TFDM Tech Talk: Substitution

Presented to: TFDM Industry Stakeholders

By: FAA TFDM Collaborative Site Implementation Team

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Introductions

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Agenda

- TFDM Overview
- TFDM Testbed
- Overview of the Surface Management Programs (SMP)
  - The SMP Concept
  - Overview of SMP Procedures
- Management of Departures via the TFDM FOS (Flight Operator System) Collaboration Service (TFCS)
  - TFCS Message Patterns
  - TFCS Flight Substitutions
  - Relinquishing an Infeasible Target Movement Area entry Time (TMAT)
  - Marking a Flight for Substitution
- TFCS Ramp Closure/Gridlock Notifications

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TFDM Overview

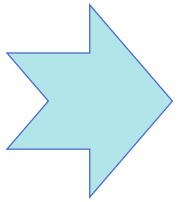
TFDM Program Overview

TFDM is the surface management solution for NextGen and iTBO.

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

- TFDM will provide an integrated tower flight data automation system, which will improve controllers' common situational awareness.
- TFDM will improve efficiencies on the airport surface and terminal airspace by providing:

- Electronic Flight Strips in the Tower
- Collaborative Decision Making for the Surface
- Traffic Flow Management Integration
- Systems Consolidation



Key Benefits:

- Fuel Savings
- Carbon Emission Savings
- Improved Situational Awareness
- Pre-scheduling flights

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TFDM's Interface to Industry

- To interact with TFDM, stakeholders will utilize two SWIM interfaces:
  - **TFDM Terminal Publication (TTP)** – Pub/sub service that provides all of TFDM's data across six business functions:
    - Flight Data
    - Airport Information
    - Flight Delay
    - Traffic Management Restrictions
    - Operational Metrics
    - Surface Management Programs
  - **TFDM FOS Collaboration Service (TFCS)** – Request/reply service that allows stakeholders to request substitution during surface metering and indicate ramp closures/gridlock events

TFDM Program Roll-Out Overview

Build 1

Key Site - PHX

- Full hardware development to support the deployment of Build 1 & 2
- Improved Electronic Flight Data Exchange and Electronic Flight Strips
- Runway Assignment Predictions
- Maintenance tools for life cycle support
- B1 TTP Service Offered

- **Initial Operating Capability:** ~~June 2020~~
- **In-Service Decision:** ~~September 2020~~

Dates being replanned due to COVID-19 Impacts
B1 IOC will not occur before November 2021

Build 2

Key Site - CLT

In addition to the Build 1 capabilities

- Surface Scheduling
- Surface Metering
- Runway Load Balancing
- Metric Reporting & Analysis (MRA)
- B2 TTP and TFCS Services Offered

- **Initial Operating Capability:** ~~May 2021~~
- **In-Service Decision:** ~~September 2021~~

Dates being replanned due to COVID-19 Impacts
B2 IOC will not occur before November 2022

TFDM Testbed

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TFDM Testbed

- TFDM has set up a testbed to allow airport stakeholders to test connectivity with a test instance of TFDM B2 software
  - Hosted in a Leidos (TFDM prime contractor) lab with simulated SWIM connections
  - Uses recorded data from CLT

- Open to airports, airlines, and 3rd party vendors to test connections to TFDM prior to TFDM B2 being deployed in the field

- If interested, contact Doug Swol (Christopher.D.Swol@faa.gov) or CSIT (csit@faa.gov)

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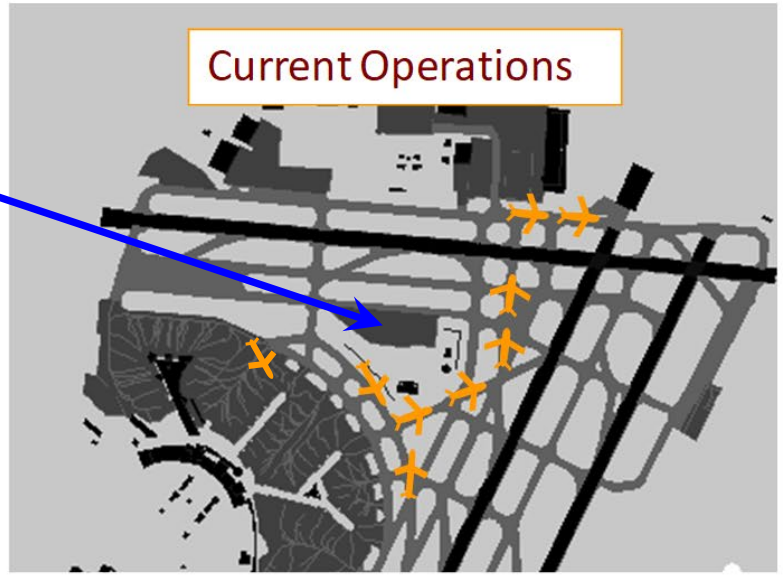
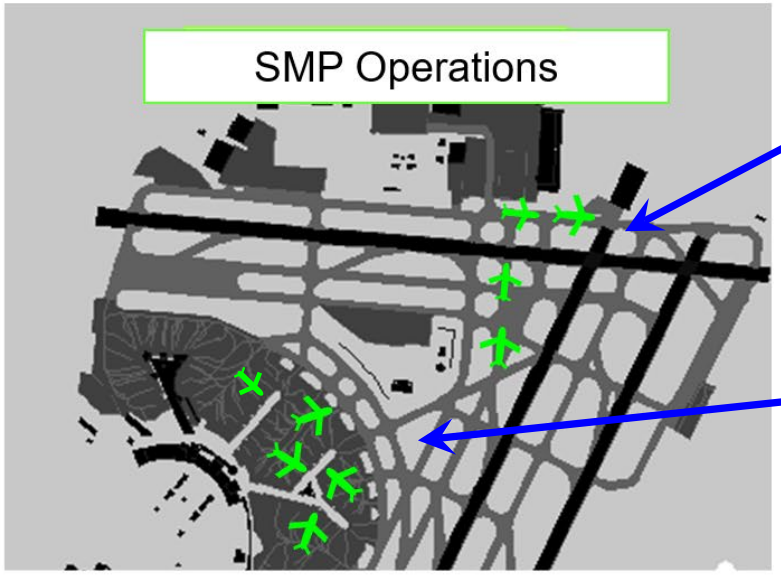
SMP Overview

