



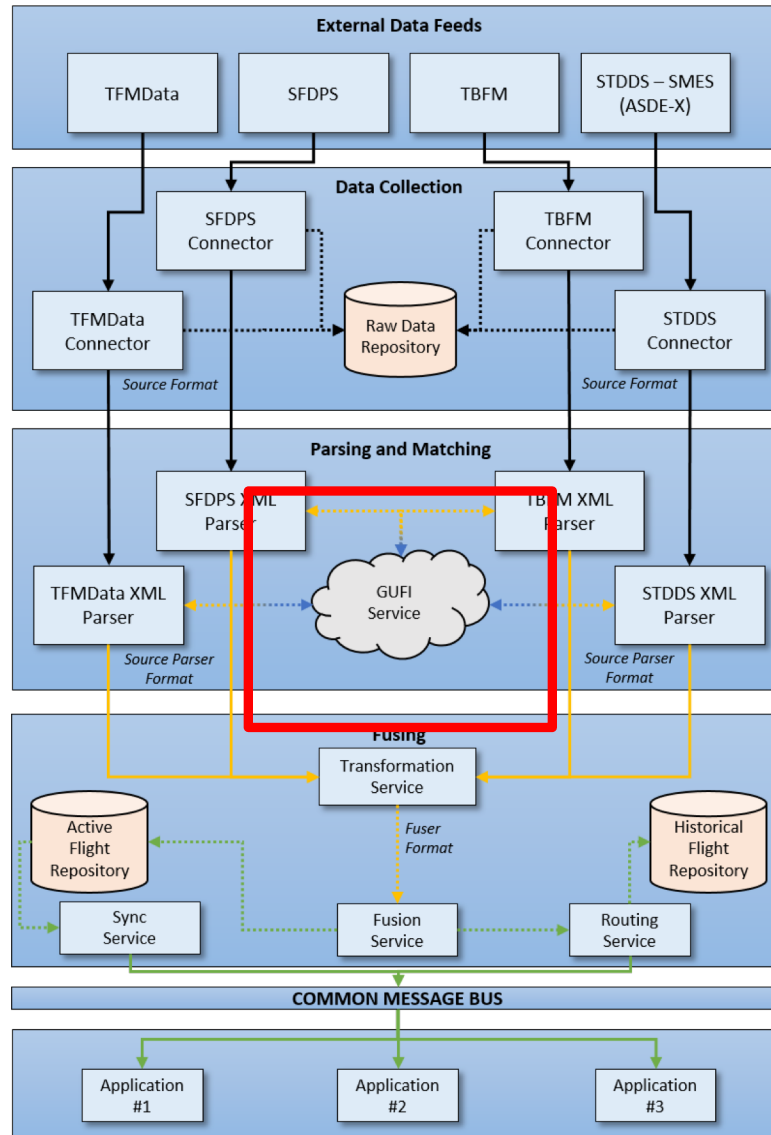
Airspace Technology Demonstration 2 (ATD-2)

Fuser Deeper Dive (Mediation & Use Cases)

May 22, 2019



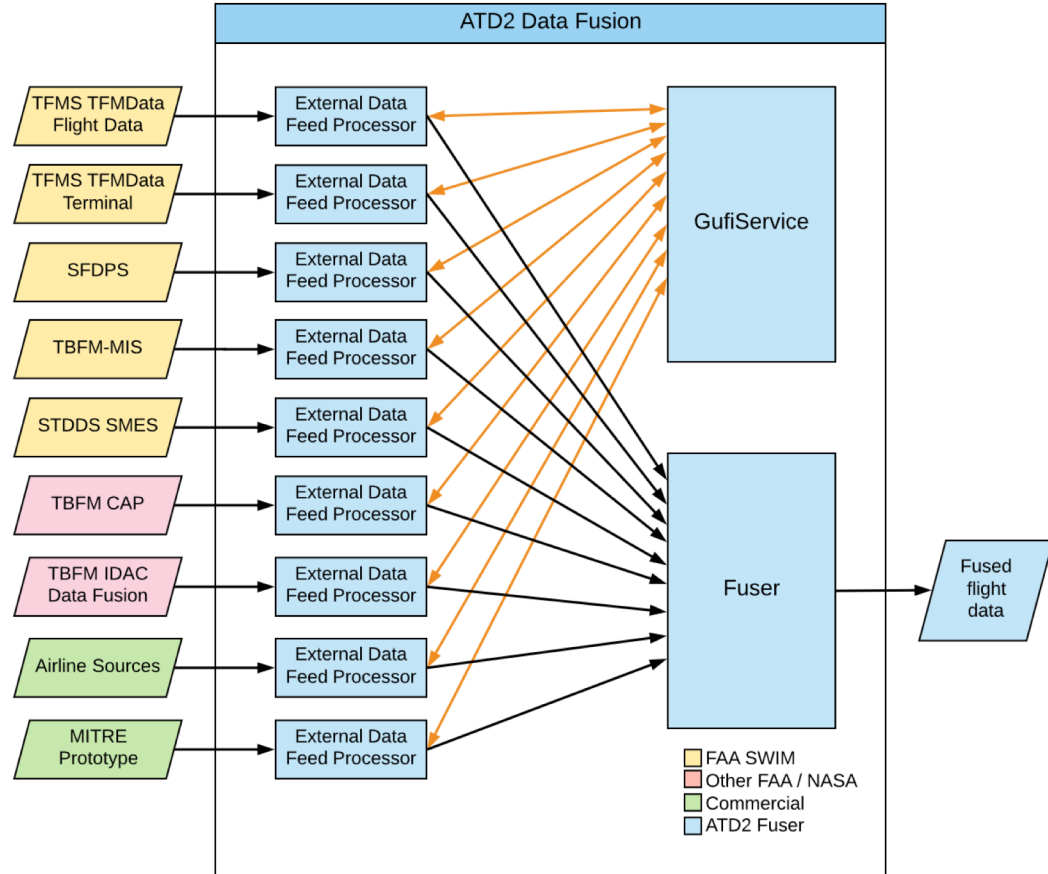
- Flight Matching
- Fuser Processing
 - Transformation
 - Filtering
 - Mediation
 - Fuser Metadata
 - Use Cases



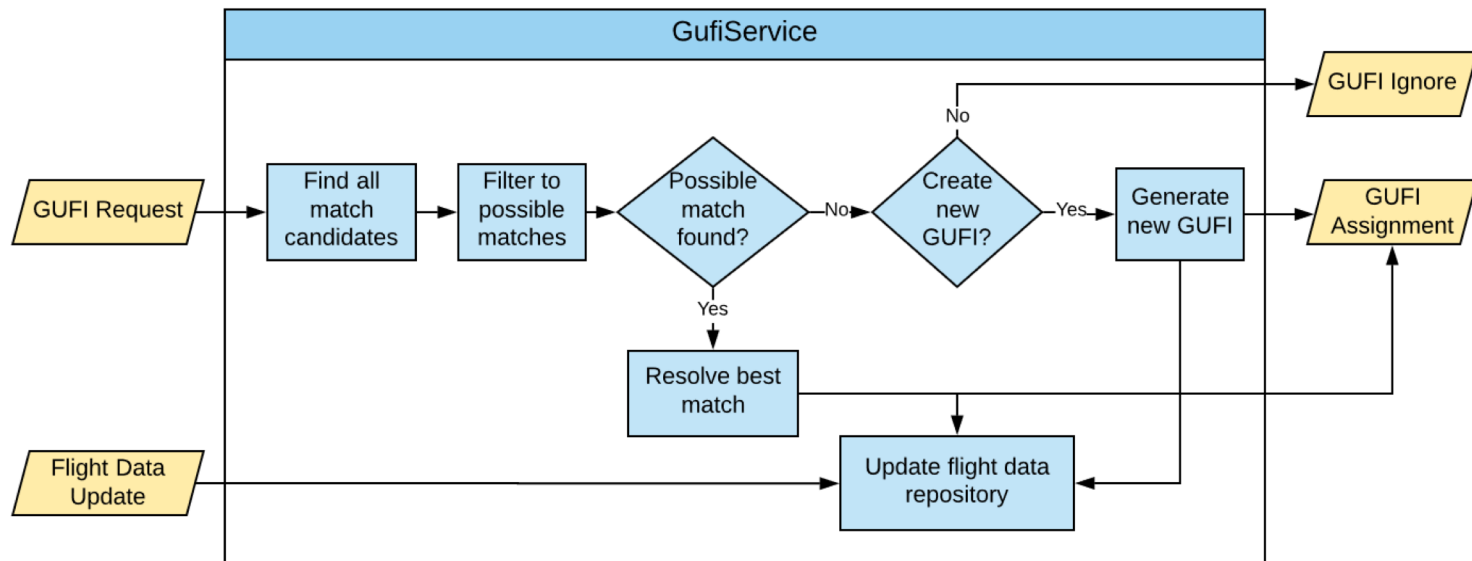


- Goal
 - Assign a Global Unique Flight Identifier (GUFID) to every flight message.
 - Ex: AAL1428.DFW.MCI.190507.1504.0132.TFM
- Why?
 - GUFID links together flight data across all external data feed sources.
 - Crucial precursor to data fusion.
- What is a flight?
 - Flight matching is where the “flight” is defined.
 - ATD2 defines a “flight” as the full lifecycle : starting with the scheduled or planned operation and ending at the arrival gate.

