Optimization of Airspace and Procedures in the Metroplex (OAPM)

Study Team Final Report
Phoenix Metroplex
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1 Background

In September 2009, the Federal Aviation Administration (FAA) received the RTCA’s Task Force 5 Final Report on Mid-Term NextGen Implementation containing recommendations concerning the top priorities for the implementation of NextGen initiatives. A key component of the RTCA recommendations is the formation of teams leveraging FAA and Industry Performance Based Navigation (PBN) expertise and experience to expedite implementation of optimized airspace and procedures.

Optimization of Airspace and Procedures in the Metroplex (OAPM) is a systematic, integrated, and expedited approach to implementing PBN procedures and associated airspace changes. OAPM was developed in direct response to the recommendations from RTCA’s Task Force 5 on the quality, timeliness, and scope of metroplex solutions.

OAPM focuses on a geographic area, rather than a single airport. This approach considers multiple airports and the airspace surrounding a metropolitan area, including all types of operations, as well as connectivity with other metroplexes. OAPM projects will have an expedited life-cycle of approximately three years from planning to implementation.

The expedited timeline of OAPM projects centers on two types of collaborative teams:

- OAPM Study Teams (OSTs) provide a comprehensive but expeditious front-end strategic look at each major metroplex.
- Using the results of the OSTs, Design and Implementation (D&I) Teams provide a systematic, effective approach to the design, evaluation and implementation of PBN-optimized airspace and procedures.
2 Purpose of Phoenix Study Team Effort

The principal objective of the Phoenix OST is to identify operational issues and propose PBN procedures and/or airspace modifications in order to address them. This OAPM project for the Phoenix Metroplex seeks to optimize and add efficiency to the operations of the area. These efficiencies include making better use of existing aircraft equipage by adding Area Navigation (RNAV) procedures, optimizing descent and climb profiles to eliminate or reduce level-offs, and adding more direct RNAV routing in both the en route and terminal environments, among others.

The OST effort is intended as a scoping function. The products of the OST will be used to scope future detailed design efforts and to inform FAA decision-making processes concerning commencement of those design efforts.
3 Phoenix OAPM Study Team Analysis Process

3.1 Five Step Process

The Phoenix OST followed the five step analysis process below:

1. Collaboratively identify and characterize existing issues:
   a. Review current operations
   b. Solicit input to obtain an understanding of the broad view of operational challenges in the metroplex

2. Propose conceptual procedure designs that will address the issues and optimize the operation:
   a. Use an integrated airspace and PBN “toolbox” (Appendix C)
   b. Obtain technical input from operational stakeholders
   c. Explore potential solutions to the identified issues

3. Identify the expected benefits, quantitatively and qualitatively, of the conceptual designs:
   a. Assess the Rough Order of Magnitude (ROM) impacts of conceptual designs
   b. To the extent possible, use objective and quantitative assessments

4. Identify considerations and risks associated with the proposed changes:
   a. Describe, at a high-level, considerations (e.g., if additional feasibility assessments are needed) and/or risks (e.g., if waivers may be needed)

5. Document the results from the above steps

Steps 1 and 2 are worked collaboratively with local facilities and operators through a series of outreach meetings. Step 3 is supported by the OAPM National Analysis Team (NAT). The methodology used for the quantitative analysis is described in Section 3.4. The NAT is a centralized analysis and modeling resource that is responsible for data collection, visualization, analysis, simulation, and modeling. Step 4 is conducted with the support of the OAPM Specialized Expertise Cadre (SEC). The SEC provides “on-call” expertise from multiple FAA lines of business, including environmental, safety, airports, and specific programs like Traffic Management Advisor (TMA).

The Phoenix OST process and schedule are shown below:

- Kickoff meeting: January 8, 2013 at Phoenix TRACON
  - Discuss concepts and proposed schedules
  - Establish facility points of contact
  - Make data requests
• Administrative Week: January 14-18, 2013
• First Outreach: Existing Operations and Planning
  - FAA Facilities:
    ▪ January 23-24, 2013 at Albuquerque ARTCC
    ▪ January 29-30, 2013 at Phoenix TRACON
  - Industry Stakeholders:
    ▪ January 31, 2013 at US Airways, Phoenix
• OST Work (focus on operational challenges): February 4-22, 2013
• Second Outreach: Enhancement Opportunities
  - FAA Facilities:
    ▪ February 26-28, 2013 at Albuquerque ARTCC
  - Industry Stakeholders:
    ▪ March 5, 2013 at US Airways, Phoenix
• OST Work (focus on solutions, costs, and benefits): March 11-29, 2013
• Final Outreach: Summary of Recommendations
  - FAA Facilities:
    ▪ April 3, 2013 at Phoenix TRACON
  - Industry Stakeholders:
    ▪ April 4, 2013 at US Airways, Phoenix
• Documentation: Final Report, Final Briefing, and Study Team Package
  - OST Work (completing documentation): April 8-18, 2013 at MITRE
  - Report due April 19, 2013

There were three rounds of outreach meetings with local facilities, industry, and other stakeholders, including Department of Defense, business and general aviation, airports, and others. The First Outreach focused on issue identification, the Second Outreach on conceptual solutions, and the Final Outreach on summarizing the analyses of benefits, impacts, and risks. Assessments at this stage in the OAPM process are expected to be high-level. More detailed analyses of benefits, impacts, costs and risks are expected after the D&I phase has been completed.
3.2 Phoenix Study Area Scope
The Phoenix Metroplex consists of airspace in Phoenix TRACON (P50) and Albuquerque ARTCC (ZAB). Operations at four airports within the Phoenix Metroplex were examined closely due to the complexity of the interactions between the airports. They are:

- Phoenix Area Airports
  - Phoenix Sky Harbor International Airport (KPHX)
  - Phoenix-Mesa Gateway (KIWA)
  - Scottsdale Airport (KSDL)
  - Deer Valley Airport (KDVT)

Fuel burn modeling was performed for the Phoenix Sky Harbor Airport only.

3.3 Assumptions and Constraints
OAPM is an optimized approach to integrated airspace and procedures projects; thus, the proposed solutions center on PBN procedures and airspace redesign. The OST is expected to document those issues that cannot or should not be addressed by airspace and procedures solutions. These issues are described in Section 4 of this report.

The OAPM expedited timeline and focused scope bound airspace and procedures solutions to those that can be achieved without requiring an Environmental Impact Statement (EIS) (e.g., only requiring an Environmental Assessment [EA] or qualifying for a Categorical Exclusion [CATEX]) and are within current infrastructure and operating criteria. The OST may also identify airspace and procedures solutions that do not fit within the environmental and criteria boundaries of an OAPM project. These other recommendations then become candidates for other integrated airspace and procedures efforts.

3.4 Assessment Methodology
Both qualitative and quantitative assessments were made to gauge the potential benefits of proposed solutions.

The qualitative assessments are those that the OST could not measure but would result from the implementation of the proposed solutions. These assessments included:

- Impact on air traffic control (ATC) task complexity
- Ability to apply procedural deconfliction (e.g., laterally or vertically segregated flows)
- National Airspace System (NAS) impacts of flow segregation
- Ability to enhance safety
- Improved connectivity to en route structure
• Reduction in transmissions (flight deck and controller) and related reduction in frequency congestion
• Improved track predictability and repeatability, with associated improvements in fuel planning
• Reduced reliance on ground-based navigational aids (NAVAIDs)
• Increased throughput

Task complexity, for example, can be lessened through the application of structured PBN procedures versus the use of radar vectors, but quantifying that impact is difficult. Reduced communications between pilot and controller, as well as reduced potential for operational errors, are examples of metrics associated with controller task complexity that were not quantified.

For the quantitative assessments, the OST relied on identifying changes in track lengths, flight times, and fuel burn. Most of these potential benefits were measured by comparing a baseline case with a proposed change using a Monte Carlo method1 to approximate aircraft behavior based on distributions from historic radar tracks. Fuel burn for these aircraft was calculated from MITRE's validated implementation of the European Organization for the Safety of Air Navigation (EUROCONTROL) Base of Aircraft Data (BADA) fuel burn model. A flight simulator was used to establish a relationship between simulator fuel burn results and BADA tables. The quantitative analyses compared full-time use of current procedures under baseline conditions with full-time use of the procedures proposed by the OST.

3.4.1 Track Data Selected for Analyses

During the study process, a representative set of radar traffic data was utilized in order to maintain a standardized operational reference point.

For determining the number, length, and location of level-offs for the baseline of operational traffic, radar track data from July 2011 was utilized.

The historical radar track data was used to visualize the flows and identify where short-cuts were routinely applied, as well as where flight planned routes were more rigorously followed. The track data were also used as a baseline for the development of conceptual solutions, including PBN routes and procedures. In many cases, the OST overlaid the historical radar tracks with PBN routes or procedures to minimize the risk of significant noise impact and an associated EIS.

3.4.2 Analysis Tools

The following tools were employed by the OST and the NAT in the process of studying the Phoenix Metroplex:

• Performance Data Analysis and Reporting System (PDARS)

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1 Monte Carlo methods are a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results.
- Historical traffic flow analysis using merged datasets to analyze multi-facility operations
- Customized reports to measure performance and air traffic operations (i.e., fix loading, hourly breakdowns, origin-destination counts, etc.)
- Identification and analysis of level flight segments
- Graphical replays to understand and visualize air traffic operations
- Terminal Area Route Generation Evaluation and Traffic Simulation (TARGETS)
  - Comparison of actual flown routes to proposed routes when developing cost/benefit estimates
  - Conceptual airspace and procedure design
- Air Traffic Airspace Lab (ATALAB) National Offload Program (NOP) data queries
  - Quantification of traffic demand over time for specific segments of airspace
- Aviation System Performance Metrics
  - Identification of runway usage over time
- National Traffic Management Log (NTML)
  - Identification of occurrence and magnitude of TMIs
- Enhanced Traffic Management System (ETMS)
  - Traffic counts by aircraft group categories for annualizing benefits
  - Examination of filed flight plans to determine impact of significant re-routes
- Leviathan (A series of metrics computed for every flight in the NAS based on radar track data, weather information, and flight plans)
  - Flow analysis for reference packages
  - Data for baselines for modeling

### 3.4.3 Determining the Number of Operations and Modeled Fleet Mix

Due to the compressed schedule associated with this study effort, there was not sufficient time to model the entire fleet mix for KPHX. A representative fleet mix consisting of seven aircraft types was developed using data from KPHX. The fleet mix used is shown in Table 1.
Table 1. Phoenix Modeled Fleet Mix

<table>
<thead>
<tr>
<th>Aircraft Type</th>
<th>Weighted Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRJ2</td>
<td>5%</td>
</tr>
<tr>
<td>CRJ7</td>
<td>3%</td>
</tr>
<tr>
<td>CRJ9</td>
<td>10%</td>
</tr>
<tr>
<td>MD8x</td>
<td>3%</td>
</tr>
<tr>
<td>B75x</td>
<td>5%</td>
</tr>
<tr>
<td>A319/20/21</td>
<td>32%</td>
</tr>
<tr>
<td>B73x</td>
<td>37%</td>
</tr>
</tbody>
</table>

To determine the number of aircraft on each flow, four days of NOP data were analyzed for each flow. One day was chosen from each season. The annual counts of aircraft on each flow were then estimated by taking the total counts for the four days and multiplying by 91. The percentages of aircraft operations in the two primary runway configurations for each modeled airport are shown in Table 2.

