Airspace Technology Demonstration 2 (ATD-2)

Concept of Use (ConUse) Addendum for Phase 2

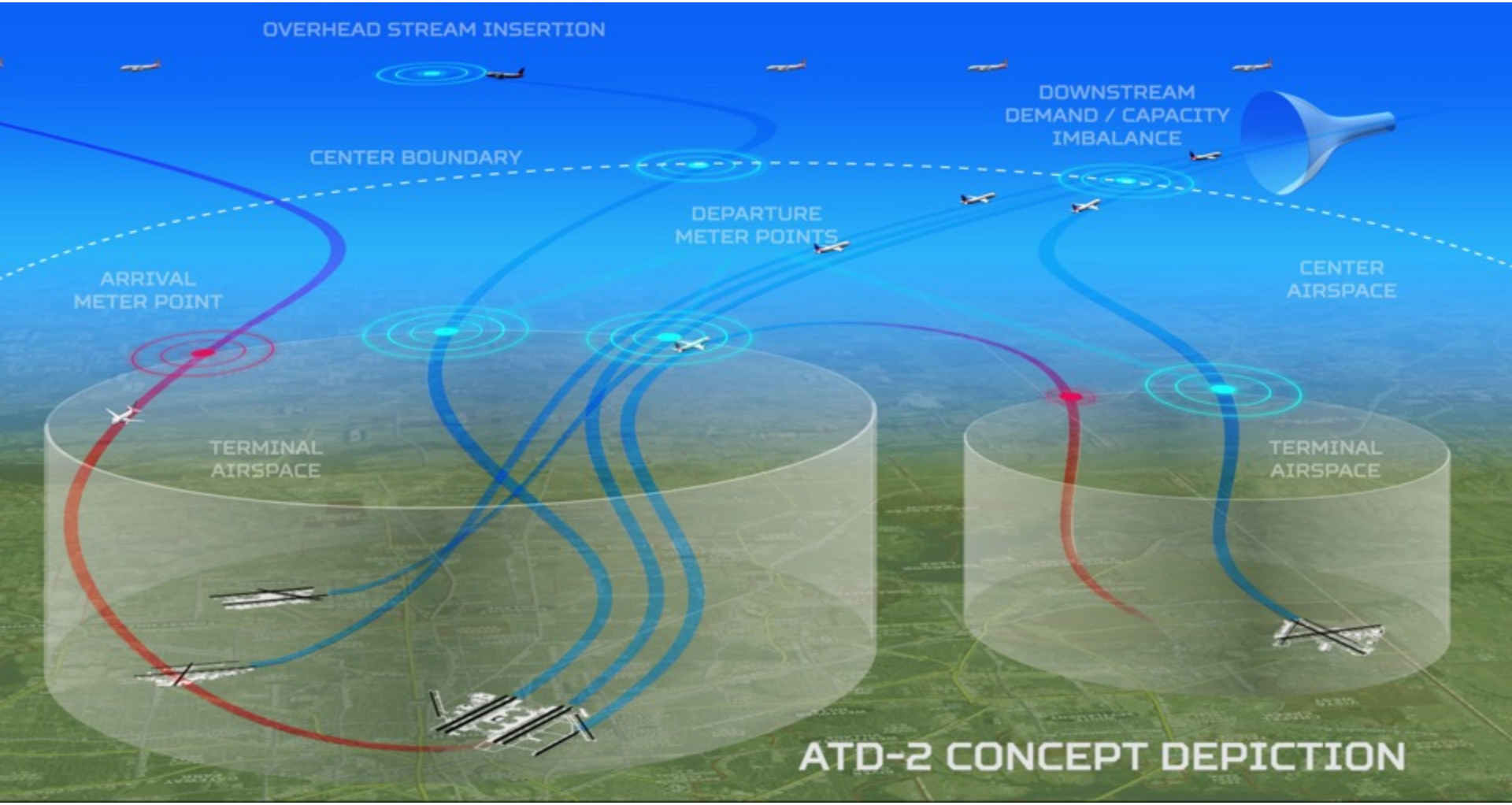
September 18, 2019

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

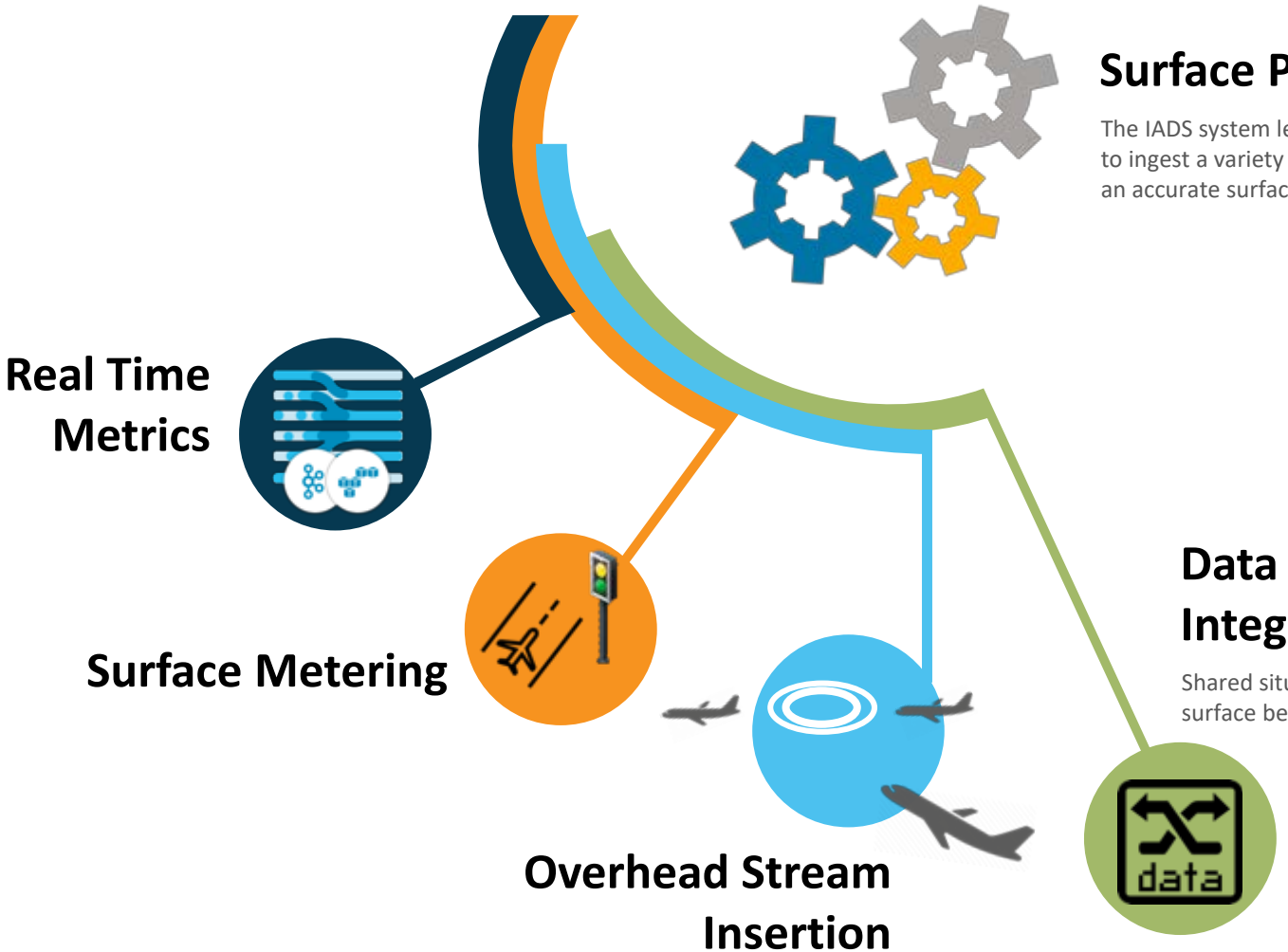
- Identification – Operational ConUse for ATD-2 Phase 2 Fused Integrated Arrival, Departure, Surface (IADS) Demonstration research activity
  - Add capabilities at CLT beyond Phase 1 Baseline IADS Demo
    - ✓**Tactical-Strategic Fusion** – extend time horizon for metering
    - ✓**TMI Evolution** – evaluation of pre-scheduling into Center
    - ✓**AEFS Integration** – electronic interface with ATC
    - ✓**TFDM Terminal Publication** – deliver IADS data via FAA SWIM
    - ✓**Mobile App** – allows GA operators to submit estimated departure time
- Background – Planned evolution from Phase 1 Baseline
- Scope – Identify changes in ConUse relative to Phase 1 Baseline
- Organization of document
  - Introduction
  - ATD-2 IADS Overview
  - Phase 2 IADS System Concepts w/ Operational Scenarios/Use Cases (by technology area)
  - Potential Impacts
  - Analysis
  - Summary
  - References

ATD-2 IADS Overview & Phase 1: 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 Overview & Phase 1: Phase 1 Baseline IADS Capabilities



Surface Predictive Engine

The IADS system leverages a surface predictive engine to ingest a variety of data feeds and inputs to produce an accurate surface model and associated schedule

Data Exchange and Integration

Shared situation awareness across the airport surface between ATC and operators

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

ATD-2 Integrated Arrival/Departure/Surface

NASA

	ATC	Ramp	Flight Deck
Micro-Phase I	• Implement runway utilization strategies, departure fix closures, runway closures, and TMIs using STBO as part of daily operations • SWIM APREQ times and EDCT times available in STBO • STBO tools and DASH used to understand demand capacity imbalances	• During Bank 2, all ramp controllers and ramp manager use 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 EDCT times • Ability to request runways for OpNec	• During Bank 2, the flight deck receives changes to runway assignments and dep fixes from ramp control • Push back advisories given based on APREQ times and EDCT times

Micro-Phase II	• IDAC style electronic negotiation with 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 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 dep fixes
			• Push back advisories given based on APREQ times and EDCT times

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

Phase 2 IADS System Concepts: Fused IADS Technology Enhancements

PHASE 2

Phase 2 Development
Fused IADS Demonstration

Agile

Agile Deve
Continued eng

Foundatio
Leveraging IAD

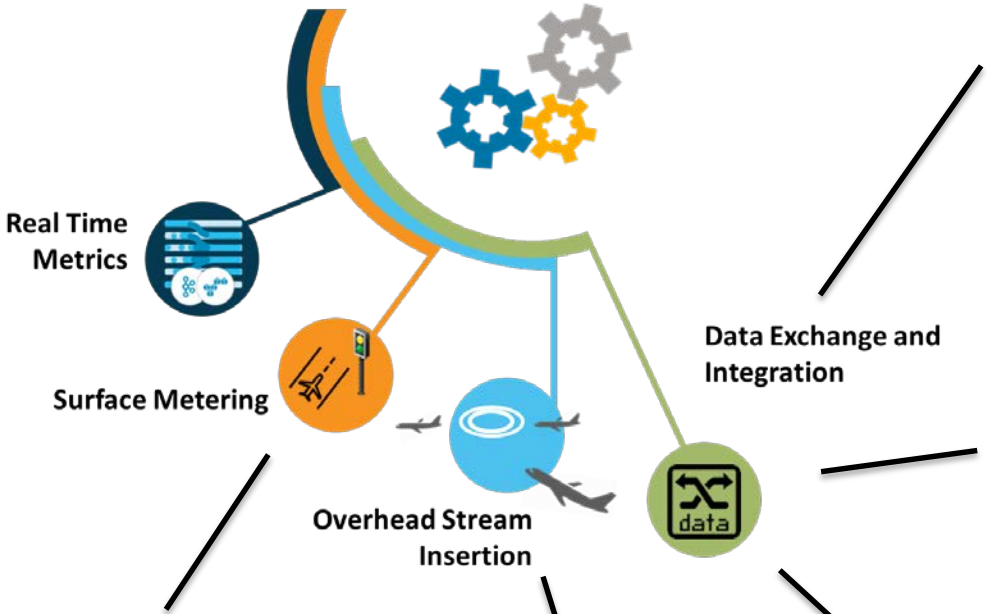
Leveragin
Iterating with

Phase 2 (IADS Fusion, Sept 2018)

- **Strategic planning tools (strategic/tactical fusion)**
- **ZTL/ATL airspace tactical scheduling**
- **Electronic Flight Data (EFD) Integration**
- **TFDM Terminal Publication (TTP) prototype**
- **Mobile App for EOBTs (GA community)**

Phase 2 IADS System Concepts: Fused IADS Introduces Five New Capabilities

Integrated Arrival, Departure, Surface (IADS) System v4.0



5. **Mobile App**: Ingest data from TTP-connected Mobile App data into IADS scheduling system (enables General Aviation operators to fully participate in ATD-2 Field Demo)

4. **TFDM Terminal Publication:** Deliver IADS data as TFDM Terminal Publication (TTP) service via FAA's SWIM system (enables all flight operators to participate in ATD-2 Field Demo)

3. **AEFS Integration:** Integrate with Tower controller electronic flight strips (enables more precise management of controlled takeoff times)

1. **Tactical-Strategic Fusion**: Extend time horizon to strategic range (enables more options for operators and passengers)

2. **TMI Evolution**: Integrate with Atlanta Center arrival metering TBFM system (enables evaluation of pre-scheduling concept)

Phase 2 IADS System Concepts Sections

- Tactical-Strategic Fusion (Strategic Planning)
- TMI Evolution
- Mobile App
- AEFS Integration
- TFDM Terminal Publication (TTP)

Tactical-Strategic Fusion (Strategic Planning)

Operational Scenarios

Tactical-Strategic Fusion (Strategic Planning): Overview of Surface Metering

- Departure surface metering reduces fuel burn and surface congestion by holding flights at the gate instead of in the AMA in departure queues

- ATD-2 assigns Target Off Block Times (TOBTs) and Target Movement Area entry Times (TMATs) to flights during Surface Metering Programs (SMPs)
  - TOBT is the time the flight should pushback from the gate
  - TMAT is the time the flight should enter the movement area

- TOBTs and TMATs are assigned to reduce excess taxi time to a target value
  - Excess taxi time is the amount of time beyond unimpeded taxi time that the flight is predicted to spend taxiing on the airport surface

Tactical-Strategic Fusion (Strategic Planning): ATD-2 Surface Metering Progression

Crawl → Walk → Run

Scheduling

- Predict TTOTs
- Schedule flights into overhead stream

Tactical Metering

- Assign TOBTs and TMATs when metering is needed

Strategic Metering

- Predict SMPs
- Freeze TOBTS and TMATs
- Freeze metering start time

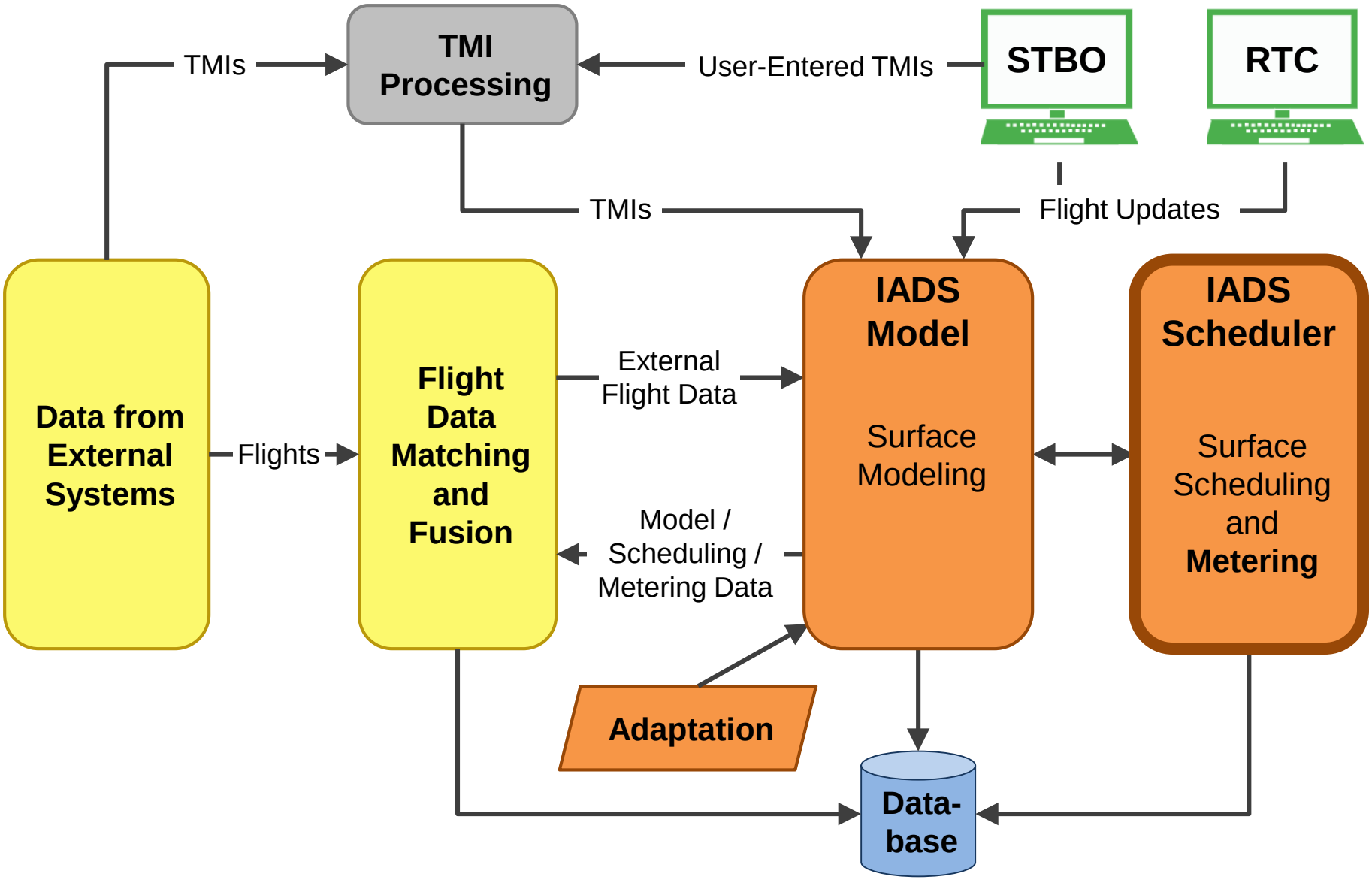
- **TTOT**: Targeted Take Off Time
- **TOBT**: Targeted Off-Block Time
- **TMAT**: Targeted Movement Area entry Time
- **SMP**: Surface Metering Program

Tactical-Strategic Fusion (Strategic Planning): Background on Strategic Surface Metering

- Goals
  - Incorporate lessons learned from tactical scheduler during Phase 1
  - Incorporate additional concepts from TFDM and prepare for transition to TFDM
  - Provide planning tools on the strategic timeframe
    - Provide predictions at longer look-ahead times
    - Provide advanced notice of metering
    - Provide TOBTs and TMATs with more lead time
  - Continue to make use of tactical data, such as readiness information

- The strategic planning tools were added to the existing tactical scheduler
  - Surface Metering Programs (SMPs) were added similar to TFDM

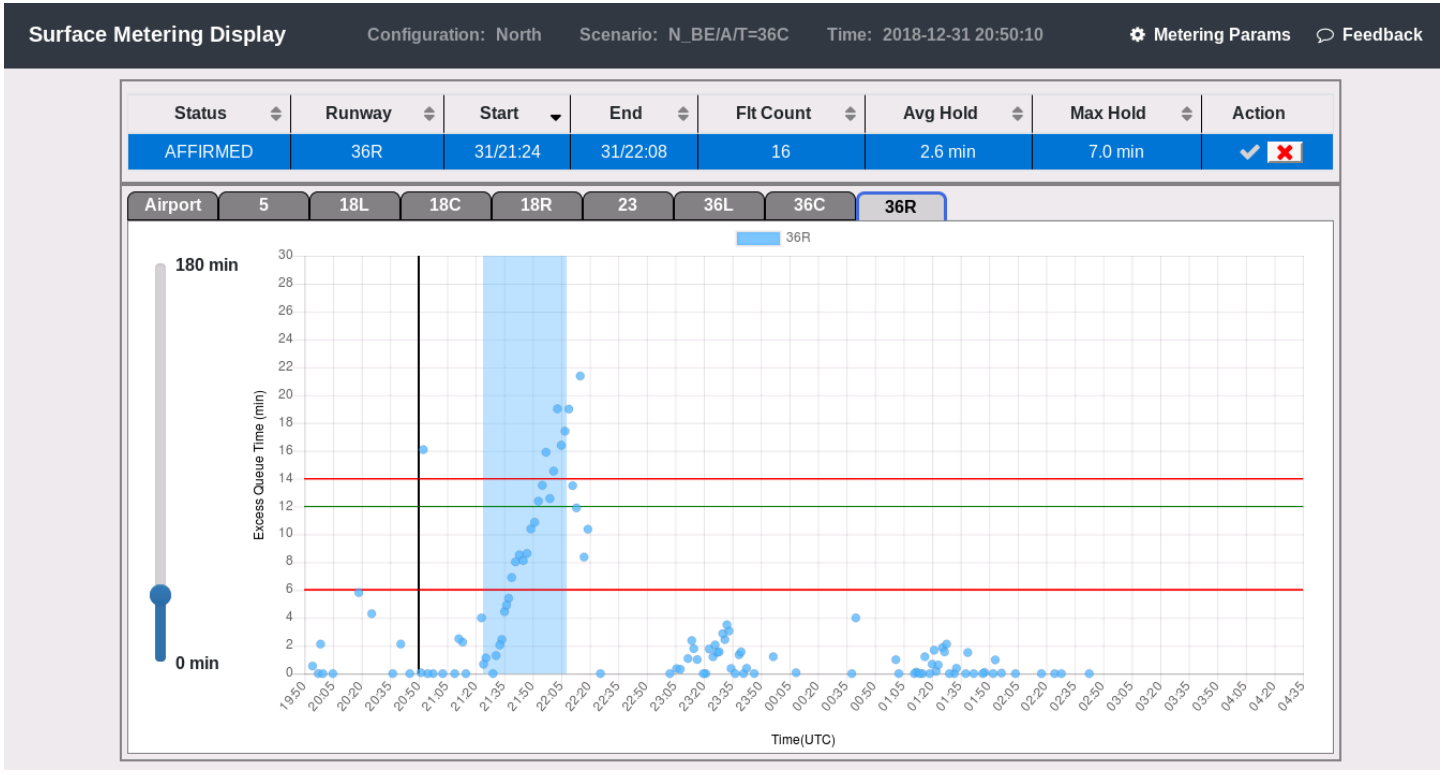
Tactical-Strategic Fusion (Strategic Planning): Surface Metering High-Level Architecture



Colors correspond to different tracks

Tactical-Strategic Fusion (Strategic Planning): Strategic Surface Metering Programs (SMPs)

- Predicts when metering will be needed in advance with web-based Surface Metering Display (SMD)
- Allows users to collaborate on recommended metering program
  - Affirm or reject the recommended SMP
- ATD-2 SMPs are automatically adjusted at regular intervals based on the latest data



Legend

Upper/Lower Threshold:

Target Threshold:

Tactical-Strategic Fusion (Strategic Planning): Strategic SMP Work Flow in SMD

- At the beginning of the day, surface metering capability is off, by default

- Prior to each bank, TMC enables the “Time-Based Metering” capability in the Surface Metering Display (SMD) tool

- TMC and ramp manager collaborate to set desired metering parameters
  - Targets and Thresholds for Excessive Queue Time are set to the same values as they were in with the Phase 1 tactical surface metering capability
  - New strategic parameters
    - Lead Time – What is the farthest in advance that an SMP should be recommended?
      - Currently set to 60 minutes
    - Static Time Horizon – Freezes TOBT and TMAT a set number of minutes in advance

Tactical-Strategic Fusion (Strategic Planning): Strategic SMP Work Flow in SMD

- Set desired metering parameters (continued)

Resource	5	36R	36C	36L
Upper Threshold	0	14	12	0
Target Threshold	0	12	10	0
Lower Threshold	0	6	5	0
Last Update Time	04/08:00	04/08:00	04/08:00	04/08:00

Airport | 5/23 | 18L/36R | 18C/36C | 18R/36L

Parameter	Current Value	New Value
Enable Metering:	TIME_BASED_METERING	(•) Time-Based Metering ( ) Departure Sequence Metering ( ) No Metering
Lead Time:	60 min	min
Static Time Horizon:	0 min	min

Set Airport Parameters | Clear Airport Parameters

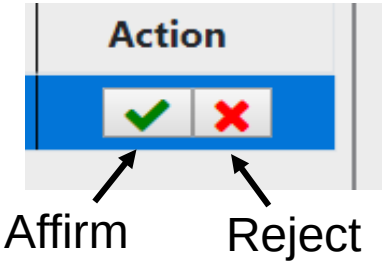
Set All Parameters | Clear All Parameters

Tactical-Strategic Fusion (Strategic Planning): Strategic SMP Work Flow

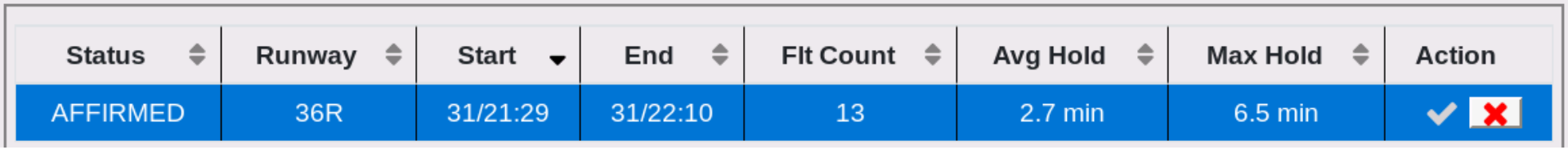
- An SMP is recommended once the need for metering is detected within the Lead Time
  - If auto-affirm is off, users are notified of the proposed SMP with an orange gear icon in the toolbar

- If auto-affirm is enabled:
  - A SMP will be immediately affirmed
  - The SMP will be labeled “Affirmed” in the Surface Metering Display tool

- If auto-affirm is not enabled, TMC and ramp manager make decision to affirm or reject SMP
  - If SMP is affirmed, metering will turn on at appropriate time
  - If SMP is rejected, metering will not turn on
  - If no action is ever taken, metering will not turn on



Tactical-Strategic Fusion (Strategic Planning): SMP Information in SMD



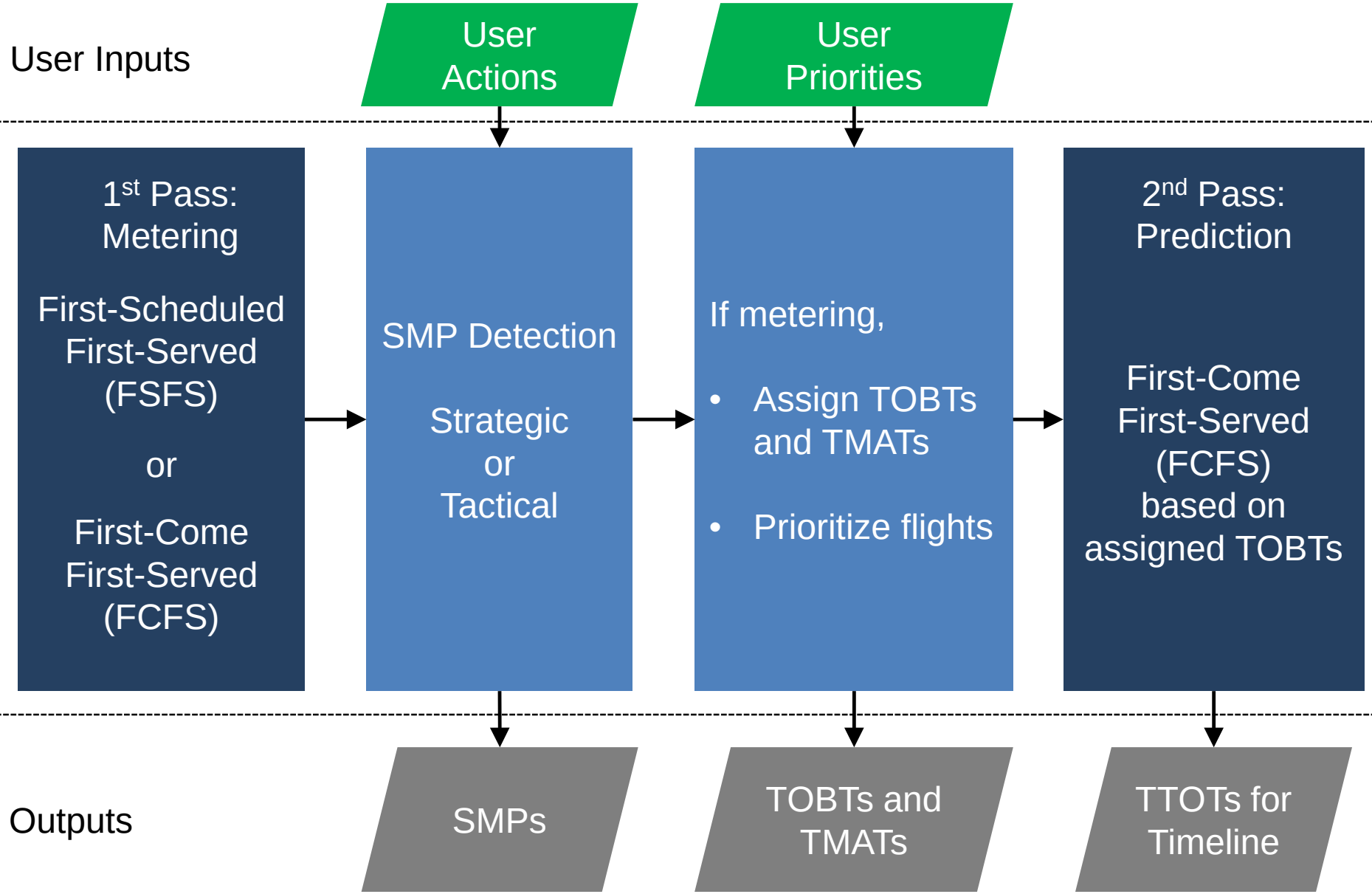
Status	Runway	Start	End	Flt Count	Avg Hold	Max Hold	Action
AFFIRMED	36R	31/21:29	31/22:10	13	2.7 min	6.5 min	✓ ✗

- The following information is provided for proposed SMPs:
  - **Status** – current status of the SMP
  - **Runway** – the runway for which metering is proposed
  - **Start** – the predicted start time of metering
  - **End** – the predicted end time of metering
  - **Flt Count** – the predicted number of flights that will be assigned a gate hold
  - **Avg Hold** – the predicted average gate hold assigned to each flight
  - **Max Hold** – the predicted maximum gate hold assigned to during metering

Tactical-Strategic Fusion (Strategic Planning): SMP Status in SMD

- The following are the possible status options for a SMP:
  - **PROPOSED**
    - The ATD-2 system is recommending metering and no user action has been taken
    - “Proposed” statues is only used when auto-affirm is off
  - **AFFIRMED**
    - A user has affirmed the SMP or auto-affirm is enabled
    - And the ATD-2 system is still predicting that metering will be needed
  - **REJECTED**
    - A user has rejected the SMP but the ATD-2 system is still recommending metering
  - **ACTIVE**
    - An affirmed SMP has started. Metering is now active for the runway
  - **COMPLETED**
    - An active SMP has ended or been terminated early by a user
  - **OBSOLETE**
    - The ATD-2 system is no longer recommending metering for this runway (Affirmed and rejected SMPs can become obsolete.)

