NextGEN Airspace Optimization Study

NextGEN

Puget Sound Regional Council

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Executive Summary

In the fall of 2014, the Puget Sound Regional Council (PSRC), in conjunction with the Federal Aviation Administration (FAA), initiated a study to analyze the next steps in preparing the Puget Sound region's general aviation airports and users for satellite-based operations with NextGen technology. This report documents the study process and results.

I. INTRODUCTION

The **Next Generation Air Transportation System** (**NextGen**) is a program designed by the FAA to enhance and modernize the air traffic control system. Elements of NextGen will be implemented in stages across the United States between 2012 and 2025. NextGen proposes to transform the air traffic control system from a ground-based system of navigation and surveillance to a satellite-based system and transition from voice communication to data communication. Satellite-based technology (often called global positioning technology – GPS) will be used to shorten routes, save time and fuel, reduce traffic delays, increase capacity, and permit air traffic controllers to monitor and manage aircraft with greater safety margins. Planes will be able to fly closer together, take more direct routes and avoid delays caused as planes wait for an open runway. To implement NextGen, the FAA will undertake a wide-ranging transformation of the entire United States air transportation system.

Purpose of study: This report supplements *Preparing Busy General Aviation Airports for Next Generation Technologies* (Phase 1 Study completed in 2013), which focused on facility improvements at general aviation (GA) airports. Sometimes called Phase 2, this report focuses on satellite-based flight procedures that have the possibility for implementation in the Puget Sound region.

Goals: The goals of this study and its work products are to:

1. Explain the benefits of NextGen to a wide range of airport and airspace stakeholders;
2. Identify how airports can facilitate NextGen implementation through recommendation of NextGen-based procedures that solve airport-specific issues; and
3. Illustrate NextGen solutions to enhance the airspace efficiency to the Puget Sound area for the GA community.

The study approach was designed to achieve these objectives. The full report is available at http://www.psrc.org/transportation/airtrans. Additionally, an iPad application is available at the Apple App Store; search "**Puget Sound NextGen"** to locate the App.

Study Area: To enable the study to be focused and provide specific recommendations within the allocated budget, the study area was defined as the area from Everett on the north, Olympia on the south, Bremerton on the west, and North Bend on the east. This area generally captures airspace serving the following nine GA airports:

- King County International – Boeing Field
- Snohomish County Airport – Paine Field

- Renton Municipal Airport
- Crest Airpark (Kent)
- Pierce County Airport - Thun Field
- Tacoma Narrows Airport
- Auburn Municipal Airport
- Bremerton National Airport
- Harvey Field

II. RECOMMENDATIONS

The Seattle Terminal Approach Control (TRACON) airspace has one major commercial airport, Seattle-Tacoma International Airport (Sea-Tac), nine general aviation airports, two float plane bases (with numerous other landing areas), and twenty-nine heliports. Three of the busiest airports are located within five nautical miles (NM) of each other (Sea-Tac, Boeing Field, and Renton), which can limit the type of arrival and departure procedures due to airspace constraints. In addition, other considerations for air traffic include terrain from the Cascade Mountains to the east, water areas that are preferred for noise abatement, noise sensitive communities, military facilities with restricted airspace, and a high percentage of inclement weather days. Including all these factors, a number of airspace issues have been identified:

- Close proximity of Sea-Tac/Renton/Boeing Field; this close proximity makes de-confliction of procedures a key mitigation item for this report. De-confliction indicates the need to separate operations that are dependent on each other and cannot operate independently in the current airspace.
    - Conflicts between Boeing Field during south flow departures with Sea-Tac airspace.
    - In north flow and inclement weather, conflicts between Boeing Field landings and Sea-Tac operations.
- Close proximity of Sea-Tac landings to the south with simultaneous Paine Field landings to the north.
- In north flow inclement weather conditions, Renton procedures require south flow approaches.
- Shared use of STARs (Standard Terminal Arrival Routes) for Sea-Tac, Boeing Field, Renton, and Paine Field airports.

The NextGen Automated Dependent Surveillance Broadcast (ADS-B) infrastructure is complete and operational in the Puget Sound region. It is the physical backbone of NextGen and allows it to operate; ADS-B, an enabling technology program, is a critical surveillance component to the implementation of NextGen. ADS-B uses GPS signals to determine aircraft location instead of radar. The ADS-B NextGen surveillance was designed to be the same or better than the current radar surveillance. The new ADS-B surveillance does provide for better coverage than occurs today.

Study recommendations were developed in response to the specific operating needs of general aviation in the Puget Sound region. A number of potential airspace actions were identified to improve operational flows for GA users. From that list, a select number of these potential actions were identified to further study as concepts. Each of the selected concepts was analyzed against the airspace issues to determine if a concept would be able to address a constraint or operational issue. Based on the concepts, then impediments to implementation, principally in the form of obstructions, were identified. These are summarized in Chapter 4.

A. Airspace and Procedure Recommendations

There are a number of different factors that constrain the airspace in the Puget Sound region for GA. The primary cause of constraints to GA users is that two of the largest GA airports are located in close proximity to Sea-Tac and these airports must share the airspace. Other factors include the mountainous terrain, weather, obstacles (man-made and natural), and various land uses that limit how and where aircraft can fly. A key focus of the concepts are designed to allow GA aircraft to fly and operate independently of Sea-Tac and to take advantage of the different way airspace can be designed with NextGen technologies.

The constraints can be summarized to include:

- Airports in close proximity to Sea-Tac (de-confliction): Sea-Tac, Boeing Field, and Renton are less than 5 NM miles apart.
- Cascade Mountains terrain.
- Poor weather access to Boeing Field, Renton, and Paine Field.
- Shared use STAR arrival procedures with Sea-Tac.
- Shared departure airspace with Sea-Tac.
- Local airport terrain/obstructions constraints.
- Environmental (noise, emissions) and land use patterns.

A number of concepts were identified as potential opportunities for improvements for which NextGen programs and technologies could be applied to the Puget Sound airspace used by GA aircraft. Many of these concepts were evaluated in the FAA's TARGETS[1] procedure design software program, as well as with BridgeNet's Volans visualization modeling. Use of TARGETS is one of the first steps in determining the viability of a procedure. Six concepts were carried forward for refinement into operational concepts:

1. **T Routes over Cascades, East and West Bound:** There are currently three conventional low-altitude routes[2] that provide access to the Puget Sound region to/from the east called V-Routes. These routes are flown by en route aircraft over the Cascade mountain range and, based upon a review of the radar data, the aircraft fly at altitudes between 9,000 feet MSL and 11,000 feet MSL. Flying in mountainous terrain at those altitudes in instrument meteorological conditions (IMC) can increase the risk of icing. Aircraft flying at a lower altitude have a lower risk for icing conditions due to air being warmer, as well as reduced air traffic controller workload to descend the aircraft.

   A NextGen solution could include providing satellite-based low-altitude T-Routes that are not constrained by the location of ground based navigation and that can provide for increased access to area airports by flying at lower altitudes. This would allow aircraft to fly east/west over the Cascades at lower altitudes (i.e., potential 7,700 feet MSL), which is lower than they typically fly today with conventional navigation. Another option would be to construct the T-route using Required Navigation

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1 TARGETS (Terminal Area Route Generation, Evaluation and Traffic Simulation) incorporates data visualization capabilities with readily accessible design elements to enable procedure designers to rapidly and easily develop [flight] procedures.

2 A "low altitude route" is an airway below 18,000 feet mean sea level used for aircraft flying in instrument flight conditions.

Performance (RNP-1) specifications. RNP-"x" defines the width of the T-route from the Route centerline. RNP-1 means that the corridor is 1 NM wide each side of the Route centerline. By using RNP-1 specifications, some of the controlling obstacles would be eliminated as an operational constraint along the route and lower the altitudes further to 6,500 feet MSL permitting another cardinal altitude (i.e., 7,000 feet MSL) for eastbound aircraft. The new T-Routes would also provide connectivity with the new proposed notional GA RNAV Standard Instrument Departures (SIDs) and STARS and provide increased access for GA aircraft and greater separation between GA and commercial traffic.

2. **RNAV Standard Instrument Departures (SID) for Study Airports:** Currently, Sea-Tac, Boeing Field, and Renton airports are largely separated by the use of radar vectors issued by Air Traffic. Vectors are headings issued by air traffic control to aircraft. Radar vectors are also used as a noise abatement tool to avoid flying over sensitive land uses. This results in a dependent operation between the three airports and potentially inefficient procedures/routes to be flown by departing aircraft from the GA airports.

   South Flow. The alternative proposed the development of south flow RNAV SID for Boeing Field, Renton and Paine Field Airports that are procedurally separated from Sea-Tac operations. These procedures can also be designed to transition to the new T-Routes or other enroute procedures. These procedures would be designed to provide for independent operations from Sea-Tac and reduce the need for controller directions.

   North Flow. RNAV SID departures in north flow are also proposed for the three General Aviation Airports (Boeing Field, Renton and Paine Field) that are separated from Sea-Tac traffic. One of the main goals of these options is to provide separation between Sea-Tac departures and Boeing Field departures where Boeing Field departures are often delayed because of Sea-Tac traffic. This alternative proposes the development of an RNAV procedure with altitude restrictions that can provide for vertical separation with Sea-Tac.

3. **Boeing Field RNAV (GPS) Approach during Plan C:** Due to the close proximity of Boeing Field to Sea-Tac, in poor weather north flow conditions (Plan C), access to Boeing Field is constrained because its airspace conflicts with Sea-Tac operations. New NextGen procedures may allow for increased access by de-conflicting the Boeing Field airspace from Sea-Tac airspace. NextGen technology procedural separation could be used to de-conflict the two airports, thereby allowing simultaneous and independent operations. With NextGen procedures, the area of required separation would be less than with conventional procedures. A potential NextGen procedure would provide for a procedure that flies an approach into Renton, and when the aircraft reaches a defined point, and can see the runway at Boeing Field, the pilot would cancel the instrument approach and land at Boeing Field in visual conditions. If the pilot is unable to see the airport, then he would perform a go-around or continue to land at Renton.

4. **Renton RNAV (GPS) Approach, Runway 34:** When Sea-Tac and the airports in the study area are in north flow and the weather is poor, there currently is not a north flow instrument approach procedure to Renton. The potential alternative would be to develop a satellite based procedure for approaches to Runway 34 at Renton. This procedure would allow for aircraft flying to Renton during conditions when the airspace is operating in north flow and poor weather, to approach and land at Renton in north flow instead of flying around to land from the south.

5. **Renton RNP-AR Approach, Runway 16:** Current Renton approaches from the north to Runway 16 require a straight-in path from the north over Mercer Island that has terrain constraints as well as noise sensitivity. An RNP-AR approach that follows the east side of Lake Washington could provide reduced terrain elevation capability and reduced total population overflown. This RNP-AR approach procedure may not yet provide a large increase in access due to the fleet mix and lack of equipage to conduct RNP-AR approaches. The AR stands for “Authorization Required”, which means the aircraft, operator, and pilot must be equipped and authorized to fly the procedure.

6. **Paine Field T or Y Transitions for RNAV (GPS) Arrival, Runway 34R:** While Sea-Tac and Paine Field are both within the Puget Sound area, there are times that these two airports experience different weather patterns. For example, there are times when Sea-Tac is in south flow and wind conditions north of the city in what is known locally as the weather convergence zone, dictate that Paine Field is in north flow. Under these conditions, arrivals into Sea-Tac and arrivals into Paine Field share the same airspace and require additional separation by controllers to de-conflict traffic utilizing the same airspace.

   The RNAV (GPS) approach procedures for north flow Paine Field (Runway 34R) could be updated to allow for transitions that intersect the final approach further to the north and closer to Paine Field, allowing transitions from both the east and west. These transitions could be connected to the RNAV STARS presented that would provide more direct routes into Paine Field, with minimal need for controller intervention and a reduction or possible elimination of interaction with Sea-Tac traffic. There are no limiting factors to implementation.

B. **Obstruction Recommendations**

Physical obstacles within the region represent one of the issues that would need to be addressed before implementing any of the recommendations. Obstacle identification surfaces play a key role in instrument procedure design, and keeping these surfaces clear of obstructions may allow development of instrument procedures with lower minima. Landings in lower visibility will keep airports open during periods of inclement weather, and improve airport operational utility.

Several runways at airports in the study area may benefit from exploration of instrument approach procedures with vertical guidance, such as the procedures described in Chapter 3. At Boeing Field, Renton Municipal, Bremerton, and Paine Field, new vertically guided procedures would not be possible without mitigation of current detected obstructions. Further – there may be obstacles that exist and are not captured by the tools used in this study. It is recommended that airports complete an airport airspace analysis per the requirements of FAA Advisory Circular AC 150/5300-18B to check for obstructions and to provide a more detailed analysis of vertically guided approach procedure applicability.

To achieve the lowest minimums possible, airport sponsors may need to invest in ground-based improvements such as runway lighting and marking, and approach lighting systems. Coordination with local land development entities such as cities and counties is essential to protect airspace from potential encroachment of would-be hazards, and protect the airport sponsor investment.

Where possible, areas under the approach surface should be designated to remain as vacant and undeveloped. Land uses such as industrial and low density commercial are acceptable for the types of procedures discussed in Chapter 3 if development must occur in under the approaches. Residential should always be avoided when possible. Airports are encouraged to achieve the land use compatibility guidelines as suggested by the Washington Department of Transportation's *Airports and Compatible Land Use Guidebook*.

IV. Next steps

The next step is to implement the concepts detailed in the previous section, shown in full in Chapter 3 of the report. Implementation will be on a local and national level; the local level will be targeted at the pilot community and airport operators, and the national level will be with the FAA.

Local Pilots: This implementation includes promoting GA aircraft to equip in the Puget Sound region. This message platform will be done through an iPad application developed as part of this study and outreach efforts by the PRSC. The iPad application information will be disseminated to the pilot communities through known stakeholders, airport owners/operators, and local pilot groups. The iPad application will contain information regarding advantages to equipping and animations of the concept procedures.

Airport Operators: The implementation of the concepts requires airports to collect up to date obstruction information. If obstruction information isn't current, the FAA procedures division that creates NextGen procedures must base their procedure design on a set of generic standards that may not represent the true obstruction landscape. Airports that have current obstruction information give the FAA the best information to create new procedures.

FAA ATC: The flight procedure concepts that were identified in this study should be submitted to the FAA flight procedure implementation process for future evaluation and design. These concepts can be vetted and presented for the next step of becoming a procedure through the FAA submittal process. It is important that the procedures are submitted into this system along with the supporting information relative to the proposed design.

Introduction

Central Puget Sound is a vibrant, growing region served by a robust general aviation user community and excellent airport facilities. The Puget Sound Regional Council (PSRC), in conjunction with the Federal Aviation Administration (FAA), is conducting a study to analyze the next steps in preparing the Puget Sound region's general aviation airports and users for satellite-based operations with NextGen technology.

NextGen is a very large and complex set of programs that will emerge over many years and will make revolutionary changes in how airplanes fly and how airspace is managed. NextGen includes improvements to technology, infrastructure, policies, procedures, and training. As NextGen procedures are implemented, delay reductions, fuel saving, lowered user costs, reduced noise, lowered aircraft exhaust emissions, and safety enhancements are expected. The flight efficiencies created by NextGen procedures will allow the nation's airports and National Airspace System (NAS) to accommodate the significant growth that is expected over the next few decades. FAA long range forecasts predict total annual aircraft operations at airports with air traffic control towers will grow at an average annual compounded growth rate of 0.89%- from 50 million to 70 million between 2012 - 2040[3].

NextGen offers many opportunities to airports and airport users, as it can ultimately change how airplanes fly and will influence how an airport should plan for the future. Many airport master planning projects are designing for 10 to 20+ years in the future. Addressing the airspace throughput limitations, especially in poor weather operations, can be difficult. In some cases, these throughput limitations can be addressed with the opportunities of NextGen technology at much lower cost than solutions that might involve building airport facilities. NextGen can address airspace and common infrastructure questions, such as: should a future runway be planned using traditional runway IFR separation criteria, or should other potential NextGen options or criteria be considered that may be available at a much lower cost?

This report follows PSRC's Phase 1 report published in May 2013, *Preparing Busy General Aviation Airports for Next Generation Technologies* (Phase 1 Study), which focused on facility improvements at general aviation airports. This report focuses on satellite-based flight procedures that have the possibility for implementation in the Puget Sound region.

The goals of this study and its work products are to:

1. Explain the benefits of NextGen to a wide range of airport and airspace stakeholders;
2. Identify how airports can facilitate NextGen implementation through recommendation of NextGen-based procedures that solve airport-specific issues; and
3. Illustrate NextGen solutions to enhance the airspace efficiency to the Puget Sound area for the GA community.

[3]FAA Terminal Area Forecast Summary Fiscal Years 2012 – 2040
https://www.faa.gov/about/office_org/headquarters_offices/apl/aviation_forecasts/taf_reports/media/TAF_summary_report_FY2012.pdf

How to Use This Report

There are two parts to this study, a document and a website. The document will be presented in a traditional chapter format. The website portion of the study contains operational information including aircraft flight paths, existing procedures, airspace boundaries, and study area airports. The website will enhance the written report, providing additional data when available. In these cases, the written report will show a computer icon next to the section header; this website can be accessed at www.airportnetwork.com/psrc with the password: NEXTGEN in all capital letters. A guide on how to use the website can be found in **Appendix A: *Website Guide***. Note that is tool currently works on Chrome, but does not work on Internet Explorer.