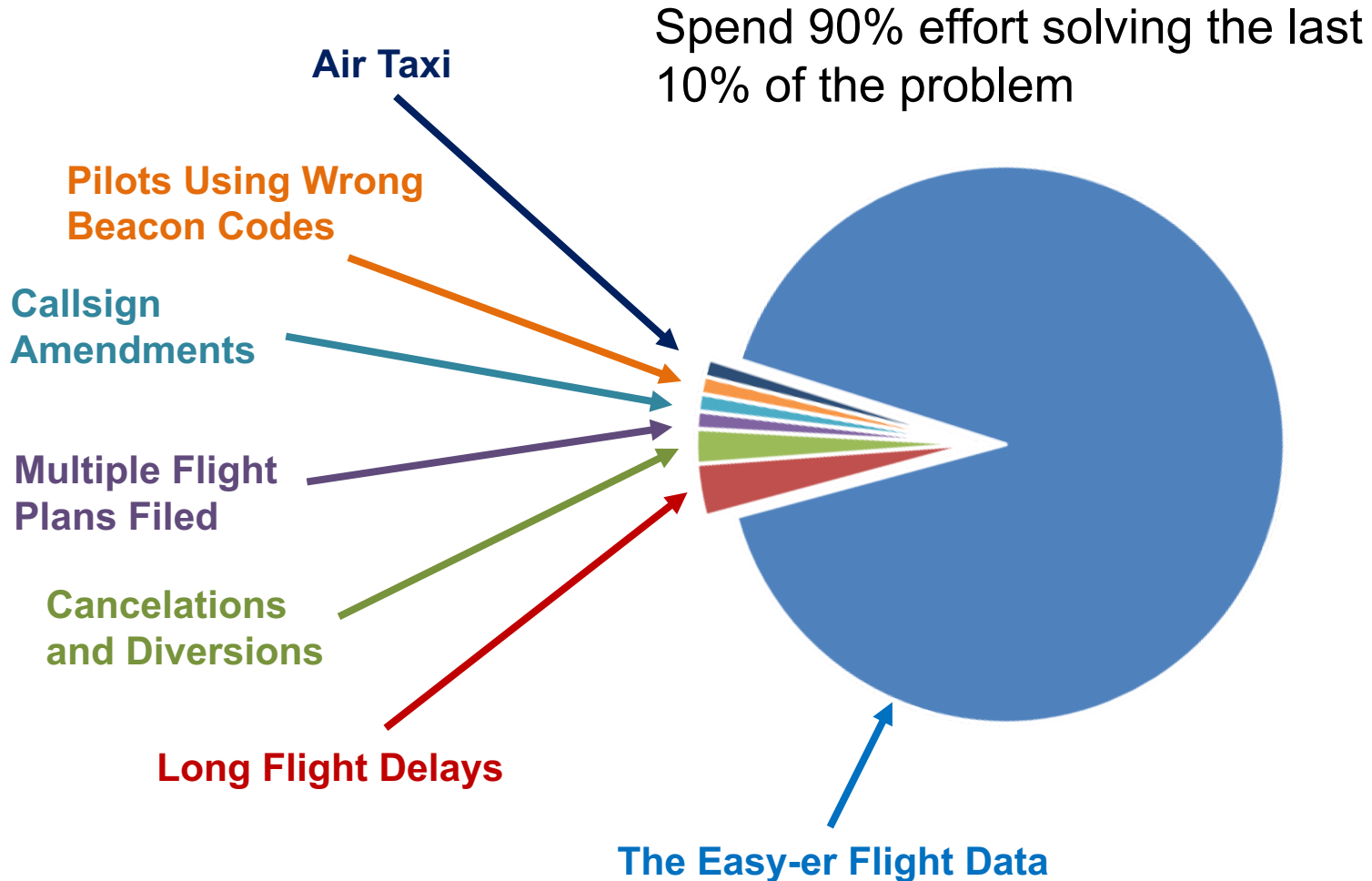
- ATD2 DFW GufiService
 - Handles GUFi requests from over 10 different data sources.
 - Stores the flight data state of each GUFi.
- External data feed processors
 - Request GUFi from GufiService.
 - Messages to Fuser include GUFi.
- GufiService performance (DFW Fuser):
 - Total:
 - ~15M avg messages handled per day.
 - ~170 per second.
 - ~110K avg GUFis managed per day.
 - ~200 avg messages per GUFi.
 - DFW:
 - ~3.5M avg messages handled per day.
 - ~7,500 avg GUFis managed per day.
 - ~1,000 avg messages per GUFi.



- Basic approach to matching a flight
 - Find the best possible flight match, if one exists in the known data.
 - Otherwise, create a new GUF, if sufficient data exists.
- Core flight matching data
 - Aircraft ID / Callsign (e.g. SWA568).
 - Origin / Destination airports (e.g. DFW -> LGA).
 - Flight time windows (e.g. 9:30 - 13:45).
 - Position (e.g. latitude / longitude / altitude).
 - External data feed system IDs (e.g. TFMDData flightRef).
 - Aircraft attributes (e.g. registration number, Mode S transponder)



| Time | Message | TFM FlightData | SFDPS | TBFM MIS | STDDS SMES | ATD2 GUF1 |
|--------------|--|----------------|-------|----------|------------|---------------------------------|
| Sunday 19:00 | Scheduled flight plan AAL045 DFW -> CLT Monday 19:00->21:59 | X | | | | AAL045.DFW.CLT.021019.1900.0000 |
| Monday 17:00 | Filed flight plan AAL045 DFW -> CLT Monday 19:00->21:59 | X | X | X | | AAL045.DFW.CLT.021019.1900.0000 |
| Monday 17:30 | Amend flight plan route AAL045 DFW -> CLT Monday 19:00->21:59 | X | X | X | | AAL045.DFW.CLT.021019.1900.0000 |
| Monday 18:30 | CDM times update AAL045 DFW -> CLT Monday 20:05->22:15 | X | | | | AAL045.DFW.CLT.021019.1900.0000 |
| Monday 19:02 | Scheduled flight plan AAL045 DFW -> CLT Tuesday 19:00->21:59 | X | | | | AAL045.DFW.CLT.021119.1902.0000 |
| Monday 19:55 | Surface surveillance AAL045 ASEX=KDFW | | | | X | AAL045.DFW.CLT.021019.1900.0000 |
| Monday 19:59 | EDCT AAL045 EDCT=20:24 | X | | X | | AAL045.DFW.CLT.021019.1900.0000 |
| Monday 20:25 | Flight Departure AAL045 | X | X | X | | AAL045.DFW.CLT.021019.1900.0000 |
| Monday 20:27 | Airborne surveillance AAL045 | X | X | | X | AAL045.DFW.CLT.021019.1900.0000 |

