Airspace Technology Demonstration 2 (ATD-2)

Learning To SWIM with ATD-2

May 22, 2019
Learning to SWIM with ATD-2

- Why ATD-2 chose to SWIM
- ATD-2 Approach to SWIM
- Overview of Data Feeds
- Data Elements of Interest to ATD-2 in Data Feed
- ATD-2 Lessons Learned
Why ATD-2 Chose SWIM

- Real time
- Single point of access
- Numerous available products
- More cost effective than legacy alternatives
Why Use Multiple Sources Of Data?

• To cover the entire flight duration and turn-around process
  – If you want the highest quality data available for the entire flight from gate to gate, this requires the use of multiple sources from SWIM
  – In general, the best data comes from the FAA system whose operational mission most closely matches your data need (e.g. if you want strategic constraints and planning info, then TFMS, tactical then TBFM or TFDM)

• Some information only exist, or is higher quality, in certain feeds
  – APREQ Release Times from TBFM SWIM
  – EDCT information from TFM Flight Data SWIM
  – Surface metering times from TFDM Terminal Publication SWIM

• Data redundancy/backup from secondary sources
  – Loss of any one feed still allows data from other feeds to provide value
Quick summary (Oct 15, 2018):

- On East (left) side, several flights have both APREQs and EDCTs
- This is a dual use runway with arrivals (gray) mixed with departures (green)
- At this moment, the ATCT TMC is searching for an APREQ time to EWR for UAL305 that also meets its existing EDCT (green space shown from ZDC TBFM IDAC)
- On West (right) side, two flights are showing gate conflict (magenta/pink gate)
- AAL875 pilot has requested West runway for operational necessity

SWIM Data

- APREQ times from TBFM
- EDCT times from TFMS and TBFM
- Flight plans from TFMS and TBFM
- Surface surveillance from STDDS
- EOBTs from TFMS Terminal Flight Data
- Gates from TFM Terminal Flight Data
- Arrival times from TBFM and TFMS
ATD-2 Approach to SWIM

- Get Familiar with Documentation
- On Ramping
- Consume
- Monitor
- Raw Archives
- Parse
- Create Database
- Match (to be discussed in more detail later in this presentation)
- Fuse (to be discussed in more detail in later presentations)
- Add value (model / scheduler)
References

- NAS Service Registry and Repository (NSRR)
  - https://nsrr.faa.gov/

- SWIFT Operational Context and Use Cases

- FAA NAS Storyboards
  - https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/Storyboard/nextgen-overview.html#home

- SWIM Main Page
  - https://www.faa.gov/air_traffic/technology/swim/

- SWIM Users Forum
  - https://www.faa.gov/air_traffic/technology/swim/users_forum/
Accessing SWIM

• Generally Two Options
  – Site to site VPN
    • Up until recently this was your only option
    • Long on ramping process
    • Great when working
    • Can be challenging to troubleshoot with something goes wrong
  – SWIM Cloud Distribution Service (SCDS)
    • Relatively new
    • Very fast on ramping process
    • Does not support request/reply
NEMS via VPN

Getting Access to SWIM

2 – 6 Month Process

https://www.faa.gov/air_traffic/technology/swim/products/get_connected/#ecbrief
SCDS

SWIM Cloud Distribution Service (SCDS)

SCDS is a publicly accessible cloud-based infrastructure dedicated to providing real-time SWIM data to the public via Solace JMS messaging. This service will include access to the same publicly available data that is currently offered via the NAS Enterprise Service Gateway (NESE) SWIM implementation.

