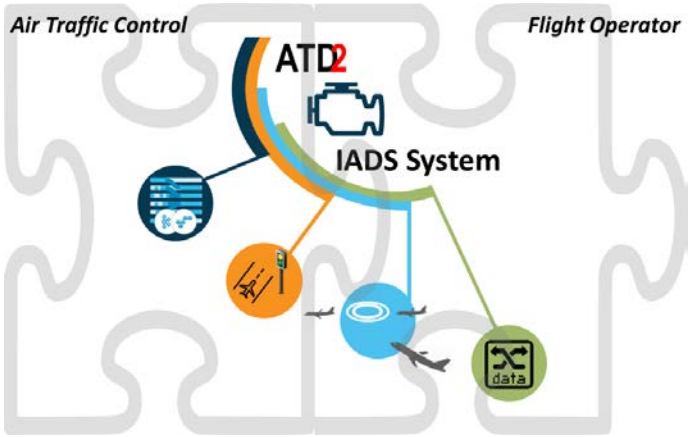
Field Demo structured in 3 year-long phases with increasing IADS system capabilities.





Phase 3 IADS System Concepts & Operational Scenarios: Builds on Previous Phases

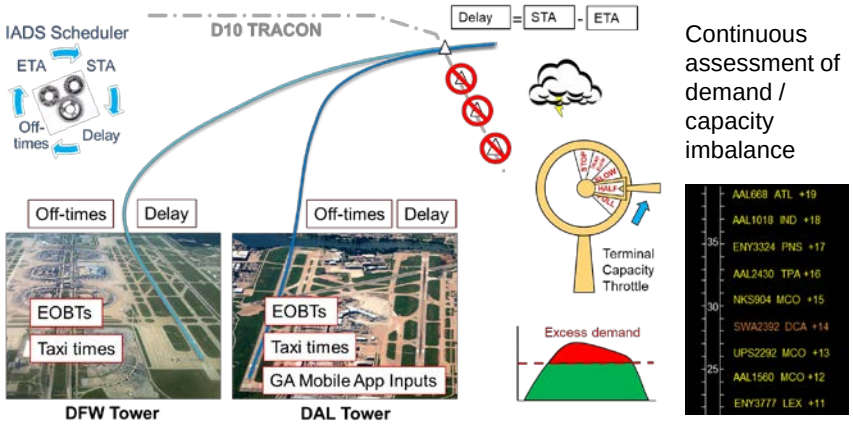
Phase 2 Continues in CLT



NASA's ATD-2 Single-Airport IADS prototype capability is a ***trailblazer*** for the FAA's Terminal Flight Data Manager (TFDM) Program

- The TFDM concept depends on unprecedented levels of collaboration between ATC and Operators
- TFDM will provide tools for ATC, but only data for Operators
- The ATD-2 IADS system implements ***both*** ATC and Operator ***pieces of the puzzle***
- ATD-2 is transferring Technology and Knowledge to ***both*** FAA and Industry (operators and vendors)

Phase 3 Commences in North Texas



Continuous assessment of demand / capacity imbalance

NASA's ATD-2 Multi-Airport IADS prototype capability builds on Phase 2 foundation to provide IADS solution for the Metroplex

- Key element of Phase 3 is application of Trajectory Option Sets (TOS) to departures
- Phase 3 evaluation begins on June 10th 2019; added increments in mid-July and mid-August
- Summer 2019 is Initial Concept Evaluation to prepare for Phase 3 Operational Evaluation in 2020
- Southwest Airlines (SWA), Envoy Airlines (ENY), GA and National Business Aviation Association (NBAA), and DFW Airport joining American Airlines (AAL), FAA, and National Air Traffic Controllers Association (NATCA) as Field Demo Partners for Phase 3

Phase 3 IADS System Concepts & Operational Scenarios: Overview

Surface Meets TOS

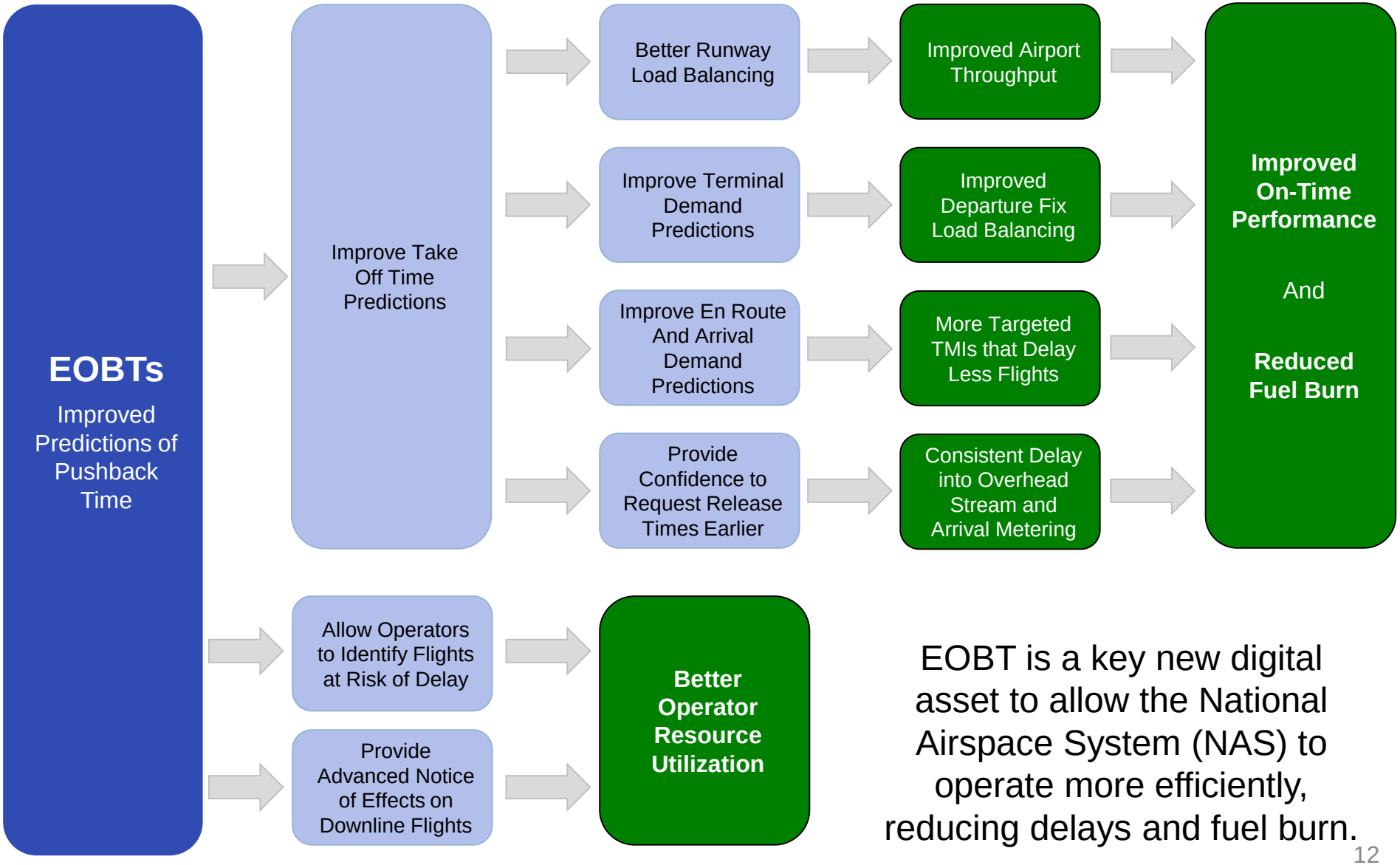
- A set of capabilities that:
  - Leverage IADS surface predictive and scheduling technology (Phases 1-2)
  - Expand IADS to the terminal boundary
  - Provide Trajectory Option Sets (TOS) to identify when alternative routes are available to reduce surface delay for departures out of the North Texas region
  - Leverage Collaborative Decision Making (CDM) products, such as Coded Departure Routes (CDRs), Playbook
    - Using existing CDRs for TOS options increases probability of ATC approval and simplifies rerouting data entry
  - Identify potential solutions to bridge Traffic Flow Management System (TFMS), TBFM, and TFDM (3T) technology gaps

Phase 3 IADS System Concepts & Operational Scenarios: Stormy 19, 20, and 21 Objectives

Crawl – Walk – Run Approach

- Stormy 19 (exploratory research – Summer of 2019)
  - Identify requirements through Shadow Sessions
  - Develop an initial capability in an *agile* manner
  - Incremental build of capability (3 micro-phases)
  - Test and use incrementally in operational environment
  - Collect data, observation, feedback
  - Identify monetizable benefits
  - Mature capability
  - Identify goals for Stormy 20
- Stormy 20 (planned test – Spring and Summer of 2020)
  - Implement lessons learned from Stormy 19
  - Identify technology transfer deliverables
  - Develop larger capability leveraging SWIM components
  - Testing and data collection interrupted by COVID-19
- Stormy 21 (formal test – Spring and Summer of 2021)
  - Test and collect data
  - Measure benefits

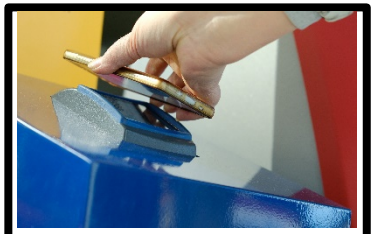
Phase 3 IADS System Concepts & Operational Scenarios: Expanded Potential Benefits of EOBT for TOS and Terminal Scheduling



EOBT is a key new digital asset to allow the National Airspace System (NAS) to operate more efficiently, reducing delays and fuel burn.

Phase 3 IADS System Concepts & Operational Scenarios: Increasing Predictability in the Overhead Stream for TOS and Terminal Scheduling by Leveraging Digital Assets (EOBT)

Sensors



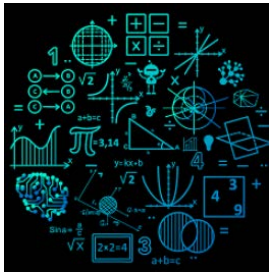
Ticket Scan

Video detection

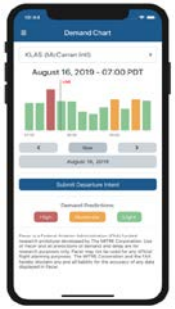
Customer bag scan

Fueler events

Operators



For air carriers, algorithms produce EOBTs and send to SWIM.



GA/BA pilots/flight operators provide EOBT to system via mobile app/web site.

NASA ATD-2

NASA system consumes EOBTs from SWIM and calculates earliest wheels OFF (departure at runway). Sends to FAA Center TBFM system.

FAA Systems

FAA system calculates release time and sends it back to NASA system, which then sends it to SWIM TFDM Terminal Publication (TTP*) for others to consume.

*TTP – currently research-only SWIM topic

New Use?

Phase 3 IADS System Concepts & Operational Scenarios: Stormy 19 Micro-Phased Evaluation

3A - June 10, 2019	3B - July 15, 2019	3C- August 12, 2019
Terminal Data Exchange & Integration	**Departure Fix Load Balancing With TOS**	**Departure Fix Load Balancing with TOS + Data Comm**
New terminal information in operational areas, but not used for operational decisions. Allows ATC restrictions to be available from NTML and SWIM while users orient to new displays.	Core 'Stormy 19' departure fix balancing with TOS concept of operations. Phased in progressively during agreed upon traffic and weather scenarios.	Expand upon 3B with Data Communication equipage information to user interfaces. Targets more benefit via use of Controller-Pilot Data Link - Departure Clearance (CPDLC-DCL) equipped flights for overall delay reduction.

Phase 3 IADS System Concepts & Operational Scenarios: Development

- Graphical User Interface: Metroplex Planner
  - Multi-airport system
  - New TOS Table and Demand and Delay Graphics
  - Enhancement of Map with TMI information
  - Enhancement of Timeline information with TOS information
- Data
  - Multi-airport Fuser
  - Ingestion of SWA's EOBT and Gate information
  - Addition of SWIM Flight Data Publication Service (SFDPS) data to ingest additional flight plan, in particular CPDLC-DCL information
  - Update TMI Service to parse TfmFlow Data from NTML entries (standardization of NTML entries with partners, handling of cancellations)
- Services
  - Creation of TOS Service
    - Handling of TOS, flights included/excluded, route and Relative Trajectory Cost (RTC) distance computation
  - User's management of flight exclusions and TOS routes (ATC – global; Flight Operator (FO) - individual)
- Predictive and Scheduler Engine
  - Creation of terminal wide scheduler
  - Integration of terminal constraints into airport schedulers
  - What-if loop over alternate routes to identify candidate routes
  - Computation of delay savings of alternative TOS routes
  - Computation of delay savings for individual and multiple flights
  - Computation of probability of estimated delay savings

Phase 3 IADS System Concepts & Operational Scenarios: ConUse Sections

- Trajectory Option Set (TOS) Service
- Scheduling to the Terminal Boundary
- TMI Propagation

Trajectory Option Set (TOS) Service

Operational Scenarios

TOS Service:
TOS Capability Overview

- **Objective**:
  - Reduce surface delay due to congestion at D10 TRACON departure gates caused by impacts of weather or TMIs
  - Identify flights which could depart earlier if they switch to a different departure route that has more available capacity than their current departure route
  - Provide common interface for increased situational awareness and easy submission / approval of TOS routes

- **Features**:
  - Scheduler
    - Continuously predicts future departure times and delay from initial pushback to crossing departure gate
    - Takes into consideration departure demand and capacity, departure fix closures, TMIs, and surface congestion
  - TOS Service
    - Generates alternative routes for Flight Operators' departures and evaluates them for potential delay savings
    - Calculates the Relative Trajectory Cost (RTC) for each TOS
  - Metroplex Display
    - Used by Flight Operators and ATC for common situational awareness and request / approval of TOS Routes
    - Includes all airports in D10 airspace

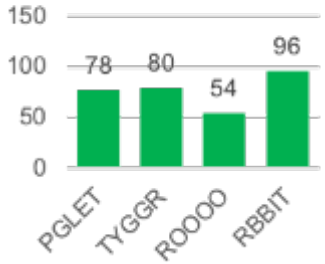
TOS Service:
TOS Capability Overview cont.

- **Scheduler**
  - Continuously predicts the Estimated Takeoff Time (ETOT) for the flight's filed route and each TOS route
  - Uses TMI constraints to predict delays at runway and terminal boundary
  - Continuously predicts delay on the filed route and delay savings by comparing the ETOT for each TOS Route with the ETOT for the filed route
- **Trajectory Options Sets (TOS)**
  - Generates and recommends TOS for flights that are estimated by the Scheduler to have reduced delay if they depart via a different departure route
  - Computes a Relative Trajectory Cost (RTC) for each route, based on nautical miles (nm) differences with the filed route, the filed speed, and a cost factor provided by the Flight Operator
  - Indicates when a TOS route delay savings benefit is superior to the RTC
  - Indicates which TOS route provides the highest savings compared to the RTC
- **Metroplex Planner Interface**
  - Allows Flight Operators to submit one or more TOS routes per flight to ATC, and allows ATC to approve a TOS route
  - Provides common situational awareness to both ATC and Flight Operators regarding:
    - Demand and delays at the terminal boundary and at D10 airports
    - TOS eligibility and coordination states
    - Additional TMI information, such as terminal restrictions and mandatory reroutes
    - CDR/TOS availability

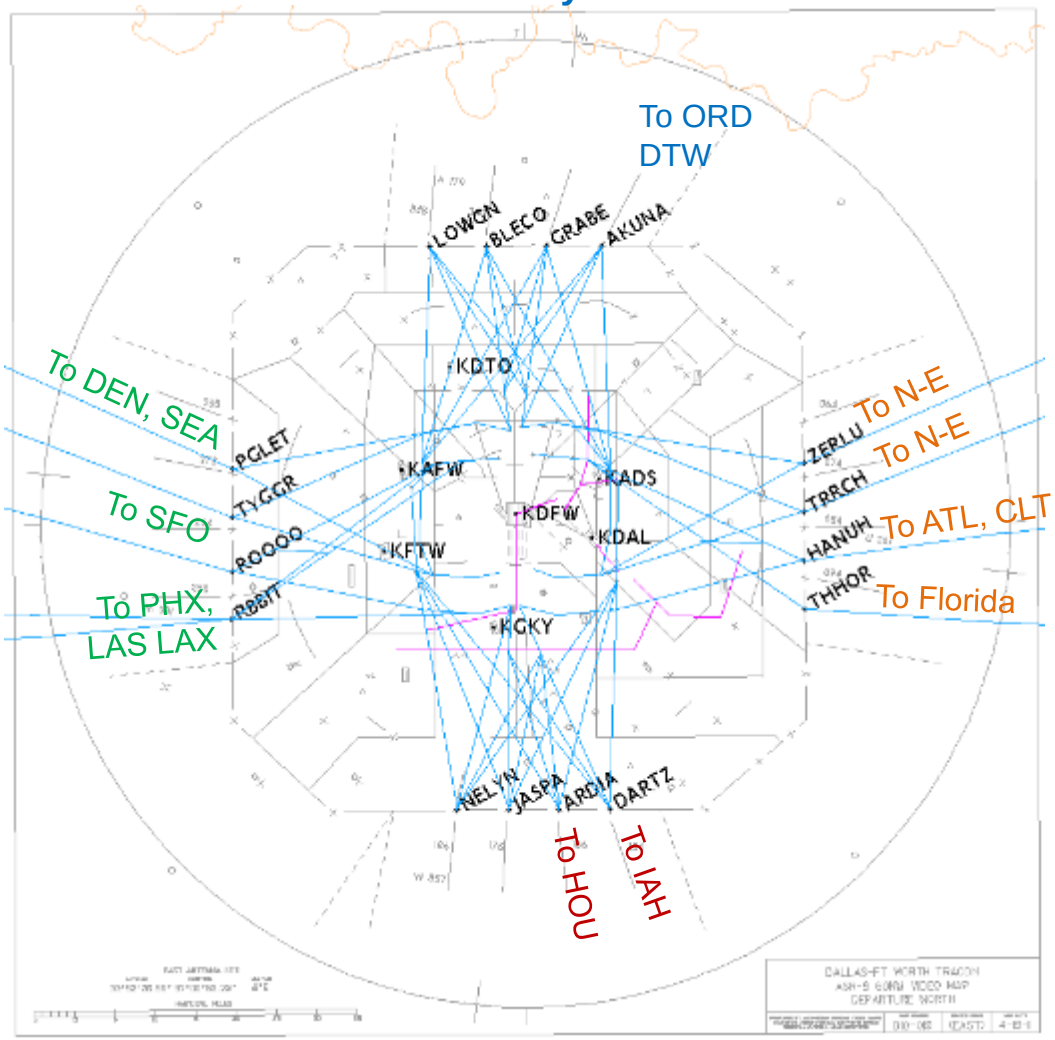
TOS Service:
D10 Departure Fix Demand Example

