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 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.

Real Time Metrics

Surface Metering

Overhead Stream Insertion

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

## ATC
- 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

## Ramp
- 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

## Flight Deck
- 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 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

### 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

### 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 Development
Fused IADS Demonstration

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

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)

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

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)

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)
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
• 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

Data from External Systems

Flight Data Matching and Fusion

TMI Processing

User-Entered TMIs

STBO

RTC

IADS Model

IADS Scheduler

Flight Updates

Surface Model / Scheduling / Metering Data

External Flight Data

Adaptation

Database

Colors correspond to different tracks
• 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
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.
Set desired metering parameters (continued)
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
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
• 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

User Inputs

1st Pass: Metering
First-Scheduled First-Served (FSFS)
or First-Come First-Served (FCFS)

User Actions

SMP Detection
Strategic or Tactical

User Priorities

If metering,
• Assign TOBTs and TMATs
• Prioritize flights

2nd Pass: Prediction
First-Come First-Served (FCFS) based on assigned TOBTs

Outputs

SMPs
TOBTs and TMATs
TTOTs for Timeline
• 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
• 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
• 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 36C Runway Prediction Accuracy

SMP Detection Count

SMP Start Time Accuracy (Actual – Predicted)
• 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
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.
• The strategic algorithms use the per flight predictions of excess taxi time to predict when metering would be on or off.
The basic flow of the SMP detection and update logic is:

1. **Using the results of the 1st scheduler pass, predict**
   - Metering on triggers will be met
   - Metering off triggers will be met

2. **Match those predicted time periods to existing SMPs**

3. **Update the end time of ACTIVE SMPs**
   - If the metering off triggers are currently met, then no update.
   - If no existing SMP matched to metering on time period and metering on time period is within SMP Lead Time, then create a new proposed SMP
   - If matched to existing SMP, then update the existing SMP
   - If an existing SMP is unmatched, then make it OBSOLETE if it is not active.

4. **Identify flights that are affected by each SMP**

5. **Update avg. and max gate hold stats for each SMP**
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

**1st Pass: Metering**

- **User Actions**
  - Update existing SMPs based on user actions
  - Predict time periods when metering should be on/off
  - Match predicted time periods with existing SMPs
  - Match found?
    - Yes
      - Update existing SMP
    - No
      - Propose new SMP
      - Update SMP flight list
      - Update SMP metrics
      - Assign TOBTs and TMATs

- **Existing SMPs**

**SMP Updates**
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
• 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

User Inputs
- 1st Pass: Metering
- First-Scheduled First-Served (FSFS)
- First-Come First-Served (FCFS)

User Actions
- SMP Detection
- Strategic or Tactical

User Priorities
- If Metering, Assign TOBTs and TMATs
- Prioritize flights

Outputs
- SMPs
- TOBTs and TMATs
- TTOTs for Timeline

2nd Pass: Prediction
- First-Come First-Served (FCFS) based on assigned TOBTs
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 perform 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 (TMI)
  – Providing tools to manage TMI 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 TMI from TFM – Flow and OIS
  – Allow ATD-2 users to generate new TMI
  – Assign TMI 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:

<table>
<thead>
<tr>
<th>TMI Type</th>
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<tr>
<td>APREQs</td>
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<tr>
<td>MITs</td>
<td>OIS, User</td>
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<td>User, Model</td>
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</table>
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
Parsed and interpreted data is stored in XML files for reference.
Contains original text from OIS page as well as interpreted data for comparison.
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

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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
TFM Flow data provides added value to the OIS TMI data

Source for the following TMI:
- Restrictions (Type=RSTR)
  - MIT/MINIT
  - Fix Closure (STOP)
- General Advisories (Type=GADV)
  - Reroutes
  - GDP/GS

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# 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.
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 Panel¹
- 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
### Airport Information

<table>
<thead>
<tr>
<th>TMI</th>
<th>OIS</th>
<th>TFM Flow</th>
<th>NTML</th>
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<tbody>
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### Airspace Flow Programs

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<tbody>
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### Ground Delay Programs

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<tbody>
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### Ground Stops

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<tr>
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### Miles/Minutes in Trail

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### Altitude Restrictions

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### APREQs

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### Advisories

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### Closures (Fixes, etc.)

