ATD-3 Dynamic Routes for Arrivals in Weather (DRAW) and Multi-Flight Common Route (MFCR)

Presented by: Matt Modderno
FAA ATD-3 Project Lead

September 22, 2021
Session Agenda & Topics

**ATD-3**
- **Airspace Technology Demonstration 3**
  - Tool Suite Overview
  - Recap: ATD-3 Tool Suite’s Transfer to the FAA

**MFCR**
- **Multi-Flight Common Routes**
  - Capability Overview & Current Status  
    - Guest Speaker: Karl Bilimoria (NASA)
  - Program Accomplishments

**DRAW**
- **Dynamic Routes for Arrivals in Weather**
  - Capability Overview & Current Status  
    - Guest Speaker: Douglas Isaacson (NASA)
  - Human-in-the-Loop (HITL) Study Overview  
    - Guest Speaker: Philip Bassett (Cavan Solutions)
Adverse weather accounts for ~70% of Total National Airspace System (NAS) Delay in U.S. Operations
- Convective Weather is the most difficult to deal with as a result of its unpredictability

Traffic Flow Management (TFM) Decision Support Tools are available to traffic managers & airspace users to help identify & apply strategic mitigations, e.g., Severe Weather Avoidance Plans (SWAPs)

Automation is not sufficient today to adequately notify traffic managers & airspace users when weather constraints have changed & avoidance routes (or segments of them) may no longer be necessary

Strategic Weather Avoidance Routes often result in large deviations from user preferred trajectories, therefore, leading to unnecessary:
- Delays
- Fuel
- Airline Operating Cost
- Environment Impact
The Solution: ATD-3

- ATD-3 was a subproject sponsored by NASA ATD Project as part of NASA's Airspace Operations & Safety Program (AOSP)

- **Addressing AOSP Technical Challenge #3:**
  - To reduce weather-induced delays through the integration of weather information to better manage aircraft, traffic flow, airspace, & schedule constraints by delivering air/ground procedure & user-tool technologies, assuming current-day data sharing & automation infrastructure limitations

- **ATD-3 Objectives:** To develop integrated air/ground automation tools that:
  - Reduce impacts of uncertainty in weather
  - Enable continuous analysis & identification of more efficient routes for either individual flights or for groups of flights
  - Efficiently share route correction or implementation options between traffic managers, pilots, dispatchers, & controllers
Integrating ATD-3 Technologies into the NAS could:

- Improve trajectory efficiency in the en route & arrival phases of flight
- Improve TFM coordination & productivity
- Improve responses to changes & uncertainty in demand & constraint predictions
- Accelerate the recovery from outdated Traffic Management Initiatives (TMIs)
- Revise long duration TMIs expeditiously
ATD-3 Tool Suite

Dynamic Weather Reroutes (DWR)  Multi-Flight Common Routes (MFCR)

Traffic Aware Strategic Aircrew Requests (TASAR)  Dynamic Routes for Arrivals in Weather (DRAW)
ATD-3’s Technology Transfer Timeline

- DWR Transferred in 2016
- MFCR Transferred in 2017
- DRAW Transferred in 2019

Multi-Flight Common Routes (MFCR) identifies opportunities for delay recovery by refreshing outdated routes
MFCR Usage

• MFCR is designed for use by Traffic Flow Managers, for possible implementation as a module of TFMS
  – NAS-wide coverage, looking for time-saving advisories in all Centers
  – Each advisory covers a group of flights currently in the same Center
  – May be used as an exit strategy from Playbook routes, but it also identifies opportunities to refresh outdated routes in other situations

• Possibly gain the benefits of large delay recovery, at the “cost” of evaluating & coordinating a small number of re-route advisories

• Establish new flows for groups of flights having a common route segment, for enhanced operational acceptability

• Present re-route advisory to Traffic Manager, with graphical functionality for review/modification prior to implementation
MFCR Advisory Features

- MFCR merges multiple flights to a common route, creating a new flow for increased operational acceptability
- Each route segment is clear of weather
- Each flight has time savings of at least 3 minutes (user selected)
- Total flight time savings for group is at least 10 minutes (user selected)
- MFCR provides graphical functionality for review & modification prior to implementation of advisory
Example MFCR Advisory

MFCR advisory has 9 flights with a total of 53 minutes time savings
Technology Transfer

- NASA completed technology transfer to FAA in December 2017

- Key deliverables include:
  - Concept of Operations
  - Functional Requirements
  - Benefits & Cost Assessment
  - HITL Evaluation Summary
  - Software; Version Description Document; User Guide
  - Technical Publications
ATD-3 MFCR Current Status