Tactical-Strategic Fusion (Strategic Planning): Overview of ATD-2 Scheduler Flow

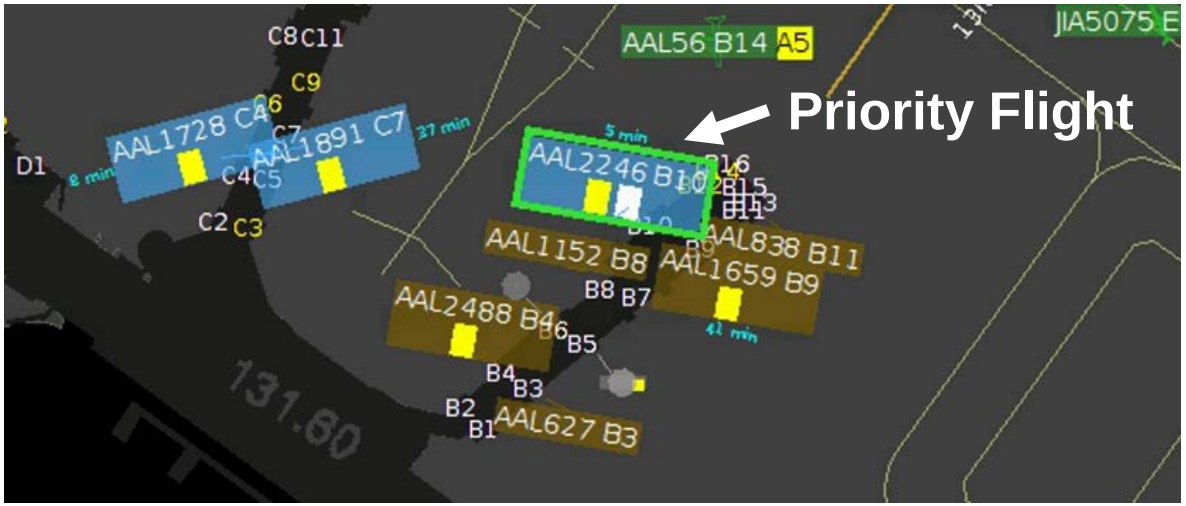


Flight Prioritization

- The ramp manager can mark a flight as priority through the Ramp Manager Traffic Console (RMTC) tool

- During metering, the scheduler will preform substitutions among flights with the same major carrier that are part of the same SMP to reduce gate hold on the priority flights
  - RTC shows updated gate hold advisories to ramp controllers
  - ATD-2 publishes the new TOBTs and TMATs out TTP SWIM

- With TFDM, airlines will need to translate priorities into a set of substitutions

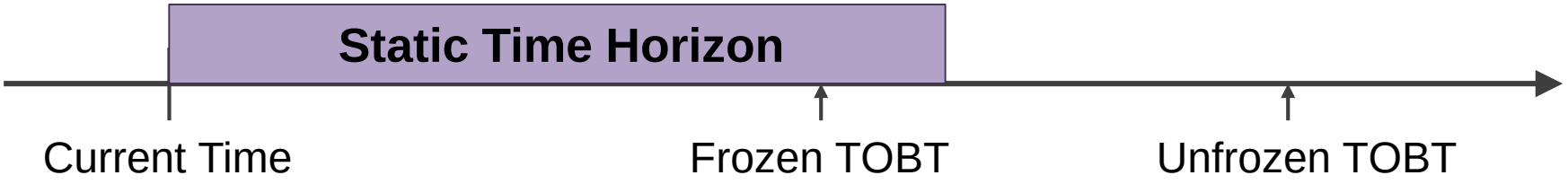


Tactical-Strategic Fusion (Strategic Planning): Leveraging Surface Metering

- Goal is to provide additional benefits of gate hold to passengers and airlines
  - Airlines need to know with confidence how much gate hold will be assigned to each flight in advance of the flight calling ready for pushback
  - Need to have a stable, predictable hold time in the Ramp Traffic Console (RTC) to enable airlines to take advantage of it
- Tactical Freeze
  - TOBT and TMAT are frozen when the pilot calls ready
  - Readiness indicated either by ramp controller putting the flight on hold or pushing back the flight in RTC
- Strategic Freeze
  - Keeps current tactical freeze
  - New strategic logic allows freeze of TOBT and TMAT prior to pilot calling ready
    - The Static Time Horizon (STH) defines how far in advance the TOBT and TMAT are frozen

Tactical-Strategic Fusion (Strategic Planning): Static Time Horizon

- Flight's with a TOBT inside the STH are frozen



- The size of the Static Time Horizon is a tradeoff between precisely managing the queue precisely and providing stability to flight operations
- Exceptions to strategic freeze
  - Flights with TMIs
  - Airline updates EOBT to a time later than TOBT
    - If new EOBT is within the STH, flight gets new frozen TOBT = EOBT
    - If new EOBT is outside STH, flight gets new unfrozen TOBT >= EOBT based on First-Scheduled, First-Served (FSFS)
  - Ramp manager enters priority through RTC that causes substitutions inside of the STH

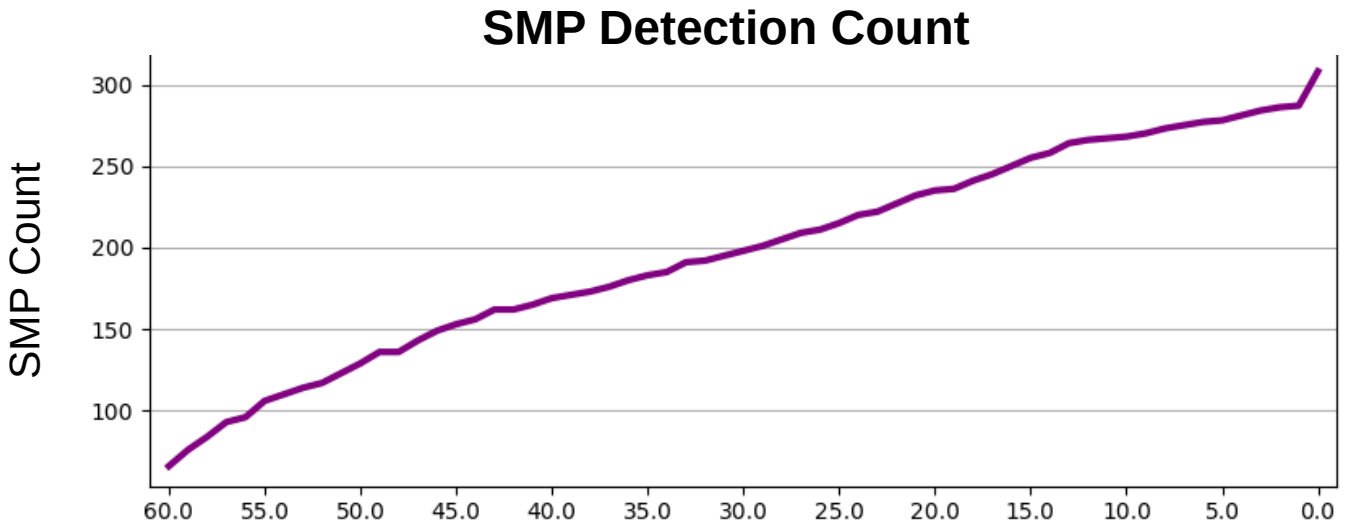
Freezing SMP Start Time

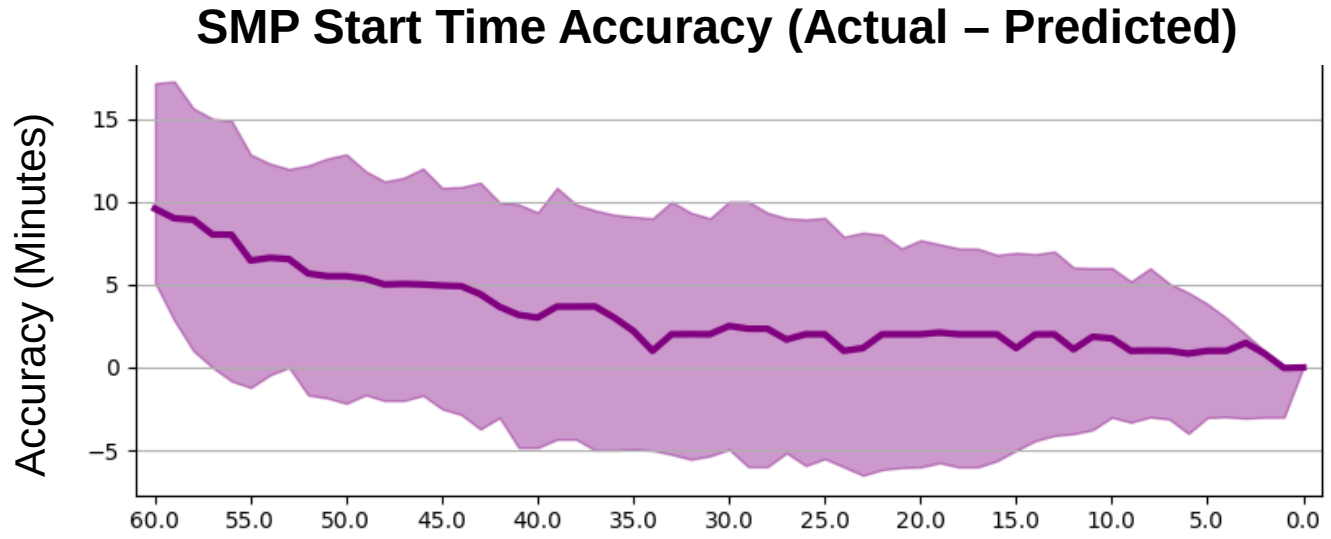
- Currently, ATD-2 SMPs predicts when metering will be tactically triggered, but metering does not start until tactical triggers are met

- To be able to leverage surface metering, airlines need to know when metering will start in advance
  - Allows for advance planning
  - Trade-off is that there is a risk of metering starting too early, resulting in a slow start to metering

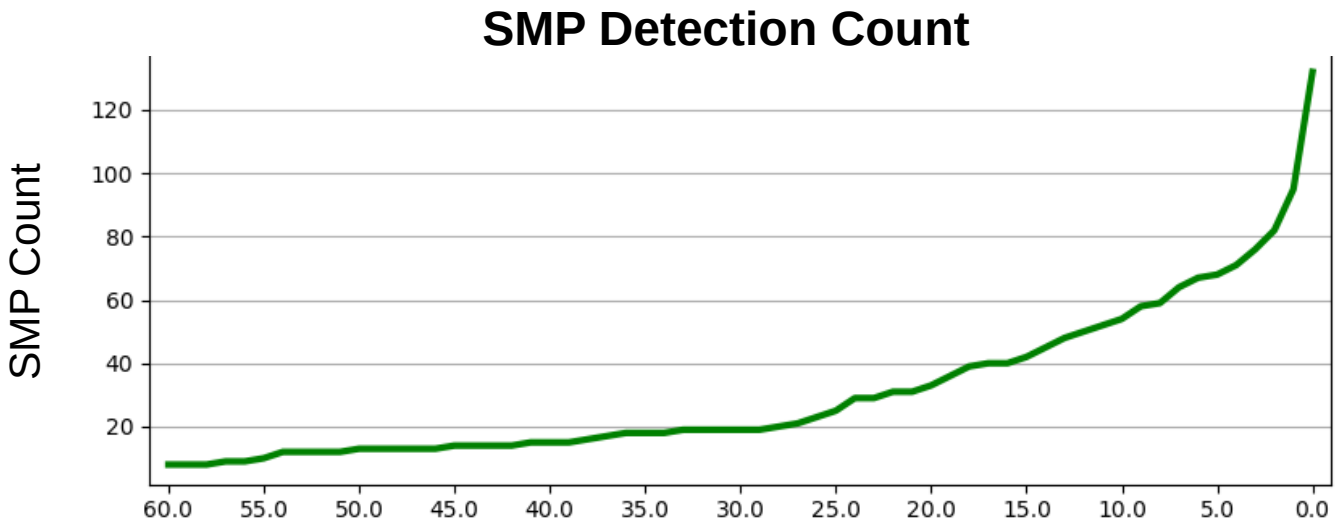
- Recently added capability to freeze SMP start time when start time is within the Static Time Horizon

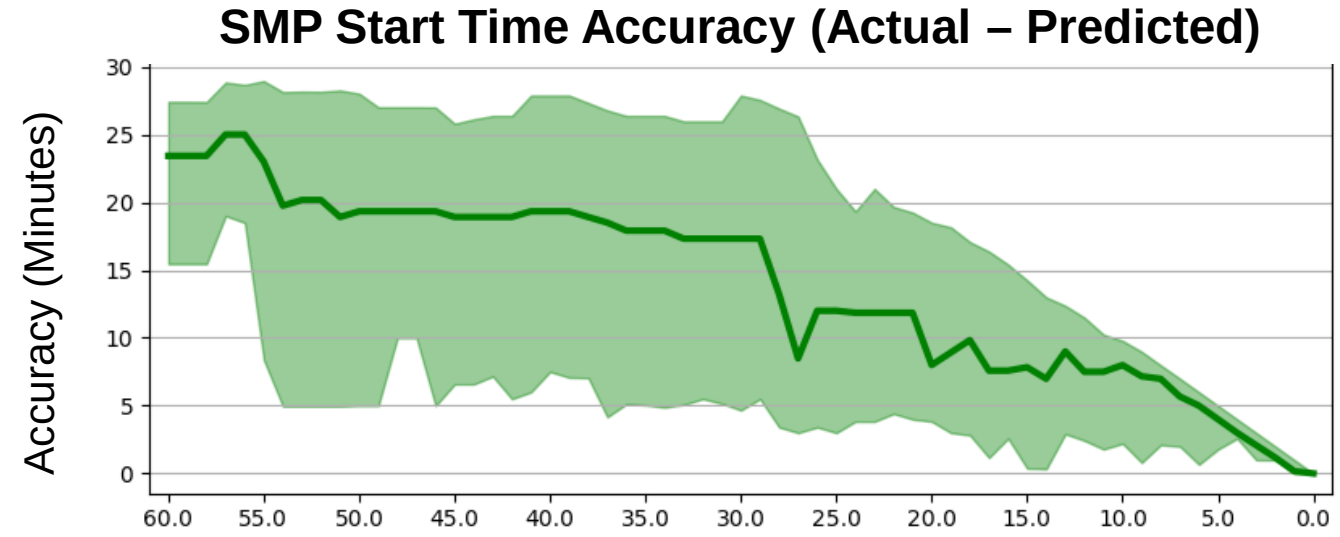
Runway 36R Runway Prediction Accuracy





Runway 36C Runway Prediction Accuracy





Tactical-Strategic Fusion (Strategic Planning): Strategic Metering Lessons Learned

- Accurate predictions of future gate holds are needed to accurately predict when metering should be started and stopped

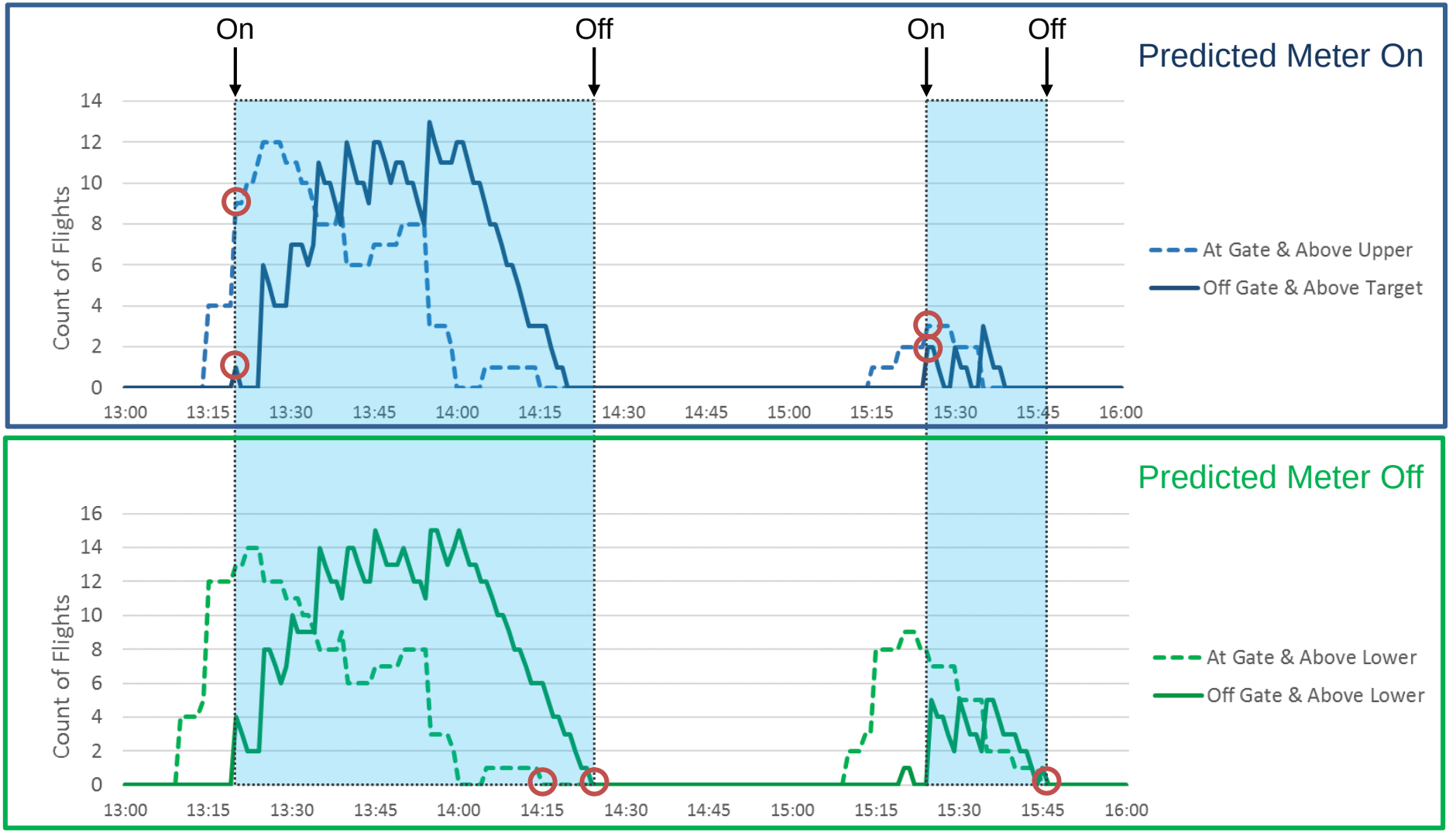
- Auto-Affirm SMPs
  - New capability added in the Surface Metering Display to reduce TMU and ramp manager workloads
  - When not auto-affirming SMPs, the notification for a recommended SMP needs to be salient.
    - A proposed SMP is now indicated with an orange gear icon in the toolbar

Tactical-Strategic Fusion (Strategic Planning): Predicting Tactical Triggers Per Flight

- The strategic SMP algorithm predict when different tactical metering conditions will be met per flight
- Tactical metering triggers
  - Metering On
    - At least one departure flight that has already pushed back from the gate is predicted to have an excess taxi time greater than Target
    - At least one departure flight on the gate predicted to pushback in the next 10 minutes is predicted to have an excess taxi time greater than the Upper Threshold
  - Metering Off
    - No departures taxiing on the airport surface or on the gate within 10 minutes of pushback are predicted to have an excess taxi time greater than the Lower Threshold

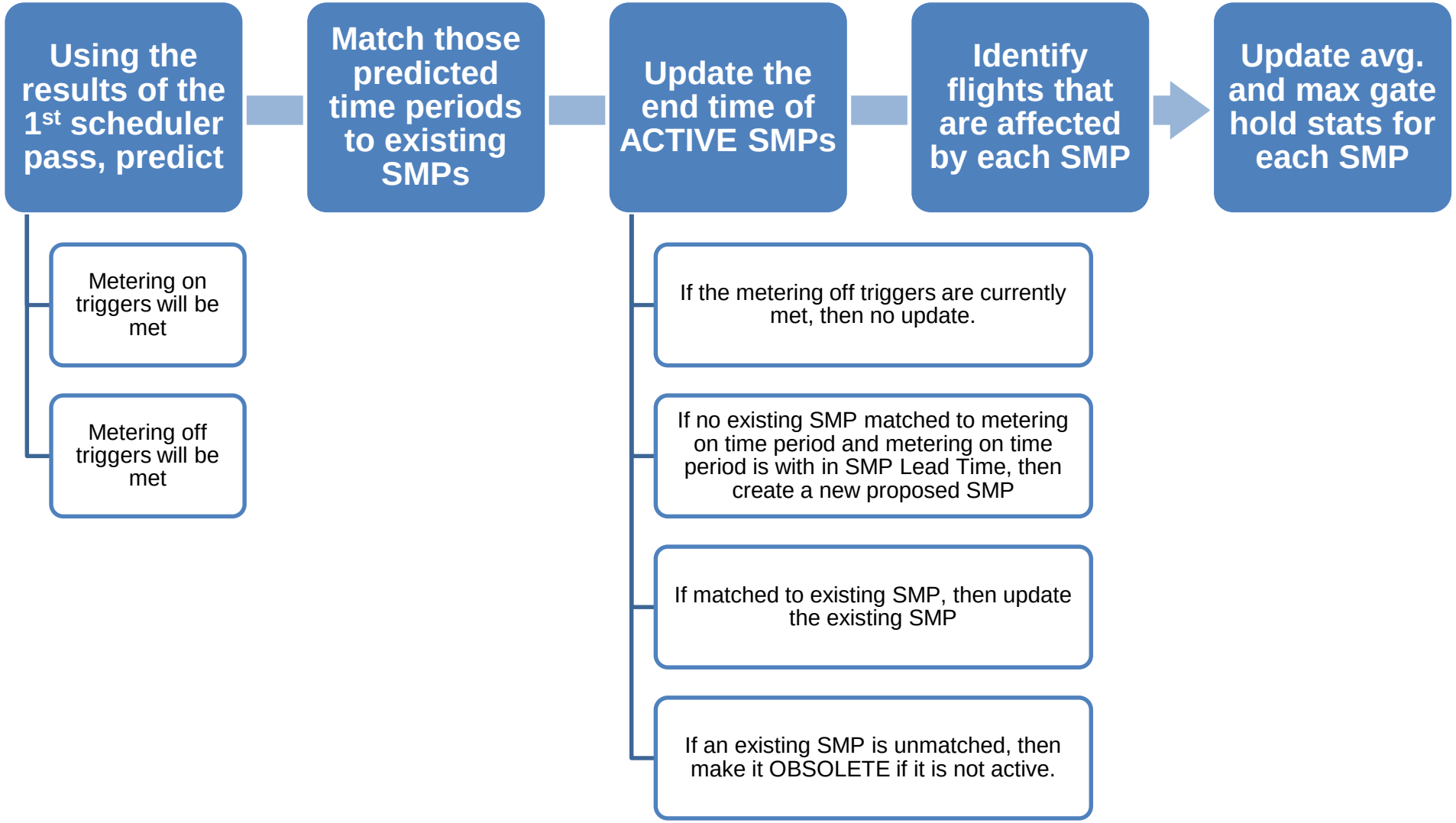
Tactical-Strategic Fusion (Strategic Planning): Predicting Tactical Metering Periods

- The strategic algorithms use the per flight predictions of excess taxi time to predict when metering would be on or off



Tactical-Strategic Fusion (Strategic Planning): SMP Detection and Update Logic

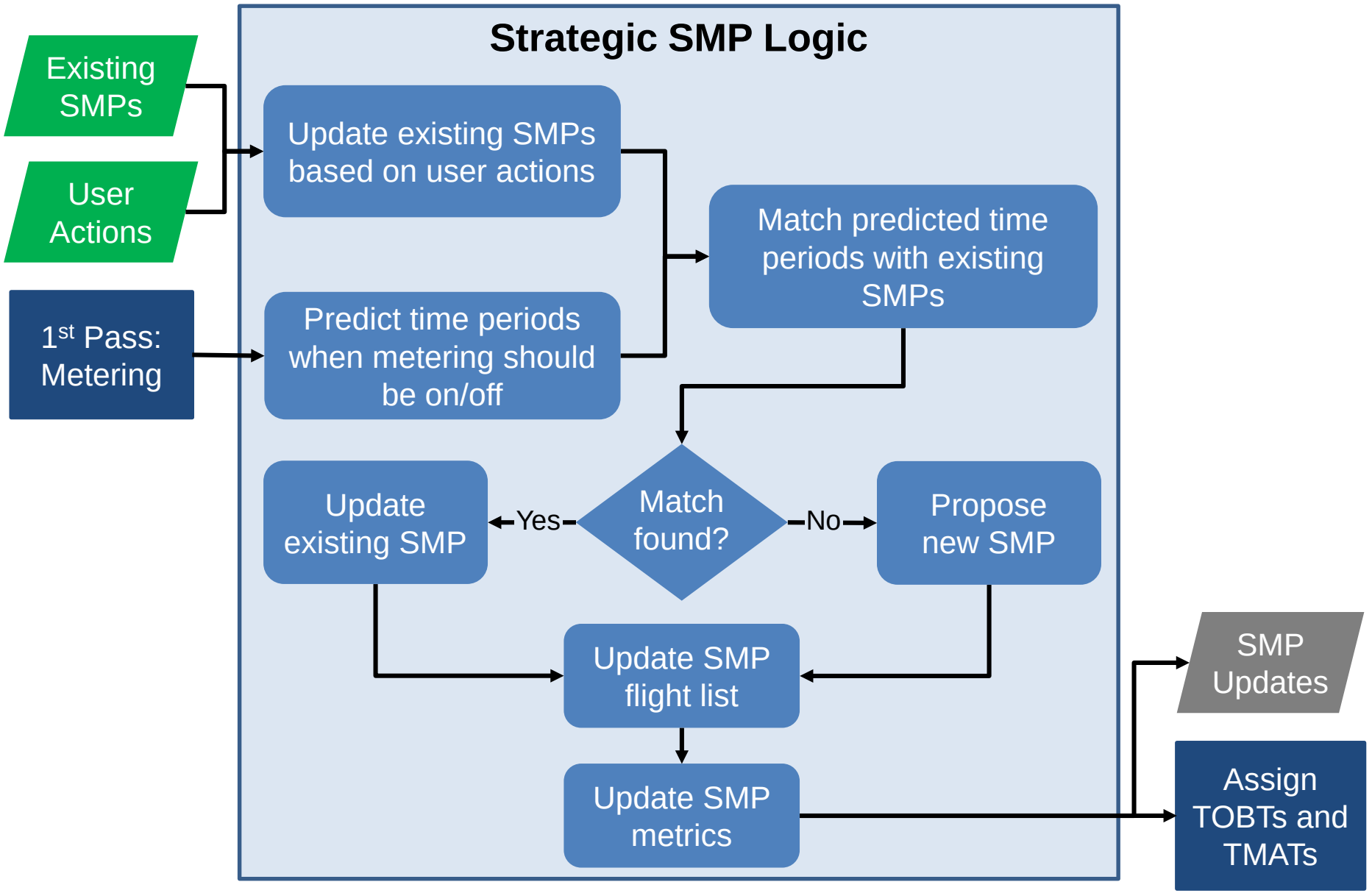
- **The basic flow of the SMP detection and update logic is:**



Tactical-Strategic Fusion (Strategic Planning): Processing of User Actions

- The strategic SMP algorithms logic first processes user actions received since that last scheduler cycle
- SMPs are initially in a PROPOSED status unless auto-affirm is turned on, in which case they start out in the AFFIRMED status
- If a user has affirmed a PROPOSED or REJECTED SMP, the SMP status is set to AFFIRMED
- If a user has rejected a PROPOSED or AFFIRMED SMP, the SMP status is set to REJECTED
- If a user has rejected an ACTIVE SMP, ending it early,
  - The SMP status is set to COMPLETED as the SMP is now finished
  - The end time of the SMP is set equal to current time

Tactical-Strategic Fusion (Strategic Planning): Strategic SMP Logic Overview



Tactical-Strategic Fusion (Strategic Planning): Match Predictions with Existing SMPs