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Chapter 1 – Key Issues for General Aviation Airports

Chapter 1 of the report presents background information about the FAA's NextGen program, with specific reference to general aviation (GA); identifies the study area and the airports and other air fields within the study area; and describes in general terms airspace issues and constraints in the Puget Sound region where NextGen could potentially provide benefits. This chapter also includes data for Seattle-Tacoma International Airport (SEA-TAC) due to its influence on operations at the region's GA airports. The figures referenced in each chapter are presented at the end of each chapter.

1.1 NextGen Overview

1.1.1 Introduction

In its October 2014 report, *NextGen Integration Working Group Final Report*, the FAA defined four top priority capabilities of NextGen to be implemented in the next one to three years. They include:

- Closely Spaced Parallel Runways/Multiple Runway Operations,
- DataComm-enabled Controller-Pilot DataLink Communications and pre-departure clearances,
- Performance Based Navigation (PBN), and
- Surface and Data Sharing.

While these four capabilities can deliver benefits to GA, with the exception of Performance Based Navigation (PBN), they are primarily focused on improving efficiency for large commercial aircraft operating at the nation's busiest airports. GA aircraft that fly into those airports, such as high-end business aircraft, will obtain these benefits. GA aircraft operating at other airports will benefit primarily from PBN and the enabling technology programs, Automated Dependent Surveillance Broadcast (ADS-B) and Wide Area Augmentation System (WAAS).

This report is focused on Puget Sound region air traffic issues including:

- deconfliction of GA traffic,
- improved access to GA airports in all weather and operational conditions,
- commercial operations; data/communications (data/comm) between pilots and air traffic control, and
- data sharing between users at the FAA; and enhanced access.

The 2013 PSRC *Phase 1 Study, Chapter 2* contains a detailed description of NextGen and its key components: communication, navigation, and surveillance. The Phase 1 study is located on the PSRC website at www.psrc.org. For an in-depth look at NextGen, the FAA has also created a website dedicated to NextGen at www.faa.gov/nextgen. The website is updated as new procedures are implemented throughout the National Airspace System (NAS) and shows information for key sites throughout the United States.

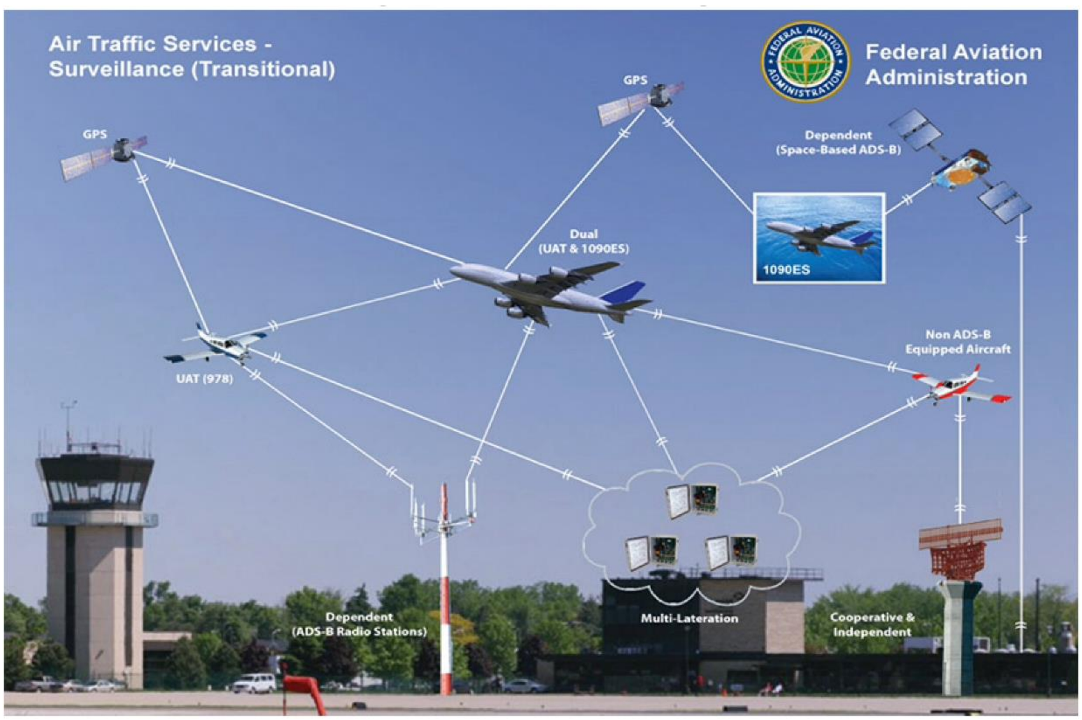
1.1.2 NextGen Programs

The following section summarizes key NextGen technologies/procedures that, when implemented, will satisfy the FAA's NextGen priority capabilities related to GA.

Automated Dependent Surveillance Broadcast (ADS-B) Services

ADS-B, an enabling technology program, is a critical surveillance component to the implementation of NextGen. ADS-B uses GPS signals to determine aircraft location instead of radar. Aircraft operating in controlled airspace must be equipped with technology ADS-B "Out" by January 1, 2020. With ADS-B technology, the aircraft broadcasts its position information to ADS-B ground stations and other aircraft. This is called ADS-B "Out." Position information includes altitude, airspace and location. Ground stations are also broadcasting valuable information to the aircraft, such that the aircraft can receive it using ADS-B "In" technology. Aircraft equipped with ADS-B In receive traffic and weather data in the cockpit. As of January 1, 2015, approximately 8,800 GA aircraft are equipped for ADS-B Out. This is approximately 4% of the GA fleet in the United States; according to the General Aviation Manufacturers Association, in 2013 there were approximately 209,000 GA aircraft registered in the United States. **Figure 1.1**, *ADS-B Architecture*, shows how the components of ADS-B communicate with aircraft and air traffic control facilities.

Figure 1.1
ADS-B Architecture



Source: Federal Aviation Administration, January 2015

Traffic Information Service – Broadcast (TIS-B), Flight Information Service – Broadcast (FIS-B), and Automatic Dependent Surveillance Rebroadcast (ADS-R) provide aircraft equipped with ADS-B In with situational awareness of other aircraft within a 15 NM radius (+/- 3500 feet). The traffic information includes:

- Altitude
- Ground track
- Speed and distance of other aircraft
- Airport surface data
- Graphic based weather data
- Text based weather advisories
- Notices to Airmen (NOTAM)

Installing an ADS-B receiver in the cockpit provides a situational display and an audio alert to warn the pilot of approaching traffic. If aircraft are flying intercept courses, the ADS-B In avionics will sound an alert, enabling the pilots to take evasive action to avoid a collision.

ADS-B In provides additional benefits specific to general aviation aircraft, including receiving and displaying weather and other aeronautical information to enhance pilots' situational awareness of in-flight hazards and help prevent accidents. Three types of FAA broadcast services provide benefits to pilots of ADS-B In-equipped aircraft:

- **Traffic Information Service–Broadcast (TIS-B)**: This advisory service provides the altitude, ground track, speed, and distance of aircraft flying in radar contact with controllers and within a 15 NM radius, up to 3,500 feet above or below the receiving aircraft's position. A GA aircraft equipped with ADS-B In can also receive position data directly from other aircraft broadcasting on the same ADS-B Out frequency. TIS-B also enables pilots to see Non-ADS-B equipped aircraft with transponders flying nearby.

- **Automatic Dependent Surveillance–Rebroadcast (ADS-R)**: ADS-R takes position information received on the ground from equipped aircraft and rebroadcasts it to commercial aircraft. In concert with TIS-B, ADS-R provides all ADS-B In-equipped aircraft with a comprehensive view of the airspace and airport situation. ADS-R delivers traffic data within a 15 NM radius 5,000 feet above or below relative to the receiving aircraft's position.

- **Flight Information Service– Broadcast (FIS-B)**: This service broadcasts graphical and text-based weather information to the cockpit, providing a weather radar-like display similar to commercial aircraft, without the need to invest in expensive radar avionics. In addition, FIS-B broadcasts text-based advisories including Notice to Airmen messages and reports on significant weather such as thunderstorm activity. Properly equipped general aviation aircraft can receive this information at altitudes up to 24,000 feet.

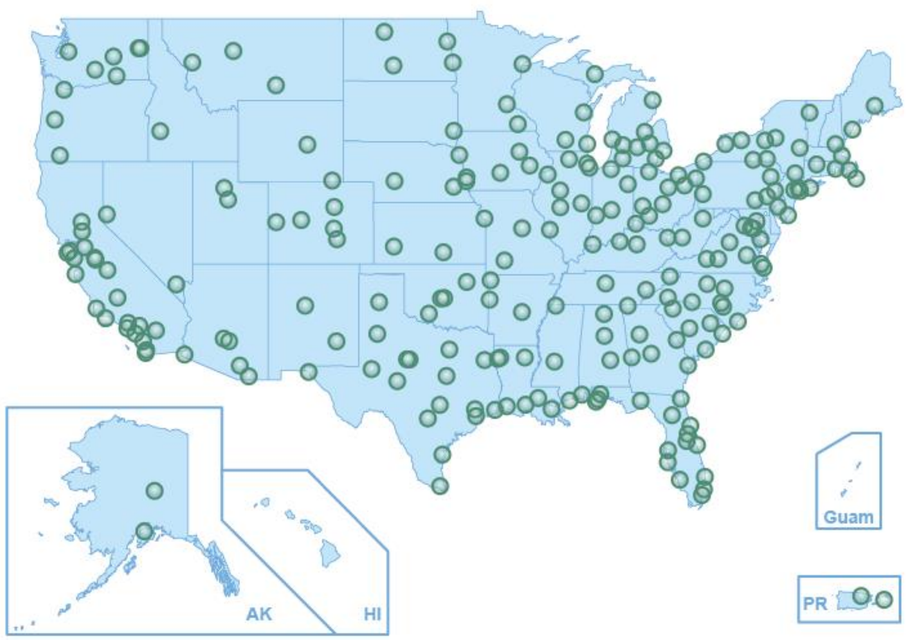
The FAA has completed the baseline deployment of more than 600 ADS-B ground stations, making TIS-B, ADS-R and FIS-B services available across the United States. The FAA is working with the aviation community to set standards for how ADS-B In provides pilots with a low-cost traffic alerting capability.

This work included flight testing in 2013. The traffic alert application uses ADS-B data to identify conflicting traffic nearby, alerting the pilot to look out the window and see the traffic being called out.

Hopefully, the new rules and regulations for ADS-B In will be completed prior to the mandate to equip with ADS-B Out with sufficient time for manufacturers to provide both ADS-B Out and In equipment to meet the ADS-B Out mandate. All things considered, ADS-B will be an attractive option for general aviation.

Figure 1.2, *ADS-B Ground Stations*, shows the location of the 600 ground stations. The specific locations within the project study area are presented in Section 2.8 of this report.

Figure 1.2
ADS-B Ground Stations



Source: Federal Aviation Administration, September 2014

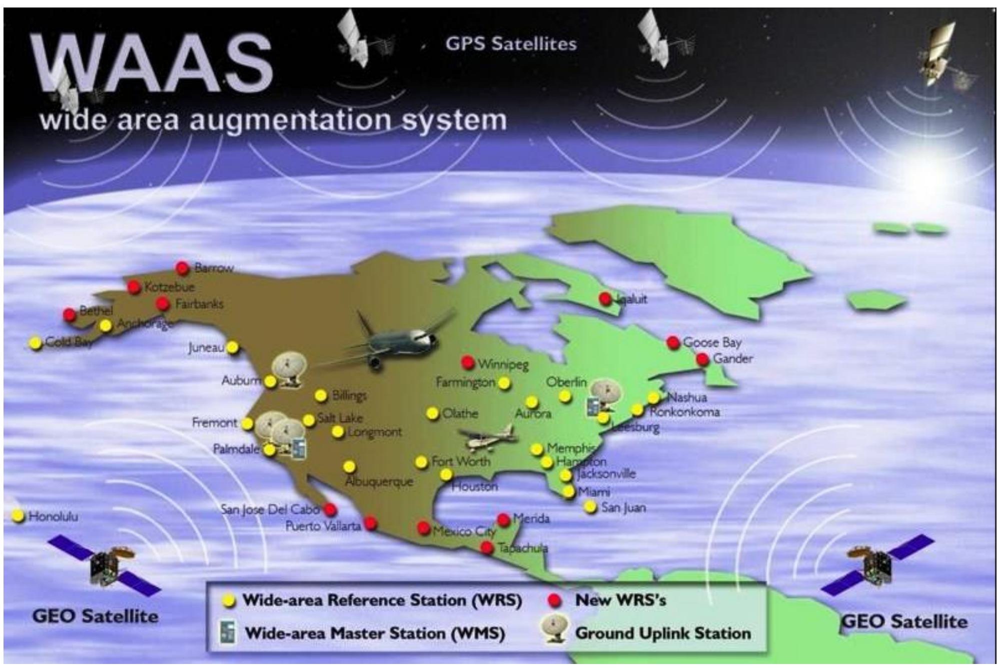
ADS-B Out equipped aircraft will also receive traffic and weather information for display on some mobile devices. Many general aviation pilots routinely use electronic tablets (such as iPads) to view aeronautical charts, so using these devices to depict weather and traffic information is a natural fit. The FAA is also exploring the possibility of setting standards for battery-powered ADS-B Out transmitters that can be used on gliders and general aviation aircraft certificated without an electrical system.

In the Puget Sound region, the baseline ADS-B infrastructure is complete. TIS-B, ADS-R, and FIS-B are available services to equipped users.

Wide Area Augmentation System (WAAS) Progress

WAAS provides general aviation pilots with Area Navigation (RNAV)[4] capabilities that in many cases rival or exceed what is used by commercial aircraft. WAAS enables aircraft to use vertically guided approach procedures to any qualifying airport in most of North America with minimums as low as 200 feet decision altitude (DA), without the need to install costly Instrument Landing System (ILS) equipment. These minimums can be lower than other conventional based navigation aide (NAVAID) approaches. When rising terrain is an issue near an airport, precise vertical guidance enhances safety regardless of visibility and whether the approach is being flown during the day or at night. **Figure 1.3**, *WAAS Infrastructure*, shows the current satellite and ground stations.

Figure 1.3
Wide Area Augmentation System *(WAAS) Infrastructure*



Source: Federal Aviation Administration

As of December 2014, the FAA has published 3,450 WAAS-enabled approach procedures that feature Localizer Performance with Vertical Guidance (LPV)[5] minima. There are 2,326 of those LPVs at airports where no ILS is available. The specific airports with LPV procedures in the project study area are presented in Section 2.9 of this report. From a pilot's perspective, LPV approaches operate in a similar manner to traditional ILS approaches with vertical guidance similar to an ILS Cat I approach, which doesn't require advanced specialized training. This is a technology that can be used at airports without an ILS to improve access. Users say that LPV procedures are more accurate and easier to fly than ILS approaches because

[4] **Area navigation** (RNAV) is a method of instrument flight rules navigation that allows an aircraft to choose any course within a network of navigation beacons, rather than navigating directly to and from the beacons.

[5] LPV procedures are the highest precision GPS aviation instrument approach procedures currently available without specialized aircrew training requirements

the flight paths are generated within the aircraft avionics, rather than from ground-based signals that are plagued by beam bends and interruptions from aircraft taxiing on the airport surface. Nationwide, more than 70,000 general aviation aircraft are equipped with the WAAS receivers needed to fly WAAS-enabled procedures with LPV minima or WAAS-enabled non-precision approach procedures with Localizer Performance (LP) minima.

LPV provides an access benefit especially to GA aircraft. RNAV (GPS) approaches with LPV minima to airports that have no ILS now make these destinations accessible when visibility is limited, rather than ruling them out, thus enhancing airport access for many users. An airport must have at least 3,200 feet of paved runway to qualify for an RNAV (GPS) procedure with either LP or LPV minima. Harvey Field is the only study area airport that does not meet this criterion. As of January 2015, the FAA has published 12 WAAS-enabled approach procedures that feature Localizer Performance with Vertical Guidance (LPV) minima at the study area airports. Additional information related to LP/LPV procedures is presented in Section 2.9.

The FAA has also published 560 RNAV (GPS) non-precision procedures as of December 2014, with LP minima that employ WAAS for lateral guidance but without the added safety benefit of vertical guidance. These approaches are needed at runways where obstacles or other infrastructure limitations prevent the FAA from publishing a vertically guided approach. Non-precision LP minima are generally higher than LPV minima, with somewhat reduced airport access in poor weather.

The widespread and growing availability of LPV and LP procedures and the high equipage rate in the general aviation fleet is making it possible for the FAA to retire some ground-based NAVAIDs from service, including Non-directional Beacon (NDB) and VOR equipment. Many GA aircraft owners have removed the now obsolete avionics needed to fly an NDB procedure and the FAA continues to shut down NDBs on the ground. LPV procedures can provide lower minima than are available with NDB approaches.

The FAA plans to meet any new requirements for Category 1 approach procedures with WAAS and LPV while maintaining an existing network of Instrument Landing Systems (ILS) to provide alternative approach and landing capability. The agency also intends to transition from defining airways, routes and procedures using VOR, and more to RNAV procedures using GPS and DME/DME/IRU (inertial reference unit) in the National Airspace System. An IRU is an internal navigation system used on large aircraft. The network of Distance Measuring Equipment stations provides an RNAV-backup to GPS for suitably equipped commercial aircraft. A Minimum Operational Network of VOR stations (VOR MON) will be maintained to provide a conventional navigation capability for aircraft that don't have DME/DME/IRU avionics.