- MFCR was tech transferred to the FAA’s Mission Support Services Organization for incorporation into their Advanced Flight Specific Technologies (AFST) program
  - AFST was a candidate for inclusion in TFMS Enhancements 5
    - TFMS Enhancements 5 is currently on hold pending technology refresh of TFMS

- NASA developed the Future ATM Concepts Evaluation Tool (FACET) to evaluate Traffic Flow Management (TFM) capabilities
  - The NAS Constraint Evaluation & Notification Tool (NASCENT) is an application within FACET that was utilized to demonstrate the MFCR concept
  - FACET/NASCENT were software transferred to the FAA’s NextGen Organization for use in evaluating future TFM concepts
• FACET provides Fast-time/Real-time simulation or playback of air traffic, weather, & airspace constraints & restrictions.
  - Can receive all this data from an external source in live mode.

• Provides variety of metrics in graphical & text format
  - Delays: minimum, maximum, average, per airline, per time bucket
  - Fuel burn, Distance flown, Time flown
  - Duration of exposure to weather
  - Number of aircraft in CONUS, ARTCCs, Sectors, Airports, geographical grid cells at each time bucket

• NASCENT provides alternative routes that can be modified & validated to be replaced with the active flight plan.
  - Proposes routes to save time or fuel, avoid airspace constraints, or avoid weather.
  - Can operate in live mode & on the fly proposed route for live traffic around live constraints or weather (can be integrated with an external lab data feed)
Dynamic Routes for Arrivals in Weather (DRAW) – Today’s Arrival Operations

- Weather is one of the primary reasons for time-based metering to be discontinued.

- Current operational system cannot adjust its scheduled times of arrival (STA) for aircraft that need to deviate around weather.

- Traffic Management Coordinators (TMCs) & Controllers revert to less efficient methods of managing arrival traffic flow in weather
  - Implement conservative alternate routes hours in advance
  - Miles-in-trail (MIT)
What is DRAW?

Traffic management decision support tool that proposes reroutes to improve arrival traffic flow
- Sustain metering operations in the presence of weather
- Find efficient arrival routes
- Balance meter fix demand

<table>
<thead>
<tr>
<th>ATCSCC</th>
<th>Traffic Management Unit</th>
<th>ARTCC</th>
<th>Sectors</th>
<th>TRACON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Departure Airport</td>
<td>90 - 120 min. to Arrival Airport</td>
<td>Freeze Horizon (30 - 40 min. to Arrival Airport)</td>
<td>Meter Fix</td>
<td>Arrival Airport</td>
</tr>
</tbody>
</table>
1) Weather-Avoidance Route Advisory

Current scheduled times of arrival do not reflect the need to deviate for weather.
2) Alternate-Route Advisory

Current Flight Plan

Freeze Horizon

Current scheduled times of arrival & delay

Adjusted times of arrival & metering impact

DRAW Efficient Reroute

Draw
### DRAW Advisory List

<table>
<thead>
<tr>
<th>TL</th>
<th>TP</th>
<th>GP</th>
<th>ACID/DEP/ARR</th>
<th>SAV</th>
<th>TRANS.STAR/AUX</th>
<th>STATUS</th>
<th>HIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>VKTRY</td>
<td>GREGS</td>
<td>1.2</td>
<td>BOOVE. BOOVE4/1</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FEVER</td>
<td>KNEAD</td>
<td>2.8</td>
<td>BOOVE. BOOVE4/1</td>
<td>OK</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AAL2289/KSAN/KDFW</td>
<td>1.1</td>
<td>BOOVE. BOOVE4/1</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AAL1117/KLAS/KDFW</td>
<td>1.3</td>
<td>BOOVE. BOOVE4/1</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AAL1243/KLAX/KDFW</td>
<td>0.3</td>
<td>JEN.JEN1/1</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AAL767/KSNA/KDFW</td>
<td>-0.2</td>
<td>BOOVE. BOOVE4/1</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AAL2705/KSJC/KDFW</td>
<td>0.2</td>
<td>BOOVE. BOOVE4/1</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AAL6731/KSNA/KDFW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AAL4421/KPHX/KDFW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>KARLA</td>
<td>SASIE</td>
<td>FINGR</td>
<td>BRDJE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>HOWDY</td>
<td>DODJE</td>
<td>ORVLL</td>
<td>YEAGR</td>
<td></td>
</tr>
</tbody>
</table>
Clicking on a flight in DRAW List displays the advisory route on the map.