North Gate
252/day

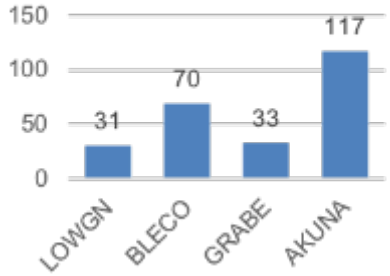
West Gate



West Gate
306/day

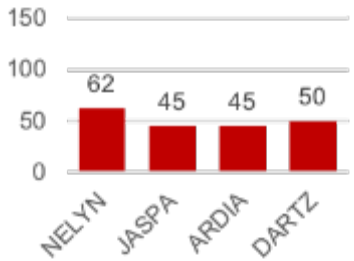


North Gate

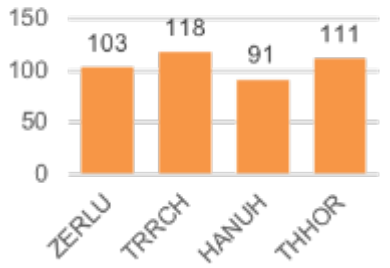


East Gate
435/day

South Gate



East Gate

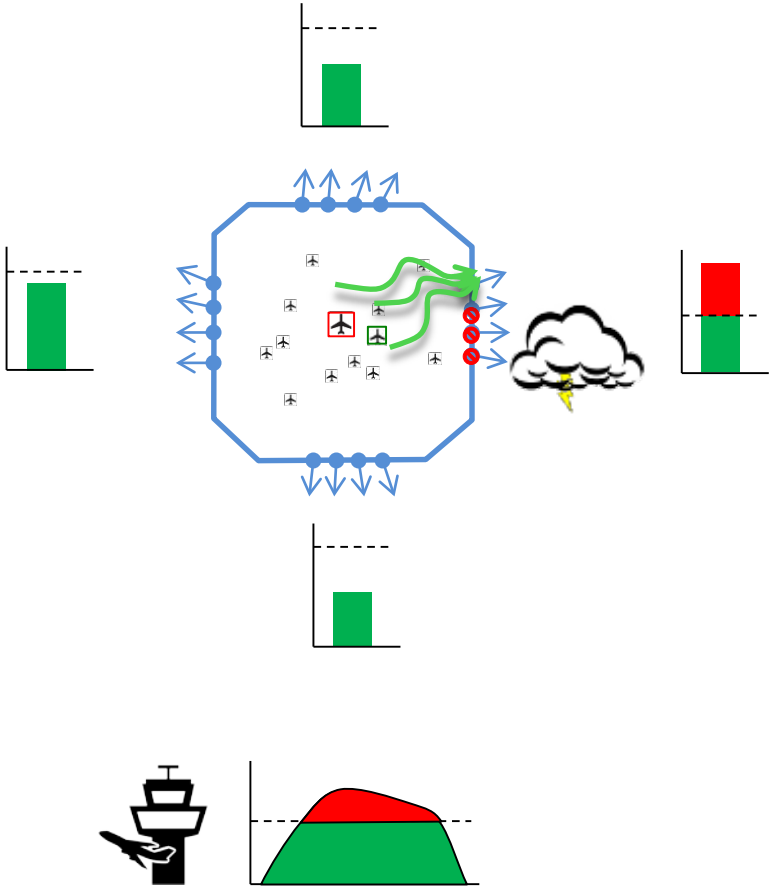


South Gate
201/day

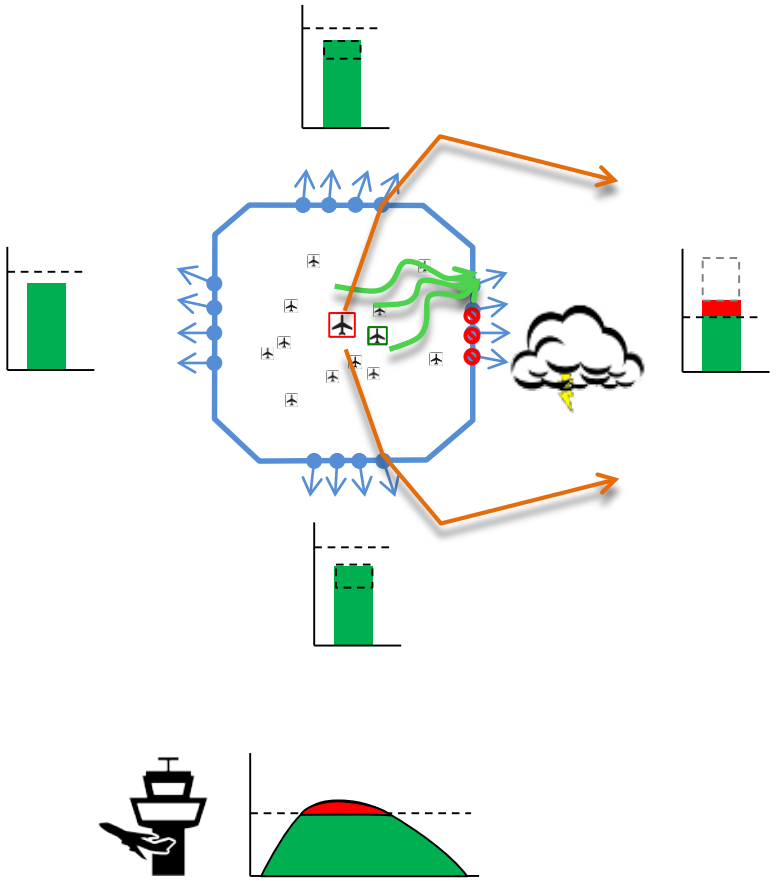
TOS Service:
Impact on Departure Fix Capacity due to Weather

Fix compression caused by weather events near TRACON airspace

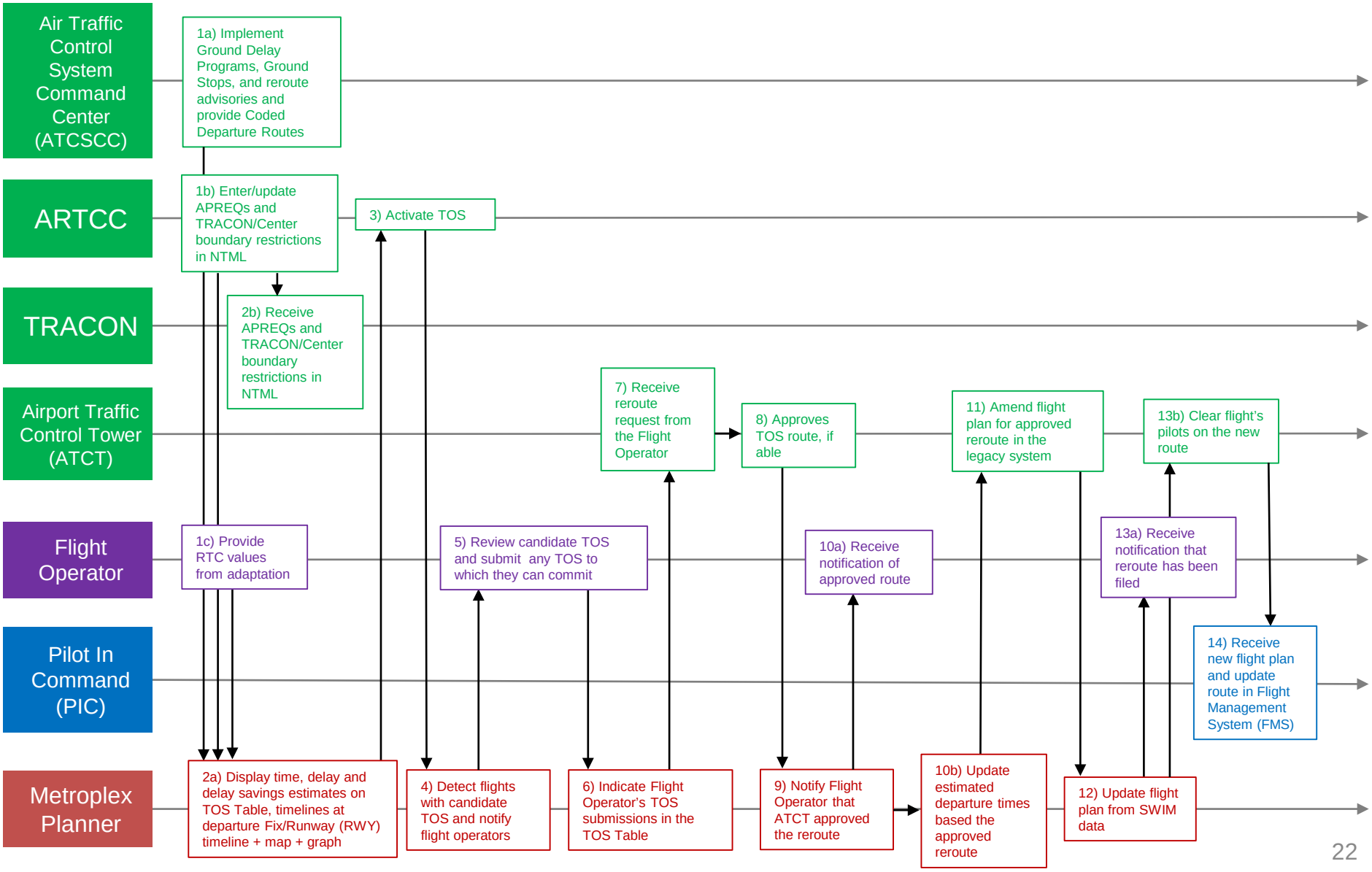
Fix Compression due to Departure Gate Closure



Load Balancing With TOS via Open Departure Gates



TOS Service: TOS Submission / Approval Process Flow



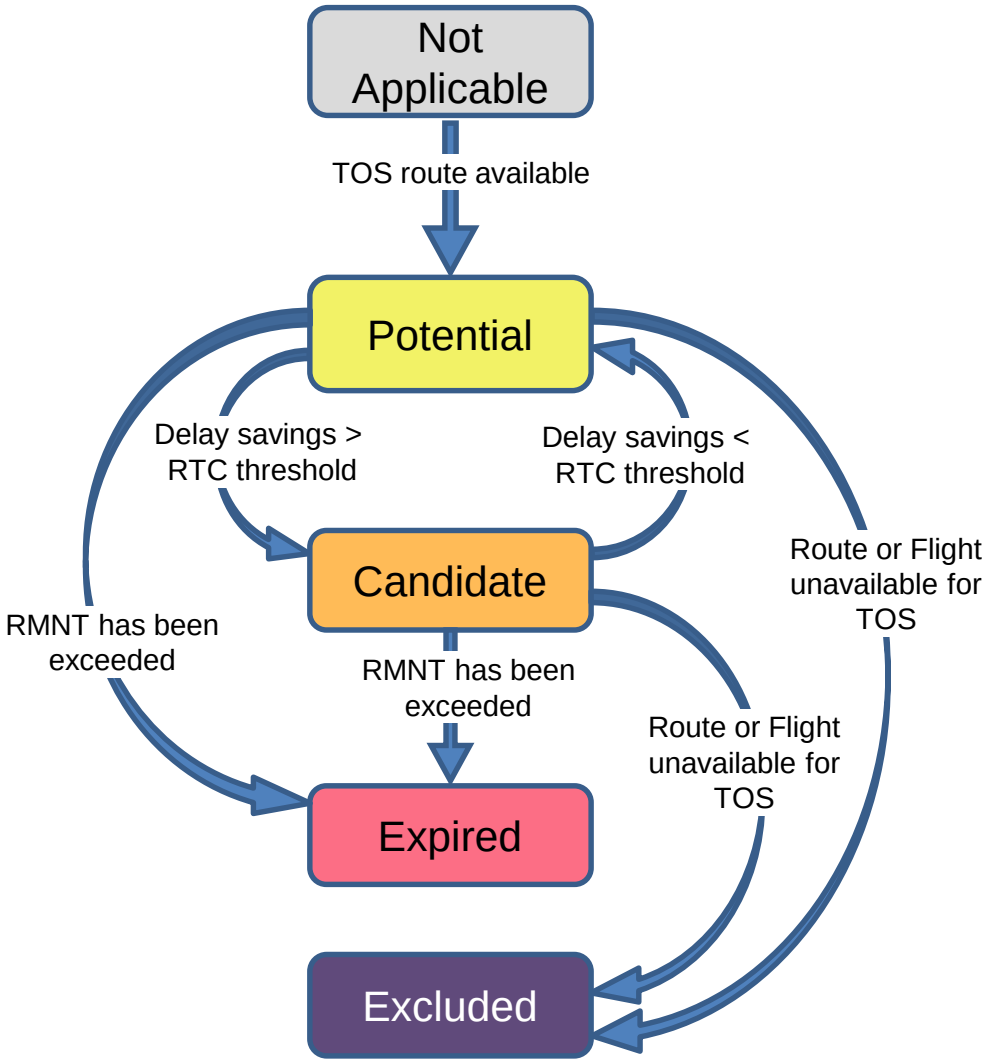
TOS Service:
TOS Eligibility States

- **Eligibility**
  - **Potential**
    - TOS generated for a flight that does not rise above the RTC threshold set by the flight operator
  - **Candidate**
    - TOS generated for a flight that has an estimated delay savings that matches or exceeds the RTC threshold set by the flight operator
  - **Expired**
    - A TOS candidate that:
      - Is no longer an option due to not meeting the Reroute Minimum Notification Time (RMNT)
      - Or, never reached the Operator Submitted status prior to flight departure
  - **Excluded**
    - A TOS candidate that:
      - Is restricted by a Traffic Management Initiative, such as APREQ, EDCT, fix closure, or mandatory routes
      - Or, is marked as excluded from the pool of TOS flights by the Flight Operator

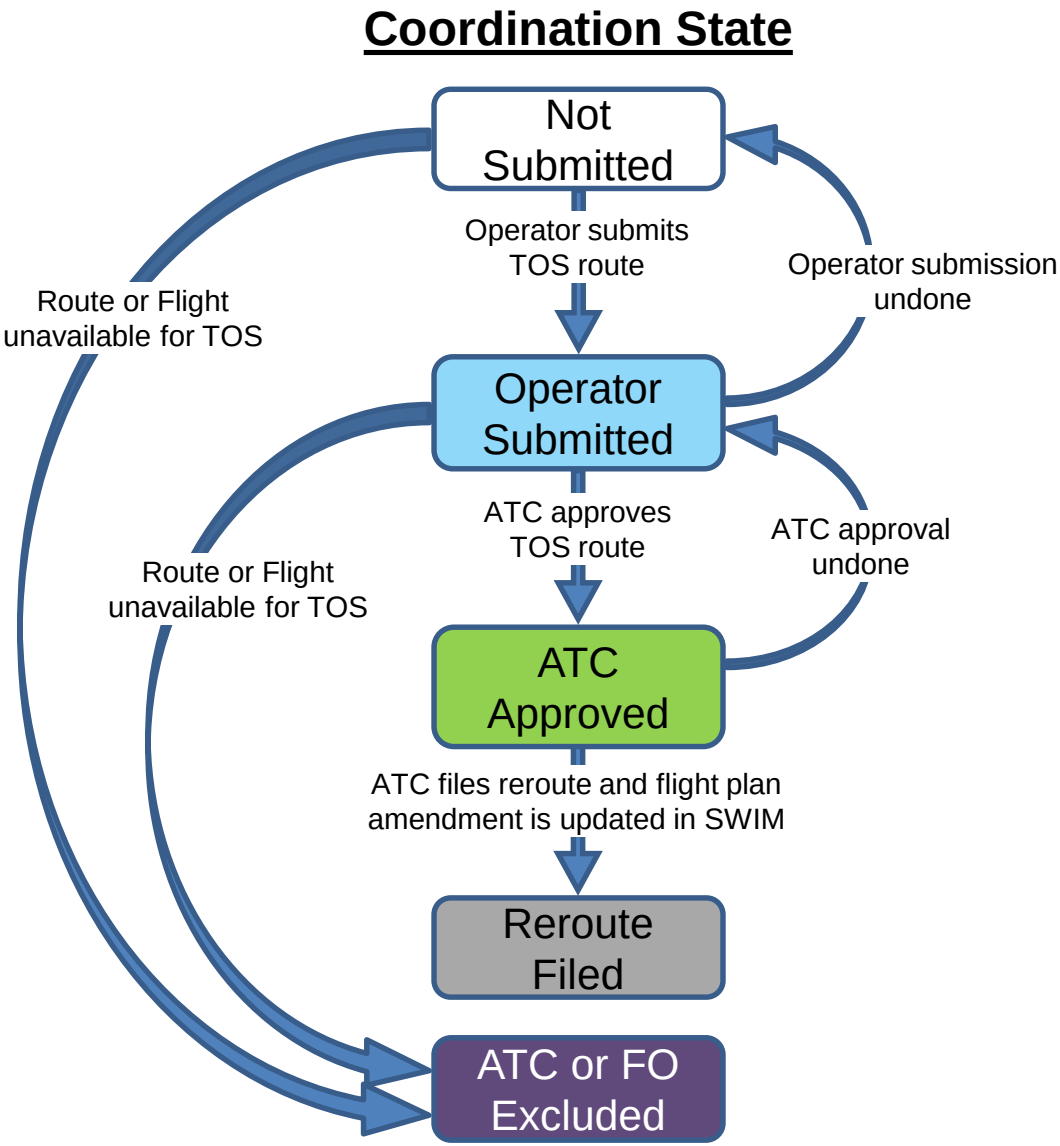
- **Coordination State**
  - **Operator Submitted**
    - TOS candidate which has been evaluated by the flight operator and submitted for approval by ATC via the Metroplex Planner
  - **ATC Approved**
    - TOS candidate submitted by the flight operator and approved by ATC
  - **Reroute Filed**
    - Flight plan has been successfully rerouted to match TOS candidate submitted and approved
  - **ATC Excluded**
    - A TOS route, or flight, that is restricted by a Traffic Management Initiative, such as APREQ, EDCT, fix closure, or mandatory routes
  - **FO Excluded**
    - A flight that is marked as excluded from the pool of TOS flights by the Flight Operator

TOS Service:
TOS Eligibility State Diagram

Eligibility State



TOS Service:
TOS Coordination State Diagram



TOS Service: TOS Eligibility vs. Coordination States Compatibility Table

Eligibility State	Coordination State
Not Applicable	Not Submitted
Potential	Not Submitted
Potential	Op Submitted
Potential	ATC Approved
Potential	Reroute Filed
Candidate	Not Submitted
Candidate	Op Submitted
Candidate	ATC Approved
Candidate	Reroute Filed
Expired	Not Submitted
Expired	Op Submitted
Excluded	ATC Excluded
Excluded	FO Excluded

TOS Service:
1 Before Day of Ops. Formulate 'Static TOS'

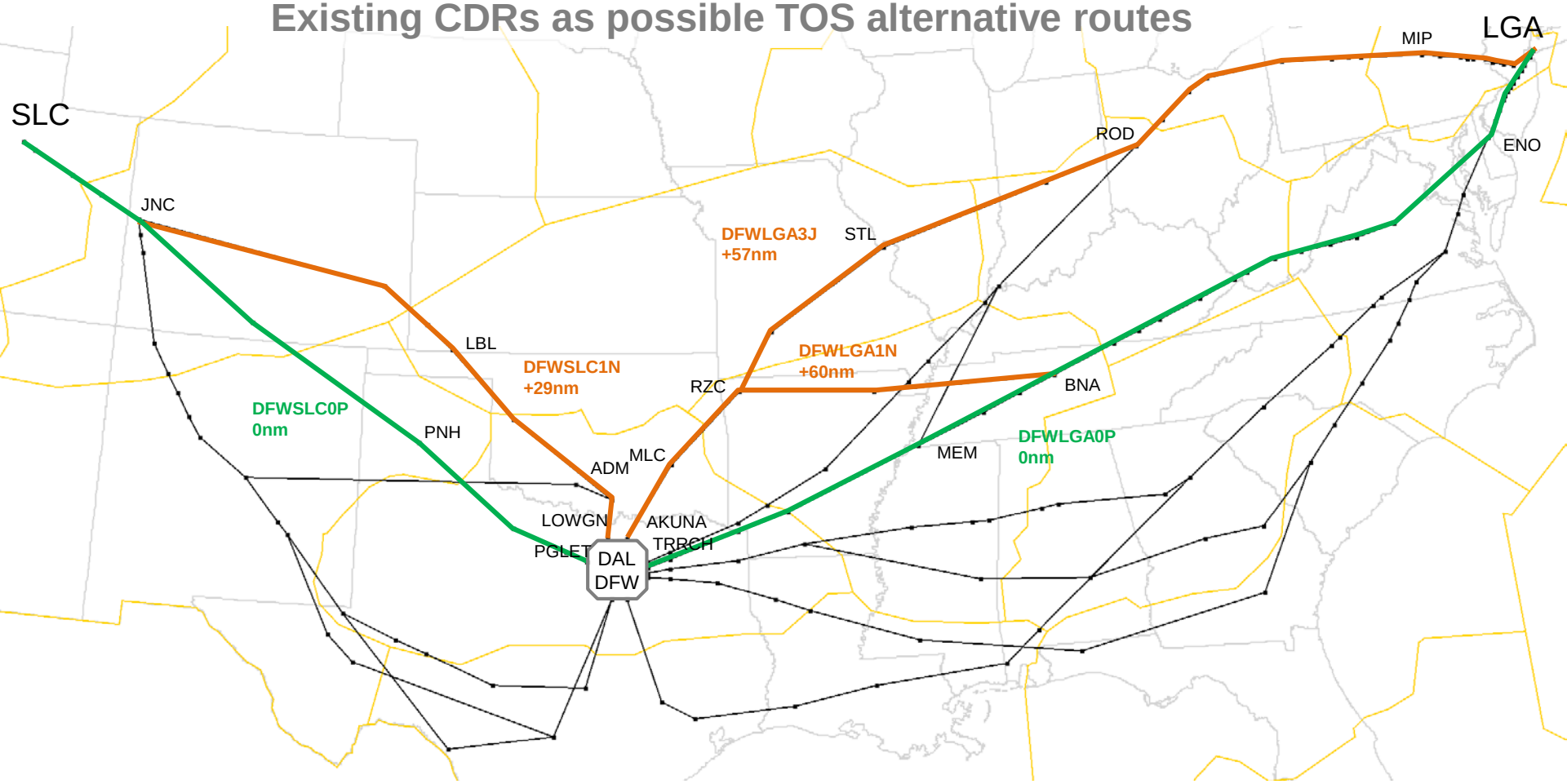
- The 'Static TOS' allows Operators to specify the TOS opportunities they would like to be notified of when the specified relative trajectory costs are met