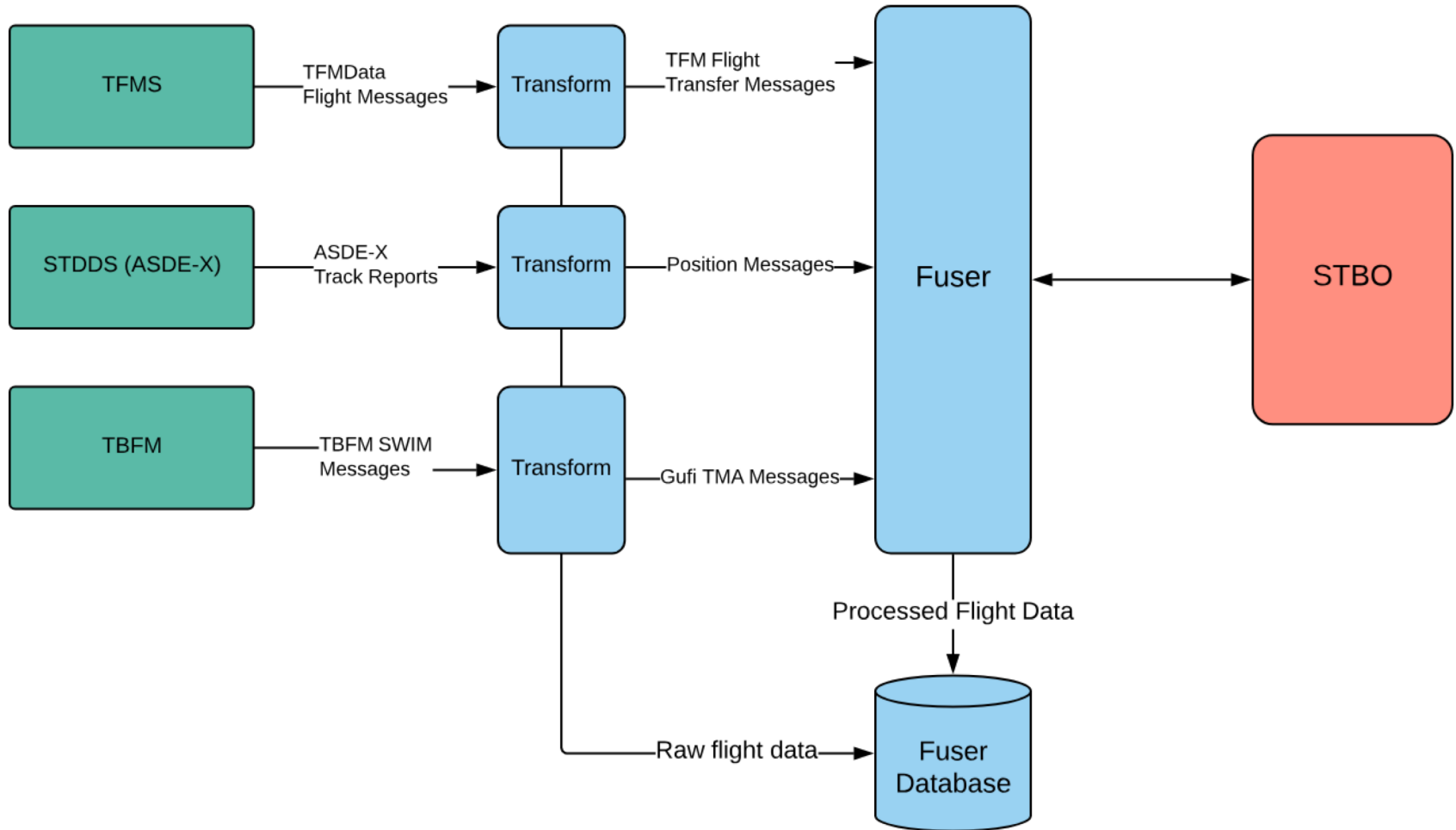


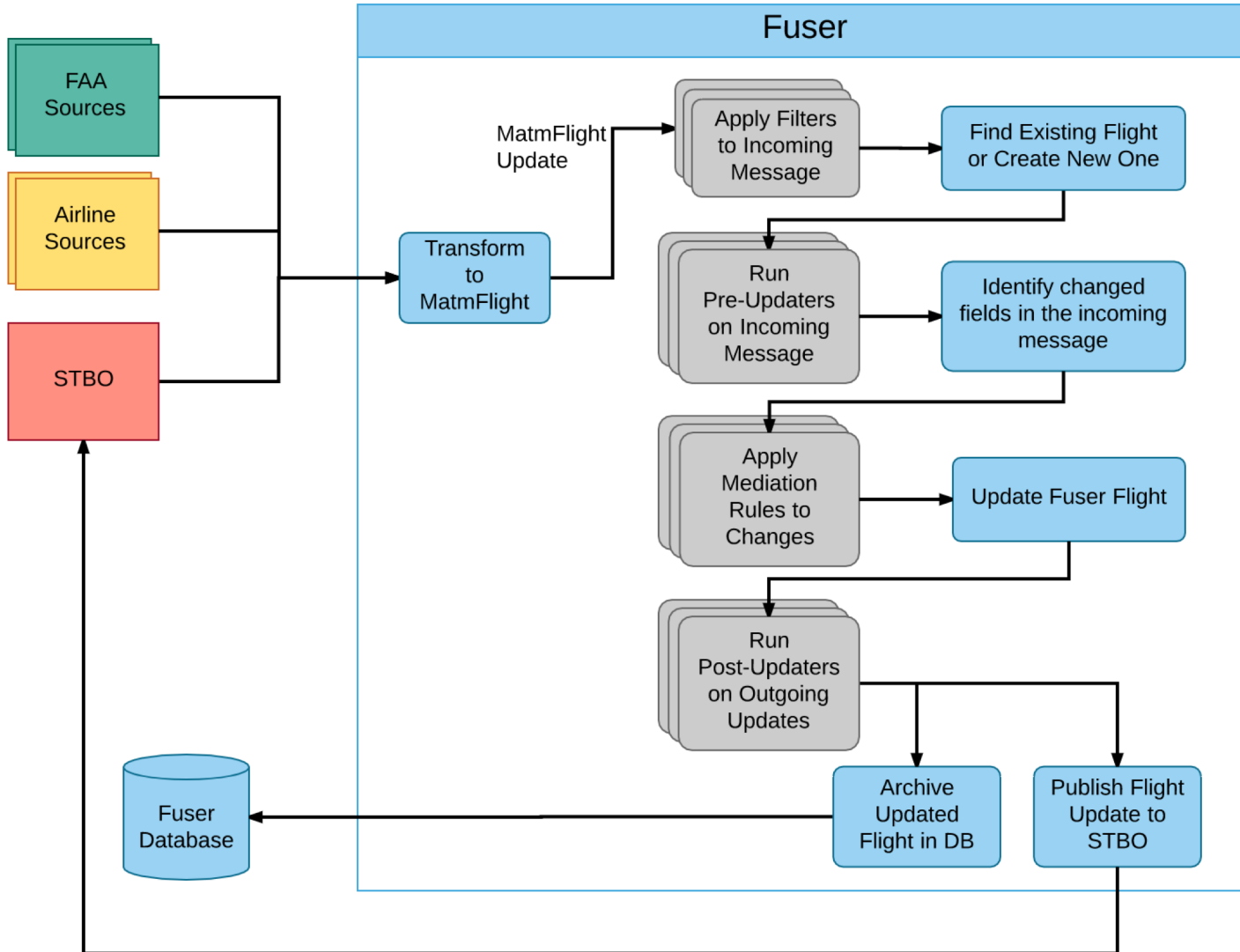
- Regression Testing = Key to matching logic improvement
 - Definition: A suite of tests that are required to pass when software changes are made.
 - Matching logic improvement is heuristic-based, adaptive process.
 - There is no 100% solution. Flight data is always scheming to defeat you.
 - Goal is intelligent whack-a-mole – fix one issue without causing another.
- Purpose
 - Emulate full matching process: replaying input messages from mock sub-components through the internal GufiService logic.
 - Reliable debugging of operational use cases.
 - Each test is simple format for analysts/testers to describe a matching problem.
 - Stockpile of regression tests to run against future development.



- Regression Test Process
 - Leverage database of historical GufiService messages.
 - Build match logic test cases with validated results.
 - GufiMatchTester software drives GufiService with test cases.
 - Currently over 100 regression test cases.
 - Iterate GufiService logic improvements until all tests pass.





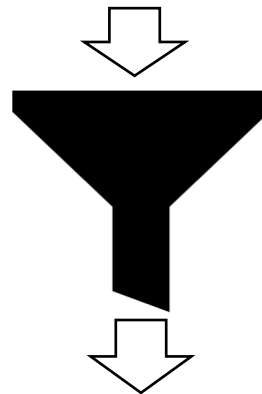


- Filtering is used to filter out an entire update before the data is applied to the fused flight
 - Eliminate unnecessary processing and/or updates that reduce data quality.
 - Filtering is based on defined rules:

| Filter Name | Description | Reason |
|-----------------------------|--|--|
| AttributeFilter | See Industry Day Documentation for more details Link . | In certain cases, we know that a source has bad data in certain fields, we don't trust the values, or we feel we will have better data from another source. |
| FlightPositionFilter | Filter out the position update if that latitude, longitude, or timestamp is null. | The systems needs to have all three to have a valid position. At times we are getting bad data with one of those three fields missing causing problems downstream. |
| GufiFilter | Filter out any messages that have not been assigned a GUFi (Global Unique Flight Identifier). | These are messages we were unable to match typically due to a lack of information. |
| LocationFilter | Filter out any messages that are not arriving at CLT, departing from CLT, or a Surveillance target at CLT. | In this case, the Fuser was for an STBO system operating for Charlotte Douglas International Airport (CLT) and Therefore only needed data relevant to CLT. Implemented to keep performance under control by not processing data not relevant to CLT. |

| acid | Departure Aerodrome | departure stand earliest time | Arrival Aerodrome | Last update source | System id | Timestamp |
|---------|---------------------|-------------------------------|-------------------|--------------------|-----------|------------------|
| ABC1234 | CLT | 2017-04-05 11:00 | DFW | TFM_TFDM | ABC | 2017-04-05 10:00 |
| ABC4567 | ATL | 2017-04-05 11:15 | ORD | TFM_TFDM | ABC | 2017-04-05 10:00 |
| ABC8999 | CLT | 2017-04-05 11:30 | JFK | TFM_TFDM | ABC | 2017-04-05 10:00 |