The TFDM SMP Concept

- Departure operations in the NAS are largely managed on a first come, first served basis
- The result is often long departure queues, surface congestion and excess fuel burn
- The goal of SMP operations is to manage the departure queue length by assigning equitable off block times without reducing departure throughput

Long departure queue develops as flights begin taxi as soon as they are ready





SMP operations result in shorter queues…

…through the control of pushback times

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Overview of SMP Procedures

- TFDM Surface Management Programs (SMP) manage the length of the departure queue during periods of high departure demand
  - TFDM continually monitors and predicts queues at departure runways
  - When the predicted queue length exceeds a user-defined threshold, SMP procedures may be initiated
- The predicted departure queue entry time for a flight is based on:
  - For flights still at the gate: assigned/predicted gate, estimated off-block time and predicted taxi time from gate to queue
  - For flights that have pushed back: current position/state and predicted taxi time from current position to queue
    - (Takeoff times for flights are based on predicted queue order and runway separation requirements)

Overview of SMP Procedures

- When SMP procedures are initiated, departures are assigned Target Movement Area entry Times (TMATs) which are:
  - Calculated to ensure maximum use of departure capacity while minimizing the departure queue to the desired/assigned length
  - Based on:
    - RBS principles and Initial Off Block Times (IOBTs)
    - Updated earliest off block times (EOBTs) provided by flight operators
    - TMATs change dynamically outside the user-defined static time horizon
    - TMATs within the static time horizon are “frozen”
- Departures also receive Target Off Block Times (TOBT) based on their assigned TMAT and Ramp Transit Times (RTTs)
  - Flight operators are responsible for getting flights to the movement area entry point within the TMAT compliance window

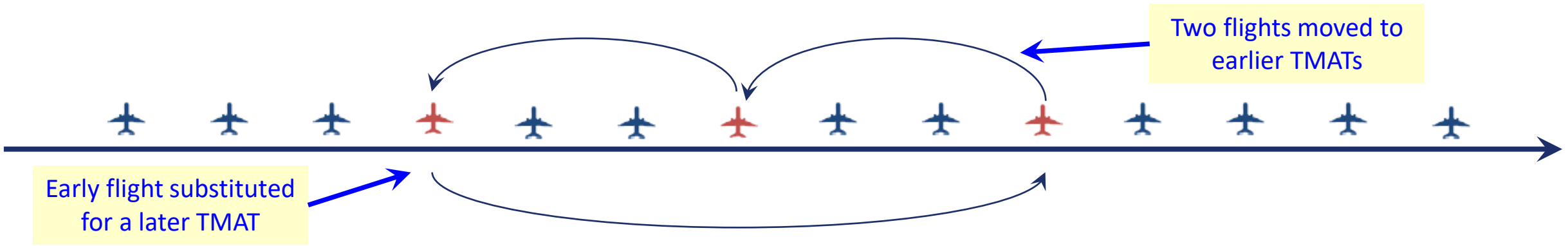
Substitution Overview

Flight Operator Management of Departures via TFCS

- TFDM Flight Operator System (FOS) Collaboration Service (TFCS) provides flight operators multiple methods for managing the dynamic nature of departures during an SMP:
  - Flight operators can substitute (swap) TMATs among its departures
  - Flight operators can “mark for substitution” a flight that is delayed or canceled (i.e., reserve for later substitution)
    - Loosely similar to holding a slot in a Ground Delay Program (GDP)
  - Flight operators can “relinquish” an infeasible TMAT and receive a new TMAT
    - Loosely similar to releasing a slot in a GDP

TMAT Substitution Overview

- The TMAT substitution process is analogous to the substitution process used by flight operators to swap EDCTs during GDPs and AFPs
- TMAT substitution can address issues including:
  - The dynamic nature of departure operations
  - Individual flight operator business priorities



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Substitution Example: *Two Flights–Exact Substitution*

- Both flights can make either TOBT
- Substituting TMATs between these flights results in an exact swap of TMATs
  - TOBT = new TMAT – Ramp Transit Time (10 minutes in this example)

Before Substitution

Callsign	EOBT	TOBT	TMAT
AAA123	12:00	12:10	12:20
AAA456	12:10	12:20	12:30

After Substitution

Callsign	EOBT	TOBT	TMAT
AAA123	12:00	**12:20**	**12:30**
AAA456	12:10	**12:10**	**12:20**

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Substitution Example: *Two Flights–Inexact Substitution*

- AAL456 cannot make the TOBT of AAA123 based on it's EOBT
  - AAL456's EOBT is 1210 which is after AAL123's TOBT
- Substituting TMATs between these flights results in AAL456 being assigned a new TMAT that it can make
  - This is referred to as an "Inexact Substitution"

Before Substitution

Callsign	EOBT	TOBT	TMAT
AAA123	12:00	12:05	12:15
AAA456	12:10	12:20	12:30

After Substitution

Callsign	EOBT	TOBT	TMAT
AAA123	12:00	**12:20**	**12:30**
AAA456	12:10	**12:10**	**12:20**

NOTE: AAL456 is not assigned the 12:15 TMAT.
It is assigned a new feasible TMAT.
- TMAT= EOBT + Ramp Transit Time = 12:20
- TOBT = EOBT = 12:10