User can modify the route by clicking & dragging, & then press “Accept” button to amend.

If the route conflicts with a Convective Weather Avoidance Model (CWAM) polygon, the conflicting polygon is presented.
- Flights that have DRAW advisory show magenta underline.

- When the user modifies flight routes via TP, the flight’s ETA & STA on Timeline are updated in real-time (magenta box) to visualize the effect of the modification.
# DRAW HITLs #1-5

<table>
<thead>
<tr>
<th>HITL #1</th>
<th>HITL #2</th>
<th>HITL #3</th>
<th>HITL #4</th>
<th>HITL #5</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>CTAS</td>
<td>CTAS</td>
<td>CTAS</td>
<td>CTAS</td>
</tr>
<tr>
<td>ARTCC (Arrival Gates)</td>
<td>ZFW (SW → DFW)</td>
<td>ZFW (NW, SW → DFW)</td>
<td>ZTL (SW, SE → ATL)</td>
<td>ZTL &amp; ZJX (SE → ATL)</td>
</tr>
<tr>
<td>DRAW vs. No-DRAW</td>
<td>Y</td>
<td>Y</td>
<td>---</td>
<td>Y</td>
</tr>
<tr>
<td># of Weather Scenarios</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td># of TMC</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td># of Sector Staffed</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Notes</td>
<td>1 Baseline run (clear weather), 6 Storyboard runs</td>
<td>TMC &amp; Controller sessions on separate days, 16 TMC-Only runs</td>
<td>1 Baseline run (clear weather)</td>
<td>2 Freeze Horizon distances</td>
</tr>
</tbody>
</table>
Why Is the DRAW Capability Important?

- Current operational TBFM system cannot adjust Scheduled Times of Arrival (STAs) for aircraft that deviate around weather
  - Causes uncertainty in downstream arrival schedules
- Presence of severe weather is the primary reason for traffic flow managers to discontinue TBFM operations & revert to less efficient methods of managing arrival flows, e.g.,
  - Conservative Alternate Routes
  - Mile-in -Trail Restrictions
- As the use of TBFM expands, the need for decision support capability to manage arrival aircraft through & around weather is evident
DRAW’s Value to Traffic Flow Managers

- Traffic Management Decision Support Tool that:
  - Proposes reroutes to improve arrival traffic flow
  - Sustain metering operations in the presence of weather
  - Proposes efficient arrival routes reducing fuel burn
  - Enables balancing of meter fix demand
  - Provides convective forecast updates every 5 minutes
  - Utilizes ERAM traffic feed from home & adjacent ARTCCs

This Photo by Unknown Author is licensed under CC BY
• **Current Goal:**
  - To assess the DRAW capability in multi-scheduler configuration environments within the TBFM System (i.e., Extended Metering [XM] / Coupled Scheduling [CS]) via a HITL experiment

• **Goal Justification:**
  - The XM & CS multi-scheduler environments are used to extend the operational range of the TBFM System, along with any speed advisories used to achieve the desired schedules at metering reference points

  - These multi-scheduler environments allow for greater flexibility & efficient options in managing schedule deconfliction & delay absorption

  - It is unknown how DRAW will function within the XM & CS environments; therefore, FAA is currently investigating the operational effects of the DRAW capability operating within these extended TBFM environments utilizing a HITL experiment
DRAW HITL Project Timeline

2020
DRAW Capability Installation & Recommendations

2021
DRAW Tech Transfer Analysis
DRAW HITL XM & CS Test Plan

2022
DRAW HITL XM & CS Scenarios
DRAW HITL XM & CS HITL & Documentation
DRAW Preliminary Program Requirements

This Photo by Unknown Author is licensed under CC BY-SA
DRAW HITL Team Overview

**FAA William J. Hughes Technical Center**
- HITL Study Environment Configuration, Scenario Development, & Experimental Design

**Cavan Solutions**
- HITL Site Selection, HITL Scenario Development, & Traffic Flow Management Subject-Matter-Experts (SMEs)

**Massachusetts Institute of Technology Lincoln Laboratory (MIT LL)**
- DRAW Software Porting & Weather Scenarios
DRAW HITL Components

- HITL Study Site Selection
- HITL Study Environment
- DRAW Software Porting & HITL Weather Scenarios
Site Selection Criteria

• Operational site must utilize TBFM XM/CS on a regular basis

• Available TBFM adaptation must be compatible with DRAW prototype software (TBFM 4.7)