Not a flight operating at CLT



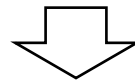
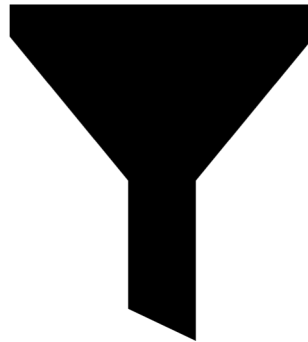
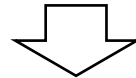
| acid | Departure Aerodrome | departure stand earliest time | Arrival Aerodrome | Last update source | System id | Timestamp |
|---------|---------------------|-------------------------------|-------------------|--------------------|-----------|------------------|
| ABC1234 | CLT | 2017-04-05 11:00 | DFW | TFM_TFDM | ABC | 2017-04-05 10:00 |
| ABC8999 | CLT | 2017-04-05 11:30 | JFK | TFM_TFDM | ABC | 2017-04-05 10:00 |

- Attribute filtering is used to filter out fields before they are applied to the fused flight, based on the defined rules

- Attribute Filtering is used when
 - A source is known to have bad or untrustworthy data in certain fields
 - Better data is likely to exist in another source for certain fields

| Field | Excluded by Sources | Reason |
|---------------------------------|--|---|
| arrivalFixActualTime | Airline Data, 3rd Party Data | Relying on STBO detection times for the actual values |
| arrivalMovementAreaActualTime | Airline Data, 3rd Party Data | Relying on STBO detection times for the actual values |
| arrivalRunwayActualTime | Airline Data, 3rd Party Data, TFMS_Flight, TFM_Terminal | Relying on STBO detection times for the actual values |
| departureFixActualTime | Airline Data, 3rd Party Data | Relying on STBO detection times for the actual values |
| departureMovementAreaActualTime | Airline Data, 3rd Party Data | Relying on STBO detection times for the actual values |
| departureRunwayActualTime | Airline Data, 3rd Party Data, TBFM, TFMS_Flight, TFMS_Terminal | Relying on STBO detection times for the actual values |
| departureQueueEntryActualTime | Airline Data, 3rd Party Data | Relying on STBO detection times for the actual values |
| departureRunwayAssigned | TBFM | The departure runway is only coming with the runway number and not an indication if is L,R, or C. For example 18 instead of 18L.. |

| acid | departure runway assigned | Last update source | System id | Timestamp |
|---------|---------------------------|--------------------|-----------|------------------|
| ABC1234 | CLT_36 | TBFM | SWIM | 2019-04-05 10:00 |



Departure Runway
From TBFM are not
Reliable
(flt.drw)

| acid | Last update source | System id | Timestamp |
|---------|--------------------|-----------|------------------|
| ABC1234 | TBFM | SWIM | 2019-04-05 10:00 |

- Fuser mediation processing
 - Input data correction
 - Data source has known errors or anomalies
 - Value-added data computations
 - Create new data elements not available in the input data source
 - Input data source priority rules
 - Used to define a precedence/authority between sources providing data for the same data elements.
 - Implemented when necessary
 - Default behavior allows any data source to modify a value
 - Filter out data modifications from one data source, if data modifications already exist from a higher priority source.
 - E.g. TFMData messages are more favorable in setting the Fuser schema “routeText” data element than TBFM MIS.
- More information
 - https://aviationsystems.arc.nasa.gov/atd2-industry-days/fuser/Data-Mediation-Overview_85328193.html

- Fuser Metadata

- In support of the mediation rules, Fuser tracks metadata of each Fuser schema data element:
 - Last modification input data source and message type.
 - Last modification timestamp.

Fuser Schema

```

<xs:element name="altitudeAssigned" type="xs:double" minOccurs="0"/>
<xs:element name="altitudeRequested" type="xs:double" minOccurs="0"/>
<xs:element name="altitudeFiled" type="xs:double" minOccurs="0"/>
<xs:element name="speedFiled" type="xs:double" minOccurs="0"/>
<xs:element name="arrivalAerodrome" type="nc:aerodrome" minOccurs="0"/>
<xs:element name="arrivalFixActual" type="xs:string" minOccurs="0"/>
<xs:element name="arrivalFixUser" type="xs:string" minOccurs="0"/>
<xs:element name="arrivalFixSourceData" type="xs:string" minOccurs="0"/>
<xs:element name="arrivalFixPositionDerived" type="xs:string" minOccurs="0"/>

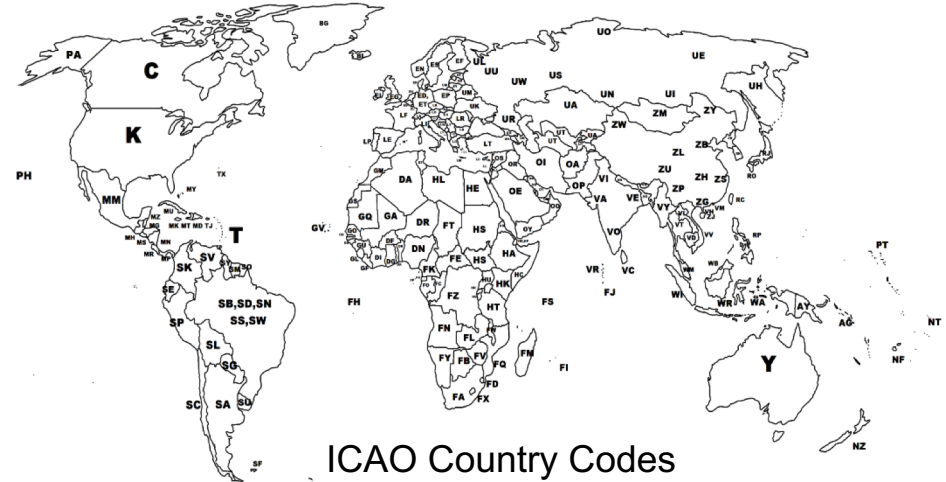
<xs:complexType name="aerodrome">
  <xs:sequence>
    <xs:element name="iataName" type="xs:string" minOccurs="0" />
    <xs:element name="icaoName" type="xs:string" minOccurs="0" />
    <xs:element name="faaLid" type="xs:string" minOccurs="0" />
  </xs:sequence>
</xs:complexType>
    
```

Fuser MetaData

```

<xs:complexType name="metaData">
  <xs:sequence>
    <element name="source" type="xs:string" minOccurs="0" />
    <element name="timestamp" type="xs:dateTime" minOccurs="0" />
    <element name="systemType" type="xs:string" minOccurs="0" />
    <element name="fieldName" type="xs:string" minOccurs="0" />
  </xs:sequence>
</xs:complexType>
    
```

- ICAO vs IATA
 - ICAO = International Civil Aviation Organization
 - IATA = International Air Transport Association
 - These organizations don't agree on how to name things.
 - FAA generally uses IDs similar to ICAO.
 - Airlines generally prefer IATA.



| | IATA | ICAO | FAA |
|------------------------------------|------|------|------|
| Dallas Love Field Airport | DAL | KDAL | DAL |
| Hilton Head Airport | HHH | KHXD | HXD |
| Ardmore Downtown Executive Airport | AHD | | 1F0 |
| Gastonia Municipal Airport | | KAKH | AKH |
| Augusta Municipal Airport | | | 3AU |
| Boeing 737-700 Aircraft Type | 73G | B737 | B737 |
| Air Carrier | AA | AAL | AAL |



- Airport Conversion and Correction by Source

- Mapping over 27k ICAO / IATA / FAA LID.
- Based upon input data source, set ICAO, IATA, and FAA LID values for all messages.