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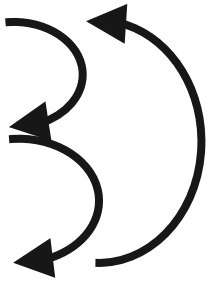
Substitution Example: *Three Flights*

- One flight moved to the back and the other two flights are shuffled forward
- This substitution can be done in a single substitution request

Before Substitution

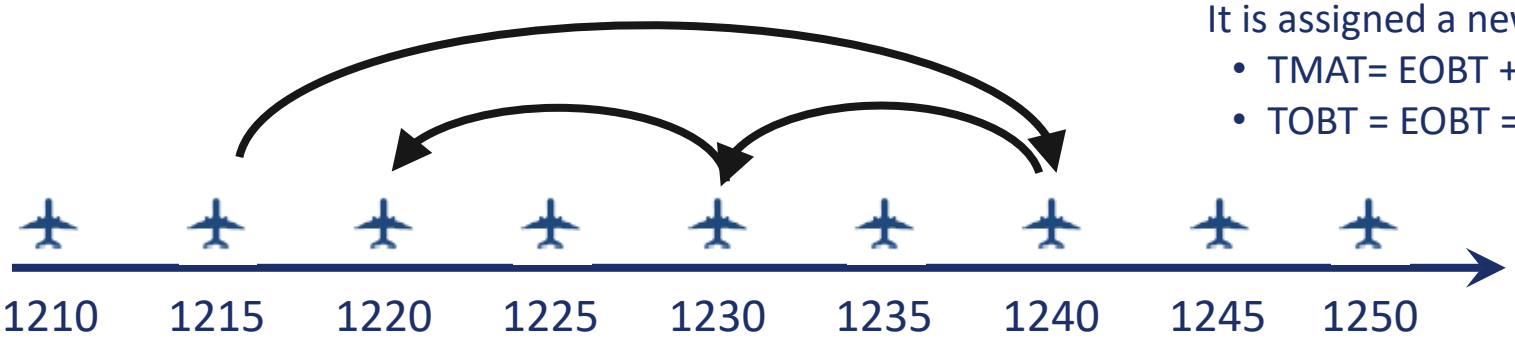
Callsign	EOBT	TOBT	TMAT
AAA123	12:00	12:05	12:15
AAA456	12:10	12:20	12:30
AAA789	12:20	12:30	12:40



After Substitution

Callsign	EOBT	TOBT	TMAT
AAA123	12:00	**12:30**	**12:40**
AAA456	12:10	**12:10**	**12:20**
AAA789	12:20	**12:20**	**12:30**

NOTE: AAL456 is not assigned the 12:15 TMAT.
It is assigned a new feasible TMAT.
- TMAT= EOBT + Ramp Transit Time = 12:20
- TOBT = EOBT = 12:10



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Substitution: *TMAT versus TOBT*

- TMATs are the time that is substituted, not TOBT
  - TOBTs are recalculated based on new TMATs and ramp transit times (RTTs)
- Ramp and AMA taxi times based on historical look-ups
  - Estimated Ramp Transit Time can be found in TTP
    - NasMessage/flight/departure/departureTaxiTime/estimatedDepartureRampTransitTime
      - NOTE: This data element is only published with a minute resolution
    - Can also be computed as difference between currently assigned TOBT and TMAT

Before Substitution

Callsign	EOBT	RTT	TOBT	TMAT
AAA123	12:00	10	12:10	12:20
AAA456	12:05	15	12:15	12:30

After Substitution

Callsign	EOBT	RTT	TOBT	TMAT
AAA123	12:00	10	**12:20**	**12:30**
AAA456	12:05	15	**12:05**	**12:20**

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NOTE: Flights exactly swapped TMATs, but TOBTs changed.

- AAA123: TOBT = TMAT - RTT = 12:30 – 10 min = 12:20
- AAA123: TOBT = TMAT - RTT = 12:20 – 15 min = 12:05

TFCS Substitution Messages

TFDM FOS Collaborative Service (TFCS) Overview

- **NOTE:** TFCS schema is still in a draft form. No major updates expected but changes are still possible

- The TFCS request/reply service provides three sets of requests to flight operators, airports, and their vendors
  - Flight Substitution Requests
    - Substitute TMATs between flights in an SMP
    - Relinquish a TMAT that a flight cannot use
    - Mark a flight for substitution (i.e. hold the slot to allow the flight operator to later manually substitute for the held flight)
  - Non-Movement Area Closure Requests
  - Non-Movement Area Gridlock Notifications