• Airspace should be conducive to DRAW HITL scenario development
  - Traffic flows/meter fix locations suitable for a variety of DRAW reroutes
  - General enough to be used to extrapolate DRAW performance to other airspaces
Site 1: Albuquerque Center (ZAB)

- Operates with both TBFM XM & CS
- ZAB operates in the XM environment with:
  - Extended Metering Points (XMPs) for Phoenix International Airport (KPHX) arrivals
  - Coupled Scheduling Metering Points (CMPs) for Los Angeles International Airport (KLAX) arrivals
- KPHX is a major airline hub
- KPHX/ZAB has multiple busy arrival streams (i.e., multiple arrival routes/meter fix options)
- ZAB operational expertise encompasses both ZLA & ZAB TBFM-XM configurations
Site 2: Los Angeles Center (ZLA)

- ZLA has operated with TBFM XM, since it’s inception
- Geographic constraints (i.e., oceanic & international airspace)
- The FAA has identified KLAX/ZLA as one of the four initial “TBO operating areas”
- KLAX has consistent traffic volume from the east with the TBFM-XM configuration extending into ZAB airspace
Site Selection Summary

• ZAB/KPHX & ZLA/KLAX selected to give research team flexibility
  - Compatible TBFM adaptations
  - Wide range of airspace characteristics
  - Options for scenario development (e.g., XM & CS operations, Multiple & varied freeze horizons/meter fixes, etc.)

• By analyzing both ZLA & ZAB configurations, we can demonstrate the best use of DRAW in the XM/CS environment, point out benefit mechanisms & identify limitations/development needs

• Conducting the simulation using unique scenarios across multiple Air Route Traffic Control Centers (ARTCCs) will provide excellent examples of DRAW-TBFM-XM & CS interaction for analysis of operational suitability & software/systems compatibility

• Utilization of ZLA & ZAB configurations provide excellent opportunities for operational TFM analysis including coordination with multiple facilities including Denver Center (ZDV), another fully deployed TBFM-XM adaptation
William J. Hughes Technical Center (WJHTC)

• Located 10 miles northwest of Atlantic City, New Jersey

• **Mission:** To provide the safest, most efficient & responsive aerospace system in the world

• Accomplishing the mission by:
  - 500,000+ square feet of lab space adapted for research, development, test & evaluation activities
  - Laboratory facilities proficient at simulating the capabilities that are operational in the NAS
    - Known as having the “NAS under one roof”
WJHTC DRAW HITL Architecture

- **CWAM**: Convective Weather Avoidance Model
- **CIWS**: Corridor Integrated Weather System
- **CM**: Communication Manager
- **CREWS**: CTAS Remote Weather System
- **CTAS**: Center TRACON Automation System
- **D-Position**: Data Position
- **DYSIM**: Dynamic Simulation
- **EDDS**: En Route Data Distribution System
- **ERAM**: En Route Automation Modernization
- **FTP**: File Transfer Protocol
- **GRI dB**: Gridded Binary
- **GSGT**: Graphic Simulation Generation Tool
- **HADDS**: Hctm ATM Data Distribution System
- **HDIF**: HADDS Data Interface
- **PGUI**: Planview GUI
- **RAP**: Rapid Refresh
- **R-Position**: Radar Position
- **RUC**: Rapid Update Cycle
- **SDRR**: Simulation Driver Radar Recorder
- **TCP**: Transmission Control Protocol
- **TGUI**: Timeline GUI
- **TSIM**: TBFM Simulation
- **VTL**: Virtual Test Lab
- **WARP**: Weather And Radar Processor
- **WDPD**: Weather Data Processor Daemon
- **WEP**: Weather Enterprise Playback
- **UDS**: User Display Systems
- **vTBFM**: virtual Time Based Flow Management

**FTP Push (Sent To TBFM)**

**ERAM VTL**
- D-Position
- R-Position

**Virtual EDDS**

**Sim CREWS system**
- GRIB Processing Tool

**WARP Emulator**

**Sim RUC/RAP (via FTP)**

**FTP RUC/RAP TBFM**

**CWAM**

**UDS Mosaic (TCP Socket)**

**DRAW vTBFM**
- HDIF
- WDPD

**DRAW Requires NFS Mount**

**WEP**

**CM**

**VTCG**
- Radar
- TSIM SDRR

**DYSIM**
- SimDrive

**TSIM GSGT**
- Scenarios
- Adaptation
- Ingested Manually RUC/RAP

**J/N Sim Pilots**
- 1
- 2
- 4
• KPHX Arrivals

• ZAB arrival TBFM system
  - vTBFM provided by MIT/LL
  - TBFM 4.7 with DRAW Prototype Software
  - TBFM Adaptation
    o ZAB_T4.7.1_6.2
    o Chart Cycle: 10/11/2018
  - ZDV & ZLA receive Metering Times