Table 2. Primary Runway Configuration for Phoenix

<table>
<thead>
<tr>
<th>Airport</th>
<th>Arrival Runways</th>
<th>Departure Runways</th>
<th>% Operations in Flow</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>KPHX</td>
<td>7L, 7R, 8</td>
<td>7L, 7R, 8</td>
<td>40%</td>
<td>East Configuration</td>
</tr>
<tr>
<td>KPHX</td>
<td>26, 25L, 25R</td>
<td>26, 25L, 25R</td>
<td>60%</td>
<td>West Configuration</td>
</tr>
</tbody>
</table>

3.4.4 Determining Percent of RNAV Capable Operations by Airport

The principal objective of the Phoenix OST was to identify operational issues and propose PBN procedures and airspace modifications in order to address them. The PBN Dashboard was used to determine the percent of operations at each airport that would benefit from these new procedures. The PBN Dashboard is an online tool that reports this percentage through analysis of two sources: the equipment suffix of instrument flight rules (IFR) flight planned operations from ETMS and the percentage of PBN-equipped aircraft by type from a Part 121 avionics database maintained by The MITRE Corporation’s Center for Advanced Aviation System Development.

2 Source: Aviation System Performance Metrics, CY2012
(CAASD). Due to the incomplete nature of the data sources used, the percentages of RNAV-equipped operations are assumed to be conservative.

Table 3 lists the RNAV equipage percentages assumed for the modeled Phoenix airports.

<table>
<thead>
<tr>
<th>Airport</th>
<th>% of Total Operations RNAV-equipped</th>
</tr>
</thead>
<tbody>
<tr>
<td>KPHX</td>
<td>94%</td>
</tr>
<tr>
<td>KSDL</td>
<td>95%</td>
</tr>
<tr>
<td>KDVT</td>
<td>89%</td>
</tr>
<tr>
<td>KIWA</td>
<td>83%</td>
</tr>
</tbody>
</table>

### 3.4.5 Track Data Analyses

In order to perform a comparison between current flight data and OST proposed procedures, the team examined track data from July 2011 to build a baseline model, as discussed previously, using Leviathan. The OST compared the baseline to the OST proposed procedures using Monte Carlo generated flight profiles based on distributions from historic radar tracks. The three primary differences between OST proposed procedure profiles and baseline profiles are the altitudes where level-offs occurred, the average length in nautical miles (NM) that aircraft were in level flight at each altitude, and the total profile distance. The OST also used TARGETS to compare the length of the proposed routes to the currently published procedures. Fuel burn was calculated with MITRE’s validated implementation of the BADA fuel flow model, taking into account the modeled aircraft fleet mixes at KPHX. The fuel savings were then annualized, assuming a fuel price per gallon of $2.96, based on fuel costs for calendar year 2012 from Research and Innovative Technology Administration (RITA) Bureau of Transportation Statistics. The resulting benefit numbers were the basis for the minimum potential fuel benefit.

Flight simulations were run on a current arrival procedure as well as the corresponding conceptual design during the Washington D.C. Metroplex prototype OST effort. The flight simulator values were obtained through a US Airways A320 flight simulator fuel burn analysis for two transitions on a proposed versus baseline arrival procedure. Derived values for fuel burn per minute in level flight, idle descent, and less-efficient descent were then used to determine and validate the relationship between the flight simulator fuel saving estimates and the BADA-based fuel burn estimates (calculated in gallons per NM). Essentially, this effort allowed for a
determination of the difference between BADA’s conservative aircraft performance numbers and what could be achieved with an actual pilot flying the plane. This method was applied to Phoenix OST results to determine a maximum fuel savings per flight. Applying both the BADA and flight simulator methods provides for a range of potential benefits:

- Lower-bound potential benefit: BADA speed/fuel burn
- Upper-bound potential benefit: Flight simulation speed/fuel burn

3.4.6 Cost to Carry (CTC)

Aircraft fuel loading is based on the planned flight distance and known level-offs. Furthermore, airlines must carry extra fuel to compensate for the weight of the total fuel required to fly a route. This extra fuel is known as the Cost-to-Carry (CTC). CTC can vary widely among airlines, generally ranging from about 2% to about 15%. For this analysis, based on feedback from multiple industry representatives, CTC was assumed to be 10%. This means that for every 100 gallons of fuel loaded, CTC is 10 gallons. This figure was chosen based on the fact that most of the aircraft in the study area are narrow-body. Heavy aircraft, international and long-haul flight values may differ.

3.4.7 Benefits Metrics

The benefits metrics were generated using the following process:

1. The radar track data from the days mentioned previously were parsed into flows into and out of Phoenix. These flows were then analyzed to determine geographic location, altitude, and length of level-offs in the airspace. The average overall track flow length was also estimated.

2. Baseline routes were developed that mimic the average vertical and lateral path of the tracks in the flows.

3. Proposed conceptual routes were designed by the OST.

4. The impacts of the proposed conceptual routes were estimated as compared to the current published procedure for the flow, if any, and the baseline route. Although vertical level-offs and lateral distance savings were not modeled independently, their impacts can best be described as separate entities.

   a. Vertical savings: Compare the baseline vertical path with its associated level-offs with the proposed vertical path, which ideally has fewer and/or shorter level-offs.

   b. Lateral filed miles savings: Compare the length of the published procedure or route to the length of the proposed procedure of route.

   c. Lateral distance savings: Compare the length of the baseline procedure or route to the length of the proposed procedure of route.

5. The fuel and cost savings were then estimated based on the above impacts.
a. Vertical profile savings accrue both fuel and CTC savings.
b. Lateral *filed* miles savings accrue CTC savings *only*.
c. Lateral *distance* savings accrue both fuel and CTC savings.

Figure 1 shows published, baseline, and proposed routes for a flow, with the comparisons for lateral savings highlighted, and sample vertical profiles as well.
3.5 Key Considerations for Evaluation of Impacts and Risks

In addition to the quantitative and qualitative benefits assessments described in Section 3.4, the Phoenix OST was tasked with identifying the impacts and risks from the FAA operational and safety perspective, as well as from the airspace user perspective. For each individual issue and proposed solution throughout Section 4 of this report, specific impacts and risks are identified. However, there are a number of impacts and risks that generally apply to many proposed solutions, as described below:

- Controller and pilot training: With the increased focus on PBN and the proposed changes in airspace and procedures, controller and pilot training will be a key consideration for nearly all proposals.

- “Descend via” procedure issues: The proposed use of “descend via” clearances will similarly require controller and pilot training, and agreement must be reached during D&I on exactly how procedures will be requested, assigned, and utilized from both the FAA and user perspectives.

- Aircraft equipage: There are challenges with working in a mixed equipage environment, and these risks must be considered during D&I. While procedures have been designed to take advantage of PBN efficiencies, procedures and processes must be developed for conventional operations as well.

- Safety Risk Management (SRM): Safety is always the primary concern, and all of the proposed solutions will require an SRM assessment, which will occur during the Operational and Environmental Review phase.

- Environmental issues: All proposed solutions are subject to environmental review, and the OAPM schedule limits that review to a CATEX or EA rather than an EIS. The OST worked with environmental specialists to determine whether any of the proposed solutions has the potential for significant environmental impacts, and developed mitigation alternatives if necessary.
4 Identified Issues and Proposed Solutions

This section presents the findings and results of the Phoenix OST analysis. It reviews identified issues, proposed solutions, benefits/impacts/risks, and analysis results.

During the First Outreach meetings, 75 issues were identified. Of those, industry stakeholders identified 9 issues for the Phoenix area. Of the 66 issues identified by FAA Air Traffic facilities, 25 of these were within the OAPM scope. Similar issues raised by all involved parties were consolidated and categorized by the OST to determine potential solutions.

Several issues required additional coordination and input and could not be addressed within the time constraints of the OST process.

All remaining issues analyzed by the OST were rendered outside the scope of OAPM.

4.1 Design Concepts

The primary goals of the Phoenix OST were to use RNAV everywhere and RNP where beneficial. The use of PBN procedures will allow efficiency gains through optimized profile climbs/descents and enhanced lateral paths not reliant on ground based navigation, while allowing predictability and repeatability and reducing ATC task complexity and frequency congestion. The OST removed unused transitions to reduce chart clutter and the potential for improper flight planning. Runway transitions were used where practical, while limiting potential environmental risks.

Currently, KPHX Metroplex controllers rely on an assortment of conventional departure procedures. The facilities use both vectors and route structure where necessary to maintain separation and expedite aircraft climbs into en route airspace.

The proposed departure procedures attempt to maintain unrestricted climbs as much as possible, while providing procedural deconfliction where practical from other Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARs). It is fully expected that ATC will continue to tactically enable shorter routings and remove climb restrictions. Additionally, the recommended use of transitional separation between terminal and en route facilities may increase airspace throughput. Transitional separation will allow terminal facilities to provide 3 NM separation increasing to 5 NM in the en route environment. Airspace modifications that enable procedural efficiencies may need to be considered during D&I.

RNAV SIDs with flow dependent transitions were designed for repeatable, predictable paths. The OST recognizes that RNAV off-the-ground procedures may create a disbenefit in track miles flown in certain circumstances. The Phoenix OST recommended a mixture of radar off-the-ground (radar vectors) and RNAV off-the-ground departures. The D&I Team may elect to further evaluate the combination of radar vectors and RNAV off-the-ground SIDs to determine the most beneficial method of departing from Phoenix airports.

