Field Evaluation of the Baseline Integrated Arrival, Departure, and Surface (IADS) Capabilities at Charlotte Douglas International Airport (CLT)

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Challenges in Today’s Operations

- Airport congestion and excess queue time due to lack of a planning tool to even out the demand
- Reactive decision making due to limited data sharing and lack of coordination among stakeholders
- Low compliance to release time due to uncertainty in gate departure time and limited coordination

NASA’s Airspace Technology Demonstration 2 (ATD-2) provides the Integrated Arrival, Departure, and Surface (IADS) solution for operational efficiency and predictability of metroplex operations.
Outline

- What is Airspace Technology Demonstration 2 (ATD-2)?
- Phase 1 Baseline Capabilities
- Phase 1 Baseline Field Evaluation Results
- Summary and Next Steps
What is Airspace Technology Demonstration 2 (ATD-2)?

- Phase 1 Baseline Capabilities
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What is Airspace Technology Demonstration 2 (ATD-2)?

- Demonstrates IADS capabilities based on Trajectory-Based Operations (TBO) technologies and procedures
- Integrates NASA’s previous IADS research and FAA’s technologies

**ATD-2 IADS System**

- **TFDM** Terminal Flight Data Manager
  - Emerging tower tool with electronic flight data and Surface CDM capabilities
- **TBFM** Time Based Flow Management
  - Existing en route tool for time based scheduling of arrivals and departure into constrained flows
- **SARDA** Spot and Runway Departure Advisor
  - Tactical surface modeling and scheduling plus user interfaces for ramp area traffic management
- **PDRC** Precision Departure Release Capability
  - Uses trajectory-based surface information to improve en route tactical departure scheduling

**Legend:**
- Orange: FAA technologies
- Blue: NASA research
• What is Airspace Technology Demonstration 2 (ATD-2)?

• Phase 1 Baseline Capabilities

• Phase 1 Baseline Field Evaluation Results

• Summary and Next Steps
Phase 1 IADS Capabilities:
Data Exchange and Integration

- A single system running with multiple users (i.e., Tower, Ramp, TRACON, Center) to interact with one another
- Users share the same data, exchange information, and make decisions collaboratively
- Inputs are from multiple sources, including FAA, Airlines, ATC, and Ramp

Ramp Traffic Console (RTC) and Ramp Manager Traffic Console (RMTC)

Surface Trajectory-Based Operation (STBO) Client - Tower, TRACON, and Center
• Reduce excess taxi-out time by shifting taxi time from the departure queue to gates while engines are off

• Generate target pushback and spot times and provide pushback advisories to the ramp controller

• Planning horizon for surface metering can vary between tactical and strategic surface CDM

• Metering parameters determined collaboratively between Ramp and Tower, e.g., target excess queue time
Phase 1 IADS Capabilities:
Departure Scheduling for Overhead Stream Insertion

Facilitates automated coordination between Tower and Center for the release time (i.e., controlled takeoff time) of the departures subject to flow restrictions.

1. Prior to pushback the pilot contacts Tower and Tower electronically submits a release time request to Center.

2. Center approves or adjusts the time based on Center constraints.

3. Tower and Ramp utilize the now visible release time on their strips and pushback advisories.

4. Release time can be renegotiated with Center for an earlier slot as necessary.

The data is made available on the SWIM feed so that Operators can get it to their pilots.

STBO Client (Timeline)
Outline

• What is Airspace Technology Demonstration 2 (ATD-2)?

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Phase 1 Baseline IADS system deployed in CLT facilities for operational evaluation (Sept 2017)

Phase 1 evaluation conducted through Sept 2018

Field evaluation conducted in micro-phases:
- 1A (Sept 2017): Data exchange and integration
- 1B (Oct 2017): Departure scheduling for overhead stream insertion
- 1C (Nov 2017): Collaborative surface metering
Charlotte International Airport (CLT)

- Sixth largest airport in US in operations (~1,600 ops/day)
- 9 banks of departures and arrivals
- Three primary runway configurations:
  - South Sim: 18L, 18C, 18R
  - South Converging: 18L, 18C, 18R, 23
  - North: 36L, 36C, 36R
- Ramp control challenges:
  - Single direction taxiway
  - Very limited holding areas
  - Single direction for wide body aircraft off C-Concourse
  - All arrivals enter from the west side of airfield during south flow
Phase 1 IADS Benefit Mechanisms