The current en route air traffic control structure will also migrate away from VOR navigation to RNAV. But instead of merely replacing the existing VOR airways with RNAV routes, the en route system will adopt a new concept called "Structure Where Necessary, and Point-to-Point Navigation Where Structure is not Needed." This phrase simplifies the overall plan for redesigning the en route system. "Structure where necessary" means that PBN routes will not replace VOR airways one-for-one. Instead, PBN routes will be published where they are actually needed, for example between Chicago, Boston, New York, Washington, Atlanta, and along the North-South corridor of the west coast. Many VOR routes are not used and ATC relies on playbooks, wind routes, and other uncharted traffic flow schemes instead of the published routes to actually make the system work. The existing route system of VOR airways is no longer needed.

"Point-to-Point Where Structure is not needed", means that outside of the busy en route flows, there is no need for published routes and aircraft will fly point-to-point direct. The reality is that most aircraft file flight plans based on VOR airways and then after they are airborne ask for a more direct route. The airways are really not used other than for a flight planning exercise and for radio outage procedures, neither of which is a sufficient justification for keeping them. The intent is to provide an en route system that matches both how aircraft actually fly and how ATC manages the flow.

As the NAS is modernized, communications, navigation, surveillance, and automation systems will enable the majority of traffic outside congested areas to proceed to their destination using the most direct great-circle routes without the need for dedicated airways. RNAV Q and T Routes[6] will be established where structure is needed for en route traffic. Routes will also be necessary to ensure the smooth flow of traffic around restricted airspace and busy terminal metroplex areas. Overall, the expectation is that the majority of VOR airways will be removed and a smaller number of Q/T Routes will replace them.

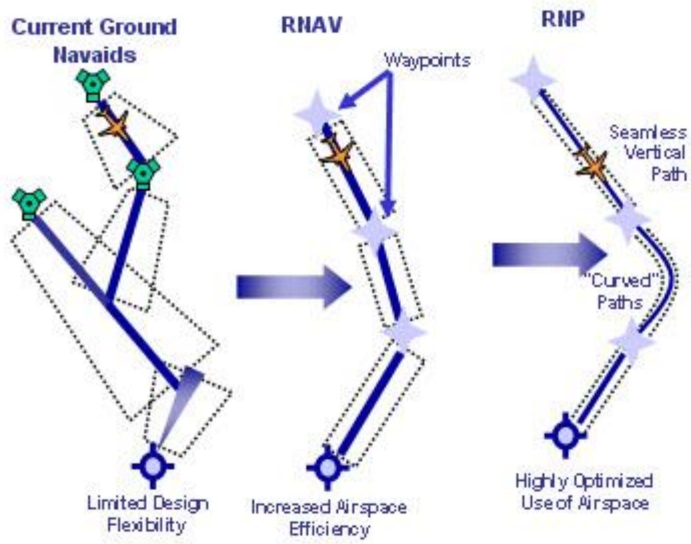
Performance Based Navigation (PBN)

One of the opportunities NextGen offers is Performance Based Navigation (PBN), which allows more efficient use of airspace through point-to-point navigation. Rather than restricting flight paths between ground-based radio navigation systems. PBN procedures consist of RNAV and Required Navigation Performance (RNP). The FAA's strategy for implementing PBN is to provide "RNAV Everywhere and RNP Where Beneficial." All RNAV and RNP approach procedures rely on satellite-based navigation, breaking free of the dependency on ground based navigation aids. PBN enables procedure designers to maximize the efficient use of the airspace, altering the traditional flight paths around an airport.

Figure 1.4, *PBN Navigation,* shows the change between ground-based NAVAIDS and RNAV/RNP procedures, and highlights the difference between current point-to-point navigation and new, more flexible, PBN navigation, which offers increased efficiency.

[6] Q routes, sometimes referred to as high altitude routes, are used by RNAV equipped aircraft operating between18,000' mean sea level (MSL) and 45,000' MSL whereas T-Routes, sometimes referred to as low altitude routes, are used by RNAV equipped aircraft operating to 18,000' MSL.

Figure 1.4
PBN Navigation



Source: Federal Aviation Administration, January 2015

Data Communications

Over the long term, pilot/controller communications will transition from voice-to-data communications, contributing significantly to increased efficiency, throughput, and safety of the NAS. The Data Communications (Data Comm) program will gradually implement new technology to transition from the current analog voice system to an International Civil Aviation Organization (ICAO) compliant system in which digital communication becomes an alternate and eventually predominant mode of communication. Data Comm is an essential enabler to shift air traffic control from a workload-intensive tactical control to automation-assisted strategic traffic management. To achieve this goal, more efficient data communications between aircraft and air traffic management must be implemented. The Data Comm program is a key element in the implementation of NextGen.

In addition, the FAA is developing concepts for Dynamic RNP (DRNP), a capability that enables real time management of traffic flow and throughput when the airspace is constrained as a result of weather, high traffic density, or the presence of special activity airspace or a combination of these. The premise is that more solutions to the problem can be made available through the generation of DRNP routes that can be uplinked to affected aircraft. This is accomplished by moving traffic streams closer together and by making minimal route adjustments to circumvent the constraint. Ultimately, DRNP will save fuel for operators by generating RNP routes that have minimal impact on the original flight plan trajectory.

Over the long-term the FAA will implement DRNP in domestic airspace. To capture the benefits, aircraft must equip with Future Air Navigation System (FANS) 1A equipment. The cost of this equipment will likely be prohibitive for all but the high-end GA aircraft. However, GA aircraft operating in the vicinity of high density airports may benefit from fewer disruptions as large aircraft fly more predictable paths using the available airspace more efficiently.

1.2 Project Study Area

The project study area is defined as the Seattle airspace boundary and the GA airports that fall within that boundary. The boundary lines represent the terminal area airspace in the Puget Sound region known as Seattle Terminal Radar Approach Control (SEA TRACON). There are nine GA airports within that boundary, presented in **Table 1.1**, *Study Area Airports*. **Figure 1.5**, *Project Study Area* shows the study area boundaries and included airports. While not part of the study itself, Sea-Tac Airport is located within this study area and is also presented in Figure 1.5.

The project study area and its associated airports define the boundary for which the navigation and aeronautical information for the operations of these airports is presented within this report. This includes heliports, NAVAIDS, obstructions, terrain, airspace, procedures, charts and low/high altitude routes. While the majority of the navigation and aeronautical information presented is limited to the study area, some data is extended beyond that boundary when it relates to operational procedures, such as the en route Q and T routes.

Table 1.1
Study Area Airports

Code	Airport	*Location*
KBFI	King County International - Boeing Field	Seattle/Tukwila
KRNT	Renton Municipal Airport	Renton
KPAE	Snohomish County Airport - Paine Field	Everett/Snohomish County
KTIW	Tacoma Narrows Airport	Tacoma/Pierce County
KPWT	Bremerton National Airport	Bremerton
KPLU	Pierce County Airport - Thun Field	Puyallup
S50	Auburn Municipal Airport	Auburn
S36	Crest Airpark (Kent)	Kent
S43	Harvey Field	Snohomish

Source: BridgeNet International, January 2015

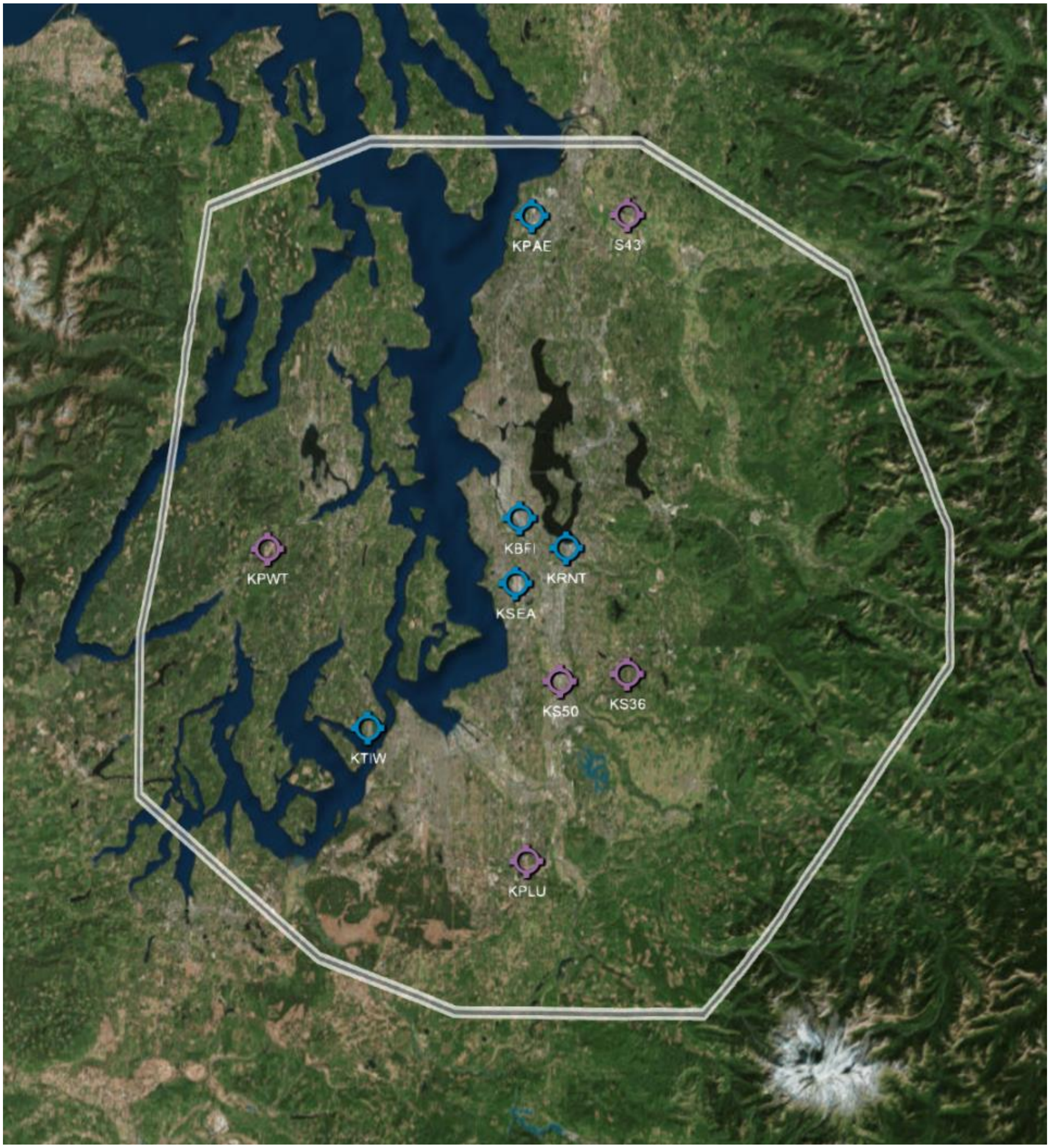
1.3 Heliports with Instrument Procedures

The heliports located within the study area are generally private or for emergency use only. There are 29 heliports in the study area; none of the heliports have published public instrument procedures or specials. **Table 1.2,** *Heliports Located in Study Area,* lists the heliports (public and private use) within the project study area that was defined in Section 1.2. **Figure 1.6,** *Heliport Locations,* presents a map that shows the location of each of these heliports.

In addition to these listed heliports, helicopter operations also occur from each of the airports within the study area. Helicopter operations generally operate under visual conditions and fly along transportation corridors that are usually agreed upon by the controlling ATC facility. These paths provide an access through a given airspace or to/from landing sites with minimum communications with ATC. The interactions of helicopter operations from other GA traffic is minimal and generally occurs at the airports that operate from. This is primarily at Boeing Field and Paine Field. Once in flight, the helicopters operate along VFR flight corridors that are separate from other GA traffic.

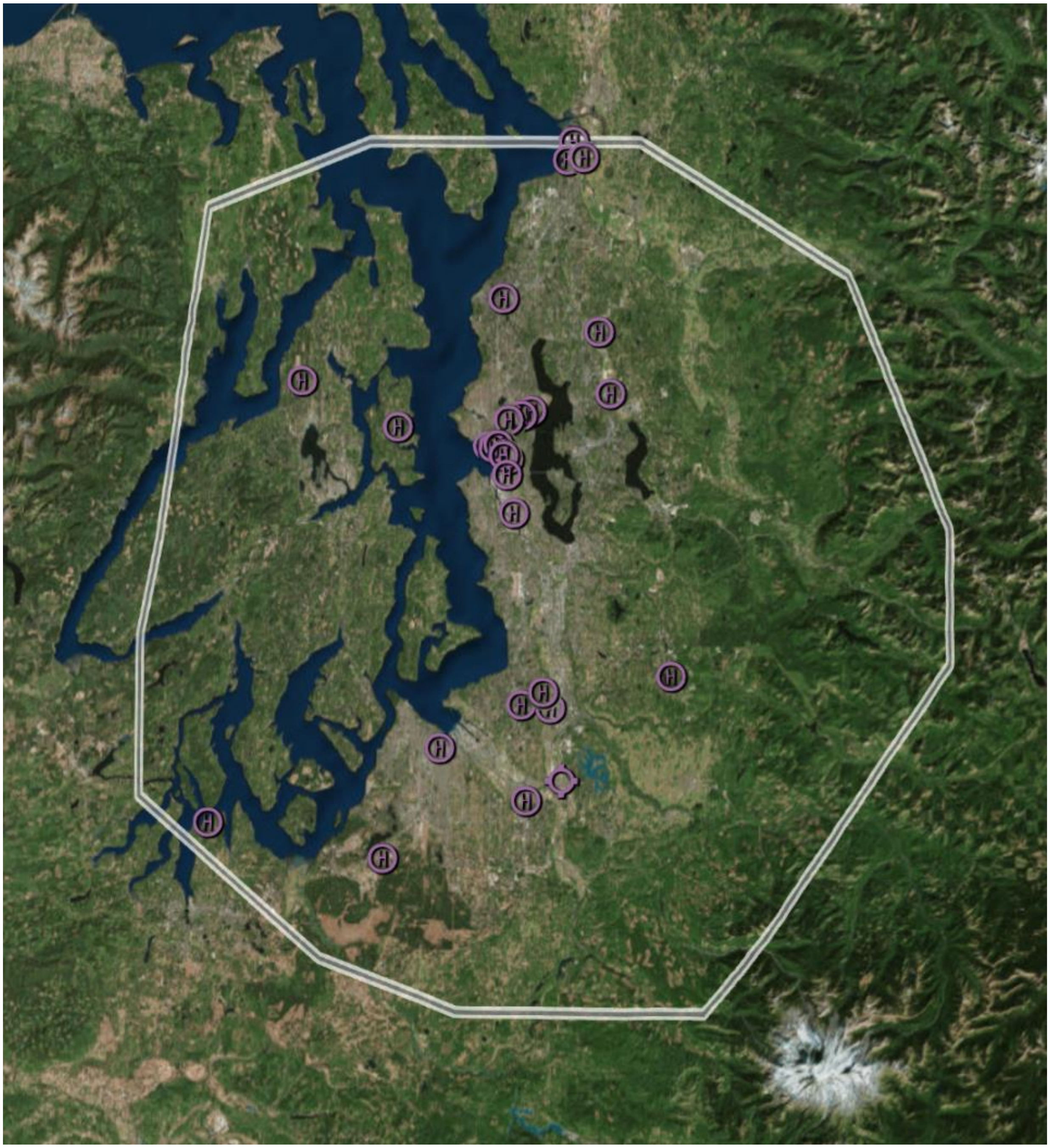
The Puget Sound region also has numerous float plane operations. There are two float plane bases at the south end of Lake Union. In addition, float planes operate throughout the region from private locations in Lake Washington, Lake Union, and other area bodies of water.

Figure 1.5
Project Study Area



Source: BridgeNet International

Figure 1.6
Heliport Locations



Source: BridgeNet International

Heliports Located in Study Area

Identifier	Heliport Name
9WA0	Boeing Plant 2 Heliport
8WA9	Broadcast House Helistop Heliport
0WA8	Children's Hospital Emergency Heliport
9WA6	Puget Sound Plaza Heliport
2WA4	Bainbridge Island Fire Department
9WA9	Naval Submarine Base Bangor
0WA6	Stevens Memorial Hospital
43WA	Wilson
81WA	Jobe Skis Plant 1
7WA8	Good Samaritan Hospital
88WA	Personal 500 Sales Company
60WA	J.J.H.
1WA3	Calkins Equipment Company
1WA4	Providence Hospital
1WA5	General Hospital of Everett
1WA8	Madigan Hospital
WA53	Harborview Medical Center Heliport
WA54	1001 Fourth Avenue Plaza Heliport
WA55	Elliott Park Heliport
WA85	Weyerhaeuser Heliport
WA86	Boeing - Auburn Complex Heliport
WA94	Washington Air Museum Heliport
WN01	Seattle Private Number One Heliport
WN12	Fishtrap Heliport
WN16	KOMO TV Heliport
WN22	Lake Union Heliport
WN50	St. Joseph Hospital Heliport
WN93	Park 90 Heliport
WT22	Graves Field Heliport

Source: BridgeNet International, January 2015

1.4 Key Airspace Issues in the Puget Sound Region

The airspace issues within the study area were organized into five general categories: safety, access, deconfliction, data/comm, and weather. These initial categories of airspace issues were defined during the scoping for this project and have been analyzed; further information on airspace actions for these issues can be found in Chapter 3. **Table 1.3**, *Airspace Issues*, shows the initial airspace issues defined by the consultant and as the study evolves will be expanded and evaluated with respect to each of the airports within the study area. These five categories represent:

- *Safety* –defines the ability of an aircraft to comply with existing flight procedure parameters while on approach or departure to/from an airport or flying enroute to/from an airport.
- *Access* –ability to fly into and out of a facility at the requested time on the preferred routes.
- *Deconfliction* – flight procedures that are unable to operate simultaneously at two or more separate airports.
- *Data/Commmunication (data/comm)* – flight procedures limited by the ability of communications in the area or the ability for air traffic control to establish radar contact.
- *Weather* – The Puget Sound region will often have overcast weather conditions that limit the ability for aircraft to fly except under instrument flight rules.