With respect to the conceptual departure proposals, Figure 2 depicts benefits, impacts, and risks for the FAA and airspace users, as well as environmental considerations.
In general, the issues associated with the current arrival procedures to Phoenix were related to inefficient lateral and vertical paths, interactions with turboprop arrivals and departure traffic, and underutilized en route transitions.

In addition to optimizing vertical profiles, lateral paths were shortened; routes were segregated; unused en route transitions were removed; and flow dependent transitions were proposed. The D&I Team will need to assess the location of fixes to add additional transitions to the STARs. STARs at all major and several satellite airports in Phoenix were modified. These new STARs are procedurally deconflicted from SIDs and other STARs where possible.

Airspace modifications that enable procedural efficiencies will also need to be considered during D&I. Conventional (non-RNAV) STARs may need modification during D&I. Holding patterns were not designed and, where required, will need to be addressed in D&I.

With respect to the conceptual arrival proposals, Figure 3 depicts benefits, impacts, and risks for the FAA and airspace users, as well as environmental considerations.

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**Figure 2. Benefits, Impacts and Risks of the Departure Proposals**

<table>
<thead>
<tr>
<th></th>
<th>FAA Operational / Safety</th>
<th>Airspace User</th>
<th>Environmental Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benefits</strong></td>
<td>• PBN benefits</td>
<td>• PBN benefits</td>
<td>• Noise screening / analysis</td>
</tr>
<tr>
<td></td>
<td>• Increased airspace</td>
<td>• Reduced fuel burn and emissions</td>
<td>• Emissions analysis</td>
</tr>
<tr>
<td></td>
<td>throughput</td>
<td>• LOA revisions</td>
<td>• Runway transition assessment</td>
</tr>
<tr>
<td></td>
<td>• Reduced delay vectoring</td>
<td>• Training</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Reduced track miles</td>
<td>• Sectorization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Optimized lateral flight paths</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2 Phoenix Area Procedures

Within P50 terminal airspace, KPHX is the busiest airport, with 1,233 daily operations on average in 2012, with 95% being either air carrier or air taxi flights. KIWA, KSDL and KDVT are primary satellite airports. P50 airspace extends from the surface to 21,000 feet mean sea level (MSL). KPHX has triple parallel east/west runway configurations, with the west flow being the predominant flow at 60%. ZAB ARTCC controls the flows into and out of P50 airspace.

4.2.1 Phoenix Sky Harbor Arrivals

This section describes the operational issues, solutions, and expected benefits the OST has identified for Phoenix arrivals.

Specifically, arrival issues include excessive speed and compression on STARs requiring additional vectors off the procedure. Procedures often provide the controller with limited time and/or distance to sequence arrivals. Efficiency can also be degraded where turboprop arrivals to KPHX and arrivals to satellite airports are mixed with jet arrivals to KPHX.
The limited throughput of a single OPD STAR frequently inhibits the TRACONs ability to meet the AAR. This is compounded by high demand in arrival areas serviced by a single arrival flow. Specifically, in the northeast, on the EAGUL STAR. The OST solutions included a designing dual, parallel arrivals where beneficial.

4.2.1.1 KPHX EAGUL OPD Arrival

The KPHX EAGUL OPD STAR accounts for approximately 35% of all KPHX turbojet arrivals.

Issues

- Facility and Industry identified several issues adversely affecting the present EAGUL STAR. Currently, numerous flight tracks do not follow the existing EAGUL STAR. Also identified were inefficient en route spacing, a dogleg at PAYSO waypoint which caused compression during the turn, daily TMIs, the need for controller intervention and reduced overall efficiency.

- External factors negatively affecting the efficiency of the EAGUL were the interactions with J74 overflight traffic requiring early descent and turboprops routed on the procedure, which restrict descents for turbojets.

Solutions

- An RNAV STAR was designed with Optimized Profile Descent (OPD) and lateral paths to reduce flight track miles. The proposed procedure was designed to optimized lateral paths and eliminates unnecessary transitions; en route transitions were shortened to provide user flexibility. An ATC assigned routing from the vicinity of INW was developed for weather re-routes. A floating waypoint was developed for routing traffic over KPHX to the south downwind on an east flow.

- The OST developed a Q-Route to replace J74 between TXO and PSP to move overflight traffic south and to optimize the EAGUL OPD STAR.

- An EAGUL Offload STAR was developed to optimize the EAGUL Primary STAR. The EAGUL Offload STAR is described in Section 4.2.1.2

Figures 4 and 5 depict the current and OST proposed designs including the terminal view.
Figure 4. Current KPHX EAGUL OPD and Proposed OST Design

Figure 5. Current EAGUL and Proposed OST EAGUL OPD STAR (Terminal View)
Notes

- Runway transitions for all runways should be developed during the Design Phase
- It is anticipated that up to 25% of traffic on the EAGUL may be routed to the proposed offload procedure
- Downwinds were widened in anticipation for RNP turns and may need to be readjusted
- At or below FL330 point was moved from TINIZ to waypoint A0029 (see Figure 4)

The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified as depicted in Figure 6.

Figure 6. Proposed EAGUL OPD and EAGUL Offload STAR: Airspace Affected
Benefits

- Projected annual benefits for the proposed KPHX EAGUL STAR are depicted in Table 4.

**Table 4. Proposed EAGUL OPD STAR Annual Benefits**

<table>
<thead>
<tr>
<th>Estimated Annual Fuel Savings *</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance and Profile</td>
<td>$498,004</td>
<td>$2,694,013</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>$89,800</td>
<td>$269,401</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
<td>$79,083</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Gallons)</td>
<td>360,435</td>
<td>1,027,870</td>
</tr>
<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
<td>3,387</td>
<td>9,659</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars) *</td>
<td>$1,066,887</td>
<td>$3,042,497</td>
</tr>
</tbody>
</table>

4.2.1.2 KPHX EAGUL OPD Arrival (Offload)

The KPHX EAGUL OPD STAR accounts for approximately 35% of all KPHX turbojet arrivals. It is anticipated up to 25% of that traffic may be routed to this proposed offload procedure.

Issues

- Restated, Facility and Industry identified several issues adversely affecting the present EAGUL STAR. Currently, numerous flight tracks do not follow the existing EAGUL STAR. Also identified were inefficient en route spacing, a dogleg at PAYSO waypoint which caused compression during the turn, daily TMIs, the need for controller intervention and reduced overall efficiency.

- To help remedy the identified issues on the EAGUL Primary STAR, this EAGUL Offload STAR was designed.
Solutions

- An Offload RNAV STAR was designed with Optimized Profile Descent (OPD) and lateral paths to reduce flight track miles. A floating fix was developed for routing traffic over KPHX for the south downwind on an east flow.

- The Offload STAR was developed to:
  - Reduce TMIs
  - Reduced controller intervention
  - Reduce compression (En Route and Terminal)
  - Accommodate turboprops
  - Connectivity to the Primary EAGUL STAR

Figures 7 and 8 depict the current and OST proposed designs including the terminal view.

![Figure 7. Current EAGUL OPD and Proposed OST Offload](image-url)
Notes

- Runway transitions for all runways should be developed in the Design Phase.
- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency.
- Downwinds were widened in anticipation for RNP turns and may need to be readjusted.
- Restrictions of at or below FL330 at waypoints A0059 and A0030 were developed to deconflict from the proposed Q-Route (see Figure 7).

Benefits

- Projected annual benefits for the KPHX EAGUL OPD STAR (offload) are depicted in Table 5.
Table 5. Proposed EAGUL OPD STAR Offload Annual Benefits

<table>
<thead>
<tr>
<th>EAGUL OPD STAR (Offload)</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Annual Fuel Savings*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance and Profile</td>
<td>$298,413</td>
<td>$895,238</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>$29,841</td>
<td>$89,524</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
<td>$89,681</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Gallons)</td>
<td>141,194</td>
<td>362,987</td>
</tr>
<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
<td>1,327</td>
<td>3,411</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars)*</td>
<td>$417,935</td>
<td>$1,074,442</td>
</tr>
</tbody>
</table>

4.2.1.3 PINNG OPD STAR Arrival

The current KOOLY STAR accounts for 15% of all KPHX turbojet arrivals.

Issues

- Parachute jump operations at KCGZ, KE60, KMZJ and KP08 impact route. Turboprops and satellite arrivals restrict turbojet optimized descents.

Solutions

- An RNAV STAR was designed with Optimized Profile Descent (OPD) and lateral paths to reduce flight track miles and remains outside of designated jump operational areas.
- A Southeast Turboprop/Satellite STAR was developed to optimize the PINNG STAR. The Southeast Turboprop/Satellite STAR is described in Section 4.2.1.4.

Figures 9 and 10 depict the current and OST proposed designs including the terminal view.
Figure 9. Current and Proposed KPHX PINNG OPD

Figure 10. Current and Proposed KPHX PINNG OPD STAR (Terminal View)
Notes

- Runway transitions for all runways should be developed
- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency
- Downwinds were widened in anticipation for RNP turns and may need to be readjusted

Benefits

- Projected annual benefits for the KPHX PINNG OPD STAR are depicted in Table 6.

<table>
<thead>
<tr>
<th>PINNG OPD STAR</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Annual Fuel Savings *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance and Profile</td>
<td>$95,598</td>
<td>$286,794</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>$9,560</td>
<td>$28,679</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
<td>$27,307</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings</td>
<td>44,752</td>
<td>115,804</td>
</tr>
<tr>
<td>(Gallons)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Estimated Annual Carbon Savings</td>
<td>421</td>
<td>1,088</td>
</tr>
<tr>
<td>(Metric Tons)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings</td>
<td>$132,465</td>
<td>$342,780</td>
</tr>
<tr>
<td>(Dollars) *</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2.1.4 Southeast Turboprop/Satellite

Issues

- Parachute jump operations at KCGZ, KE60, KMZJ and KP08 impact route. Turboprops and satellite arrivals restrict turbojet optimized descents
Solutions

- The OST developed an RNAV STAR for turboprops landing at KPHX and satellite airports. The new STAR terminates with connectivity to the OST proposed T-Route over the top of KPHX. The new route is laterally segregated from, and allows for optimized descents on, the PINNG STAR. The design remains outside of designated jump operations south of P50 airspace, as depicted by green circles in Figure 11 below.