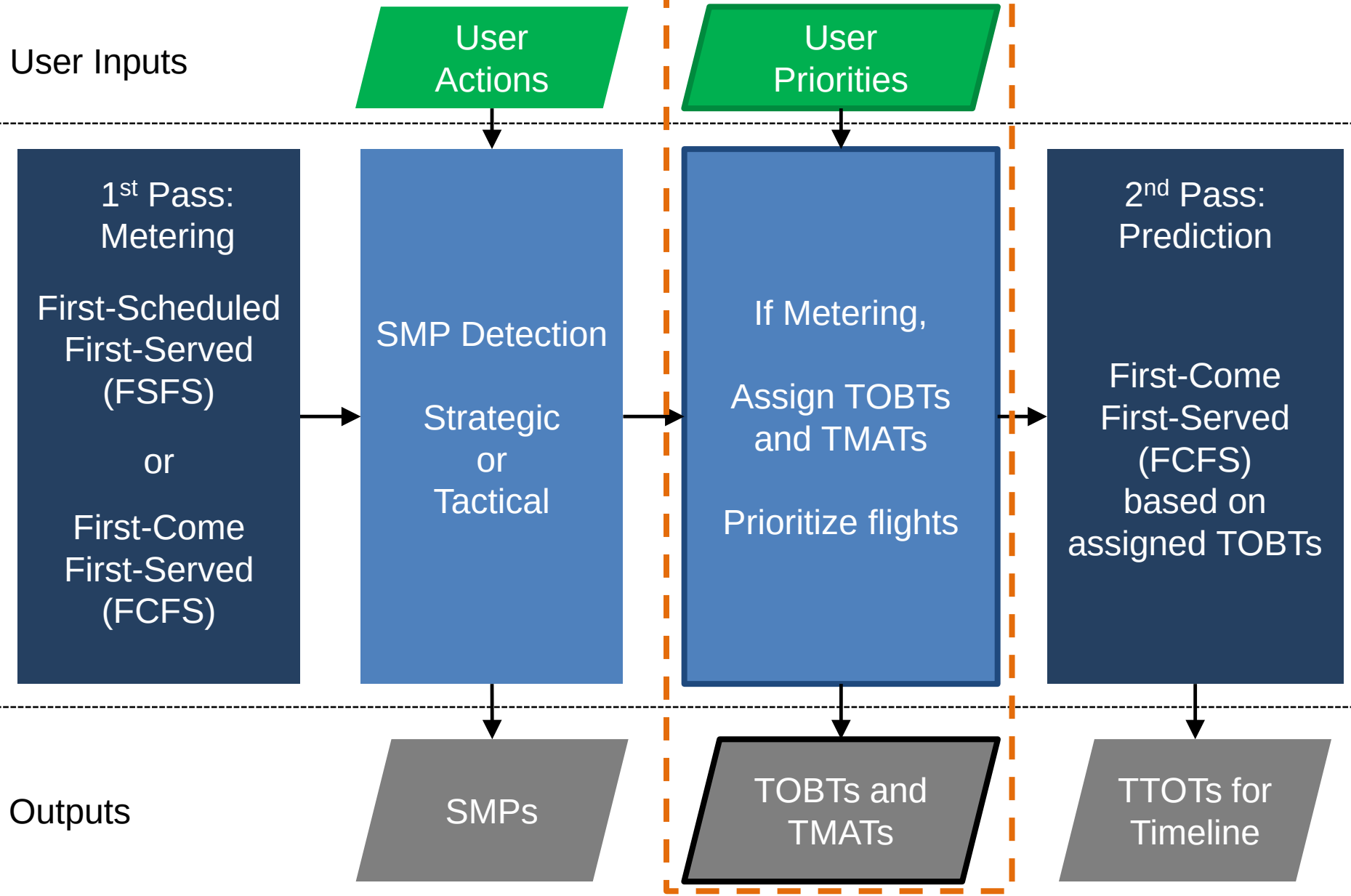
- The predicted metering on and off time periods are matched to existing SMPs that were created in earlier scheduler cycles
- Matches are made based on overlapping times
- If a match is found,
  - The existing SMPs start and end time are updated
  - If the existing SMP was OBSOLETE, its state is set to the status prior to OBSOLETE
  - If the existing SMP is AFFIRMED and its start time is equal to current time, its start is set equal to ACTIVE
- If no match is found for a predicted metering on time period,
  - A new SMP will be created if the start time is within the Lead Time
    - The status is set to PROPOSED if auto-affirmation is disabled
    - The status is set to AFFIRMED if auto-affirmed is enabled
- If no match is found for an existing SMP,
  - The existing SMP is made OBSOLETE if it is not already active
  - The existing SMP is made COMPLETED if it is active

Tactical-Strategic Fusion (Strategic Planning): Updating Flights and Metrics

- For all SMPs that are not COMPLETED or OBSOLETE, the scheduler
  - Identifies flights that are predicted to pushback during the SMP
  - Computes the average and max gate holds for these flights

- These metrics are displayed to the users to help with decision making

Tactical-Strategic Fusion (Strategic Planning): Overview of ATD-2 Scheduler Flow



Tactical-Strategic Fusion (Strategic Planning): TMAT Assignment

- If a departure is part of an ACTIVE SMP (whether tactical or strategic mode) or an AFFIRMED SMP (strategic mode only), the departure is assigned a TOBT and TMAT
- The TOBT and TMAT are assigned using the delay propagation calculations unless the TOBT and TMAT are frozen, in which case frozen times are used
- The TOBT and TMAT are published over TTP to users
- The gate hold advisories based on TOBT are only displayed to ramp controllers once the SMP becomes ACTIVE

Tactical-Strategic Fusion (Strategic Planning): Flight Prioritization

- The ramp manager can mark a flight as priority through the RMTC tool
- During metering, the scheduler will preform substitutions among flights with the same major carrier that are part of the same SMP to reduce gate hold on the priority flights
- These priority changes will reflect in gate hold advisories shown to ramp controllers and the TOBTs and TMATs published out over TTP

TMI Evolution

Operational Scenarios

TMI Evolution: Overview

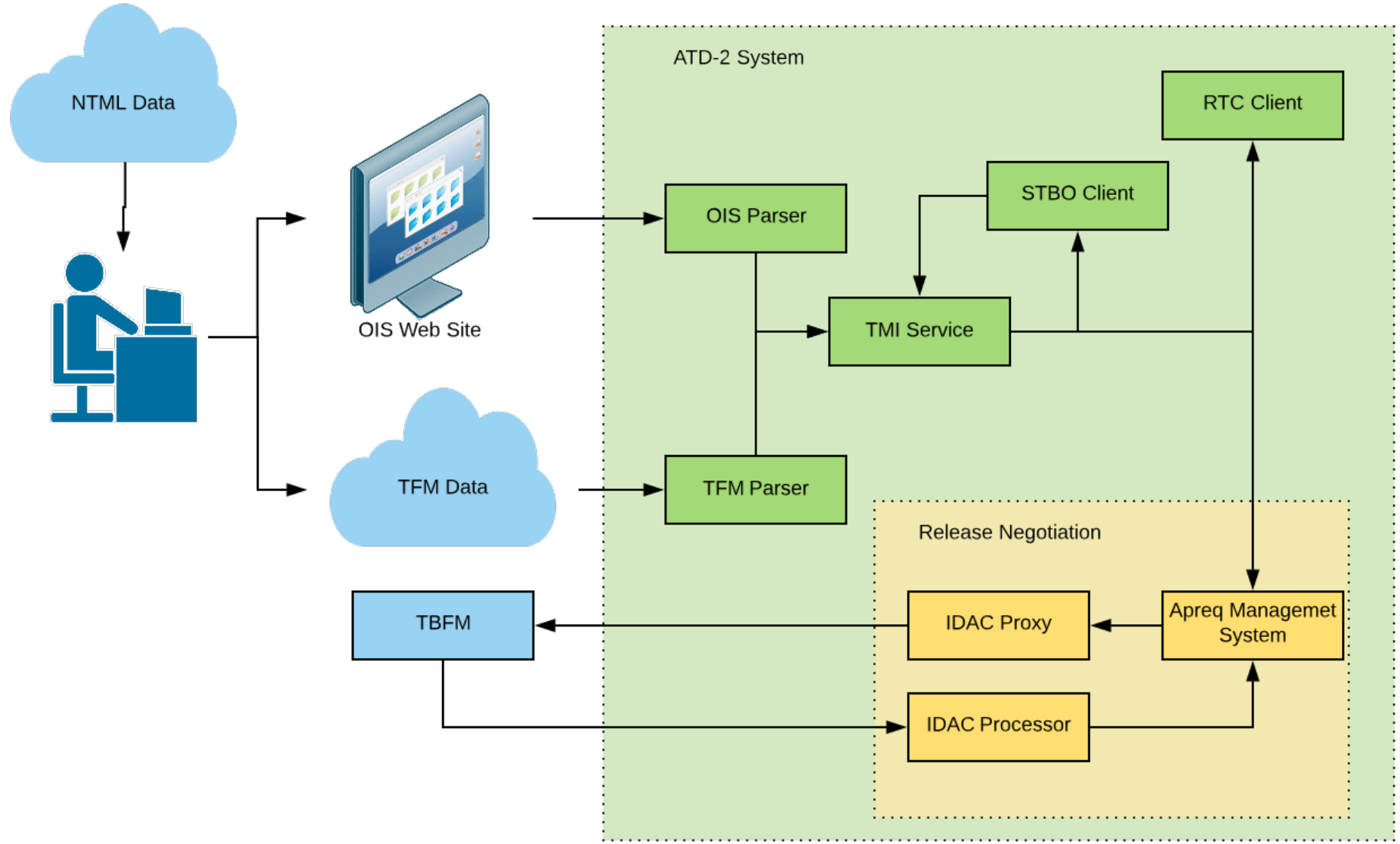
- Reduce verbal communication in the NAS by:
  - Automatically detecting Traffic Management Initiatives (TMIs)
  - Providing tools to manage TMIs within the ATD-2 system
  - Interfacing with existing FAA system to improve the speed and accuracy of controlling TMI affected flights
    - TFM – Flow
    - OIS
- Create a TMI Service to:
  - Manage the detection of TMIs from TFM – Flow and OIS
  - Allow ATD-2 users to generate new TMIs
  - Assign TMIs to flights managed by ATD-2

TMI Evolution:
Traffic Management Initiative (TMI) Service

- Used to process, store, and distribute TMIs throughout the IADS system
- Keeps TMIs in sync throughout the system without each individual component having to track additions, updates, and removals
- Possible TMIs:

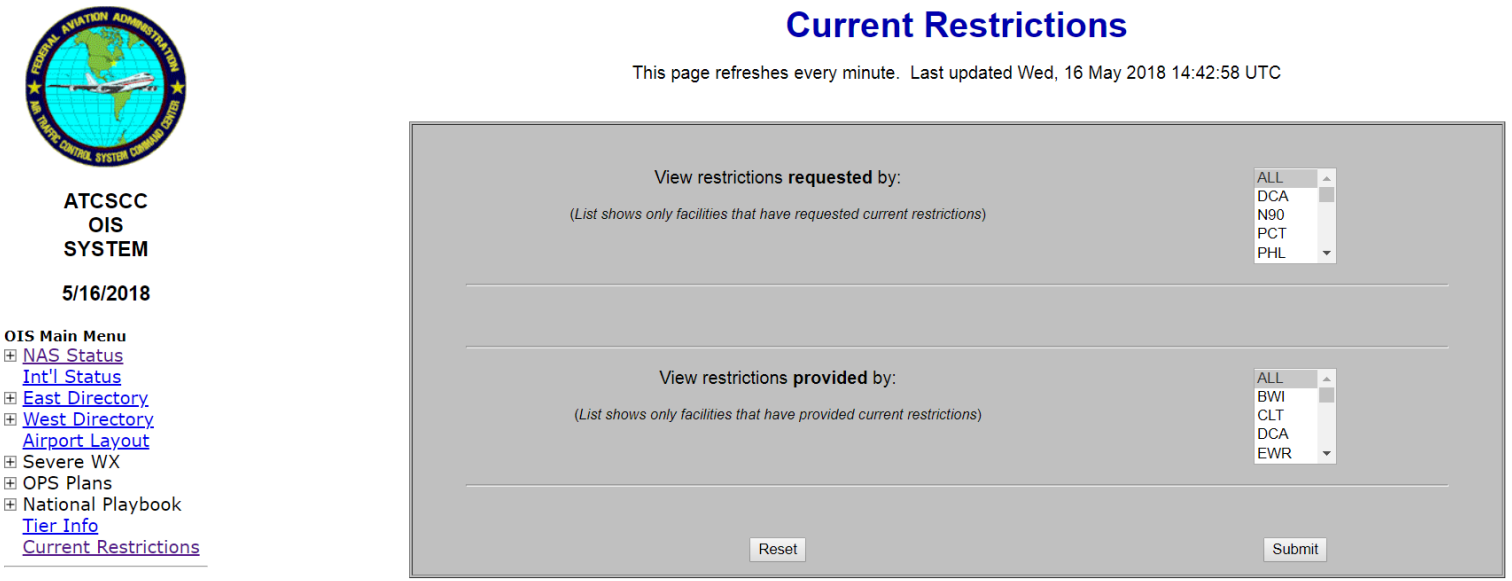
TMI Type	Sources
APREQs	OIS, User
MITs	OIS, User
Ground Stops	TFM, User
Fix Closures	OIS, User
Runway Closures	User
Jet Route Closures	User
Taxiway Closures	User
Ramp Closures	User
Gate Closures	User
Scheduled Metering Modes	User
Surface Metering Programs	Scheduler
Ground Delay Programs	TFM
Airport Configurations	User, Model
Runway Rate Restrictions	User

TMI Evolution: 10,000 Ft View



TMI Evolution: Operational Information System (OIS)

- Web page managed by ATCSCC that provides information about current restrictions in the NAS including:
  - APREQs
  - MITS
  - Fix Closures
- Accessible at http://www.fly.faa.gov/ois > Current Restrictions
- Filter by requesting and providing facilities



TMI Evolution:
OIS – Data Storage and Analysis

- Parsed and interpreted data is stored in XML files for reference
- Contains original text from OIS page as well as interpreted data for comparison

Scraped OIS Data

Interpreted Data

```
<ois-envelope timestamp="2018-05-16T15:00:06.871Z">
 <current-restrictions>
  <restriction requesting="ZDC" providing="CLT/ZTL" start-time="2018-05-16T11:30:00.000Z" stop-time="2018-05-17T01:30:00.000Z">
   <text>APREQ CLT,ZTL to DCA via BARMY,KILNS JETS 1130-0130 ZDC:CLT,ZTL</text>
  </restriction>
 </current-restrictions>
 <apreq-restrictions>
  <apreq-restriction start-time="2018-05-16T11:30:00.000Z" stop-time="2018-05-17T01:30:00.000Z">
   <requesting name="ZDC" type="CENTER"/>
   <providing name="CLT" type="AIRPORT"/>
   <providing name="ZTL" type="CENTER"/>
   <origins>
    <origin name="CLT" type="AIRPORT"/>
   </origins>
   <equipment-type>J</equipment-type>
   <text>APREQ CLT,ZTL to DCA via BARMY,KILNS JETS 1130-0130 ZDC:CLT,ZTL</text>
   <constraints>
    <constraint constraintAction="INCLUDE" constraintType="NAS_ELEMENT">
     <constraintValues>
      <constraintValue>FIX:BARMY</constraintValue>
      <constraintValue>FIX:KILNS</constraintValue>
     </constraintValues>
    </constraint>
   </constraints>
   <remove>false</remove>
   <resource-type>DESTINATION</resource-type>
   <destinations>
    <destination name="DCA" type="AIRPORT"/>
   </destinations>
  </apreq-restriction>
 </apreq-restrictions>
 <mit-restrictions/>
 <closures/>
</ois-envelope>
```

TMI Evolution: OIS - Filtering and Scraping

- Filtering includes CLT, DAL, or DFW as providing facilities and all requesting facilities
- Scrape HTML data for all 5 columns of the OIS table to use during parsing/interpretation

Current Restrictions

This page refreshes every minute. Last updated Wed, 16 May 2018 14:46:39 UTC

REQUESTING	PROVIDING	RESTRICTION	START TIME	STOP TIME
ZDC	CLT/ZTL	APREQ CLT,ZTL to DCA via BARMY,KILNS JETS 1130-0130 ZDC:CLT,ZTL	05/16/2018 1130	05/17/2018 0130
ZDC	CLT/ZTL	APREQ CLT,ZTL to EWR via BARMY,KILNS JETS 1015-0130 ZDC:CLT,ZTL	05/16/2018 1015	05/17/2018 0130
ZDC	CLT/ZTL	APREQ CLT,ZTL to IAD via BARMY,KILNS JETS 1330-2100 ZDC:CLT,ZTL	05/16/2018 1330	05/16/2018 2100
ZDC	CLT/ZTL	APREQ CLT,ZTL to LGA via BARMY,KILNS JETS 1015-0130 ZDC:CLT,ZTL	05/16/2018 1015	05/17/2018 0130
ZJX	CLT/ZTL	CLT SOUTHBOUND 10MIT SINGLE STREAM 1300-1600 ZJX:ZTL,CLT	05/16/2018 1300	05/16/2018 1600

TMI Evolution: OIS - Challenges

- Restriction column in OIS table is free text entry
  - Typos in keywords
  - Keywords out of expected order (i.e., start/end time values before APREQ/MIT keyword when they are expected after)
- Not all restrictions are available from OIS
- Not all airports/centers publish data to OIS
- OIS page does not display future restrictions
  - Only shows those already started
- Lag time between when a restriction goes into effect and when it shows on the OIS page
- Occasional OIS page down time results in missing restrictions

TMI Evolution: Traffic Flow Management (TFM)

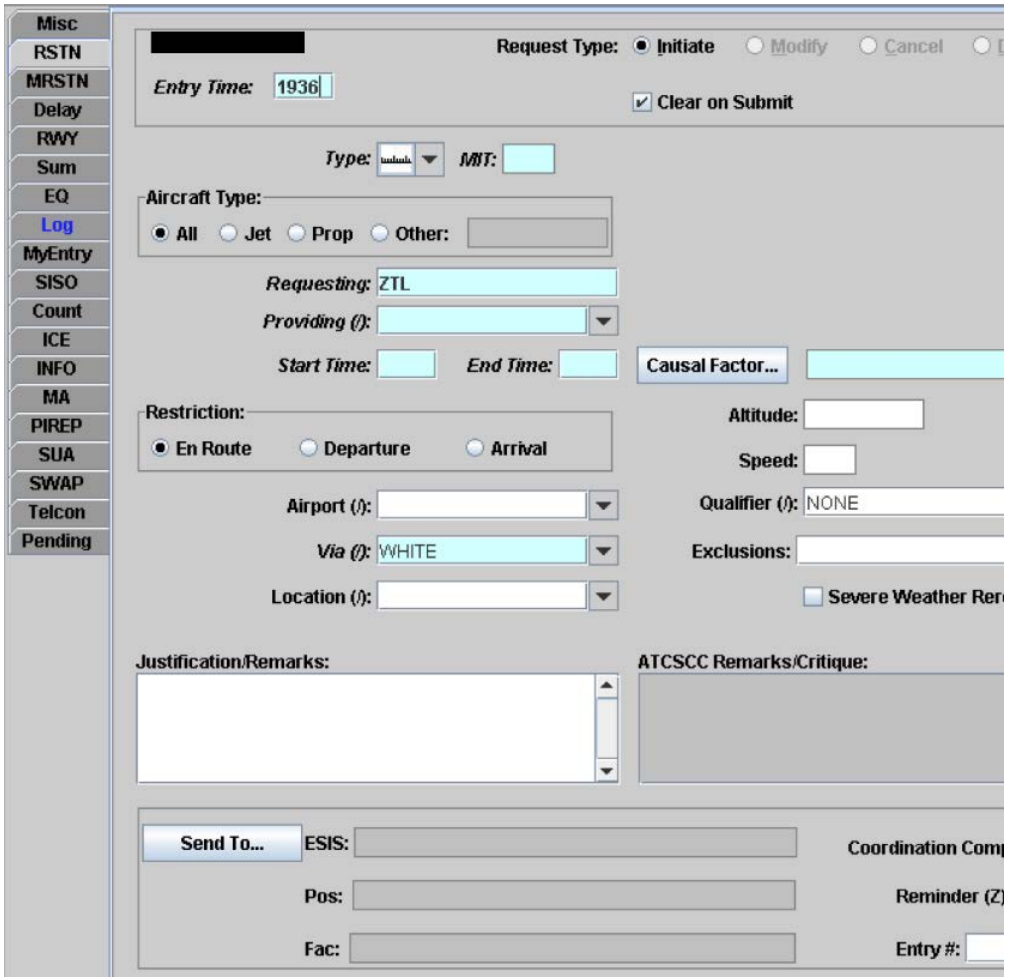
- TFM Flow data provides added value to the OIS TMI data
- Source for the following TMIs:
  - Restrictions (Type=RSTR)
    - MIT/MINIT
    - Fix Closure (STOP)
  - General Advisories (Type=GADV)
    - Reroutes
    - GDP/GS

Facility	Total RSTR Msg #	MIT Msg #	MINIT Msg #	STOP Msg #
N90	5590	3002	1637	14
PCT	4504	4389	0	114
PHL	1758	1288	0	31
EWR	1496	16	949	19
LGA	1493	13	948	16
HPN	1040	13	548	15
TEB	979	12	531	19
JFK	959	462	3	13
SCT	932	901	16	14
D21	801	785	0	16
DCA	691	622	0	68
NCT	558	524	0	0
IAD	412	343	0	68
I90	391	382	9	0
BWI	375	321	0	53
ATL	267	252	4	11
F11	214	214	0	0
LAS	202	196	0	6
CLT	154	111	1	41
MSP	107	107	0	0
IND	104	104	0	0

Restriction messages by facility, Sep-Nov 2017
Some messages had multiple types in the same message (e.g. MIT and SPD),
A facility was counted if it was requesting or providing, excluded DCC and ARTCCs.

TMI Evolution: TFM Flow - Data Origin

- The process of TMIs getting to TFM Flow messages is currently being investigated (by observation at ZFW/D10)
- In general, the process appears to be:
  - TRACON/ARTCC TMC determines need for TMI
  - Requesting facility TMC enters restriction in NTML using the Restriction Panel[1]
  - Automation broadcasts the restriction via TFM Flow



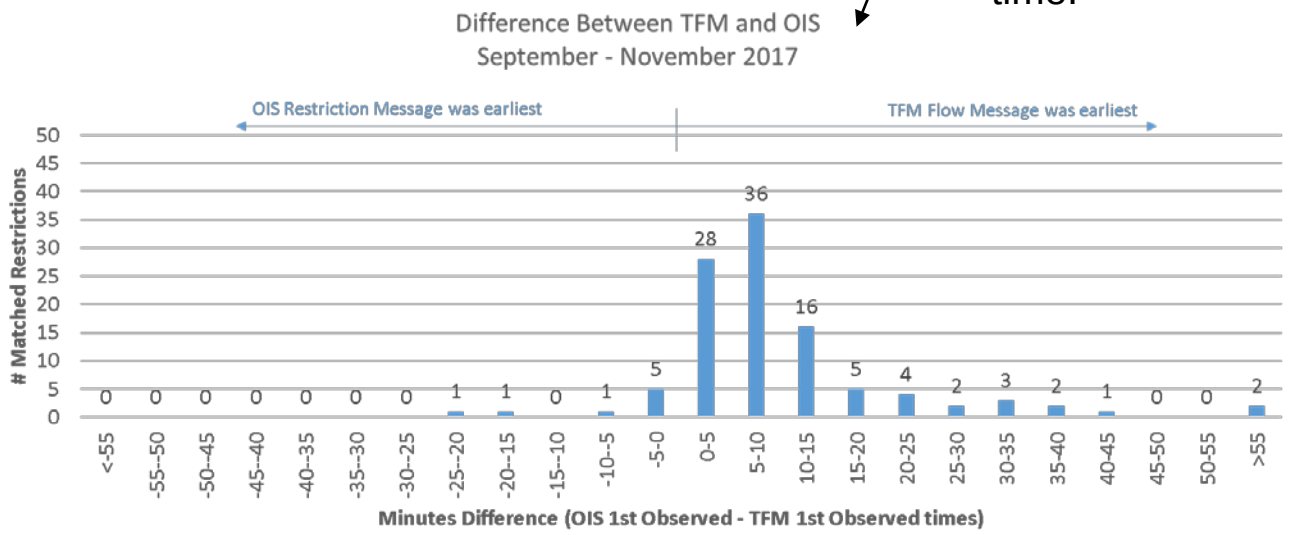
1. Picture is from the NTML Reference Guide R11, v3.9, available at https://faaco.faa.gov/index.cfm/announcement/view/23765

TMI Evolution: TFM Flow – Value to ATD-2

TMI	OIS	TFM Flow	NTML
Airport Information	NO	YES	YES
Airspace Flow Programs	NO	YES	YES
Ground Delay Programs	NO	YES	YES
Ground Stops	NO	YES	YES
Miles/Minutes in Trail	YES	YES	YES
Altitude Restrictions	YES	YES	YES
APREQs	YES	NO	YES
Advisories	NO	YES	YES
Closures (Fixes, etc.)	YES	YES	YES
FADT	NO	YES	NO
RAPT	NO	YES	NO
CTOP	NO	YES	NO
DICE	NO	YES	NO
REROUTEs	NO	YES	NO
TMI FLIGHT LIST	NO	YES	NO

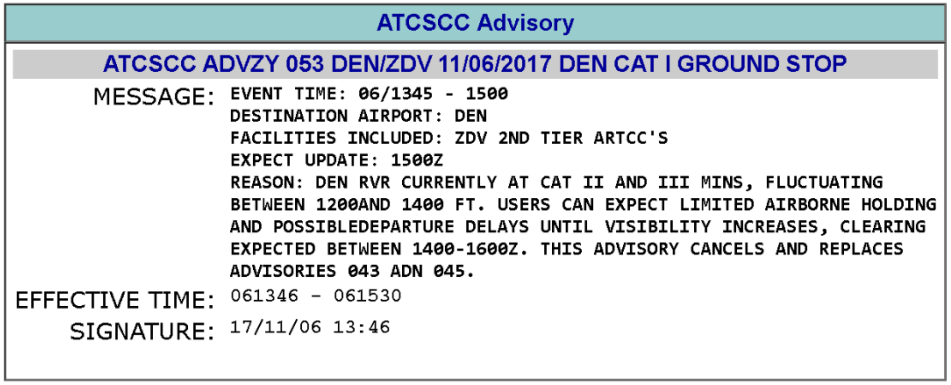
- A source comparison was conducted, looking at several days' data from the OIS restrictions page, TFM Flow, and NTML entries
- A combination of OIS restrictions page and TFM Flow data was the recommended source

- Later, comparison between TFM Flow and the OIS restrictions page revealed restrictions in TFM Flow messages typically arrived several minutes before the appearing OIS restrictions page; also, restrictions only appeared on the OIS page at or after the restriction start time.



TMI Evolution: TFM Flow - Challenges

- APREQs are not currently observed in TFM Flow
- Manual entry of the restrictions can result in typos that cause difficulties in parsing or dropped data
- If TMIs are not entered into NTML, they may not end up in TFM Flow. FDIO, phone, or internal systems may be used to distribute TMI information
- If ATC makes a free text log entry rather than using NTML's restriction panel, the automated publishing of the restriction data may not happen
- Ground Stop advisories are usually generated automatically when a Ground Stop is entered into FSM.[2] However, some stops are initiated verbally with a free-text advisory manually created. These stops will not follow the same format as the automated Ground Stop advisories.



ATCSCC Advisory

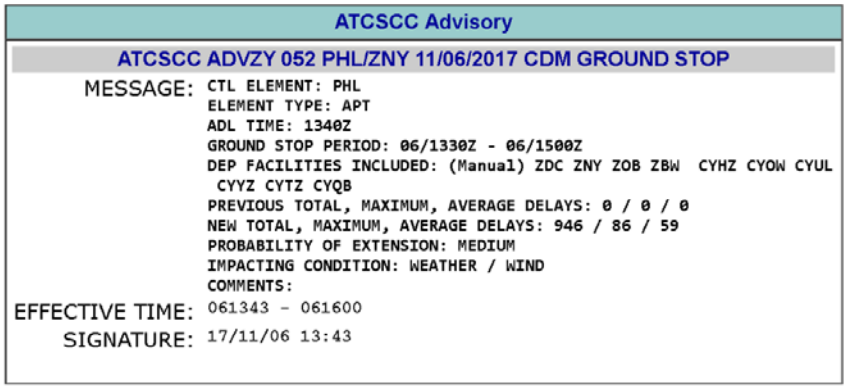
ATCSCC ADVZY 053 DEN/ZDV 11/06/2017 DEN CAT I GROUND STOP

MESSAGE: EVENT TIME: 06/1345 - 1500
DESTINATION AIRPORT: DEN
FACILITIES INCLUDED: ZDV 2ND TIER ARTCC'S
EXPECT UPDATE: 1500Z
REASON: DEN RVR CURRENTLY AT CAT II AND III MINS, FLUCTUATING BETWEEN 1200AND 1400 FT. USERS CAN EXPECT LIMITED AIRBORNE HOLDING AND POSSIBLEDEPARTURE DELAYS UNTIL VISIBILITY INCREASES, CLEARING EXPECTED BETWEEN 1400-1600Z. THIS ADVISORY CANCELS AND REPLACES ADVISORIES 043 ADN 045.

EFFECTIVE TIME: 061346 - 061530

SIGNATURE: 17/11/06 13:46

Example of Manual Ground Stop Advisory



ATCSCC Advisory

ATCSCC ADVZY 052 PHL/ZNY 11/06/2017 CDM GROUND STOP

MESSAGE: CTL ELEMENT: PHL
ELEMENT TYPE: APT
ADL TIME: 1340Z
GROUND STOP PERIOD: 06/1330Z - 06/1500Z
DEP FACILITIES INCLUDED: (Manual) ZDC ZNY ZOB ZBW CYHZ CYOW CYUL CYYZ CYTZ CYQB
PREVIOUS TOTAL, MAXIMUM, AVERAGE DELAYS: 0 / 0 / 0
NEW TOTAL, MAXIMUM, AVERAGE DELAYS: 946 / 86 / 59
PROBABILITY OF EXTENSION: MEDIUM
IMPACTING CONDITION: WEATHER / WIND
COMMENTS:

EFFECTIVE TIME: 061343 - 061600

SIGNATURE: 17/11/06 13:43

Example of Automated Ground Stop Advisory

2. Ground stop advisories can be found in context here:
https://www.fly.faa.gov/adv/adv_list.jsp?WhichAdvisories=ATCSCC&AdvisoryCategory=NotAll&dates=A%2C+11-06-2017&Gstop=Gstop

TMI Evolution: TMI Service - Messaging

- Proposed Actions
  - OIS, TFM, and User entered data are sent to TMI Service with PROPOSED Actions:
    - PROPOSED_ADD
    - PROPOSED_UPDATE
    - PROPOSED_REMOVE
  - TMI Service processes the data according to the PROPOSED action
  - If accepted, TMI is distributed to other components with finalized action
- Finalized Actions
  - TMIs with these actions are only distributed by the TMI Service:
    - ADD
    - UPDATE
    - REMOVE
  - Other components in the IADS system receive the TMIs for these finalized actions to react accordingly (update displays, trigger scheduling, etc.)