• VTL ERAM
  - ZAB, ZLA, ZHU, ZFW, ZDV, ZKC
    o Chart Cycle: 9/13/18
    o National: eae4102a

• Weather & Aircraft Scenario
  - SDRR, DYSIM, GSGT (TSIM)
  - WEP Version: TBD
  - Traffic Date: TBD
• KLAX Arrivals

• ZLA arrival TBFM system
  - vTBFM provided by MIT/LL
  - TBFM 4.7 with DRAW Prototype Software
  - TBFM Adaptation
    o ZLA_T4.7.1_9.1
    o Chart Cycle: 10/11/2018
  - ZAB only receives Metering Times

• VTL ERAM
  - ZLA, ZAB, ZOA, ZLC, ZDV
    o Chart Cycle: 9/13/18
    o National eae4102a

• Weather & Aircraft Scenario
  - SDRR, DYSIM, GSGT (TSIM)
  - WEP Version: TBD
  - Traffic Date: TBD
All tests will be run with both CS or XM, i.e.,

- CS will be tested in the ZLA configuration
  - Only operational site in NAS that runs CS metering operation
  - Will allow for a realistic CS operational checkout of DRAW functionality
  - Neighboring ZAB is one of a few NAS sites to utilize Ground Interval Management-Spacing (GIM-s) allowing team to realistically test the interaction of GIM-s speed advisories in conjunction with DRAW reroutes

- XM will be tested in the ZAB configuration
  - XM is utilized at ZAB in the NAS operationally
  - Allows the team to evaluate XM DRAW functionality realistically
  - ZAB is one of a few NAS sites to utilize GIM-s allowing team to realistically test the interaction of GIM-s speed advisories in conjunction with DRAW reroutes
The DRAW software that was tech-transferred from NASA to MIT LL was running on Linux CentOS 6
- Incompatible with MIT LL & FAA security standards & is at its end of life

With NASA support, MIT LL upgraded DRAW to CentOS 7 with all working functionalities:
- DRAW reroutes shown on Planview Graphical User Interface (PGUI) & downstream arrival schedule impacts on Timeline Graphical User Interface (TGUI)
- PGUI displays CWAM polygons
- Trial Planner presents reroute options around weather & downstream arrival schedule impact highlighted on TGUI
DRAW Software Porting: Current Status

• DRAW is now running on a dedicated workstation at the WJHTC in preparation for the HITL

• Integration & TBFM Adaptation Testing On-going
  - To test basic integration issues, the Initial DRAW package is adapted to ZFW the original site received from NASA
  - MIT LL is testing different DRAW adaptations in preparation for the HITL sites of ZAB & ZLA

• A number of software functionality issues have been identified as part of the porting process & by general testing of the system
  - Some of these issues are being resolved in preparation for the HITL
• MIT LL weather archive data will be used to identify how often certain locations are impacted by convective weather & identify scenarios

• Select weather events or extreme weather useful for system evaluation may not have occurred or have been identified in the region of analysis (e.g., ZLA or ZAB)
  - If necessary, weather taken from different regions, (e.g., the southeast) may be translated to the HITL region of interest

• Coupled weather required for HITL include:
  - “Truth” wind & temperature data for simulated aircraft, e.g., High Resolution Rapid Refresh (HRRR) 0-hour
  - Forecasted winds/temps from Rapid Update Cycle (RUC) for TBFM trajectory estimators
  - CWAM forecasts from NextGen Weather Processor (NWP)
• At the conclusion of the DRAW HITL, the FAA’s NextGen Organization will package results, findings, & lessons learned for tech transfer to appropriate FAA stakeholders

• DRAW will be a candidate capability for consideration in future TBFM Enhancements
Thank You For Your Time!

Contact Information:
Matt Modderno
FAA Co-Lead for ATD-3, Strategic Flow Management Applications Project Lead
NextGen Organization
Technology Development & Prototyping Division
Email: matt.modderno@faa.gov
Zoom-In: Albuquerque Center (ZAB)
Zoom-In: Los Angeles Center (ZLA)