- Alternative routes are limited to Coded Departure Routes (CDR)
  - ATC and Operators agree on 'static TOS' that are also CDRs

- The 'static TOS' is intended to emulate the same/similar data that would be filed through SWIM dynamically

TOS Service:
Adapting Static TOS – CDRs

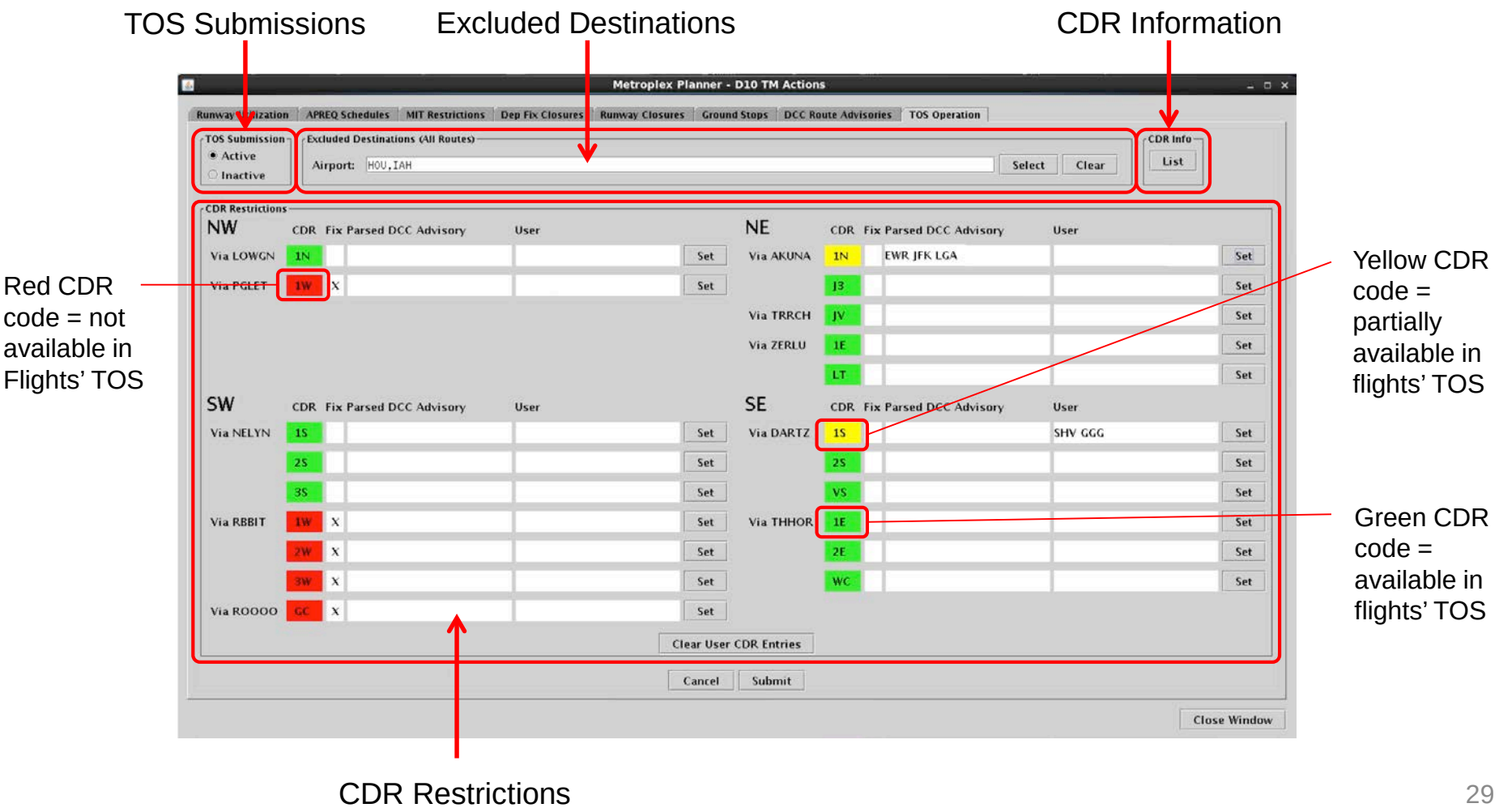
Existing CDRs as possible TOS alternative routes



- The ATD-2 team and partners agreed upon static TOS
- Some important criteria:
  - Available CDR and ability to fly it
  - Relative Trajectory Cost

TOS Service:
TOS Operation Tab

The Trajectory Option Set (TOS) Operation tab is used by ATC to activate/deactivate TOS submissions and restrict routes and destinations in the flights' TOS



TOS Service:
TOS Operation Tab cont.

- **Excluded Destinations (All Routes)**
  - The “Excluded Destinations (All Routes)” field is used to inform the ATD-2 Metroplex Planner when a destination is ineligible for TOS rerouting
  - When a destination is excluded, flights bound for that destination are displayed in the TOS Departure Table, but their Eligibility and Coordination States are “Excluded” and “ATC Excluded”, respectively.

- **CDR Restrictions**
  - Use the “CDR Restrictions” portion of the TOS Operation tab to view and enter CDR restrictions.
  - A CDR can be *partially* closed when one or more destinations are excluded from using that particular CDR.
  - Or, a CDR can be *fully* closed when it is unavailable for all destinations with which it is associated or because of Departure Fix closures.

- **CDR Info**
  - Use the CDR Info to view a list of each unique CDR/city-pair used in ATD-2 TOS operations.
  - Because the CDRs are based, in part, on the airport of origin, the CDRs included in the list vary by version of the Metroplex Planner.

TOS Service: DCC Route Advisories Tab

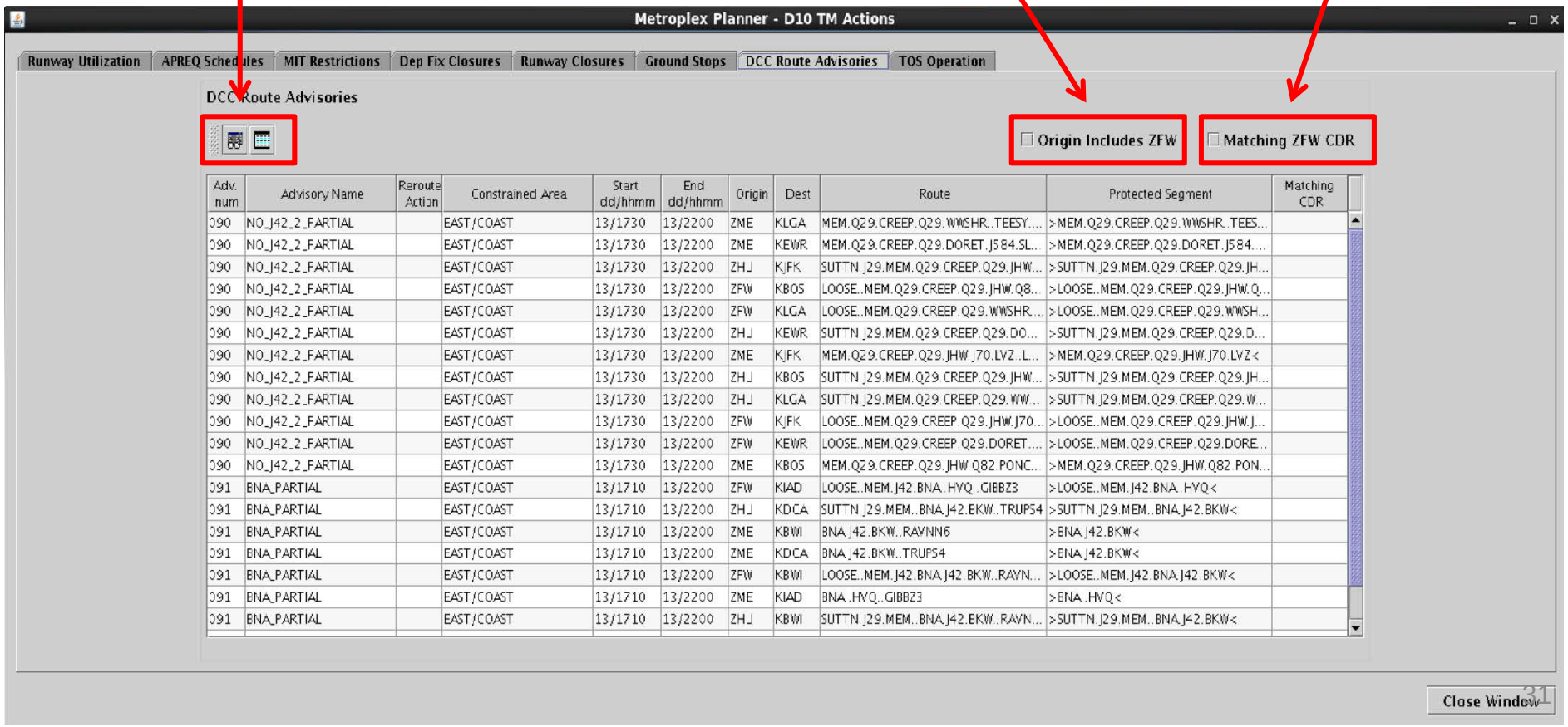
- Displays DCC (Common abbreviation for the FAA Air Traffic Control System Command Center - ATCSCC) Advisories
- Shows Advisories for: ZFW, ZHU, ZME, ZAB, and ZKC (Fort Worth, Houston, Memphis, Albuquerque, and Kansas City ARTCCs, respectively).

Use Settings to:

1. Select which columns to display in the table
2. Set row and field colors

Check the box to see the route advisories applicable to ZFW only

Check to see only the routes that match a CDR



Adv. num	Advisory Name	Reroute Action	Constrained Area	Start dd/hhmm	End dd/hhmm	Origin	Dest	Route	Protected Segment	Matching CDR
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZME	KLGA	MEM.Q29.CREEP.Q29.WWSHR..TEESY....	>MEM.Q29.CREEP.Q29.WWSHR..TEES..	
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZME	KEWR	MEM.Q29.CREEP.Q29.DORET.J584.SL..	>MEM.Q29.CREEP.Q29.DORET.J584....	
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZHU	KJFK	SUTTN.J29.MEM.Q29.CREEP.Q29.JHW...	>SUTTN.J29.MEM.Q29.CREEP.Q29.JH...	
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZFW	KBOS	LOOSE..MEM.Q29.CREEP.Q29.JHW.Q8..	>LOOSE..MEM.Q29.CREEP.Q29.JHW.Q...	
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZFW	KLGA	LOOSE..MEM.Q29.CREEP.Q29.WWSHR....	>LOOSE..MEM.Q29.CREEP.Q29.WWSH...	
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZHU	KEWR	SUTTN.J29.MEM.Q29.CREEP.Q29.DO...	>SUTTN.J29.MEM.Q29.CREEP.Q29.D...	
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZME	KJFK	MEM.Q29.CREEP.Q29.JHW.J70.LVZ..L...	>MEM.Q29.CREEP.Q29.JHW.J70.LVZ<	
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZHU	KBOS	SUTTN.J29.MEM.Q29.CREEP.Q29.JHW...	>SUTTN.J29.MEM.Q29.CREEP.Q29.JH...	
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZHU	KLGA	SUTTN.J29.MEM.Q29.CREEP.Q29.WW..	>SUTTN.J29.MEM.Q29.CREEP.Q29.W..	
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZFW	KJFK	LOOSE..MEM.Q29.CREEP.Q29.JHW.J70...	>LOOSE..MEM.Q29.CREEP.Q29.JHW.J...	
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZFW	KEWR	LOOSE..MEM.Q29.CREEP.Q29.DORET....	>LOOSE..MEM.Q29.CREEP.Q29.DORE..	
090	NO_J42_2_PARTIAL		EAST/COAST	13/1730	13/2200	ZME	KBOS	MEM.Q29.CREEP.Q29.JHW.Q82.PONC..	>MEM.Q29.CREEP.Q29.JHW.Q82.PON...	
091	BNA_PARTIAL		EAST/COAST	13/1710	13/2200	ZFW	KIAD	LOOSE..MEM.J42.BNA..HVQ..GIBBZ3	>LOOSE..MEM.J42.BNA..HVQ<	
091	BNA_PARTIAL		EAST/COAST	13/1710	13/2200	ZHU	KDCA	SUTTN.J29.MEM..BNA.J42.BKW..TRUPS4	>SUTTN.J29.MEM..BNA.J42.BKW<	
091	BNA_PARTIAL		EAST/COAST	13/1710	13/2200	ZME	KBWI	BNA.J42.BKW..RAVNN6	>BNA.J42.BKW<	
091	BNA_PARTIAL		EAST/COAST	13/1710	13/2200	ZME	KDCA	BNA.J42.BKW..TRUPS4	>BNA.J42.BKW<	
091	BNA_PARTIAL		EAST/COAST	13/1710	13/2200	ZFW	KBWI	LOOSE..MEM.J42.BNA.J42.BKW..RAVN...	>LOOSE..MEM.J42.BNA.J42.BKW<	
091	BNA_PARTIAL		EAST/COAST	13/1710	13/2200	ZME	KIAD	BNA..HVQ..GIBBZ3	>BNA..HVQ<	
091	BNA_PARTIAL		EAST/COAST	13/1710	13/2200	ZHU	KBWI	SUTTN.J29.MEM..BNA.J42.BKW..RAVN...	>SUTTN.J29.MEM..BNA.J42.BKW<	

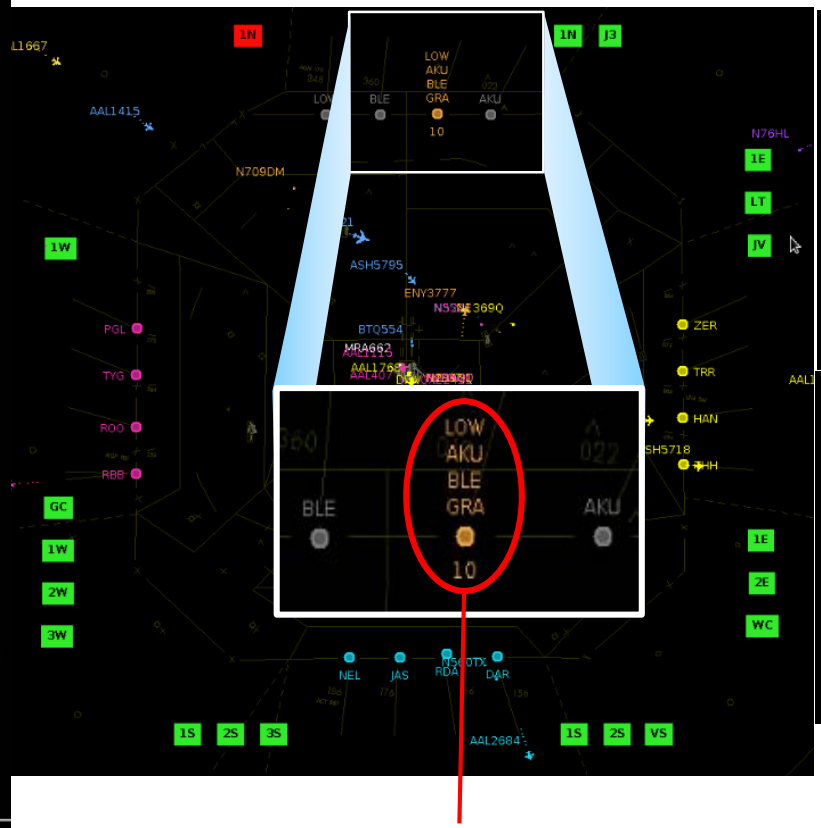
TOS Service:
Terminal Predictive Engine Determines Impact

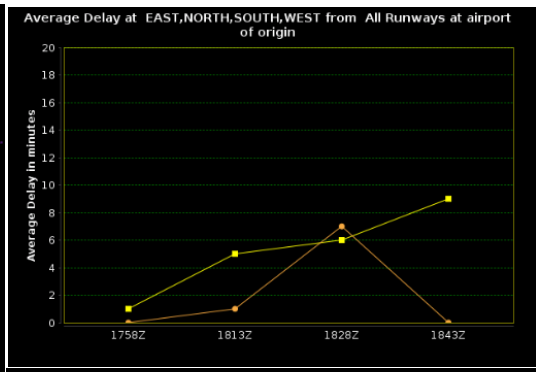
- On the day of operations, the back end Terminal predictive engine calculates demand/capacity imbalances over runways and departure fix resources
  - A key output is the estimated total delay
    - This delay is compared to the relative trajectory cost (RTC) to determine the operator-preferred trajectory
  - The RTC is computed using filed data (filed route and filed speed) and agreed upon cost factors provided by the Flight Operators
  - Provides notification of when total delay meets RTC

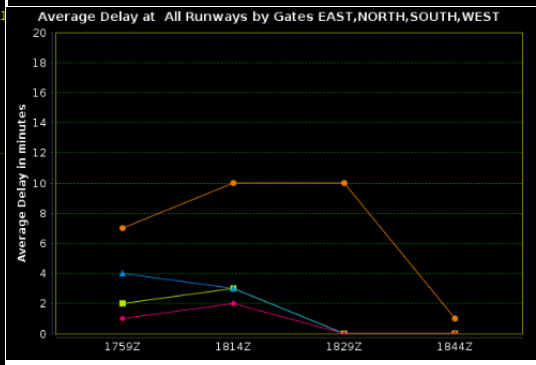
- These estimates make use of
  - Restrictions from ATC (existing and forecasted)
  - Earliest Off-Block Times (EOBTs) from Operators
  - GA/BA mobile app inputs (as available)
  - Surface taxi prediction models of DFW and DAL
  - Actual wheels-off from Operators (or detection)
  - Terminal flight times from research TBFM (rTBFM) trajectory predictions

TOS Service: Terminal Restrictions and Pass Back Delay

- ATD-2 system monitors for surface delay either because of volume or TMI
- ATC personnel enter the restriction at the terminal boundary into NTML and/or ATD-2 interface
- The system immediately begins estimating delays at the terminal boundary, which are passed back to the surface







Example of 4 departure routes restricted into 1 with 10 Miles-in-Trail (MIT)

TOS Service: Restriction Handling

Restriction Example:

- 1 route to the East with 10 MIT
- ZFW Requesting, D10 providing
- Start: Now
- End: N/A

