Study for Grand Canyon Working Group

Impact on Restricting Flights from Grand Canyon Airspace

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Background

• A flight-free zone over the heart of the Grand Canyon National Park (18,000 ft and above) has been evaluated

• MITRE CAASD has been asked to assess impact of restricting flights
  – Area where flights are restricted defined by members of Grand Canyon Working Group
  – Several traffic scenarios, also defined by members of Grand Canyon Working Group
Study Area

For Internal Grand Canyon Workgroup Discussion Only
Traffic Scenarios

- Daytime (7:00 am to 7:00 pm) at or above 18,000 ft
  - All flows
  - Only Las Vegas (LAS) arrivals and departures
  - Only North-South routes, mainly Phoenix (PHX) arrivals and departures
  - Only East-West overflights to/from Basin area airports*

* Los Angeles (LAX), Burbank (BUR), Santa Monica (SMO), Van Nuys (VNY), Ontario (ONT), Santa Barbara (SBA), Palm Springs (PSP), Carlsbad (CRQ), San Diego (SAN), Orange County (SNA), Long Beach (LGB)
Impact Assessment Process

Step 1: Characterization of Study Area
- Describe affected flights
  - Number of flights by airports, city pairs, carriers
- Identify study date
  - Busy day (90th percentile) for involved airspace

Step 2: Assess first-tier impact due to reroutes
- Develop strategy for revising routes
- Develop new routes for affected flights
- Identify safety concerns with new routes
- Estimate first-tier user costs

Step 3: Assess second-tier impact
- Identify potential Traffic Management Initiatives (TMIs) to manage new traffic flows
- Calculate resulting delays, conflicts with nearby flows, sector/route/fix loadings

Step 4: Identify potential airspace changes
- Explore what airspace redesign could be involved in order to respond to second-tier impacts
Overview of Indicators and Metrics

Revised Flight Routes

Routing Penalties
- Extra flight distance/time
- Sector & fix loading
- Added complexity
- Potential conflicts

Safety Impacts

Step 2 Results

Apply traffic restrictions to ensure safe operations

Step 3 Results

Additional Operational Penalties
- Additional distance/time impacts
- Fuel impacts

Other Impacts
- Severe weather inflexibility
- Schedule unpredictability
- Lost connections

Delays have additional operational repercussions
Step 1: Characterization of Traffic in Study Area
General Characterization of Affected Flights

- Based on 2005 historical ETMS data, almost 130,000 daytime flights at or above 18,000 ft would be affected per year

### Daytime Traffic

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<th>Traffic Flow</th>
<th>Annual Flight Counts</th>
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### Nighttime Traffic

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Military Operations

- Military aerial refueling route AR624 traverses the Grand Canyon area
- AR624 encompasses FL190-220 with occasional vertical limits expanded up to include FL290
Study Day

- Offload radar data from 11 July 2005, representing a 90\textsuperscript{th} percentile day; flights at or above 18,000 ft

- Number of flights within polygon
  - 476 daytime flights
  - 190 nighttime flights

- Traffic management logs reviewed to ensure no major TMIIs were active

![ETMS Flights thru Proposed Area](image)
Step 2: Revising Flight Routes, Safety Consequences and First-Tier User Impact
Revised Flight Routes

• The preliminary set of revised routes to avoid proposed polygon have been reviewed

• Revised routes designed
  – Based on MITRE CAASD operational expertise
  – To use existing navigation aids (NAVAIDs) and waypoints
  – To retain current arrival and departure fixes, if possible

• Only a new transition for SILOW ONE terminal departure procedure for PHX added (49 flights)
Current Routes
Revised Routes

Routes for LAS traffic
Routes for PHX traffic
Routes for Basin traffic
Routing Difference

Current Routing

Revised Routing

Routes for LAS traffic
Routes for PHX traffic
Routes for Basin traffic
Revised Routes – PHX traffic

Flights arriving at PHX

Flights departing from PHX
LAS Traffic

Flights arriving at LAS

Flights departing from LAS
Basin Traffic

Flights arriving at Basin area airports

Flights departing from Basin area airports
Overview of Safety Impacts

• Revising routes has several operational consequences
  – Moves flights from one sector to another
    • Increases the number of aircraft in sectors
    • Introduces new workload and increases sector responsibilities
  – Concentrates additional flights over specific fixes
  – Moves some flows closer to other flows
  – Creates new merge points in the airspace, adding to the complexity of the traffic flows
Safety Concerns with LAS Reroutes to Restrict Flights from Study Area