Table 1.3
Airspace Issues

Code	Airport	Airspace Issues				
		Safety	Access	Deconfliction	Data/Comm	Weather
KBFI	King County International - Boeing Field	✓	✓	✓		✓
KRNT	Renton Municipal Airport	✓	✓	✓		✓
KPAE	Snohomish County Airport - Paine Field	✓		✓	✓	✓
KTIW	Tacoma Narrows Airport	✓				✓
KPWT	Bremerton National Airport	✓				✓
KPLU	Pierce County Airport - Thun Field	✓				✓
S50	Auburn Municipal Airport	✓				✓
S36	Crest Airpark (Kent)	✓				✓
S43	Harvey Field	✓				✓

Source: BridgeNet International, January 2015
While three are no specific identified safety issues, enhancing safety is always a goal of this study.

1.5 Causes of Airspace Issues

The causes of airspace issues within the Study Area has been put into five categories; proximity, high activity, weather, airspace, and procedures. **Table 1.4,** *Causes of Airspace Issues*, defines these issues by airport. The cause(s) of an airspace issue are the lack of specific infrastructure or capabilities to users. These initial categories of airspace causes were defined during the scoping for this project. These five categories are represented by:

- *Proximity*– location of airports with respect to each other and flight procedures used by the facilities.
- *High Activity* – number of operations at an airport or adjoining airports.
- *Weather* – lack of infrastructure and/or procedures to allow operations during periods of inclement weather.
- *Airspace* – limitations of available airspace and related infrastructure, including terrain.
- *Procedures* – limitations of existing procedures for aircraft arriving and departing from an airport or adjoining airports.

Table 1.4
Cause of Airspace Issues

Code	Airport	Causes of Airspace Issues				
		Proximity	High Activity	Procedures	Airspace	Weather
KBFI	King County International - Boeing Field	✓	✓	✓	✓	✓
KRNT	Renton Municipal Airport	✓		✓	✓	✓
KPAE	Snohomish County Airport - Paine Field				✓	✓
KTIW	Tacoma Narrows Airport					✓
KPWT	Bremerton National Airport					✓
KPLU	Pierce County Airport - Thun Field					✓
S50	Auburn Municipal Airport			✓		✓
S36	Crest Airpark (Kent)			✓		✓
S43	Harvey Field			✓		✓

Source: BridgeNet International, January 2015
NWD: No weather data for these airports.

1.6. Resource Guide

Since its inception in 2003, the FAA has developed a mature set of planning and execution documents for NextGen. The NextGen planning documents provide an essential integration of activities from multiple FAA lines of business, program offices, and implementation teams to ensure new operational capabilities are implemented successfully. There are a number of documents that are helpful to understand the history of NextGen, its long and short-term goals as well as technical documentation of the components of NextGen. The following is a list of documents that can serve as a guide for stakeholders to gain more insight to NextGen.

- The NAS Concept of Operations (NAS ConOps) provides the high level narrative description of the operational capabilities refined into one or more operational improvements (Ois). The NAS Concept of Operations document may be found here: www.dtic.mil/dtic/tr/fulltext/u2/a535795.pdf

- The NAS Enterprise Architecture (NAS EA) provides a framework where all operational concepts and operational improvements (OI) from the NAS ConOps are cataloged in a database structure linking multiple views (operational, services, systems and infrastructure) for alignment with long range strategic plans for NAS Modernization. The NAS EA Portal is accessed via the following URL: http://nasea.faa.gov.

- The NextGen Implementation Plan (NGIP) is a high level description of the roadmap for improving the NAS to meet the growth of Air Traffic operations through the year 2025. Appendix B of the NGIP lists specific activities and their expected completion date that are extracted from the NextGen Segment Implementation Plan (NSIP). http://www.faa.gov/nextgen/library/media/NextGen_Implementation_Plan_2014.pdf

- Radio Technical Commission for Aeronautics (RTCA) has partnered with the FAA to work on NextGen priorities. In October 2014, they published a document that will guide implementation of NextGen in the next one to three years. This document discusses the four top priorities for short term implementation. http://www.rtca.org/Files/Miscellaneous%20Files/NextGen_Integration_Working_Group_Report_Oct_2014.pdf

- NextGen Priorities Joint Implementation Plan, Report to Congress http://www.faa.gov/nextgen/media/ng_priorities.pdf

- Puget Sound Regional Council's Phase 1 report -*Preparing Busy General Aviation Airports for Next Generation Technology* - may be found here: www.psrc.org/assets/7340/NextGen.pdf

- The FAA's Satellite Navigation Team maintains a website with information related to WAAS, LAAS, GBNA, and lighting systems at gps.faa.gov.

- The FAA has developed an iPAD application for NextGen and General Aviation. It can be located on the apple store by searching on "FAA NextGen."

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CHAPTER 2 - INVENTORY OF EXISTING INFORMATION

Chapter 2 provides an inventory of navigation and aeronautical information for the nine GA airports within the study area. This also includes data for Sea-Tac Airport due to its influence on operations at the GA airports.

Based upon the existing operational and navigation information, various findings in terms of airspace constraints and opportunities for NextGen enhancements have been identified. These are presented in the last section of this chapter, Section 2.11, *Preliminary Identified Airspace Constraints*.

2.1. Existing Activity Levels

Aircraft operations data in the study area has been evaluated for each airport. **Table 2.1,** *Aircraft Activity Levels for 2013 by Airport,* shows operations by aircraft category based upon the latest published FAA operational data (Terminal Area Forecast – TAF) on the top and the airport-reported activity levels on the bottom. The TAF data represents the general number of airport operations and the bottom of the table shows this data broken down by aircraft category to represent the fleet mix at the study airports.

Boeing Field King County International Airport (KBFI) is the busiest GA airport with 181,941 annual operations (498 operations per day). Harvey Field (S43) is the busiest in terms of local touch and go operations with 91,122 annual operations (249 operations per day). The operations at Boeing Field, Renton Municipal, and Paine Field are primarily focused on business aviation, while the remaining airports have more of a focus on recreational aviation.

Table 2.1

Aircraft Activity Levels for 2013 by Airport

	Yearly Aircraft Operations (Landings + Takeoffs)								
TAF Operations (2013)	KBFI	KRNT	KPAE	KTIW	KPWT	KPLU	S50	S36	S43
Air Carrier	9,107	438	3,905	1	0	0	0	0	0
Air Taxi	33,531	973	1,480	676	625	3,438	6,100	0	51
General Aviation Local	46,903	53,854	50,020	14,708	32,438	34,695	60,882	16,250	91,122
General Aviation Itinerant	90,980	38,133	48,347	21,615	21,625	63,712	99,874	130,000	50,430
Military Local	275	334	291	492	0	0	0		0
Military Itinerant	554	103	618	695	900	0	100		74
TOTAL	**181,350**	**93,835**	**104,661**	**38,187**	**55,588**	**101,845**	**166,956**	**146,250**	**141,677**
Operations by Category	KBFI	KRNT	KPAE	KTIW	KPWT	KPLU	S50	S36	S43
Air Carrier/Boeing	9,200	485	2,700	0	0	0	0	*	0
Business Jet	23,000	3,452	4,400		602		0		0
Twin Propeller	8,000	3,938	12,000		1,253				
Single Propeller	138,371	84,103	83,641		52,833				
Helicopter	2,500	1,447	1,300						
Military Fixed Wing	870	440	620		900				
	181,940	**93,895**	**104,661**		**55,588**				

Source: Terminal Area Forecast, Federal Aviation Administration, January 2015
Airport-reported operation information, Study Area Airports, January 2015
**Airports do not report their operations beyond the TAF*
***Airport Operations by Category are estimated at airports where there is no definitive source*

KBFI: King County International Airport, Boeing Field
KRNT: Renton Municipal Airport
KPAE: Snohomish County Airport, Paine Field
KTIW: Tacoma Narrows Airport
KPWT: Bremerton National Airport
KPLU: Pierce County Airport – Thun Field
S50: Auburn Municipal
S36: Crest Airpark (Kent)
S43: Harvey Field

For a more detailed look at the breakdown between visual and instrument flights, **Table 2.2**, *Towered Airport Operations*, shows operations for the four study airports with air traffic control tower facilities. The data shows that IFR operations occur on average 32% of the time.

Table 2.2

Towered Airport Operations

Category	Yearly Operations, Towered Airports			
IFR Itinerant	BFI	KRNT	KPAE	KTIW
Air Carrier	9,187	459	3,858	0
Air Taxi	19,600	232	880	388
General Aviation	26,437	3,724	9,815	6,792
Military	390	3	303	103
VFR Itinerant	BFI	KRNT	KPAE	KTIW
Air Carrier	13	1	170	0
Air Taxi	13,458	732	557	312
General Aviation	66,382	34,508	40,640	15,238
Military	178	81	282	529
Percent IFR	BFI	KRNT	KPAE	KTIW
All Categories	41%	11%	26%	31%
Local	BFI	KRNT	KPAE	KTIW
Civil	46,998	53,689	54,605	14,806
Military	298	280	372	439
TOTAL	**182,941**	**93,709**	**111,482**	**38,607**

Source: Federal Aviation Administration Air Traffic Activity System, January 2015

Note: KBFI: King County International Airport, Boeing Field, KRNT: Renton Municipal Airport, KPAE: Snohomish County Airport, Paine Field, KTIW: Tacoma Narrows Airport

In addition, the FAA NextGen performance snapshots track usage of NextGen procedures at airports with a larger number of operations. KBFI is the only one of the nine GA airports in the study area for which this information is tracked. The data for KBFI show that there was an average of 174 IFR operations per day (based upon data from April 1, 2013 through March 31, 2014). The Required Navigation Performance Authorization Required (RNP-AR) procedure was rarely flown, with less than 1 percent of the GA or commercial aircraft equipped to fly the procedure, which includes Boeing aircraft operations as GA operations. While there are no specific RNAV procedures at KBFI to measure usage, it is estimated that more than 85% of the GA aircraft in the United States are equipped to fly such procedures. RNP-AR requires more advanced equipment than RNAV procedures.

The FAA Metroplex study evaluated the airspace in Seattle, including SEA-TAC and three GA airports: KBFI, KPAE and KTIW. That study identified the number of GA operations in the airspace; for 2013, the study assumed that 756 average daily operations would be flying using navigation services as shown in **Table 2.3**, *Historic General Aviation Operations in the Seattle Airspace.*

Table 2.3
Historic General Aviation Operations in the Seattle Airspace

Year	General Aviation *Average Daily Operations*
2009	963
2010	930
2011	884
2012	813
2013	756

Source: FAA Seattle Metroplex Study

2.2. Historic Radar Data

To evaluate current flight tracks and operations, historic radar data was collected. The source of this radar data is the FAA's SDAT (Sector Design and Analysis Tool). The data included the first five days of each month from August 2013 through September 2014. This data was collected for the nine study area airports and SEA-TAC. Radar data for SEA-TAC was also collected because operations and flight tracks associated with SEA-TAC influence the operations at the region's GA airports. This data was used as the base period for this study. Flight tracks can be viewed by airport or by procedure on the study website. A more detailed presentation on the flight track information appears in the following sections.

2.3. Determine Traffic Segregation by Operation

The radar data was processed and analyzed to identify operational conditions within the Puget Sound Region. SEA-TAC is a major factor in determining the direction and flow of aircraft operations. There are typically airfield operating flows that ATC staff refer to as "plans": Plan A, Plan B and Plan C. The other airports in the region generally operate in the same flow as SEA-TAC; for example, when SEA-TAC is operating to the south on Runways 16 in Plan A, KBFI will also operate to the south on Runways 13. The exception are the airports to the north in the Everett region (KPAE and S36) where wind conditions sometimes dictate approaches and departures in the opposite direction. The following generally identifies the three flows:

Plan A – South Flow

- IFR and VFR.
- Normal operations.
- Most inclement weather conditions also occur under this flow.
- Approximately 65% of the time.

Plan B – North Flow

- VFR.
- Generally occurs in the summer.
- Approximately 30% of the time.

Plan C – North Flow

- IFR.
- Generally occurs in the late summer into fall.
- Approximately 5% of the time.

2.4. Assess General Aviation Flight Tracks

The SDAT radar data for each airport was processed to present departures and arrivals under north flow and south flow conditions. Where possible, this data was also presented under VFR and IFR conditions and for different categories of aircraft. The data was also processed for different user categories, such as air carrier, business jet, small general aviation, military, etc.

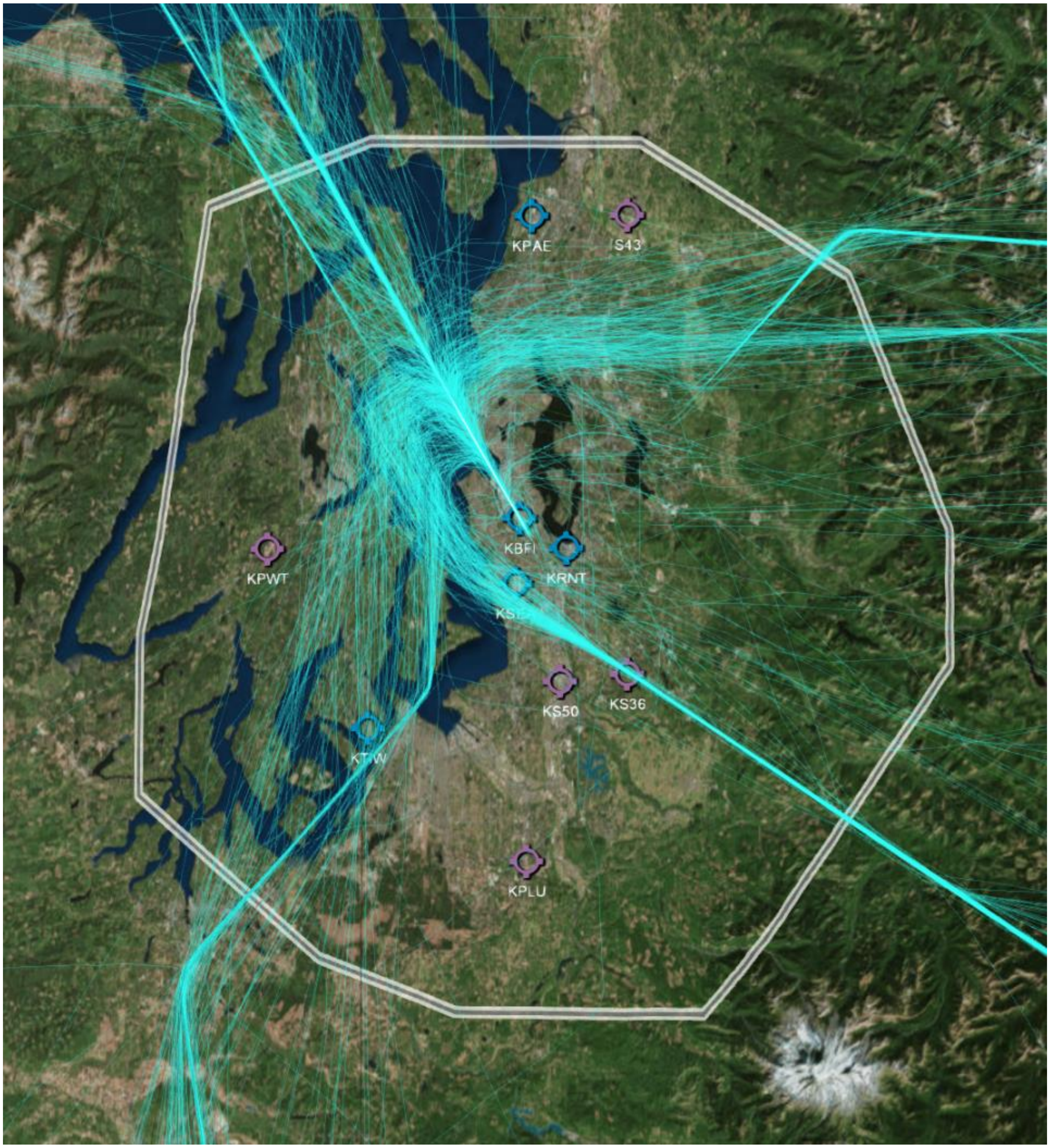
The data is presented in two formats, one is to present a random sample of flight tracks of a specified category of operation and second to present a track density map of all the flight tracks of a specific category. Because of the large number of possible flight track combinations, this data is presented interactively on the Project web site. Example flight track maps are presented in **Figure 2.1** through **Figure 2.5** for sample flight track information which illustrates activity from August 2013 to September 2014.

