Rapid Assessment of Air Traffic Impact of Blocking Airspaces

Integrated Communications Navigation and Surveillance (ICNS) Conference

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Problem: Airspace is a limited resource

FL3300+ (Space)

Satellites

Orbital debris

FL600

Spaceplanes

Demand on its use is becoming limitless

Satellites

FL600-FL3300

Recoverable rocket motors

Manned/Unmanned balloons

Manned orbital capsules

UAS

FL350: Commercial aviation

Hazard Areas

SAA

Note: Rendering notional. Sizes of buildings and representational air/space craft not to scale.

Image Source: MITRE

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Research Objectives

• **Increase transparency** and **collaboration** in integration of new entrants into National Airspace System (NAS) by:
  • Enabling instantaneous assessment of the impact of blocking airspaces using a what-if analysis paradigm
  • Ensuring accessibility to a broad range of airspace users
    • FAA, new entrants, DoD & airlines
    • Require no prior knowledge of air traffic pattern
Scenario 1  Space Operator Flyback Option Analysis
Scenario 2  ANSP’s Launch Site Analysis
Scenario 3

ANSP’s Future Operations Impact Analysis

Data: NOAA, US Navy, NGA, Geospatial Image Lambda, DigitalGlobe
Research Tasks

Data Reduction & Encoding
(Support Interactive Querying & Efficient Memory Management)

Traffic Projection Model

NAS Impact Model

Prototype to Test Intended Use

Instrumentation for massively parallel runs on MITRE High Performance Computing Environment
Instantaneous Response – Using Route Segment Density Map

Cape Canaveral Launch Site

Impacted Flights = X + y + (z+Z)

Traffic on 8th August, 2014
Reduce to Traffic Pipes

Route Segment SNAKR.MYDIA
Bi-directional Traffic Density
Generating Route Segment Density Map

Step 1. Generate Database of Nodes using historical flight plans

Step 2. Select flights deviating more than 10 NM from the flight plan

Step 3. Infer flown flight route for selected flights

Step 4. Aggregate bi-directional flight traversals for each hour

Route Segments with bi-directional usage count

<table>
<thead>
<tr>
<th>Route Segment</th>
<th>Forward Count</th>
<th>Reverse Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAH.BOTLL</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>APPLE.LGA</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>DOSBE.IKICO</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>CEDOX.DOSBE</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>BOTLL.FLYZA</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>JOHNS.FOSSE</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>FOSSE.CEDOX</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>IAH.SHAAK</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>DVR.KONAN</td>
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<td>0</td>
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<tr>
<td>IKICO.CLT</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>FRWAY.TUNNE</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>FLCN.DIRTY</td>
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<td>0</td>
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<tr>
<td>HYDRR.PHX</td>
<td>17</td>
<td>0</td>
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<tr>
<td>MCO.ORL</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>SHAAK.BNDTO</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>ERLIN.ATL</td>
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<td>RMG.ERLIN</td>
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<tr>
<td>FRNCH.SKARF</td>
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<tr>
<td>DIRTY.ATL</td>
<td>16</td>
<td>0</td>
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<tr>
<td>SKARF.TOMSN</td>
<td>16</td>
<td>0</td>
</tr>
</tbody>
</table>
NAS Wide Route Segments

MITRE visualization over Google Earth
Efficacy of Route Segment Maps – Actual vs Assessed Flight Crossings

<table>
<thead>
<tr>
<th>Airspace</th>
<th>RSquare</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Airspace</td>
<td>0.983004</td>
</tr>
<tr>
<td>Florida Airspace</td>
<td>0.948678</td>
</tr>
<tr>
<td>Center Airspace</td>
<td>0.938896</td>
</tr>
<tr>
<td>North-West Airspace</td>
<td>0.866413</td>
</tr>
<tr>
<td>West Airspace</td>
<td>0.948552</td>
</tr>
</tbody>
</table>

Data Sources: NOAA, U.S. Navy, NGA, GEBCO
Image Landsat Copernicus

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Model Traffic Projections

Step 1. Analyze historical traffic trends by aggregating on daily, weekly and monthly

Step 2. Predict using distribution of Route Segment usage in historical days similar to the predicted day:

- 2010 to 2015 data used to predict 2016
- Similar historical days are the same day-of-week and in the week number of predicted
- Previous and next 2 weeks are additionally selected to arrive at a sample size of 30 similar historical days
- Estimated range is based on 25 and 75 percentile distribution values
Projection Accuracy

Projection Accuracy for Sample Airspaces

<table>
<thead>
<tr>
<th>Airspace</th>
<th>Percent In Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Airspace</td>
<td>81.4</td>
</tr>
<tr>
<td>Florida Airspace</td>
<td>82.4</td>
</tr>
<tr>
<td>Center Airspace</td>
<td>79.7</td>
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<tr>
<td>North-West Airspace</td>
<td>96.7</td>
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<tr>
<td>West Airspace</td>
<td>88.5</td>
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</tbody>
</table>
Modeling Impact

Impact Metrics Supported
- Flights
- Airline Mix
- Sectors Levels
- Origin-destination pairs
- Domestic-foreign proportions

Planned Additional Metrics
- Extra Distance
- Delay

Segment information
- Bi-directional flight count
- Sector usage
- Airline mix
- Origin-destination pairs
- Domestic flights

MITRE visualization over Google Earth


Approved for Public Release; Distribution Unlimited. Case Number 17-3974
Impact Assessor (ANSP View)

Fights Impacted
66

Sectors: (H) 06 (M) 0 (L) 0

Image Source: MITRE

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World-wide Traffic Data
Impact Assessor (Space Operator View)
Conclusions & Next Steps

- Research demonstrated viability of assessing the impact of blocking airspaces, using a “what-if” analysis paradigm.
- Data reduction technique resulted in efficiency in data size and memory management, with negligible loss in accuracy.
- Traffic projection model performed well, given the uncertainties of traffic pattern.
- Research results are preliminary, further study to evaluate sensitivity of model performance to constraints such as location, airspace size and closure time are ongoing.
- Alternate approach to projection based on using a grid to capture traffic is being explored.
- Assessing additional impact metrics, namely delay and extra distance is being researched.