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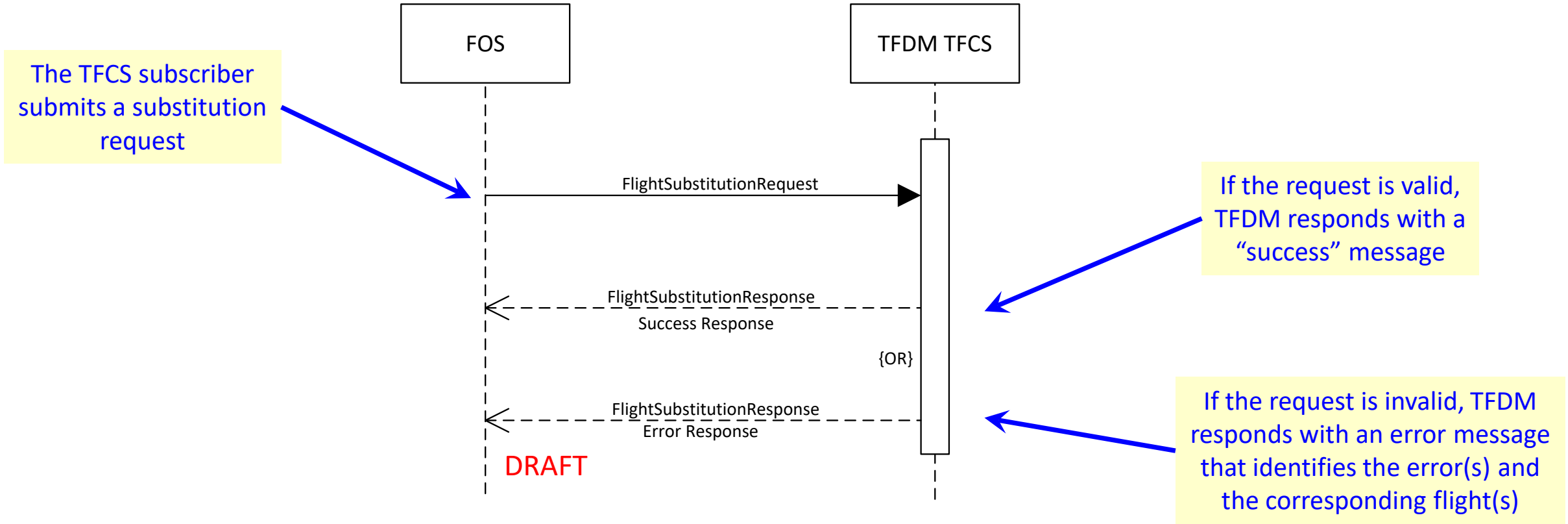
The TFCS Message Pattern for Substitutions*



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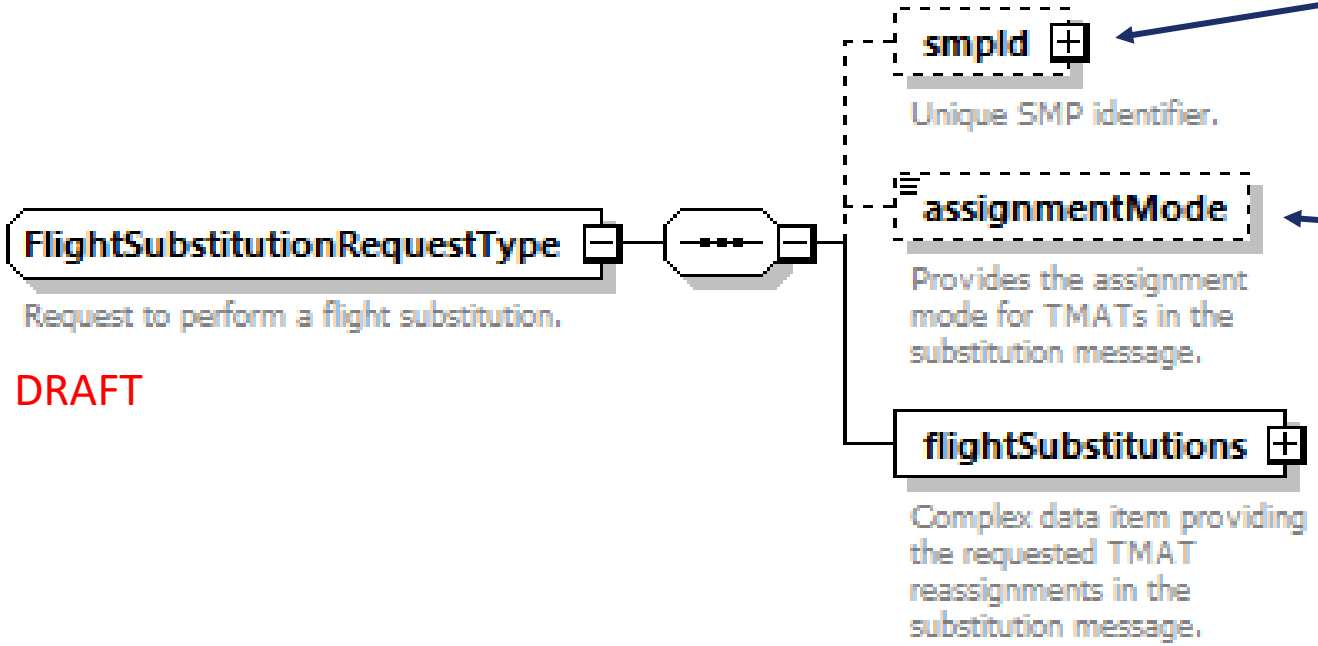
* Substitution requests are primarily used to swap TMATs between flights, but can also be used for relinquishing TMATs and marking flights for substitution (see later slides)

Substitution Message Format



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ID of the SMP that the flights in the substitution request are a part of

- Required for substitution
- Not used for TMAT relinquish and mark for substitution

NOTE: Not currently used by TFDM.

- If substituting TMATs, this is the list of flights to substitute and the requested TMATs after the substitution
- If relinquishing a TMAT or marking a flight for substitution, this is the flight to set the flag for