2.5. Define Airspace Interaction

The Seattle TRACON airspace has one major commercial airport (SEA-TAC), nine general aviation airports, two float plane bases (with numerous other landing areas), and 29 heliports. Three of the busiest airports are located within 5 NM of each other (SEA-TAC, KBFI, KRNT), which can limit the type of arrival and departure procedures due to airspace constraints. In addition, other considerations for air traffic include terrain from the Cascade Mountains to the east, water areas that are preferred for noise abatement, noise sensitive communities, military facilities with restricted airspace, and a high percentage of inclement weather days. Including all these factors, a number of airspace issues have been identified:

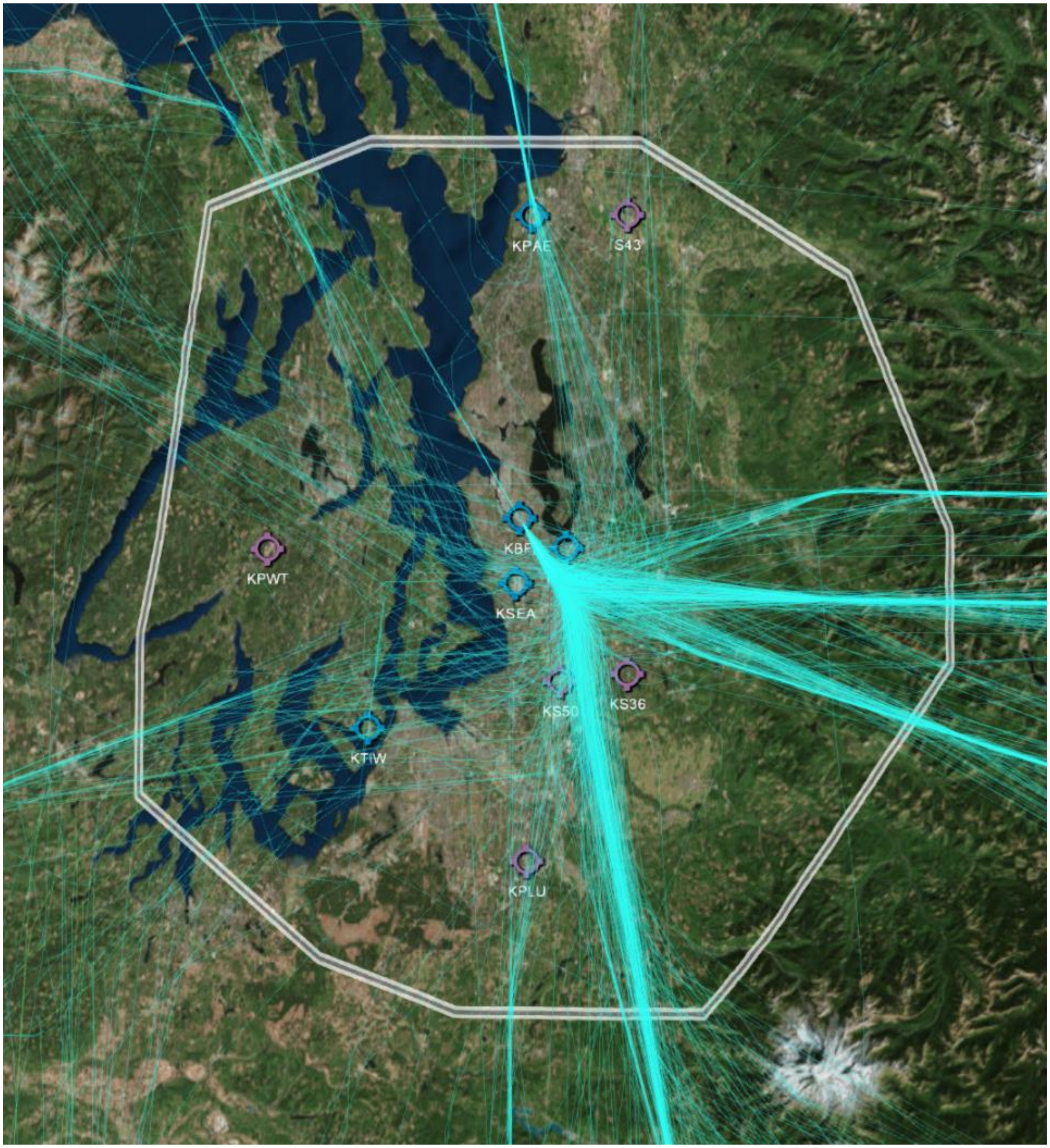
- Close proximity of SEA-TAC, KBFI, and KRNT; this close proximity makes deconfliction of procedures a key mitigation item for this report.
    - Conflicts between KBFI landings and SEA-TAC landings in south flow
    - Conflicts between KBFI south flow departures turning south into SEA-TAC airspace
    - Conflicts between KBFI and KRNT simultaneous departures in south flow
    - Conflicts between KBFI landings in north flow and SEA-TAC north flow departures in inclement weather
- Close proximity of SEA-TAC landings to the south with simultaneous KPAE landings to the north.
- In north flow inclement weather conditions, KRNT available procedures require south flow approaches.
- Shared use of STARs (*Standard Terminal Arrival Routes)* for SEA-TAC, KBFI, KRNT, and KPAE airports.

Figure 2.1
KBFI Arrivals (Runway 13R)



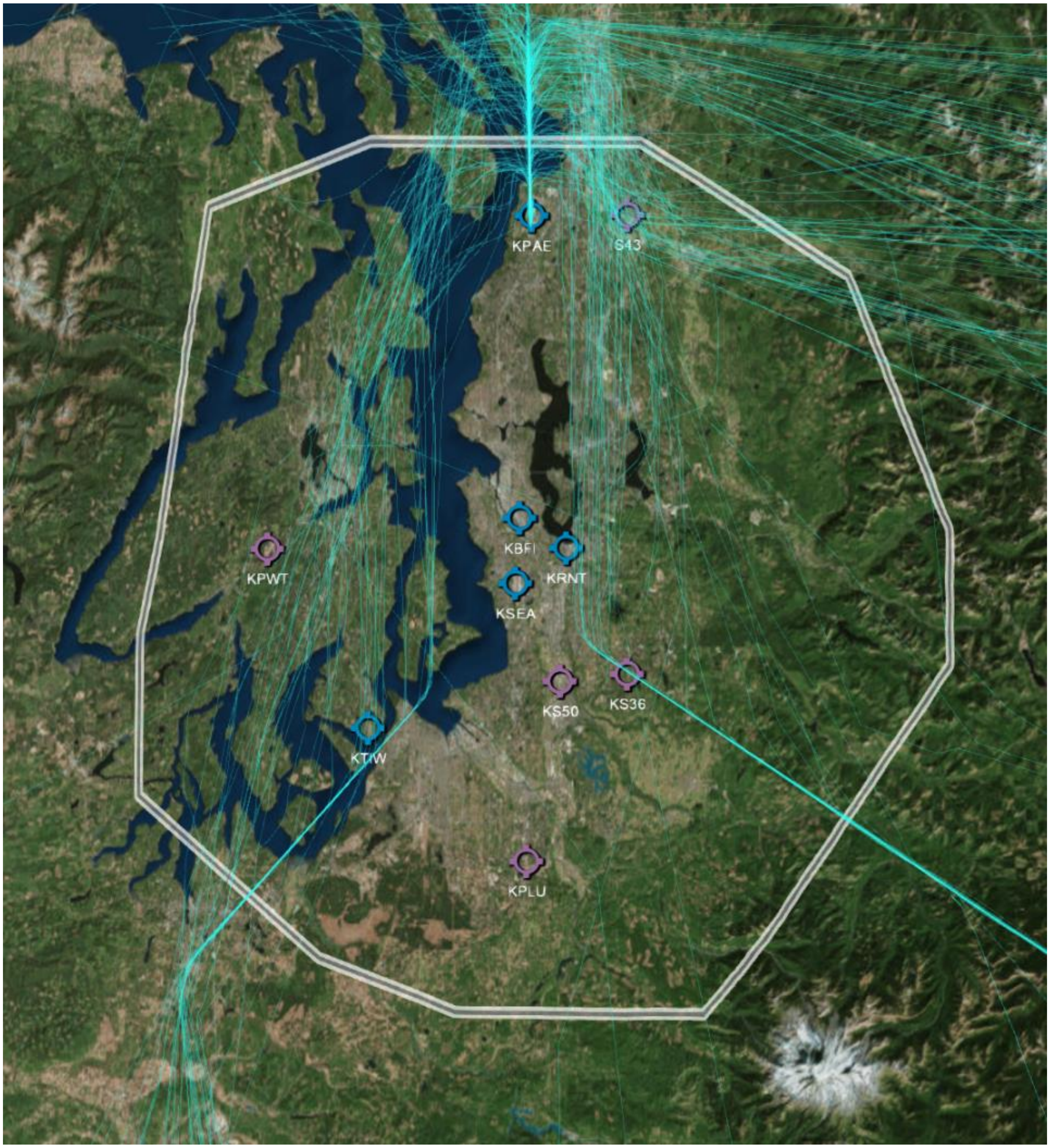
Source: BridgeNet International

Figure 2.2
KBFI Departures (Runway 13R) Flight Tracks



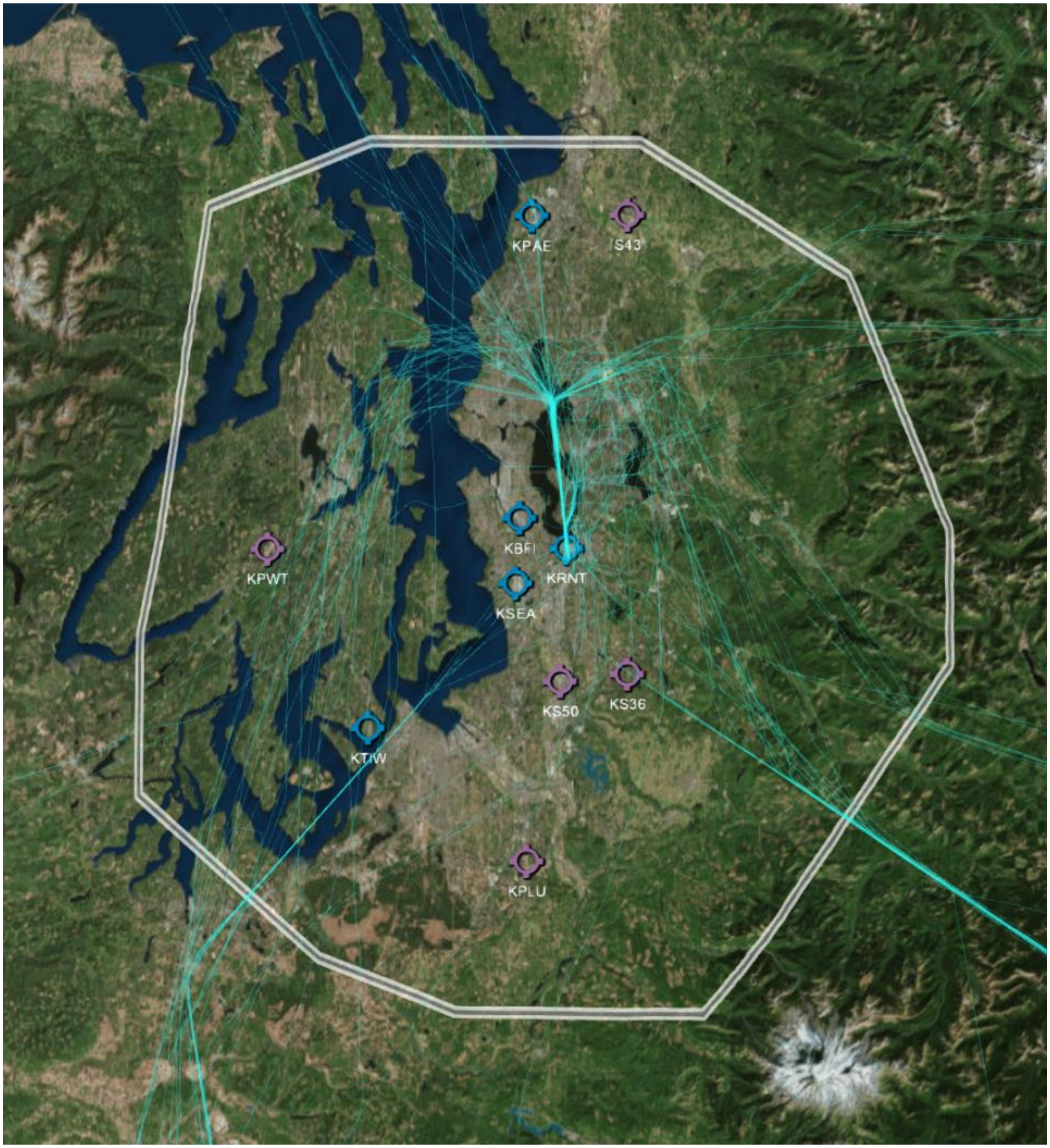
Source: BridgeNet International

Figure 2.3
KPAE Arrivals (Runway 16R) Flight Tracks



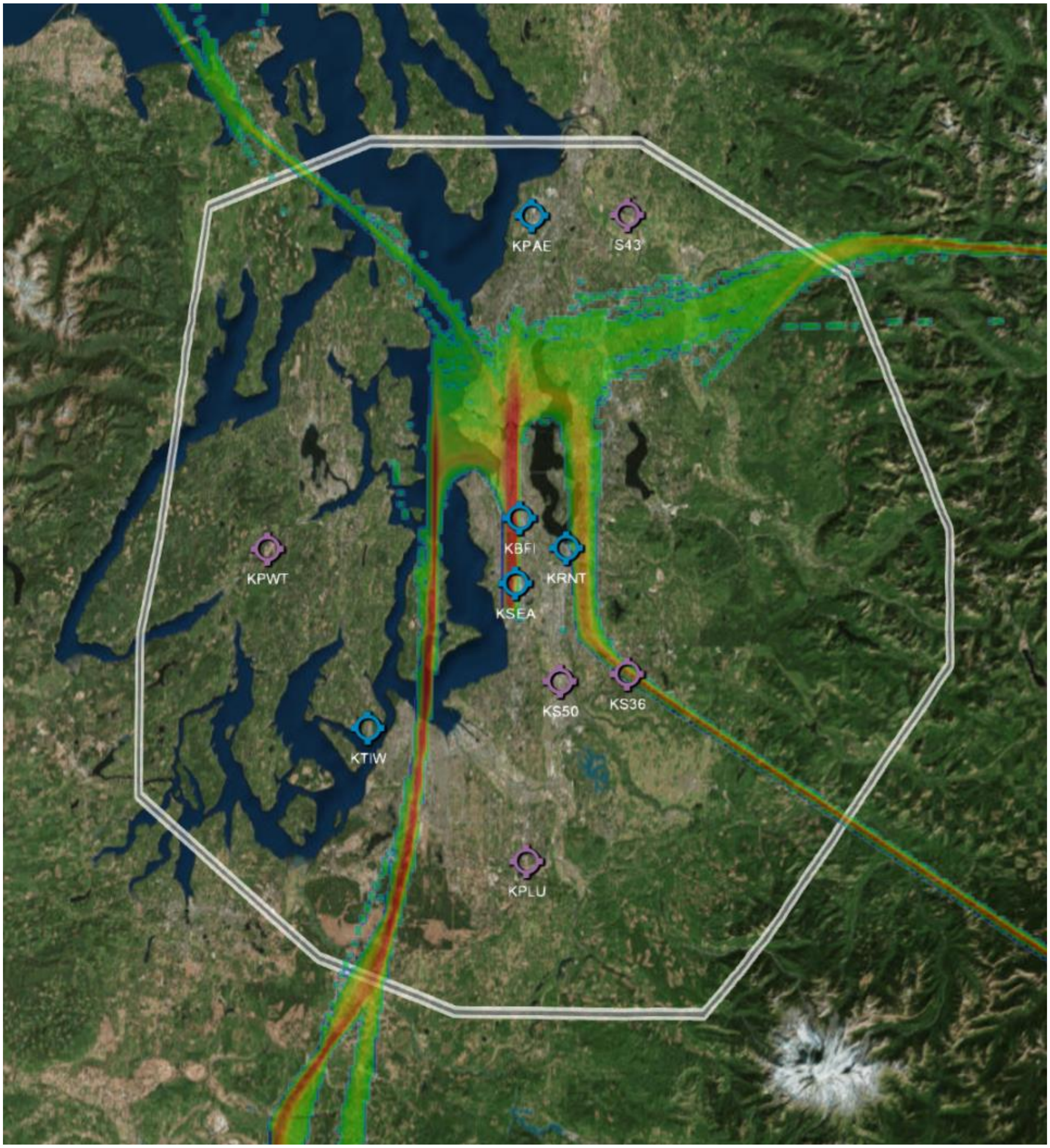
Source: BridgeNet International

Figure 2.4
KRNT Arrivals (Runway 16) Flight Tracks



Source: BridgeNet International

Figure 2.5
KSEA Arrival Track Density (Runway 16)