Figures 11 and 12 depict the current and OST proposed designs including a view with the turboprop route, PINNG arrival and the proposed KPHX area T-Route.

Figure 11. Proposed Southeast Turboprop/Satellite STAR
Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency.
- Satellite turbojets should be routed on the PINNG unless KPHX traffic conditions dictate offloading to this Southeast Turboprop/Satellite STAR.

4.2.1.5 HYDRR North/South OPD STAR

The current GEELA STAR accounts for 27% of all KPHX turbojet arrivals.

Issues

- Turboprops on the GEELA STAR restrict turbojet OPD. There is limited airspace available for ZAB to blend two feeds, one from the Los Angeles Basin and one from the San Diego area on the GEELA STAR. This results in inefficient en route spacing and compression.
- Current ZLA-ZAB LOA altitude constraints cause inefficient vertical paths. There was an unused en route transition and flight tracks did not follow the existing procedure.
Solutions

- Separate RNAV STARs for Los Angeles Basin and San Diego/Yuma routes were developed with optimized lateral and vertical paths (OPD) which maximize throughput on the Los Angeles Basin flow (HYDRR North STAR). The OST proposed procedures eliminate unnecessary transitions.

- A separate STAR was developed to segregate KPHX turboprop and south satellite arrivals. The KPHX turboprop and south satellite STAR is described in Section 4.2.1.6.

- Additionally, a STAR was developed to segregate north satellite arrivals. That north satellite STAR is described in Section 4.2.4.5.

Figure 13 depicts the current GEELA STAR and both proposed HYDRR north and south STARs. Figures 14 and 15 depict both north and south terminal views as proposed by the KPHX OST.
Notes

- Runway transitions for all runways should be developed
- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency
• Downwinds were widened in anticipation for RNP turns and may need to be readjusted
• 80% of current GEELA arrivals originate in the LA Basin
• ZLA/ZAB LOA needs to be addressed to raise Top of Descent (TOD)

Benefits
• Projected annual benefits for the proposed HYDRR North/South OPD STAR are depicted in Tables 7 and 8.

<table>
<thead>
<tr>
<th>HYDRR North OPD STAR</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance and Profile</td>
<td>$1,102,177</td>
<td>$3,306,531</td>
</tr>
<tr>
<td>Cost to Carry</td>
<td>$110,218</td>
<td>$330,653</td>
</tr>
<tr>
<td>Filed Mileage Savings</td>
<td>$130,272</td>
<td></td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Gallons)</td>
<td>453,604</td>
<td>1,272,789</td>
</tr>
<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
<td>4,263</td>
<td>11,961</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars)</td>
<td>$1,342,667</td>
<td>$3,767,457</td>
</tr>
</tbody>
</table>
Table 8. Proposed HYDRR South OPD STAR Annual Benefits

<table>
<thead>
<tr>
<th>HYDRR South OPD STAR</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance and Profile</td>
<td>$241,739</td>
<td>$725,218</td>
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<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>$24,174</td>
<td>$72,522</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td>$39,819</td>
<td></td>
</tr>
<tr>
<td><strong>Total Estimated Annual Fuel Savings (Gallons)</strong></td>
<td>103,288</td>
<td>282,959</td>
</tr>
<tr>
<td><strong>Total Estimated Annual Carbon Savings (Metric Tons)</strong></td>
<td>971</td>
<td>2,859</td>
</tr>
<tr>
<td><strong>Total Estimated Annual Fuel Savings (Dollars)</strong></td>
<td>$305,733</td>
<td>$837,559</td>
</tr>
</tbody>
</table>

4.2.1.6 HYDRR KPHX Turboprop/South Satellite STAR

**Issues**

- Turboprops and satellite arrivals flying the same lateral paths restrict KPHX turbojet optimized descents. Numerous flight tracks do not follow the existing GEELA STAR.

**Solutions**

- The OST proposed a notional STAR to accommodate south satellite and KPHX turboprop arrivals. The STAR was designed to deconflict satellite and turboprop flows from the OST proposed HYDRR North STAR.

Figure 16 depicts the proposed HYDRR KPHX Turboprop/South Satellite STAR. Figure 17 depicts HYDRR North/South OPD STAR and HYDRR KPHX Turboprop/South Satellite STAR as proposed by the OST.
Figure 16. Proposed HYDRR Turboprop/South Satellite STAR

Figure 17. HYDRR North/South OPD STAR and HYDRR KPHX Turboprop/South Satellite STAR
Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency.
- Due to design constraints, individual STARs may need to be designed, one for south satellites and one for KPHX turboprops.

4.2.1.7 BROAK OPD STAR

The current MAIER STAR accounts for 22% of all KPHX turbojet arrivals.

Issues

- KPHX turboprop arrivals flying the same lateral paths restrict turbojet optimized descents. Numerous flight tracks do not follow the existing BROAK STAR. ZLA-ZAB LOA constraints and interaction with the LAS TYSSN STAR cause inefficient vertical and lateral paths. The facilities identified the need to develop a weather route. This ATC assigned weather reroute would be used when the OST proposed EAGUL STAR is unavailable.

Solutions

- The KPHX OST proposed an RNAV STAR with optimized lateral and vertical paths (OPD), reduces track miles. A floating waypoint was developed for routing traffic over KPHX to opposite downwind. The en route transition was shortened to provide user flexibility. An ATC assigned only route was added from the INW area for weather reroutes from the northeast.

Figures 18 and 19 depict the current MAIER and proposed KPHX BROAK OPD STARs including the terminal view.
Figure 18. Current and Proposed KPHX BROAK OPD STAR

Figure 19. Current and Proposed KPHX BROAK OPD STAR (Terminal View)
Notes

- Transitions for all runways should be developed
- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency
- Downwinds were widened in anticipation for RNP turns and may need to be readjusted
- ZLA/ZAB LOA needs to be addressed to raise Top of Descent (TOD) and resolve LAS TYSSN interaction

Benefits

- Projected annual benefits for the KPHX BROAK OPD STAR are depicted in Table 9.

Table 9. Proposed KPHX BROAK OPD STAR Annual Benefits

<table>
<thead>
<tr>
<th>BROAK OPD STAR</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Annual Fuel Savings *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance and Profile</td>
<td>$1,127,183</td>
<td>$3,381,550</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>$112,718</td>
<td>$338,155</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td>$251,433</td>
<td></td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Gallons)</td>
<td>485,186</td>
<td>1,285,672</td>
</tr>
<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
<td>4,559</td>
<td>12,082</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars) *</td>
<td>$1,491,335</td>
<td>$3,971,138</td>
</tr>
</tbody>
</table>
4.2.1.8 Summary of Potential Benefits for KPHX STARs

Benefits

- The projected annual savings for the OST proposed KPHX STARs are estimated to be from 4.8 to 13 million dollars. The estimated savings are depicted in Table 10.

### Table 10. Proposed KPHX STAR Annual Benefits

<table>
<thead>
<tr>
<th>Phoenix Arrival Benefits</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance and Profile</td>
<td>$3,763,114</td>
<td>$11,289,343</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>$376,311</td>
<td>$1,128,934</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
<td>$617,596</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimated Annual Fuel Savings *</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Estimated Annual Fuel Savings (Gallons)</td>
<td>1,588,459</td>
<td>4,348,082</td>
</tr>
<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
<td>14,927</td>
<td>40,859</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars) *</td>
<td>$4,757,021</td>
<td>$13,035,873</td>
</tr>
</tbody>
</table>

4.2.2 Phoenix Sky Harbor Departures

This section describes the operational issues, solutions, and expected benefits the OST has identified for departures from KPHX.

Departure issues include a lack of RNAV procedures, connectivity to Q-Routes, inefficient lateral paths, interaction with STARs, unused transitions and lack of weather (WX) routes/connectivity between the northeast departure procedures.

KPHX noise abatement procedures restrict departure headings on east and west operations. When departing to the east, noise abatement compliance is achieved when an aircraft passes through an imaginary 5,550 foot wide gate located at 4 DME east of the PXR VOR. West bound departures must fly one of two headings, either a 240 degree or 260 degree heading until 9 DME from the PXR VOR. Another major departure challenge for KPHX is the large number of SAAs.

4-23
surrounding KPHX TRACON which limits flexibility when designing routes. Extensive parachute operations at KE60, KCGZ, KP08 and KMZJ impact arrival and departure routes south of KPHX.

There are seven conventional SIDs serving the Phoenix Sky Harbor airport. There are nine new RNAV procedures currently in development for KPHX. Although the publication date was uncertain at the time of this study, these procedures were used as the starting point for procedures developed by the OST. The OST identified potential issues with the facility’s designs, which will likely create the need for an Environmental Impact Statement (EIS). The 3-5 year time frame needed for completion of an EIS prohibits the OST from mimicking portions their proposed procedures.

4.2.2.1 KPHX YOTES SID

The OST proposed YOTES RNAV SID replaces the northeast transitions (Dove Creek and Rattlesnake) of the existing conventional SILOW SID and accounts for 8% of all KPHX turbojet departures.

Issues

- Currently there are no RNAV procedures for northbound departures. Numerous flight tracks do not follow the existing SILOW SID and some aircraft level off at FL290 due to ZAB92/67 boundary alignment.

Solutions

- RNAV SID was designed with connectivity to all runways transitions via RNAV VM legs (radar vectors). The proposed procedure optimized lateral paths to reduce flight track miles.

- An additional en route transition was added to increase throughput and all transitions were shortened to provide user flexibility

Figure 20 depicts the current SILOW and the OST proposed YOTES SIDs. Figure 21 depicts the terminal view of the proposed YOTES SID.
Figure 20. Current SILOW and Proposed KPHX YOTES SIDs

Figure 21. Proposed KPHX YOTES (Terminal View)
Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency. One example would be current airspace alignment which restricts the departures’ ability to climb unimpeded and the boundaries between ZAB92/67/45/39 should be reviewed.

- Eastbound departures are restricted to 210 knots until waypoint SPRKY due to the proposed HBUUB SID. Industry has a concern that 210 knots may be below minimum climb speed requirements at certain temperatures.

- Runway transitions for all runways should be developed.

Benefits

- Projected annual savings for the KPHX YOTES SID are estimated in Table 11.

