Reducing Departure Delays at LaGuardia Airport with Departure-Sensitive Arrival Spacing (DSAS) Operations

Paul U. Lee, Nancy Smith
NASA Ames Research Center

Jeffrey Homola, Connie Brasil, Nathan Buckley, Chris Cabrall, Eric Chevalley, Bonny Parke, Hyo-Sang Yoo
San Jose State University / NASA ARC
Motivation

• New York Metroplex air traffic management is challenging due to excess demand, chronic delays, and inefficient routes.

• LaGuardia airport (LGA) departure delays is one of the chronic NY Metroplex problems.
Proposed Solution

• “Departure-Sensitive Arrival Spacing” (DSAS)
  – Leverage past research on arrival/departure scheduling
    • Diffenderfer et al., 2013; Bohme, 2005
  – Leverage TSS (Terminal Sequencing and Spacing) capability to schedule arrivals in TRACON to the runway threshold
  – Add new procedures and enhancements to TSS to allow arrival schedule adjustment for greater departure throughput

• The research is now a part of a new NASA sub-project called “NY Trajectory-Based Operations”
  – Explore and integrate near and mid-term NextGen technologies
  – Problem focused (not technology focused)
  – Rely on inputs from stakeholders and subject matter experts to identify chronic problems in NY and potential solutions
  – Identify solutions that can be transferred to NASA ATM Technology Demonstration (ATD) project
Outline

- LGA Traffic and Airport Characteristics
- DSAS Concept of Operations
- Concept Evaluation Study
- Results
- Conclusion
Contributing Factors to LGA Departure Delay

- Limited runway, taxiway, and gate capacity
- Runway dependencies for arrivals and departures
- Preference given to the arrivals at the cost of excessive departure delays
- High traffic volume that persist throughout the day

Departures fall behind schedule early in the morning…

…and “recovery” isn’t seen until the end of the day.

ETMS (Actual) vs. Scheduled Departures at LGA (ASPM, 2010-2012)
LGA Runway Configurations

- Four most common configurations have similar arrival/departure dependencies.
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Concept of Operations

• Current Operations
  – Difficult to recover if departure slots are lost and arrival demand is high
  – Cannot maintain one departure for one arrival pair operations if inter-arrival spacing is occasionally too tight
  – Departure queue can build up even if one-for-one operation is maintained if inter-arrival spacing is inefficient – e.g. spacing is larger than needed for one departure but not enough for two departures

• TSS Solution
  – Create precise arrival scheduling to ensure one-for-one operations
    • Deliver arrivals to a runway schedule that ensures enough spacing for a departure

• DSAS Solution
  – Optimize arrival schedule to create multiple departure gaps
    • Adjust arrival schedule to create inter-arrival spacing that is optimal for one, two, or more departures between arrival pairs
TSS and DSAS Scheduling Illustration

**Current**
- Dep 1 (85 s) Arrival 1
- Dep 2 (105 s) Arrival 2
- Dep 3 (55 s) Arrival 3
- Dep 4 (100 s) Arrival 4
- RWY22

**TSS**
- Dep 1 (85 s) Arrival 1
- Dep 2 (95 s) Arrival 2
- Dep 3 (75 s) Arrival 3
- Dep 4 (90 s) Arrival 4
- RWY22

**DSAS**
- Dep 1 (75 s) Arrival 1
- Dep 2 (75 s) Arrival 2
- Dep 3 (75 s) Arrival 3
- Dep 4 (120 s) Arrival 4
- RWY22

- Missed slots
- Inefficient spacing

- One-for-one operation ensured

- Optimize one-for-one spacing
- Create enough space for a two-for-one gap
TSS Tools and Procedures

(1) TSS scheduling to the runway threshold ensures a departure slot

(2) RNAV/RNP approach procedures to support precision scheduling

(3) Slot markers (circles) allow controllers to precisely deliver aircraft to their schedule
DSAS Enhancements to TSS

- “TMU Planner” adjusts the runway schedule to optimize departure gaps.
- The updated schedule is propagated to the controllers.
- TSS slot markers reflect the updated schedule.
- Controllers deliver the aircraft to the updated schedule.

(1) Bracket around DAL1046 show one-for-one spacing. Green bar shows slack in the schedule.

(2) Click on the callsign to bring up a menu of pre-defined inter-arrival spacing. Hovering on “Double” show spacing bracket for two departures after DAL1046.

