Method to Enhance Scheduled Arrival Robustness (MESAR)

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Outline

• Background
• Motivations
• Objectives
• Methods
• Lessons learned (so far)
Background

NASA developed Terminal Sequencing and Spacing (TSS) System with Technology from ATD-1.
2013 NASA, the FAA, MITRE CAASD joint human-in-the-loop (HITL) simulation

Phoenix Sky Harbor International Airport (PHX)
Among the 2013 TSS HITL simulation runs, differences observed

- Operation entered “Stressed” state
- Higher schedule nonconformance (2.7x)
- Higher lateral route inefficiency (+22%)
- Higher time inefficiency (+12%)
- More controller instruction (+1.8)
Motivation

Enhance robustness and resilience of scheduled arrival operation, in presence of disturbances

• Resist entering stressed state
• Expedite return from stressed state
Objectives

“Operational Sequencing Quality”
“Operational Sequencing Quality”
Apply tactical schedule update to resist entering stressed state
Apply tactical schedule update to expedite return from stressed state
“Operational Sequencing Quality”
a: aircraft 1 is behind-schedule

Method
MESAR monitors operation, and detects potential conflict.
MESAR reschedules to aid controller to delay aircraft 2, for conflict mitigation.
b: Unscheduled priority arrival 0 enters TRACON
MESAR monitors operation, and detects unplanned maneuvering of a
MESAR reschedules to provide final controller time to recover
MESAR Experiment Setup

- 4 Shakedowns, Data collection August 2014
- PHX West Flow configuration (2 Feeders and 2 Finals)
- Mostly Area Navigation equipped jets
- Instrument Meteorological Condition
- Independent two runway arrival operation, with altitude separation
- Terminal area Traffic Management Coordinator (TMC) provides support in handling disturbances
- TSS system, with Automate Terminal Proximity Alert (ATPA)
ATPA is used once aircraft approaches final, TSS advisories suppressed.
Tools- Creeping Slot Markers

The slot markers change color and gradually move to their new position calculated by the MESAR reschedule.
Tools - Creeping Slot Markers

After moving, slot markers go back to regular white
<table>
<thead>
<tr>
<th>Type of Disturbance</th>
<th>Tactical Schedule Adjustment</th>
<th>By MESAR</th>
<th>By Terminal Traffic Management Coordinator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Excessive Delay</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Pop up Priority VFR</td>
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<td></td>
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<tr>
<td></td>
<td>Missed Approach</td>
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1. Does tactical reschedule enhance the existing robustness and resiliency of schedule based arrival operation?

2. What are advantages and disadvantages of tactical schedule adjustment performed by MESAR and TMC?
Lessons Learned (so far)

• Coordination and communication is essential in handling disturbances (TMC roles and responsibilities)

• MESAR schedule adjustment is consistent and predictable, but is reactive

• TMC schedule adjustment is proactive, but requires accurate situational awareness

• Potential future work is to develop synergistic interaction between human and algorithm
Questions?
Backup slides
Metrics

• Measure of Operational Performance
  • Ratio between actual and planned arrival makespan
  • Proportion of arrivals with extra track distance
  • Average extra track distance
  • Estimated Fuel efficiency: average time below 10,000 ft
  • Estimated objective workload: average clearance
  • Estimated subjective workload: WAK, TLX
  • Inter arrival spacing
  • Landing sequence mismatch, number and magnitude

• Measure of Schedule Nonconformance

• Measure of Robustness

• Measure of Resilience
Missed RNP approach