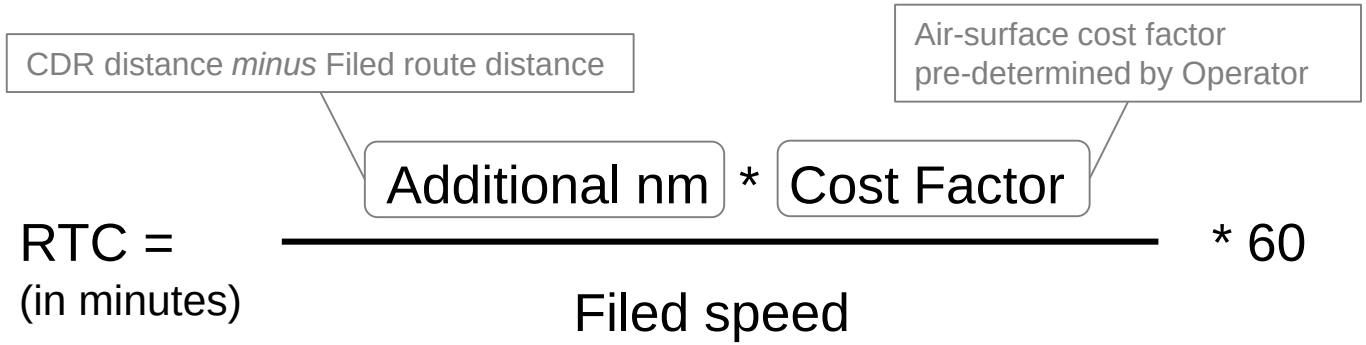
ZFW enters the restriction in NTML

- ATD-2 system parses the TfmFlow data
  - Looks for restrictions for given facilities and requesters and providers
- ATD-2 system then populates the clients accordingly with the restriction information

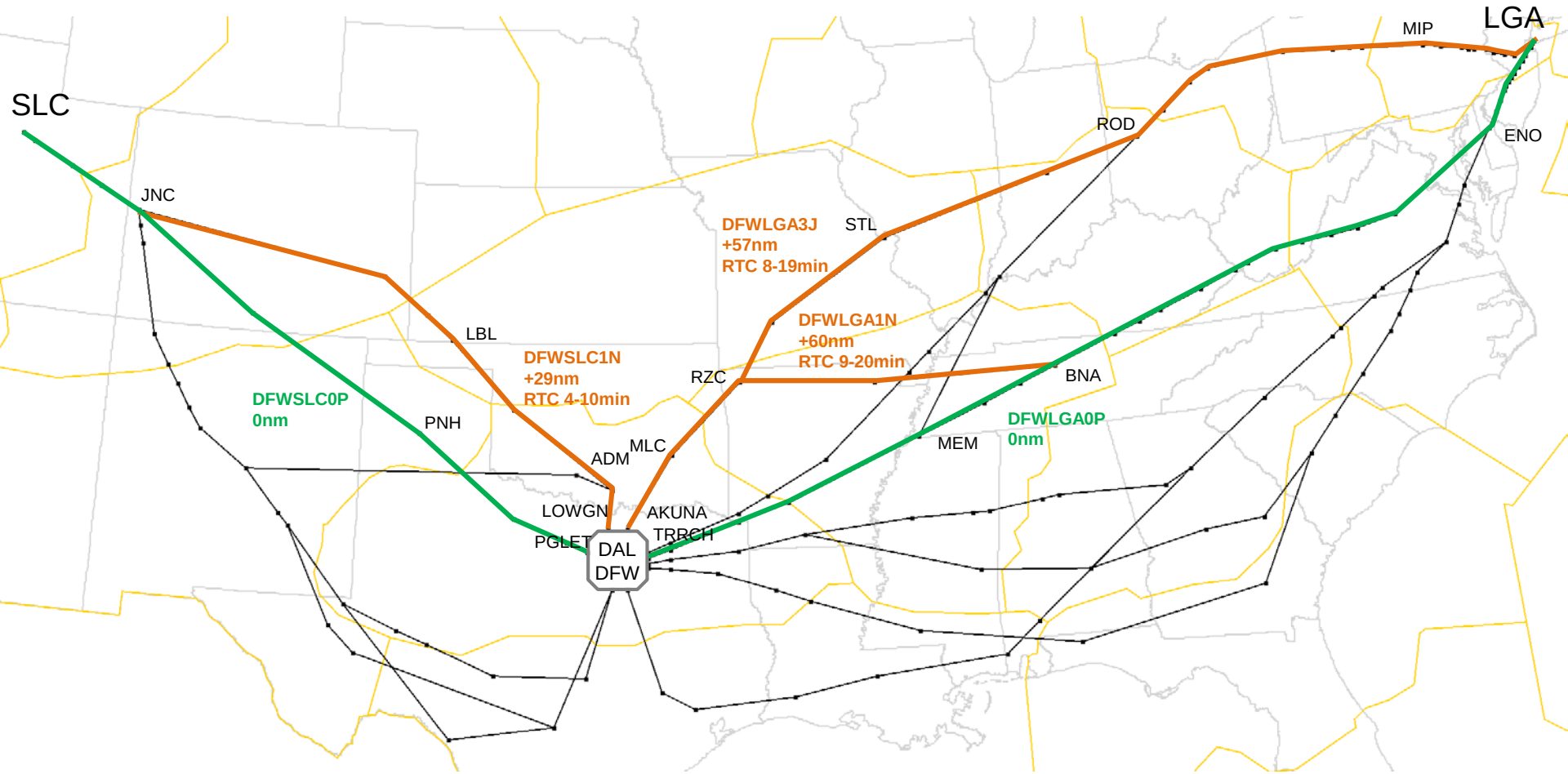
In case an entry via NTML is not possible, ZFW can manually enter the restriction in the Metroplex Planner

TOS Service: Relative Trajectory Cost Computation

- Computed for each flight operator for their own flights based on agreed upon formula (operator specific)
- Additional distance, in nautical miles (nm) = CDR distance – Filed Route distance
- Cost (in delay minutes) to fly an alternative route, ***relative*** to the filed route
- Used by flight operator to determine when TOS route becomes more advantageous to fly than the filed route
  - When predicted delay savings is equal or higher than RTC, than the TOS becomes a candidate for rerouting the flight



TOS Service:
RTC Values For the Example CDR



TOS Service:
❸ 'Candidate TOS' are Presented to Operators

- On the day of operation, a TOS interface will notify users which flight has one or more Candidate TOS alternative routes
  - The estimated delay and estimated OFF time for the alternative routes, and additional nm, will be available to evaluate the candidate routes

- TOS alternative routes are vetted by the Flight Operator personnel
  - Evaluate feasibility of TOS alternative routes
  - Select a subset of TOS alternative routes among potentially numerous options

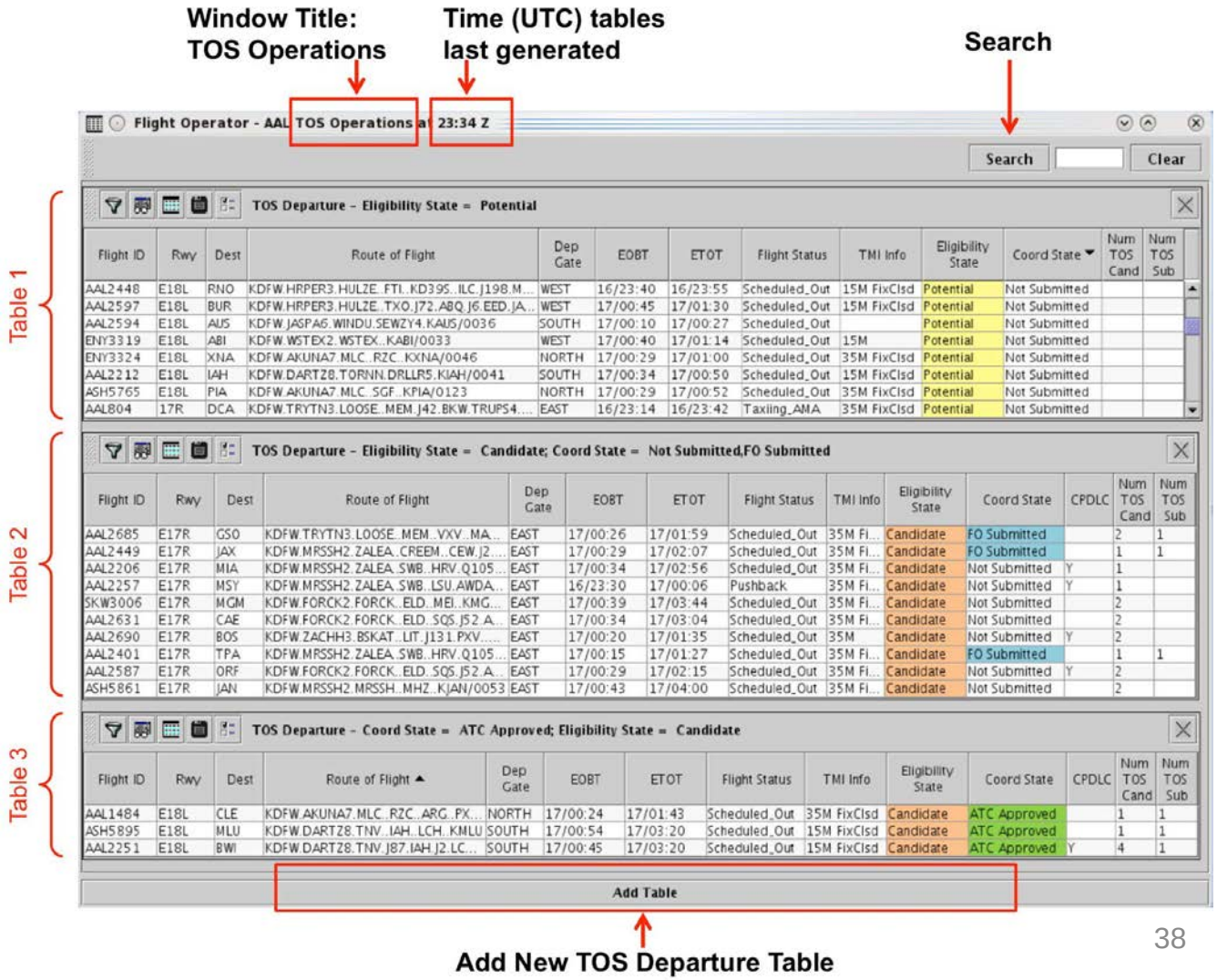
- TOS alternative routes are then presented to ATCT personnel for consideration

TOS Service:
TOS Departure Tables

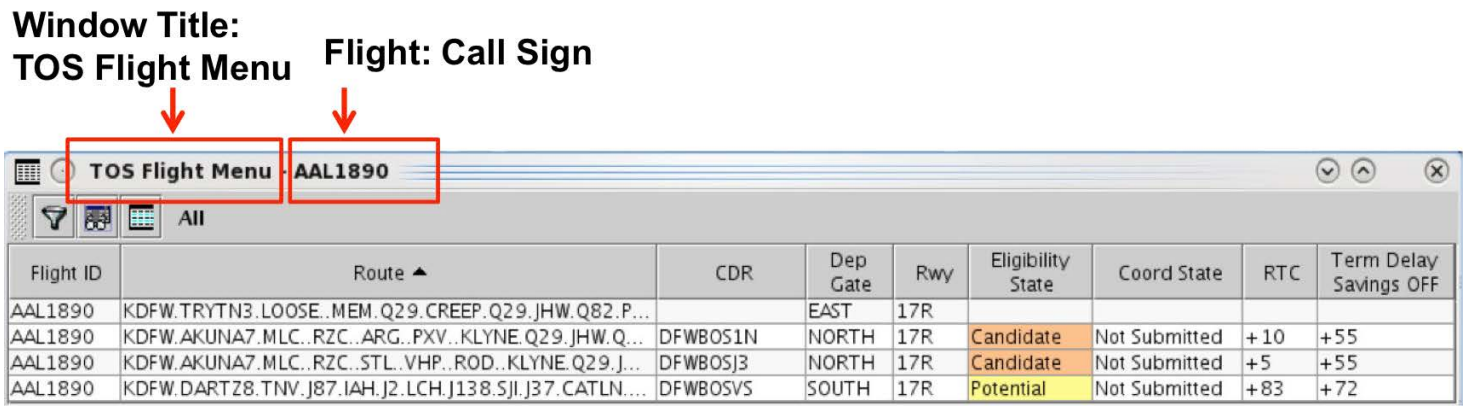
TOS Departure Tables display flights for which one, or more, TOS route options have been identified.

Default TOS Departure Tables:

- **Table 1:** All Potential TOS Routes for the Operator
- **Table 2:** All Candidate TOS Routes for the Operator without ATC Approval
- **Table 3:** All Candidate TOS Routes for the Operator with ATC Approval



TOS Service:
TOS Flight Menu



Flight ID	Route	CDR	Dep Gate	Rwy	Eligibility State	Coord State	RTC	Term Delay Savings OFF
AAL1890	KDFW.TRYTN3.LOOSE..MEM.Q29.CREEP.Q29.JHW.Q82.P...		EAST	17R				
AAL1890	KDFW.AKUNA7.MLC..RZC..ARG..PXV..KLYNE.Q29.JHW.Q...	DFWBOS1N	NORTH	17R	Candidate	Not Submitted	+10	+55
AAL1890	KDFW.AKUNA7.MLC..RZC..STL..VHP..ROD..KLYNE.Q29.J...	DFWBOSJ3	NORTH	17R	Candidate	Not Submitted	+5	+55
AAL1890	KDFW.DARTZ8.TNV.J87.IAH.J2.LCH.J138.SJI.J37.CATLN....	DFWBOSVS	SOUTH	17R	Potential	Not Submitted	+83	+72

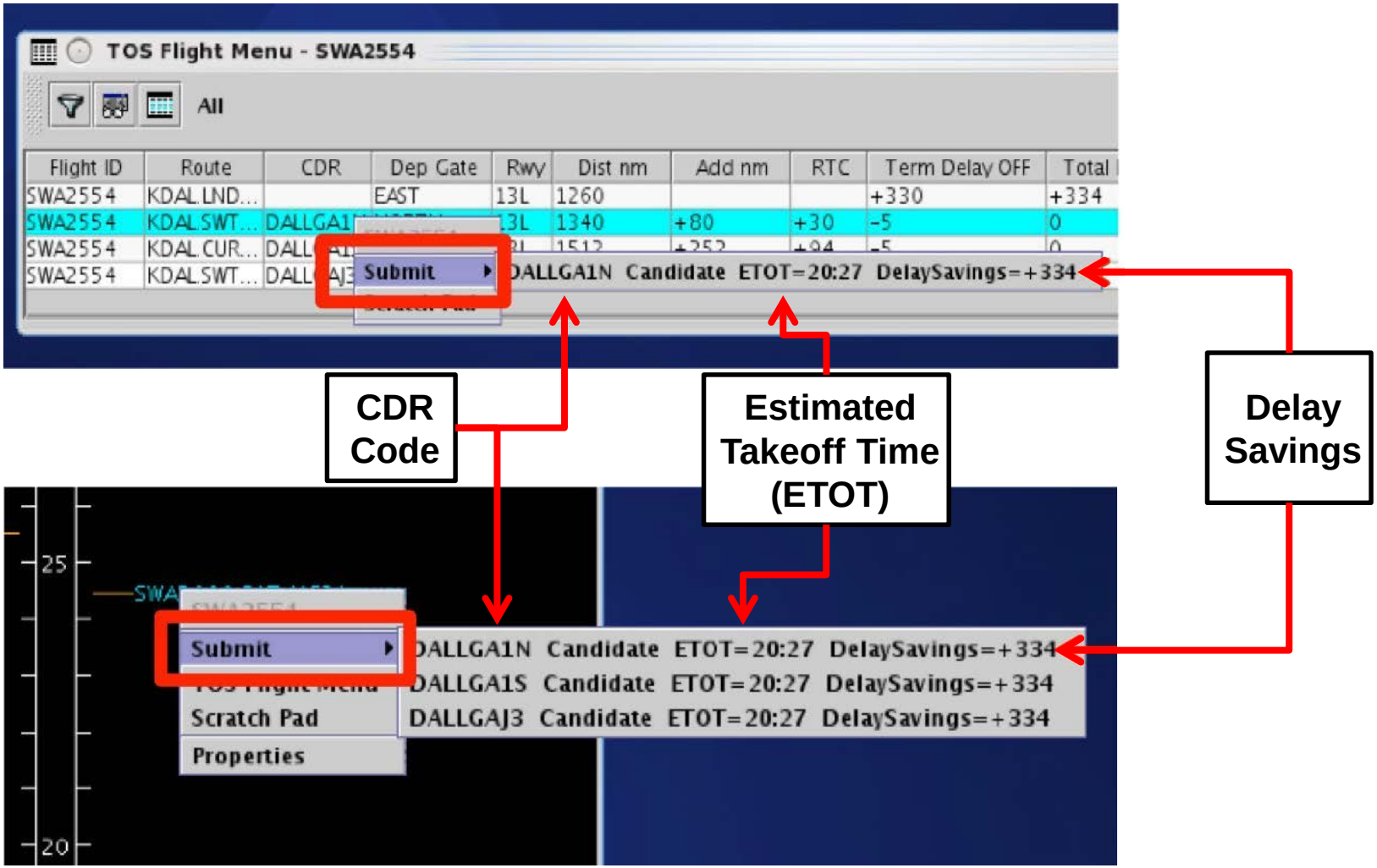
- TOS Flight Menus display TOS route options for a *single* flight
- Flight Menus can be used to evaluate TOS route options (e.g., route distance, delay savings, and RTC).
- In a TOS Flight Menu, the flight's current departure route is displayed on the first row of the table.