- Departures moved to OVETO, closer to LAS arrivals from the northeast
- LAS arrivals moved further south into Albuquerque ARTCC (ZAB) Sector 67 which would increase sector count
- ZAB 67 would be required to merge and descend the LAS traffic for Los Angeles ARTCC (ZLA) Sector 35
- The LAS arrivals would be a problem with the PHX departures climbing from SILOW to Tuba City (TBC), mixing arrivals and departures
Safety Concerns with PHX and Basin Revised Routes to Restrict Flights from Study Area

- **PHX Routes**
  - Arrivals move westward, *increasing number of aircraft over PGS*
    - PGS is currently used by LAX arrivals and departures
  - Departures move east over TBC
- **Basin Routes**
  - ZAB 67 would be required to *merge/cross* the ZLA Basin departures that fly over Needles (EED) to FLG J10 with the departures over PGS J72 to J10, and the LAS eastbound departures to Gallup (GUP) or J72 to J10
Safety Impact Indicators

- **Sector loading**: number of aircraft in a sector
  - The number of aircraft in a sector is an indicator of complexity

- **Fix loading**: number of aircraft that flow over a single point in the airspace
  - An increase in fix loading is an indicator of added complexity and higher workload

- **Potential conflicts**: number of aircraft that come within close proximity of each other
  - The number of potential conflicts indicate the potential increased risk of collision

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Diagram:

- **Revised Flight Routes** -> **Routing Penalties** -> **Additional Operational Penalties** -> **Other Impacts**

For Internal Grand Canyon Workgroup Discussion Only
Sectors and Fixes of Interest

For Internal Grand Canyon Workgroup Discussion Only
Sector Loading Example
Daytime All Traffic Scenario

ZAB67 - All Flows, daytime traffic

225 flights added to ZAB67

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Fix Loading Example
Daytime All Traffic Scenario

FLG - All flows

Number of Flights per 5-min

145 flights added to FLG

~180% increase


Time (GMT)

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Fix Loading Example
Daytime LAS Scenario - Departures to NE

OVETO

~35% increase

115 flights added to OVETO

Number of Flights per 5-min

Time (GMT)

Baseline
Alternative
Fix Loading Example
Daytime LAS Scenario - Arrivals from SE

FLG - LAS flow only

~50% increase

42 flights added to FLG

Baseline
Alternative

Number of Flights per 5-min

Time (GMT)
Fix Loading Example
Daytime PHX Scenario

PGS - PHX flow

57 flights added to PGS
~30% increase

For Internal Grand Canyon Workgroup Discussion Only
Sector Loading Example
Daytime Basin Traffic Scenario

ZAB67 - Basin flow only, daytime traffic

Number of Flights per Minute

Time (GMT)

Alternative
Baseline
MAP
Fix Loading Example
Daytime Basin Traffic Scenario

FLG - Basin Flow, daytime

- Baseline
- Alternative

~125% increase

109 flights added to FLG
Potential Conflicts

• Potential conflicts between existing traffic flows and aircraft using revised routes to avoid the Grand Canyon were examined
  – Potential conflicts are defined as two aircraft that are less than 5 nautical miles (nm) horizontally and 1,000 ft vertically of each other in en route airspace
  – Potential Conflicts identified using FAA’s Sector Design and Analysis Tool (SDAT)

• Potential conflicts added due to revised routes (daytime traffic only)
  – PHX flow: 19 conflicts/day
  – LAS flow: 44 conflicts/day
  – Basin flow: 114 conflicts/day
  – All flows: 336 conflicts/day
Overview of Routing Penalties

- Extra distance flown is translated into extra flying time, based on type of aircraft and associated performance characteristics.
Example of Revised Routes
First-Tier Efficiency Impacts

• Average distance added
  – LAS arrivals: 25 nm
  – LAS departures: 0.5 nm – 3 nm
    • 0.5 nm (to northeast airports)
    • 3 nm (to southeast airports)
  – PHX arrivals: 30 nm
  – PHX departures: 7 – 20 nm
    • 7 nm (to SLC)
    • 20 nm (to northwest airports)
  – Basin arrivals: 10 nm – 35 nm
  – Basin departures: 10 nm – 25 nm
Step 3: Assessment of Potential Traffic Management Initiatives
Overview of Traffic Management Restrictions