Table 11. Proposed KPHX YOTES SID Annual Benefits

<table>
<thead>
<tr>
<th>Estimated Annual Fuel Savings *</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance and Profile</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
<td>$26,211</td>
</tr>
</tbody>
</table>

| Total Estimated Annual Fuel Savings (Gallons) | 8,855 |
| Total Estimated Annual Carbon Savings (Metric Tons) | 83 |
| Total Estimated Annual Fuel Savings (Dollars) * | $26,211 |

4.2.2.2 KPHX FORPE Departure

The OST proposed KPHX FORPE RNAV SID replaces the existing conventional ST. JOHNS SID and accounts for 13% of all KPHX turbojet departures.
Issues

- Currently there are no RNAV procedures for northeast bound departures and flight tracks do not follow the existing ST. JOHNS SID. During weather events, there is a lack of connectivity between the ST. JOHNS and MAXXO SIDs.

Solutions

- RNAV SID was designed with connectivity to all runways with RNAV VM leg (radar vectors) to join the course on a west flow and RNAV off-the-ground when on an east flow. The proposed procedure optimized lateral paths to reduce flight track miles.

- An additional en route transition was added to provide connectivity to the OST proposed FTHLS SID and en route transitions were shortened to provide user flexibility.

Figure 22 depicts the current ST. JOHNS and OST proposed FORPE SIDs. Figure 23 depicts the terminal view of the proposed FORPE SID.

![Figure 22. Current SJN and Proposed KPHX FORPE SID](image)
Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency.
- Eastbound departures are restricted to 210 knots until waypoint SPRKY due to the proposed HBUUB SID. Industry has a concern that 210 knots may be below minimum climb speed requirements at certain temperatures.
- Runway transitions for all runways should be developed.

Benefits

- Projected annual savings for the KPHX FORPE SID are estimated in Table 12.
Table 12. Proposed KPHX FORPE SID Annual Benefits

<table>
<thead>
<tr>
<th>FORPE SID</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Annual Fuel Savings *</td>
<td>Distance and Profile</td>
<td>No Significant Benefits</td>
</tr>
<tr>
<td></td>
<td>Cost to Carry (Distance and Profile)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Gallons)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars) *</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2.2.3 KPHX FTHLS Departure

The OST proposed KPHX FTHLS RNAV SID replaces the existing conventional MAXXO SID and accounts for 10% of all KPHX turbojet departures.

Issues
- Currently there are no RNAV procedures for northeast bound departures and flight tracks do not follow the existing MAXXO SID. During weather events, there is a lack of connectivity between the MAXXO and ST. JOHNS SIDs.

Solutions
- RNAV SID was designed with connectivity to all runways with RNAV VM leg (radar vectors) to join the course on a west flow and RNAV off-the-ground when on an east flow. The proposed procedure optimized lateral paths to reduce flight track miles.
- An additional en route transition was added to provide connectivity to the OST proposed FORPE SID and en route transitions were shortened to provide user flexibility.
Figure 24 depicts the current MAXXO and the OST proposed FTHLS SIDs. Figure 25 depicts the terminal view of proposed FTHLS SID.

Figure 24. Current Procedure and Proposed FTHLS

Figure 25. Proposed KPHX FTHLS SID (Terminal View)
Notes

• The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency.

• Eastbound departures are restricted to 210 knots until waypoint SPRKY due to the proposed HBUUB SID. Industry has a concern that 210 knots may be below minimum climb speed requirements at certain temperatures.

• Runway transitions for all runways should be developed.

Benefits

• Projected annual savings for the KPHX FTHLS SID are estimated in Table 13.

Table 13. Proposed KPHX FTHLS Annual Benefits

<table>
<thead>
<tr>
<th>FTHLS SID</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Estimated Annual Fuel Savings</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance and Profile</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
<td>$14,142</td>
</tr>
<tr>
<td><strong>Total Estimated Annual Fuel Savings (Gallons)</strong></td>
<td></td>
<td>4,788</td>
</tr>
<tr>
<td><strong>Total Estimated Annual Carbon Savings (Metric Tons)</strong></td>
<td></td>
<td>45</td>
</tr>
<tr>
<td><strong>Total Estimated Annual Fuel Savings (Dollars)</strong></td>
<td></td>
<td>$14,172</td>
</tr>
</tbody>
</table>

4.2.2.4 KPHX SHRIF Departure

The OST proposed KPHX SHRIF RNAV SID replaces the existing conventional STANFIELD SID (OLIIN transition) and accounts for 11% of all KPHX turbojet departures.
Issues

• There are no RNAV procedures for southeast bound departures and flight tracks do not follow the existing STANFIELD SID. Approximately 80% of the southeast departures utilize the east departure gate through the SAAs (OUTLAW, JACKAL).

Solutions

• To maximize track mile savings, the OST relocated the arrival flow to the west to accommodate a more efficient departure procedure. To accomplish the concept, the OST designed the SHRIF RNAV SID in the previous arrival’s location. The new SHRIF RNAV SID was designed to closely parallel the boundaries of the southeastern SAAs.

• The OST proposed SHRIF RNAV SID was designed with connectivity to all runways with RNAV VM leg (radar vectors) to join the course on a west flow and RNAV off-the-ground when on an east flow. The proposed procedure optimized lateral paths to reduce flight track miles.

Figure 26 depicts the current STANFIELD and OST proposed SHRIF SIDs. Figure 27 depicts the terminal view for the SHRIF SID.
Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency.
- Eastbound departures are restricted to 210 knots until waypoint AZCRD due to the proposed HBUUB SID. Industry has a concern that 210 knots may be below minimum climb speed requirements at certain temperatures.
- Runway transitions for all runways should be developed.

Benefits

- Projected annual savings for the KPHX SHRIF SID are estimated in Table 14.
### Table 14. Proposed KPHX SHRIF SID Annual Benefits

<table>
<thead>
<tr>
<th>SHRF SID</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Annual Fuel Savings *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance and Profile</td>
<td>$531,559</td>
<td>$1,594,678</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>$53,156</td>
<td>$159,468</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
<td>$189,926</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Gallons)</td>
<td>261,703</td>
<td>656,781</td>
</tr>
<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
<td>2,459</td>
<td>6,172</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars) *</td>
<td>$774,641</td>
<td>$1,944,071</td>
</tr>
</tbody>
</table>

#### 4.2.2.5 KPHX BNYRD Departure

The OST proposed KPHX BNYRD RNAV SID replaces the existing conventional STANFIELD SID (TUCSON Transition) and accounts for 5% of all KPHX turbojet departures.

**Issues**
- Currently there are no RNAV procedures for southbound departures and flight tracks do not follow the existing conventional STANFIELD SID (Tucson Transition).

**Solutions**
- The OST proposed BNYRD RNAV SID was designed with RNAV VM legs (radar vectors) to join the course on a west flow and RNAV off-the-ground when on an east flow. The proposed procedure optimized lateral paths to reduce flight track miles and en route transitions were shortened to provide user flexibility.

Figure 28 depicts the current STANFIELD and the OST proposed BNYRD SIDs. Figure 29 depicts the terminal view of the proposed BNYRD SID.
Figure 28. Current and Proposed KPHX BNYRD SID

Figure 29. Proposed KPHX BNYRD (Terminal View)
Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency.
- Eastbound departures are restricted to 210 knots until waypoint D0053 due to the proposed HBUUB SID. Industry has a concern that 210 knots may be below minimum climb speed requirements at certain temperatures.
- The ending point on the SID was placed to allow a direct routing to VYLLA intersection which is a coordination fix between ZAB and Mazatlan Center and remains clear of SELLS ATCAA.
- Runway transitions for all runways should be developed.

Benefits

- Projected annual savings for the proposed KPHX BNYRD SID are estimated in Table 15.

Table 15. Proposed KPHX BNYRD SID Annual Benefits

<table>
<thead>
<tr>
<th>Estimated Annual Fuel Savings *</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance and Profile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No Significant Benefits

<table>
<thead>
<tr>
<th>Total Estimated Annual Fuel Savings (Gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars) *</td>
</tr>
</tbody>
</table>

4-36
4.2.2.6 KPHX GBEND Departure

The OST proposed KPHX GBEND RNAV SID replaces the existing conventional MOBIE SID and accounts for 5% of all KPHX turbojet departures.

Issues

- Currently there are no RNAV procedures for southwest bound departures and flight tracks do not follow the existing conventional MOBIE SID.

Solutions

- RNAV SID was designed with RNAV VM leg (radar vectors) to join the course on a west flow and RNAV off-the-ground when on an east flow. The proposed procedure optimized lateral paths to reduce flight track miles.

Figure 30 depicts the current MOBIE and the OST proposed GBEND SIDs. Figure 31 depicts the terminal view.

![Figure 30. Current and Proposed KPHX GBEND SID](image)

Figure 30. Current and Proposed KPHX GBEND SID
Figure 31. Proposed KPHX GBEND SID (Terminal View)

Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency
- Eastbound departures are restricted to 210 knots until waypoint D0053 due to the proposed HBUUB SID. Industry has a concern that 210 knots may be below minimum climb speed requirements at certain temperatures
- Runway transitions for all runways should be developed

Benefits

- Projected annual savings for the new KPHX GBEND SID are estimated in Table 16.
Table 16. Proposed KPHX GBEND SID Annual Benefits

<table>
<thead>
<tr>
<th>GBEND SID</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Annual Fuel Savings *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance and Profile</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
<td>$7,545</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Gallons)</td>
<td></td>
<td>2,549</td>
</tr>
<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars) *</td>
<td></td>
<td>$7,545</td>
</tr>
</tbody>
</table>

4.2.2.7 KPHX HBUUB Departure

The OST proposed KPHX HBUUB RNAV SID replaces the existing conventional BUCKEYE SID and accounts for 23% of all KPHX turbojet departures.

Issues

- Currently there are no RNAV procedures for westbound departures and flight tracks do not follow the existing conventional BUCKEYE SID. There is also an unused en route transition.

Solutions

- RNAV SID was designed with RNAV off-the-ground on an east and west flow. The proposed procedure optimized lateral paths to reduce flight track miles and en route transitions were shortened to provide user flexibility.

Figure 32 depicts the current BUCKEYE and the OST proposed HBUUB SIDs. Figure 33 depicts the terminal views as proposed by the KPHX OST.
Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency.