| | A | B | C | D | E |
|------|----------------------|-----------------------------------|------|------|---------|
| 1 | country | name | icao | iata | FAA LID |
| 6820 | Russian Federation | Turlatovo Airport | UUWR | RZN | |
| 6821 | Philippines | Cesar Lim Rodriguez Airport | RPSD | RZP | |
| 6822 | Iran | Ramsar Airport | OINR | RZR | |
| 6823 | Pakistan | Sawan Airport | OPSW | RZS | |
| 6824 | USA | Halifax County Airport | KRZZ | RZZ | |
| 6825 | USA | Shively | KSAA | SAA | SAA |
| 6826 | Netherlands Antilles | J. Yrausquin | TNCS | SAB | |
| 6827 | USA | Sacramento Executive Airport | KSAC | SAC | SAC |
| 6828 | USA | Safford Municipal Airport | KSAD | SAD | SAD |
| 6829 | Indonesia | Sangir Airport | | SAE | |
| 6830 | USA | Santa Fe County Municipal Airport | KSAF | SAF | SAF |
| 6831 | USA | Sagwon | KSAG | SAG | |
| 6832 | Yemen | Sana'a International | OYSN | SAH | |
| 6833 | Iceland | Comalapa International | BIKR | SAK | |
| 6834 | El Salvador | El Salvador International Airport | MSLP | SAL | |
| 6835 | USA | San Diego International-Lindbergh | KSAN | SAN | SAN |
| 6836 | Honduras | Ramon Villeda Morales Internatio | MHLM | SAP | |
| 6837 | Bahamas | San Andros Airport | MYAN | SAQ | MYAN |
| 6838 | USA | Sparta Community | KSAR | SAR | SAR |
| 6839 | USA | Salton City | KSAS | SAS | SAS |

- Special Cases and Data Anomalies

- TBFM MIS “airport” can be a waypoint.
 - Airborne IFR filed flight plans.
- TFM Schedule flight plan OAG errors.
 - E.g. Doha OTBD airport closed in 2014 (replaced by OTHH), but is published in TFMS Scheduled flight plan messages.

```

<constructor-arg name="airportReplaceMap">
  <map>
    <entry key="PHIK" value="PHNL" />
    <entry key="HIK" value="HNL" />
    <entry key="MKPL" value="TLPL" />
    <entry key="OTBD" value="OTHH" />
    <entry key="SPIM" value="SPJC" />
  </map>
</constructor-arg>

```

- Fuser Airport Mediation Rule

- Problem: When flights amend the arrival airport, some TFM messages continue to use the old arrival airport.
 - Without mediation, the arrival airport toggles between the current and old values.
- Solution: Fuser mediation to ignore data modifications by TFM sources that may use the incorrect arrival airport.

Fuser Mediation Rule

```

<!-- Give priority in the Aerodrome values to filed flight plans -->
<bean id="fuser-rules.AerodromeRule" class="com.mosaicatm.fuser.rules.MultiplePriorityMediationRule" >
  <property name="active" value="${fuser.rules.AerodromeRule.enable}" />
  <property name="priority" value="${fuser.rules.AerodromeRule.priority}" />
  <property name="name" value="${fuser.rules.AerodromeRule.name}" />
  <property name="idLookup" ref="fuser.core.MatmIdLookup" />
  <property name="sourcePriorityListFromString">
    <list>
      <value>TFM_FLIGHT_PLAN_INFORMATION,TFM_FLIGHT_PLAN_AMENDMENT_INFORMATION,TMA,SFDPS,FUSER</value>
      <value>TFM_FLIGHT_SCHEDULE_ACTIVATE,TFM_FLIGHT_CREATE,TFM_FLIGHT_MODIFY,TFM_TFDM</value>
    </list>
  </property>
  <property name="includes" >
    <list>
      <value>arrivalAerodrome.iataName</value>
      <value>arrivalAerodrome.icaoName</value>
      <value>arrivalAerodrome.faaLid</value>
      <value>departureAerodrome.iataName</value>
      <value>departureAerodrome.icaoName</value>
      <value>departureAerodrome.faaLid</value>
    </list>
  </property>
</bean>

```

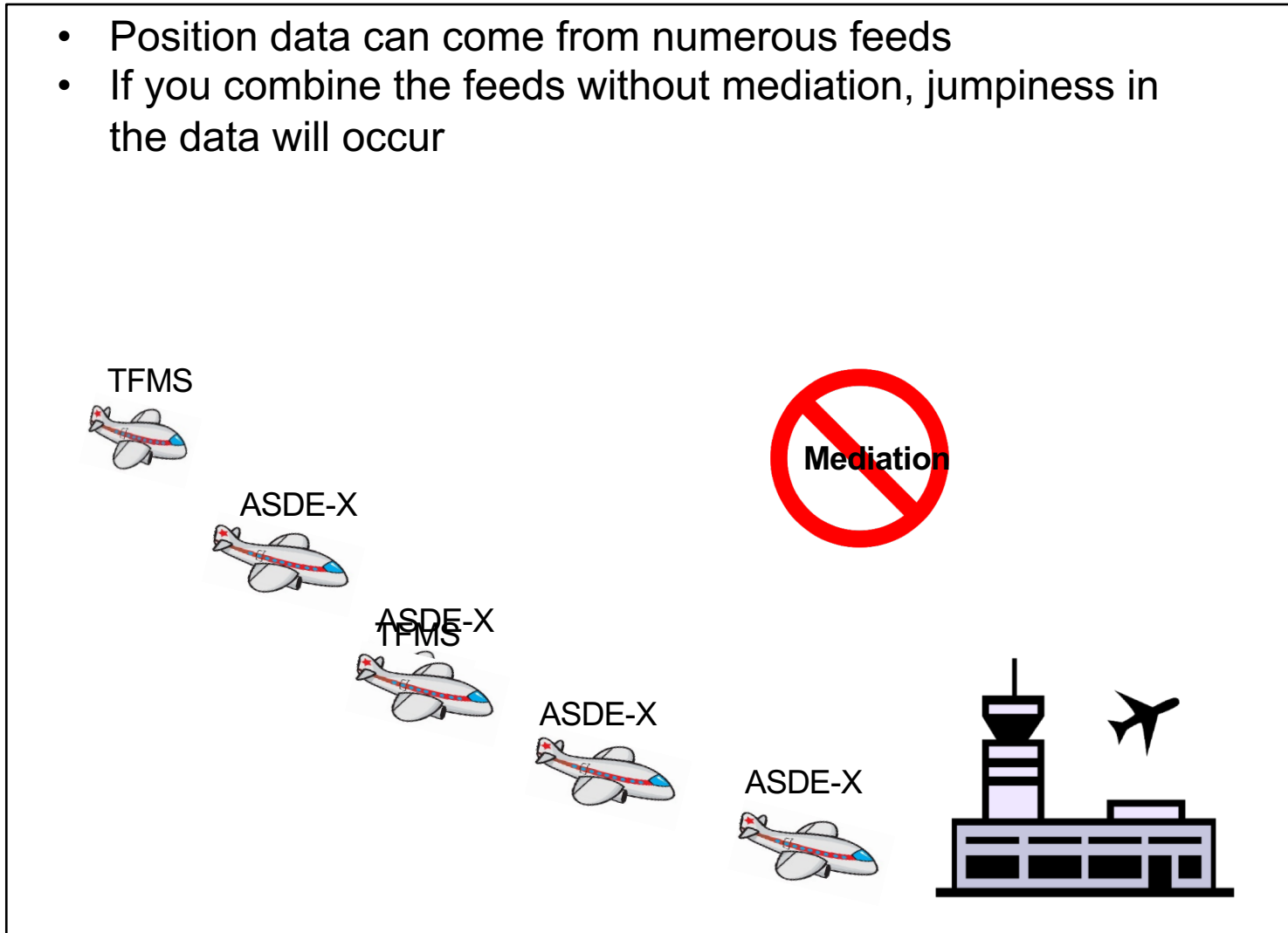
- Arrival Airport Mediation Messaging Example.

```
<property name="sourcePriorityListFromString">
  <list>
    <value>TFM_FLIGHT_PLAN_INFORMATION,TFM_FLIGHT_PLAN_AMENDMENT_INFORMATION,TMA,SFDPS,FUSER</value>
    <value>TFM_FLIGHT_SCHEDULE_ACTIVATE,TFM_FLIGHT_CREATE,TFM_FLIGHT_MODIFY,TFM_TFDM</value>
  </list>
</property>
```