Source: BridgeNet International

2.6. Military Operating Areas

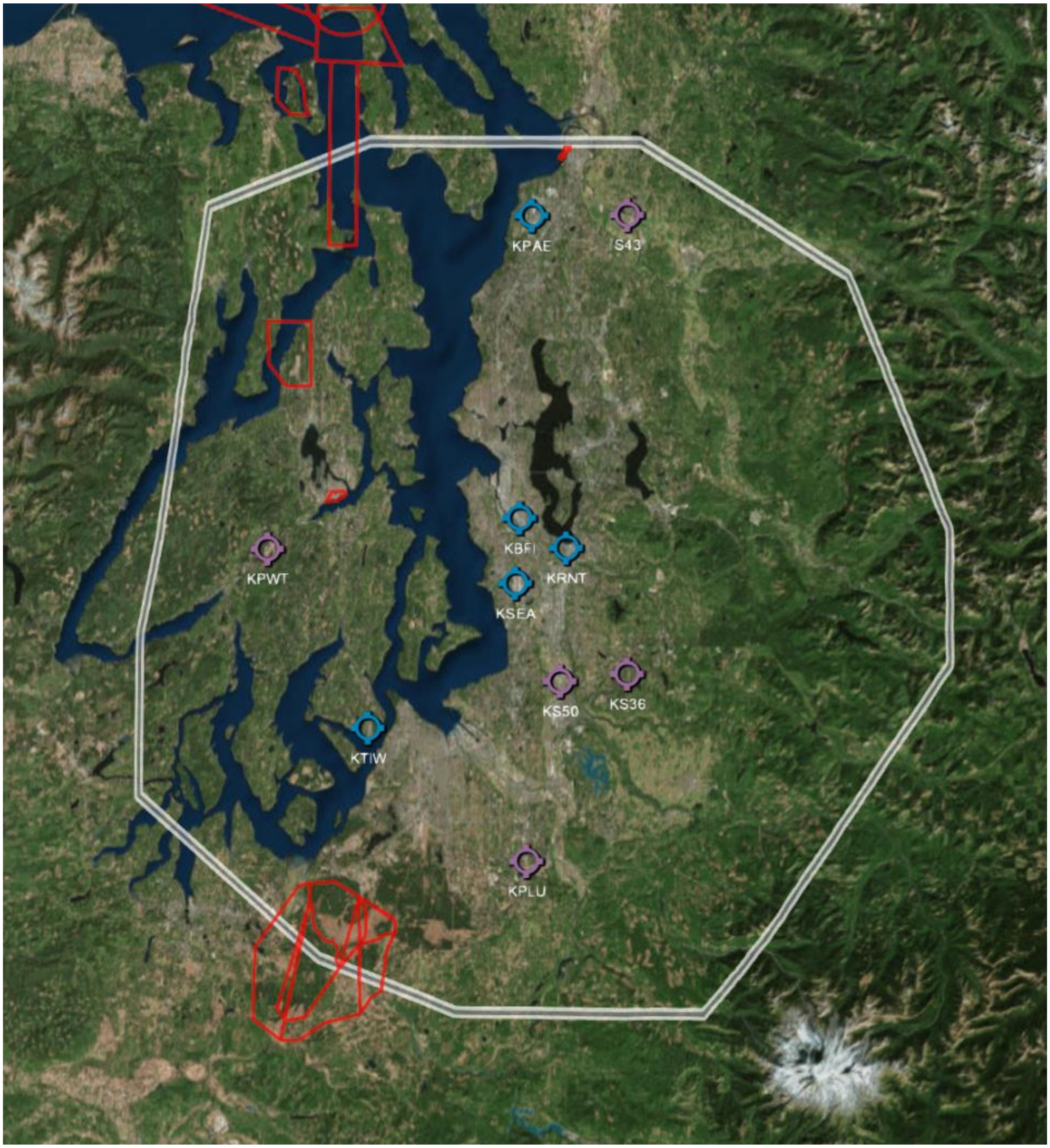
The project study area has five military operating areas (MOA). These are listed below in **Table 2.4,** *Military Operating Areas within Study Area,* and presented in **Figure 2.6**, *Military Operating Areas and Restricted Use Airspace.* The two largest areas are associated with McCord Air Force Base (now McChord Field, part of Joint Base Lewis-McChord, located near Tacoma) and Port Townsend NSA to the north.

Table 2.4
Military Operating Areas within Study Area

Military Operating Areas (MOA)
McChord Air Force Base/McChord Field
Bremerton NSA
P51 Banger
Everett NSA
Port Townsend NSA

Source: BridgeNet International, January 2015

Figure 2.6
Military Operating Areas and Restricted Use Airspace



Source: BridgeNet International

2.7. Inventory Weather

Weather patterns have a large role in determining the direction aircraft fly. In the Puget Sound region, the winds flow predominately from the south in winter and from the north in summer; aircraft generally depart and arrive into the wind, therefore the majority of winter operations are in a southern flow. In addition to the direction aircraft fly, precipitation, visibility, and cloud cover determine if aircraft operate under VFR (Visual Flight Rules) or IFR (Instrument Flight Rules).

For the four towered GA Airports in the study area, aircraft use IFR for 32% of the operations. KBFI has the highest share of IFR operations (41%) while KRNT had the lowest: 11%. Generally airports with a higher level of business aviation, such as KBFI, have users who need to fly in all types of weather conditions, while recreational pilots tend to fly more in favorable weather conditions.

Within the study area, there are six Automated Weather Observation System (AWOS) stations (SEA-TAC, KBFI, KRNT, KPAE, KTIW, KPLU) and one Automated Surface Observation System (ASOS) at PWT. According to available weather data for airports with instrument or minimum VFR procedures, **Table 2.5** shows the percentage of time the airports are in IFR, marginal VFR, VFR condition, and below minimums. The minimum weather conditions depend on the type of equipment and instrument approach available; there are numerous categories of instrument approaches that determine the visibility required for operations. Crest Airpark, Pierce County (Thun Field), Bremerton, and Harvey Field operate in VFR conditions only.

Table 2.5
Weather Conditions

Airport	*VFR*	*IFR / Minimum VFR*	*Below Minimums*
BFI	91.3%	5.5%	3.2%
PAE	89.0%	8.9%	2.0%
RNT	90.5%	7.7%	1.8%
TIW	91.5%	6.7%	1.8%

Source: BridgeNet International, August 2015

2.8. Inventory Existing Airspace Facilities

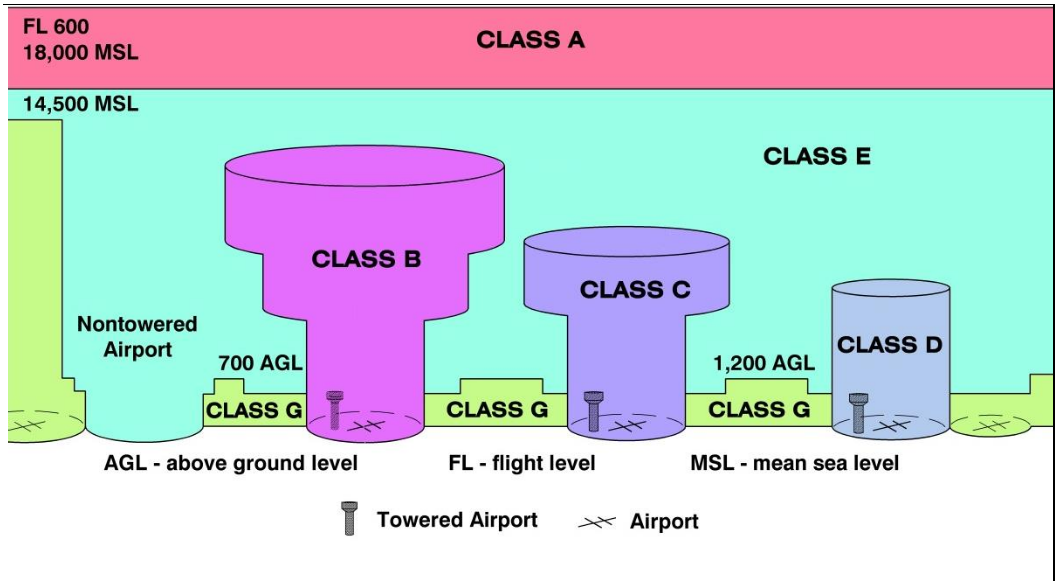
This section describes airspace, air traffic control facilities, navigation aids and surveillance in the study area.

The airspace over the study area and all of the US is under the jurisdiction of the FAA. This authority was granted by Congress via the Federal Aviation Act of 1958. The FAA established the National Airspace System (NAS) to protect persons and property on the ground and to establish a safe and efficient airspace environment for civil, commercial, and military aviation. The NAS is defined as the common network of US airspace, including air navigation facilities; airports and landing areas; aeronautical charts; associated rules, regulations, and procedures; technical information; personnel; and material. This section also discusses system components shared jointly between civilian users and the military.

Federal Aviation Regulations (FAR) define six categories of airspace, each with distinct operating requirements, which conform in both name and description with airspace designations used internationally. The categories are Class A, B, C, D, E, and G, and each has decreasingly restrictive requirements regarding ATC communications, aircraft entry, aircraft separation, and VFR operations. The general shape and requirements of each airspace class are shown in **Figure 2.7**, *Airspace Classifications*. The airspace in the vicinity of the Study Area is shown in the PSRC web site and is also presented in **Figure 2.8**, *Study Area Airspace*.

Figure 2.7

Airspace Classifications

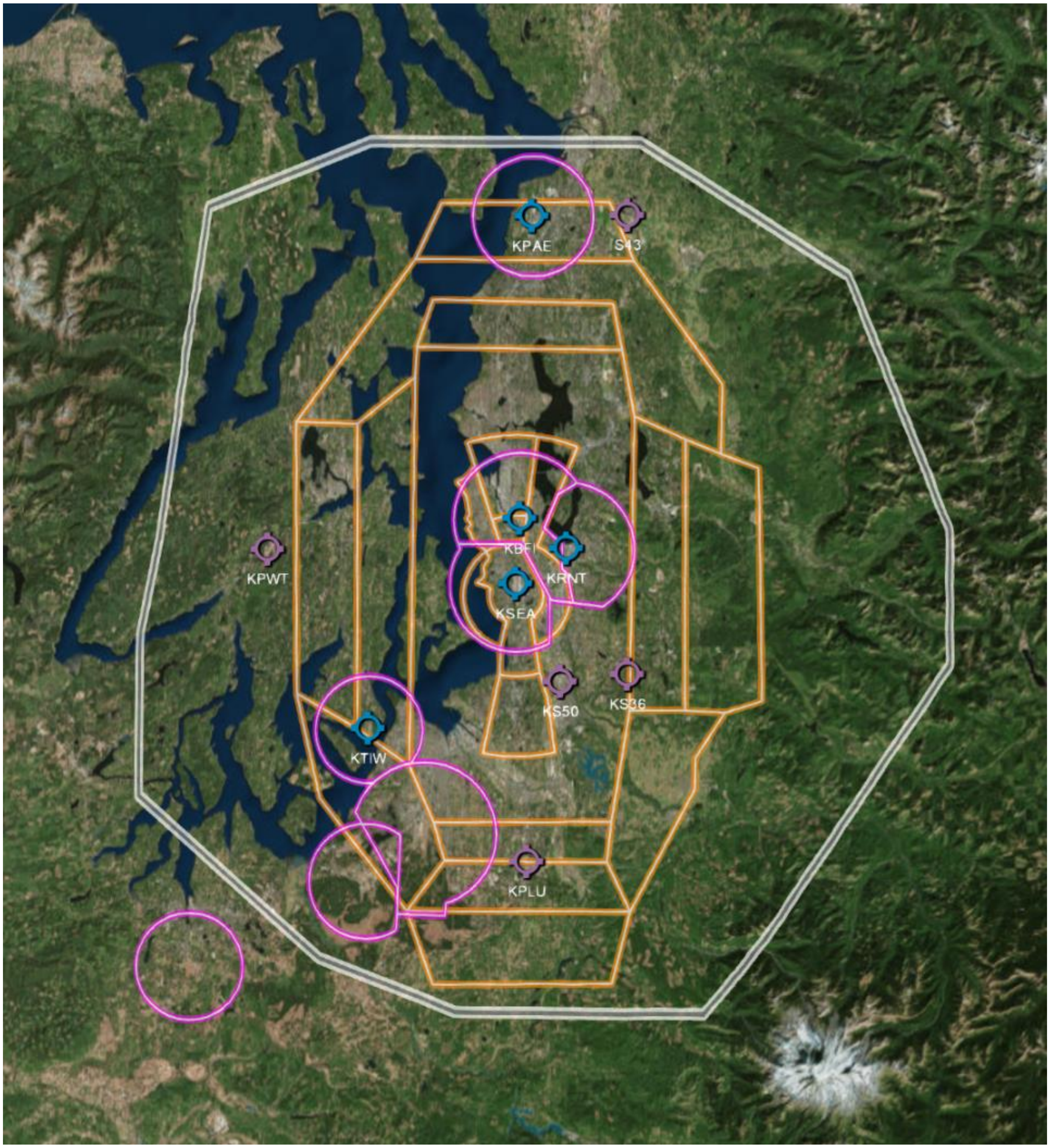


AGL = above ground level FL = flight level MSL = mean sea level

Airspace Class	Communication with ATC	Entry Requirements	Separation Services	Special VFR in Surface Area
A	Required for all operations	ATC clearance	All	N/A (No surface area)
B	Required for all operations	ATC clearance	All	Yes
C	Required for all operations	Two-way communications required prior to entry	VFR/IFR	Yes
D	Required for operations	Two-way communications required prior to entry	Runway operations	Yes
E	Required for IFR operations	Required for IFR operations	Required for IFR operations only	Yes
G	Not required	None	None	N/A (No surface area)

Source: Mead & Hunt, December 2014

Figure 2.8
Study Area Airspace



Source: BridgeNet International

Within the project study area the FAA maintains two VORs located at SEA-TAC and KPAE. A VOR is a *Very High Frequency Omni Directional Radio Range (a ground-located navigation aid).* The Olympia VOR, OLM, is just outside the study area in Olympia. In addition, the Air Force maintains a VOR at McChord Field that is also used for civilian navigation in the NAS. The two FAA VORs are part of the NAS VOR infrastructure that the FAA is evaluating as to which VORs are to be decommissioned. The McChord VOR is maintained by the Air Force and its future is unknown at this time. Generally, the Air Force does not need to maintain the McChord VOR facility for military use - this VOR is now more commonly used by civil aircraft. The maintenance cost of a VOR is roughly $80,000 per year. VORs are presented in **Table 2.6**, *List of VORs in Project Study Area.* Terminal VOR operates near or on an airport and is used within the terminal airspace; Low VOR operates between 1,000 – 14,000 feet above ground level (AGL) and High VOR operates between 14,001 – 60,000 feet AGL. As described in more detail in Chapter 1 of this report, VORs in a NextGen airspace environment are becoming obsolete and in many cases are no longer needed for navigation.

Table 2.6
VORs in Project Study Area

VOR	Name	*Type*	Owner	*Use**
SEA	Seattle	Vortac	FAA	High
PAE	Paine	VOR/DME	FAA	Low
OLM	Olympia	Vortac	FAA	High
TCM	McChord	Vortac	Air Force	Terminal

Source: BridgeNet International, January 2015
**VOR =*

Within the project study area there are 11 Instrument Landing Systems (ILSs), six at SEA-TAC (one serving each of the airport's runway ends). Of the nine general aviation airports located within the study area, four have ILSs. Two ILSs at KBFI provide instrument approaches to both runway ends, and one each at KPAE, KTIW, and KPWT serve south flow arrivals. South flow is the primary flow during inclement weather. The ILSs at SEA-TAC and KPAE are CAT II while all other ILSs are CAT I. The annual maintenance cost for a CAT I ILS is $125,000 while a CAT II/III is $325,000 per year. A more detailed description of the ILS and other procedures is presented in Section 2.9.

The current radar in the study area includes one Terminal radar near SEA-TAC and one long-range radar near Magnolia in Seattle. There are no other long-range radars within 100 NM of SEA-TAC; there are six with 250 NM. The 250 NM distance is generally considered the outer limit of line-of-sight coverage of the long-range radar.

The NextGen ADS-B infrastructure is complete and operational. Within the project study area, there are four ADS-B ground stations, a foundational technology for NextGen implementation. Two are located at SEA-TAC, and one at KPAE and one at KPWT (Bremerton National Airport). Surrounding the study area, there are also three ADS-B ground stations within 100 NM of SEA-TAC and 17 within 250 NM. Similar to radar coverage, the 250 NM distance is generally considered the outer limit of line-of-sight coverage for ADS-B. Chapter 3 of this study evaluates, in more detail, the potential expanded coverage with the new

ADS-B system, and will compare that to current coverage with conventional radar technology. A cursory review shows that the low altitude coverage to the north and west in the study area should be significantly improved as ADS-B use increases over time. Areas such as Auburn and to the southeast may not show much change. The mountainous area along the Cascades would have improved coverage with an enhanced ADS-B system. Under FAA rules for the ADS-B installation, ADS-B coverage is required to be the same or better than what is achieved with the current radar system.

2.9. Existing Procedures

There are a total of 79 published flight procedures for the study area airports and SEA-TAC. This includes Standard Terminal Arrival Procedures (STARs), Standard Instrument Departure Procedures (SIDs) and Instrument Approach Procedures (IAPs). Included in these categories are conventional and NextGen procedures. Because of the shared airspace of the study area airports with SEA-TAC and the shared use of many procedures, SEA-TAC and the study area airport procedures are presented. A graphical display of each of these procedures by airport is available on the project study website.