- Eastbound departures are restricted to 210 knots on all east flow until waypoint USEYE in order to make the turn and cross MASVE at or above 7000 MSL. Industry has a concern that 210 knots may be below minimum climb speed requirements at certain temperatures.

- Runway transitions for all runways should be developed.

- Industry expressed a desire, and the OST supports investigating an RF leg for this departure.

Benefits

- Projected annual savings for the new KPHX HBUUB SID are estimated in Table 17.
4.2.2.8 KPHX ZEPER Departure

The OST proposed KPHX ZEPER RNAV SID replaces the existing conventional CHILY SID and accounts for 12% of all KPHX turbojet departures.

Issues

- Currently there are no RNAV procedures for northwest bound departures and flight tracks do not follow the existing conventional CHILY SID. The BAGHDAD and GLADDEN SAAs restrict westbound route design.

Solutions

- The OST proposed RNAV SID was designed with RNAV VM leg (radar vectors) to join the course on an east flow and RNAV off-the-ground when on a west flow. The proposed procedure optimized lateral paths to reduce flight track miles, en route transitions were removed and shortened to provide user flexibility and Q-Route accessibility.

Figure 34 depicts the current CHILY and the OST proposed ZEPER SIDs. Figure 35 depicts the terminal view.
Figure 34. Current and Proposed KPHX ZEPER SID

Figure 35. Proposed KPHX ZEPER SID (Terminal View)
Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency
- Eastbound departures are restricted to 210 knots on all east flow until waypoint SPARKY. Industry has a concern that 210 knots may be below minimum climb speed requirements at certain temperatures
- Runway transitions for all runways should be developed

Benefits

- Projected annual savings for the new KPHX ZEPER SID are estimated in Table 18.

<table>
<thead>
<tr>
<th>ZEPER SID</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance and Profile</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td>$30,978</td>
<td></td>
</tr>
</tbody>
</table>

Table 18. Proposed KPHX ZEPER SID Annual Benefits

4.2.2.9 KPHX SNOBL Departure

The OST proposed KPHX SNOBL RNAV SID replaces the existing conventional SILOW SID (BRYCE CANYON transition) and accounts for 10% of all KPHX turbojet departures.
Issues

- Currently there are no RNAV procedures for northbound departures. Current flight tracks do not follow the existing conventional SILOW SID and some aircraft level off at FL290 due to ZAB92/67 boundary alignment. Does not provide Q35 Route accessibility.

Solutions

- The OST proposed RNAV SID was designed with RNAV VM legs (radar vectors). The proposed procedure optimized lateral paths to reduce flight track miles and en route transition was shortened to provide user flexibility and Q35 connectivity.

Figure 36 depicts the current SILOW and the OST proposed SNOBL SIDs. Figure 37 depicts the terminal view.
Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency.
- Eastbound departures are restricted to 210 knots on all east flow until waypoint SPARKY. Industry has a concern that 210 knots may be below minimum climb speed requirements at certain temperatures.
- Runway transitions for all runways should be developed.

Benefits

- Projected annual savings for the new KPHX SNOBL SID are estimated in Table 19.
Table 19. Proposed KPHX SNOBL SID Annual Benefits

<table>
<thead>
<tr>
<th>SNOBL SID</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance and Profile</td>
<td>$278,703</td>
<td>$836,110</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>$27,870</td>
<td>$83,611</td>
</tr>
<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
<td>$107,324</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimated Annual Fuel Savings *</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Estimated Annual Fuel Savings (Gallons)</td>
<td>139,830</td>
<td>346,975</td>
</tr>
<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
<td>1,314</td>
<td>3,261</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars) *</td>
<td>$413,897</td>
<td>$1,027,045</td>
</tr>
</tbody>
</table>

4.2.2.10 Summary of Potential Benefits for KPHX SIDs

The projected annual savings for the OST proposed KPHX SIDs are estimated to be from 1.2 to 3 million dollars. The estimated savings are depicted in Table 20.
4.2.3 Phoenix Alternative Procedures

At the request of the facilities, the OST discussed two alternative procedures. Though not recommended by the OST, they are included in this report to provide the Design Team with the opportunity to further explore potential benefits.

4.2.3.1 Phoenix Northeast Alternative

Concept Description

- ZAB and P50 requested the OST analyze swapping the lateral path of the EAGUL STAR with ST. JOHNS SID. This would take place when KPHX is on a west flow. The OST further developed the proposal to retain dual arrival routes at industry’s request. As depicted in Figure 38, the OST Primary EAGUL STAR becomes a departure route, the OST EAGUL Offload STAR becomes the primary arrival route, and the OST proposed FORPE SID converts to the offload arrival. The OST proposed FTHLS SID does not change. The resulting configuration locates the two arrival flows between the two departure flows.

### Table 20. Proposed Annual Departure Benefits

<table>
<thead>
<tr>
<th>Departure Benefits</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Annual Fuel Savings *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance and Profile</td>
<td>$810,263</td>
<td>$2,430,788</td>
</tr>
<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>$81,026</td>
<td>$243,079</td>
</tr>
<tr>
<td>Cost to Carry (Filled Mileage Savings)</td>
<td></td>
<td>$376,154</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Gallons)</td>
<td>427,273</td>
<td>1,029,495</td>
</tr>
<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
<td>4,015</td>
<td>9,674</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars) *</td>
<td>$1,264,728</td>
<td>$3,047,305</td>
</tr>
</tbody>
</table>

*Based on a fuel cost of $2.96 per gallon
Additional Considerations

- With this new design, the OST anticipates the potential for reduced benefits due to:
  - Anticipated need to relocate the OST designed Q-Route (J74)
  - Anticipated non-optimized descent angle in terminal airspace due to high Minimum Vectoring Altitudes (MVA)
  - Increase in ATC task complexity in ATCT, TRACON, and ARTCC

Figure 38 depicts the northeast alternative.

4.2.3.2 Phoenix Southeast Alternative

Concept Description

- ZAB and P50 requested the OST look at swapping the lateral paths of the OST proposed SHRIF SID and the OST proposed PINNG STAR on a west flow. As depicted in Figure 39, the PINNG STAR becomes a departure route and the SHRIF SID becomes the arrival route.
Additional Considerations

- It is anticipated this design may increase ATC task complexity in ATCT, TRACON, and ARTCC. Today, 80% of departures filed on the STANFIELD SID are vectored through inactive SAAs (OUTLAW/JACKAL MOA) southeast of KPHX. The current routing through the inactive SAA realizes notable miles flown benefits for Industry. Any future increase in OUTLAW/JACKAL MOA usage would have a direct adverse effect on track mile savings described above. Therefore, if the expected increase in the usage of SAAs occurs, the OST recommendation are more beneficial than the southeast alternative.

![Figure 39. Southeast Arrival/Departure Alternative](image)

4.2.4 Satellite Airport Procedures

Both industry and facilities requested procedures be developed for Phoenix satellite airports. The OST designed procedures for the Phoenix-Mesa Gateway Airport (KIWA), the Scottsdale Airport (KSDL), the Phoenix Deer Valley Airport (KDTV).
4.2.4.1 KIWA SIDs

Issues
- Both Industry and Facilities identified a lack of RNAV departure procedures and connectivity to KPHX SIDs

Solutions
- Three RNAV SIDs were designed with connectivity to Runway 12R/30L. The NE-NW and S-SW SIDs were designed with RNAV VM leg (radar vectors) to join the course. The southeast SID was designed with RNAV VM leg (radar vectors) to join the course on a northwest flow and RNAV off the ground on a southeast flow. All OST proposed KIWA SIDs were tied into TRACON exit points for OST proposed KPHX RNAV SIDs.

Figures 40 depicts the OST proposed KIWA SIDs. Figure 41 depicts the terminal view.

![Figure 40. Proposed KIWA SIDs](image)
Notes
- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency
- Runway transitions for all runways should be developed

4.2.4.2 KIWA STAR

Issues
- Both Industry and Facilities identified a need for redesign the HUUTY STAR crossing multiple streams of KPHX traffic and excessive altitude restrictions

Solutions
- The new OST proposed KIWA RNAV STAR laterally segregates from the OST proposed KPHX FORPE SID. The primary arrival transition mimics the OST proposed EAGUL Offload STAR for KPHX and should be developed as an OPD.

Figure 42 depicts the current HUUTY STAR and the OST proposed KIWA RNAV STAR.
Notes

- The INW transition would need additional altitude restrictions in order to deconflict from the primary EAGUL STAR
- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency
- Runway transitions for all runways should be developed

4.2.4.3 KSDL SIDs

Issues

- Both Industry and Facilities identified a lack of KSDL RNAV SIDs, a lack of connectivity to KPHX SIDs and the inability to simultaneously release KSDL and KDVT departures due to Class D proximity.

Solutions

- The OST developed five new KSDL RNAV SIDs and were designed with connectivity to runway 21. All were designed with RNAV VM legs (radar
vectors) to join the outbound course and were tied into TRACON exit points for OST proposed KPHX SIDs. Figure 43 depicts the OST proposed KSDL SIDs. Figure 43 depicts the OST proposed KSDL SIDs. Figure 44 depicts the runway view.

Figure 43. Proposed KSDL SIDs

Figure 44. Proposed KSDL SIDs
(Runway View)
Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency
- Transitions for all runways should be developed

KSDL departures cannot be separated from KDVT Class D airspace without adjustment to noise abatement procedures

4.2.4.4 KDVT SIDs

Issues

- Both Industry and Facilities identified a lack of KDVT RNAV SIDs with connectivity to KPHX SIDs.

Solutions

- The new OST proposed DVT RNAV SIDs was designed with connectivity to runway 25L and 7R. All were designed with RNAV VM legs (radar vectors) to join the outbound course and were tied into TRACON exit points for proposed KPHX SIDs.

Figure 45 depicts the OST proposed KDVT RNAV SID. Figure 46 depicts the runway view.
Notes

- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency
- Transitions for all runways should be developed

4.2.4.5 North Satellites STAR (West arrival)

Issues

- Both Industry and Facilities identified a lack of an independent RNAV STAR from the west serving the P50 north satellite airports. Currently ZAB vectors North Satellite arrivals to TIRON intersection and route them through LUF RAPCON.

Solutions

- The OST proposed North Satellite RNAV STAR delivers arrivals from the Los Angeles Basin and San Diego/Yuma area over TIRON intersection to LUF RAPCON.