1. Collaborative surface metering
   - Reduced engine run time
   - Reduced fuel consumption and emissions
   - More time for passenger boarding and baggage loading

2. Departure Scheduling for Overhead stream insertion
   2a. Scheduling controlled flights at the gate
       - Reduced engine run time
       - Reduced fuel consumption and emissions
   2b. Renegotiating release time for an earlier slot
       - Reduced total delay
       - Reduced engine run time
       - Reduced fuel consumption and emissions
       - Passenger value of time and crew costs

Benefits 1 and 2a achieved through gate holds

Benefit 2b achieved through release time renegotiation process
Surface metering in CLT started in late Nov 2017

- Bank 2 was metered in 258 of 303 (85.1%) days since 2017-11-29
- Bank 3 was metered in 170 of 223 (76.2%) days since 2018-02-19
Among all the departures in Bank 2 (Bank3)

- 26.3% (16.3%) of departures were subject to metering
- 23.2% (14.4%) of departures were advised a gate hold
- 16.6% (10.4%) were actually held at the gate
Excess taxi out time = Actual taxi out time – Undelayed taxi out time

**Airport Movement Area (AMA) Excess Taxi Out Time**
- Post-metering: Mean = 5.55 STD = 5.14
- Pre-metering: Mean = 7.21 STD = 6.55

**Lower is Better**

**Ramp Area Excess Taxi Out Time**
- Pre-metering: Mean = 1.52 STD = 2.33
- Post-metering: Mean = 1.64 STD = 2.45
Collaborative Surface Metering Phase 1 Benefits (Banks 2 & 3)

**Benefit 1**

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

Saved approximately 278,786 kgs of fuel by holding 14.2% of departures with average gate hold of 6 minutes.

Reduced approximately 858,662 kgs of CO2, equivalent to planting 22,017 urban trees.
Departure Scheduling for Overhead Stream Insertion – Phase 1 Benefits

<table>
<thead>
<tr>
<th>Benefit Mechanism</th>
<th>Taxi time reduction (hr)</th>
<th>Fuel savings (Kg)</th>
<th>CO$_2$ reduction (kg)</th>
<th>Urban trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate hold</td>
<td>298.52 (12,865)</td>
<td>201,002.08</td>
<td>619,086.41</td>
<td>15,874</td>
</tr>
<tr>
<td><strong>Benefit 2a</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renegotiation</td>
<td>92.59 (658)</td>
<td>59,126.64</td>
<td>182,110.05</td>
<td>4,669</td>
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<tr>
<td><strong>Benefit 2b</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>391.11</td>
<td>260,128.72</td>
<td>801,194.46</td>
<td>20,543</td>
</tr>
</tbody>
</table>

( ) Number of flights affected

- The benefits described here are associated with better use of existing capacity in the overhead stream, and technology to reduce surface delay.
- These benefits are in addition to (distinct from) surface metering savings.
Outbound A0 On Time Performance

- A0 metric = Aircraft arrives in gate at or earlier than scheduled arrival time
- Used FAA’s Aviation System Performance Metrics (ASPM) database

<table>
<thead>
<tr>
<th></th>
<th>2017 Compliance</th>
<th>2018 Compliance</th>
<th>YoY Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across All Banks</td>
<td>58.0%</td>
<td>56.9%</td>
<td>-1.1%</td>
</tr>
<tr>
<td>Banks 2 &amp; 3</td>
<td>68.2%</td>
<td>67.4%</td>
<td>-0.8%</td>
</tr>
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</table>
Inbound A0 On Time Performance

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<tr>
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<th>2017 Compliance</th>
<th>2018 Compliance</th>
<th>YoY Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across All Banks</td>
<td>61.0%</td>
<td>63.9%</td>
<td>+2.9%</td>
</tr>
<tr>
<td>Banks 2 &amp; 3</td>
<td>67.9%</td>
<td>71.9%</td>
<td>+4.0%</td>
</tr>
</tbody>
</table>

No negative impact on arrival ON time performance due to gate hold
• Phase 1 Baseline IADS system was developed in collaboration with FAA, ATC, Airlines, Ramp, pilot community, and Surface CDM Team

• Throughout a year-long field evaluation ATD-2 IADS system demonstrated Phase 1 objectives:
  – Improved data exchange and integration
  – Reduced taxi out time, fuel burn & emissions via surface metering
  – Reduced taxi out time, fuel burn & emissions via automated coordination of release times