<table>
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### FADT

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### RAPT

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### CTOP

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### DICE

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### REROUTEs

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### TMI FLIGHT LIST

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- 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.
• 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. 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.

Example of Manual Ground Stop Advisory
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
• 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.)
• 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
• 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
• 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
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
• 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
• 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.

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.

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

**Important Note:** Providing an EOBT gives you an advantage!
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.
• 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.
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
• 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
• 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
• 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
• 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
• 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
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
• Impact to STBO Client
  – Flights marked as APREQ-constrained on timelines and map

• Impact to RTC Client
  • Flight strips marked as APREQ-constrained
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
• 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
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
• 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)
• 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
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
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
• 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
• 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
• 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
• 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
• Set Release
  – Tower controller manually enters a negotiated release time (required for Manual mode, optional for Semi and Auto modes)
  – Modes: Manual, Semi, Auto
• Request Release Time
  – Modes: Semi, Auto
  – Flight scheduled departure runway time sent as the requested release time (flight representation: yellow arrow)
• 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
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.
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.
• 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
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.
Two-Way Information Exchange Example

**RTT Location**

Pilots stop and contact Ground Control for their Taxi Clearance.

Pilot transports passengers to the aircraft. Pilots start engines and begin taxiing from their parking spot to the edge of the Ramp area.

One pilot waits in the FBO for passengers.

When the passengers arrive...

... the pilot submits their best estimate of when they expect to arrive at the RTT Location, i.e., their Ready-to-Taxi Time (RTT). (In Image: 22:35Z)

Pilots receive Data Elements. (In Image: Expected wheels-up time 22:42Z Expected departure runway 36R)
The data elements presented to pilots are TTOT, Expected Departure Runway, and TMI information (when applicable).

For TMI s, 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 TMI s:
  - “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) TMI s 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.
**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.

Flight-specific information is sent to MITRE, via the TFDM Terminal Publication (TTP) that NASA publishes on the System Wide Information Management (SWIM) research and development network.

Those data elements include:
1) TTOT, 2) expected RWY, and 3) an indication that the flight is subject to an APREQ or Miles-in-Trail (MIT) restriction when applicable.

*Note: EDCT information is not sent via TTP.*

The AEFS system also receives the RTT.

**MITRE** receives the RTT and sends it to the CLT IADS STBO Scheduler.

**MITRE** receives the data elements via TTP and sends them to the pilot via text.

*Note: If MITRE detects a significant change (i.e., TTOT change of 5 min or more, a runway change, or TMI addition, they send another update to the pilot.)*

The ATC System receives filed departure time.

The IADS STBO Scheduler receives the RTT.
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

**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
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
• 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
• 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/
Applications that Leverage the TTP Prototype Feed

- Mobile Application for GA Flights
- Airline Carrier Ingestion
- TBD

TFDM Terminal Publication:
IADS and Data Sharing

IADS System

Data Fusion and Mediation (Fuser)

- TFDM SWIM
- TFMS SWIM
- TBFM SWIM
- Surface SWIM
- Operational TBFM IDAC
- R-TBFM CAP/SWIM
- R-TBFM IDAC/WSRT
- AAL Flight Hub
- AAL Surface Surveillance
- Commercial Flight Service
- NTML/OIS Operational info

SWIM TTP Service
<table>
<thead>
<tr>
<th>Service</th>
<th>Includes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight Data</td>
<td>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</td>
</tr>
<tr>
<td>Airport Information</td>
<td>Airport configurations, airport and runway rates, ramp closures, runway closures, taxiway closures</td>
</tr>
<tr>
<td>Traffic Management Restrictions</td>
<td>Call for Release programs, departure MIT/MINIT restrictions, departure stop/ground stop programs (along with list of impacted flights for each)</td>
</tr>
<tr>
<td>Flight Delay</td>
<td>Airport and runway delay by arrival, departure, and total</td>
</tr>
<tr>
<td>Operational Metrics</td>
<td>Metrics on airport throughput and individual flight metrics</td>
</tr>
<tr>
<td>Surface Metering Program</td>
<td>SMP start / end times, metering constraint type / details, updates to existing programs, TMAT compliance window, departure queue length, and more</td>
</tr>
</tbody>
</table>
### TFDM Terminal Publication: TTP Services (cont.)