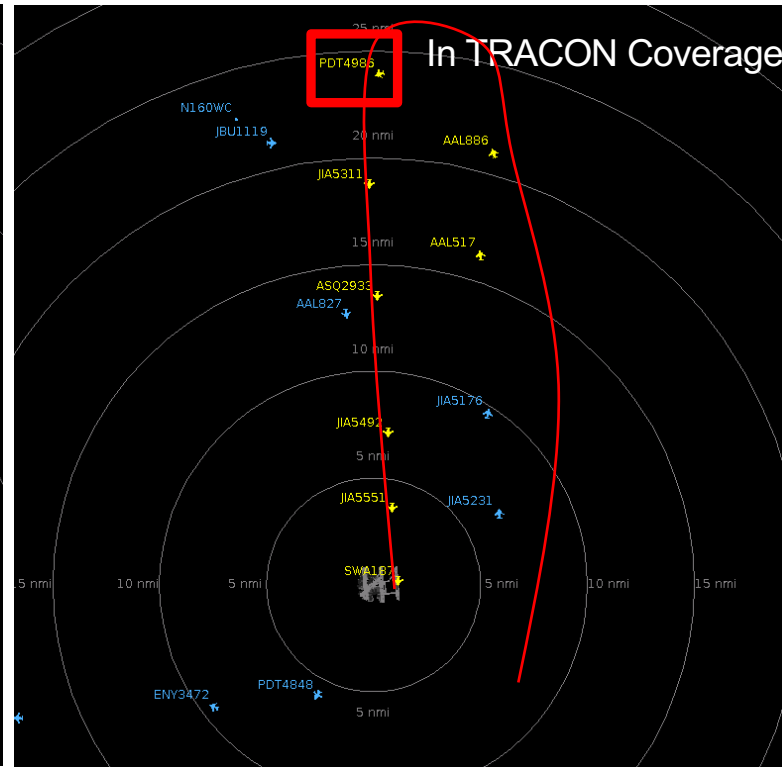
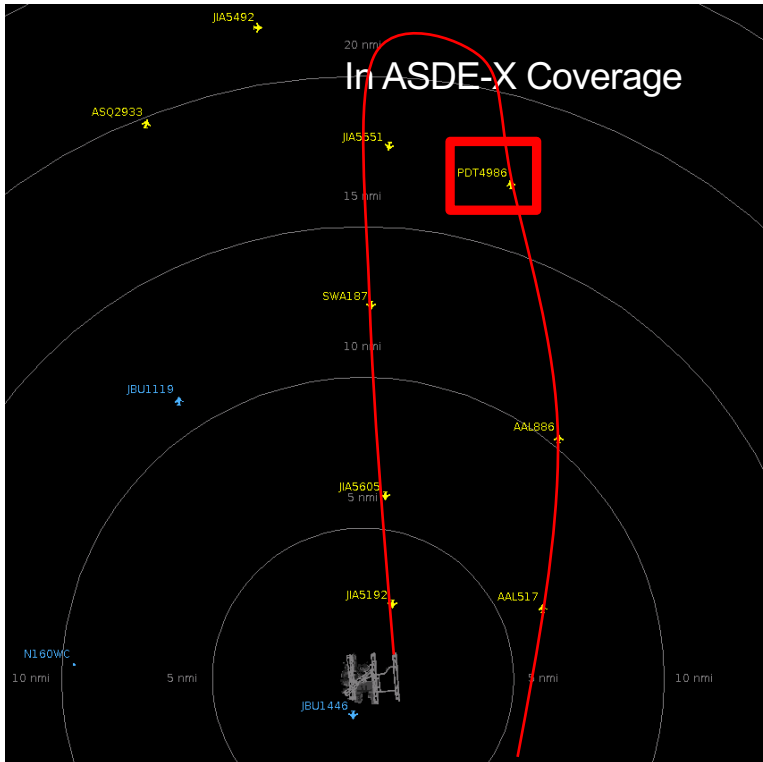
| Input Source | | | Fuser | | | |
|--------------|---------------------------|-----------------|-------|------|------|----------------------------------|
| Time | Source | Arrival Airport | IATA | ICAO | FAA | MetaData |
| 1500 | TFMData Schedule | OTBD (error) | DOH | OTHH | OTHH | 1500 (TFMData Schedule) |
| 0900 | Airline Source | DOH | DOH | OTHH | OTHH | 1500 (TFMData Schedule) |
| 1100 | TFMData Filed Flight Plan | OTHH | DOH | OTHH | OTHH | 1100 (TFMData Filed Flight Plan) |
| 1130 | TFMData Amend Flight Plan | OMDB | DXB | OMDB | OMDB | 1130 (TFMData Amend Flight Plan) |
| 1150 | TFMData Flight Modify | OTHH | DXB | OMDB | OMDB | 1130 (TFMData Amend Flight Plan) |

Mediation Position Data

- Position data can come from numerous feeds
- If you combine the feeds without mediation, jumpiness in the data will occur



- The images below show the path of a flight in the terminal airspace
- In this case the flight transition from TRACON coverage to ASDE-X back to TRACON and finally back to ASDE-X

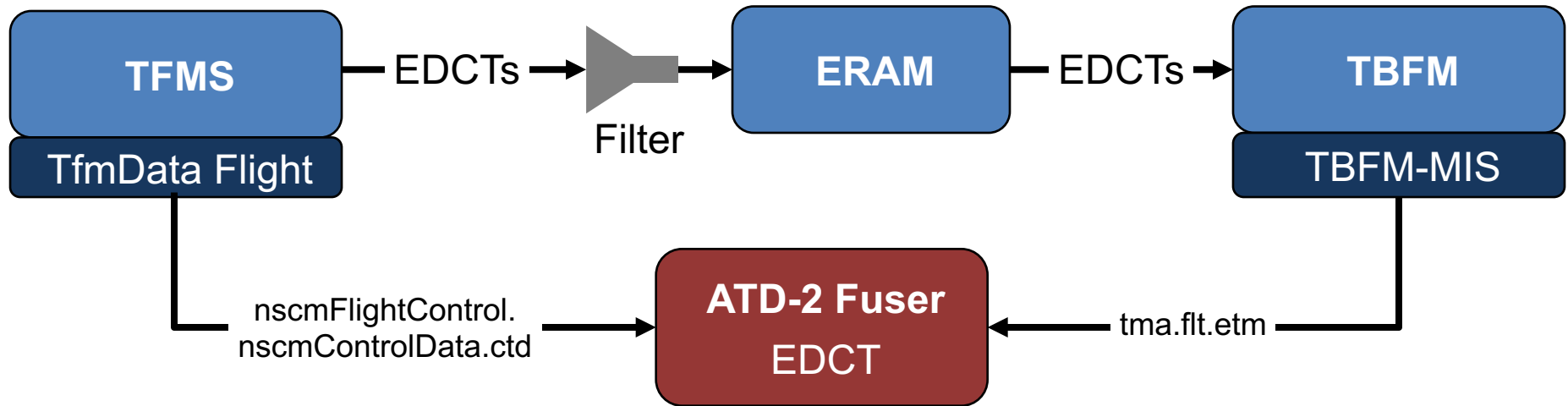




- Mediate to avoid jumpiness in the display and data
 - Define priority
 - Define a timeout
 - Transition back to a lower priority source if we quit getting data

| Source | Frequency | Coverage | Priority | Timeout |
|----------------|------------|-------------------------------|----------|------------|
| STDDS (ASDE-X) | 1 second | Surface to about 16 miles | 1 | 5 seconds |
| STDDS TAIS | 6 seconds | TRACON | 2 | 30 seconds |
| SFDPS | 12 seconds | NAS by CENTER stops in TRACON | 3 | 60 seconds |
| TFMS | 60 seconds | NAS stops in TRACON | 4 | 60 seconds |

- ATD-2 needs EDCTs for common situational awareness and runway predictions
- ATD-2 mediates TFMS and TBFM as equal sources
 - ATD-2 does not have to track filtered EDCTs separately from unfiltered



*TBFM SYNC messages had to be handled as syncs and not updates
Prevented resetting the EDCT back to an old value