Figure 47 depicts the OST proposed North Satellite STAR.
Notes

- Coordination with LUF RAPCON and P50 will need to occur to determine delivery altitude and routing after TIRON
- The OST recognizes that ZAB and P50 internal airspace boundaries may need to be modified to gain maximum efficiency

4.2.4.6 Other Satellite Airports Identified by Industry for Procedure Development during the Design Phase

Identified Issue

- Industry requested PBN approaches into all satellite airports. There is significant flight training activity in the Phoenix area, and Industry feels there is a lack of instrument approach procedures which hinders general aviation operations.

Conceptual Solutions

- During the Design Phase, the Phoenix Design Team should evaluate potential benefits from modifying existing or implementing new PBN procedures at these airports;
  - Chandler Municipal Airport (CHD)
  - Phoenix Goodyear Airport (GYR)
– Glendale Municipal Airport (GEU)
– Falcon Field Airport (FFZ)

4.2.5 Q- and T-Routes

The OST identified increased optimization opportunities by employing the use of Q-Routes in the en route stratum. Additionally, industry requested a T-Route to provide predictable, repeatable passage through the KPHX Class B Airspace.

4.2.5.1 Proposed East/West Q-Routes

Issues

• Interaction between J74 overflight traffic and the current EAGUL STAR causes premature, lower top of descents. Additionally, overflights into and out of the Los Angeles Basin are not optimized due to legacy jet route design.

Solutions

• To optimize the OST proposed Primary EAGUL STAR, a proposed TXO-PSP Q-Route was developed which will move traffic currently on J74 to the south. CIM-TNP and NOFLY-TNP Q Routes were developed to improve traffic flow into and out of the Los Angeles Basin. All three proposed Q Routes save filed miles over the current conventional routings, as depicted in Figures 48 and 49.

Figure 48. Proposed East/West Q-Routes
Notes

- The OST recognizes that ZAB internal airspace boundaries may need to be modified to gain maximum efficiency.
4.2.5.2 Proposed North/South T-Route

Issues
- Industry requested a T-Route to provide predictable, repeatable passage through the KPHX Class B Airspace.

Solutions
- As depicted in Figure 50, a north/south KPHX Area T-Route was developed by the OST to provide predictable flight path over the top of KPHX through Class B airspace.

![Figure 50. Proposed KPHX Area T-Route](image)

Notes
- The OST recognizes that P50 internal airspace boundaries may need to be modified to gain maximum efficiency.

4.2.6 RNP and RNAV Approaches

Both Industry and P50 requested RNP approaches for all runway configurations. Our Industry partners were interested in designing RNP approaches to all runways which utilize RF turns to the final approach course. The initial concept was submitted by Industry and refined by the
OST. P50 requested the OST develop notional RNAV procedures which mimic radar vector tracks used to flow arrivals to alternative runways.

4.2.6.1 Proposed KPHX West and East Flow RNP Procedures

Issues
- Both Industry and P50 identified a lack of RNP approaches to all KPHX runways

Solutions
- As depicted in Figures 51 and 52, RNP procedures with RF turns to the final approach course were designed for the four primary landing runways (25L/07R and 26/08).

Figure 51. Proposed KPHX West Flow RNP Procedures
Notes
- Downwinds were widened to accommodate RF turns to final at 210 knots.

4.2.6.2 Proposed KPHX Offset RNAV Approaches: East/West Flow

Issues
- The facilities identified a lack of useful runway transitions used to flow arrivals to alternative runways, for arrivals from the southeast and northwest.

Solutions
- In lieu of runway transitions, the OST developed notional RNAV procedures which mimic radar vector tracks used to flow arrivals to alternative runways, as depicted in Figure 53.
Notes

- This is not an OST recommendation but a design concept provided at the request of P50. Due to the frequency of Visual Meteorological Conditions (VMC), radar vectors may be more efficient.

4.2.7 Issues for Consideration during the Design Phase

As the OST finalized designs, the following issues were identified as needing to be addressed during the design phase. The issues for consideration are:

- P50 and ZAB will require sector modifications in conjunction with the new proposed procedures. The example shown in Figure 54 is a depiction of airspace sector changes needed to accommodate optimized procedure designs.

- Benefits realized by the OST on procedures which cross the ZLA/ZAB boundary depend on modifications to current ZLA/ZAB Letter of Agreement which permits higher transfer altitudes and more direct flight paths.

- The Aviation Safety Information Analysis and Sharing (ASIAS) program has a large database of voluntary pilot Aviation Safety Action Program (ASAP) text reports. Those reports have been aggregated for several safety issues. An ASIAS Directed Study into STAR (RNAV) Operations and Procedures (OPs) has examined the aggregated ASAP reports for STAR related issues. Shown in the graph below are the rates of reported Missed Crossing Restrictions (MCR).
identified by text auto-classification models, and which mention an RNAV Optimized Profile Descents (OPDs) into KPHX.

As compared to the overall rate among STARs at the FAA Core 30 airports (and a few additional high priority airports), the GEELA, MAIER, and EAGUL STARs have higher MCR rates (see Figure 55). Initial reviews of the KPHX MCR reports have shown that amendments to restrictions, runway changes, removal from and reestablishment on the STAR, automation confusion, procedure complexity, workload, distraction, and complacency are contributors to human error that can lead to a MCR event.

ASIAS has developed a radar based Traffic Alert and Collision Avoidance System (TCAS) Resolution Advisory (RA) metric which takes National Offload Program (NOP) radar tracks and passes them through a full TCAS II v7.0 logic engine to simulate TCAS RA events. Based on simulated NOP radar tracks, there existed a high rate of TCAS RA events for approaches vectored off the SUNSS STAR into KSDL and KDVT. Shown in Figure 56 are the tracks during 2012 that had an RA after being vectored off the SUNSS.

![Figure 54. Airspace Modifications for EAGUL Offload STAR](image)
Figure 55. KPHX ASAP MCR Rates

![Bar chart showing MCR rates per 10,000 operations for Core 30+ STARs, GEELA, MAIER, EAGUL, KOOYY.](image)

Figure 56. Approaches into KSDL and KDVT with Simulated TCAS RA

![Map showing approaches into KSDL and KDVT with simulated TCAS RA.](image)
4.3 Phoenix OAPM Issues Requiring Additional Input

The Phoenix OST identified and characterized a range of problems and developed a number of conceptual solutions. Some issues require additional coordination and input and could not be addressed within the time constraints of the OST process. These issues may be explored further during D&I. These issues are:

- Phoenix Alternative Procedures
- Coordination with Mexican Civil Aviation Authority on changes to routes crossing the U.S./Mexico border

4.4 Issues Outside of the Scope of OAPM

Additional issues were identified that were beyond the scope of the Phoenix OST. All out-of-scope issues were recorded via the Phoenix OST Issues Matrix. Explanations of the scoping decisions and the OST’s recommendations for Industry/Facility action were provided. The Industry/Facility partners agreed with all OST recommendations.
5 Summary of Benefits

5.1 Qualitative Benefits

5.1.1 Near-Term Impacts

The benefits of the PBN procedures proposed by the OST include the following:

- Reduced phraseology, frequency congestion, and pilot workload:
  Reduced phraseology due to PBN will reduce the number of transmissions needed to accomplish required restrictions by combining multiple clearances into a single transmission. Prior studies have demonstrated transmission reductions on the order of 18% to 34% with 85% RNAV equipage3 and the OST believes it is reasonable to expect a similar level of savings. Reduced transmissions will translate into less frequency congestion which could potentially reduce “hear back/read back” errors. In addition, the consolidation of clearances associated with an RNAV procedure reduces pilot workload, which allows for more “heads-up” time and allows the crew to focus on high-workload situations.

- Repeatable, predictable flight paths and accurate fuel planning:
  The introduction of PBN ensures lateral flight path accuracy. The predictable flight paths help assure procedurally deconflicted traffic flows and allow airlines to more accurately plan for a consistent flight path. It also allows users to more accurately predict the amount of fuel required for a procedure.

- Enhanced lateral and vertical flight paths:
  Optimized climbs and descents and shorter lateral paths reduce the number and length of level-offs and total distance flown, thereby reducing fuel burn and carbon emissions. Altitude windows can vertically separate traffic flows and allow for industry-standard glide paths.

5.1.2 Long-Term Impacts to Industry

Implementation of these proposed procedures will have long-term effects for industry.

- Flight planning
  OAPM proposed procedures will result in reduced mileage and fuel burn in the long-term, particularly as more metropoles are optimized. In the near-term, more direct paths that are not dependent on ground-based navigational aids, plus optimized flight profiles, will lead to reduced fuel burn only within an optimized metroplex. Reduced fuel loading will also allow for a reduction in cost to carry.

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• Timetable
  Shortened, more efficient routes will necessitate timetable adjustments, particularly as more metropoles are optimized. This will potentially benefit crew scheduling, connecting information, time on gates, ramp scheduling, etc.

5.2 Quantitative Benefits
The quantified benefits of the Phoenix OST recommendations are broken down into annual fuel savings in dollars, annual fuel savings in gallons, and annual carbon emissions reductions in metric tons. The primary benefit drivers are improved vertical profiles and reduced miles flown. The Phoenix OST saved approximately two million filed miles annually.