- Provides access to all publicly available pub/sub SWIM services
  - Data is forwarded from NAS Enterprise Security Gateway (NESE) via a secure connection and will automate failover between ACY and OEX
  - Distributes data to SCDS users over a TLS connection

* Slide copied directly from SWIM Users Forum 24 Briefing
# Consumer Services NESG vs. SCDS

<table>
<thead>
<tr>
<th>CONSUMER SERVICES</th>
<th>NESG</th>
<th>SCDS</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Request</td>
<td>✓</td>
<td>✓</td>
<td>SCDS expedites data request process</td>
</tr>
<tr>
<td>Data Access Approval</td>
<td>✓</td>
<td>✓</td>
<td>SCDS expedites data release process</td>
</tr>
<tr>
<td>Self Provisioning</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>No Service Acceptance Tests</td>
<td></td>
<td>✓</td>
<td>SCDS does not require SAT</td>
</tr>
<tr>
<td>Required (L3, SA, etc.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitive Data Availability</td>
<td>✓</td>
<td></td>
<td>Sensitive data will not be shared via SCDS</td>
</tr>
<tr>
<td>Help Desk Resolution</td>
<td>✓</td>
<td>✓</td>
<td>Enterprise Data Services (EDS) provides 24/7/365 resolution</td>
</tr>
<tr>
<td>Web Services</td>
<td>✓</td>
<td></td>
<td>SCDS does not currently support web services</td>
</tr>
<tr>
<td>Sample Data Availability</td>
<td>✓</td>
<td>✓</td>
<td>NESG request is manual, SCDS is automated</td>
</tr>
<tr>
<td>Jumpstart Kit Availability</td>
<td>✓</td>
<td>✓</td>
<td>NESG available on request, SCDS is self-service</td>
</tr>
<tr>
<td>Data Metrics / Statistics</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>SWIM Service Status (self-service)</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Client Data Compression</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Client Data Encryption (required)</td>
<td>VPN</td>
<td>SSL/TLS</td>
<td></td>
</tr>
</tbody>
</table>

*Slide copied directly from SWIM Users Forum 24 Briefing*
Start Consuming

• Develop your own consumer application
  – Getting started resources
    • NEMS jumpstart kit -
      [https://www.faa.gov/air_traffic/technology/swim/documents/media/user-guide/JumpstartKit-5.1.1.zip](https://www.faa.gov/air_traffic/technology/swim/documents/media/user-guide/JumpstartKit-5.1.1.zip)
    • SCDS jumpstart kit – available after registering with SCDS

• Use a 3rd party vendor
  – Fastest way to start consuming (if you haven’t developed something already)
  – Bonus, you can skip the testing steps if you are using software from a vendor that has already gone through the process
ATD-2 SWIM Consumer Application

• ATD-2 uses a JMS consumer application
  – Capabilities
    • Connecting to various JMS brokers including
      – Solace
      – Weblogic
      – ActiveMQ
      – IBM MQ
      – AWS SQS
    • Filtering
    • Splitting
    • Recording
    • Repeating
    • Performance Monitoring
Datahub Architecture

- SWIM Data is distributed over queues
  - Can only have one consumer per queue
- Typically an organization will connect and then repeat the data to an internal message bus to allow for other internal functions.
Record the data

• Why
  – Inspect and understand the data
  – Playback
  – Historical archives
  – Recovery option

• Not without effort and cost
  – Need a process for recording the data to files (or other data store)
  – Has to be managed
  – ATD-2 archives TBs of data

• General guidance
  – Capture headers and message content
  – Store by hour
  – Organize by year, month, day
  – Compress the files
  – Prepare a lot of storage space or have an expandable storage solution
    • Never met an analyst willing to get rid of data
Monitoring

- Grafana Reports
- System Monitor
- Prometheus Alerts/Emails
Grafana

• Monitors feeds over time
• Allows us to compare feeds from multiple sources (ACY and OEX)
System Monitor

- Quick look view of the status of key ATD-2 Systems
- Ability to drill down to the specific metrics
- Custom developed for ATD-2
1 alert for job=dfwdatahub

[1] Firing

Labels
alertname = rateAlert_dfwdatahub_TFM_TFDM
instance = datahub2:9097
job = dfwdatahub
topic = TFM_TFDM

Annotations
subject = No messages for topic TFM_TFDM on dfwdatahub
summary = Topic TFM_TFDM on dfwdatahub has not received a message for at least 10 minutes