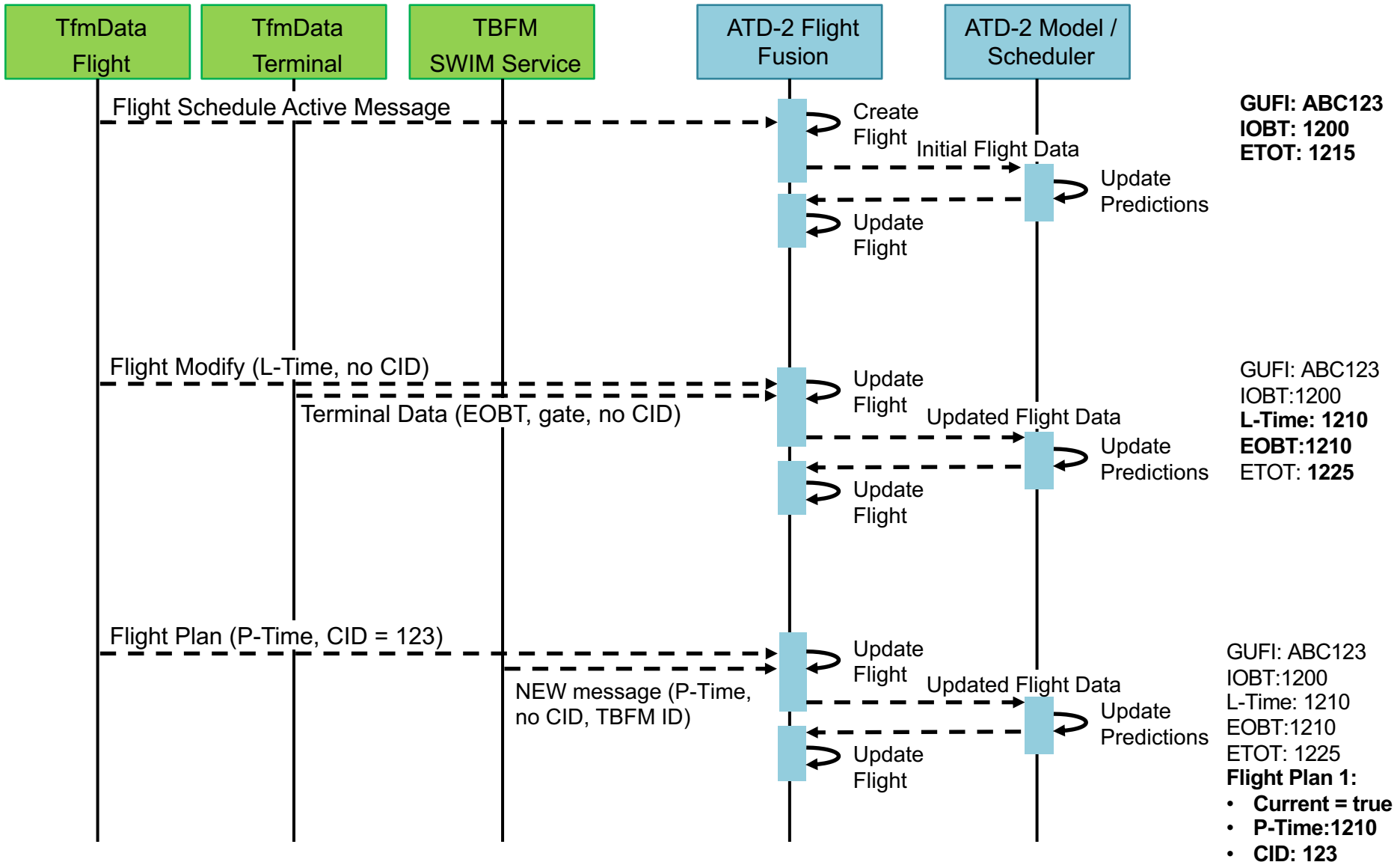
Multiple Flight Plans



- ATD-2 tracks individual flight plans for AEFS integration
- ATD-2 manages a list of pre-departure flight plans
 - Tracks when each flight plan was updated
 - Tracks when a flight plan is cancelled
 - Most recently updated, non-cancelled, flight plan is used as the current plan for surface modeling and scheduling
- The flight plan specific data elements are tracked per flight plan
 - P-Time, Route, Filed altitude, CID, etc.
- All other data elements are stored for the entire flight regardless of flight plan
 - L-Time, EOBT, TOBT, AOBT, Flight state, EDCT, aircraft position, etc.
- Currently uses TfmData as authoritative source for flight plan status and updates

Multiple Flight Plans

(initially the same as single flight plan use case)



GUFI: ABC123

IOBT:1200

L-Time: **1230**

EOBT: **1230**

ETOT: **1245**

Flight Plan 1:

- Current = true
- P-Time:1210
- CID: 123

GUFI: ABC123

IOBT:1200

L-Time: 1230

EOBT: 1230

ETOT: 1245

Flight Plan 1:

- Current = **false**
- P-Time:1210
- CID: 123

Flight Plan 2:

- **Current = true**
- **P-Time: 1230**
- **CID: 456**

GUFI: ABC123

IOBT:1200

L-Time: 1230

EOBT: 1230

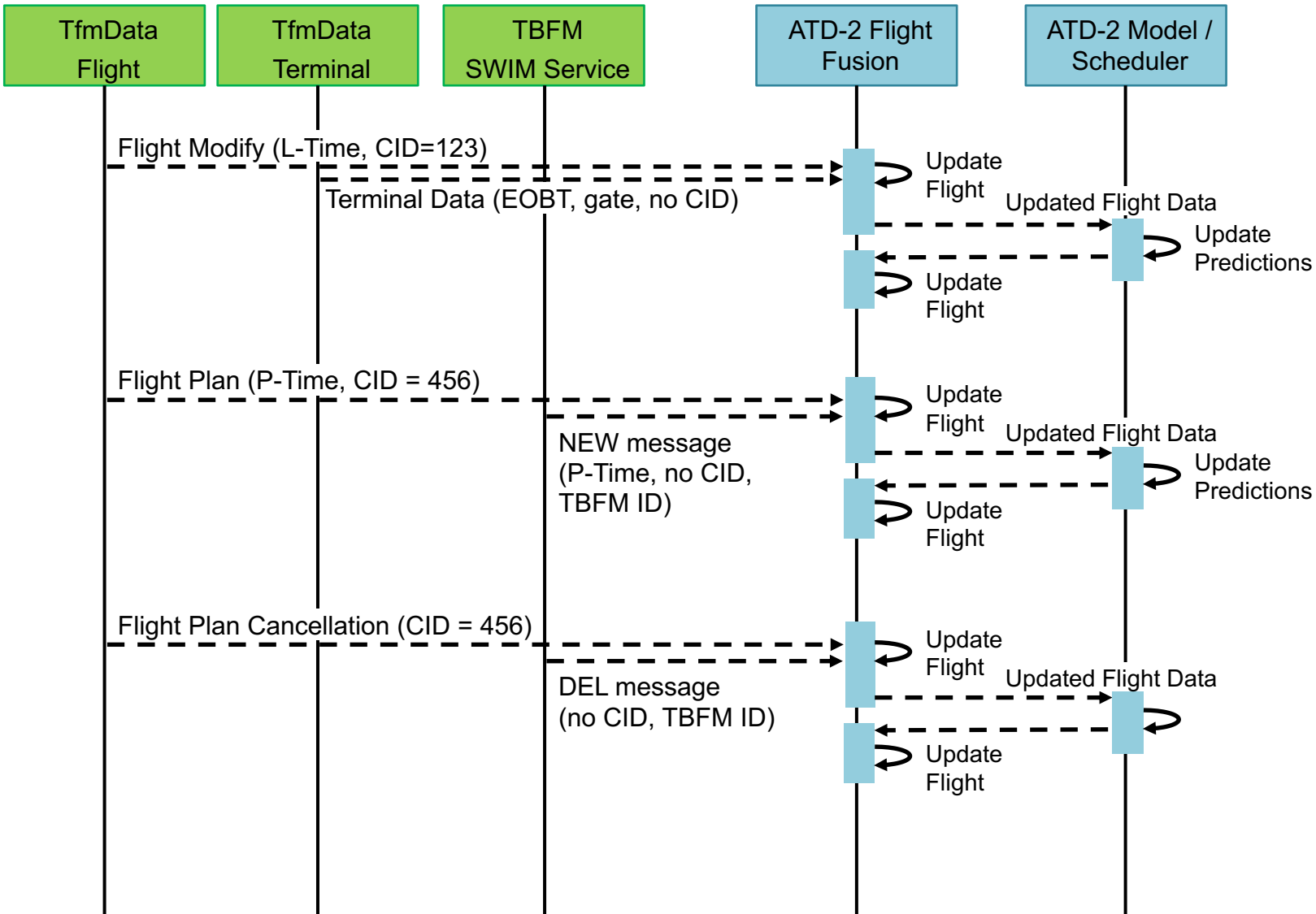
ETOT: 1245

Flight Plan 1:

- Current = **true**
- P-Time:1210
- CID: 123

~~Flight Plan 2:~~

- ~~• Current = true~~
- ~~• P-Time: 1230~~
- ~~• CID: 456~~



Fuser Flight Data



- Standard naming convention used with most data elements in the Fuser Flight
- Naming convention is based on a flattened version of the Flight Object Data Dictionary (FODD) and FIXM Schema.
- Named so that related elements are close together alphabetically
- Self documenting for the most part
- Each name consists of three parts
 - Information category
 - Resource Type
 - Source Type
- Naming convention: `category_resourceType_sourceType`
- Examples:
 - `arrival_runway_actual_time`
 - `departure_spot_predicted`



| Prefix | Description |
|-------------|--|
| aircraft_* | Information about the physical airframe operating the flight |
| arrival_* | Information about the arrival portion of the flight |
| departure_* | Information about the departure portion of the flight |
| position_* | Information about the flight's position |
| release_* | Information about the APREQ negotiation process |



| Resource Type | Description |
|-------------------|--|
| *_runway_* | The data element related to the runway used by the flight |
| *_fix_* | The data element related to the fix used by the flight |
| *_stand_* | The data element related to the parking gate used by the flight |
| *_movement_area_* | The date element related to the time the flight enters or exits the movement area |
| *_spot_* | The data element that pertains to the physical location the flight enters or exits the movement area |
| *_queue_* | The data element that pertains to the time when the flight enters the departure runway queue |

| Source Type | Description |
|------------------------|---|
| *_actual_time | The time the flight actually made use of the resource |
| *_controlled_time | The controlled time from a TFM TMI (GDP, AFP, GS) |
| *_earliest_time | The earliest time a flight is expected to use the resource by external sources (EOBT) |
| *_estimated_time | The time the flight is estimated to use the resource by external sources |
| *_initial_time | The first event time received for the resource |
| *_metered_time | The TMA-metered time (STA) that the flight will use the resource |
| *_proposed_time | The flight time based on the filed flight plan |
| *_scheduled_time | The time the flight is scheduled to operate by the airline |
| *_surface_metered_time | The time a flight should comply with as part of a Surface Metering Program |
| *_targeted_time | The time the flight is predicted to use the resource as set by the scheduler |
| *_undelayed_time | The unimpeded time the flight would use the resource is not constrained by external restriction |



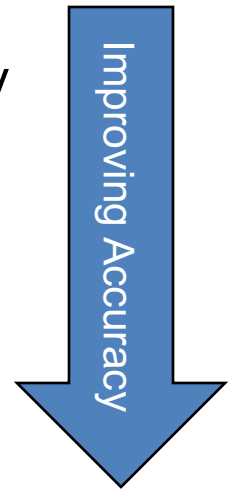
| Source Type | Description |
|--------------------|---|
| *_actual | The actual resource used by the flight |
| *_airline | The resource provided by an airline source or user entering the information in the RTC or STBO client display |
| *_assigned | The resource set by an FAA controller |
| *_position_derived | The resource derived from position data and adaptation by STBO |
| *_model | The resource derived from STBO modeling |
| *_decision_tree | The resource derived from STBO decision trees |

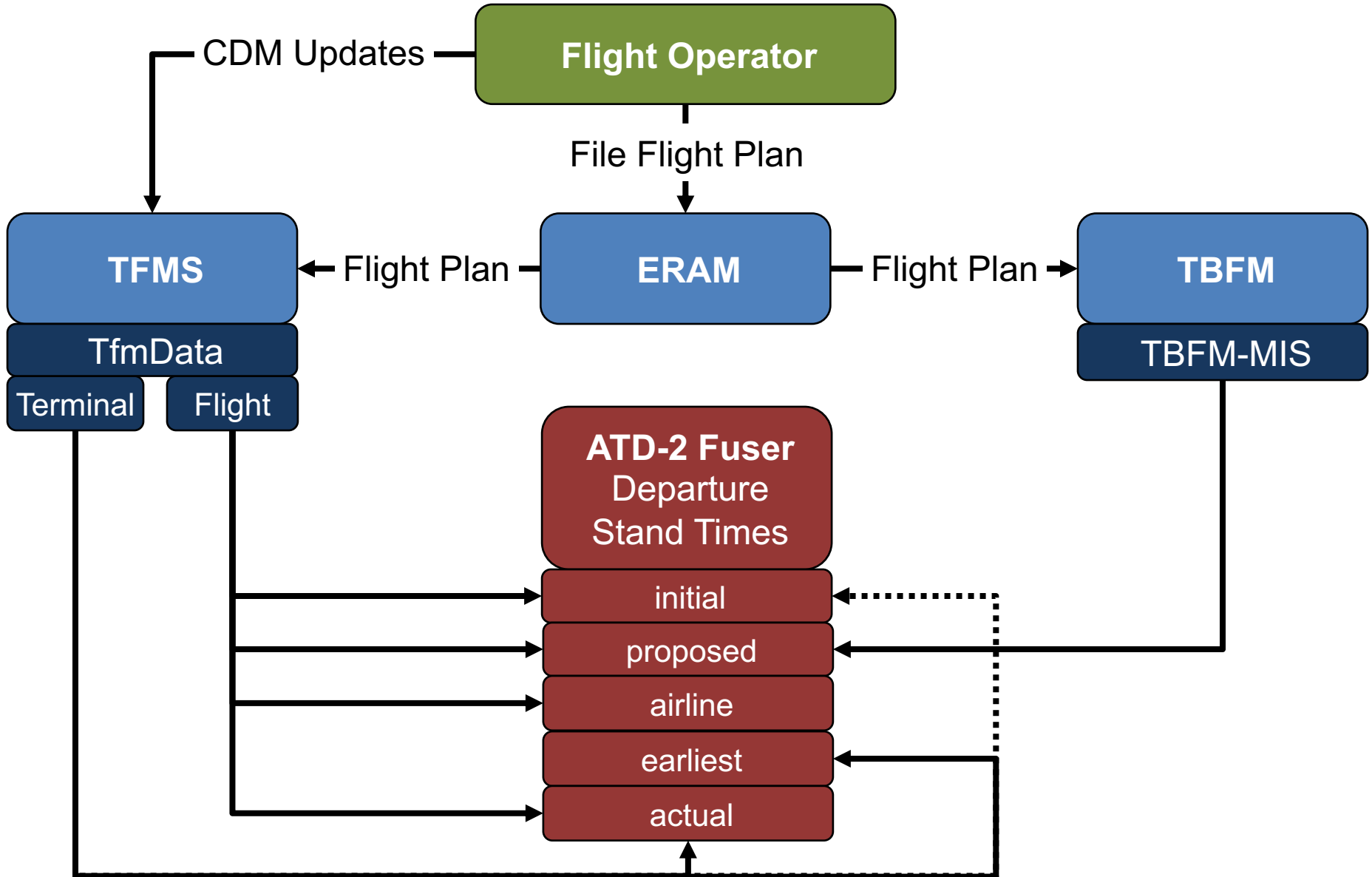
| Column Name | Description |
|----------------------------|---|
| timestamp | Typically the timestamp of the source message |
| timestamp_fuser_processed | The time the fuser finished processing the message |
| timestamp_fuser_received | The time the fuser received the message |
| timestamp_source | The timestamp in the message supplied by the source system when available |
| timestamp_source_processed | The time the message was processed by the data parser |
| timestamp_source_received | The time the message was received by the data parser |

The most common flight identifying field must be consistent across sources, right?

| Source System | Term Used |
|-------------------------------|---|
| Fuser/MatmFlight | acid |
| TFMS | qualifiedAircraftId. aircraftId |
| TBFM | tmaType.air.flt. aid |
| TFM Terminal Flight Data | acid |
| STDDS Position Report (ASDEX) | flightId.aircraftId.value |
| FIXM | flightIdentification. aircraftIdentification |

- ATD-2 departure predictions start with when the flight will leave the gate
- There are multiple data elements that provide an estimate of pushback time
 - Some data elements are available in multiple sources
- The Fuser mediates and stores each data element individually
 - departure_stand_initial_time (IOBT / IGTD)
 - departure_stand_proposed_time (P-Time from flight plan)
 - departure_stand_airline_time (L-Time from CDM messages)
 - departure_stand_earliest_time (EOBT)
 - departure_stand_actual_time (AOBT / OUT)
- The ATD-2 prediction engine then uses the best available data element as the start of it's predictions





| Departure Stand Time | TfmData Flight* | TfmData Terminal | TBFM-MIS** |
|----------------------|--|--|--|
| Initial | flight.qualifiedAircraftId.igtd | flight.departureNas. runwayDepartureTime. original.time | |
| Proposed | [flightPlanInformation / flightPlanAmendmentInformation]. coordinationTime.value (if coordinationPoint == departureAirport && coordinationType == PROPOSED) | | tma.air.flt.ctm (if tma.air.flt.acs == PROPOSED && tma.air.flt.fps == PROPOSED && tma.air.dap == tma.air.flt.cfx) |
| Airline | [nscmFlightCreate / nscmFlightModify]. airlineData.flightTimeData. airlineOutTime | | |
| Earliest | | flight.departureNas. runwayDepartureTime. earliest.time | |
| Actual | nscmFlightModify. airlineData.flightTimeData. gateDeparture | flight.departureNas. standPositionAndTime. standTime.actual.time | |

* Multiple TfmData Flight message types can contain this data. Only the most common ones are listed here.

** TBFM-MIS mapping not currently used on ATD-2 because of feedback loop between ATD-2 and TBFM



- Full Fuser Mappings Available
 - https://aviationsystems.arc.nasa.gov/atd2-industry-days/fuser/Fuser-Database-Input-Mapping-Table_85328219.html





- “Whack A Mole Fever,” Author: TPapi,
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