• When airspace or other system resources are overloaded, TMI s are issued to ensure safe operations
  – Aircraft-to-aircraft restrictions: Spacing between aircraft is increased to ensure that controllers have enough time to address volume or complexity
    • Miles-in-Trail (MIT): increases spacing in flight
    • Ground delay: keep aircraft on ground until space is available
  – Flow-to-flow restrictions: flows of aircraft are separated from other flows
    • Capping: limits the altitude of a specified flow
Overview of TMI (concluded)

• Restrictions are resource dependent and were only applied to applicable flows

• Examined modeled sector volume and compared with thresholds that are currently used by the FAA’s Traffic Management Units and the Air Traffic Control System Command Center

• Reviewed logs and playbooks to ascertain appropriate restrictions

• Completed peer review of proposed restrictions
Potential Traffic Management Initiatives

• LAS arrivals from north/northeast
  – MIT restrictions imposed to manage ZLA07 volume
  – ZLA07 works arrivals from and departures to north/northeast

• LAS departures to north/northeast
  – MIT restrictions (ground delays) imposed to manage ZLA07 volume
  – ZLA07 works arrivals from and departures to north/northeast
• LAS arrivals from southeast
  – MIT restrictions imposed to facilitate merging current arrivals from southeast with arrivals from east moved over RSK to FLG and alleviate ZLA08 workload
  – Capping imposed to separate descending traffic from level traffic to and from Basin area in ZAB67
Potential Traffic Management Initiatives
(continued)

• Basin departures to east
  – MIT restrictions to merge departures flows going to east and alleviate ZAB67 volume
• MIT restrictions were calculated for affected flights and translated into additional flying time
• Capping restrictions were translated into fuel penalties
Overview of TMI Impacts

• MIT
  – LAS Arrivals from SE 166 delay min/day
  – LAS Arrivals from N/NE 529 delay min/day
  – Basin Departures over Needles and Peach Springs 37 delay min/day

• MIT (ground delay)
  – LAS Departures to N/NE 136 delay min/day

• Capping
  – LAS Arrivals from SE 1098 additional gal/day
Step 4: Potential Airspace System Changes
Potential Airspace Changes

- This analysis identified several major safety concerns and efficiency consequences.
- Significant airspace redesign covering over 100,000 square miles involving at least six facilities would be required to address these issues.
  - Revision of terminal arrival and departure procedures.
  - New RNAV-based routes in en route/transition airspace.
  - Significant realignment of sector boundaries.
  - Realignment of facility boundaries.
  - FAA predefined plans to handle Severe Weather events (playbook).

Area for Potential Airspace Redesign
Additional User Considerations
Factors Impacting User Costs

Impacts to the airspace users is not limited to the direct operational penalties of time and distance

Examined:
- Added complexity during severe weather from newly routed Grand Canyon traffic over frequently used fixes
- Increased unpredictability of enroute performance as a result of added complexity
- Lost connection opportunities at arrival airports from later arrival times

Others (Not Examined):
- Airline fleet utilization and productivity
- Missed passenger connections from delays (if schedules are not modified)
- Changes in ground delay
Additional Complexity During Severe Weather

• During Severe Weather events, routes typically used by flights may not be available

• FAA will respond by coordinating with appropriate Air Traffic Control facilities and users to develop a plan in which aircraft can avoid weather

• Restricting flights from the Grand Canyon will limit options available to the FAA during Severe Weather

• Impact could be significant during marginal weather conditions, which occur with relative frequency in this region

Convective Sigmet*  
United States, July 2006

* Source: www.ncdc.noaa.gov. “Sigmet” = significant meteorological Information.
Added Complexity from Revised Routes

- FAA has developed reroute advisories, defined in playbooks, used during Severe Weather events
- Revised routings for LAS, PHX, and Basin area traffic share some waypoints/NAVAIDS that define these reroute advisories
  - 21% of all reroute advisories in 2006 used at least one of the fixes planned for use in Grand Canyon revised routes
- Revised routes could add congestion to key points in the airspace and adversely impact the National Airspace System’s ability to respond to Severe Weather
- The operational impact would depend on
  - Degree of added complexity
  - Current fix loading

### Fixes Planned for Grand Canyon Revised Routes and Measures of Utilization

<table>
<thead>
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<th>NAVAIDS/ Waypoints Involved</th>
<th>Instances in Current Playbooks</th>
<th>Reroute Advisories in 2006</th>
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Increased Unpredictability