Benefits from conceptual arrival procedures came from:
  • RNAV STARs with OPDs
  • More efficient lateral paths created by adjusting terminal entry points and removing doglegs
  • Removal of unused en route transitions and development of runway transitions

Benefits from conceptual departure procedures came from:
  • A combination of RNAV off-the-ground procedures and radar vector procedures to join RNAV routes
  • Departure procedures designed to facilitate unrestricted climbs by removing or mitigating existing level-offs
  • Procedural deconfliction, where practical, from other SIDs and STARs

Table 21 breaks down the total benefits for Phoenix. The total potential annual fuel savings is estimated between $6.0 million and $16.1 million. These numbers were derived by comparing currently flown track miles, published procedure miles, and vertical profiles to proposed PBN procedure track miles and vertical profiles. The benefits analysis assumes aircraft will fly the specific lateral and vertical RNAV procedures. It is fully expected that ATC will continue to offer shorter routings and remove climb restrictions, when feasible, further increasing operator benefits.
Table 21. Annual Fuel Benefits Associated with Distance, Profile, and Filed Miles

<table>
<thead>
<tr>
<th>Study Team Notional Benefits</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Annual Fuel Savings *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance and Profile</td>
<td>$4,573,377</td>
<td>$13,720,131</td>
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<tr>
<td>Cost to Carry (Distance and Profile)</td>
<td>$457,338</td>
<td>$1,372,013</td>
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<tr>
<td>Cost to Carry (Filed Mileage Savings)</td>
<td></td>
<td>$993,750</td>
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<tr>
<td>Total Estimated Annual Fuel Savings (Gallons)</td>
<td>2,015,732</td>
<td>5,377,577</td>
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<tr>
<td>Total Estimated Annual Carbon Savings (Metric Tons)</td>
<td>18,942</td>
<td>50,534</td>
</tr>
<tr>
<td>Total Estimated Annual Fuel Savings (Dollars) *</td>
<td>$6,021,749</td>
<td>$16,083,179</td>
</tr>
</tbody>
</table>

*Based on a fuel cost of $2.96 per gallon
## Appendix A  Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR</td>
<td>Airport Arrival Rate</td>
</tr>
<tr>
<td>ADOC</td>
<td>Aircraft Direct Operating Cost</td>
</tr>
<tr>
<td>AR</td>
<td>Authorization Required</td>
</tr>
<tr>
<td>ARTCC</td>
<td>Air Route Traffic Control Center</td>
</tr>
<tr>
<td>ASPM</td>
<td>Airport Specific Performance Metrics</td>
</tr>
<tr>
<td>ATALAB</td>
<td>Air Traffic Airspace Lab</td>
</tr>
<tr>
<td>ATC</td>
<td>Air Traffic Control</td>
</tr>
<tr>
<td>ATCT</td>
<td>Air Traffic Control Tower</td>
</tr>
<tr>
<td>BADA</td>
<td>Base of Aircraft Data</td>
</tr>
<tr>
<td>CAASD</td>
<td>Center for Advanced Aviation System Development</td>
</tr>
<tr>
<td>CATEX</td>
<td>Categorical Exclusion</td>
</tr>
<tr>
<td>CTC</td>
<td>Cost to Carry</td>
</tr>
<tr>
<td>CY</td>
<td>Calendar Year</td>
</tr>
<tr>
<td>D&amp;I</td>
<td>Design Phase, or Design and Implementation</td>
</tr>
<tr>
<td>DEP</td>
<td>Departure</td>
</tr>
<tr>
<td>EA</td>
<td>Environmental Assessment</td>
</tr>
<tr>
<td>EIS</td>
<td>Environmental Impact Statement</td>
</tr>
<tr>
<td>EQ</td>
<td>Equipment/Frequency Fail</td>
</tr>
<tr>
<td>ETMS</td>
<td>Enhanced Traffic Management System</td>
</tr>
<tr>
<td>EUROCONTROL</td>
<td>European Organization for the Safety of Air Navigation</td>
</tr>
<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
</tr>
<tr>
<td>IAP</td>
<td>Instrument Approach Procedure</td>
</tr>
<tr>
<td>IAS</td>
<td>Indicated Air Speed</td>
</tr>
<tr>
<td>ICAO</td>
<td>International Civil Aviation Organization</td>
</tr>
<tr>
<td>IFR</td>
<td>Instrument Flight Rules</td>
</tr>
<tr>
<td>iTRAEC</td>
<td>Integrated Terminal Research, Analysis, and Evaluation Capabilities</td>
</tr>
<tr>
<td>KCGZ</td>
<td>Casa Grande Municipal Airport</td>
</tr>
<tr>
<td>KCHD</td>
<td>Chandler Municipal Airport</td>
</tr>
<tr>
<td>KDVT</td>
<td>Phoenix Deer Valley Airport</td>
</tr>
<tr>
<td>KE60</td>
<td>Eloy Municipal Airport</td>
</tr>
<tr>
<td>KFFZ</td>
<td>Falcon Field Airport</td>
</tr>
<tr>
<td>KGYR</td>
<td>Phoenix Goodyear Airport</td>
</tr>
<tr>
<td>KIWA</td>
<td>Phoenix-Mesa Gateway Airport</td>
</tr>
<tr>
<td>KLUF</td>
<td>Luke Air Force Base</td>
</tr>
<tr>
<td>Acronyms</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>KMZJ</td>
<td>Pinal Airpark Airport</td>
</tr>
<tr>
<td>KP08</td>
<td>Coolidge Municipal Airport</td>
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<tr>
<td>KPHX</td>
<td>Phoenix Sky Harbor International Airport</td>
</tr>
<tr>
<td>KSDL</td>
<td>Scottsdale Airport</td>
</tr>
<tr>
<td>KTUS</td>
<td>Tucson International Airport</td>
</tr>
<tr>
<td>L/R</td>
<td>Left/Right</td>
</tr>
<tr>
<td>LOA</td>
<td>Letter of Agreement</td>
</tr>
<tr>
<td>MIT</td>
<td>Miles-in-Trail</td>
</tr>
<tr>
<td>MSL</td>
<td>Mean Sea Level</td>
</tr>
<tr>
<td>NAS</td>
<td>National Airspace System</td>
</tr>
<tr>
<td>NAT</td>
<td>National Analysis Team</td>
</tr>
<tr>
<td>NAVAID</td>
<td>Navigational Aid</td>
</tr>
<tr>
<td>NM</td>
<td>Nautical Mile/s</td>
</tr>
<tr>
<td>NOP</td>
<td>National Offload Program</td>
</tr>
<tr>
<td>NTML</td>
<td>National Traffic Management Log</td>
</tr>
<tr>
<td>OAPM</td>
<td>Optimization of Airspace and Procedure in the Metroplex</td>
</tr>
<tr>
<td>OPD</td>
<td>Optimized Profile Descent</td>
</tr>
<tr>
<td>OST</td>
<td>OAPM Study Team</td>
</tr>
<tr>
<td>P50</td>
<td>Phoenix TRACON</td>
</tr>
<tr>
<td>PBN</td>
<td>Performance Based Navigation</td>
</tr>
<tr>
<td>PDARS</td>
<td>Performance Data Analysis and Reporting System</td>
</tr>
<tr>
<td>PHX</td>
<td>Phoenix ATCT</td>
</tr>
<tr>
<td>PRM</td>
<td>Precision Radar Monitor</td>
</tr>
<tr>
<td>PXR</td>
<td>Phoenix VORTAC</td>
</tr>
<tr>
<td>RITA</td>
<td>Research and Innovative Technology Administration</td>
</tr>
<tr>
<td>RNAV</td>
<td>Area Navigation</td>
</tr>
<tr>
<td>RNP</td>
<td>Required Navigation Performance</td>
</tr>
<tr>
<td>ROM</td>
<td>Rough Order of Magnitude</td>
</tr>
<tr>
<td>RTCA</td>
<td>Radio Technical Commission for Aeronautics</td>
</tr>
<tr>
<td>SEC</td>
<td>Specialized Expertise Cadre</td>
</tr>
<tr>
<td>SID</td>
<td>Standard Instrument Departure</td>
</tr>
<tr>
<td>SOP</td>
<td>Standard Operating Procedure</td>
</tr>
<tr>
<td>SRM</td>
<td>Safety Risk Management</td>
</tr>
<tr>
<td>STAR</td>
<td>Standard Terminal Arrival Route</td>
</tr>
<tr>
<td>SWAP</td>
<td>Severe Weather Avoidance Program</td>
</tr>
<tr>
<td>TAAM</td>
<td>Total Airport and Airspace Model</td>
</tr>
<tr>
<td>Acronyms</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>TACAN</td>
<td>Tactical Air Navigation</td>
</tr>
<tr>
<td>TARGETS</td>
<td>Terminal Area Route Generation Evaluation and Traffic Simulation</td>
</tr>
<tr>
<td>TCAS</td>
<td>Traffic Collision and Avoidance System</td>
</tr>
<tr>
<td>TMA</td>
<td>Traffic Management Advisor</td>
</tr>
<tr>
<td>TMI</td>
<td>Traffic Management Initiatives</td>
</tr>
<tr>
<td>TRACON</td>
<td>Terminal Radar Approach Control</td>
</tr>
<tr>
<td>VMC</td>
<td>Visual Meteorological Conditions</td>
</tr>
<tr>
<td>VOR (TAC)</td>
<td>Very High Frequency Omni-Directional Range (with TACAN)</td>
</tr>
<tr>
<td>WX</td>
<td>Weather</td>
</tr>
<tr>
<td>ZAB</td>
<td>Albuquerque Air Route Traffic Control Center</td>
</tr>
<tr>
<td>ZLA</td>
<td>Los Angeles Air Route Traffic Control Center</td>
</tr>
</tbody>
</table>
## Appendix B  PBN Toolbox

<table>
<thead>
<tr>
<th>Sample PBN Toolbox Options</th>
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<tbody>
<tr>
<td>Adding an arrival route</td>
</tr>
<tr>
<td>Adding a departure route</td>
</tr>
<tr>
<td>Extend departure routes</td>
</tr>
<tr>
<td>Build in procedural separation between routes</td>
</tr>
<tr>
<td>Reduce route conflicts between airports</td>
</tr>
<tr>
<td>Changing airspace to accommodate a new runway</td>
</tr>
<tr>
<td>Adding a parallel arrival route (to a new runway)</td>
</tr>
<tr>
<td>Splitting a departure fix that serves more than one jet airway</td>
</tr>
<tr>
<td>Increased use of 3 NM separation</td>
</tr>
<tr>
<td>Increased use of terminal separation rules</td>
</tr>
<tr>
<td>Static realignment or reassignment of airspace</td>
</tr>
<tr>
<td>Adaptive realignment or reassignment of airspace</td>
</tr>
<tr>
<td>Improving sector boundaries (sector split, boundary move, new area of specialization)</td>
</tr>
<tr>
<td>Shifting aircraft routing (Avoiding re-routes, shorter routes)</td>
</tr>
<tr>
<td>Eliminating altitude restrictions</td>
</tr>
<tr>
<td>More efficient holding (design, usage and management)</td>
</tr>
<tr>
<td>Adding surveillance coverage</td>
</tr>
<tr>
<td>Adding en route access points or other waypoint changes (NRS)</td>
</tr>
<tr>
<td>Adding en route routes</td>
</tr>
<tr>
<td>Reduce restrictions due to Special Use Airspace</td>
</tr>
<tr>
<td>TMA initiatives</td>
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