Measuring Performance of Initial Ground-based Interval Management – Spacing (GIM-S) Operations

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Outline

- Overview of Time Based Flow Management and GIM-S
- Research objectives
- Analysis methodology
- Results of operational data analysis
- Summary of findings and conclusions
The vision for Time-Based Flow Management (TBFM) is the expanded use of time-based metering to enable gate-to-gate improvements in both fuel and throughput efficiencies by applying spacing only where needed, allowing for the routine use of Performance Based Operations (PBO) to capitalize on cockpit Flight Management System (FMS) capabilities, and adding more predictability to the ATC system.
GIM-S Enhancements & Changing Operational Models

- GIM-S introduces two fundamental enhancements to en route operations
  - Enhancements to current time-based metering operations
    - Coupled Scheduling
    - Extended Metering
  - En route controller tools
    - Speed advisories
- GIM-S is a structured approach to aircraft scheduling & management
  - Supports Performance Based Navigation (PBN) enhancements by keeping aircraft on PBN route structures through descent to the approach control transfer
    - Avoidance of miles-in-trail & vectoring
- GIM-S requires greater operational coordination
  - GIM-S expands metering operation schedules as an inherent feature of GIM-S designs
    - Time-line expansion necessary for speed advisories to be effective (pushes schedule out up to 500 miles, rather than traditional 150-200 mile schedule)
    - Expanded time-line drives need for coordination across additional sectors/facilities
  - Increased need for coordinated departure scheduling
Enhancements to TBFM
Ground-based Interval Management - Spacing

Extended Metering  Coupled Scheduling  Speed Advisories

Without GIM-S

Miles In Trail

With GIM-S

XMP Freeze Horizon

M0.78 Speed Advisory

CMP Freeze Horizon

Meter Fix

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GIM-S Implementation

- **GIM-S Initial Operating Capability (IOC) achieved September 22, 2014**
  - Arrivals through Albuquerque Center (ZAB) into KPHX
- **Currently active on seven different arrival flows into KPHX, KDEN, KSEA, KSLC, and KLAX**

### Meter Reference Point list

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- Aircraft Id
- Scheduled Time of Arrival (STA)
- Delay Countdown Timer (DCT)
- GIM-S Speed Advisory
Challenges to GIM-S Integration

- **Four general operational categories**
  1. Operational metering design that is inconsistent with GIM-S application
  2. Operational staffing models necessary to support GIM-S integration
  3. GIM-S application not reflected in facility Standard Operating Procedures (SOPs) & Letters of Agreement (LOA)
  4. Portfolio of tools not considered with operational deployment

- **Two technical issues**
  1. Inconsistent speed advisories
     - Corrective fixes identified and under development
     - Packaging expected with Fall 2017 TBFM SW release (4.8)
  2. Wind processing anomalies (Albuquerque Center – winter jet stream)
     - Under analysis by engineering teams
Research Objective

- Research Objective: Develop a methodology to measure the operational impact of GIM-S in relation to expected benefits.

- Expected Benefits
  - Increase adherence to PBN arrival procedures
  - Improve meter point delivery accuracy
  - Reduce vectoring and lower fuel burn
  - Reduce flight time variance
GIM-S Impact Assessment
Analysis Methodology

Factors considered when developing methodology

- Effective interpretation of operational data analysis relies on site-specific context
- Numerous variables (weather, nearby airspace constraints, initial arrival conditions) impact the results

Methodology Principles

- Apply site-specific adaptation parameters to a generic set of metrics applicable across sites
- Discuss site-specific operational metering objectives with ATC or site SMEs
- Analyze each individual arrival flight over large time period, then apply appropriate filters
- Develop applicable categories for comparisons
Data Sources Used

**Track Data**
- Aircraft ID, Aircraft Type, Latitude, Longitude, Altitude, Track Heading, Time

**TBFM Operations Data**
- Estimated Time of Arrival (ETA)
- Scheduled Time of Arrival (STA)
- Observed Meter Point crossing times
- GIM-S advisory messages

**Site-Specific Adaptation Parameters**
- Meter point locations
- PBN arrival procedure information
- GIM-S adaptation parameters

Extract data from Hadoop computing architecture
Join data and apply metrics algorithms using MATLAB
Organize (filter and categorize) and visualize outputs/results using Tableau®
Categorization of Results

Organized Results into Five Groups

- Before GIM-S
- After GIM-S
- After GIM-S and GIM-S Off
- After GIM-S and GIM-S Speeds Available
- After GIM-S and GIM-S Speeds Accepted

Results also Filtered by:

- Peak Hours: 7-9am, 11am-1pm, 530-730pm local
- Traffic density as percentage of peak meter fix throughput rate
Results
PBN Conformance Metric
PBN Conformance Results
EAGUL Arrival Flow to Meter Fix HOMRR

- Methodology used to indicate that PBN conformance higher when GIM-S used upstream compared to when it was not used
- Speed acceptance to the Extended Meter Point does not have major impact on PBN conformance
Delivery Accuracy Results

Delivery Accuracy = Frozen Scheduled Time of Arrival – Observed Cross Time

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<th>± 1 minute</th>
<th>± 1.5 minutes</th>
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<td>84.2%</td>
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<tr>
<td>Accepted Speed</td>
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<td></td>
<td></td>
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<tr>
<td>Not Required</td>
<td>77.5%</td>
<td>93.5%</td>
<td>97.8%</td>
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<tr>
<td>Not Available</td>
<td>0.6%</td>
<td>27.0%</td>
<td>63.9%</td>
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</table>

Extended Meter Point into KPHX FROM JANUARY 2015 – JUNE 2016

Methodology successfully used to conclude that speed advisories can be used to improve delivery accuracy
Vectoring Metric

Straight Flights

Flights with Heading Change

Flights Classified as Vectored
## Vectoring Results

### Between Extended Meter Point (XMP) Freeze Horizon and XMP

<table>
<thead>
<tr>
<th>Before GIM-S</th>
<th>After GIM-S</th>
<th>After GIM-S: Off</th>
<th>After GIM-S: On</th>
<th>After GIM-S: Accepted</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.4% (12088)</td>
<td>17.9% (18842)</td>
<td>21.8% (8522)</td>
<td>14.6% (10320)</td>
<td>11.0% (3323)</td>
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</table>

- **Methodology used to indicate that vectoring is reduced when speed advisories are used**
- **Vectoring not completely eliminated, speed + vector solution sometimes used**

Results filtered to Peak Hours and 50-100% Traffic Rates
Flight Time Metric

Closest Track Point to HOMRR

First Track Point through XMP
Flight Time Results
XMP freeze horizon to Meter Fix HOMRR

- The variance in flight times when GIM-S speeds are accepted is significantly (p<0.001) lower than when GIM-S is not used.
Flight Time Results
Meter Fix HOMRR to Wheels Down Time

On average, flight times in the terminal are one minute faster for the aircraft that conform to the arrival procedure.
Summary

- This work demonstrated a methodology for measuring GIM-S impacts on the initial arrival flow into KPHX
- This methodology can be applied to other arrival flows
- Applying this methodology indicates the use of GIM-S has translated into some positive results
- Future implementations and adaptation updates should strive to balance site-specific considerations with the fundamental changes that enable the full benefits of a time-based metering environment that includes the GIM-S functionality.
Questions?

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