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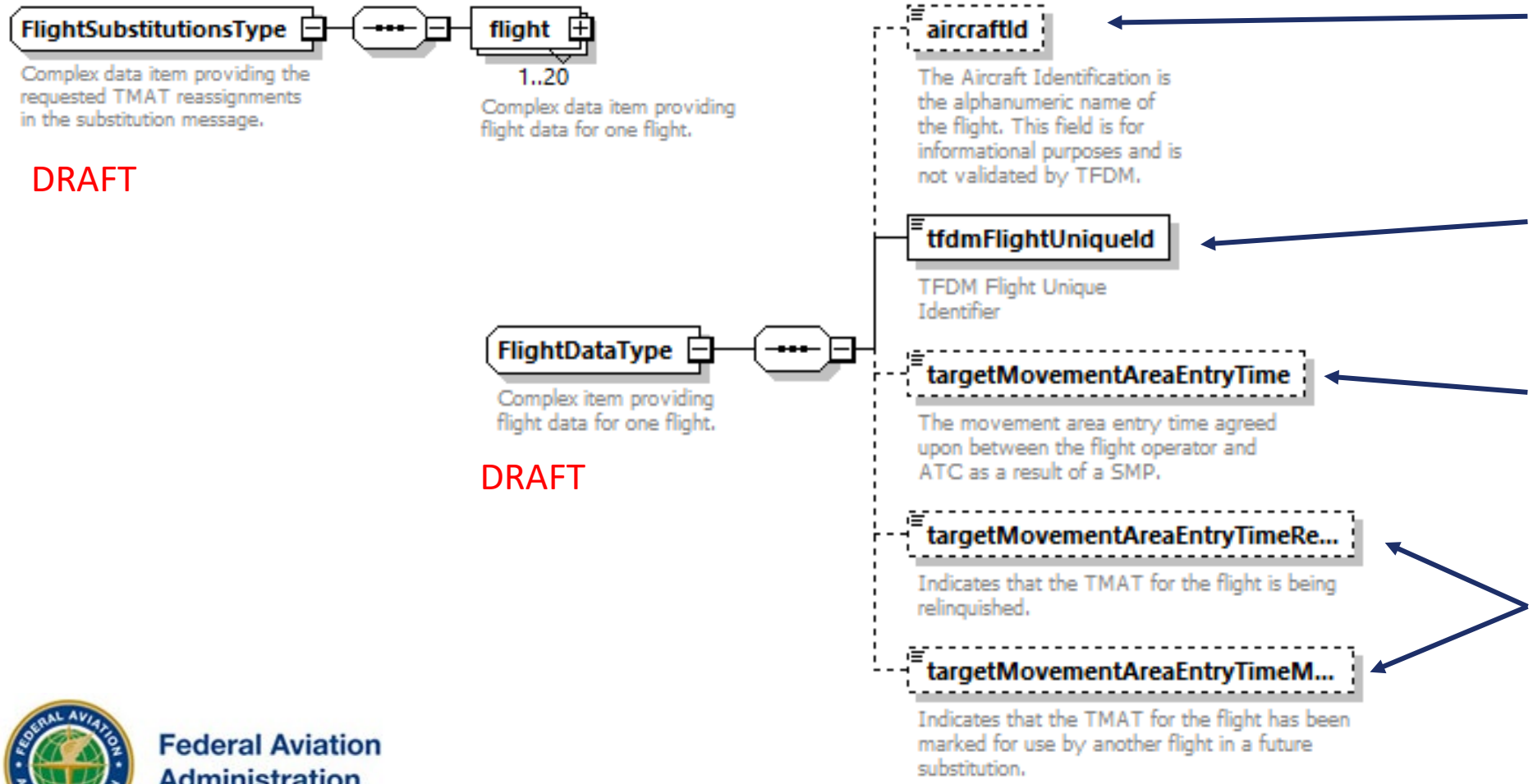
Substitution Message Format



Optional informational only field with the flight callsign

Unique ID assigned by TFDM

TMAT that is requested for the flight as part of a substitution request

See later slides for information on TMAT relinquish and mark-for-substitution

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Sample Substitution Request

```
<?xml version="1.0" encoding="UTF-8"?>
<tfcs xmlns="urn:us:gov:dot:faa:atm:terminal:services:towerFosCollaboration">
  <request>
    <flightSubstitutionRequest>
      <smpId>
        <identification>200112310001</identification>
        <aerodrome>KPHX</aerodrome>
      </smpId>
      <assignmentMode>STRICT</assignmentMode>
      <flightSubstitutions>
        <flight>
          <aircraftId>DAL1234</aircraftId>
          <tfdmFlightUniqueId>AAAAAAAA-AAAA-4AAA-9AAA-AAAAAAAAAAAA</tfdmFlightUniqueId>
          <targetMovementAreaEntryTime>2001-12-31T01:00:00</targetMovementAreaEntryTime>
        </flight>
        <flight>
          <aircraftId>DAL2345</aircraftId>
          <tfdmFlightUniqueId>BBBBBBBB-BBBB-4BBB-9BBB-BBBBBBBBBBBB</tfdmFlightUniqueId>
          <targetMovementAreaEntryTime>2001-12-31T12:00:00</targetMovementAreaEntryTime>
        </flight>
      </flightSubstitutions>
    </flightSubstitutionRequest>
  </request>
</tfcs>
```

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TFCS Substitution Request Validation

Substitution Request Validation – High Level

- The TFCS subscriber sends requests for substitutions, TMAT relinquishes and flights marked for substitution
- If no substitution rules are violated, TFDM implements the changes and sends an “accepted” reply to the subscriber (the flight-specific changes are reflected in TFDM TTP Flight Data services)
- If any rules are violated, TFDM rejects the request and sends a “rejected” reply, with an error code, to the subscriber
  - See next slides

Substitution Validation Rules

- All flights must be part of the same SMP as included in request
- All flights must be operated by the same major carrier as defined in TFMS (includes regional affiliates)
- A flight must not have entered the AMA
- A flight must not be exempt from rationing
  - For example, flights with FAA assigned control times (EDCT/APREQ), diversion recovery, ground stops, etc. are exempt
- Substitution times in request must exist as TMATs currently assigned to flights
  - Cannot create new TMATs that are not currently assigned to flights in request

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TTP Data Needed to Understand Substitution Rules

- All flights must be part of the same SMP
  - TTP SMP Data: See SMP flight list update message
- All flights must be operated by the same major carrier as defined in TFMS (includes regional affiliates)
  - TTP FlightData: NasMessage/flight/flightIdentification/@majorCarrierIdentifier
- A flight must not have entered the AMA
  - TTP FlightData: NasMessage/flight/departure/movementAreaActualEntryTime should be null
- A flight must not be exempt from rationing
  - TTP FlightData: NasMessage/flight/additionalFlightInformation/SurfaceMeteringProgramExemptionStatus
- Substitution times between flights match according to exact or inexact rules
  - TTP FlightData: NasMessage/flight/departure/movementAreaTargetEntryTime
  - Each requested TMAT must be currently assigned to another flight in the substitution request