Table 2.7, *Existing STAR and SID Procedures,* presents the seven STARs within the study area, including five conventional and two RNAV procedures. The RNAV procedures are for SEA-TAC, while conventional procedures are shared by SEA-TAC, KBFI, KRNT, and KPAE. For example, aircraft arriving at SEA-TAC, KBFI, KRNT, or KPAE from the east will all be assigned the CHINNS NINE STAR. SEA-TAC has two RNAV STARs that are used as the primary arrival paths from the southwest and northwest. As is typical in the national airspace system, the lower activity GA airports serving primarily recreational users do not have STAR procedures.

Table 2.6 also presents the 14 SIDs within the study area. The four RNAV SIDs are specific to SEA-TAC while the remaining 10 procedures are conventional procedures. Each airport has separate SIDs, where unlike with STARs, there are no shared SIDs among airports. As is typical in the NAS, the lower activity GA airports do not have SID procedures.

Table 2.7
Existing STAR and SID Procedures

		Study Area Airports									
STARs	TYPE	SEA-TAC	KBFI	KRNT	KPAE	KTIW	KPWT	KPLU	S50	S36	S43
CHINS NINE	Conventional	X	X	X	X						
EPHRATA SIX	Conventional	X	X								
GLASR NINE	Conventional	X	X	X							
HAWKZ FOUR (RNAV)	NextGen	X									
JAWBN THREE	Conventional	X	X								
MARNR FOUR (RNAV)	NextGen	X									
OLYMPIA NINE	Conventional	X	X	X	X						
SIDs	TYPE	SEA-TAC	KBFI	KRNT	KPAE	KTIW	KPWT	KPLU	S50	S36	S43
BANGR SEVEN (RNAV)	NextGen	X									
ELMAA ONE	Conventional	X									
HAROB FOUR (RNAV)	NextGen	X									
KMORE THREE (RNAV)	NextGen	X									
KTSAP FOUR (RNAV)	NextGen	X									
MOUNTAIN SIX	Conventional	X									
SEATTLE FOUR	Conventional	X									
SUMMA SEVEN	Conventional	X									
KENT SIX	Conventional		X								
NEEDLE EIGHT	Conventional		X								
BELLEVUE TWO	Conventional			X							
RENTN TWO	Conventional			X							
PAINE TWO	Conventional				X						
NARROWS ONE	Conventional					X					

Source: BridgeNet International, January 2015

KBFI: King County International Airport, Boeing Field
KRNT: Renton Municipal Airport
KPAE: Snohomish County Airport, Paine Field
KTIW: Tacoma Narrows Airport
KPWT: Bremerton National Airport
KPLU: Pierce County Airport – Thun Field
S50: Auburn Municipal
S36: Crest Airpark (Kent)
S43: Harvey Field

Table 2.8, Existing *Instrument Approach Procedures,* presents a list of each of the published IAPs for the study area airports and SEA-TAC. Table 2.7 presents the category and type of procedure available at each airport based upon the navigation technology, including both conventional and NextGen procedures. **Table 2.9**, *Type of IAP Procedure and Height Above Touchdown,* displays the best available Height Above Touchdown (HAT) for each approach procedure for the study airports. This is presented for both north and south flow operations, which can be used to evaluate the accessibility of the airport in poor weather as well as in different flow conditions. Each of the types of NextGen procedures are described below:

Localizer Performance with Vertical Guidance (LPV). LPV approaches take advantage of the refined accuracy of WAAS lateral and vertical guidance to provide an approach very similar to a Category I ILS. Like an ILS, an LPV has horizontal and vertical guidance and is flown to a Decision Altitude (DA). The design of an LPV approach incorporates angular guidance with increasing sensitivity as an aircraft gets closer to the runway [or point in space (PinS) type approaches for helicopters]. Sensitivities are nearly identical to those of the ILS at similar distances. This is intentional to aid pilots in transferring their ILS flying skills to LPV approaches. The production schedule for LPV procedures is presented in **Figure 2.9**, *LPV and LP Production Schedule*.

Lateral Navigation/Vertical Navigation (LNAV/VNAV). LNAV/VNAV approaches provide both horizontal and approved vertical approach guidance. Vertical Navigation (VNAV) utilizes an internally generated glideslope based on WAAS or baro-VNAV systems. A baro-VNAV system determines barometric altitude and RNAV information. Minimums are published as a DA. If baro-VNAV is used instead of WAAS, the pilot may have approach restrictions as a result of temperature limitations and must check predictive receiver autonomous integrity monitoring (RAIM). RAIM monitors the integrity of the GPS signal.

Localizer Performance without Vertical Guidance (LP). LPs are non-precision approaches with WAAS lateral guidance. They are added in locations where terrain or obstructions do not allow publication of vertically guided LPV procedures. Lateral sensitivity increases as an aircraft gets closer to the runway (or PinS type approaches for helicopters). Unlike and ILS, LP is not a fail-down system. While flying an ILS, if the glideslope goes out of service, the pilot can continue the approach using just the localizer and switching from descent to a DH to the higher MDA. LPV does not have the feature to fail down to the LP (localizer equivalent). LP and LPV are independent procedures. LP minimums will not be published with lines of minima that contain approved vertical guidance (LNAV/VNAV or LPV). LP lines of minima are Minimum Descent Altitudes (MDAs) rather than DAs. It is possible to have LP published on the same approach chart; an LP is published if it provides lower minima than the LNAV.

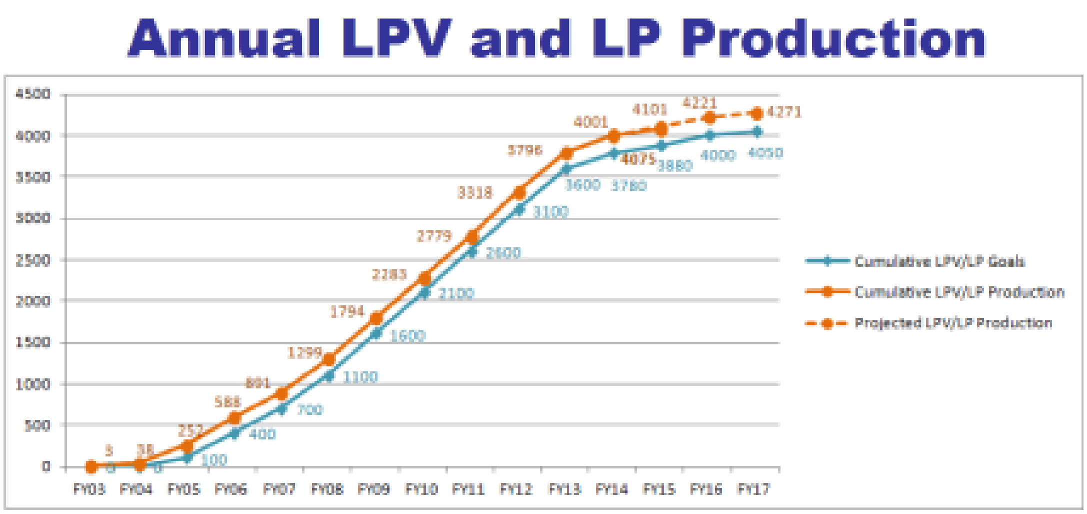
Lateral Navigation without Vertical Guidance (LNAV). LNAV approaches are non-precision approaches that provide lateral guidance. The pilot must check RAIM prior to the approach when not using WAAS equipment. Both LP and LNAV lines of minima are Minimum Descent Altitudes (MDAs) rather than DAs. It is possible to have LP and LNAV published on the same approach chart. An LP is published if it provides lower minima than the LNAV.

<u>GPS Approaches</u>. These are legacy GPS approaches that use GPS without the benefit of WAAS. They are being updated and replaced over time with one of the above WAAS enabled procedures.

Currently there are LPV procedures in the study area, of which six are at SEA-TAC. Of the nine GA airports in the study area, four have LPV procedures (KRNT, KPAE, KTIW, KPWT). At KPAE, KTIW, and KPWT the LPVs are in both runway directions, while KRNT is from north. The LPVs from the north at KPAE and KPWT have HAT values of 200 feet, while all the other LPVs do not achieve the optimum 200 HAT value. There are no new LPV procedures in the study area scheduled for the current fiscal year.

Figure 2.9

LPV and LP Production Schedule



	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17
Non-ILS Runway Ends	0	7	80	188	195	263	259	375	412	463	443	182	69	0	0
ILS Runway Ends	3	28	134	148	108	145	236	114	84	76	35	23	5	0	0
LPVs/LPs	3	35	214	336	303	408	495	489	496	539	478	205	74	0	0
Annual LPV/LP Goals	0	0	100	300	300	400	500	500	500	500	500	180	100	120	50
Cumulative LPV/LP Goals	0	0	100	400	700	1100	1600	2100	2600	3100	3600	3780	3880	4000	4050
Cumulative LPV/LP Production	3	38	252	588	891	1299	1794	2283	2779	3318	3796	4001	4075	4075	4075

FY15 LPV/LPs Produced	74
FY15 LPV/LPs Counted Towards Goal	69

Source: Tetra Tech, January 2015

Table 2.8
Existing Instrument Approach Procedures

Airport	IAP Procedure	Type
KBFI	ILS OR LOC RWY 31L	Conventional
KBFI	ILS RWY 13R	Conventional
KBFI	RNAV (RNP) Z RWY 13R	NextGen
KBFI	RNAV (GPS) Y RWY 13R	NextGen
KBFI	LOC/DME RWY 13R	Conventional
KBFI	HARBOR VISUAL RWY 13R	Conventional
KRNT	RNAV (GPS) Y RWY 16	NextGen
KRNT	RNAV (GPS) Z RWY 16	NextGen
KRNT	NDB RWY 16	Conventional
KPAE	ILS OR LOC/DME Y RWY 16R	Conventional
KPAE	ILS OR LOC/DME Z RWY 16R	Conventional
KPAE	ILS Z RWY 16R (SA CAT II)	Conventional
KPAE	RNAV (GPS) RWY 34L	NextGen
KPAE	RNAV (GPS) Y RWY 16R	NextGen
KPAE	RNAV (GPS) Z RWY 16R	NextGen
KPAE	VOR/DME RWY 16R	Conventional
KPAE	VOR RWY 16R	Conventional
KTIW	ILS OR LOC RWY 17	Conventional
KTIW	RNAV (GPS) RWY 17	NextGen
KTIW	RNAV (GPS) RWY 35	NextGen
KTIW	NDB RWY 35	Conventional
KPWT	ILS OR LOC RWY 20	Conventional
KPWT	RNAV (GPS) RWY 02	NextGen
KPWT	RNAV (GPS) RWY 20	NextGen
KPLU	GPS RWY 34	NextGen
S50	RNAV (GPS)-A	NextGen
S36	NO IAP PROCEDURES	
S43	RNAV (GPS) –A	NextGen

Source: BridgeNet International, January 2015

Table 2.9

Type of IAP Procedure and Height Above Touchdown (HAT)

		Study Area Airports (Best HAT-Height Above Touchdown -- Feet)									
South Flow IAP	Type	SEA-TAC	KBFI	KRNT	KPAE	KTIW	KPWT	KPLU	S50	S36	S43
ILS CAT II	Conventional	100			100						
ILS CAT I	Conventional	200	273		200	200	200				
Localizer	Conventional	385			370	466	759				
VOR/DME	Conventional				490						
VOR	Conventional				530						
NDB	Conventional			975							
LPV	NextGen	200		518	200	344	200				
LP	NextGen										
LNAV/VNAV	NextGen	332			374	698	954				
LNAV	NextGen	407	703	736	490	686	859		1257		1198
GPS	NextGen										
RNP AR	NextGen	328	505								
Circling		567	759	968	494	465	756	662	1257		1198
North Flow IAP	Type	SEA-TAC	KBFI	KRNT	KPAE	KTIW	KPWT	KPLU	S50	S36	S43
ILS CAT II	Conventional	100									
ILS CAT I	Conventional	200	407								
Localizer	Conventional	381	697								
Circling	Conventional	567	759	968	494	465	756	662	1257		1198
VOR/DME	Conventional										
VOR	Conventional										
NDB	Conventional					705					
LPV	NextGen	200			311	266	328				
LP	NextGen										
LNAV/VNAV	NextGen	439			458	474	469				
LNAV	NextGen	457			422	546	716		1257		1198
GPS	NextGen							662			
RNP AR	NextGen	316									
Circling		567	759	968	494	465	756	662	1257		1198

Source: BridgeNet International, January 2015

2.10. Avionics Equipage

Commercial and GA aircraft have been equipping for NextGen technology, preparing to use ADS-B for surveillance and WAAS for navigation.

ADS-B. The FAA tech center tracks the number of domestically registered aircraft flying in the NAS that are ADS-B equipped. As of January 1, 2015, there were approximately 8,800 U.S. registered GA aircraft that are equipped with ADS-B Out and 255 US registered commercial aircraft that are ADS-B equipped to the latest standard; this represents 4% and less than 1% of the fleet, respectively. A number of commercial airlines equipped to an earlier ADS-B standard that are yet to be upgraded; those aircraft are not included in these totals. Newly manufactured aircraft, both general aviation and commercial, will not necessarily be equipped with ADS-B in that it is an option by the customer. At this point in time, the consulting team was not able to determine the number of these equipped aircraft that are flying in the Puget Sound airspace after consulting with primary stakeholders including AOPA and airport operators. For the Puget Sound GA airports, United Postal Service (UPS) aircraft (operating at KBFI) and a majority of the new Boeing commercial aircraft (operating at KBFI, KRNT, and KPAE) are equipped with ADS-B. Equipage for GA is still meeting resistance because of the high cost and compliance issues (under discussion for resolution). The central issue remains cost, with an average ADS-B unit cost of $5,000; this can represent up to 15% of the value of a small GA aircraft.

WAAS. The number of GA aircraft equipped with WAAS is substantially higher than those equipped for ADS-B. A majority of general aviation aircraft that fly in IFR conditions are equipped. The higher performance the aircraft, the more likely it is WAAS equipped. WAAS is a technology that is primarily used by GA, and will not normally be equipped by Boeing aircraft used in the commercial fleet. Currently there are approximately 79,000 GA aircraft equipped with WAAS, which represents approximately 38% of the fleet (assumed 209,000 total GA aircraft). There are approximately 8,350 GA aircraft registered in Washington. Today about 80% of GA aircraft that file and fly IFR in the NAS will have WAAS avionics; an assumption was made by the consultant team that most all Washington state registered aircraft will have pilots carrying at least a non-certified hand held GPS for situational awareness. **Table 2.10,** *WAAS GA Aircraft Equipage,* lists the manufacture and the type of aircraft that would utilize this equipment.

Table 2.10
WAAS GA Aircraft Equipage

Manufacture	*Models*
Garmin	Covers most GA Part 23 aircraft: See FAA Garmin Approved Model List (AML) http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgstc.nsf/
Universal Avionics	121 fixed wing and 12 helicopter types and models: Airframes to include (Boeing, de Havilland, Dassault, Bombardier, Gulfstream, Lear, Bell)
Rockwell Collins	32 types and models Airframes to include (Beechjet, Bombardier, Challenger, Citation, Dassault, Gulfstream, Hawker, KingAir, Lear) Airbus 350 certification pending
Honeywell	19 types and models: Airframes to include (Gulfstream, Challenger, Dassault, Hawker, Pilatus, Viking)
Avidyne	3 types and models (Cirrus, Piper Matrix, and EA500) 300 IFD 540 WAAS LPV units pre sold (STC Pending June 2013)
Innovative Solutions & Support (IS&S)	Types: Eclipse 550/500 Boeing 737-400 (Pending)
Cobham (Chelton)	Multiple types and models: (407, Bell,412, Cessna 501, 550, Eurocopter AS350 Piper, PA42, Beechcraft C90&A, Augta AW109SP)

Source: BridgeNet International, January 2015

2.11. Preliminary Identified Airspace Constraints

This section describes a preliminary set of airspace constraints that have been identified by the project team. The constraints were derived by examining existing conditions information and discussing issues with FAA technical staff and some airport sponsors. In a subsequent task, the study team gathered input from additional stakeholders including airports and the GA industry and used that data to help shape the airspace actions in Chapter 3. For each airspace constraint issue, measures were identified for airspace improvements which might be achieved through implementation of NextGen technology. The key improvement measures include deconfliction, efficiency, access, and safety. PSRC staff, FAA, and the consultant team met in December 2014 to outline these measures and possible implementation measures to carry forward through use of satellite-based procedures, surveillance and data communications. The technical stakeholders preliminarily identified 14 issues, with seven of the issues being higher priority. **Table 2.11,** *NextGen Preliminary Airspace Study Issues,* shows these top 14 issues in order of generalized importance. **Table 2.11** also shows the goal which might be achieved by resolving each issue.