- Increased use of TMIs due to restricting flights over the Grand Canyon could increase variability in aircraft flight times

- Variability creates operational uncertainty for airlines

- Airline response strategies involve trade-offs
  - “Pad” schedules: maintain desired on time performance. May impact connecting passenger itineraries, decrease fleet productivity
  - Do not pad schedules: market shorter flights to the public, curb labor (crew) costs. May compromise on-time performance and bank integrity

- Impact depends on increase in flight time variability, and could be much greater than increase in average times

To ensure that a flight’s enroute time is within its target 62% of the time, an airline would allocate (N) minutes to this phase.
Increased Unpredictability (concluded)

- Sensitivity analysis suggests a wide range in the schedule increase required to accommodate greater unpredictability.
- Lowest impact corresponds to high time under “normal” operations, and low increases in uncertainty.

### Required Increase in Scheduled Block Time To Maintain Baseline On-Time Performance

(Concluded)

#### Required Increase in Scheduled Block Time To Maintain Baseline On-Time Performance

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<th>Time under &quot;Normal&quot; Operations</th>
<th>Increase in StDev during Irregular Ops (minutes)</th>
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Lost Connection Opportunities

• Description: Increased schedules could result in fewer “bookable” connecting passenger itineraries at arrival airport
  – *All else equal*, later arrival time for affected flights could violate passenger minimum connect times on existing itineraries
  – These exact itineraries would not be sold

* While this assumption is not realistic, the analysis indicates the extent to which carriers would have to make operational (and marketing) trade-offs to mitigate the most adverse effects.
Lost Connection Opportunities (continued)

- Looked at arrival airports with the greatest enroute time increases due to Grand Canyon revised routes*
- These airports comprise almost 60% of carrier time increases

* Excluding any airline response to possible increased variability, as described previously.

<table>
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<tr>
<th>Arrival Airport</th>
<th>Carrier</th>
<th>Avg Time Increase</th>
<th>Avg Flights</th>
<th>Avg Time Increase</th>
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<td>49</td>
<td>4.44</td>
<td>49</td>
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</table>

% of Total GC Time Increase
- 22.8%
- 11.8%
- 7.4%
- 7.0%
- 5.8%
- 3.1%
Lost Connection Opportunities (concluded)

- Some “lost” connection opportunities from later arrivals due to Grand Canyon revised routes

- Applying flight-specific time increases to scheduled arrival time at destination airport

- These reflect potentially unviable itineraries, ignoring market demand

- Assumed 30 minute minimum passenger connect time, 3 hour maximum layover

<table>
<thead>
<tr>
<th>Arrival Airport</th>
<th>Carrier</th>
<th>Possible Connections</th>
<th></th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline</td>
<td>With GC Reroutes</td>
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<tr>
<td>LAX</td>
<td>SWA</td>
<td>2,205</td>
<td>2,198</td>
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<tr>
<td></td>
<td>UAL</td>
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<td>222</td>
<td>221</td>
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<td>MEP</td>
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<td>2</td>
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<td>PHX</td>
<td>AWE</td>
<td>7,483</td>
<td>7,471</td>
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<td>2,871</td>
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<td>SWA</td>
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<tr>
<td>ORD</td>
<td>UAL</td>
<td>16,501</td>
<td>16,495</td>
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</table>
Valuation of Efficiency Impacts
Executive Summary of User Costs

• Value of the previous operational impacts has been estimated
  – First Tier Costs: Aircraft Direct Operating Costs (ADOC) associated with initial reroutes
  – Second Tier Costs: ADOC and fuel costs associated with TMIs applied after reroutes
• Conservative estimated user cost of ~$30M* annually if all traffic above 18,000 ft is restricted from the polygon of airspace above the heart of the Grand Canyon
  – Additional user costs factors could triple annual estimates

* Annual costs will vary based on fuels costs and assumed traffic scenario.
Aircraft Direct Operating Costs (ADOC)*

- Standard method to compute costs
  - Increases directly with flight time
  - Includes Crew, Fuel, and Maintenance expenses
- Calculated average costs per minute that reflect the fleet mix of three scenarios:
  - LAS arrivals and departures only
  - PHX arrivals and departures only
  - Basin area arrivals and departures
- Treated Carrier and General Aviation (GA) flights separately to account for different cost structures
- Average ADOCs for each scenario are weighted by fleet mix and operator (carrier and GA)

ADOC (concluded)