Substitution Error Messages

Error codes (DRAFT)	Description
INVALID_SCHEMA_VERSION	Provided schema version does not match TFDM schema version.
BAD_MESSAGE_FORMAT	The message has bad formatting.
INTERNAL_ERROR	There was an issue processing the message that does not have to do with an invalid message or bad message format.
INVALID_MESSAGE	The message has invalid data.
UNAUTHORIZED_USER_ERROR	The user is not authorized to make substitutions for the carrier.
TMATS_IN_DIFFERENT_SMPS	The TMATS specified are in different SMPs.
FLIGHT_PASSED_METERING_CONTROL_POINT	The flight passed the metering control point.
FLIGHT_EXEMPT_FROM_RATIONING	The flight is exempt from rationing.
INVALID_SUBSTITUTION_TIMES	The substitution time specified are invalid.

Error codes related to general message processing

Message does not meet validation criteria. See previous slides

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The Current Implementation of TFCS Permissions

- TFCS Subscriptions
  - Subscribers receive a user name and password during on-ramping
  - Subscribers reach NAS Enterprise Messaging Service (NEMS) via a VPN connection to the NAS Enterprise Security Gateway (NESG)
    - TFDM uses a CLIENT_ID property in the message to verify the user identity and permissions

- A TFCS subscriber's permissions are based on the "major" designator in TFMS
  - A permission is defined by a set of one or more Major Carrier designators
  - Permissions are NAS-wide, i.e., a TFCS subscriber with permissions at one airport has the same permissions at all other airports implementing SMPs via TFDM
  - Permissions can overlap, i.e., more than one subscriber can have permission to substitute flights from the same "Major" flight operator

The Standard Case: *A CDM Member Running a Large Operation via a Ramp Tower*

- Flight Operator has permission to:
  - Submit substitutions, mark for Substitution, and relinquish TMATs for its flights and its subcarrier flights

- Example of operational procedures:
  - Substitutions via TFCS done “strategically” at the Operations Center
  - Ramp tower makes “tactical” substitutions via Operations Center connection

Vendor-Hosted TFCS Subscriber Systems

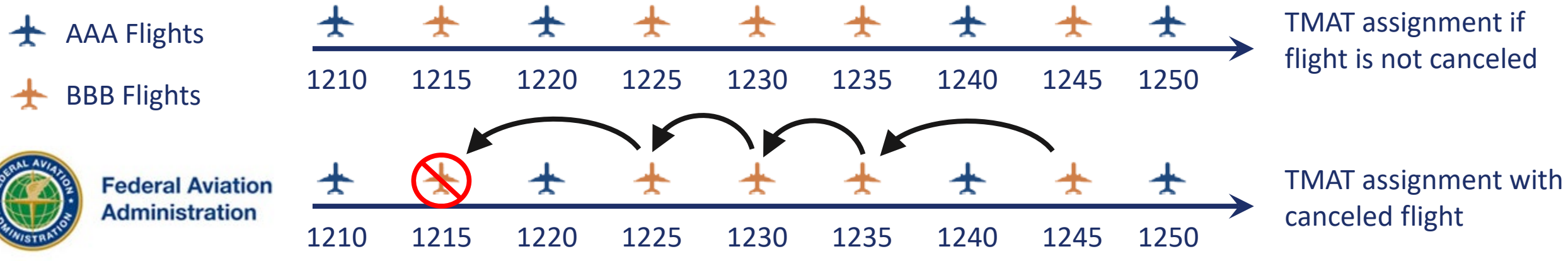
- Third parties may develop vendor-hosted systems for flight operators to execute substitutions
  - Method needed for managing permissions for such tools
  - Vendor and flight operator will need to agree on permissions

- Potential options for managing permissions:
  - Require the vendor to subscribe separately for each flight operator
  - Provide the vendor with permission to all client flights and rely on the vendor to manage permissions and message routing
  - Require the flight operator to manage the connection to TFCS and have the message flow be: vendor←→flight operator ←→ TFCS

Marking For Substitution

Marking a Flight for Substitution: *Background*

- If this flag is not set for a flight,
  - An un-canceled flight will be assigned a TMAT >= EOBT+RTT
    - Includes delayed flights (EOBT > IOBT)
  - A canceled flight will not be assigned a TOBT or TMAT
- TMATs are assigned based on Ration By Schedule (RBS) ordering
  - Flights are sorted based on scheduled (IOBT) order at the runway
  - A flight operator receives “RBS credit” for delayed or canceled flights
    - For example, if a flight operator “BBB airline” cancels a flight at the beginning of a departure push, all other flights from “BBB” will be automatically shuffled forward during TMAT assignment if the canceled flight is not marked for substitution



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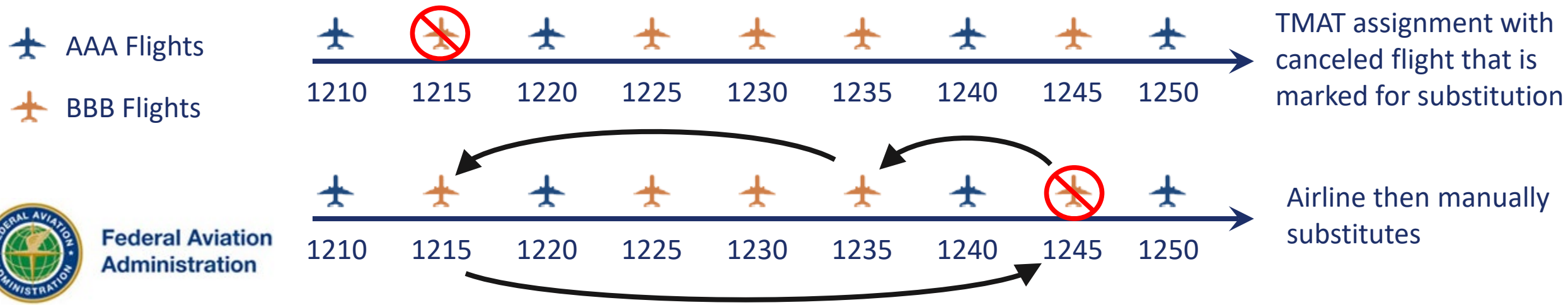
Marking a Flight for Substitution: *Effects on TFDM*