TMI Evolution: TMI Service – TMI Constraints

- TMIs may support a mixed set of inclusion/ exclusion constraints
- Constraints are used as a subset of criteria for binding a flight to a TMI
- Constraints are configurable per TMI
- Available constraints:

1. Aircraft Type
2. Airline
3. Airway
4. APREQ
5. Center
6. Destination
7. Engine Type
8. Filed Altitude
9. MIT
10. Sector
11. User Category
12. Weight Class
13. Fix
14. Departure Gate
15. Diverted Flights
16. Call Sign
17. Flight Key

TMI Evolution: TMI Service – Adding

- Additions from OIS
  - OIS page is scraped for current restrictions every 10 seconds
  - If resource and start time of a current OIS restriction matches a current restriction or recently removed restriction in the TMI Service, it is not re-added
  - Start times are matched within 15 minutes of each other to prevent duplicates between user and OIS added TMIs
- Additions from TFM
  - If resource and start time of a current TFM ground stop matches a current or recently removed ground stop in the TMI Service, it is not re-added
- User-Added Restrictions
  - Checked for matching resource and start time within 15 minutes of current TMIs.
  - If match is found, then the addition is handled as an update instead
  - If match is found against recently removed restriction, it is allowed to be re-added by the user
- Every new TMI is assigned a unique identifier

TMI Evolution: TMI Service – Updating

- Updates from OIS
  - The OIS website is screen scraped and the data is compared to currently known restrictions to check for any updates
  - Updates will be applied only for inclusion/exclusion constraints, MIT values, and end times
- Updates from TFM
  - If resource and start time of a current TFM ground stop matches a current ground stop in the TMI Service, then inclusions/exclusion constraints and end time may be updated
- Updates from User Action
  - Users can update restrictions from both the OIS and those that were originally user-added
  - Current restrictions
    - Can only update the end time, MIT value, CDR fix, and the inclusions/exclusion constraints
  - Future restrictions
    - Can update start time, end time, MIT value, CDR fix, and inclusions/exclusion constraints

TMI Evolution: TMI Service - Removing

- Removals from OIS
  - When OIS data is parsed, it is compared to the previous batch of parsed restrictions
  - The TMI Service will remove a previous restriction if it is no longer included in the parsed data
- Removals from TFM
  - If a cancellation message is received for a ground stop, the TMI Service will remove the ground stop
- User Removals
  - Users may remove any current or future restriction from the client at any time.
  - Once removed, it will not be re-added through OIS or TFM
  - The user may manually re-add the restriction, if needed
- Automatic Removals
  - Once the end time of a TMI has passed, it will be removed from the in-memory map and from Redis
  - An automatic reset runs daily at 08:00 GMT to clear out any old TMIs that may be stuck in the system

TMI Evolution: Persistent TMIs

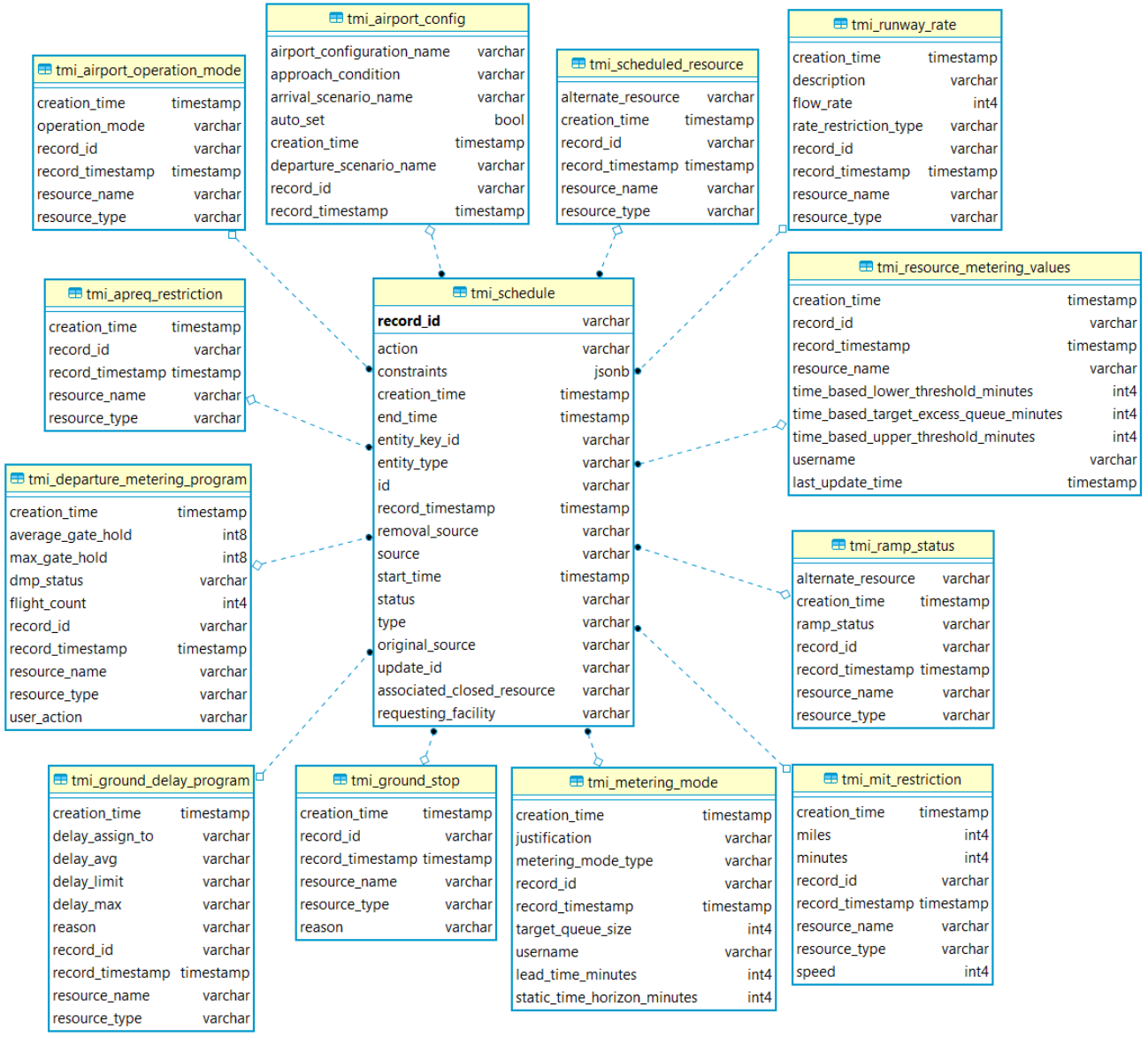
- Persistent TMIs are stored in a JSON configuration file which is reloaded during each TMI reset (0800 daily)
- The start/end times can be specified, but are adjusted as a part of the loading to be applicable for the current date
- If there is no start time for a persistent TMI, the current time is used as the start time. If there is no end time set for a persistent TMI, there is no end time applied for the TMI
- TMI types that can be loaded as persistent TMIs:
  - APREQs
  - Ground Stops
  - Ground Delay Programs
  - MITs
  - Fix Closures
  - Gate Closures
  - Jet Route Closures
  - Runway Closures
  - Taxiway Closures
  - Airport Operation Modes
  - Runway Rates
  - Metering Mode

TMI Evolution:
TMI Service - Flight Association

- Triggers
  - TMIs are added, updated, or removed
  - Flights are added, updated, or removed from the system
- Flight Criteria
  - A flight's Undelayed Takeoff Time (UTOT) or best available runway time is between the start/end time of the TMI
    - Chose to use UTOT since it is not changed by scheduling logic
    - This prevents possibility of flight times repeatedly changing over the threshold for inclusion and thrashing between inclusion and exclusion from the TMI
  - Matches TMI resource
    - Uses destination resource specified in APREQ, Ground Stop, or MIT
    - Uses departure fix specified in Fix Closures or MIT
    - Uses runway/taxiway/jet route or any other resource specified by the TMI
  - TMI Constraints
    - If TMI constraints are defined, a flight will be included or excluded if matching the defined set of constraints

TMI Evolution: TMI Service – Data Analysis

- All TMIs are persisted to a relational database for post analysis
- Data is stored for up to 6 days before being removed
- The full history of a TMI is captured in the tables
- Summary tables are provided to query the latest TMI data



TMI Evolution:
TBFM Pre-Scheduling with EOBT out of CLT

- Flights out of CLT that are scheduled with TBFM are subject to Approval Request (APREQ, also known as Call For Release)
  - About 1 in 10 flights that depart CLT are subject to APREQ
  - Other facilities, like SFO, have similar percentages

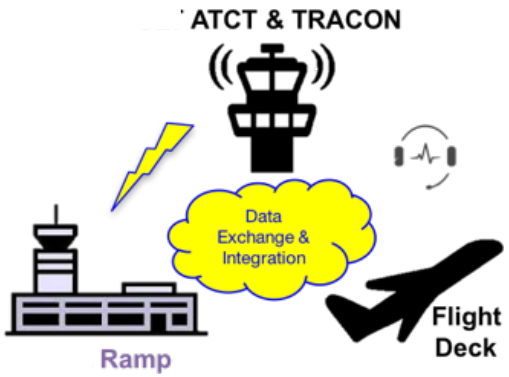
- TFDM has a plan to use the Earliest Off-Block Times (EOBT) provided by Operators plus new scheduling automation to secure a slot in TBFM at a set time prior to departure
  - ATD-2 has implemented this logic (plus a few additional features) and has been running this for all flights from CLT to ATL since Oct 2018 and to ORD since late June 2019

- Pre-scheduling with EOBT has gone well at CLT, and led to improved predictability (reduced variation)
  - At the same time, departure compliance to APREQ has risen. This helps the downstream facilities into which flights are scheduled achieve a more stable schedule.

TMI Evolution: Pre-Scheduling with EOBTs

1. At an adaptable time prior to departure (e.g. 20 min), the ATD-2 system uses the EOBT, taxi time estimate and a buffer to electronically submit a release time request to TBFM

- ***Important Note***: Providing an EOBT gives you an advantage!

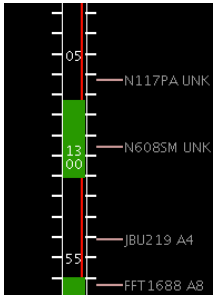


2. Center TMC approves or adjusts the time based on center constraints

3. ATCT and Ramp utilize the now visible APREQ time on their strips and pushback advisories

The data is made available on the TTP SWIM feed so that Operators can get it to their pilots

4. IDAC-style scheduling between TBFM and ATD-2 is used to re-schedule as necessary



TMI Evolution:
Current Pre-Scheduling Logic in ATD-2 Leverages TBFM, SWIM and ATD-2

1) ATD-2 utilizes the Earliest Off-Block Time (EOBT) data from Operators, an adapted buffer, and the predicted surface taxi time to generate an Earliest Feasible Takeoff Time (EFTT)

2) ATD-2 automatically sends an APREQ release request to the appropriate Center TMC at an adapted time period prior to departure (currently 20 minutes prior to the best estimate of pushback)

3) TFBM allows Center TMCs to respond to the release request just like it came from a native FAA IDAC system (i.e., no new training required)

4) SWIM provides the release time to the ATD-2 system, which in turn provides it to the ATC controller's flight strips, ramp controllers display, and SWIM TTP

5) Using ATD-2, CLT ATCT and ramp monitors progress toward the release time using agreed upon local procedures

6) <If necessary> ATD-2, TBFM and SWIM are used for re-planning the APREQ

7) ATD-2 captures data at each step for detailed measurement and analysis

TMI Evolution:
Important Note on Buffer Time Calculation

- An important topic with pre-scheduling is the process used by the ATD-2 system to determine the Earliest Feasible Takeoff Time (EFTT) buffer size

- ATD-2 has two buffers that are relevant, EFTT and Controlled Time of Departure (CTD)

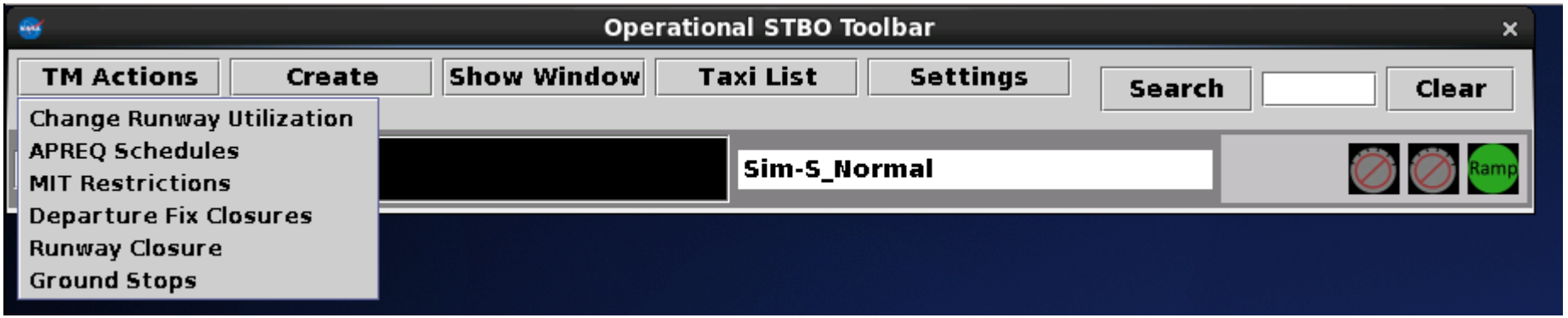
- EFTT Buffer
  - A statically adapted value that is added to the system's estimate of takeoff
  - The EFTT does not include surface metering delay, but does account for some congestion that may prevent the flight from reaching the runway. The idea is not to 'double delay' the flight, but also to provide a realistic OFF time into TBFM
  - ATD-2 uses a **1 minute buffer for flights with EOBTs**, and a **4 minute buffer for flights that have no EOBT**
  - These buffers are necessary to ensure high compliance with earlier scheduling

- CTD Buffer
  - Used to help ensure flights to push back early/on-time to meet the APREQ
  - This value is the same for all Operators and independent of EOBT submission or not
  - Example: the system calculates a pushback time of 12:10, but with a CTD buffer of 6 minutes, 12:04 is given as guidance to ramp personnel (and verbally to pilot)

TMI Evolution:
Benefits of Pre-Scheduling Solution

- Lower and/or more predicable TBFM assigned delay
  - Allows continuation of pre-scheduling process while making progress toward the end state FAA and Industry plan
- Preparation for TFDM
  - Allows Operators time to calibrate EOBTs and operations ahead of TFDM deployment. Note: the resulting APREQ times are available to Operators on the TFDM Terminal Publication (TTP) SWIM feed
- Simplified Center operations
  - Reduces the need to manually enter times from surface into TBFM
  - Allows ZTL to delegate pre-scheduling monitoring functions to the site
- Greater Operator support in meeting release times
  - Allows ramp and pilots to help ATCT in the conformance to the controlled OFF time
- Metrics for Data-Driven Analysis and Improvement
  - Each step of the scheduling process is captured in a highly instrumented system that can be used to analyze and improve the process.

TMI Evolution: STBO - TMI Interface, Traffic Management (TM) Action Panel



- Traffic Management Action Panel
  - Utility to customize surface operations through restriction management
  - Augments OIS data
  - Accessible from the Operational STBO Toolbar
  - Schedule, Remove, and Modify TMI events
  - Supported TMIs
    - Runway Utilization
    - APREQ Schedules
    - MIT Restrictions
    - Departure Fix Closures
    - Runway Closures
    - Ground Stops

TMI Evolution: STBO
TM Action Panel - Limitations

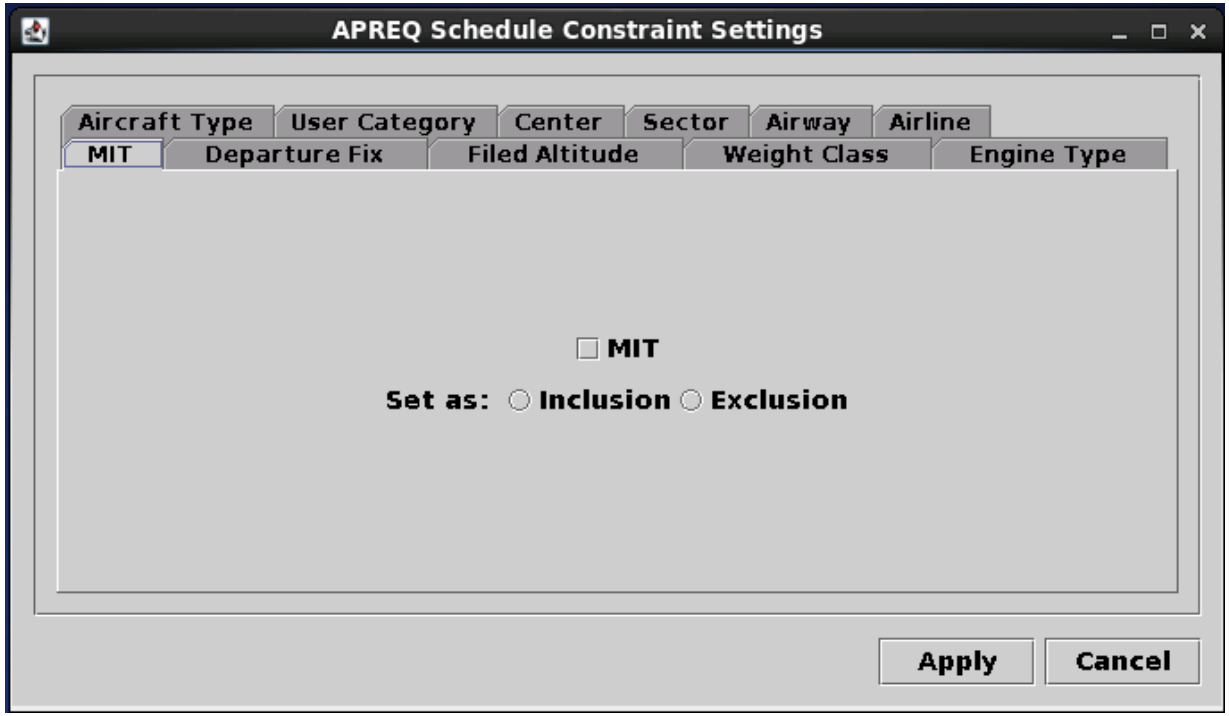
- The TM Action Panel only shows TMIs validated and approved by the TMI Service
- Schedule Limitations
  - TMI start time must be greater than or equal to the current time
  - TMI start time must not conflict with another TMI referencing the same resource
- Modify Limitations
  - Active TMI start time cannot be modified
  - TMI resource field cannot be modified
  - When a user edits a TMI originating from TFM-Flow or OIS, the source is changed to “User” and future updates from TFM-Flow or OIS for the edited TMI are ignored

TMI Evolution: STBO
TM Action Panel – Data Entry Format

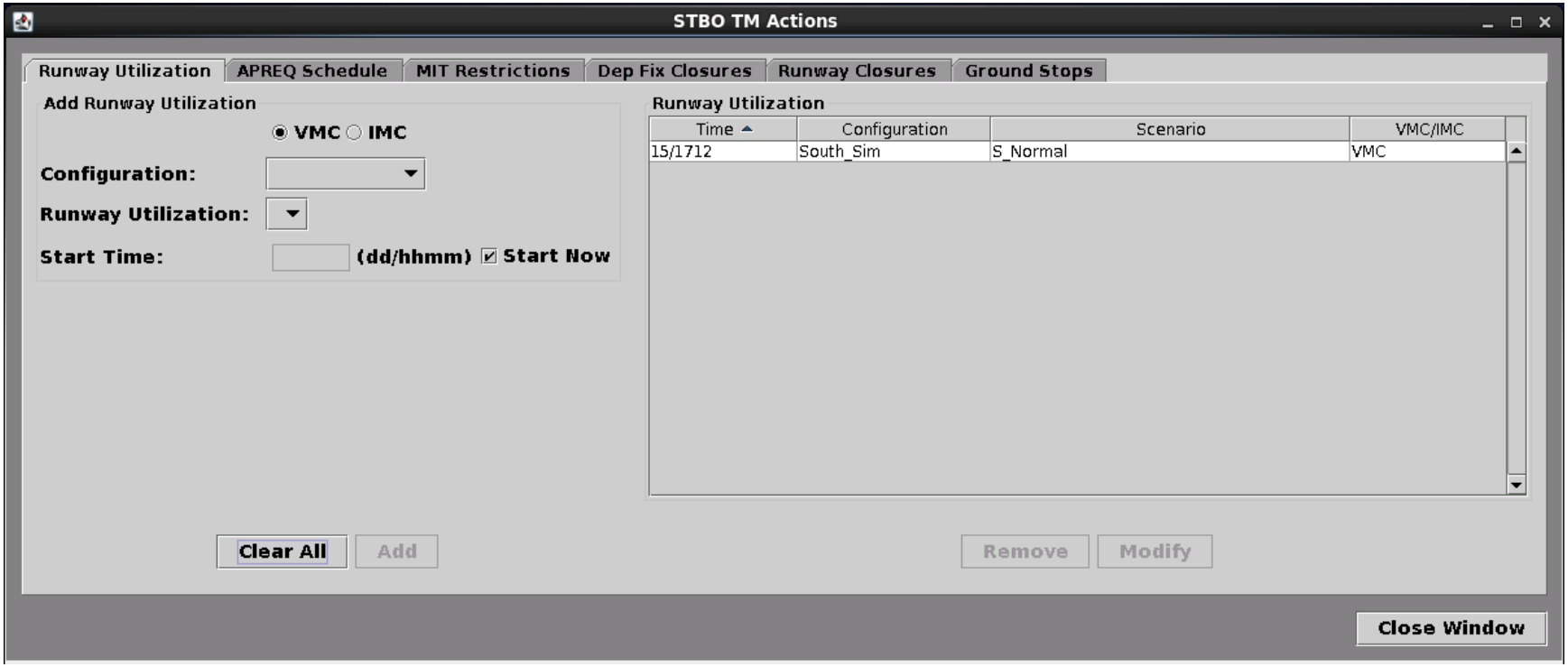
- Basic representation of TMIs
  - Resource
    - Airport or flight characteristic that binds a flight to a TMI (e.g. airport, departure fix, runway, etc.)
  - Restriction
    - Specific limitation(s) imposed on a flight (e.g., alternate fix, separation value, etc.)
  - Start Time
  - End Time
  - Constraints
    - Subset of airport or flight characteristics to refine the set of flights bound to a TMI

TMI Evolution: STBO
TM Action Panel - TMI Constraints

- Constraints are used to refine the criteria for binding a flight to a TMI
- Multiple constraints may be set as either inclusion or exclusion criteria
- The set of constraints types are AND'd together, while multiple values for a given type are OR'd together
  - Example: (exclude flights with an MIT) AND (include flights where (departure fix is KILNS OR BARMY))
- Not all TMIs support constraints



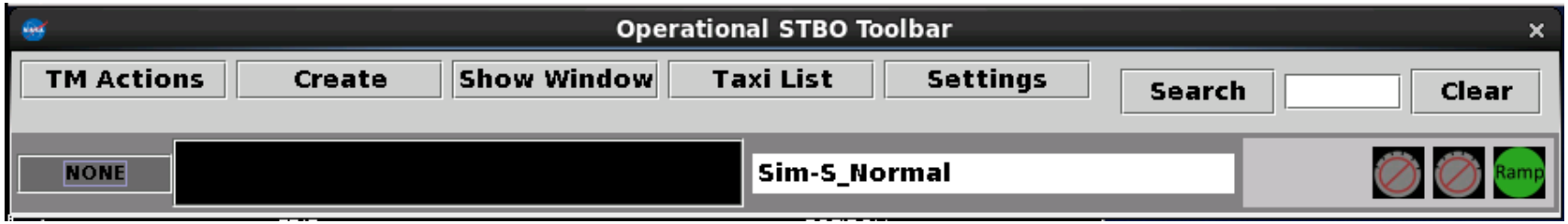
TMI Evolution: STBO
TM Action Panel - Runway Utilization



- Controls the surface arrival and departure flow
  - VMC/IMC: visual or instrument meteorological conditions
  - Configuration: predefined set of runway groupings
  - Runway Utilization: playbooks describing how the runways for a given configuration are to be used
  - Start Time: time when the TMI becomes active (defaults to current time if none is entered)
  - End Time: not required because an airport must always have an active configuration; a configuration ends when the next scheduled configuration begins

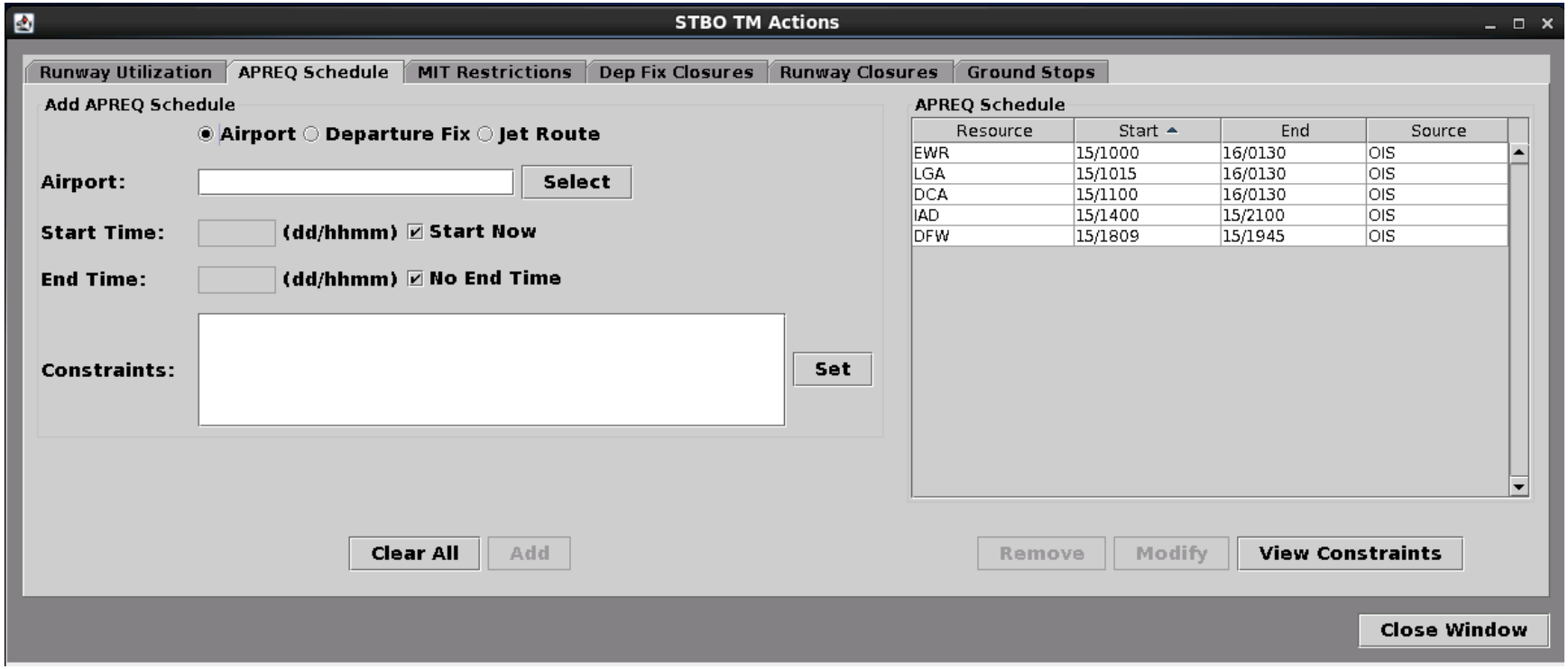
TMI Evolution: STBO
TM Action Panel - Runway Utilization

- Impact to STBO Client
  - Flights will switch runways to reflect the configuration change (e.g., 18L in South flow to 36R in North flow)
  - Toolbar will show active configuration and runway utilization



- Impact to RTC Client
  - Flight will switch runways to reflect the configuration change

TMI Evolution: STBO
TM Action Panel - APREQ Schedules



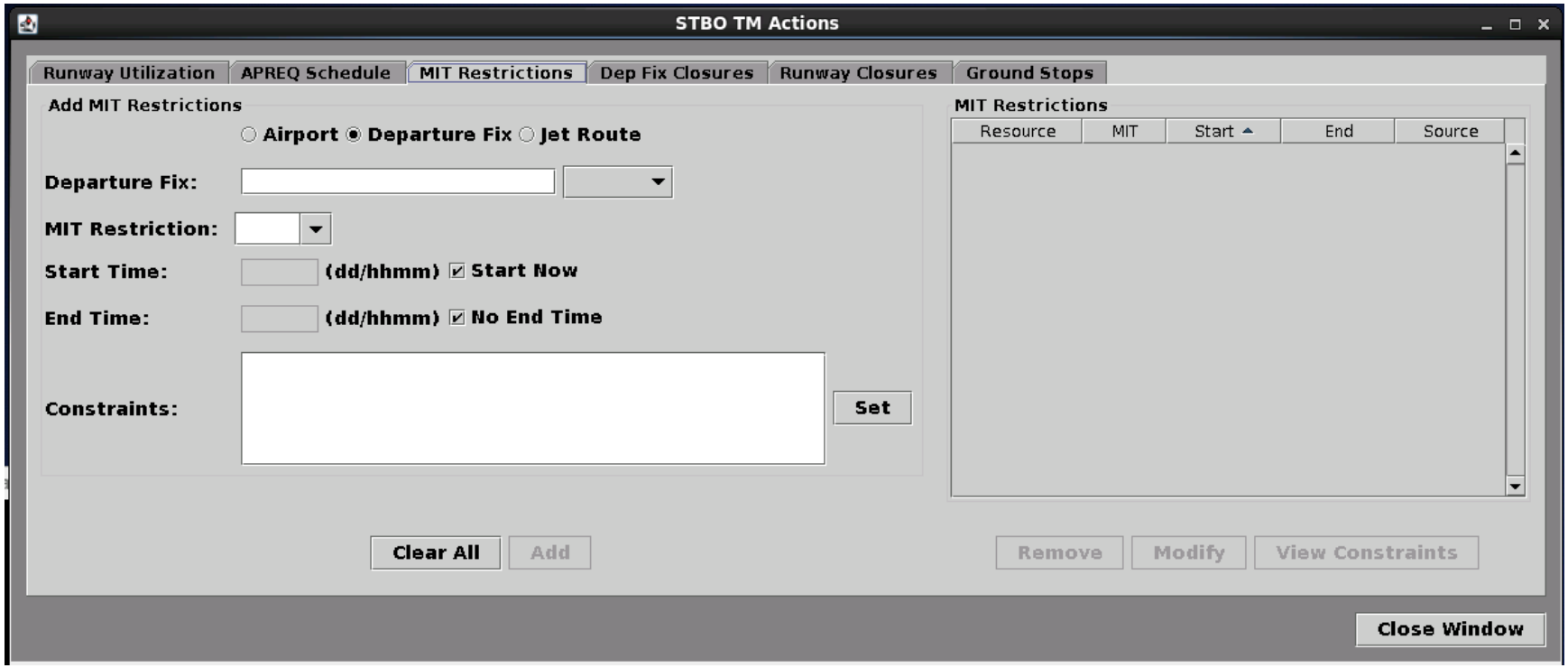
- Schedules resources requiring an approval request or call for release
  - Type of resource to be constrained: Airport, Departure Fix, Jet Route
  - Start Time: time when the TMI begins (defaults to current time if none is entered)
  - End Time: time when the TMI expires (defaults to no end time if none is entered)
  - Constraints: sub-restrictions for a resource

TMI Evolution: STBO
TM Action Panel - APREQ Schedules

- Impact to STBO Client
  - Flights marked as APREQ-constrained on timelines and map

- Impact to RTC Client
  - Flight strips marked as APREQ-constrained

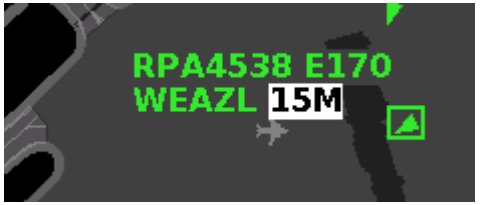
TMI Evolution: STBO
TM Action Panel - MIT Restrictions

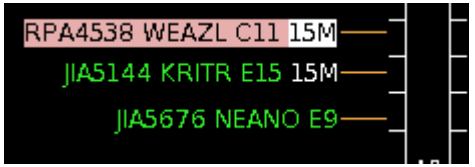


- Schedules resources subject to Miles-in-Trail
  - Type of resource to be constrained: (Airport, Departure Fix, Jet Route)
  - MIT Restriction: flight separation in nautical miles
  - Start Time: time when the TMI begins (defaults to current time if none is entered)
  - End Time: time when the TMI expires (defaults to no end time if none is entered)
  - Constraints: sub-restrictions for a resource

TMI Evolution: STBO
TM Action Panel - MIT Restrictions

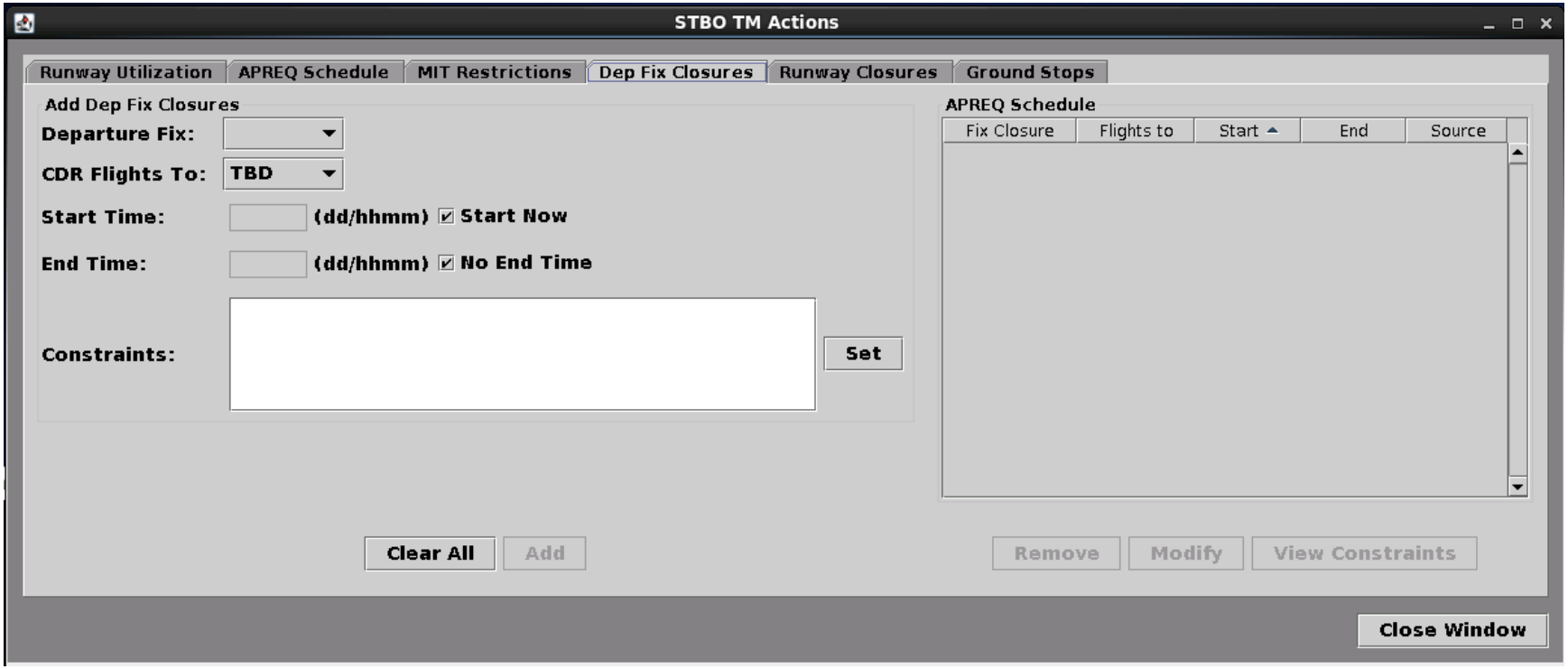
- Impact to STBO Client
  - Display the nautical mile separation next to the flight on the timeline and datablock.