<table>
<thead>
<tr>
<th>Name</th>
<th>Event Driven</th>
<th>Full Update</th>
<th>Implemented in NASA TTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight Data</td>
<td>Yes</td>
<td>Every 15 minutes</td>
<td>Yes (subset)</td>
</tr>
<tr>
<td>Airport Information</td>
<td>Yes</td>
<td>Every 15 minutes</td>
<td>Yes (subset)</td>
</tr>
<tr>
<td>Traffic Management Restrictions</td>
<td>Yes</td>
<td>Every 15 minutes</td>
<td>Yes (subset)</td>
</tr>
<tr>
<td>Flight Delay</td>
<td>Yes</td>
<td>Every 15 minutes</td>
<td>Yes (subset)</td>
</tr>
<tr>
<td>Operational Metrics</td>
<td>No</td>
<td>Every 15 minutes</td>
<td>Yes (subset)</td>
</tr>
<tr>
<td>SMP</td>
<td>Yes</td>
<td>Every 15 minutes</td>
<td>Yes (subset)</td>
</tr>
</tbody>
</table>

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

4. Source: [NASA TTP NSRR](#)
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

<table>
<thead>
<tr>
<th>Header</th>
<th>Flight Data</th>
<th>Airport Information</th>
<th>Traffic Management Restrictions</th>
<th>Flight Delay</th>
<th>Operational Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA_GROUP</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MESSAGE_TYPE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>AERODROME</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>AIRLINE</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>SYNC</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>TIME_STAMP</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>PRIVACY_LEVEL</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>TFDM_RELEASE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SCHEMA_VERSION</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>TIME_STAMP</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>UUID</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>DATA_GROUP</th>
<th>MESSAGE_TYPE</th>
<th>SYNC</th>
<th>MESSAGE BODY</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>FlightData</td>
<td>PeriodicStart</td>
<td>per</td>
<td>Empty</td>
<td>Periodic sync has started</td>
</tr>
<tr>
<td>FlightData</td>
<td>FlightAdd</td>
<td>per</td>
<td>xml</td>
<td>All data on flight1</td>
</tr>
<tr>
<td>FlightData</td>
<td>FlightAdd</td>
<td>per</td>
<td>xml</td>
<td>All data on flight2</td>
</tr>
<tr>
<td>FlightData</td>
<td>FlightAdd</td>
<td>per</td>
<td>xml</td>
<td>All data on flight3</td>
</tr>
<tr>
<td>FlightData</td>
<td>PeriodicEnd</td>
<td>per</td>
<td>Empty</td>
<td>Periodic sync has ended</td>
</tr>
</tbody>
</table>
Getting Access to SWIM

1. External Consumer Contacts SWIM Team
   - Send email to Data-To-Industry@faa.gov
   - Review SWIM Consumer Brief and follow the outlined process
   - FAA POC assigned to external consumer

2. Select Data Service(s) and Sign Access Agreement(s)
   - Review and identify one or multiple Data Sets available at data.faa.gov
   - Create account and sign Access Agreement
   - Receive notification via email that an Access Agreement for specific Data Set(s) has been signed

3. Consumer Processing / Formalize Requirements
   - Create SWIM account and review service metadata
   - Confirm service to be consumed and complete On-ramping Form

4. Testing of Consumer Interface in the Dev Test Environment
   - Establish connectivity to the FAA Dev Test Environment
   - Develop consumer interface
   - Test with the NAS Enterprise Messaging Service (NEMS)

5. Integration Testing in the FTI National Test Bed (FNTB)
   - Conduct a series of formal tests to ensure operational readiness.