- **NOTE**: This flag is **not** required to substitute a flight
  - It only affects TMAT assignment for delayed or canceled flight

- For flights that are delayed and canceled prior to the affirmation of an SMP, the flight operator can mark the flight for substitution:
  - When the SMP starts, flights marked for substitution are assigned a TMAT based on IOBT regardless of EOBT or cancelation status
  - The flight operator can then substitute other flights into the TMATs of the flights marked for substitution



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Marking a Flight for Substitution: *Validation Rules*

- TFCS subscriber must have permission to update the flight
  - Error code: UNAUTHORIZED_USER_ERROR
- The flight must not be exempt from rationing
  - Error code: INVALID_MESSAGE
- The flight must either be delayed (EOBT > IOBT) or canceled
  - Error code: INVALID_MESSAGE
- The flight can be marked for substitution before or after a TMAT is assigned
  - But the marked-for-substitution flag only has an affect when the flight is assigned a new TMAT when an SMP or SMP adjustment is affirmed

Sample Mark for Substitution Request

```
<?xml version="1.0" encoding="UTF-8"?>
<tfcs xmlns="urn:us:gov:dot:faa:atm:terminal:services:towerFosCollaboration">
  <request>
    <flightSubstitutionRequest>
      <flightSubstitutions>
        <flight>
          <aircraftId>DAL1234</aircraftId>
          <tfdmFlightUniqueId>AAAAAAAA-AAAA-4AAA-9AAA-AAAAAAAAAAAA</tfdmFlightUniqueId>
          <targetMovementAreaEntryTimeMarkedForSubstitution>TRUE</targetMovementAreaEntryTimeMarkedForSubstitution>
        </flight>
      </flightSubstitutions>
    </flightSubstitutionRequest>
  </request>
</tfcs>
```

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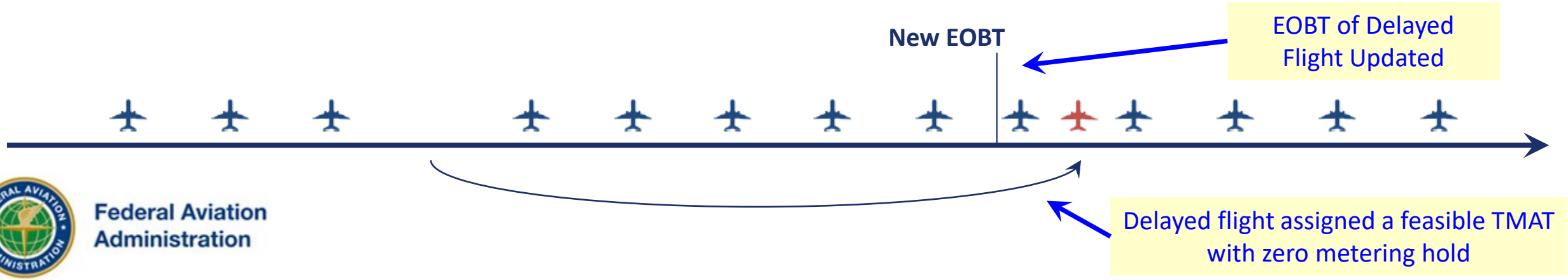
Relinquishing a TMAT

Relinquishing an Infeasible TMAT

- When a departure is delayed beyond an assigned TOBT (i.e. EOBT > TOBT), the flight operator has a period of time to take action before losing the TMAT
  - If no action taken during that time period, the flight will be assigned a new TMAT with zero metering hold (TOBT = EOBT and TMAT = EOBT + RTT)
- The flight operator can:
  - Update the flight's EOBT (via TfmData) to a feasible time after the TOBT
  - Substitute the flight with another flight (via TFCS)
  - Set the TMAT relinquish flag to TRUE (via TFCS)
    - TFDM will then assign the flight a new TMAT with zero metering hold (TOBT = EOBT and TMAT = EOBT + RTT)



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Relinquishing an Canceled Flight's TMAT

- When a departure with an assigned TMAT is canceled, the flight operator has a period of time to take action before losing the TMAT
  - If no action taken during that time period, TFDM will remove the assigned TOBT and TMAT and the flight operator will no longer be allowed to substitute for the flight

- The flight operator can:
  - Substitute the flight with another flight (via TFCS) for a later TMAT to extend the amount of time to take action on the flight
  - Set the TMAT relinquish flag to TRUE (via TFCS)
    - TFDM will remove the assigned TOBT and TMAT and the flight operator will no longer be allowed to substitute for the flight

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TMAT Relinquish: *Validation Rules*

- TFCS subscriber must have permission to update the flight
  - Error code: UNAUTHORIZED_USER_ERROR

- The flight can have TMAT relinquish = TRUE before or after a TMAT is assigned
  - But the flag only has an affect when the flight has an assigned TMAT that it cannot meet