- Impact to RTC Client
  - Display the nautical mile separation as part of the flight strip

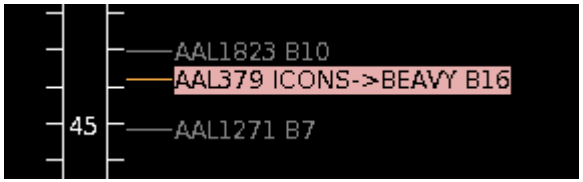
TMI Evolution: STBO
TM Action Panel - Departure Fix Closures



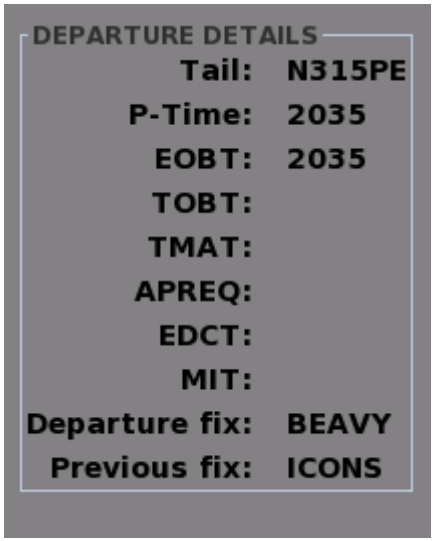
- Schedules departure fix closures
  - Departure Fix: name of the departure fix to close
  - CDR Flights To: coded departure route, or TBD (to be determined) if no alternate is specified
  - Start Time: time when the TMI begins (defaults to current time if none is entered)
  - End Time: time when the TMI expires (defaults to no end time if none is entered)
  - Constraints: sub-restrictions for a resource

TMI Evolution: STBO
TM Action Panel - Departure Fix Closures

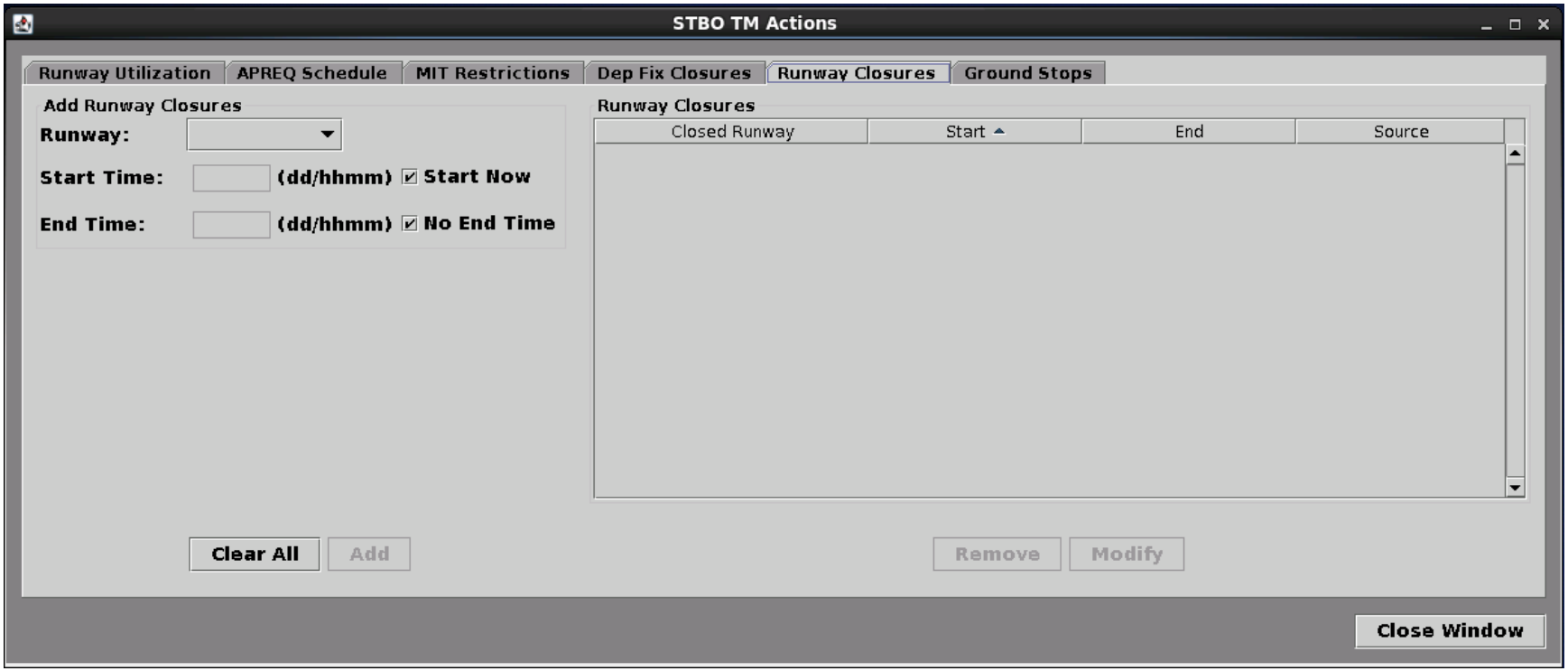
- Impact to STBO Client
  - When CDR is TBD, the flights are rescheduled 2 hours later as there is no valid fix assigned to the flight
  - If a CDR is not TBD, flights remain at the scheduled time on the timeline and show FIX → CDR as part of the timeline and map datablock



- Impact to RTC Client
  - When CDR is TBD, the display continues to show the closed fix highlighted in red on the flight strip
  - When CDR is not TBD, the display continues to show the previous fix on the flight strip highlighted in yellow on the flight strip. The Flight Menu dialog shows both the previous and CDR fix



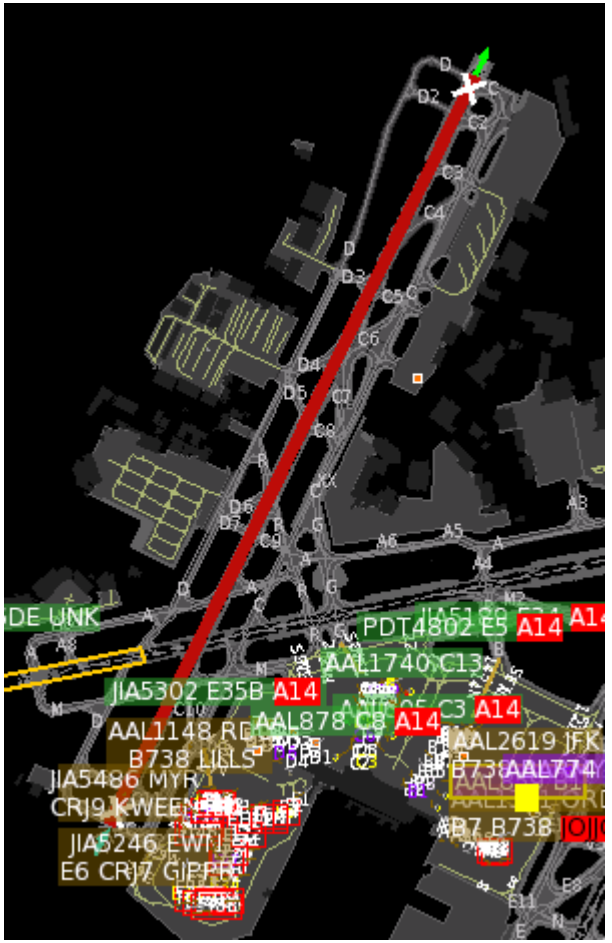
TMI Evolution: STBO
TM Action Panel - Runway Closures



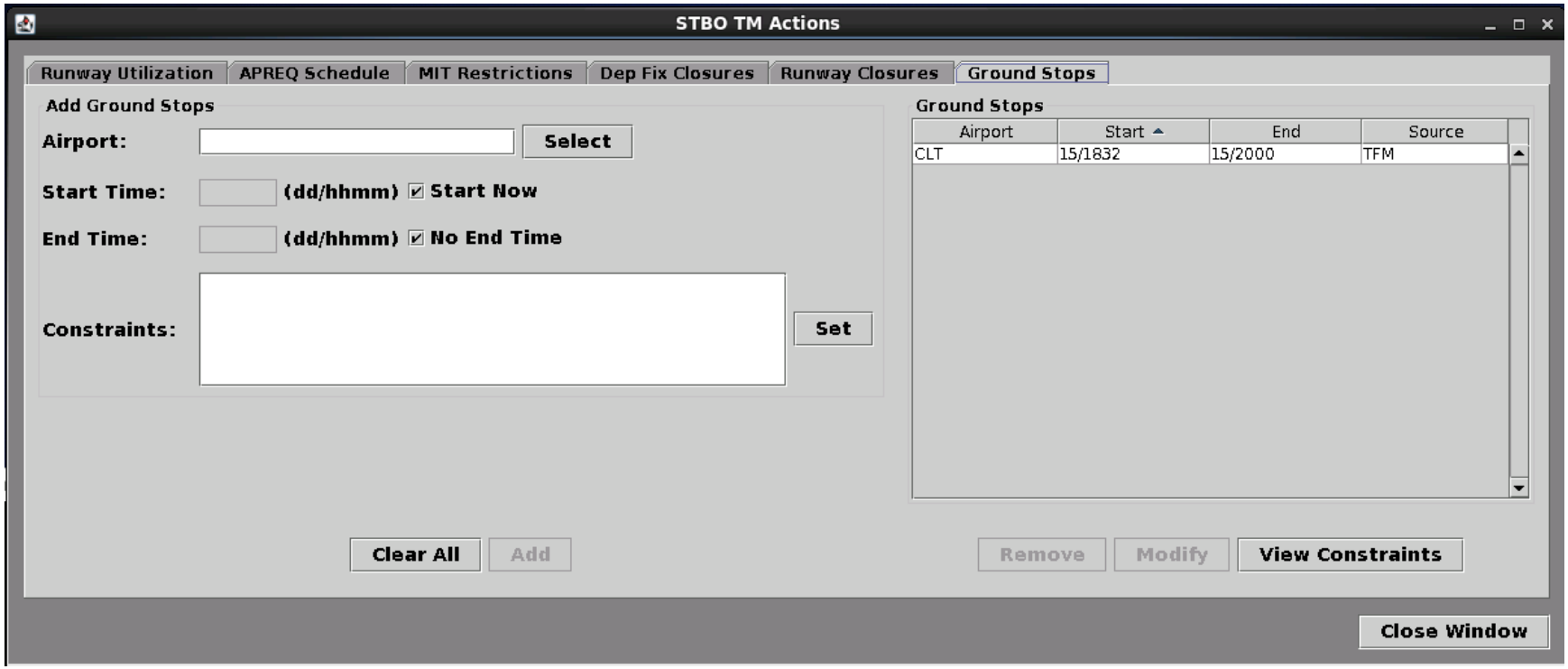
- Schedules runway closures (opposites are automatically closed)
  - Runway: list of runways for the given airport
  - Start Time: time when the TMI begins (defaults to current time if none is entered)
  - End Time: time when the TMI expires (defaults to no end time if none is entered)

TMI Evolution: STBO
TM Action Panel - Runway Closures

- Impact to STBO Client
  - Flights will be automatically reassigned to another runway
  - Runway shows blocked out in red on STBO map
- Impact to RTC Client
  - Runway shows as blocked out in red on RTC map



TMI Evolution: STBO
TM Action Panel - Ground Stops

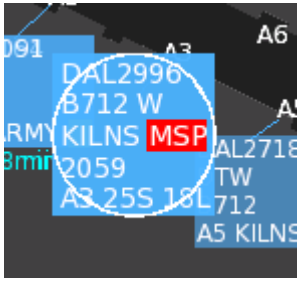


- Schedules ground stop programs
  - Airport for which the ATCSCC has put a Ground Stop Program in place
  - Start Time: time when the TMI begins (defaults to current time if none is entered)
  - End Time: time when the TMI expires (defaults to no end time if none is entered)
  - Constraints: sub restrictions for a resource

TMI Evolution: STBO
TM Action Panel - Ground Stops

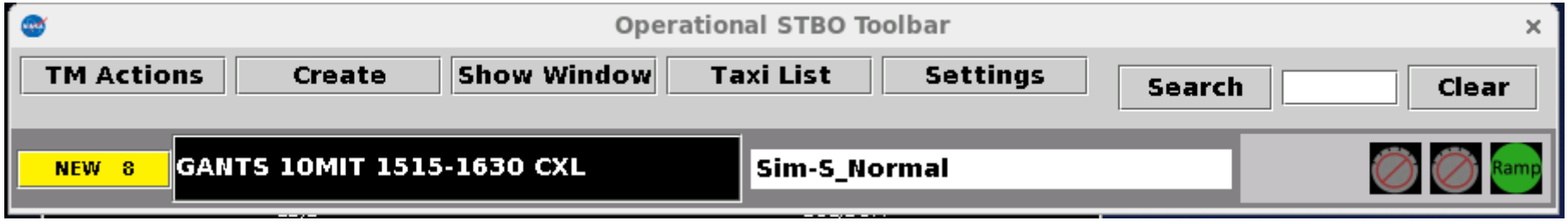
- Impact to STBO Client
  - If no end time is provided, the flight is removed from scheduling and disappears from the timeline
  - If an end time is provided, the flight will show ‘GS’ next to the timeline and map data blocks

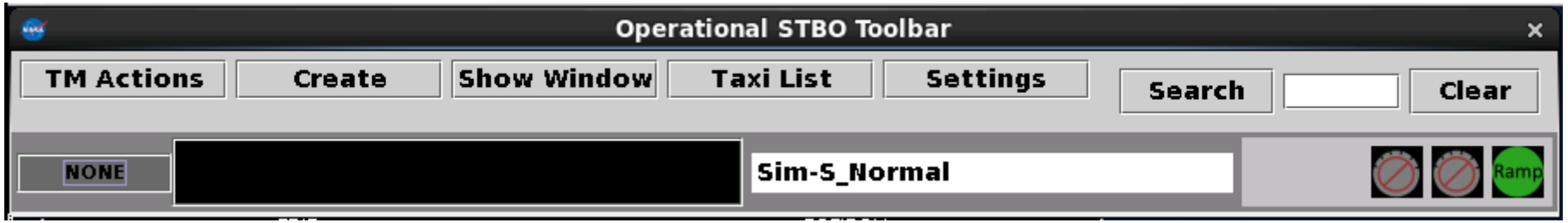
- Impact to RTC Client
  - The flight strip will show the destination airport highlighted in red



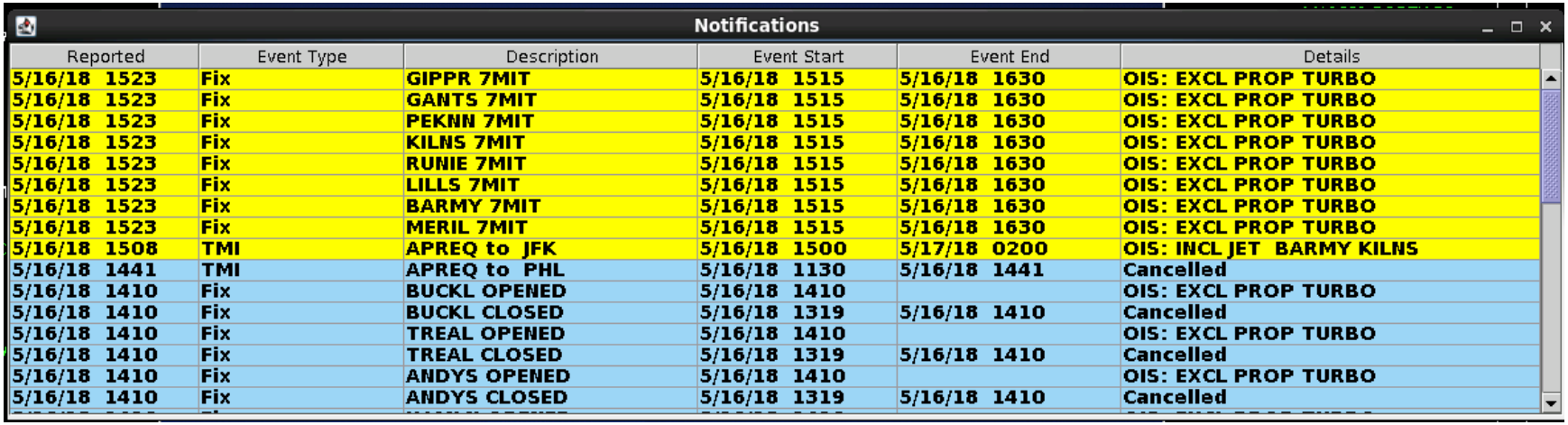
TMI Evolution: STBO Notification Banner

- Integrated into the RTC and STBO toolbars
- Supports acknowledgement of TMI changes
  - Click the yellow button labeled “New #” to acknowledge updates
  - Button will display as “None” if there are no updates to acknowledge
- Provides quick view of updates
  - Indicator of unacknowledged TMIs
  - Time-sharing view of unacknowledged TMIs
  - Click the banner to open detailed table view of TMIs





TMI Evolution: STBO Notification Table

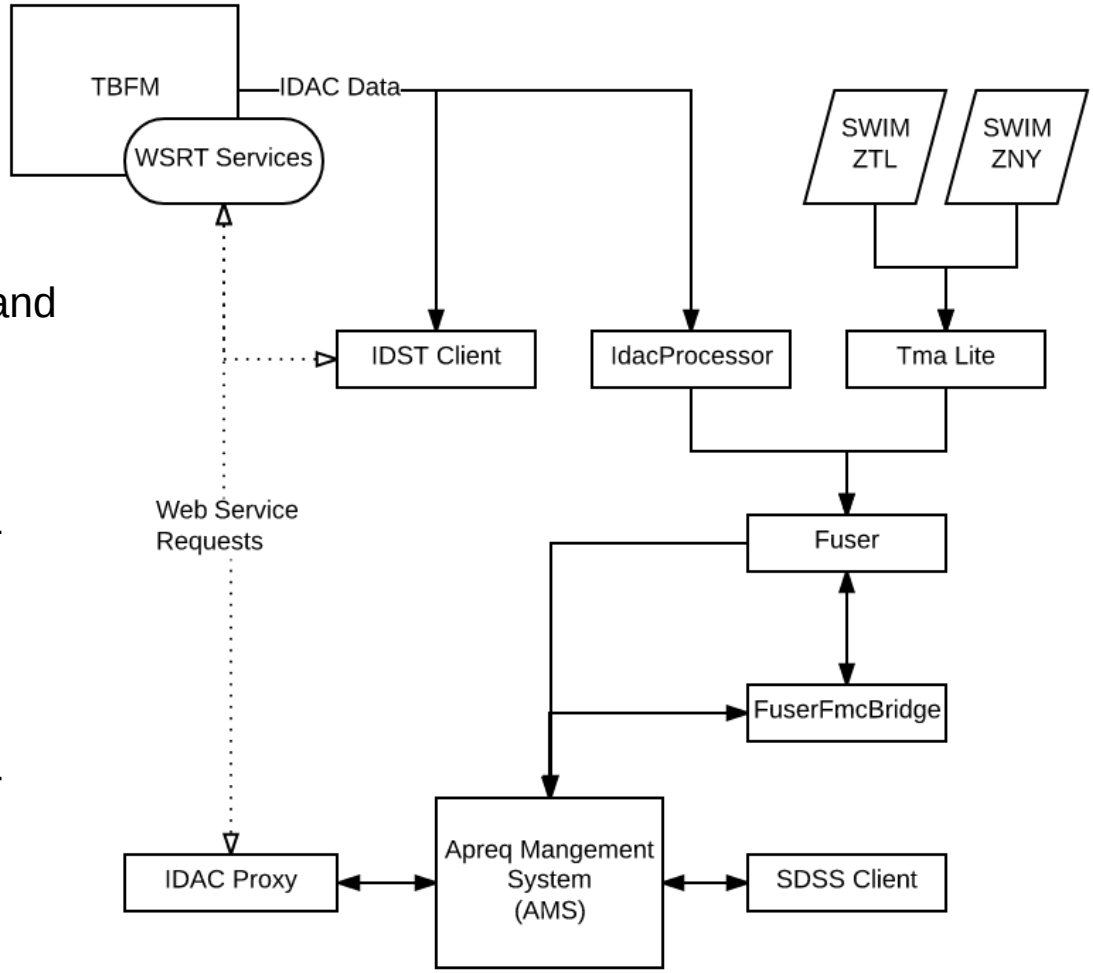


Reported	Event Type	Description	Event Start	Event End	Details
5/16/18 1523	Fix	GIPPR 7MIT	5/16/18 1515	5/16/18 1630	OIS: EXCL PROP TURBO
5/16/18 1523	Fix	GANTS 7MIT	5/16/18 1515	5/16/18 1630	OIS: EXCL PROP TURBO
5/16/18 1523	Fix	PEKNN 7MIT	5/16/18 1515	5/16/18 1630	OIS: EXCL PROP TURBO
5/16/18 1523	Fix	KILNS 7MIT	5/16/18 1515	5/16/18 1630	OIS: EXCL PROP TURBO
5/16/18 1523	Fix	RUNIE 7MIT	5/16/18 1515	5/16/18 1630	OIS: EXCL PROP TURBO
5/16/18 1523	Fix	LILLS 7MIT	5/16/18 1515	5/16/18 1630	OIS: EXCL PROP TURBO
5/16/18 1523	Fix	BARMY 7MIT	5/16/18 1515	5/16/18 1630	OIS: EXCL PROP TURBO
5/16/18 1523	Fix	MERIL 7MIT	5/16/18 1515	5/16/18 1630	OIS: EXCL PROP TURBO
5/16/18 1508	TMI	APREQ to JFK	5/16/18 1500	5/17/18 0200	OIS: INCL JET BARMY KILNS
5/16/18 1441	TMI	APREQ to PHL	5/16/18 1130	5/16/18 1441	Cancelled
5/16/18 1410	Fix	BUCKL OPENED	5/16/18 1410		OIS: EXCL PROP TURBO
5/16/18 1410	Fix	BUCKL CLOSED	5/16/18 1319	5/16/18 1410	Cancelled
5/16/18 1410	Fix	TREAL OPENED	5/16/18 1410		OIS: EXCL PROP TURBO
5/16/18 1410	Fix	TREAL CLOSED	5/16/18 1319	5/16/18 1410	Cancelled
5/16/18 1410	Fix	ANDYS OPENED	5/16/18 1410		OIS: EXCL PROP TURBO
5/16/18 1410	Fix	ANDYS CLOSED	5/16/18 1319	5/16/18 1410	Cancelled

- Open detailed view by single clicking the notification banner on the toolbar
- Select any row to acknowledge all TMIs
- Colors
  - White: TMI has been acknowledged by the user
  - Yellow: TMI is new, or TMI has been changed and waiting user acknowledgement
  - Blue: TMI expired before the scheduled end time

TMI Evolution: APREQ Negotiation - Overview

- Component Overview
  - **IDAC Processor**
    - Consumes and processes IDAC data
    - Source of negotiation data and states
  - **IDAC Proxy**
    - Hosts negotiation services
    - Interfaces with IDAC WSRT services
  - **APREQ Management System (AMS)**
    - Tracks negotiation state per flight
  - **TBFM**
    - Schedules flights into overhead stream



TMI Evolution:
APREQ Negotiation - Manual Mode

- Manual
  - Requires phone calls between Tower and Center
  - No network communication between Tower and Center
  - Release times must be manually entered by the Tower
  - Flight representation on the STBO timeline: telephone icon

TMI Evolution:
APREQ Negotiation - Semi Mode

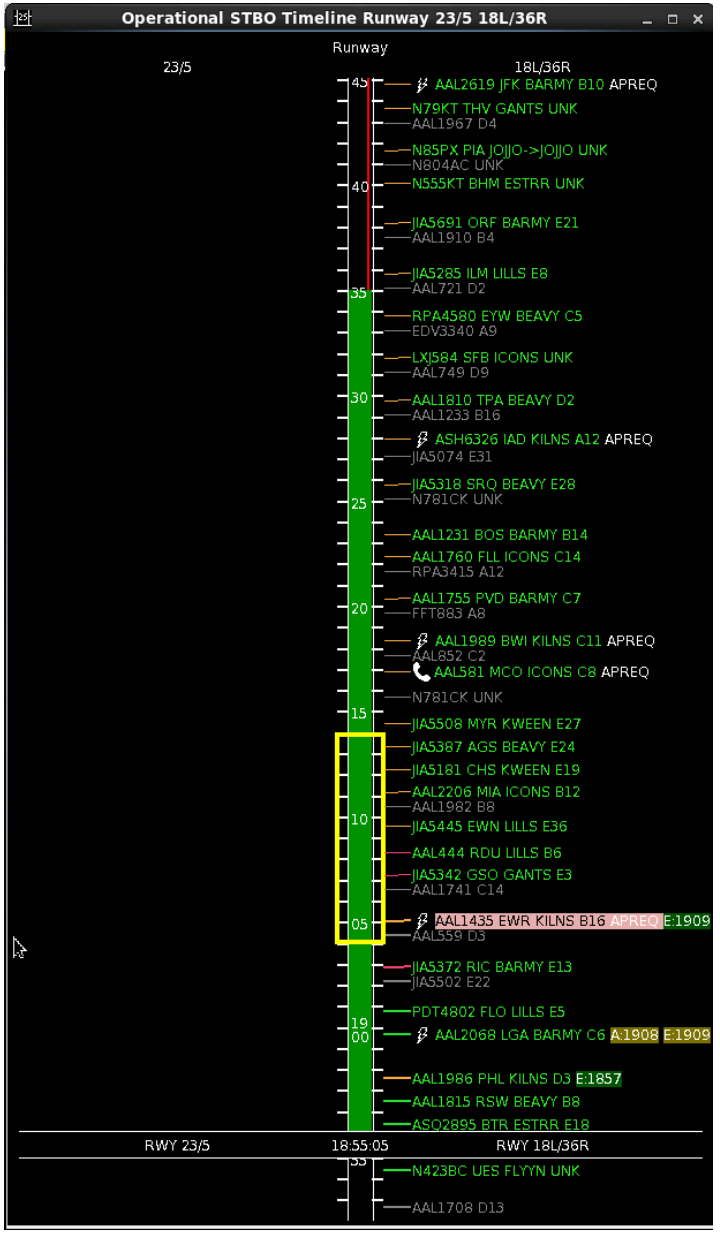
- Semi (Automatic)
  - No phone call between Tower and Center
  - Requests are sent to TBFM which must be approved by the Center
  - Responses from the Center are received through the IDAC data
  - Release times are automatically populated into the ATD-2 system
  - Flight representation on the STBO timeline: hollow lightning bolt

TMI Evolution:
APREQ Negotiation - Automatic Mode

- Automatic
  - No phone call between Tower and Center
  - Requests are sent to TBFM and automatically scheduled and accepted
  - Responses from the Center are received through the IDAC data
  - Release times are automatically populated into the ATD-2 system
  - Flight representation on the STBO timeline: solid lightning bolt