TOS Service:
4 Operator Submitted TOS Presented to ATC

- Once the operator has submitted a TOS alternative route, it becomes available to ATC for reroute on the Timeline or the TOS Departure Table
  - TOS interface will be accessible to users at D10 Terminal, ZFW Center, DFW and DAL Towers
- ATC personnel evaluates the submitted TOS alternative route and coordinate as required to execute the reroute
  - Likely coordination between en route, terminal, and tower TMCs
  - Use of NASA/FAA North Texas Research Station (NTX) hotline may also be a means of coordination, aided by common situational awareness provided by ATD-2 tools
- ATCT personnel approves a TOS alternative route
  - TOS interface will display the TOS alternative route that best meets the RTC values and RMNT
- A notification is generated and the system updates the prediction of the demand
  - Notification to ATC and operator users
  - The terminal predictive engine will update delay predictions for all departures
- ATCT personnel will assess subsequent flights with submitted TOS alternative routes
  - ATCT personnel evaluates the reroute request to determine if it can be approved from an operational perspective
- ATCT amend flight plan in legacy system
  - ATCT personnel update the flight plan change in the legacy tools
  - Provided we succeed in submitting TOS reroute via SWIM on behalf of operators, in the future, there may be opportunities to use Pre-Departure ReRoute (PDRR) (in Route Amendment Dialogue (RAD) or departure viewer) to simplify the flight plan amendment
- Once the updated flight plan is filed, all users will receive it via current day systems
  - ATD-2 system will track the flight plan amendment to verify it matches the TOS reroute

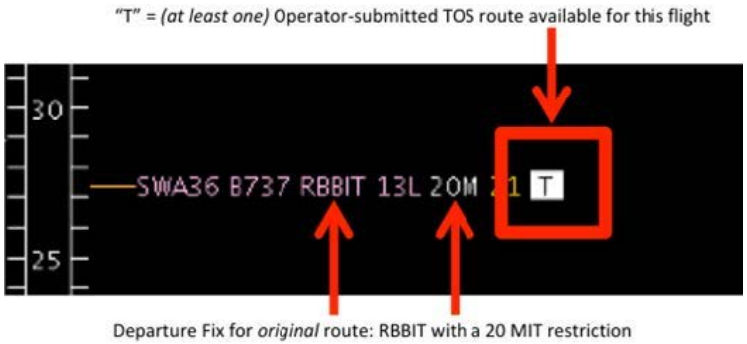
TOS Service: Operator Submits a Route Option

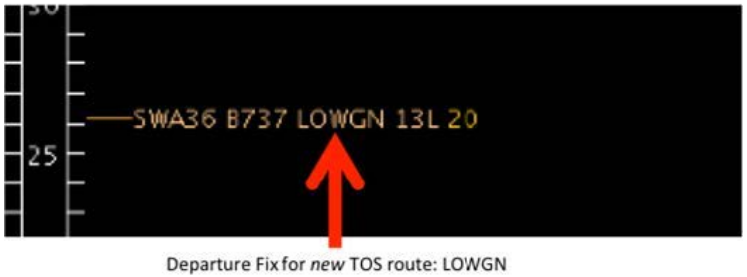
- Flight Operator submits the TOS routes that they can fly (if approved by ATC)
- Flight Operator can submit TOS routes via the TOS Flight Menu (top), Timeline (bottom), and TOS Flight Menu (not pictured)

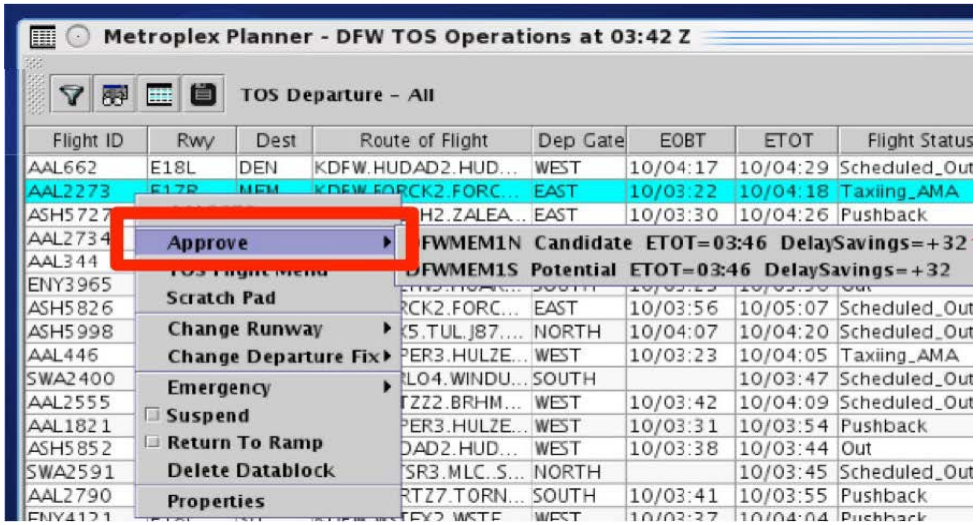


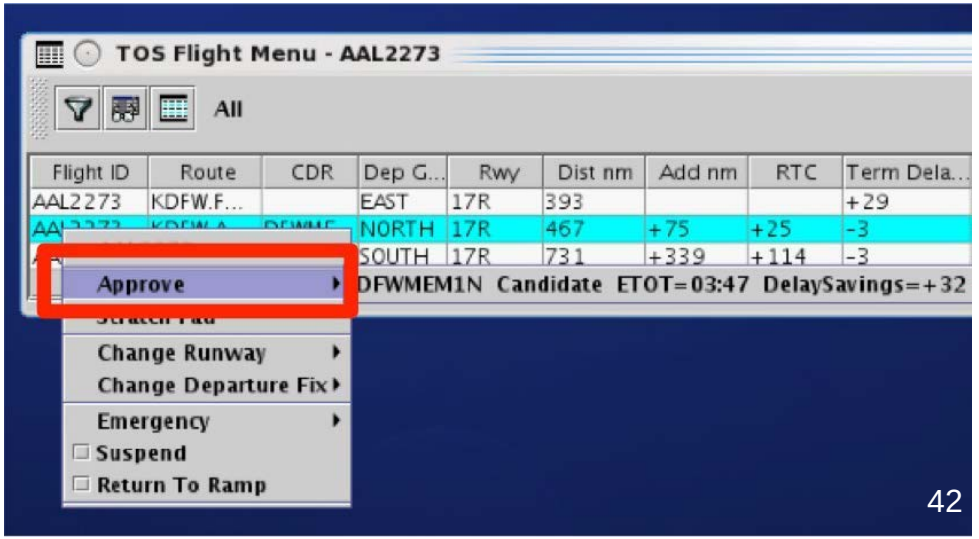
TOS Service:
ATCT Approves a TOS Route

- Upon Operators submission, the ATCT approves submitted TOS routes, as needed
- ATCT can approve submitted TOS routes via the Timeline (left), TOS Departures Table (top right) or TOS Flight Menu (bottom right)



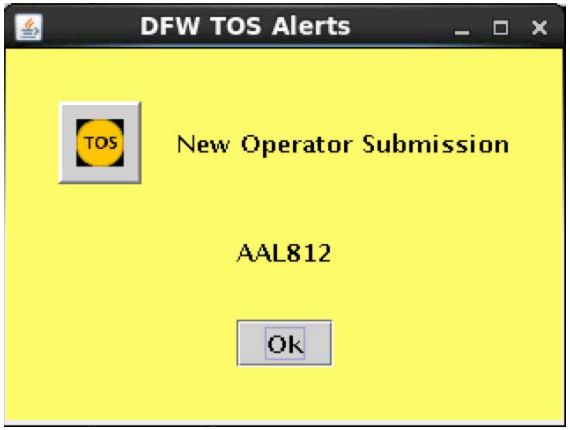






TOS Service:
TOS Pop-up Alerts

- Users can turn on/off visual and audible TOS alerts
  - A pop-up window appears on the ATC's client when the Flight Operator has submitted a flight for TOS rerouting



Example: DFW ATCT is alerted that American Airlines has submitted a reroute for AAL812

  - A pop-up window appears on the Flight Operator's client when ATC has approved the reroute of a flight

Example: SWA is alerted that DAL ATCT has approved a reroute for SWA1168

Scheduling to the Terminal Boundary

Operational Scenarios

Scheduling to the Terminal Boundary: Overview

- Foundational ingredient to ATD-2 Phase 3 Terminal departure concept is improved predictive accuracy of the departure demand from the surface of multiple airports (e.g., DFW and DAL).

- ATD-2 Phase 3 uses a terminal predictive engine that provides high quality real-time estimates of departure demand at the terminal departure fix and corresponding pass back surface delay due to terminal demand/capacity imbalances.

- *The **Terminal predictive engine** is new research that leverages the surface predictive engine from earlier ATD-2 work.*

- *Goal: Build on the **single-airport** Integrated Arrival/Departure/Surface (IADS) system being demonstrated at CLT to develop and demonstrate a **multi-airport** (i.e., metroplex) IADS system to satisfy ATD-2 top level requirements.*

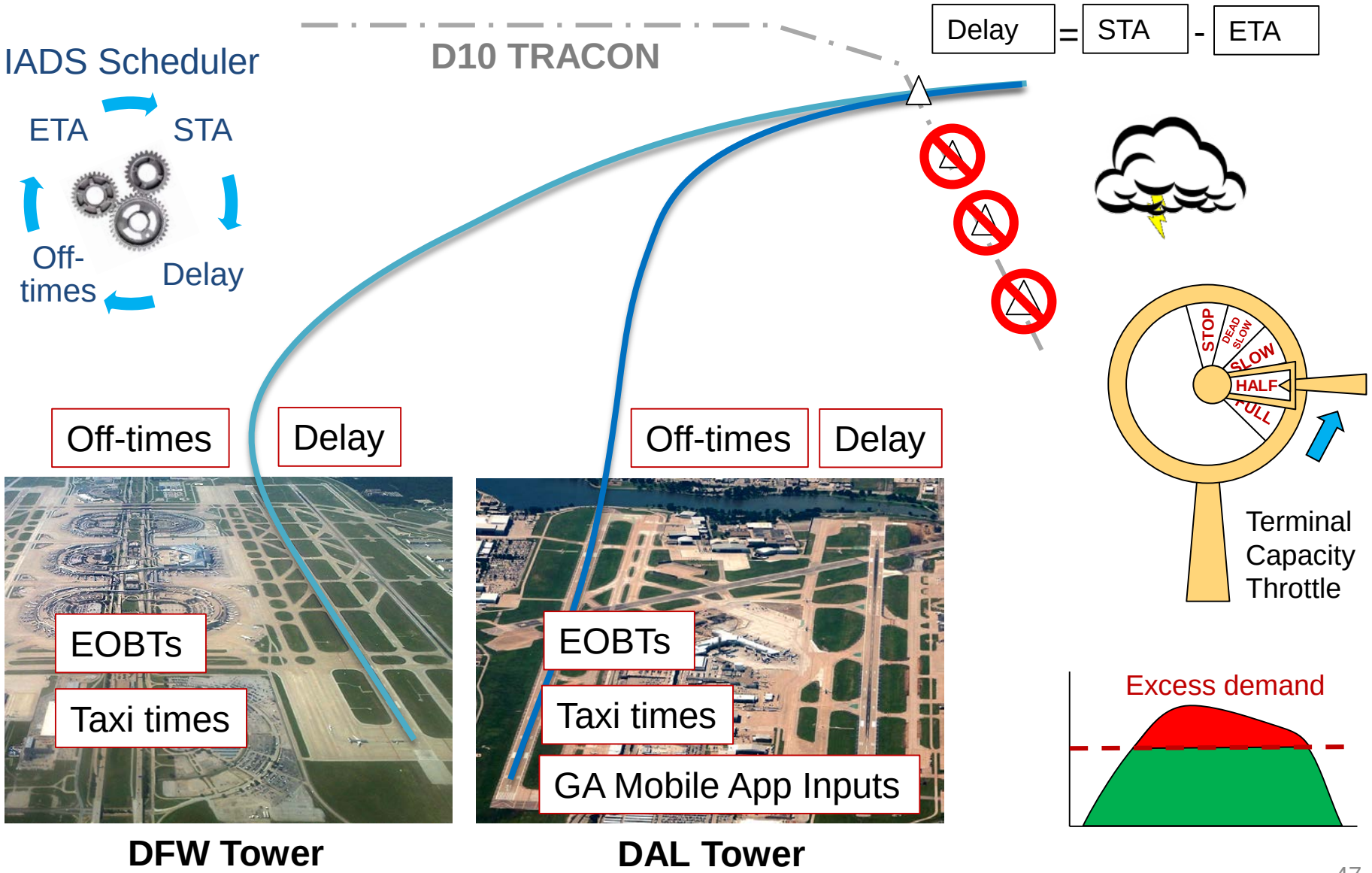
Scheduling to the Terminal Boundary: Terminal Predictive Engine Determines Impact

- On the day of operations, the backend Terminal predictive engine calculates demand/capacity imbalances over departure fix resources.
  - A key output is the estimated ETOT and delay savings that are compared to the TOS route RTC values

- These estimates make use of:
  - Restrictions from ATC (existing and forecasted)
  - Earliest Off-Block Times (EOBTs) from Operators
  - GA/BA Mobile App (started at DAL, but since expanded to DFW, Fort Worth Alliance Airport (AFW), Fort Worth Meacham International Airport (FTW) and Addison Airport (ADS) in mid-2020)
  - Surface taxi prediction models of DFW and DAL
  - Actual wheels-off from Operators (or from detection systems)
  - Terminal flight times from research TBFM (rTBFM) trajectory predictions

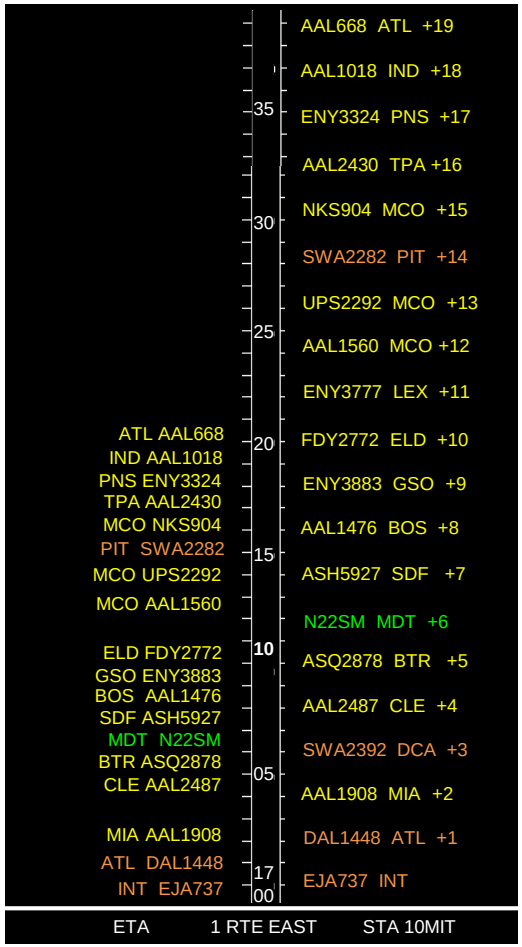
- The Terminal predictive engine provides notification when the RTC is met.

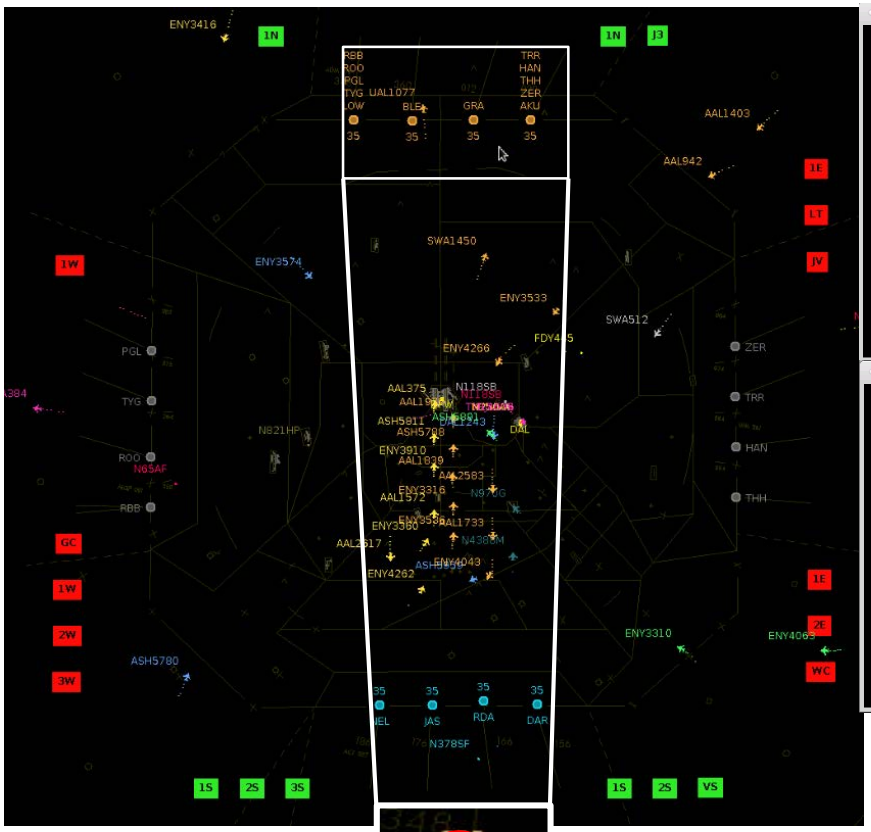
Scheduling to the Terminal Boundary: Terminal Predictive Engine

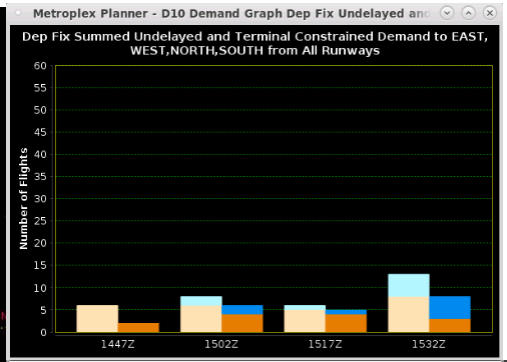


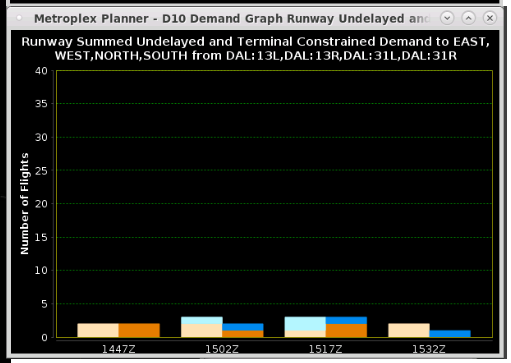
Scheduling to the Terminal Boundary: Terminal Restrictions and Pass Back Delay

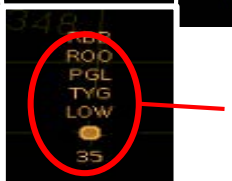
- ATD-2 system monitors for surface delay created by either volume or TMI.
- ATC personnel enter the restriction at the terminal boundary into NTML. Restrictions have a start time and may have an estimated stop time.
- The system immediately begins estimating delays at the terminal boundary, which are passed back to the surface.





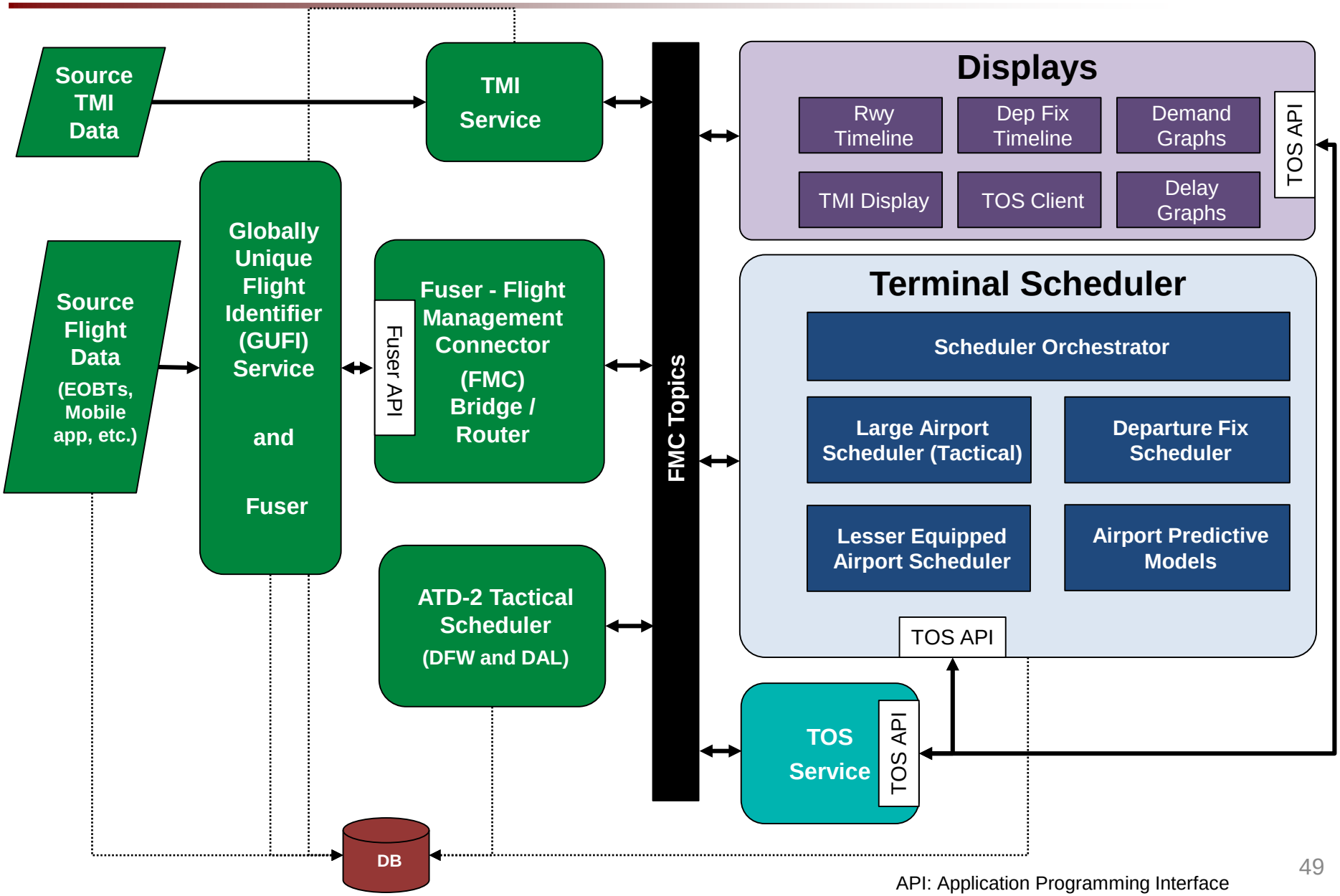






Example of 4 departures' routes combined into 1 with 35 MIT

Scheduling to the Terminal Boundary: Terminal Scheduler Software Architecture



API: Application Programming Interface

Scheduling to the Terminal Boundary: Computation of Delay and Delay Savings

With spacing and sequencing at RWY (Surface delay)