Sample TMAT Relinquish Request

```
<?xml version="1.0" encoding="UTF-8"?>
<tfcs xmlns="urn:us:gov:dot:faa:atm:terminal:services:towerFosCollaboration">
  <request>
    <flightSubstitutionRequest>
      <flightSubstitutions>
        <flight>
          <aircraftId>DAL1234</aircraftId>
          <tfdmFlightUniqueId>AAAAAAAA-AAAA-4AAA-9AAA-AAAAAAAAAAAA</tfdmFlightUniqueId>
          <targetMovementAreaEntryTimeRelinquished>TRUE</targetMovementAreaEntryTimeRelinquished>
        </flight>
      </flightSubstitutions>
    </flightSubstitutionRequest>
  </request>
</tfcs>
```

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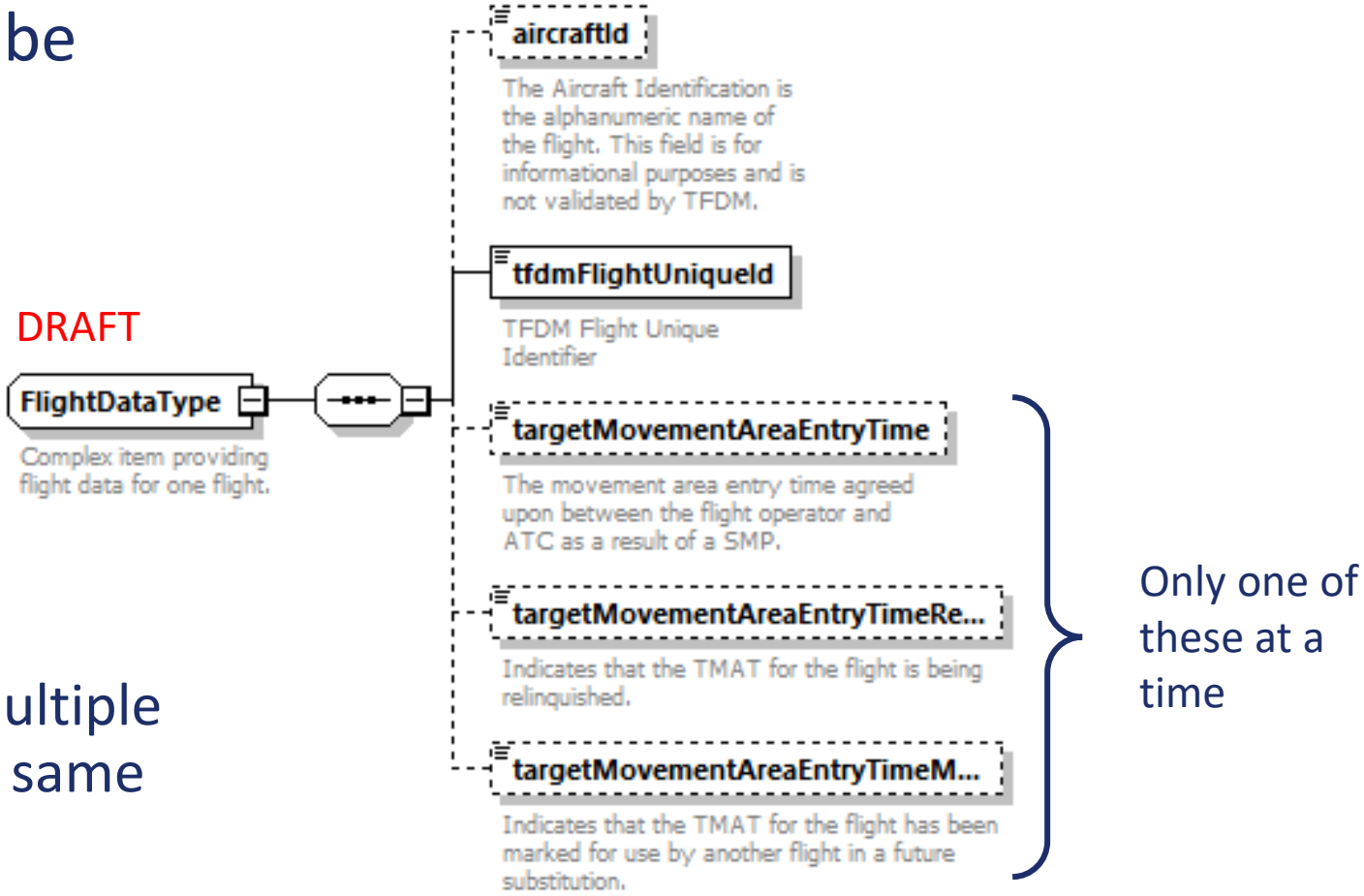
Interactions Between Messages

Request Types are Mutually Exclusive

- Only one type of request can be made at a time
  - Substitution
  - TMAT Relinquish
  - Mark for Substitution

- Error Message
  - Error code: INVALID_MESSAGE
  - Error string: Will indicate that multiple request types were made in the same request



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Relinquish and Mark-for-Substitution Interactions

- Default for each flight
  - TMAT relinquish = FALSE
  - Marked for substitution = FALSE
- Relinquishing a TMAT
  - Sets TMAT relinquish = TRUE
  - Sets marked for substitution = FALSE
- Marking a flight for substitution
  - Sets marked for substitution = TRUE
  - Sets TMAT relinquish = FALSE

Ramp Closures and NMA Gridlock Notifications

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TFCS Ramp Closure/Gridlock Notifications

- In addition to SMP flight substitutions, TFCS allows subscribers to submit:
  - Ramp closure notifications
    - TFDM will remove the TMATs of flights affected by the ramp closure
  - Non-Movement Area gridlock notifications
    - Situational awareness only
- Notifications:
  - Include a start time and may include an end time
  - Identify the ramp in question
  - Can be Created, Activated, Deactivated, Updated and Removed

Next Steps

Tech Talks Moving Forward

- What's Next: How an SMP works (with TTP messages)

  March 24, 2021 at 1PM EST

- What topics are you interested in learning more about?

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Questions?

- Contact CSIT at csit@faa.gov

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