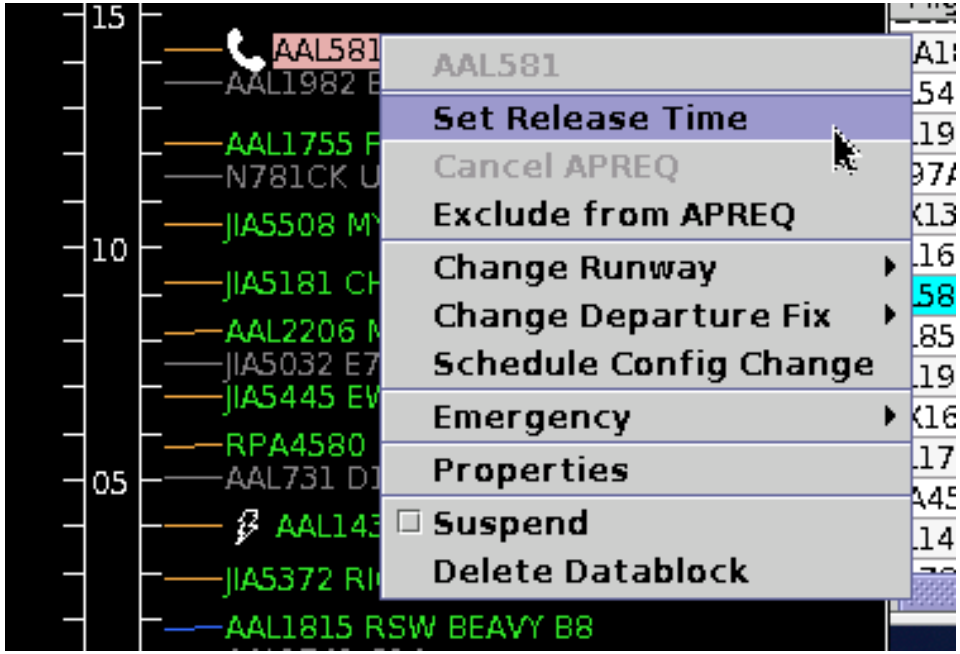
TMI Evolution:
APREQ Negotiation - Red/Green

- Selecting flight displays slots (green) on timeline for scheduling APREQ
- Show yellow EDCT compliance window for AAL1435 to help with APREQ scheduling
- Red space is unavailable for scheduling APREQ



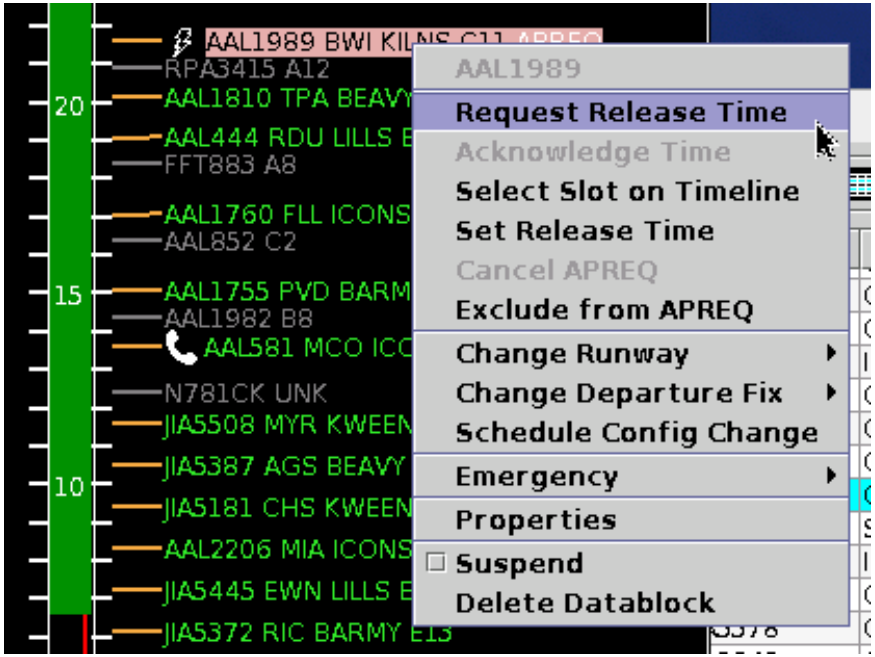
TMI Evolution:
APREQ Negotiation - Set Release

- Set Release
  - Tower controller manually enters a negotiated release time (required for Manual mode, optional for Semi and Auto modes)
  - Modes: Manual, Semi, Auto



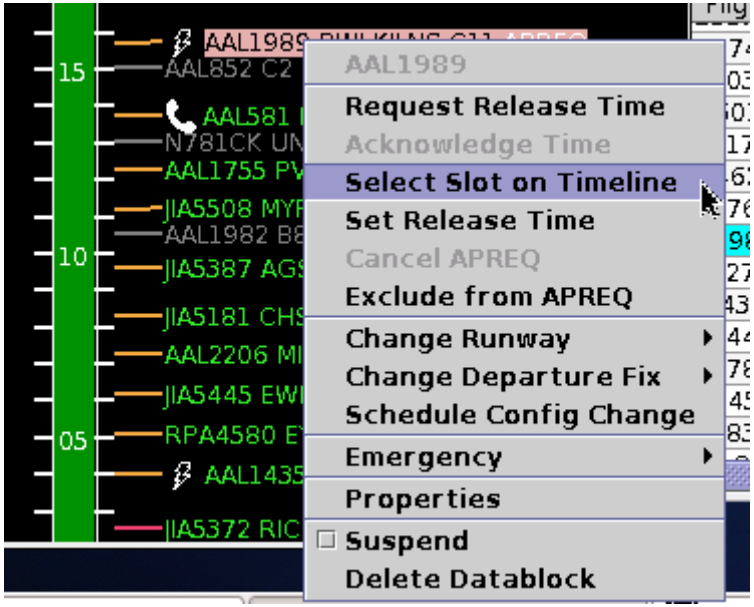
TMI Evolution:
APREQ Negotiation - Request Release

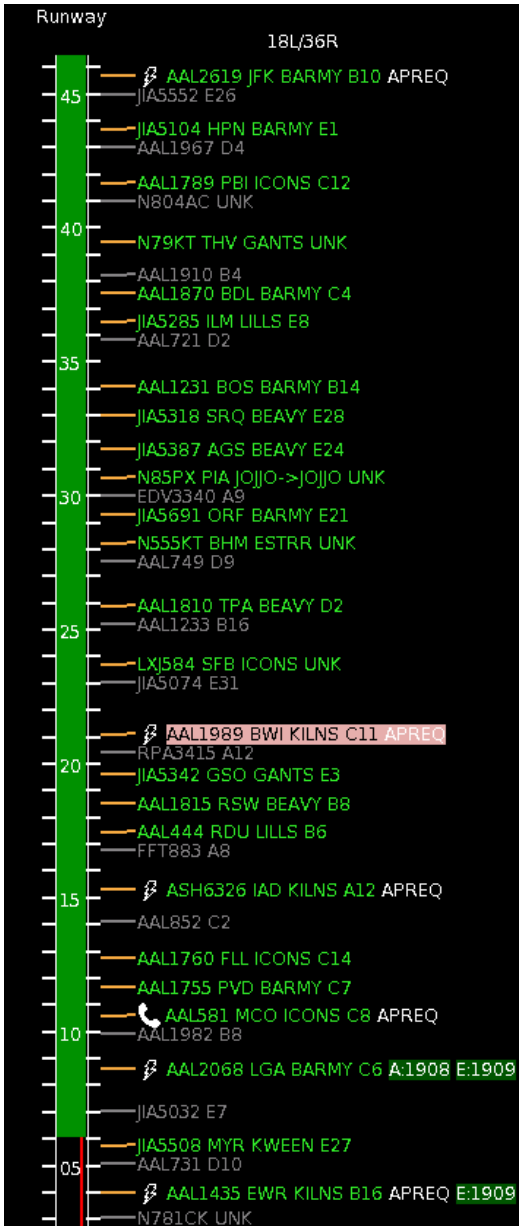
- Request Release Time
  - Modes: Semi, Auto
  - Flight scheduled departure runway time sent as the requested release time (flight representation: yellow arrow)



TMI Evolution:
APREQ Negotiation - Select Slot

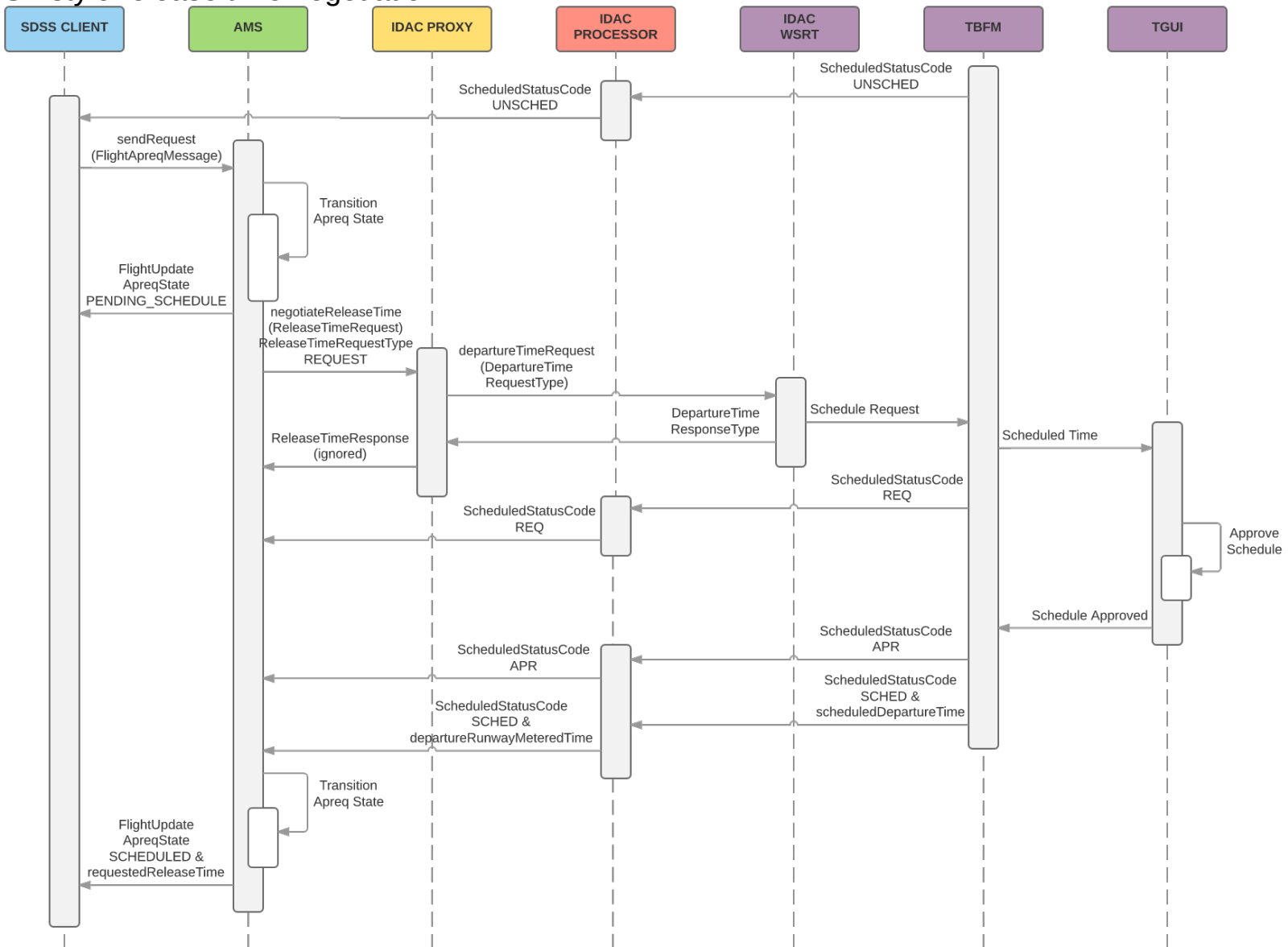
- Select Slot on Timeline
  - Modes: Semi, Auto
  - Red/Green slots representing available space are displayed on the timeline
  - User selects a time on the timeline. The user-selected time is sent as the requested release time





TMI Evolution: APREQ Negotiation – Message Flow

- IDST style release time negotiation



Mobile App

Operational Scenarios

Mobile App: Overview

- Need for Mobile App Technology
  - Unlike commercial airlines, GA/Corporate operations did not have a mechanism to submit ready-times to the ATD-2 Scheduler in the same manner as the airlines
  - The MITRE Corporation has developed Mobile Application (App) technology that allows General Aviation (GA)/Corporate operators to participate in ATD-2
  - MITRE began beta-testing this technology with a small group of Corporate Flight Operators at CLT in October 2017

Mobile App: Overview (cont.)

- Using the Mobile App technology, Corporate pilots participating in MITRE's beta-test at CLT provide intent information by submitting a Ready-to-Taxi Time (RTT)
- RTT represents the time at which a GA/Corporate flight will reach the edge of the GA Ramp Area and contact Ground Control for taxi
- An RTT in GA/Corporate operations is analogous to an Earliest Off-Block Time (EOBT) in commercial operations
- When an RTT is submitted to MITRE, it is passed to the ATD-2 system and ingested by the Operational IADS STBO system at CLT, where it is treated as an EOBT
- Flights that submit an RTT (EOBT) are placed in the Planning category by the Scheduler
- GA/Corporate flights are not subject to Surface Metering at CLT whether they submit an RTT or not

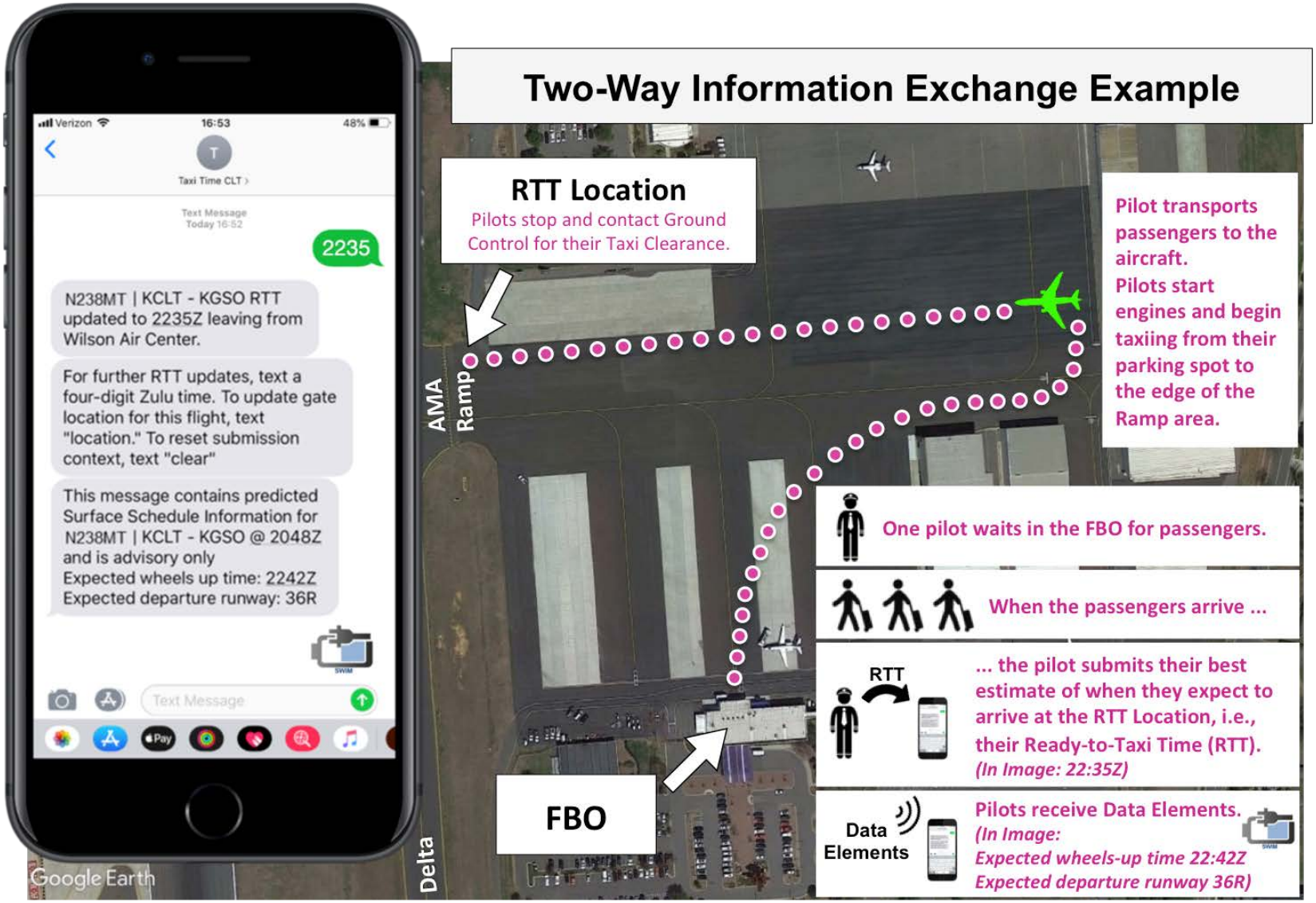
Mobile App: Benefits

- System and pilot benefits of submitting RTT:
  - In general, the ATD-2 system as a whole benefits from receiving GA RTTs because they help to increase the accuracy of the Surface Scheduler's runway demand and taxi time predictions
  - Given the variability in GA/Corporate operations (e.g., uncertainty in passenger arrival time), the RTT submission provides a more accurate prediction of the flight's intended schedule than the *filed* departure time
  - When a GA/Corporate pilot submits an RTT at CLT, they receive flight-specific scheduling and planning information in return (i.e., Targeted Takeoff Time (TTOT), Expected Runway, and, if applicable, an indication that the flight is subject to an APREQ or Miles-in-Trail (MIT) restriction)
- Development and testing of the Mobile App technology at CLT has demonstrated:
  - RTTs can be successfully integrated into the operational ATD-2 IADS STBO system, where they are treated as EOBTs
  - GA/Corporate pilots can generally predict their RTT with an accuracy of +/-5 minutes when they make the submission within 15 minutes of actually reaching the edge of the Ramp Area

Mobile App: Beta-Test Milestones

- Milestones of MITRE's CLT beta-test
  - October 2017: Corporate pilots (beta-test participants) at CLT began submitting Ready-to-Taxi Times (RTTs) using MITRE's 'Taxi Time' Mobile App
  - February 2018: RTT Integration with CLT Operational System
  - May 2018: Based on pilot feedback and preferences, MITRE introduced an SMS Texting capability which allows participants to submit their RTT via SMS text rather than through a mobile application ('Taxi Time' App was deactivated).
  - November 2018: Two-way information exchange with the ATD-2 system was enabled. When pilots submit an RTT, they receive flight-specific schedule and planning information in return. Data elements include: Targeted Takeoff Time (TTOT), Expected Runway, and, if applicable, an indication that the flight is subject to an APREQ or Miles-in-Trail (MIT) restriction.

Mobile App: Two-Way Information Flow at CLT



Mobile App: Data Elements

- The data elements presented to pilots are TTOT, Expected Departure Runway, and TMI information (when applicable)

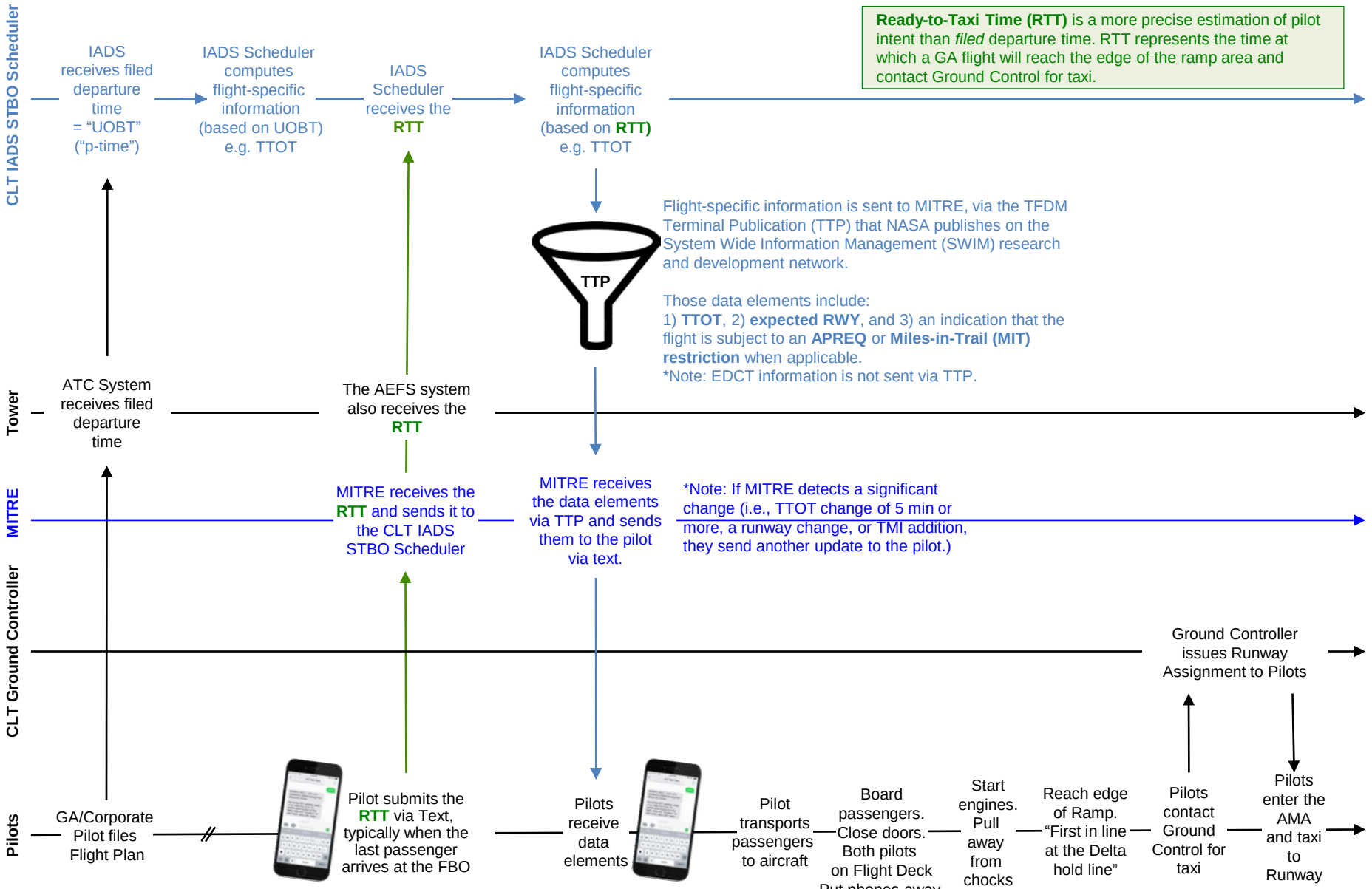
- For TMIs, there are slight changes to the messaging depending on the flight's data. The full logic for presenting TMI information is:

  - Flight has an EDCT and no TMIs:
    - **"There is a ground delay program in effect for your destination or route. Expect to be assigned an EDCT."**
  - Flight has an EDCT and some (one or multiple) TMIs applied:
    - **"There may be delays for your route. Contact ATC for more information."**
  - Flight has no EDCT, and has *exactly one* TMI:
    - If that one TMI is an APREQ:
      - **"There may be delays for your route. Contact ATC prior to engine start."**
      - In this case, the flight's TTOT is presented as "**Earliest wheels up time**", rather than "expected wheels up time"
    - That one TMI is not an APREQ (e.g. Miles-In-Trail):
      - **"There may be delays for your route. Contact ATC for more information."**
  - Flight has no EDCT, more than one TMI applied:
    - **"There may be delays for your route. Contact ATC for more information."**

- If there is a significant change (TTOT change of 5 or more minutes, runway change, or TMI addition), they receive updated information

Mobile App: Concept of Operations

Ready-to-Taxi Time (RTT) is a more precise estimation of pilot intent than *filed* departure time. RTT represents the time at which a GA flight will reach the edge of the ramp area and contact Ground Control for taxi.



Advanced Electronic Flight Strips (AEFS) Integration

Operational Scenarios

AEFS: ATD-2 Integration Overview

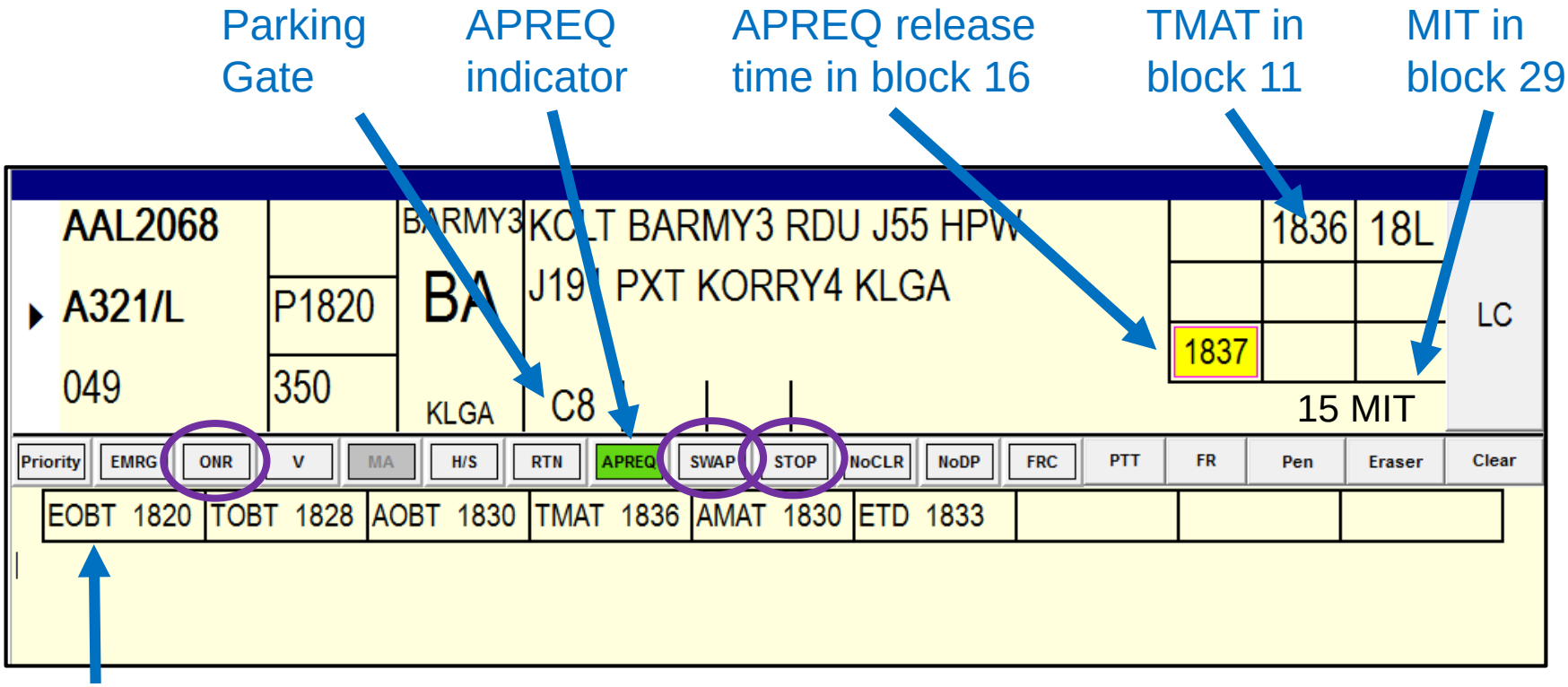
- AEFS is an interim Electronic Flight Strip (EFS) system developed at WJHTC by the FAA and its contractors
- AEFS is intended to be a prototype but has been expanded in scope to operational use at a few towers including CLT, PHX, CLE, others
- The purpose of integrating the FAA AEFS and NASA ATD-2 IADS systems at CLT is to validate TFDM requirements for the integration of flight operator data, TMI data, and surface metering procedures
- The AEFS and ATD-2 integration enables two-way, real-time exchange of data between the two systems to:
  - Reduce duplicate manual entries by controllers and TMC's
  - Replace verbal with digital data exchange
  - Provide more complete and accurate data between airline ramp and ATCT
- AEFS will be replaced by TFDM Program's improved Electronic Flight Data (EFD) solution at CLT
  - ATD-2 will remain at CLT until TFDM is deployed in 2021 under an agreement with the FAA

AEFS: Synced Data Elements

- AEFS and ATD-2 integration includes mechanisms to ensure the two systems stay in sync with each other and have ways to detect stale data
- AEFS data elements are sent to ATD-2 and updated in ATD-2
  - Runway assignment change by ATCT
- ATD-2 data elements are sent to AEFS and displayed on flight strips
  - TIMES: EOBT, TOBT, AOBT, TMAT, AMAT, ETD
    - Note: ATD-2 TTOT field is labeled ETD in AEFS per FAA requirements
  - GATE: Gate Number
  - APREQ: APREQ On/Off, APREQ Time
  - SWAP: Departure Fix Closure On/Off
  - STOP: Ground Stop On/Off
  - ONR: Operational Necessity Runway On/Off
  - MIT: Miles-In-Trail
  - Gate Conflicts: Gate conflict notification for arrivals OnFinal and ON (landed/taxiing)
- AEFS and ATD-2 exchange data elements on a per-flight basis
  - Example 1: AAL1234 at Gate B8, APREQ is On, No APREQ time yet, SWAP is Off, STOP is Off, ONR is Off
  - Example 2: AAL2566 at Gate C12, APREQ is Off, No APREQ time, SWAP is On, STOP is Off, ONR is Off

AEFS: ATD-2 Data on AEFS

- ATD-2 data elements were integrated into AEFS V5.5 which deployed to CLT as part of Phase 2 in September 2018. Additional features were deployed in AEFS V5.6 in April 2019.