With Terminal restriction applied at the runway (Surface + Terminal delay)

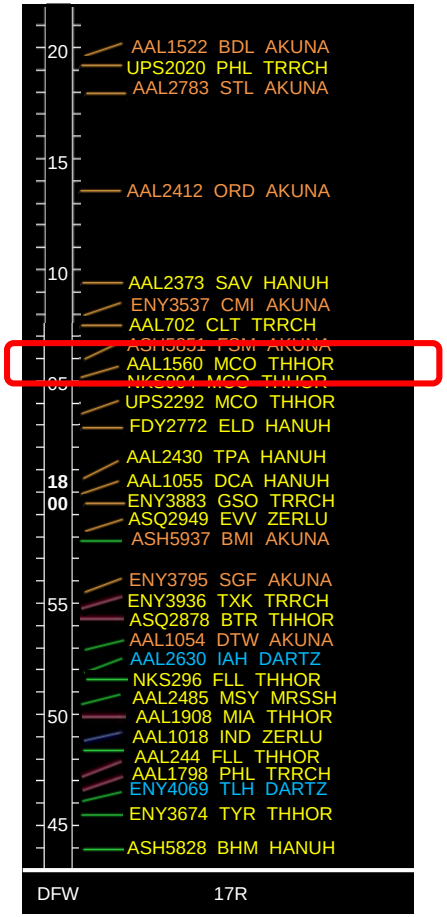
Earlier ETOT for an alternative TOS Route (Delay savings)

Delay AAL1560 = 0min

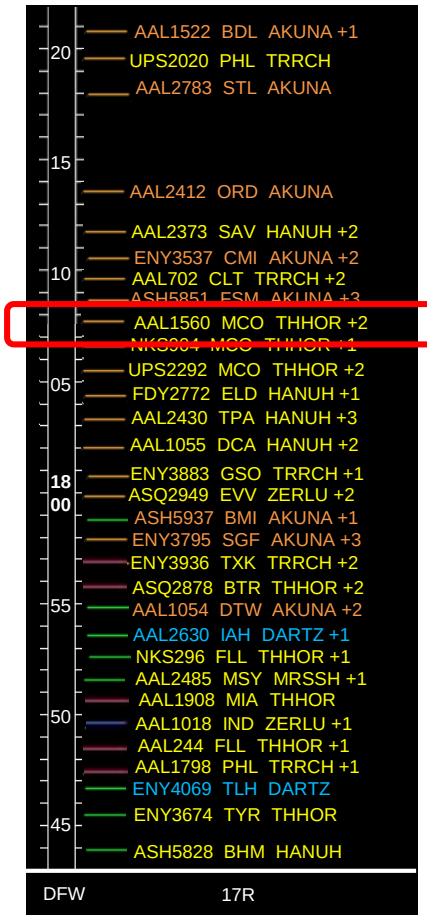
Delay AAL1560 = 2min

Delay AAL1560 = 12min

Delay AAL1560 = 0min
Delay Savings = 10min

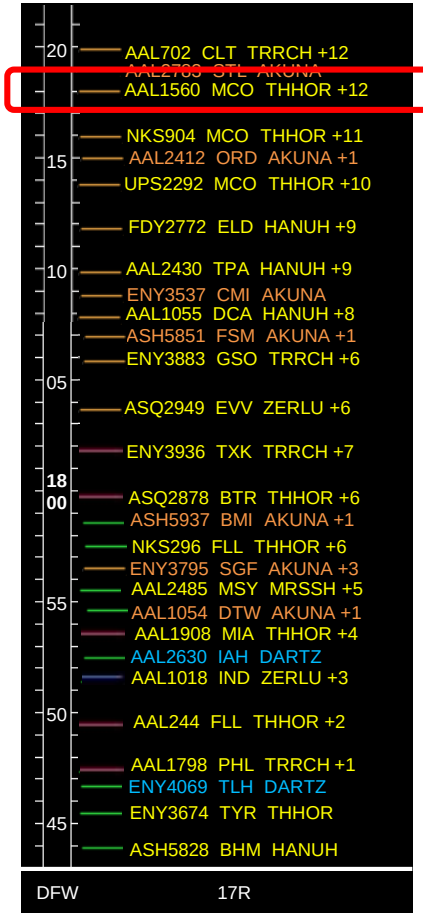


Undelayed Takeoff Times (UTOT)

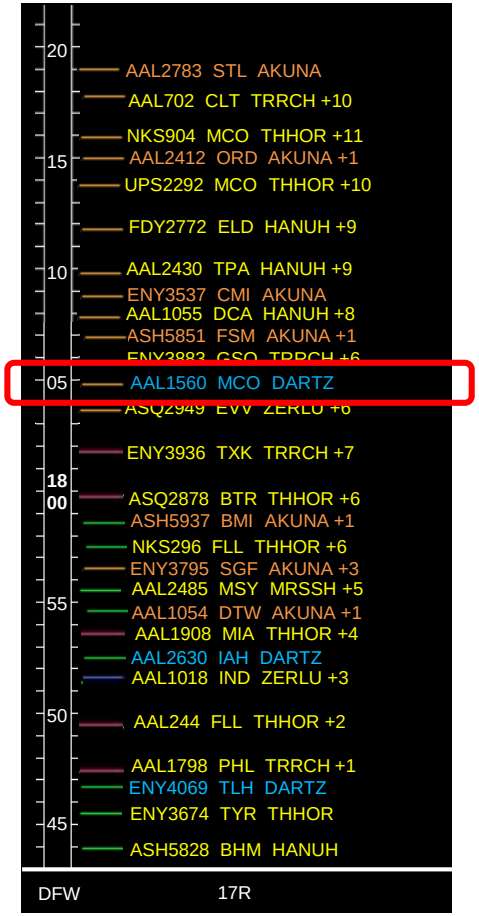


Target Takeoff Times (TTOT)*

*TTOT are computed by the scheduler



Estimated Takeoff Times (ETOT)



TOS Estimated Takeoff Times

Scheduling to the Terminal Boundary: Modifications to Scheduler and Delay Savings

- Manage Uncertain flights (i.e., flights with Uncertain EOBTs) from the terminal scheduler
  - Terminal Scheduler assigns flights to an Uncertain group of flights either when the flight passes its EOBT by pre-determined amount of time or when the flight does not have an EOBT or Airline Time (L-Time)
  - The terminal scheduler and what-if scheduler are both using an embedded tactical scheduler
  - Treatment for uncertain flights are the same in both schedulers
  - 5 minutes is added to uncertain scheduled flight's UTOT in both schedulers to account for the uncertainty of the take-off time
  - 30 minutes is added to uncertain GA flight's UTOT in both schedulers to account for the uncertainty of the take-off time

Scheduling to the Terminal Boundary: Aggregate Delay Savings

- In addition to an individual flight's predicted Delay Savings, the system also computes **aggregate** Delay Savings (in minutes)
  - Aggregate Delay Savings is the sum of predicted Delay Savings for the TOS flight itself, *as well as*, subsequent departures scheduled to depart after the TOS flight. That is, rerouting this flight on a particular TOS route is predicted to save subsequent flights x minutes.
  - Subsequent departures are broken down by
    - Airline (flights from the same air carrier)
    - Fleet (flights from multiple air carriers under the same major airline group)
    - Airport (all flights from a given airport)
    - Metroplex (all flights from multiple airports)
  - The sample of flights includes those scheduled to depart within one hour of the TOS flight's Undelayed Takeoff Time.

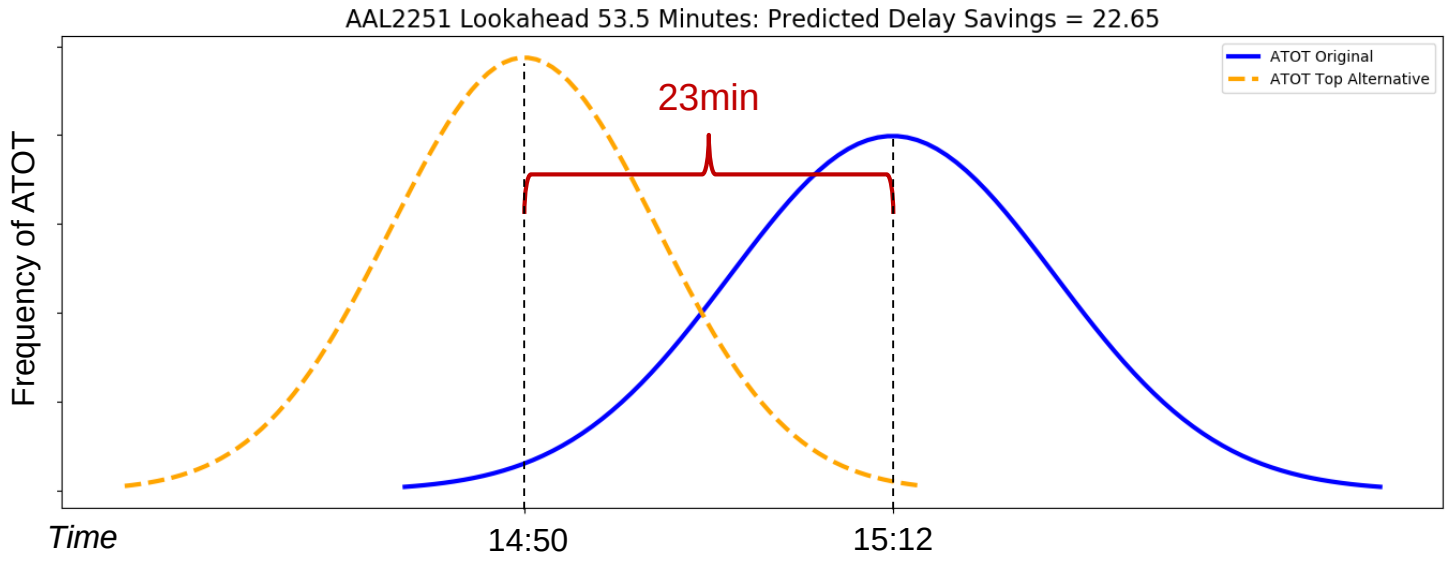
Scheduling to the Terminal Boundary: Probability of Delay Savings

- Definition
  - Probability that a flight's Delay Savings will be greater than its Relative Trajectory Cost (RTC) threshold.

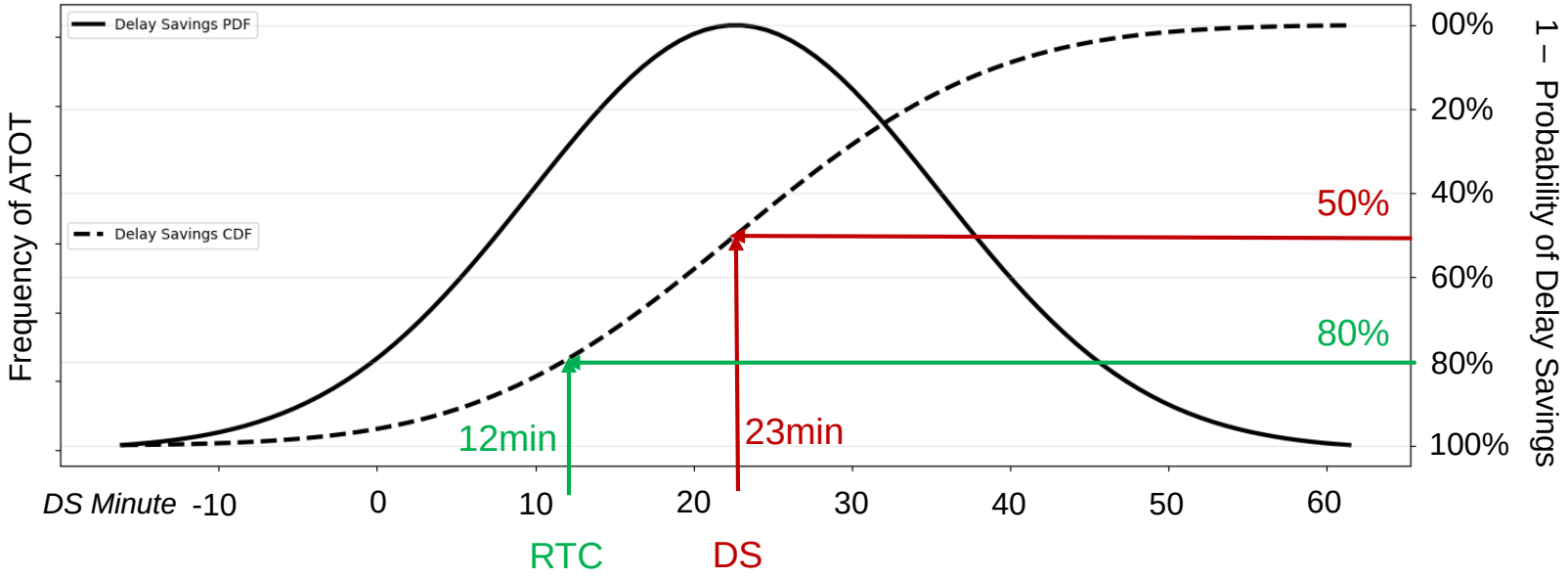
- Computation
  - Computing the *probability* that taking an alternative TOS route will result in Delay Savings depends on *accurately* predicting Actual Takeoff Time (ATOT) for both the **original** and **alternative** TOS routes.
  - Uses **algebra of random variables** to compute the probability distribution of the predicted ATOT on both the **original** and **alternative** TOS routes, given:
    1. Each route's ETOT, and
    2. The scheduler's historical accuracy of ATOT prediction.

- The Probability of Delay Savings is driven by:
  - Scheduler's historical accuracy of ATOT Prediction:
    - The greater the prediction accuracy, the greater the probability for Delay Savings above the RTC threshold.
  - Delay Savings
    - The greater the predicted Delay Savings, the greater the probability that it will be higher than the RTC threshold.

Scheduling to the Terminal Boundary: Probability of Delay Savings



Predicted Delay Savings (DS) = 23min



50% chance for 23 min of DS to occur

80% chance of DS greater than RTC to occur

Scheduling to the Terminal Boundary: Delay And Probability Metrics In The TOS Table

Flight Operator - AAL TOS Operations at 16:43 Z

Search | Clear

TOS Departure – Airline = AAL

Flight ID	Rwy	Dest	Dep Gate	EOBT	ETOT	Top ETOT	Flight Status	Top CDR	Top Total Delay Savings OFF	Top Prob Del Sav > RTC	Top Agg AAL Fleet Del Sav	Top N AAL Fleet Del Sav	Top Agg AAL Mainline Del Sav	Top N AAL Mainline Del Sav	Top Agg DFW Del Sav	Top Agg D10 Del Sav	Eligibility State
AAL1148	E17R	BOS	EAST	19/17:30	19/18:28	17:40	Scheduled_Out	DFWBOSJ3	-48	94.2%	-56.8	28	-47.5	11	-56.8	-56.8	Candidate
AAL1768	E17R	LGA	EAST	19/17:25	19/18:23	17:39	Scheduled_Out	DFWLGAJ3	-44	86.2%	-56.8	28	-47.5	11	-56.8	-56.8	Candidate
AAL1586	E17R	MSY	EAST	19/17:20	19/18:09	17:34	Scheduled_Out	DFWMSY1S	-36	76.6%	-63.5	28	-49.7	11	-63.5	-63.5	Candidate
AAL1360	E17R	DCA	EAST	19/17:22	19/18:14	17:34	Scheduled_Out	DFWDCA1N	-40	72.8%	-63.5	28	-49.7	11	-63.5	-63.5	Candidate
AAL701	E17R	CLT	EAST	19/17:20	19/17:37	17:31	Scheduled_Out	DFWCLT1N	-7	23.4%	-66.6	28	-25.0	11	-66.6	-66.6	Potential
AAL1331	E18L	LAX	WEST	19/17:10	19/17:23	17:23	Scheduled_Out	DFWLAX1N	0	9.1%	0.0	28	0.0	11	0.0	0.0	Potential
AAL2509	E17R	JAX	EAST	19/17:20	19/17:33	17:30	Scheduled_Out	DFWJAX1S	-2	8.2%	-66.9	28	-25.4	11	-66.9	-66.9	Potential
AAL407	E18L	PHX	WEST	19/17:30	19/17:47	17:47	Scheduled_Out	DFWPHX1N	0	0.0%	0.0	28	0.0	11	0.0	0.0	Potential
AAL1630	E17R	ATL	EAST	19/17:35	19/18:42	17:44	Scheduled_Out	DFWATL1N	-58	0.0%	0.0	28	0.0	11	0.0	0.0	Candidate
AAL2630	E17R	IAH	SOUTH	19/17:29	19/17:39		Scheduled_Out										Excluded

Add Table

Note: RTC values were removed

Predicted Delay Savings assuming the flight uses the alternative TOS route

Probability of Delay Savings greater than the Relative Trajectory Cost (RTC) threshold assuming the flight uses the alternative TOS route

Aggregate Delay Savings for subsequent flights (air carrier, Fleet, Airport, metroplex), assuming the flight uses the alternative TOS route

Scheduling to the Terminal Boundary: Delay And Probability Metrics In The Flight TOS Menu

TOS Flight Menu - AAL1360

All

Flight ID	Route	CDR	Dep Gate	Rwy	Dist nm	Add nm	ETOT	Total Delay Savings OFF	Prob Del Sav > RTC	Agg AAL Mainline Del Sav	Eligibility State	Coord State
AAL1360	KDFW.TRYTN3.LOOSE..M...		EAST	17R	1048		18:14		0.0%	0.0		
AAL1360	KDFW.DARTZ8.TNV.J87.I...	DFWDCAVS	SOUTH	17R	1333	+286	17:34	-40	0.9%	-54.3	Potential	Not Submitted
AAL1360	KDFW.AKUNA7.MLC..RZC...	DFWDCAJ3	NORTH	17R	1154	+106	17:34	-40	57.2%	-54.3	Candidate	Not Submitted
AAL1360	KDFW.DARTZ8.TNV..IAH...	DFWDCA1S	SOUTH	17R	1324	+276	17:34	-40	1.3%	-54.3	Potential	Not Submitted
AAL1360	KDFW.AKUNA7.MLC..RZC...	DFWDCA1N	NORTH	17R	1123	+75	17:34	-40	72.8%	-54.3	Candidate	Not Submitted

Note: RTC values were removed

Predicted Delay Savings assuming the flight uses the alternative TOS route

Probability of Delay Savings greater than the Relative Trajectory Cost (RTC) threshold assuming the flight uses the alternative TOS route

Aggregate Delay Savings for subsequent flights (air carrier, Fleet, Airport, metroplex), assuming the flight uses the alternative TOS route

Scheduling to the Terminal Boundary: Modifications to Scheduler and Delay Savings

- ATD-2 computes delay and delay savings using a delay basis between
  - Delay on filed route = $ETOT_{filed}$ – delay basis
  - Delay on TOS route = $ETOT_{TOS}$ – delay basis
  - Delay savings on TOS route = (delay on filed route) – (delay on TOS route)

- Delay Basis Change
  - From Flight's $UTOT_{TOS}$
  - To Flight's $UTOT_{filed}$

- Delay Basis is the baseline time that the flight could have taken off given no delay

- ATD-2 used to use the UTOT for each route, but that would change depending on the runway.
  - That led to odd results where we would recommend a flight change to a different runway which would result in less "delay" but it would take longer to taxi to that new runway.
  - And in the end, it had a later ETOT than if it had stayed on the original runway. And it didn't make any sense to recommend a route change that actually resulted in a later ETOT, if the excess taxi time was shorter.