(3) When “Double” is clicked, DAL1046 is marked with “db” to indicate two-for-spacing. Green bar shows remaining slack in the schedule.
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Experimental Setup

- **Airspace**
  - Three TRACON sectors
    - South Feeder (Empyr)
    - North Feeder (Haarp)
    - Final

- **Runway Configuration**
  - 22 land / 31 depart

- **Participant positions**
  - TMU Planner
  - Three TRACON controllers
  - TRACON Sequencer / Supervisor
  - Four Ghost En Route Sector controllers
  - Ghost Tower controller
  - Cab Coordinator
  - Pseudo-pilots
Experimental Setup

• Experimental conditions
  – Tools/Operations
    • Baseline (no terminal scheduling)
    • TSS (terminal scheduling but no departure related adjustments)
    • DSAS (arrival schedule adjustments for departures)
  – Traffic Level
    • High – approximately 40 AC/hr
      – Roughly matches upper quartile traffic levels during busy weekday afternoon
    • Moderate – approximately 35 AC/hr
      – Roughly matches median traffic levels during busy weekday afternoon

• Simulation duration: one week
• Six runs in total – 100 min per run
TMU Planner Station
DSP Emulation

- Departure Spacing Program (DSP) Emulation
  - Aircraft in the right column (Local) represents taxiway queue
  - Departure release capability added to support the simulation activity
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Results: Departure Throughput

- **High Traffic**
  - Baseline comparison
    - 6 AC/hr increase for TSS
    - 9 AC/hr increase for DSAS

- **Moderate Traffic**
  - Baseline comparison
    - Only 1 AC/hr increase for TSS
    - 5 AC/hr increase for DSAS

- TSS provides throughput benefit only when the arrival demand is high.

- DSAS scheduling can increase throughput in both high and moderate traffic situations.
Results: Departure Delays

• Delay results mirror the throughput results.

• High Traffic
  – Shorter departure queues translated to taxi-out delay reductions of 6.5-10.4 min/flight in the simulation

• Moderate Traffic
  – Delay reduction was prominent for DSAS (5.5 min/flight)
  – Not for TSS (0.9 min/flight)

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<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>TSS</th>
<th>DSAS</th>
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<tbody>
<tr>
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<td></td>
<td></td>
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<tr>
<td>High Traffic</td>
<td>23.7</td>
<td>17.2</td>
<td>13.3</td>
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<td>Delay Savings</td>
<td>-</td>
<td>6.5</td>
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<td>17.4</td>
<td>16.5</td>
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<tr>
<td>Delay Savings</td>
<td>-</td>
<td>0.9</td>
<td>5.5</td>
</tr>
</tbody>
</table>
Results: Inter-arrival Spacing

![Graph showing inter-arrival spacing for different conditions]

- Baseline (High)
- TSS (High)
- DSAS (High)
- Baseline (Moderate)
- TSS (Moderate)
- DSAS (Moderate)

Inter-arrival spacing (seconds):
- 300
- 250
- 200
- 150
- 100
- 50
- 0

Key:
- 220 (Quadruple)
- 180 (Heavy)
- 170 (Triple)
- 120 (Double)
- 75 (Single)
- 60 (Minimum)
Results: Taskload Distribution

- More clearances were issued in Baseline than TSS or DSAS.

- In Baseline, clearances were concentrated at the final merge fix prior to landing.

- In TSS and DSAS, clearances were re-distributed to the feeder sectors.
Results: Positive Participant Feedback

• Final Controller Participant
  – "I think it's a great tool [DSAS]. ...it takes a lot of pressure off me, I could see exactly what was coming. With the timelines, I knew where the slot markers were and knew where I had to be. That's how I was getting them from [the feeder controllers], I just had to make very minor speed adjustments and that was it. In the last two days, I don't think I vectored anybody off the routing. So it was good. It's a nice tool."

• Participant from LGA Tower
  – "Bottom line after 40 years of getting killed at La Guardia, seeing a tool that could ease the pain, I think it's a good way to go, and I hope this builds to something they can use in the field. . . . I was thinking from a Final controller's perspective, if he doesn't have to worry and it's just kind of laid out there for him, and stays within the markers, the pressure is off. I mean, that's the bottom line. You're not sitting there with, what is it, 10 minutes of sheer terror and 15 minutes of nothing. It's a good way to go."
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**Problem:** LGA departure bottleneck caused by intersecting runway configuration. Chronic issues with large taxi-out delay per flight and surface congestion.

**Solution:** Departure Sensitive Arrival Spacing (DSAS). TBO solution includes new procedures and enhancements to TSS and its interface to coordinate arrival and departure runway operations.

**Results:** TSS/DSAS showed ability to reduce taxi-out time by approximately 6-10 minutes/flight on average during high traffic scenarios.

**Applicability to other airports:** DSAS concept was developed for LGA but should work for other runway configurations with arrival / departure dependencies

**Stakeholders:** Port Authority of NY/NJ, Delta Airlines were actively engaged and interested in supporting ongoing work.
Questions?

Email: paul.u.lee@nasa.gov