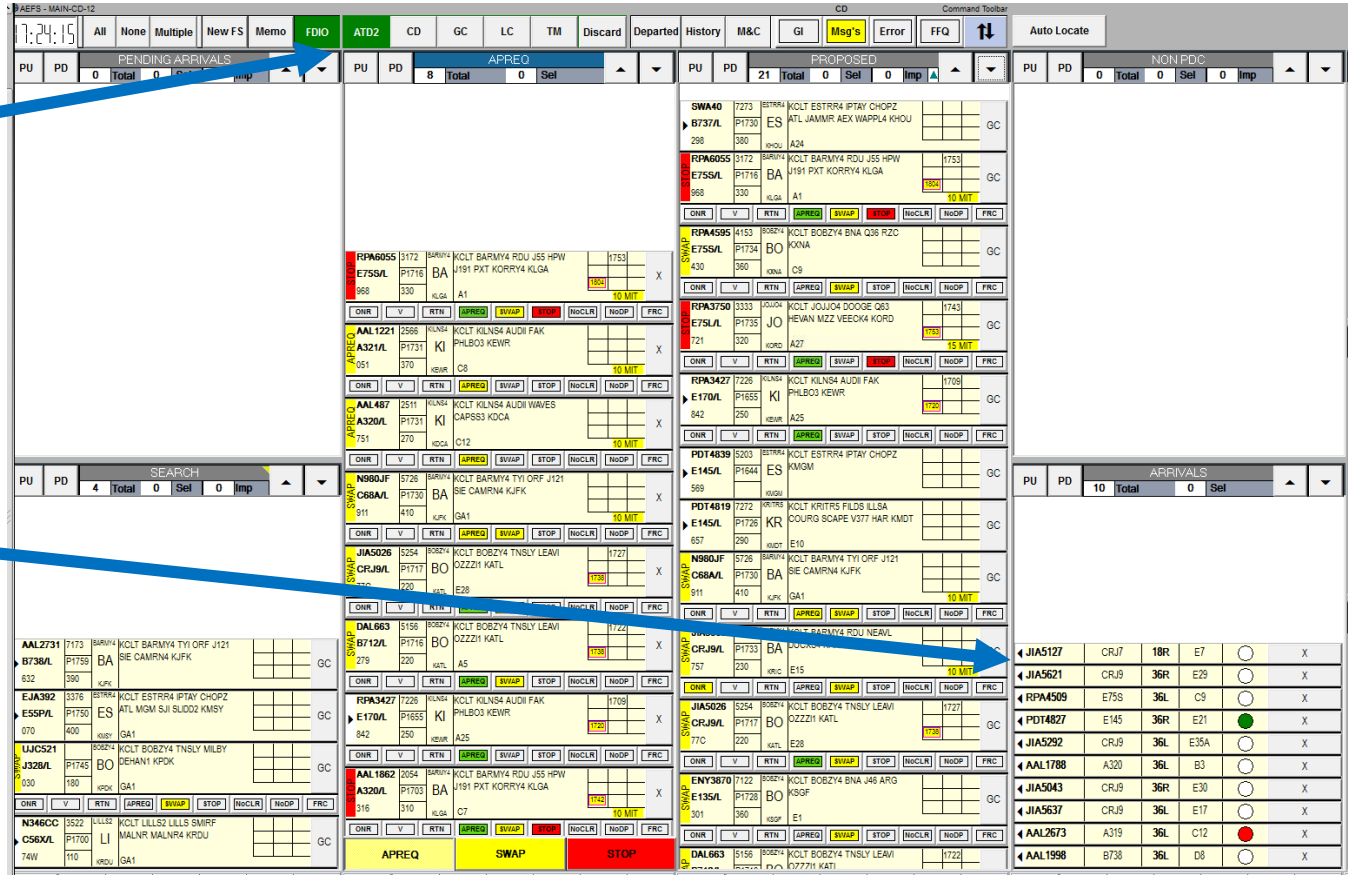
ATD-2 Times: EOBT, TOBT, AOBT, TMAT, AMAT, ETD (TTOT)

Other data from ATD-2: ONR, SWAP, STOP

AEFS: Integrated Display

ATD-2 Status Button

Gate List



New Integrated Display Features

- ATD-2 Status Button: Indicates whether ATD-2 is connected (green) or not (red); also used to disconnect ATD-2 from AEFS when operationally necessary (“kill switch”)
- Gate List: New list shows if the gate assigned to an arrival OnFinal or On (landed/taxiing) is still occupied by a departure; informs Ground and Local if arrival needs to be held outside of the ramp or in a hardstand

AEFS: Operational Scenarios (1)

The AEFS and ATD-2 integration extends the data exchange and integration coordination between Ramp and Tower to include all ATCT controller positions, such as Clearance Delivery, Ground, and Local, enabling improved situational awareness in the Tower.

- Predicted Schedule Times: EOBT, TOBT, AOBT, TMAT, AMAT, ETD (TTOT)
  - These times from ATD-2 are displayed in the extended AEFS strip
  - Target times (TOBT, TMAT, ETD) are blank unless surface metering is in effect or when an APREQ is applied
- APREQs
  - Phase 1: Only the Tower TMC had access to both ATD-2 STBO and AEFS displays. When an APREQ time for a flight appeared on STBO, the TMC manually entered the time into AEFS to inform the other ATCT positions
  - Phase 2: Flights subject to APREQs are given a special marking on their AEFS strips. When APREQ times are available, they are automatically sent to AEFS and displayed at all ATCT positions. Any changes to the APREQ data, including Free Releases, APREQ exclusions, and APREQ cancellations, are updated on AEFS

AEFS: Operational Scenarios (2)

- MITs
  - Phase 2: MIT restrictions input by the Tower TMC on STBO are automatically displayed in block 29 on the AEFS display, in addition to being shared with RTC/RMTC.
- Departure Fix Closures
  - Phase 2: Flights affected by departure fix closures have the SWAP field on their AEFS strips highlighted in yellow. Both flights with (CDR) and without (TBD) reroutes to a different fix are shown in the same way – per FAA specification. When the fix reopens, the SWAP field is cleared.
- Ground Stops
  - Phase 2: Flights affected by ground stops at the destination airport have the STOP field on their AEFS strips highlighted in red. When the ground stop is over, the STOP field is cleared.
- Runway Change for Operational Necessity (RMTC or STBO)
  - Phase 2: Departures needing a different runway are marked as OpNec by the Ramp Manager or Tower TMC. These are automatically shared with AEFS and result in the ONR field of the strip being highlighted in yellow. If ONR is undone, the AEFS field is cleared.

AEFS: Operational Scenarios (3)

- Runway Change from AEFS
  - Phase 2: Departure runway assignments initiated from AEFS are automatically sent to ATD-2 and result in that flight moving to the assigned runway. STBO and RTC/RMTC displays are updated to the changed runway.
- Parking Gate
  - Phase 2: The parking gate of each flight is displayed on the AEFS strip. Any gate changes from STBO and RTC/RMTC result in updates on AEFS.
- Gate Conflicts
  - Phase 2: AEFS Gate List shows arrival flights with flight states of OnFinal (within 10 nm and lined up for landing) and On (landed and taxiing to ramp). A conflict indicator (colored circle) next to the callsign shows whether the parking gates are currently open (white), occupied (red), or previously occupied but now available (green).
  - This information helps the Local and Ground controllers decide whether to hold the arrival in the AMA or at a hardstand until the gate is clear.
  - Note that some changes to the gate conflict display have been requested by ATCT but not implemented yet due to all ATD-2 resources being focused on Phase 3.

TFDM Terminal Publication (TTP)

Operational Scenarios

TFDM Terminal Publication (TTP): Overview

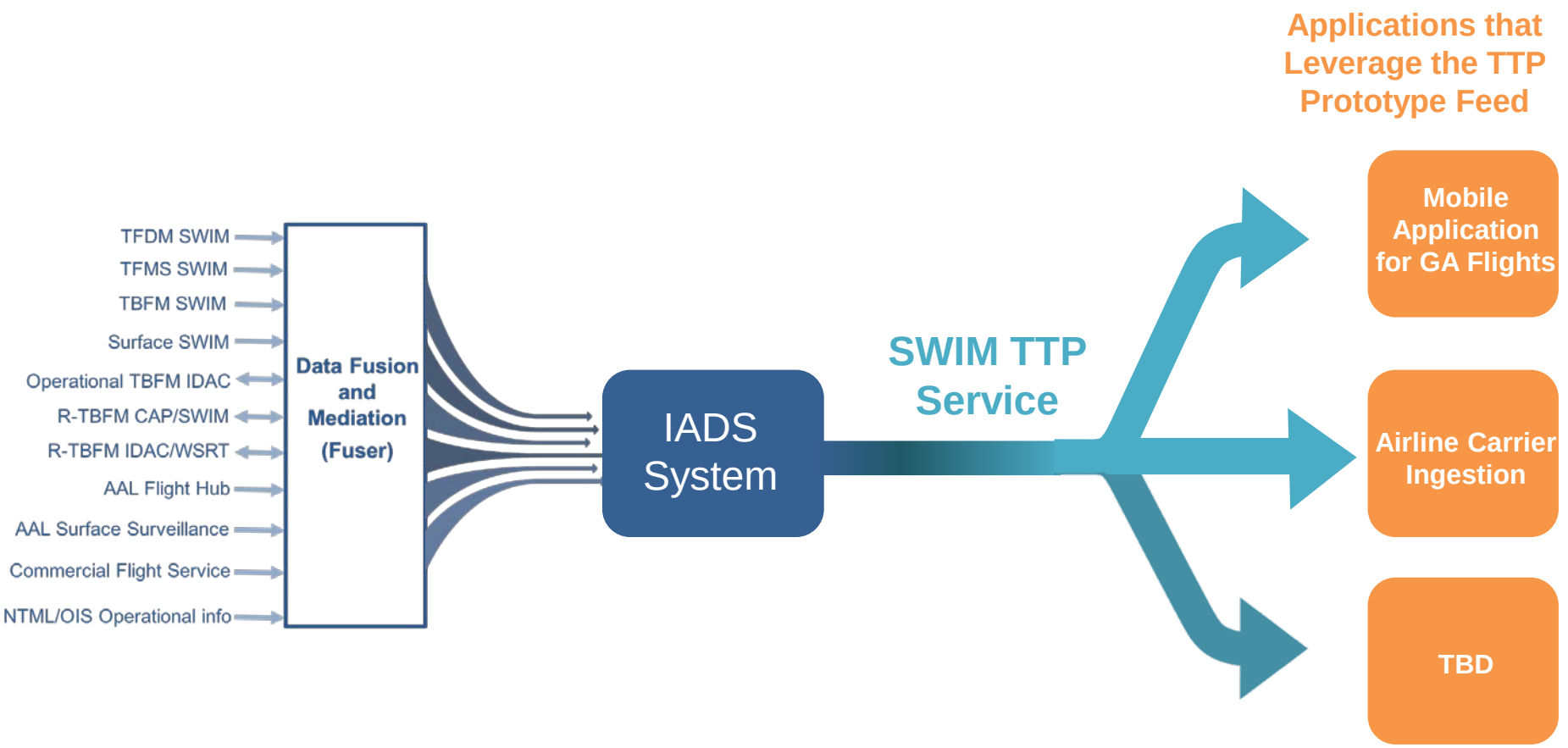
- TFDM data feed publishing Flight and Flow data to consumers
- Will provide data exchange between TFDM and National Airspace System (NAS) Systems and the NAS users (e.g., airlines, air carriers, air freight, military or general aviation/business aviation operators)
- Accessible via the NAS Enterprise Messaging Service (NEMS)
- Uses the publish-subscribe (pub-sub) Message Exchange Pattern (MEP)
- XML data format, using Flight Information Exchange Model (FIXM) standard for Flight Data
- Airport Information, Surface Metering Program, Traffic Management Restrictions use a schema defined by the TFDM team

TFDM Terminal Publication: ATD-2 Implementation of TTP

- Registered as “NASA TTP” in NAS Service Registry/Repository (NSRR)
- Currently available via SWIM R&D Gateway
- Based on TFDM specifications
  - Currently no deviations from TFDM specifications
  - Does not include all information published by TFDM
- Publishing data for:
  - Charlotte Douglas International Airport
  - Dallas/Fort Worth International Airport
  - Dallas Love Field Airport
- Planning support of NASA TTP for CLT until TFDM proper installed (May 2021)[3]
- Goal - work invested in integrating with ATD-2 via TTP could be utilized when TFDM is deployed

3. Source: https://www.faa.gov/air_traffic/technology/tfdm/implementation/

TFDM Terminal Publication: IADS and Data Sharing



TFDM Terminal Publication: TTP Services

Service	Includes
Flight Data	Individual flight updates containing flight identifiers, targeted times, actual times, runway, parking gate, spot, departure fix (predicted, assigned, actual as appropriate), flight states, and more
Airport Information	Airport configurations, airport and runway rates, ramp closures, runway closures, taxiway closures
Traffic Management Restrictions	Call for Release programs, departure MIT/MINIT restrictions, departure stop/ground stop programs (along with list of impacted flights for each)
Flight Delay	Airport and runway delay by arrival, departure, and total
Operational Metrics	Metrics on airport throughput and individual flight metrics
Surface Metering Program	SMP start / end times, metering constraint type / details, updates to existing programs, TMAT compliance window, departure queue length, and more

TFDM Terminal Publication: TTP Services (cont.)

Name	Event Driven	Full Update	Implemented in NASA TTP
Flight Data	Yes	Every 15 minutes	Yes (subset)
Airport Information	Yes	Every 15 minutes	Yes (subset)
Traffic Management Restrictions	Yes	Every 15 minutes	Yes (subset)
Flight Delay	Yes	Every 15 minutes	Yes (subset)
Operational Metrics	No	Every 15 minutes	Yes (subset)
SMP	Yes	Every 15 minutes	Yes (subset)

- ATD-2 will continue to track and align with TFDM as much as possible
- See reference for implementation details of specific messages[4]

4. Source: NASA TTP NSRR

TFDM Terminal Publication: Use of TTP Headers

- Each TTP message has a message header and a message body
- While the message body contains the bulk of the information, the message header also contains useful information
- Message header uses:
  - Use to filter data and route data
    - The header communicates the type of information contained in the message body
    - This is used by FAA SWIM to filter messages unwanted by the consumer
    - Can also be used by users to route information internally
- Some messages do not have a body and only have a header
  - Heartbeat message
  - SystemStart message
  - PeriodicStart message
  - PeriodicEnd message
- The TTP header will indicate whether it is a sync or a real time message

TFDM Terminal Publication: TTP Headers

Header	Flight Data	Airport Information	Traffic Management Restrictions	Flight Delay	Operational Metrics
DATA_GROUP	Yes	Yes	Yes	Yes	Yes
MESSAGE_TYPE	Yes	Yes	Yes	Yes	Yes
AERODROME	Yes	Yes	Yes	Yes	Yes
AIRLINE	Yes	No	No	Yes	No
SYNC	Yes	Yes	Yes	Yes	No
TIME_STAMP	Yes	Yes	Yes	Yes	Yes
PRIVACY_LEVEL	Yes	No	No	Yes	Yes
TFDM_RELEASE	Yes	Yes	Yes	Yes	Yes
SCHEMA_VERSION	Yes	Yes	Yes	Yes	Yes
TIME_STAMP	Yes	Yes	Yes	Yes	Yes
UUID	Yes	Yes	Yes	Yes	Yes

TFDM Terminal Publication: Sync

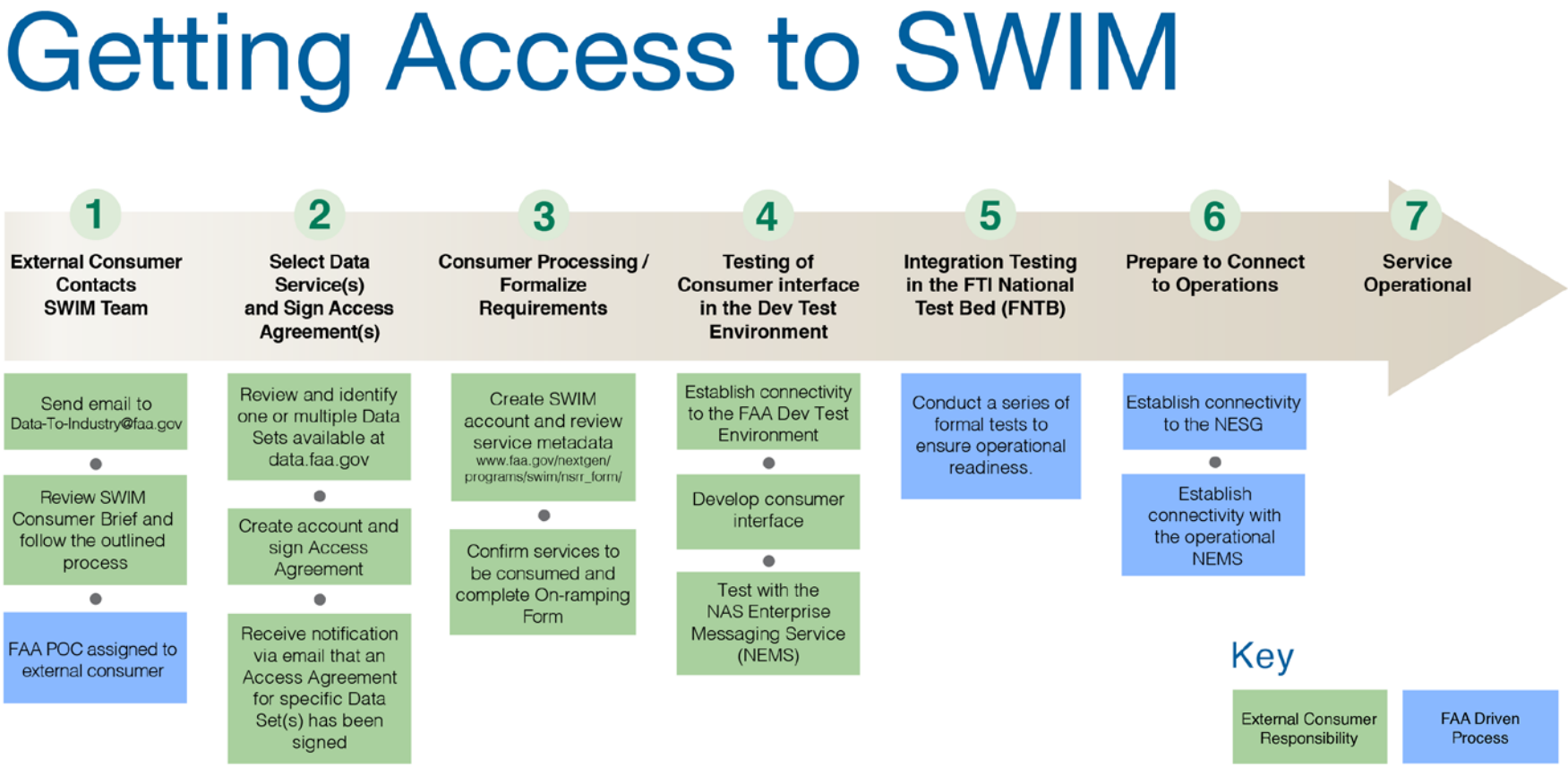
- Most services have a periodic sync
- Occurs every 15 minutes (configurable on the server side)
- A full dump of all the latest data for that service is published
- Pros and Cons:
  - Pros
    - You are guaranteed to know about all data within 15 minutes
    - If you miss or drop a message you get the full state the next 15 minute sync
  - Cons
    - You can not request a sync
    - Can be confusing if not accounted for in the data processing
    - Additional processing load
    - Could be getting messages and nothing has changed

TFDM Terminal Publication: Flight Data Sync Example

- A sequence of messages are published
  - Periodic Start Message
  - A Flight Add Message for each flight
  - Periodic End Message

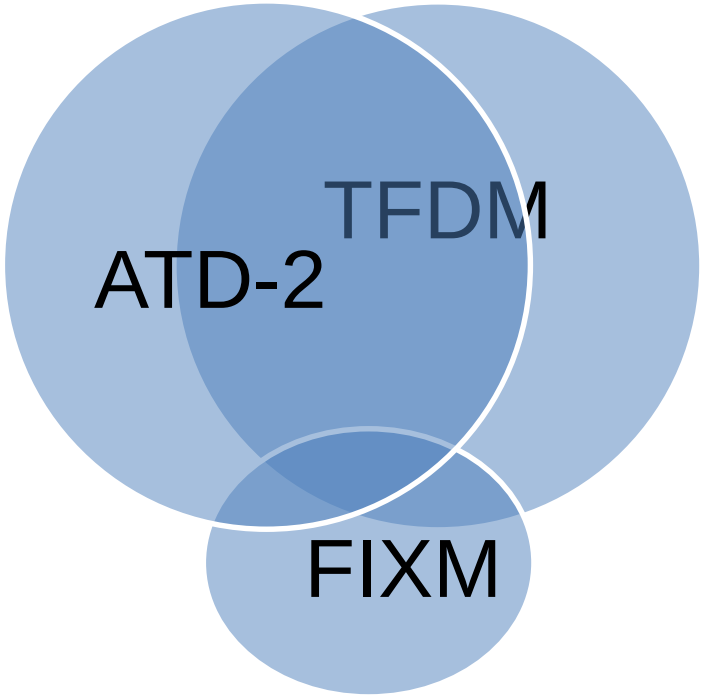
DATA_GROUP	MESSAGE_TYPE	SYNC	MESSAGE BODY	Notes
FlightData	PeriodicStart	per	Empty	Periodic sync has started
FlightData	FlightAdd	per	xml	All data on flight1
FlightData	FlightAdd	per	xml	All data on flight2
FlightData	FlightAdd	per	xml	All data on flight3
FlightData	PeriodicEnd	per	Empty	Periodic sync has ended

TFDM Terminal Publication: SWIM Connection Process[5]



5. Source: https://www.faa.gov/air_traffic/technology/swim/products/get_connected/

TFDM Terminal Publication: Limitations



- **Program intersection limitation**
  - NASA ATD-2 has data that is not in the TFDM requirements
  - NASA ATD-2 does not have all the data to fill the TFDM requirements.
  - TFDM is expected to produce all flight data in FIXM format
  - FIXM does not currently support everything TFDM will need to publish
- **Not a one stop shop**
  - TTP is generally not intended to include data that is found in other feeds

TFDM Terminal Publication: TTP NSRR Documentation[6]

- **Java Messaging Service Description Documents (JMSDD)**
  - Required for all FAA SWIM Services
  - Provides technical details for TTP including:
    - Service Profile
    - Service Interface
    - Service Implementation
  - One document for each service
- **TTP Message Description Documents**
  - Describes the messages published by each services including message headers, description of each data element, and relevant details
  - Indicates for each element whether it is in FIXM, FIXM Extension, or non-FIXM format
  - Provides breakdown of adherence to TFDM specification for each element
  - Includes a sample message
  - One for document each service
- **Sample Data**
  - Zip file contains samples of messages from each service
- **Schemas**
  - FIXM 4.0 schema and extensions used for services publishing flight information (Flight Data and Flight Delay)
  - NASA TTP schema used for services publishing non-flight information (Airport Info., Operational Metrics, and Traffic Management)

6. Source: https://nsrr.faa.gov/services/nasa-ttp/documents

Operational Concepts & Impacts

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

- Operational Policies, Procedures, and Constraints
  - No change from Phase 1
- 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
CLT Tower	Ground and Local Controller	• TFDM EFD for surface traffic control	Operational
	TMC	• STBO Client display with TBFM/IDAC for APREQ/CFR coordination	Operational
		• RTC display	Observer
		• TFDM EFD for surface traffic management	Operational
	CD	• TFDM EFD for surface traffic management	Operational
CLT TRACON	TMU	• STBO Client display	Operational
		• RTC display	Observer
Center (ZDC, ZTL)	TMU	• STBO Client display	Observer
		• Enhanced TBFM/IDAC for APREQ/CFR coordination with CLT Tower	Operational
AAL Ramp Tower	Ramp Controller	• Ramp Traffic Console (RTC)	Operational
		• STBO Client display (optional)	Observer
	Ramp Traffic Manager	• Ramp Manager Traffic Console (RMTC)	Operational
		• STBO Client display	Observer
AAL Integrated Operations Center (IOC)	Research Observer	• Ramp Traffic Console (RMTC)	Observer
		• STBO Client display	Observer
CLT Airport	Airport Authority and Facility Manager	• STBO Client display and RTC display	Observer
Corporate Flight Operators	Pilots/Dispatchers	• Two-way information flow via Mobile App, enabled by TTP	Operational

Operational Concepts & Impacts: Operational and Organizational Impacts

- Operational Impacts
  - Automated data exchange expanded with AEFS integration
  - RTCs/RMTC receives gate pushback advisories at longer lead-times
  - Center TMCs evaluate pre-scheduling into arrival streams with integration of ATD-2 IADS into arrival metering TBFM system
  - Ramp controllers have better situational awareness prior to pushback, thus passing more accurate information to the flight crews
  - NAS Flight Operators have access to TFDM and NAS Systems data via TTP
  - Corporate pilots text Ready-to-Taxi Time (RTT) (i.e., EOBT) to ATD-2 Scheduler, via MITRE Mobile App technology and receive back TTOT, Expected Runway, and any TMIs
- Organizational Impacts
  - Participation in training on the new capabilities prior to and during Phase 2 (time and resources) – all users
  - Added other airline and corporate pilots to training list

Analysis

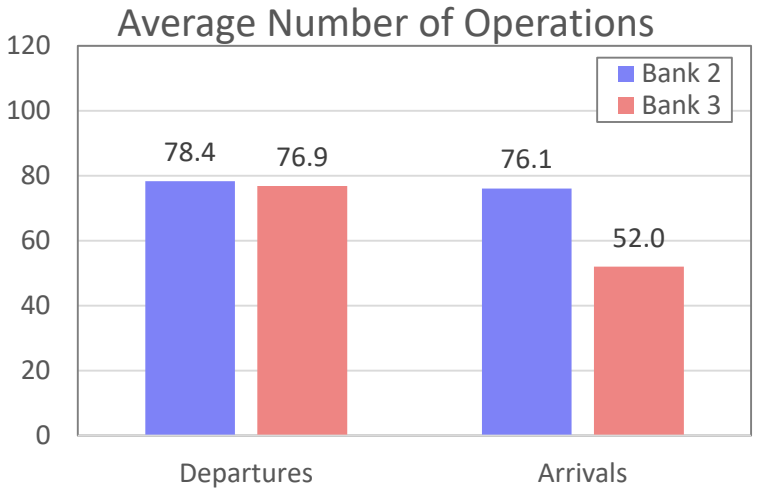
(Data in Analysis section show statistics through August 31, 2019.)

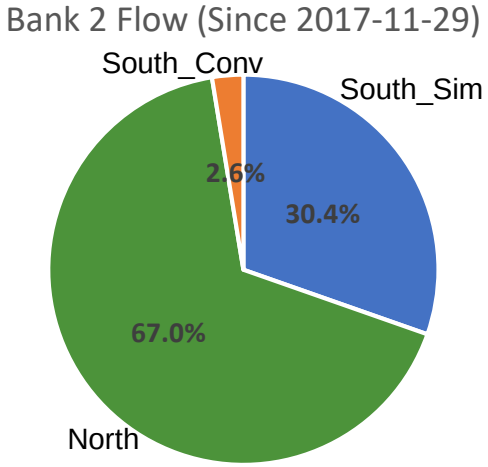
Surface Metering Usage

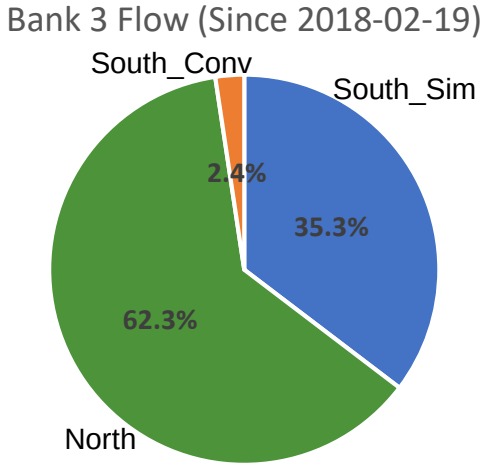
- Surface metering started in late Nov 2017 (Phase 1C)
  - Bank 2 was metered in 494 of 640 (77.2%) days (11/29/17 ~ 08/31/19)
  - Bank 3 was metered in 391 of 558 (70.1%) days (02/19/18 ~ 08/31/19)

- Bank 2 and Bank 3 have similar number of departures

- Bank 2 has 46.4% more arrivals than Bank 3 which causes increased surface congestion



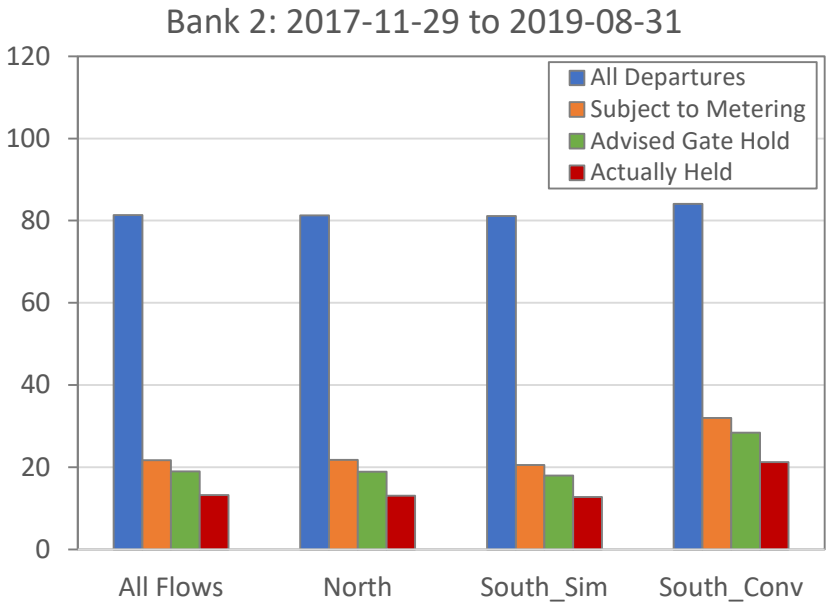


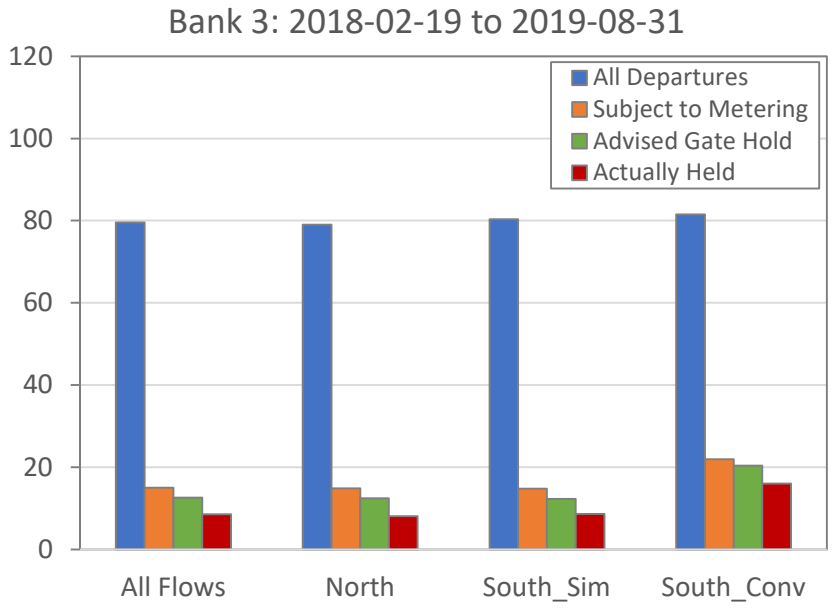


Avg. Number of Departures During Metering

- More departures were subject to metering and held at the gate in bank 2 compared to bank 3