Source
Overview of Data Feeds

<table>
<thead>
<tr>
<th>Feed</th>
<th>Data Source</th>
<th>ATD-2 Use</th>
<th>Data</th>
</tr>
</thead>
</table>
| TfmData Flight        | TFMS        | • Schedule data  
                      |             | • CDM data  
                      |             | • Flight plans  
                      |             | • EDCTs  
                      |             | • Track data | Flight |
| STDDS SMES            | ASDE-X/ASSC | • Surface track data | Track |
| TBFM MIS              | TBFM        | • Release times  
                      |             | • EDCTs | Flight Plan |
| TfmData Terminal      | TFMS        | • EOBTs  
                      |             | • Gates  
                      |             | • Tail Numbers | Flight |
| TfmData Flow          | TFMS        | • Ground Stops  
                      |             | • MIT restrictions (planned) | TMI |
| SFDPS                 | ERAM        | • Support for NASA research TBFM | Flight Plan |
Overview of Data Feeds

- The NAS systems generating flight data SWIM feeds are interconnected.
  - Basic understanding the NAS architecture helps make sense of the SWIM data.

<table>
<thead>
<tr>
<th>NAS System</th>
<th>SWIM Feeds</th>
<th>Primary Inputs</th>
<th>Secondary Inputs</th>
<th>Deployments</th>
</tr>
</thead>
</table>
| TFMS       | • TfmData Flight  
             • TfmData Flow  
             • TfmData Terminal | • ERAM flight/track data  
             • OAG schedule  
             • Airline CDM messages  
             • ATOP oceanic track | • TBFM release times  
             • STDDS surface times  
             • OIS / NTML  
             • International feeds  
             • TFDM predictions | 1 |
| ERAM       | • SFDPS     | • ATC flight plan data  
             • En route radar track | • TFMS EDCTs  
             • TFMS reroutes | 1 per ARTCC  
(20 total) |
| TBFM       | • TBFM MIS  | • ERAM flight/track data  
(adjacent ARTCCs)  
• TRACON fight/track data | • TFMS international track  
• TFDM release time negotiation | 1 per ARTCC  
(20 total) |
| ASDE-X     | • STDDS SMES | • Surface radar track  
• ERAM flight data | | 1 per airport  
(38 total) |
| TFDM       | • TTP       | • All the above | | 1 per airport  
(future) |
# Overview of Data Feeds

<table>
<thead>
<tr>
<th>Feed</th>
<th>Daily Volume</th>
<th>Sync Messages?</th>
<th>Diff or Full Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>TfmData Flight</td>
<td>280k (note: much larger batches)</td>
<td>No</td>
<td>Full</td>
</tr>
<tr>
<td>STDDS SMES</td>
<td>22.5 million</td>
<td>No</td>
<td>Diff (with full at regular intervals per flight)</td>
</tr>
<tr>
<td>TBFM MIS</td>
<td>25 million</td>
<td>Yes</td>
<td>Diff</td>
</tr>
<tr>
<td>TfmData Terminal</td>
<td>225k</td>
<td>No</td>
<td>Full</td>
</tr>
<tr>
<td>TfmData Flow</td>
<td>1.7 million</td>
<td>Yes</td>
<td>Full</td>
</tr>
<tr>
<td>SFDPS</td>
<td>5.3 million</td>
<td>No</td>
<td>Full</td>
</tr>
</tbody>
</table>
## Overview of Data Feeds

<table>
<thead>
<tr>
<th>Source</th>
<th>Flights Included</th>
<th>Earliest Flight Data</th>
<th>Latest Flight Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFMDData Flight</td>
<td>All IFR</td>
<td>~24 hours before scheduled OAG operation</td>
<td>“Actual” arrival gate time published by Operators (up to 2 hours after taxi in)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFMDData Terminal</td>
<td>Only flights that publish CDM messages including Terminal Flight Data elements</td>
<td>~24 hours before scheduled operation</td>
<td>“Actual” arrival gate time published by Operators (up to 2 hours after taxi in)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SFDPS</td>
<td>All IFR and some VFR</td>
<td>Filed flight plan</td>
<td>Flight lands</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBFM MIS</td>
<td>Impacted by a TBFM arrival (TMA) or departure (EDC) system</td>
<td>Flight plan filed within TBFM adapted region</td>
<td>Track ends or leaves TBFM adapted region</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STDDS SMES</td>
<td>Operating at or near ASDEEX airport</td>
<td>First correlated flight track</td>
<td>Last correlated flight track</td>
</tr>
</tbody>
</table>
## Overview of Data Feeds
### SWIM Feed IDs