6. Prepare to Connect to Operations
   - Establish connectivity to the NESG
   - Establish connectivity with the operational NEMS

7. Service Operational

Key
- External Consumer Responsibility
- FAA Driven Process

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
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)

Operational Concepts & Impacts
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

<table>
<thead>
<tr>
<th>Facility</th>
<th>Personnel</th>
<th>Capability</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLT Tower</td>
<td>Ground and Local Controller</td>
<td>• TFDM EFD for surface traffic control</td>
<td>Operational</td>
</tr>
<tr>
<td></td>
<td>TMC</td>
<td>• STBO Client display with TBFM/IDAC for APREQ/CFR coordination</td>
<td>Operational</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• RTC display</td>
<td>Observer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• TFDM EFD for surface traffic management</td>
<td>Operational</td>
</tr>
<tr>
<td></td>
<td>CD</td>
<td>• TFDM EFD for surface traffic management</td>
<td>Operational</td>
</tr>
<tr>
<td>CLT TRACON</td>
<td>TMU</td>
<td>• STBO Client display</td>
<td>Operational</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• RTC display</td>
<td>Observer</td>
</tr>
<tr>
<td>Center (ZDC, ZTL)</td>
<td>TMU</td>
<td>• STBO Client display</td>
<td>Observer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Enhanced TBFM/IDAC for APREQ/CFR coordination with CLT Tower</td>
<td>Operational</td>
</tr>
<tr>
<td>AAL Ramp Tower</td>
<td>Ramp Controller</td>
<td>• Ramp Traffic Console (RTC)</td>
<td>Operational</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• STBO Client display (optional)</td>
<td>Observer</td>
</tr>
<tr>
<td></td>
<td>Ramp Traffic Manager</td>
<td>• Ramp Manager Traffic Console (RMTC)</td>
<td>Operational</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• STBO Client display</td>
<td>Observer</td>
</tr>
<tr>
<td>AAL Integrated Operations Center (IOC)</td>
<td>Research Observer</td>
<td>• Ramp Traffic Console (RMTC)</td>
<td>Observer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• STBO Client display</td>
<td>Observer</td>
</tr>
<tr>
<td>CLT Airport</td>
<td>Airport Authority and Facility Manager</td>
<td>• STBO Client display and RTC display</td>
<td>Observer</td>
</tr>
<tr>
<td>Corporate Flight Operators</td>
<td>Pilots/Dispatchers</td>
<td>• Two-way information flow via Mobile App, enabled by TTP</td>
<td>Operational</td>
</tr>
</tbody>
</table>
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
• 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 extended beyond Bank 2 & 3 since October 2018
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
Initial benefits observed from S-CDM surface metering at CLT

- 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

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

* Based on the updated equivalency factor (0.061 metric tons CO2 per urban tree planted)7

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

#### Across All Banks

<table>
<thead>
<tr>
<th></th>
<th>2017 Compliance</th>
<th>2018 Compliance</th>
<th>YoY Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across All Banks</td>
<td>58.8%</td>
<td>57.5%</td>
<td>-1.3%</td>
</tr>
<tr>
<td>Banks 2 &amp; 3</td>
<td>68.1%</td>
<td>66.8%</td>
<td>-1.3%</td>
</tr>
</tbody>
</table>

#### CLT Outbound A0 Compliance Across All Banks

![Graph showing compliance across all banks from January to December with a YoY change of -1.3% for Banks 2 & 3.](image)

#### CLT Outbound A0 Compliance in Banks 2 and 3 (Metered Banks)

![Graph showing compliance in Banks 2 and 3 from January to December with a YoY change of -1.3% for Banks 2 & 3.](image)
### Inbound A0 On Time Performance

<table>
<thead>
<tr>
<th></th>
<th>2017 Compliance</th>
<th>2018 Compliance</th>
<th>YoY Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across All Banks</td>
<td>62.1%</td>
<td>64.4%</td>
<td>+2.3%</td>
</tr>
<tr>
<td>Banks 2 &amp; 3</td>
<td>68.6%</td>
<td>71.9%</td>
<td>+3.3%</td>
</tr>
</tbody>
</table>
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
  - CO₂ 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:
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:
4. Slide 111 - Source: NASA TTP NSRR
5. Slide 116 - Source: https://www.faa.gov/air_traffic/technology/swim/products/get_connected/

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