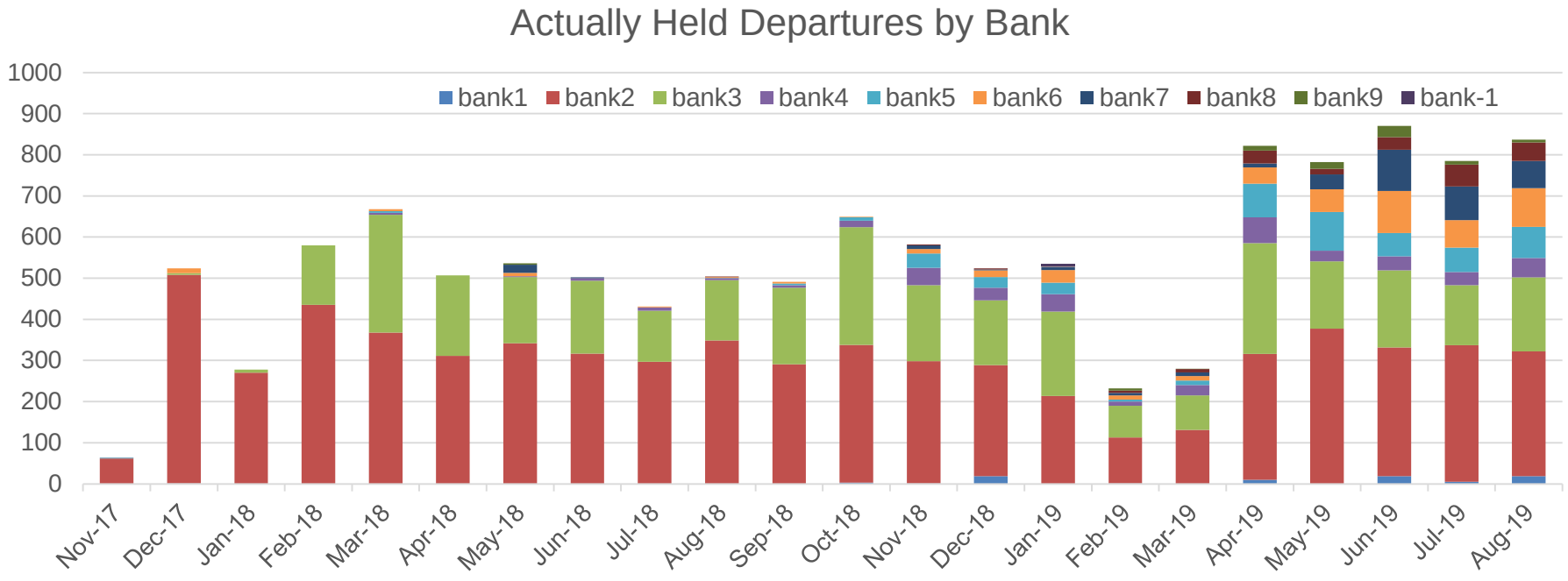
- Among all the departures in Bank 2 (Bank 3)
  - 26.7% (18.9%) of departures were subject to metering
  - 23.3% (15.9%) of departures were advised a gate hold
  - 16.3% (10.7%) were actually held at the gate



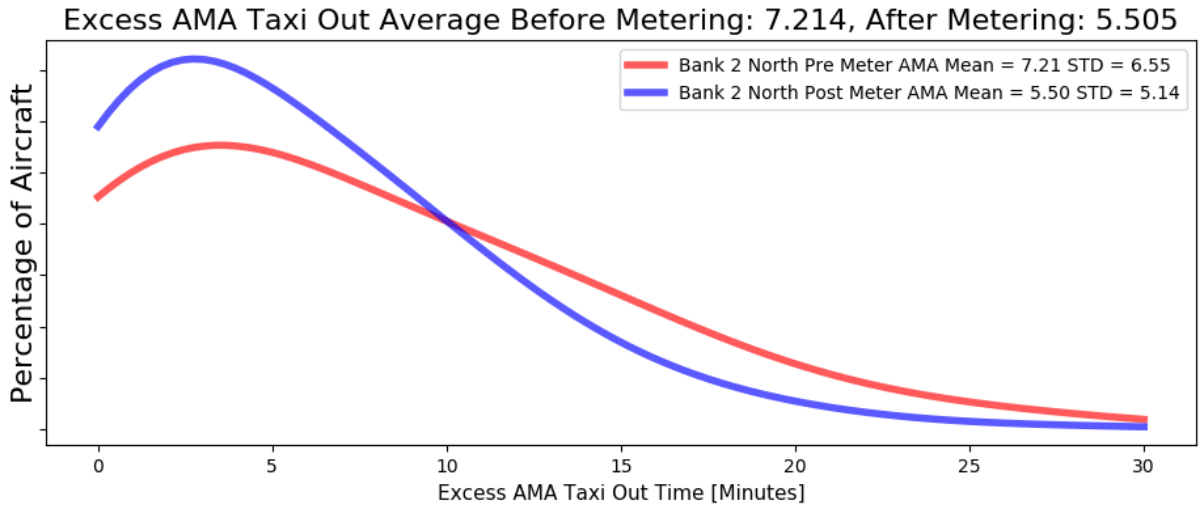


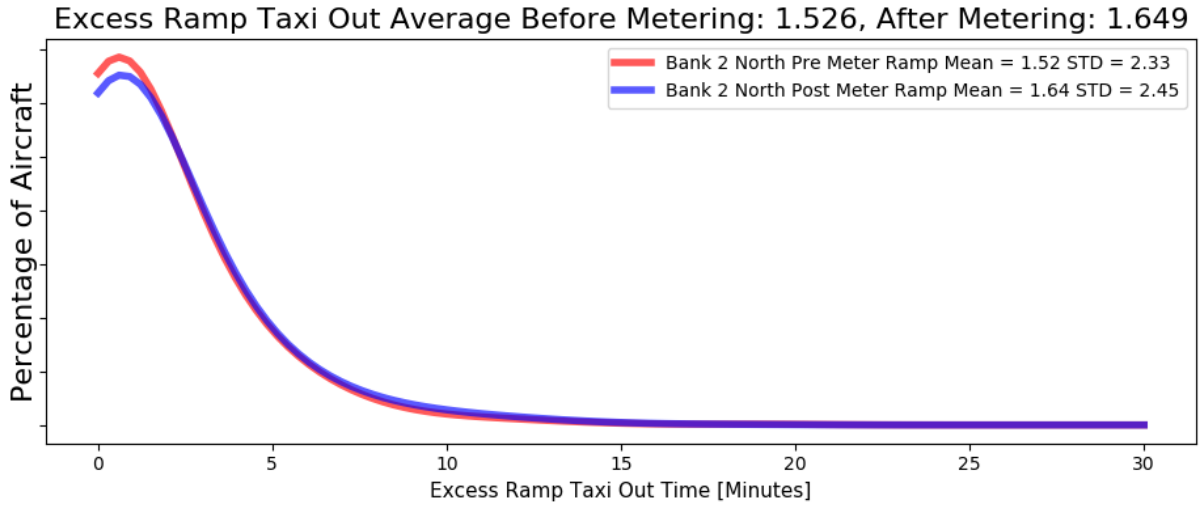
Surface Metering by Bank

- Surface metering extended beyond Bank 2 & 3 since October 2018



Bank 2 North Flow Excess Taxi Out Time





By reducing the percentage of flights with AMA excess taxi out greater than 10 minutes we reduce average taxi time

IADS Phase 1 Benefit Mechanisms

1. **Collaborative surface metering**
   - Reduced engine run time
   - Reduced fuel consumption and emissions

2. **Overhead stream operational integration**
   a. Scheduling controlled flights at the gate
      - Reduced engine run time
      - Reduced fuel consumption and emissions
   b. APREQ renegotiating for an earlier slot
      - Reduced total delay
      - Passenger value of time and crew costs
      - Reduced engine run time
      - Reduced fuel consumption and emissions

Benefits (1) and (2a) achieved through tactical gate holds

Benefit (2b) achieved through APREQ renegotiation process described below

Step 1: APREQ flight has a release time but is capable of taking off earlier

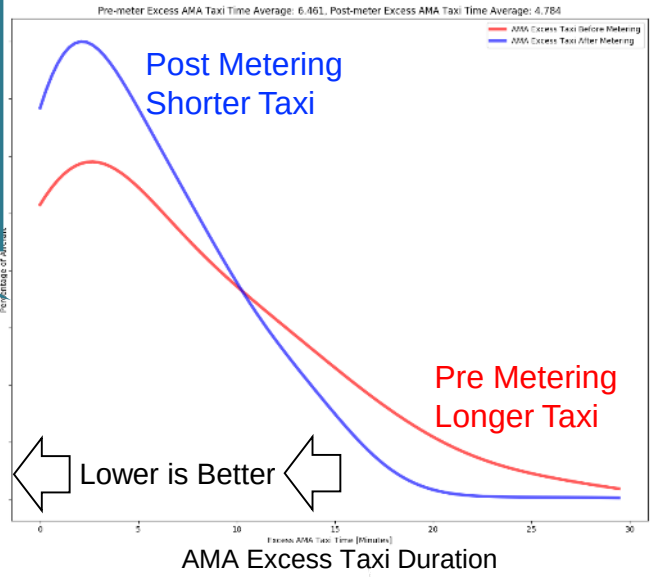
Step 2: FAA TMC uses the IDAC green space / red space to identify and request an *earlier* slot in the overhead stream

Step 3: Aircraft receives *earlier* release time and the difference between the release times is the reduction in delay

Collaborative Surface Metering Benefits through 2019-08-31

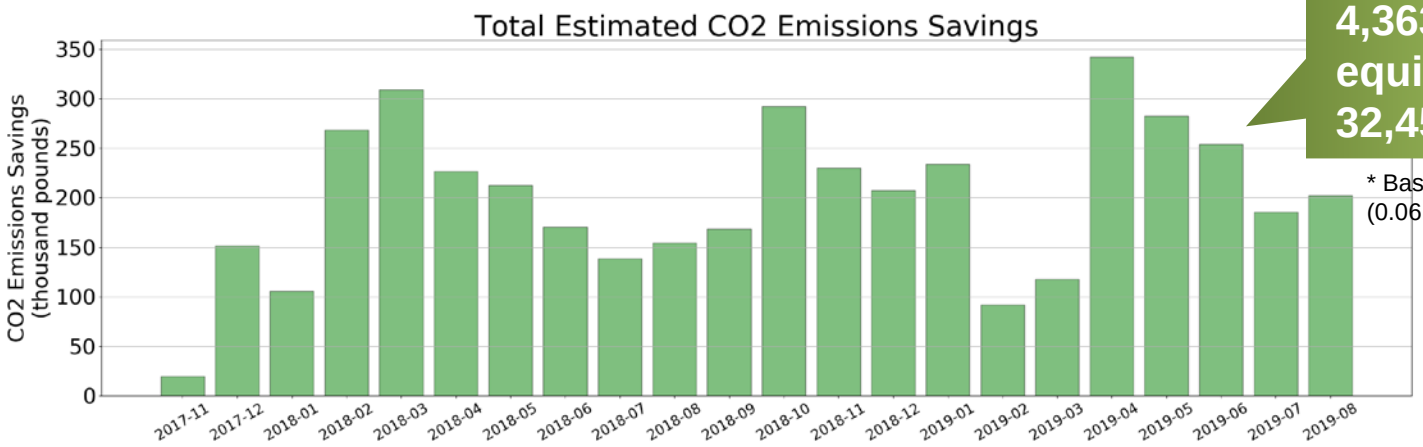
Initial benefits observed from S-CDM surface metering at CLT

Reduced AMA taxi out times during its use via small holds at gate



AMA Excess Taxi Duration

Saved approximately 1,416,851 lbs of fuel by holding 13.8% of departures with average gate hold of 5.8 minutes. Benefit mechanism (1).



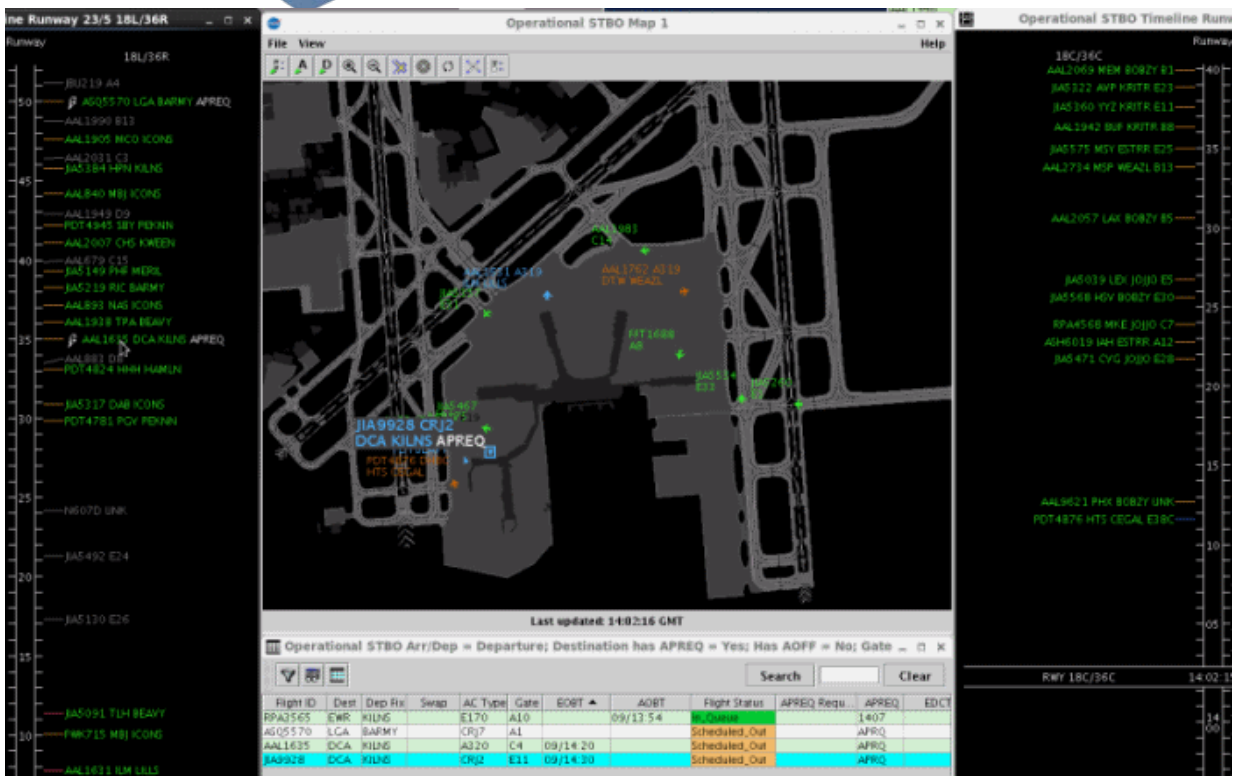
Saved approximately 4,363,901 lbs of CO2, equivalent to planting 32,450* urban trees

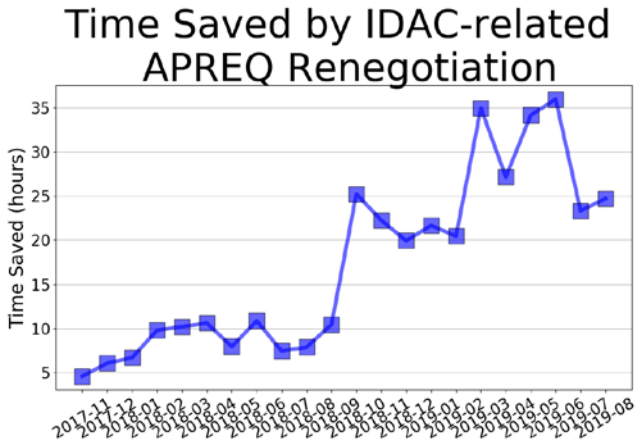
* Based on the updated equivalency factor (0.061 metric tons CO_2 per urban tree planted)[7]

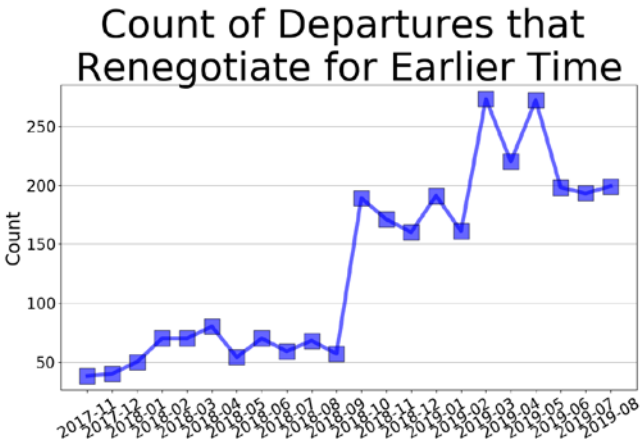
7. Source: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator-revision-history

Overhead Stream Operational Integration Benefits through 2019-08-31

382.1 hours of delay saved by electronically renegotiating a better overhead stream time for 2,883 flights. Benefit mechanism (2b).





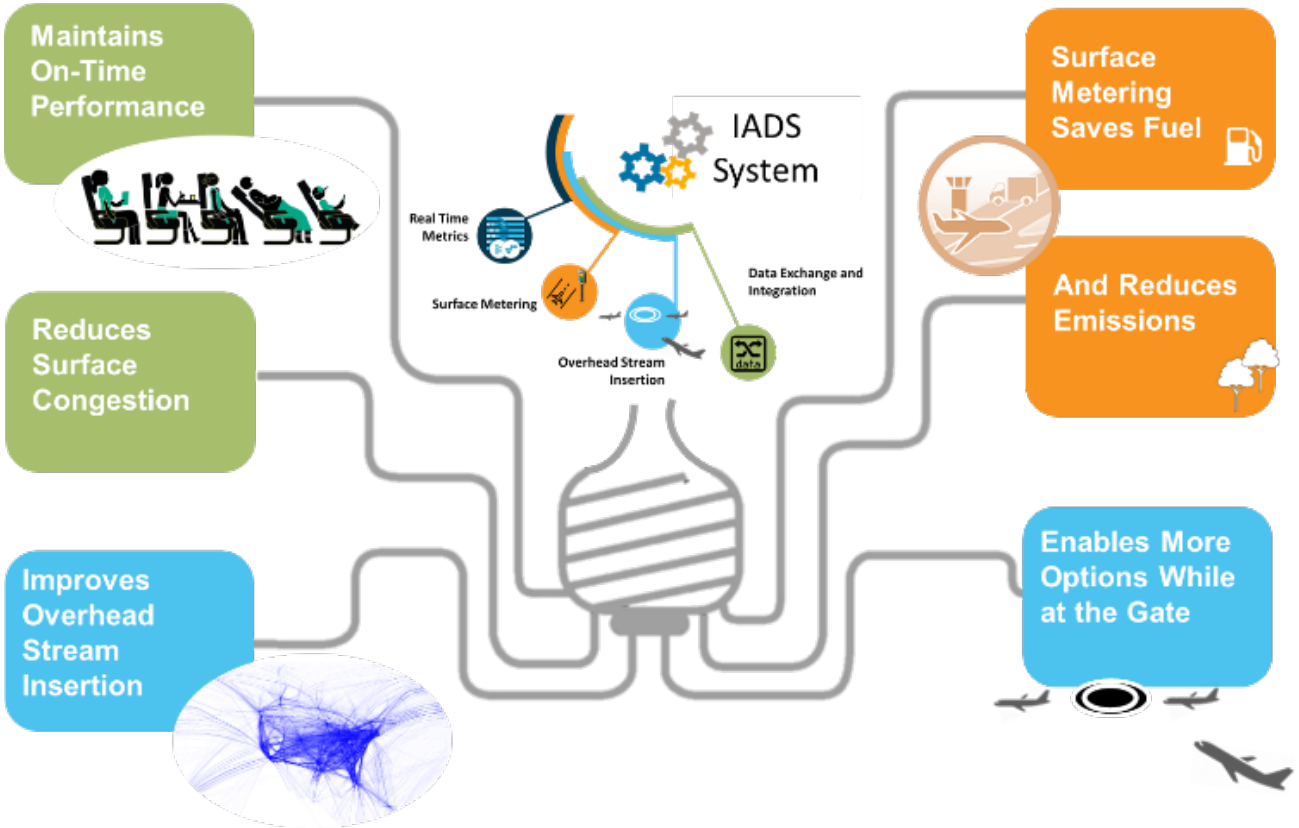


- The benefits described here are associated with better use of existing capacity in the overhead stream, and technology to reduce surface delay.
- These benefits are in addition to (distinct from) surface metering savings.

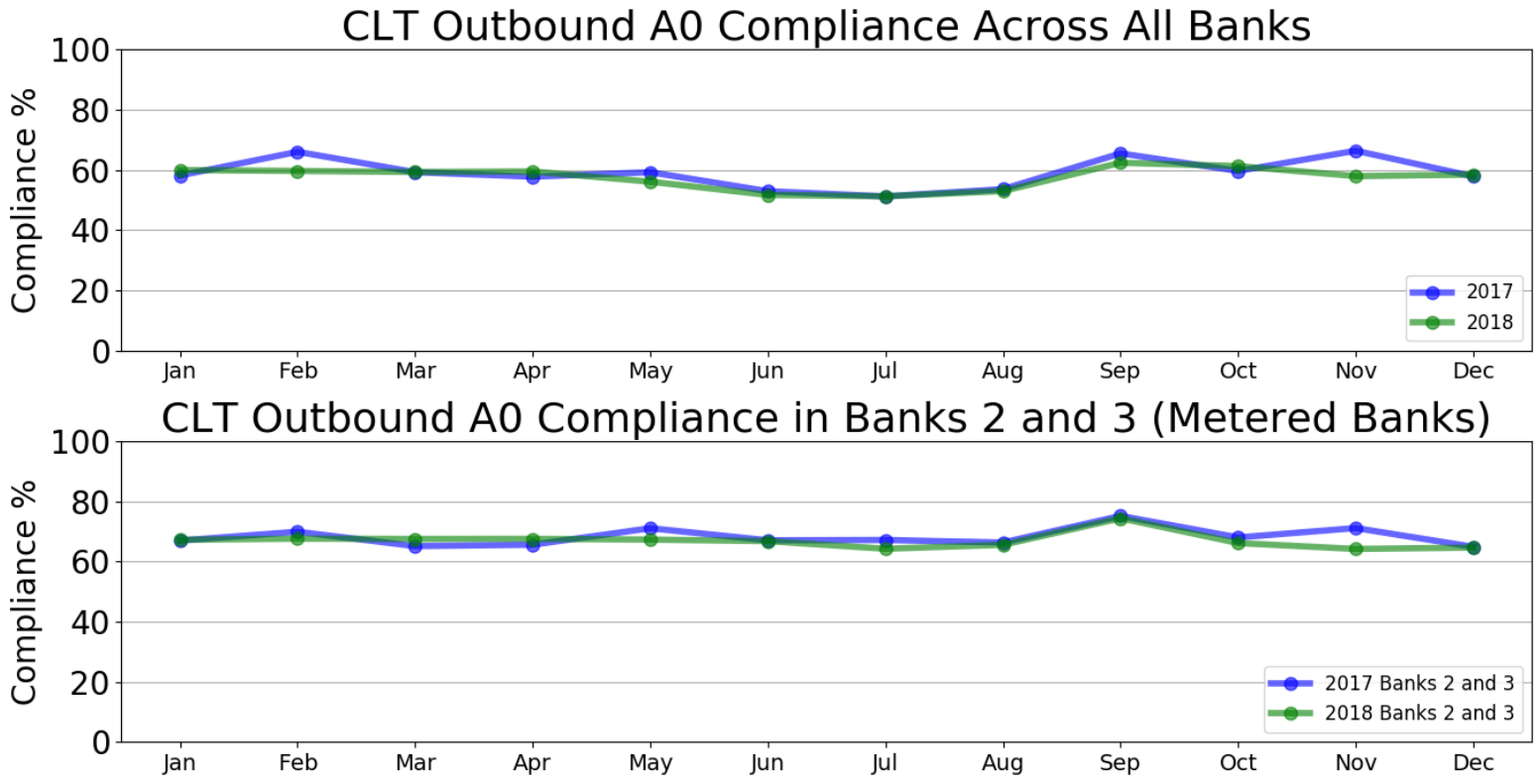
Demonstrating Benefits in the Field

- Multiple benefits mechanisms (benefits through 2019-08-31)
  - 2,892,148 lbs. of fuel saved
  - CO_2 savings equivalent to 66,238* urban trees
  - 382.1 hours of surface delay saved
    - $1,834,251 passenger value of time
    - $519,759 flight crew costs
  - 2,259 hours of reduced runtime on engines

* Based on the updated equivalency factor (0.061 metric tons CO_2 per urban tree planted)

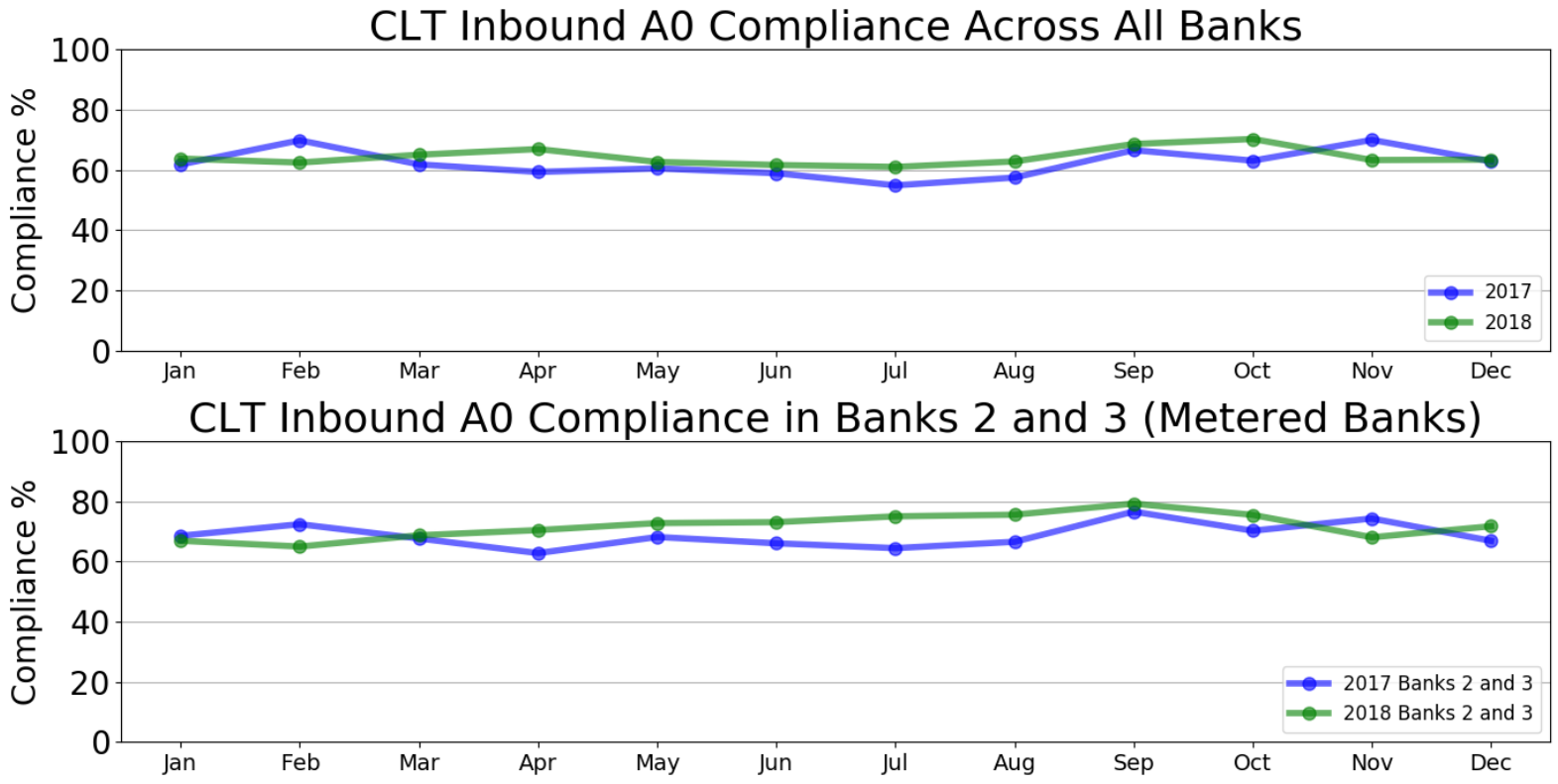


Outbound A0 On Time Performance



	2017 Compliance	2018 Compliance	YoY Change
Across All Banks	58.8%	57.5%	-1.3%
Banks 2 & 3	68.1%	66.8%	-1.3%

Inbound A0 On Time Performance



	2017 Compliance	2018 Compliance	YoY Change
Across All Banks	62.1%	64.4%	+2.3%
Banks 2 & 3	68.6%	71.9%	+3.3%

Summary

- ATD-2 Phase 2 Fused IADS Demonstration research
  - Added capabilities at CLT to achieve Phase 2 Fused IADS system
    - ✓**Tactical-Strategic Fusion** – extend time horizon for metering
    - ✓**TMI Evolution** – evaluation of pre-scheduling into Center
    - ✓**AEFS Integration** – electronic interface with ATC
    - ✓**TFDM Terminal Publication** – deliver IADS data via FAA SWIM
    - ✓**Mobile App** – allows GA operators to submit estimated departure time
- Fused demo includes users at: CLT Tower, CLT TRACON, multiple Centers (ZTL, ZDC), AAL Ramp Tower, AAL IOC, CLT Airport, Corporate Flight Operators
- Multiple benefits achieved (through 2019-08-31):
  - 2,892,148 lbs. of fuel saved
  - CO_2 savings equivalent to 66,238 urban trees
  - 382.1 hours of surface delay saved
    - ✓ $1,834,251 passenger value of time
    - ✓ $519,759 flight crew costs
  - 2,259 hours of reduced runtime on engines

References

TMI Evolution:

1. *Slide 47* - Picture from the NTML Reference Guide R11, v3.9, available at https://faaco.faa.gov/index.cfm/announcement/view/23765
2. *Slide 49* - Example ground stop advisories can be found in context here: https://www.fly.faa.gov/adv/adv_list.jsp?WhichAdvisories=ATCSCC&AdvisoryCategory=NotAll&dates=A%2C+11-06-2017&Gstop=Gstop

TTP:

3. *Slide 108* - Source: https://www.faa.gov/air_traffic/technology/tfdm/implementation/
4. *Slide 111* - Source: NASA TTP NSRR
5. *Slide 116* - Source: https://www.faa.gov/air_traffic/technology/swim/products/get_connected/
6. *Slide 118* - Source: https://nsrr.faa.gov/services/nasa-ttp/documents

Analysis:

7. *Slide 129* - Source: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator-revision-history