- To be consistent across all TOS options ATD-2 uses UTOT of the filed route for its Delay Basis value

Scheduling to the Terminal Boundary: Aggregate Delay Savings

- In addition to an individual flight's predicted Delay Savings, the system also computes **aggregate** Delay Savings (in minutes)
  - Aggregate Delay Savings is the sum of predicted Delay Savings for the TOS flight itself, *as well as*, subsequent departures scheduled to depart after the TOS flight. That is, rerouting this flight on a particular TOS route is predicted to save subsequent flights x minutes.
  - Subsequent departures are broken down by
    - Airline (flights from the same air carrier)
    - Fleet (flights from multiple air carriers under the same major airline group)
    - Airport (all flights from a given airport)
    - Metroplex (all flights from multiple airports)
  - The sample of flights includes those scheduled to depart within one hour of the TOS flight's Undelayed Takeoff Time.

Traffic Management Initiative (TMI) Propagation

Operational Scenarios

TMI Propagation: Terminal Restrictions Handling Overview

- TMIs are a major source of departure delay
- Restrictions are an essential input into the schedulers
- ATD-2 restriction displays provide situational awareness to multiple users

- ATD-2 obtains the data for the restrictions affecting the specific requesting and providing facilities from multiple sources:
  - Traffic Flow Management (TFM)
    - Includes restrictions parsed from SWIM feed which were entered by ZFW Traffic Management Coordinator (TMC) personnel in NTML
  - Operational Information Service (OIS) Restrictions Page
  - ATC user input
    - TMC personnel may enter a new restriction or modify an existing restriction using the ATD-2 Client
  - ATD-2 Model
    - Model can use radar tracks to detect if there was a runway utilization change which was not entered into the system by a user, such as when a TMC is busy or the position is unstaffed
  - ATD-2 Scheduler
    - Scheduler calculates the demand for resources such as runways and departure fixes
  - User input

- Restrictions are an essential input into the schedulers

- Provides situational awareness to multiple users

TMI Propagation:
TMI Handled by ATD-2 System

TMI Type	Possible Sources
Runway Utilization	User, Model
APREQs	User, TFM, OIS
Surface Metering Programs	Scheduler
Departure Fix Closures	User, TFM, OIS
Departure Gate Closures	User, TFM, OIS
Ground Delay Programs	TFM
Ground Stops	User, TFM
MITs	User, TFM, OIS
Ramp Closures	User
Runway Closures	User
Scheduled Metering Modes	User
Taxiway Closures	User
Airspace Flow Programs	TFM
DCC Route advisories	TFM

Typical Terminal Restrictions

TMI Propagation: Frequency of Terminal Restrictions (June 2017)

	No of days with restrictions	No of restrictions	Total no of departures	No of restricted departures	% of total departures
June 2017	**27**	**309**	**34,258**	**4,533**	**13.2%**

Focus of Restrictions during Stormy 19 Field Evaluation

Restrictions	No of restrictions	% of restrictions	Avg duration in min	No of restricted departures	% of restricted departures	% of total departures
MIT	**130**	**42%**	**92**	**2,471**	**55%**	**7%**
10	105	34%	88	2,109	7%	6%
15	8	3%	123	219	5%	1%
20	10	3%	84	127	3%	0%
>25	7	2%	96	16	0%	0%
Combined routes/fixes	**196**	**63%**	**83**	**3,380**	**75%**	**10%**
1 flow/route	82	27%	88	1,697	37%	5%
2 flows/routes	63	20%	71	1,080	24%	3%
3 flows/routes	50	16%	89	594	13%	2%
SWAP	**54**	**17%**	**80**	**630**	**14%**	**2%**
Combined routes/fixes + MIT	68	22%	75	1,661	37%	5%
SWAP + MIT	30	10%	80	172	4%	1%
SWAP + combined routes/fixes	31	10%	91	197	4%	1%

Notes:

- Data based on reported restrictions in NTML
- Traffic based on radar data. D10 departures below 11,000ft were excluded.
- Fix restrictions only. APREQ/CFRs, terminal gate was not included. There were 22 stops, lasting 25min on average.

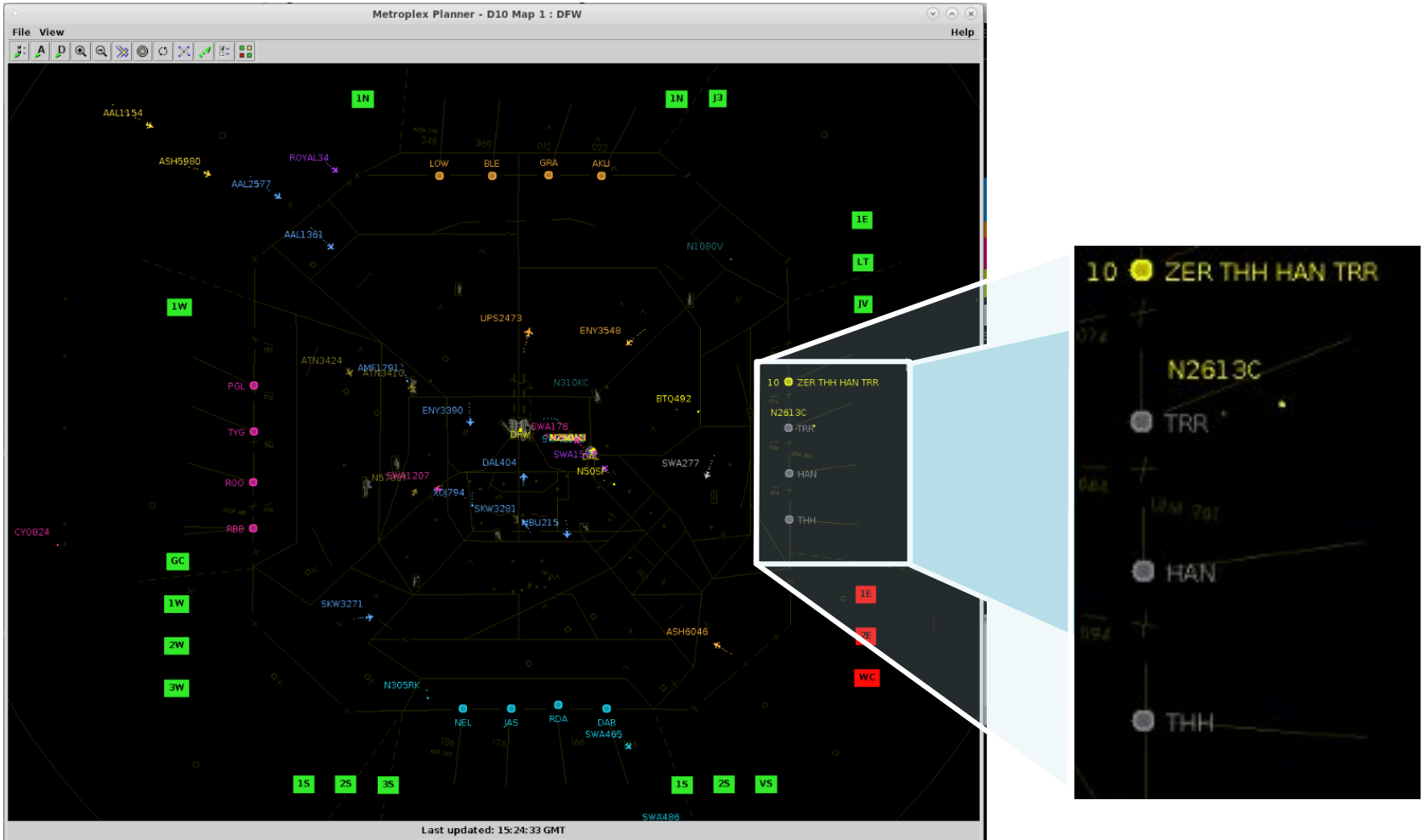
TMI Propagation: Challenges with Parsing Terminal Restriction in NTML Entries and TFM Data

- Not all NTML restriction entries are parsed by ATD-2
  - Entries made via the "RSTN" tab do
  - Entries made via the "SWAP", "MISC" tabs don't
- Standardization of entries is required to have consistent data parsing
  - Manual entries can be prone to errors
- Qualifier and Remarks fields are required to provide additional information
  - Qualifier
    - When fixes are closed they need to be listed under "Via" in NTML client (NasResources in TfmFlow data)
    - While the alternate/combined fix needs to be indicated in the "Qualifier" field
      - Qualifiers are free text that can be set in an adaptation file
      - Requires syntactic convention to parse correctly (i.e., OTG, SWAP EAST, INNERS ON OUTERS)
  - Remarks
    - Have been used to provide inclusion or exclusion information (also requires syntactic convention)

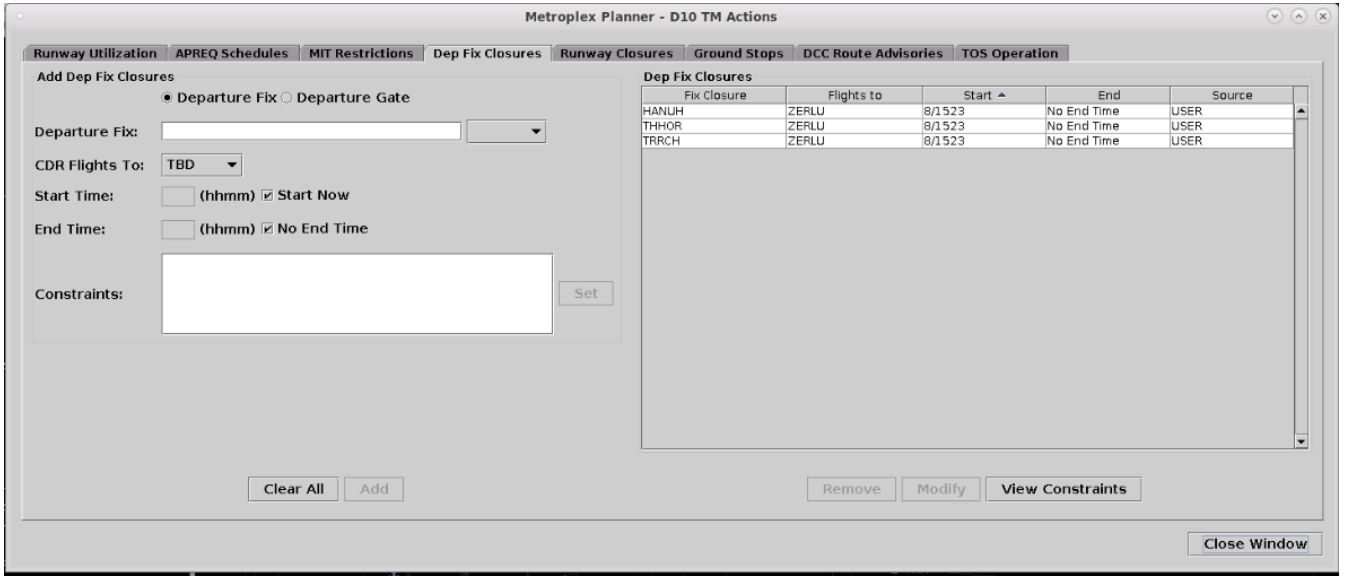
TMI Propagation: TMIs in the Notification Panel and Map

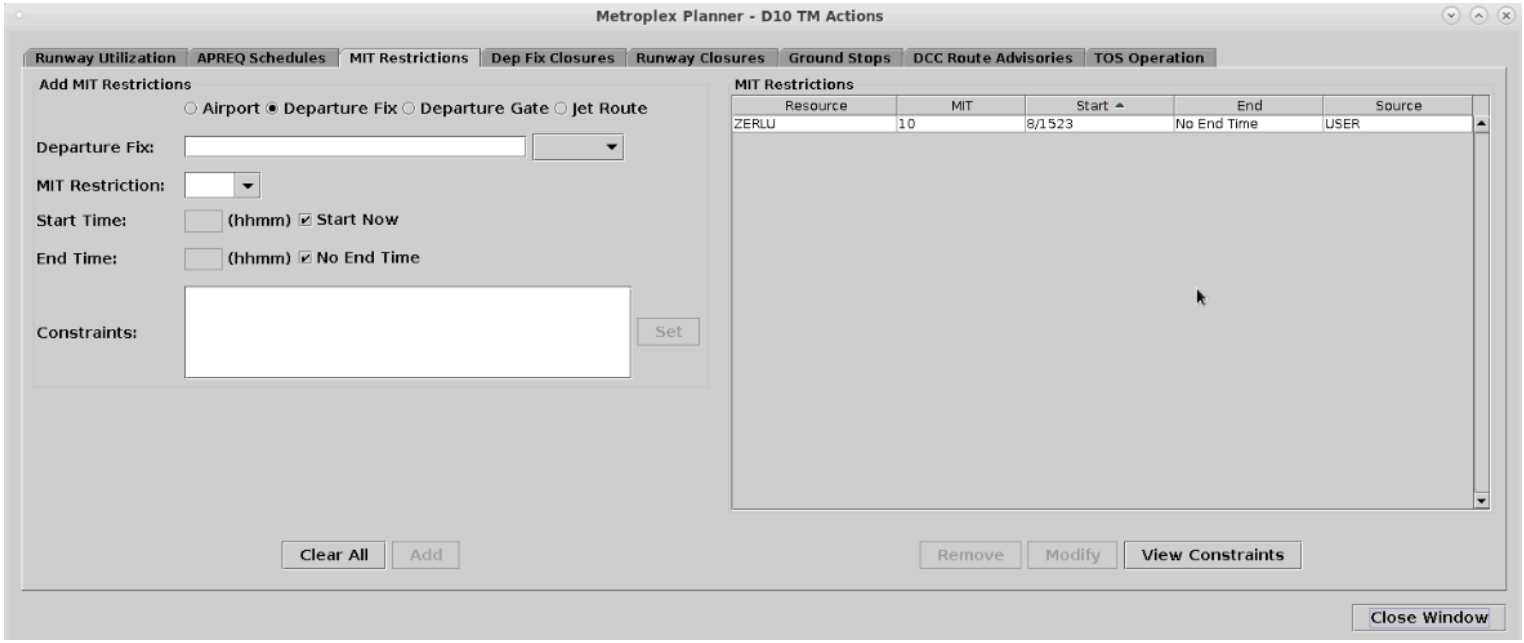
Notifications

Reported	Event Type	Description	Event Start	Event End	Details
5/8/20 1523	Fix	ZERLU 10MIT	5/8/20 1523		USER: TRACON D10 EXCL: PROP T...
5/8/20 1523	CDR	THHOR_1E RESTRICTED	5/8/20 1348		USER: TRACON D10 INCL: THHOR
5/8/20 1523	CDR	THHOR_2E RESTRICTED	5/8/20 1348		USER: TRACON D10 INCL: THHOR
5/8/20 1523	CDR	THHOR_WC RESTRICTED	5/8/20 1348		USER: TRACON D10 INCL: THHOR



TMI Propagation:
TMI in the Traffic Management Panel





Operational Concepts & Impacts

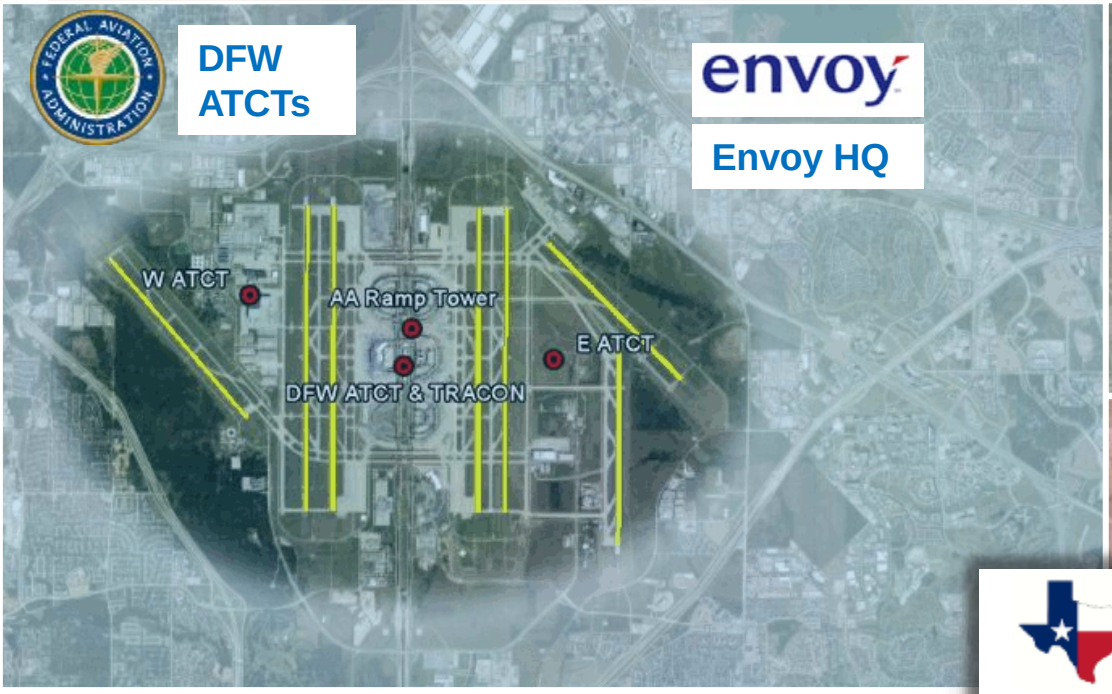
Operational Concepts & Impacts: Operational Policies, Modes, Support and Users

- Operational Policies, Procedures, and Constraints
  - No change from Phase 2
- Modes of Operation
  - Operational
  - Observer
- Support Environment Elements - entirely supported by the ATD-2 research team for the duration of the demonstration period
  - NASA Ames
  - NASA Langley
  - NASA/FAA North Texas Research Station (NTX)
  - Mosaic ATM, Inc.
  - William J. Hughes Technical Center
- User Classes and Other Involved Personnel (see next slide)
  - Scope of ConUse limited to the field demonstration environment for the ATD-2 research activity

Operational Concepts & Impacts: Users and Modes

Facility	Personnel	Capability	Mode
DFW Tower	TMU	• Standard Metroplex display to monitor, evaluate, and approve TOS routes submitted by American Airlines (AAL) or Envoy Airlines (ENY)	Operational
DAL Tower	OS/CIC	• Standard Metroplex display to monitor, evaluate, and approve TOS routes submitted by Southwest Airlines (SWA)	Operational
D10 TRACON	TMU	• Metroplex Planner display to monitor, evaluate, and approve TOS routes for AAL or ENY flights at DFW, and SWA flights at DAL, if Towers are not able	Operational
ZFW Center	TMU	• Metroplex Planner display to activate TOS when benefits can be attained by utilizing alternate routes • Monitor impact of weather and TMIs on route structure; update availability of alternate route structures	Operational
AAL Integrated Operations Center (IOC)	ATC Coordinator	• Metroplex display to monitor, evaluate, and submit TOS routes for AAL flights and subsidiaries to FAA for approval	Operational
SWA Network Operations Center (NOC)	ATC Coordinator	• Metroplex display to monitor, evaluate, and submit TOS routes for SWA flights to FAA for approval	Operational
ENY Headquarters (HQ)	ATC Coordinator	• Metroplex display to monitor, evaluate, and submit TOS routes for ENY flights to FAA for approval	Operational
DFW Airport Operations Center	Monitors	• STBO Client display showing only airport-specific flights – no TOS functionality	Situational Awareness