<table>
<thead>
<tr>
<th>Source</th>
<th>Unique Flight IDs</th>
<th>Examples</th>
<th>ID Recycles</th>
<th>Multiple IDs per Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFMDATA Flight</td>
<td>• flightRef • gufi</td>
<td>• 100725389 • KT44707500</td>
<td>Infrequent Infrequent</td>
<td>Rare Yes</td>
</tr>
<tr>
<td>TBFM MIS</td>
<td>• tmald</td>
<td>• T06629</td>
<td>Immediately</td>
<td>Yes</td>
</tr>
<tr>
<td>SFDPS</td>
<td>• fdpsGufi • uuidGufi • flightPlanIdentifier</td>
<td>• us.fdps.2019-05-09T13:40:40Z.000/19/501 • b443e49c-0cdf-47ed-bce5-5275a54a8cc0 • KT44707500</td>
<td>Never Unlikely Infrequent</td>
<td>Rare Yes, on failover Yes</td>
</tr>
<tr>
<td>STDDS SMES</td>
<td>• stid • track • enhancedData.erahGufi • enhancedData.sfdpsGufi</td>
<td>• 1716539 • 862 • KT44707500 • us.fdps.2019-05-09T13:40:40Z.000/19/501</td>
<td>Infrequent Frequent Infrequent Never</td>
<td>Possible Yes Rare</td>
</tr>
</tbody>
</table>
Data Elements in SWIM Feeds

• Full mappings available publically here:
  – [https://aviationsystems.arc.nasa.gov/atd2-industry-days/fuser/TFMS-Flight-Data-Mapping_85328230.html](https://aviationsystems.arc.nasa.gov/atd2-industry-days/fuser/TFMS-Flight-Data-Mapping_85328230.html)

• Mapping Example – TfmData Flight Messages

<table>
<thead>
<tr>
<th>Data Element</th>
<th>TfmData Flight Message Type</th>
<th>TfmData Flight Data Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>acid</td>
<td>&lt;all&gt;</td>
<td>qualifiedAircraftId.aircraftId</td>
</tr>
<tr>
<td>aircraftType</td>
<td>BOUNDARY_CROSSING_UPDATE</td>
<td>flightAircraftSpecs</td>
</tr>
<tr>
<td></td>
<td>DEPARTURE_INFORMATION</td>
<td>flightStatusAndSpec.aircraftspecification</td>
</tr>
<tr>
<td></td>
<td>FLIGHT_CREATE</td>
<td>airlineData.flightStatusAndSpec.aircraftspecification</td>
</tr>
<tr>
<td></td>
<td>FLIGHT_MODIFY</td>
<td>airlineData.flightStatusAndSpec.aircraftspecification</td>
</tr>
<tr>
<td></td>
<td>FLIGHT_PLAN_AMENDMENT_INFO</td>
<td>newFlightAircraftSpecs</td>
</tr>
<tr>
<td></td>
<td>FLIGHT_PLAN_INFORMATION</td>
<td>flightAircraftSpecs</td>
</tr>
<tr>
<td></td>
<td>FLIGHT_ROUTE</td>
<td>flightStatusAndSpec.aircraftspecification</td>
</tr>
<tr>
<td></td>
<td>FLIGHT_SCHEDULE_ACTIVATE</td>
<td>flightStatusAndSpec.aircraftspecification</td>
</tr>
<tr>
<td></td>
<td>FLIGHT_TIMES</td>
<td>flightStatusAndSpec.aircraftspecification</td>
</tr>
</tbody>
</table>
flight.getDepartureNas().getStandPositionAndTime().getStandTime().getActual().getTime()  

flight.getActualOffBlockTime()
• One parser per feed
  – Transforms raw XML file into flattened object structure
    • Leveraging JAXB with jaxb2-basics to simply XML->Java Object conversion
    – In some cases, perform aggregation against messages from the same source