- Derived estimate of airborne ADOC from block-to-block average*
- 2002 FAA values adjusted to reflect current dollars using annual inflation rates**
- Fuel component adjusted from 2002 levels to account for recent trend
  - Applied the following ratio to the fuel cost per minute:
    - (Projected Jet Fuel Price per gal) / (2002 Jet Fuel price per gal)***
  - Projected Jet Fuel Price used: $2.00/gallon

<table>
<thead>
<tr>
<th>Airborne ADOC</th>
<th>Cost per minute</th>
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</thead>
<tbody>
<tr>
<td>LAS arrivals and departures Only</td>
<td>$ 59.13</td>
</tr>
<tr>
<td>PHX arrivals and departures Only</td>
<td>$ 49.38</td>
</tr>
<tr>
<td>Basin arrivals and departures Only</td>
<td>$ 66.58</td>
</tr>
</tbody>
</table>

*An average air to ground fuel burn ratio of 6 to 1 was applied.
**Source of annual inflation data: Bureau of Labor Statistics.
***Source of Jet fuel data: ATA; based on average of three U.S. sport market prices.
User Cost Related to Revised Routes

- User costs due to *extra time flown only*, for 18,000 ft and above
  
  - Daytime flights only

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Number of Affected Flights</th>
<th>Extra Time Flown (min)</th>
<th>Weighted ADOC ($/min)</th>
<th>Daily Cost ($)</th>
<th>Estimated Annual Cost ($)</th>
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<tbody>
<tr>
<td>All traffic</td>
<td>476</td>
<td>1005.2</td>
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<td>60,495</td>
<td>16,400,000</td>
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<tr>
<td>LAS traffic</td>
<td>136</td>
<td>140.5</td>
<td>59.13</td>
<td>8,309</td>
<td>2,300,000</td>
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<tr>
<td>PHX traffic</td>
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<td>308.2</td>
<td>49.38</td>
<td>15,220</td>
<td>4,100,000</td>
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<td>Basin traffic</td>
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<td>546.7</td>
<td>66.58</td>
<td>36,395</td>
<td>9,800,000</td>
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</table>

- Nighttime flights only

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Number of Affected Flights</th>
<th>Extra Time Flown (min)</th>
<th>Weighted ADOC ($/min)</th>
<th>Daily Cost ($)</th>
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<tbody>
<tr>
<td>All traffic</td>
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<td>338.0</td>
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<td>20,531</td>
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<td>169.6</td>
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<td>11,291</td>
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However, the future of the jet fuel prices is uncertain, so is ADOC
User Cost Related to Revised Routes (concluded)

- If $3.00/gallon (daytime flights only)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Number of Affected Flights</th>
<th>Extra Time Flown (min)</th>
<th>Weighted ADOC ($/min)</th>
<th>Daily Cost ($)</th>
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- If $4.00/gallon (daytime flights only)

<table>
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<th>Scenario</th>
<th>Number of Affected Flights</th>
<th>Extra Time Flown (min)</th>
<th>Weighted ADOC ($/min)</th>
<th>Daily Cost ($)</th>
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<tbody>
<tr>
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</table>
Estimated Future User Costs Due to Revised Routes for Daytime Flights

- Assuming $2.00/gallon
- Estimated future traffic levels based on FAA Terminal Area Forecasts for LAS, PHX, and LAX
- Estimated traffic level increase for impacted flights assumed to be similar to each individual airport

For Internal Grand Canyon Workgroup Discussion Only
User Cost Related to Potential Traffic Management Initiatives

- User Cost due to potential TMI (daytime flights only)

<table>
<thead>
<tr>
<th>Flow Affected</th>
<th>Restriction</th>
<th>Delay Incurred (min)</th>
<th>Weighted ADOC ($/min)</th>
<th>Daily Cost ($)</th>
<th>Annual Cost ($)</th>
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<td>LAS arrivals from SE</td>
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<td>LAS arrivals from SE</td>
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<td>2.00</td>
<td>2,197</td>
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<td>Basin departures over EED and PGS</td>
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<td>Total Cost</td>
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<td>49,702</td>
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Briefing Summary
Briefing Summary

• A flight-free zone over the heart of the Grand Canyon National Park (18,000 ft and above) would have a significant impact on the users of the airspace
  – Reroutes would add thousands of extra miles and minutes of extra flying time
  – Safety of the airspace and operation would be negatively impacted through increased complexity and risks
  – To address safety and efficiency issues, the FAA would have to take significant tactical and strategic actions