• System performance and benefits were measured, and the results showed improvements in operational efficiency and predictability

• Phase 1 Technology Transfer was made to the FAA and industry partners: https://aviationsystemsdivision.arc.nasa.gov/publications/atd2/tech-transfer1/
Next Steps – Phase 2 Enhancement

• Refinement of surface scheduler is an on-going effort *(Note: A companion paper by William Coupe in Track 3, 11:15am, Thursday)*

• Usage of surface metering extended to other banks beyond Banks 2 & 3

• Planning horizon for demand-capacity prediction has been extended to enable strategic surface metering

• Flight operator plans to leverage surface metering by freezing gate hold advisories

• Enhanced predictability in flight ready time has allowed pre-scheduling of controlled flights

• Additional capabilities have been deployed in the field for operational evaluation:
  – Integration with Advanced Electronic Flight Strips (AEFS)
  – Terminal TFDM Publication (TTP)
  – Mobile App for General Aviation
Questions?

For more information visit:

https://aviationsystemsdivision.arc.nasa.gov/research/atd2/index.shtml
Backup Slides
### Past and Present IADS R&D

#### Surface Departure Queue Management

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Year(s)</th>
<th>Sponsor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative Departure Queue Management (CDQM)</td>
<td>2010</td>
<td>FAA, MEM</td>
</tr>
<tr>
<td>Pushback Rate Control (N-Control)</td>
<td>2010</td>
<td>MIT, BOS</td>
</tr>
<tr>
<td>Spot and Runway Departure Advisor (SARDA)</td>
<td>2012, 2014</td>
<td>NASA, DFW, CLT</td>
</tr>
<tr>
<td>Controller Assistance for Departure Optimization (CADEO)</td>
<td>2004, 2008, 2009</td>
<td>DLR / Eurocontrol, ESSA, PRG, LGAV,</td>
</tr>
<tr>
<td>Airport Collaborative Decision Making (A-CDM)</td>
<td>2007 - present</td>
<td>Eurocontrol, 18 airports (as of 2016)</td>
</tr>
<tr>
<td>Terminal Flight Data Manager (TFDM)</td>
<td>2021 - 2025</td>
<td>FAA, 27 airports</td>
</tr>
</tbody>
</table>

#### NASA’s Arrival and Departure Scheduling

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Year(s)</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Terminal Sequencing and Spacing (TSAS)</td>
<td>2009 - 2015</td>
<td>Terminal area scheduling and controller managed spacing</td>
</tr>
<tr>
<td>Precision Departure Release Capability (PDRC)</td>
<td>2011 - 2013</td>
<td>Tactical departure scheduling for overhead stream insertion</td>
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</tbody>
</table>
## Deployment of ATD-2 System for Phase 1 Field Evaluation

<table>
<thead>
<tr>
<th>Facility</th>
<th>User</th>
<th>Display/Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLT Tower</td>
<td>Tower TMC</td>
<td>STBO Client, RMTC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Release time coordination with Center</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Surface metering</td>
</tr>
<tr>
<td>CLT TRACON</td>
<td>Traffic Management Unit (TMU)</td>
<td>STBO Client, RTMC</td>
</tr>
<tr>
<td>ZDC Center</td>
<td>TMU</td>
<td>STBO Client</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Release time coordination with Tower</td>
</tr>
<tr>
<td>CLT AAL Ramp Tower</td>
<td>Ramp controller and Manager</td>
<td>RTC, RMTC, STBO Client</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Surface metering</td>
</tr>
</tbody>
</table>
Surface Metering – Process Flow

1. Generate Demand and Capacity Predictions

   - ATC TMC Runway Utilization Intent
   - TRACON controller runway intent
   - Highly accurate T/B/FM de-conflicted
   - ON time estimate
   - TFM SWIM ETAs
   - TMIs. Controlled Take Off Times (CTOT)
   - Flight Operator Provided COBTs
   - Tactical airline intent (ramp controller)

2. Monitor Surface Demand Capacity Imbalances

3. Enable Metering. Set Hold Level

4. Honor TMAT advisories

5. Evaluate Metering Effectiveness
Compliance of Gate Hold Advisory (TOBT)

- Ramp controllers are advised to release the aircraft within ±2 min of Target Off-Block Time (TOBT)
- Measured time between TOBT and Actual Off-Block Time (AOBT)
- Ramp controllers tend to pushback aircraft earlier than TOBT