• Aggregation examples
  – STDDS SMES
    • Track data is sent as diffs
    • Have to aggregate with previous messages for same flight so that complete position update is processed by Fuser

  – TBFM-MIS
    • Need to be able to handle SYNC messages properly

• Parsers archive raw message to databases for analysis
TFMData Flight Parser

• Parser features
  – Message splitting/filtering
    • Filter to MessageType=FlightDataMessageOutgoing.
    • Un-batch incoming messages.
  – Message aggregation
    • Sort messages within each by time order.
    • Messages are full, but message types contain different types of data.
  – Message matching
    • Global GUFI assigned from ATD2 GufiService.
    • Locally match data on Flight Ref with additional internal validation.
  – Message Transformation
    • Common format with GUFI and all possible data across TFM message types.

• Key headers
  – MessageType : FlowInformationMessageOutgoing / FlightDataMessageOutgoing
• Lessons learned
  – TFMS Flight Ref is good for matching NAS-wide flight data.
  – Schema is somewhat challenging to parse -- most messages are different format.
  – Message types (and message trigger) are important to interpreting the message intent.
    • E.g. MsgType=FLIGHT_TIMES, Trigger=NEMS_TBFM_FLT_DEPARTURE_MSG
  – Some JMSDD data elements are not available yet (e.g. etdTimeType=METERED).
STDDS SME Parser

• Parser features
  – Message splitting/filtering
    • Process each airport independently.
  – Message aggregation
    • Merge input data on track number.
    • Handle “full=true” sync messages.
    • Handle the delete element (r=1) attribute.
  – Message matching
    • Global GUFI assigned from ATD2 GufiService.
    • Locally match data on STDDS Surface Track ID with additional internal validation.
  – Message Transformation
    • Common format with value-added fields (e.g. GUFI).

• Key headers
  – airport
  – msgType : AT (PositionReport), AY (SystemStatus), AD (adsbReport), ML (mlatReport)
STDDS SME Parser

• Lessons learned
  – Beacon code used to retrieve core data from ERAM (e.g. ACID, aircraft type, etc).
    • When aircraft emit the “wrong” beacon code, ACID will also be wrong.
  – Track messages are interpolated (may indicate wrong location).
  – Schema updates are deployed to different airports at different times.
• Parser features
  – Message filtering
    • ATD2 filters to messages from TBFM ARTCCs of interest.
  – Message aggregation
    • Merge input data on TMA ID.
    • Merge elements in sta, eta, sch, mrp data groups by common “mfx” name.
    • Handle NEW, AMD, DEL message types.
    • Handle messages out of order.
    • Handle sync messages.
  – Message matching
    • Global GUFI assigned from ATD2 GufiService.
    • Locally match data on TMA ID with additional internal validation.
  – Message Transformation
    • Common format with value-added fields (e.g. GUFI).

• Key headers
  – ARTCC – TBFM originating ARTCC.
  – SYNC – sync message.
  – STDCHG – indicator that release time either set or unset.
TBTFM-MIS Parser

• Lessons learned
  – Tmaldi used for merging data, but can recycle very quickly.
  – TBTFM SYNC messages had to be handled as syncs and not updates.
    • Sync messages can take many minutes to complete. Prevented resetting the EDCT back to an old value.
  – Treat AMD/NEW the same.
Additional References

• Animated storyboards
  – About ERAM in general
  – About TBFM in general
  – About TFMS in general
  – About TFDM in general

• Operation Context and Use Cases
  – About TfmData Flow Operational Context and Use Cases
  – About TfmData Flight Operational Context and Use Cases
  – About TBFM SWIM Operational Context and Use Cases
  – About SFDPS Operational Context and Use Cases
Wrap Up

- SWIM contains lots of data

- The data has lots of value

- But consuming that data is challenging

- If only there were some way to fuse the data together…
Questions