Operational Concepts & Impacts: Facilities

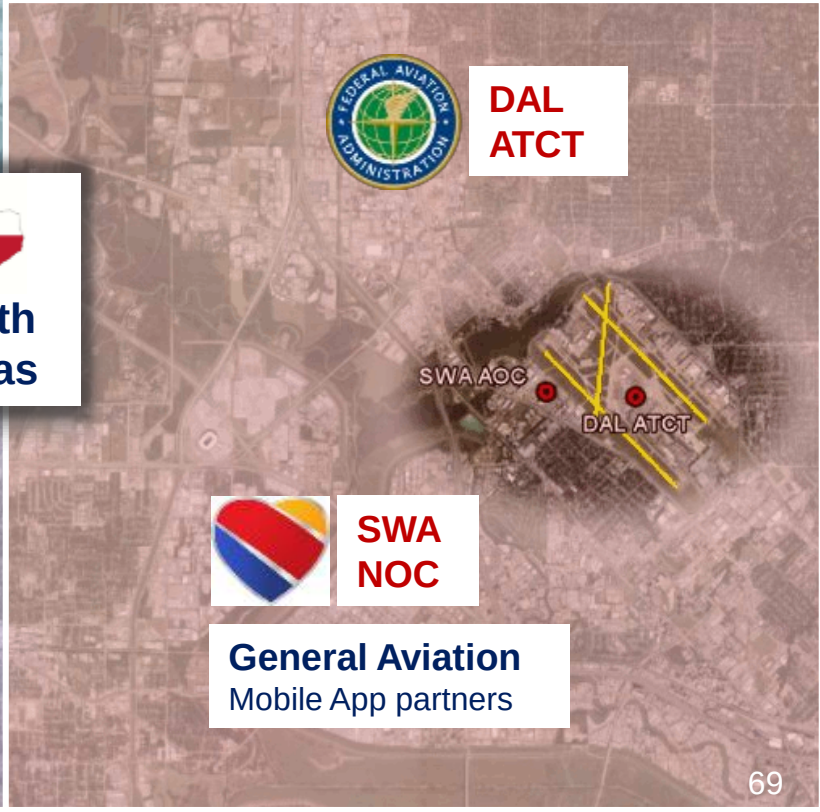


DFW ATCTs

Envoy HQ

D10 TRACON

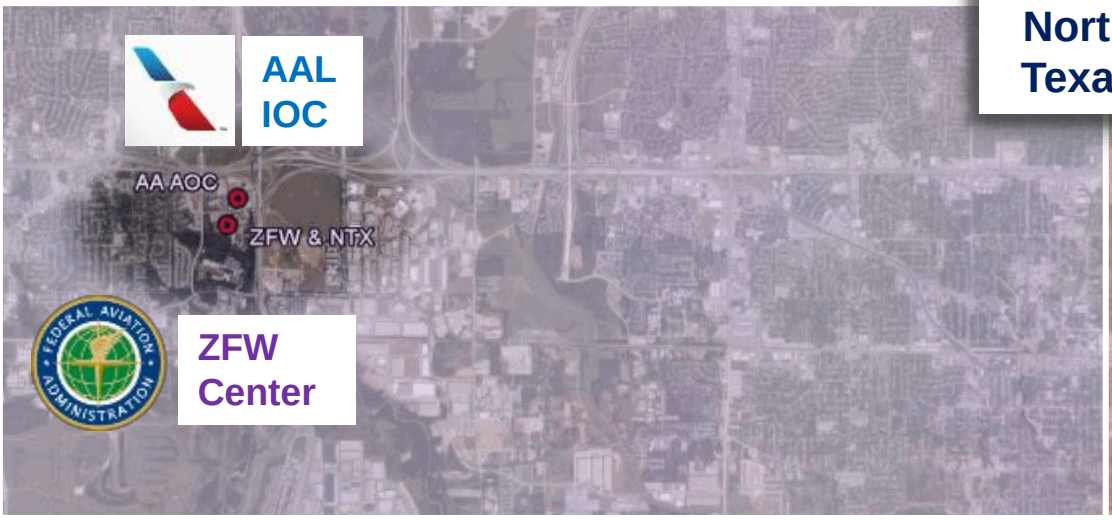
North Texas



DAL ATCT

SWA NOC

General Aviation
Mobile App partners



AAL IOC

ZFW Center

Operational Concepts & Impacts: Operational and Organizational Impacts

- Operational Impacts
  - Additional flight operators and airport personnel included in data exchange and enhanced situational awareness
  - Predicted delay savings for alternative TOS routes are presented to Flight Operators in the Metroplex Planner
  - Flight Operators use the Metroplex Planner interface to submit a flight for TOS reroute to the ATC Tower
  - ATCTs have ability to approve flight operator-requested TOS alternative routes electronically
  - All ATC users are immediately aware of approved reroutes
  - Restrictions are propagated through system to all users
- Organizational Impacts
  - Participation in training on the new capabilities prior to and during Phase 3 (time and resources) – all users
  - Added additional flight operators' personnel to training list

Summary

- Identification – Operational ConUse for ATD-2 Phase 3 Metroplex IADS Demonstration research
  - Add capabilities at DFW and DAL that build on the Phase 2 Fused IADS Demo at CLT
    - ✓**TOS Service** – flight operator submitting requests to reroute flights on pre-coded routes
    - ✓**Scheduling to the Terminal Boundary** – multi-airport scheduling via the D10 TRACON
    - ✓**TMI Propagation** – restrictions entered by the ZFW ARTCC propagated via the NTML
- Metroplex demo includes participants from:
  - DFW Tower
  - DAL Tower
  - D10 TRACON
  - Fort Worth Center (ZFW)
  - AAL IOC
  - SWA NOC
  - ENY HQ
  - GA/BA
  - DFW Airport

Acronyms (A-C)

ACRONYM	ACRONYM DEFINITION
3D	Three-Dimensional
3T	TFMS, TBFM, and TFDM
4D	Four-Dimensional
AAL	American Airlines
AAR	Airport Arrival Rate or Airport Acceptance Rate
ABRR	AirBorne ReRoute
AC or A/C	Aircraft
ADG	Airplane Design Group
ADR	Airport Departure Rate
ADS	Addison Airport
ADS-B	Automatic Dependent Surveillance Broadcast
ADW	Arrival Departure Window
AEFS	Advanced Electronic Flight Strips
AFP	Airspace Flow Program
AFW	Fort Worth Alliance Airport
AIBT	Actual In-Block Time
AIXM	Aeronautical Information Exchange Model
AJM	FAA ATO Program Management Operations
AJR	FAA ATO Systems Operations Services
AJV	FAA ATO Mission Support Services
ALDT	Actual Landing Time
AMA	Airport Movement Area
AMAT	Actual Movement Area entry Time
ANG	FAA NextGen Office
ANSP	Air Navigation Service Provider
AOBT	Actual Off-Block Time
AOC	Airline Operations Center
AODB	Airport Operational Database
AOL	Airspace Operations Laboratory
AOSP	Airspace Operations and Safety Program
API	Application Programming Interface
APM	Assistant Project Manager
APP	Application

ACRONYM	ACRONYM DEFINITION
APREQ	Approval Required
APT	Analysis, Planning, and Tracking
ARC	Ames Research Center
ARCR	Airport Resource Capacity Rates
ARM	Airport Resource Management
ARMD	Aeronautics Research Mission Directorate
ARTCC	Air Route Traffic Control Center
ASD	Aviation Systems Division
ASDE-X	Airport Surface Detection Equipment – Model X
ASDI	Aircraft Situation Display to Industry
ATC	Air Traffic Control
ATC Lab	Air Traffic Control Laboratory
ATCSCC	Air Traffic Control System Command Center
ATCT	Airport Traffic Control Tower
ATD-1	ATM Technology Demonstration 1
ATD-2	Airspace Technology Demonstration 2
ATD-3	Airspace Technology Demonstration 3
ATG	Airspace Target Generator
ATL	Hartsfield-Jackson Atlanta International Airport
ATM	Air Traffic Management
ATO	Air Traffic Organization
ATOT	Actual Takeoff Time
BA	Business Aviation
BOS	General Edward Lawrence Logan International Airport
CAP	Collaborative Arrival Planning
CCB	Change Control Board
CD	Clearance Delivery
CDM	Collaborative Decision Making
CDR	Coded Departure Routes
CEED	Charlotte EDC Evaluation and Demonstration
CFR	Call For Release
CLE	Cleveland Hopkins International Airport
CLT	Charlotte Douglas International Airport

Acronyms (C-F)

ACRONYM	ACRONYM DEFINITION
CLTlab	CLT ATD-2 Field Laboratory
CLTops	CLT Operational Facilities
CMS	Controller Managed Spacing
Comm	Communications
ConOps	Concept of Operations
ConUse	Concept of Use
CORE™	Computer-Assisted Systems Engineering Support Tool
CPDLC	Controller-Pilot Data Link
CPM	Composite Predictability Metric
CRM	Continuous Risk Management
CSV	Comma Separated Value
CTD	Controlled Time of Departure
CTOP	Collaborative Trajectory Options Program
CTOT	Controlled Takeoff Time
CVSRF	Crew Vehicle Systems Research Facility
D0	Flight operator on-time departure metrics
D10	DFW TRACON
DAL	Dallas Love Field Airport
DASH	Data Analysis and System Health
DCC	Common abbreviation for ATCSCC
DCL	Departure Clearance
DE&I	Data Exchange and Integration
DFW	Dallas/Fort Worth International Airport
DICE	Deicing
DLR	German Aerospace Center
DMP	Departure Metering Program
DoD	Department of Defense
DOT	Department of Transportation
DPM	Deputy Project Manager
DQM	Departure Queue Management
DRC	Departure Reservoir Coordinator
DRM	Departure Reservoir Management
DSP	Departure Sequencing Program

ACRONYM	ACRONYM DEFINITION
DSPM	Deputy Sub-Project Manager
DSS	Decision Support System
DST	Decision Support Tool
EDC	En route Departure Capability
EDCT	Expect Departure Clearance Time
EDIF	ETMS Data Interface
EFD	Electronic Flight Data
EFSTS	Electronic Flight Strip Transfer System
EFTT	Earliest Feasible Takeoff Time
ENY	Envoy Airlines
EOBT	Earliest Off-Block Time
ERAM	En Route Automation Modernization
ERTD	Earliest Runway Time of Departure
ESE	Engineering Shadow Evaluation
ETA	Estimated Time of Arrival
ETMS	Enhanced Traffic Management System
ETOT	Estimated Takeoff Time
EWR	Newark Liberty International Airport
FAA	Federal Aviation Administration
FADT	Fuel Advisory Delay Time
FANS	Future Air Navigation System
FCA	Flow Constraint Area
FCFS	First-Come, First-Served
FDIO	Flight Data Input/Output
FEA	Flow Evaluation Area
FFC	Future Flight Central
FID	Final Investment Decision
FIM	Flight-deck Interval Management
FIXM	Flight Information Exchange Model
FMC	Flight Management Connector
FMS	Flight Management System
FO	Flight Operator
FRZ	Freeze

Acronyms (F-N)

ACRONYM	ACRONYM DEFINITION
FSM	Flight Schedule Monitor
FTE	Full Time Equivalent
FTW	Fort Worth Meacham International Airport
FY	Fiscal Year
FYI	For Your Information
GA	General Aviation
GC	Ground Control/Controller
GDP	Ground Delay Program
GIS	TFDM WSRD Publication Service
GS	Ground Stop
GUFI	Globally Unique Flight Identifier
GUI	Graphical User Interface
HITL	Human-in-the-Loop
HQ	Headquarters
IADS	Integrated Arrival, Departure, Surface
ICE	Independent Cost Estimate
ICN	Incheon International Airport
ID	Identify/Identification
IDAC	Integrated Departure Arrival Capability (TBFM)
IDS	Integrated Display System
IDS5	Systems Atlanta, Inc's (SAI's) Information Display Systems - Generation 5
IDST	Integrated Departure Scheduling Tool
IIAC	Incheon International Airport Corporation
IMS	Integrated Master Schedule
IN	Arrival at Gate
IOBT	Initial Off-Block Time
IOC	Integrated Operations Center
IRD	Interface Requirement Document
IRP	Independent Review Panel
ISAS	Integrated Surface/Airspace Simulation
IT	Information Technology
J-22	TFDM Specification Artifact

ACRONYM	ACRONYM DEFINITION
JFK	John F. Kennedy International Airport
JMS	Java Message Service
JPMP	Joint Project Management Plan
KAIA	Korea Agency for Infrastructure Technology Advancement
KARI	Korea Aerospace Research Institute
KDP-F	Key Decision Point – F (project closeout) (KDPs are numbered A-F per NASA SysEngr Handbook)
KPP	Key Performance Parameter
L-Time	Airline Time (manual update from airline for pushback time)
LaRC	Langley Research Center
LAS	Las Vegas McCarran International Airport
LC	Local Control/Controller
LGA	LaGuardia Airport
LOB	Long On Board
MACS-ATG	Multi-Aircraft Control System – Airspace Traffic Generator
MC	Metroplex Coordinator
MINIT	Minutes-in-Trail
MISC	Miscellaneous tab
MIT	Miles-in-Trail
MOE	Measures of Effectiveness
MOP	Measure of Performance
MP	Meter Point
MRA	Metrics, Reporting & Analysis (DRM component)
N/A	Non Applicable
N-value	Target number of flights in queue
N90	New York TRACON
NAC	NextGen Advisory Committee (FAA)
NARP	National Aviation Research Plan
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NATCA	National Air Traffic Controllers Association
NBAA	National Business Aviation Association
NCT	Northern California TRACON

Acronyms (N-R)

ACRONYM	ACRONYM DEFINITION
NextGen	Next Generation Air Transportation System
NIWG	NextGen Integration Working Group
NM or NMI	Nautical Mile
NOC	Network Operations Center
NPR	NASA Procedural Requirement
NRA	NASA Research Announcement
NTML	National Traffic Management Log
NTX	NASA/FAA North Texas Research Station
OAG	Official Airline Guide
OAK	Metropolitan Oakland International Airport
OCE	Office of the Chief Engineer (NASA Ames)
OER	Operational Evaluation Report
OEU	Operational Evaluation and Use
OFF	Departure at Runway
OGA	Other Government Agency
OIA	Operational Integration Assessment
OIS	Operational Information Service
ON	Arrival at Runway
OP	Operator
OpNec	Operational Necessity
OS/CIC	Operational Supervisor/Controller in Charge
OSE	Operational Shadow Evaluation
OUT	Departure off Gate
OV-1	High Level Operational View
P-time	Proposed Departure Time
P3	Process, Procedures and Policies
PBN	Performance-Based Navigation
PCT	Potomac Consolidated TRACON
PDC	Pre-departure Clearance
PDRC	Precision Departure Release Capability
PDRR	Pre-Departure ReRoute
PGUI	Planview Graphical User Interface
PHX	Phoenix Sky Harbor International Airport

ACRONYM	ACRONYM DEFINITION
PIC	Pilot in Command
PM	Project Manager
PMP	Project Management Plan
PRP	Performance Review Panel / AOSP Program Director Panel
QA	Quality Assurance
QSR	Quarterly Status Review
R	Restricted TFMData messages
R&D	Research and Development
R&R	Roles and Responsibilities
R&T	Research and Technology
R13	TFMS Release 13
RAD	Route Amendment Dialogue
RAPT	Regional Airspace and Procedures Team
RBS	Ration By Schedule
RDR	Runway Departure Rate
RFP	Request For Proposal
RFRT	Request For a Release Time
RMD	Recommended
RMNT	Reroute Minimum Notification Time
RMTC	Ramp Manager Traffic Console
RNAV	Area Navigation
RNP	Required Navigation Performance
RQD	Required
RSTN	Restriction tab
rTBFM	Research TBFM
RTC	Ramp Traffic Console (Phases 1 and 2)
RTC	Relative Trajectory Cost (Phase 3)
RTCA	(formerly) Radio Technical Committee on Aeronautics
RTOT	Requested Takeoff Time
RTP	Research Transition Product
RTT	Research Transition Team
RVM	Requirements Verification Matrix
RWY	Runway

Acronyms (S-U)

ACRONYM	ACRONYM DEFINITION
SA	System Architect
SAA	Space Act Agreement
SAIC	Science Applications International Corporation
SARDA	Spot and Runway Departure Advisor
SBIR	Small Business Innovative Research
SBS	Surveillance and Broadcast Service (FAA)
SDSS	Surface Decision Support System
SDT	Scheduled Departure Time
SE	Systems Engineering
SEMP	Systems Engineering Management Plan
SER	Shadow Evaluation Readiness
SFDPS	SWIM Flight Data Publication Service
SFO	San Francisco International Airport
SID	Standard Instrument Departure
SDT	Scheduled Departure Time
SIP	Strategic Implementation Plan
SJC	Norman Y. Mineta San Jose International Airport
SLE	Second Level Engineering
SMA	Safety and Mission Assurance
SMA	Surface Movement Advisor
SME	Subject Matter Expert
SOA	Surface Operation Automation
SOAR	Sharing of Airspace Resources
SOBT	Scheduled Off-Block Time
SPM	Sub-Project Manager
SRD	System Requirements Document
SRR	Systems Requirements Review
STA	Scheduled Time of Arrival
STAR	Standard Approach Route
STARS	Standard Terminal Automation Replacement System
STBO	Surface Trajectory Based Operations
STDDS	SWIM Terminal Data Distribution System
STMC	Supervisory Traffic Management Coordinator

ACRONYM	ACRONYM DEFINITION
SUA	Special Use Airspace
SW	Software
SWA	Southwest Airlines
SWAP	Severe Weather Avoidance Plan tab
SWIM	System Wide Information Management
T2T	TBFM-to-TBFM
TBD	To Be Determined
TBFM	Time Based Flow Management
TC	Technical Challenge
TDLS	Tower Data Link Service
TFDM	Terminal Flight Data Manager
TFM	Traffic Flow Management
TFMS	Traffic Flow Management System
TGUI	Timeline Graphical User Interface
TIM	Technical Interchange Meeting
TMA	Traffic Management Advisor
TMAT	Target Movement Area entry Time
TMC	Traffic Management Coordinator
TMI	Traffic Management Initiative
TMU	Traffic Management Unit (FAA)
TOBT	Target Off-Block Time
TOC	Top Of Climb
TOD	Top of Descent
TOS	Trajectory Option Set
TQET	Target Queue Entry Time
TRACON	Terminal RADAR Approach Control
TRL	Technology Readiness Level
TS	Trajectory Synthesizer
TSAS	Terminal Sequencing and Spacing (formerly, TSS)
TT	Technology Transfer
TTOT	Target Takeoff Time
TTP	TFDM Terminal Publication
UDB	Unscheduled Demand Buffer

Acronyms (U-Z)

ACRONYM	ACRONYM DEFINITION
UDP	Unified Delay Program
UI	User Interface
US	United States
UTC	Universal Time Coordinated
UTOT	Undelayed Takeoff Time
V&V	Verification and Validation
Wake RECAT	Wake Turbulence Recategorization
WBS	Work Breakdown Structure
WJHTC	William J. Hughes Technical Center (FAA)
WS	Web Services
WSRD	Web Service Requirements Document
WSRT	Web Services Routing Tool (TBFM)
WYE	Work Year Equivalent
XML	Extensible Markup Language
XSD	XML Schema
ZAB	Albuquerque Air Route Traffic Control Center (ARTCC)
ZDC	Washington Air Route Traffic Control Center (ARTCC)
ZFW	Fort Worth Air Route Traffic Control Center (ARTCC)
ZHU	Houston Air Route Traffic Control Center (ARTCC)
ZJX	Jacksonville Air Route Traffic Control Center (ARTCC)
ZKC	Kansas City Air Route Traffic Control Center (ARTCC)
ZME	Memphis Air Route Traffic Control Center (ARTCC)
ZTL	Atlanta Air Route Traffic Control Center (ARTCC)

ACRONYM	ACRONYM DEFINITION

Image Credits

"Self-check-in with a barcode reader and printout of a boarding pass" by Fotina, https://www.shutterstock.com/image-photo/selfcheck-barcode-reader-printout-boarding-pass-1062851123, Image purchased.

Airport Gate Monitoring Using Computer Vision Techniques, 2016 Gamtos, from "Airport Gate Monitoring Using Computer Vision" by H. Lu, V. Cheng, J. Tsai, AIAA 2016. Image used with permission from authors.

"Woman Scanning Tag On Luggage At Airport Check-in" by Tyler Olson, https://www.shutterstock.com/image-photo/woman-scanning-tag-on-luggage-airport-719192776, Image purchased.

"Refueling of aircraft" by Standard store88, https://www.shutterstock.com/image-photo/refueling-aircraft-294143033, Image purchased.

"Artificial Intelligence Line Icon Circle Concept. Vector Illustration of Outline Design" by Anna Leni, https://www.shutterstock.com/image-vector/artificial-intelligence-line-icon-circle-concept-1545619127, Image purchased.