Table 2.11

NextGen Preliminary Airspace Study Issues

No.	Issue	*Goal*
1*	Boeing Field and Renton Airport dual approach during Plan C	Deconfliction
2*	Boeing Field RNAV south departure for new eastbound T routes	Efficiency and Deconfliction
3*	T Routes for operations over Cascades east and westbound	Safety and lower operating altitude
4*	Paine Field Runway 34 approach T or Y configuration	Deconfliction
5*	Paine Field Runway 16 RNAV departures	Deconfliction
6*	Renton Runway 16 RNP-AR Arrival	Safety and deconfliction
7*	Renton Runway 16/34 RNP Departure	Safety and deconfliction
8	Boeing Field RNAV departure for north and south operations	Deconfliction
9	Reduce VOR usage at McChord	Preparation for decommission
10	Paine Field and Cascades pilot/controller communications	Increase communication capabilities
11	Renton Runway 34 RNAV approach	Counterflow elimination
12	LPV/WAAS for smaller GA airports	Access and situational awareness
13	ADS-B equipage advantages	Access
14	Merging and spacing tool for ATC	Access

Source: BridgeNet International based on input received from the Study participants

* Priority issue.

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Chapter 3 – Evaluate Airspace Actions

The next step in the study process was to identify NextGen techniques and procedures that could address specific operating needs of general aviation aircraft in the Puget Sound Region. Chapter 3 of the report presents these potential airspace concepts. These actions were identified based upon the airspace inventory, evaluation of operating constraints, and the available NextGen programs, detailed in Chapter 2. A number of potential airspace actions were identified to improve operational flows for general aviation users. From that list, a select number of these potential actions were identified to further study as concepts. Each of the selected concepts was analyzed against the airspace issues to determine if a concept would be able to address a constraint or operational issue. This chapter organizes the airspace actions into categories and then airport-specific concepts. Many of the existing and concept procedure descriptions in this chapter will have an associated graphic on the project website in 3D and as animations. The project website is located at www.airportnetwork.com/psrc, using the password NEXTGEN in all caps.

3.1 Airspace Constraints

There are a number of different factors that constrain the airspace in the Puget Sound Region for General Aviation. With NextGen technology and programs, many of these constraints can be overcome or partially mitigated. The primary cause of constraints to GA users is that two of the largest GA airports are located in close proximity to Seattle-Tacoma International Airport (Sea-Tac) and these airports must share the airspace. Other factors include the mountainous terrain, weather, obstacles (man-made and natural), and land use patterns that limit how and where aircraft can fly. Many of the actions described in the following sections are designed to allow GA aircraft to fly and operate independently of Sea-Tac and to take advantage of the different ways airspace can be designed with NextGen technologies.

The constraints considered in this chapter may be characterized by the following list:

- Airports in close proximity to Sea-Tac (de-confliction).
    - Sea-Tac, Boeing Field, and Renton are less than 5 NM miles apart.
- Cascade Mountains terrain.
- Poor weather access to Boeing Field, Renton, and other GA airports.
- Shared use Standard Terminal Arrival Route (STAR) arrival procedures with Sea-Tac.
- Shared departure airspace with Sea-Tac.
- Local airport terrain/obstructions constraints.
- Environmental (noise, emissions) and land use patterns.

Many of the actions described in the following sections are designed to allow GA aircraft to fly and operate independently of Sea-Tac and to take advantage of the different way airspace can be designed with NexGen technologies.

3.2 Potential Actions

A number of concepts were identified as potential opportunities for improvements for which NextGen programs and technologies could be applied to the Puget Sound GA airspace. Of those concepts, a number were identified, with input from the study committee, for more detailed evaluation as shown in **Table 3.1**, *Potential Airspace Actions*. This more detailed evaluation was to study, to a preliminary concept level, to demonstrate how the concept might be applied, and what potential benefits could be derived. Many of these concepts were evaluated in the FAA's TARGETS[7] procedure design software program, as well as with visualization modeling. Use of TARGETS is one of the first steps in determining the viability of a procedure. Those that are described for further detail and evaluated to concept level are listed on the right side of Table 3.1 and evaluated to greater detail within this chapter.

The primary action proposed are the development of PBN flight procedures. PBN flight procedures are NextGen procedures based upon satellite navigation. The different types of PBN flight procedures were presented in Section 1.1 of this report.

One of the navigation technologies that was evaluated in this study was GBAS (Ground Based Augmentation System). GBAS is a technology that has had limited use in the United States, and primarily at large commercial airports such as Newark Liberty International and Houston Intercontinental. It is not a navigation technology that is being adapted by GA and is therefore not evaluated further in this study.

The concepts in this chapter were evaluated from an airspace standpoint with regard to limitations; should these concepts carry forward, they will also be evaluated for ground-based physical limitations. These will be covered in Chapter 4.

[7] TARGETS (Terminal Area Route Generation, Evaluation and Traffic Simulation) incorporates data visualization capabilities with readily accessible design elements to enable procedure designers to rapidly and easily develop [flight] procedures.

Table 3.1.
Potential Airspace Actions

LOCATION	NEXTGEN AIRSPACE ACTION	DETAIL CONCEPT
ALL GA	T Routes for operations over Cascades east and westbound	✓
	RNAV SIDs for General Aviation Airports (BFI, RNT, PAE)	✓
	RNAV STARS serving General Aviation Airports	
	LPV/WAAS for smaller GA airports	
KING COUNTY (BFI)	Boeing Field RNAV (GPS) Approach during Plan C	✓
	Boeing Field RNAV SID for North Flow	
	Boeing Field RNAV SIDs for All Runways (presented in All GA)	✓
RENTON (RNT)	Renton Runway 34 RNAV approach	✓
	Renton Runway 16 RNP-AR Arrival	✓
	Renton RNAV SIDs for All Runways (presented in All GA)	✓
	Renton Runway 16/34 RNP Departure	
PAINE (PAE)	T or Y Transitions for RNAV (GPS) Arrival, Runway 34R	✓
	Paine Field RNAV SIDs for All Runways (presented in All GA)	✓
	Paine Field and Cascades pilot/controller communications	
OTHER	ADS-B equipage advantages	
	Merging and spacing tool for ATC	
	Reduce VOR usage at McChord	

3.3 Puget Sound Regional Airspace - Study Airports

As noted earlier, nine actions were carried forward for refinement into operational concepts. In addressing each concept, the evaluation considered: issue to be addressed, current conventional conditions, preliminary NextGen concept**,** benefits of the concept, and technical factors.

3.3.1 T Routes over Cascades, East and West Bound

Issue to be addressed

There are currently three conventional low-altitude routes[8] that provide access to the Puget Sound Region to/from the east called V-Routes. These routes are flown by en route aircraft over the Cascade mountain range and, based upon a review of the radar data, the aircraft fly at altitudes between 9,000 feet MSL and 11,000 feet MSL. Flying in mountainous terrain at those altitudes in instrument meteorological conditions (IMC) can increase the risk of icing. Aircraft flying at a lower altitude have a lower risk for icing conditions due to air being warmer, as well as a reduced air traffic controller workload to descend the aircraft.

Current Conventional Conditions

The primary route directly from the east is Route V-2.[9] The location of that route is shown in **Figure 3.1**, *T-Routes for General Aviation*. The route flies between the SEA VOR, located west of the Cascades, and the ELN VOR, located east of the Cascades. This route serves all east/west low altitude operations for the nine general aviation airports in this study. When arriving into the Puget Sound region, these aircraft are radar vectored to their destination airport (i.e., Boeing Field or Renton). During departure, they are also radar vectored from their originating airport/filed flight procedure to a V route, such as V-2.

Preliminary NextGen Concept

A NextGen solution could include providing satellite-based low-altitude T-Routes that are not constrained by the location of ground based VORs and that can provide for increased access to area airports by flying at lower altitudes. This lower flight altitude, in addition to increasing access to general aviation airports, may also reduce the potential hazard of GA aircraft flying in icing conditions.

The implementation of up to three new T-Routes for east/west access over the Cascade Mountains was identified and recommended for consideration as a NextGen program that could improve the operations for smaller GA aircraft that access the Puget Sound region from areas east of the Cascades.

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[8] A "low altitude route" is an airway below 18,000 feet mean sea level used for aircraft flying in instrument flight conditions.

[9] A "V-Route" or Victor Airway is a Low Altitude IFR Route that aircraft flying at or below 17,500 use for en route navigation using ground-based navigational aids. A "T-Route" is a low altitude route (below FL180) requiring Global Navigation Satellite System navigation.

This would allow aircraft to fly east/west over the Cascades at lower altitudes (i.e., 7,700 feet MSL), which is lower than they typically fly today with conventional navigation. Another cardinal altitude would be provided for westbound aircraft. Generally, cardinal altitudes are used by air traffic; aircraft flying eastbound fly at an odd altitude and westbound fly at an even altitude (i.e., reported to the thousand feet – for example 8,000 feet MSL). Another option would be to construct the T-route using RNP-1 performance specifications versus RNP-2. RNP-“x” defines the width of the T-route from the Route centerline. RNP-1 means that the corridor is 1 NM wide each side of the Route centerline. By utilizing RNP-1 specifications, some of the controlling obstacles would be eliminated as an operational constraint along the route and lower the altitudes further to 6,500 feet MSL permitting another cardinal altitude (i.e., 7,000 feet MSL) for eastbound aircraft. A controlling obstacle could be a stationary, ground-based obstacle or lack of radio/radar coverage. The new T-Routes would also provide connectivity with the new proposed notional GA RNAV SIDs and STARS and provide increased access for GA aircraft and greater separation between GA and commercial traffic.

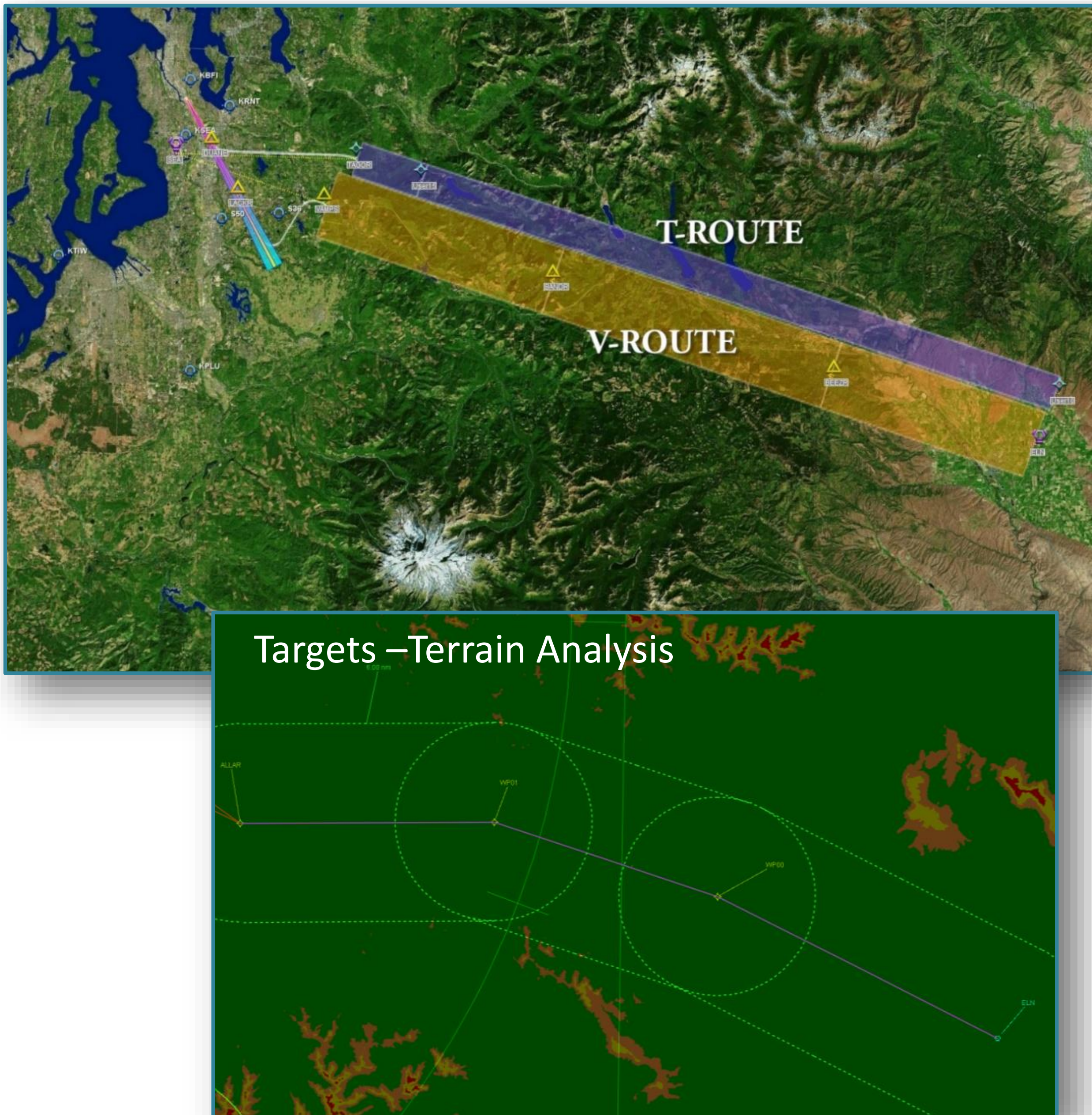
Benefits

1. *Data/Comm* - Reduced controller workload as the procedures would be more direct, requiring less transmissions between pilots and controllers.
2. *Access and Efficiency* - Increased access to/from the Puget Sound region general aviation airports with lower altitude routes from flights originating at frequently used airports east of the Cascade Mountains.
3. *Safety* - Improve safety by reducing icing potential.
4. *Environmental* - No changes to noise would be expected.

Technical Factors

The technical factors for this airspace concept involve the ability to ensure ADS-B can be “installed” to allow radio communications at lower altitudes.

Figure 3.1
T-Routes over Cascades, East and West Bound



Source: BridgeNet International

3.3.2 RNAV Standard Instrument Departures (SID) for Study Airports

Issue

The primary focus was to examine the departure scenarios between Sea-Tac, BFI, and RNT along with PAE. Currently, these airports are largely de-conflicted by the use of radar vectors issued by ATC/SEA TRACON. Radar vectors are also used as a noise abatement tool to avoid flying over sensitive land uses. This results in a dependent operation between the three airports and potentially inefficient procedures/routes to be flown by departing aircraft from the general aviation airports.

Current Conventional Conditions

Aircraft departing BFI and RNT must be released separately because of the existing configuration and air traffic rules, one being dependent on the other and safely integrated with activity at Sea-Tac. In IFR conditions especially, this causes aircraft to be delayed at the GA airports on a regular basis.

South Flow. In south flow in IFR or marginal VFR (MVFR) conditions when instrument approaches are being conducted to Sea-Tac, the departures from BFI and RNT can also interact with operations at Sea-Tac. This causes additional restrictions and delays due to the interactions between these three airports. During high activity periods, the necessity to protect airspace for missed approach aircraft further complicates the operation. Occasionally BFI traffic flying conventional procedures in south flow can turn early and into Sea-Tac airspace. See South Flow Scenarios 1-4 below for preliminary concepts.

North Flow. Conversely, in north flow, departures from BFI and RNT are largely independent of each other as are Sea-Tac and RNT departures. The challenge comes when BFI uses Runway 31 for departures (departing to the north) when there are also northbound departures from Sea-Tac.

Aircraft departing northbound off of Sea-Tac Runways 34 and aircraft departing Runway 31 at BFI are routinely in conflict due to the proximity of the airports, the runway configurations, and associated flight patterns. As described in Scenarios 1-4 below, in a south flow the departures can be de-conflicted laterally; however, in north flow Sea-Tac and BFI departures must be de-conflicted vertically, which means they must be separated by altitude. This is due to the desired path from both airports traversing through Elliott Bay to avoid overflying residential areas.

Currently, there is no means to separate departing aircraft in IFR or MVFR conditions between these two airports in a north flow use conventional technology and procedures. The team reviewed proposed enhancements by the SEA TRACON and found merit with the proposal to impose climb restrictions for departures off Sea-Tac and BFI. Current FAA order 8260.46E does not allow aircraft to be climb restricted for ATC separation; there is the ability to apply for a waiver from this order. The study team noted there is precedence for a waiver, including a GA airport in New Jersey, as at Teterboro climb restrictions for aircraft separation is used. Without de-confliction of the departure paths, numerous departure delays can be expected to continue at BFI.

Preliminary NextGen Concept

South Flow. There is a potential solution to the southbound dilemma caused by the proximity of the three primary airports, Sea-Tac, BFI, and RNT. The Equivalent Lateral Spacing Operations (ELSO) procedure currently in use at the Atlanta Hartsfield-Jackson International Airport (ATL) could be modified for use in a multiple airport scenario. ELSO is a new concept that allows aircraft to depart simultaneously from parallel runways, separated by 2,500 feet or more, while diverging by as little at 10-degrees. ELSO is an ATC procedure that has been approved for national deployment in the fall of 2015. ELSO SIDs can be used by all aircraft equipped with specific navigational equipment (GPS or DME/DME/IRU) as long as the aircraft is capable of flying RNAV SIDs under RNAV-1 criteria. RNAV-"x" defines the width of the procedure's protected airspace from centerline. RNAV-1 means that the corridor is 1 NM wide each side of the track's centerline. The concept for use in the Puget Sound Region would be for south operation in IFR or MVFR conditions, which could potentially be the next step in the evolution of the ELSO concept.

In the examples depicted below, aircraft departing the three airports would be assigned RNAV1 routes that are predictable, repeatable, and much more accurate than radar vectors, resulting in the de-confliction of the three airports. South flow scenarios are visually shown in the top portion of **Figure 3.2.** These scenarios are ELSO concepts that use diverging paths to de-conflict traffic. In the following scenarios, 'track' refers to aircraft using RNAV technology; 'heading' refers to aircraft flying a vector heading issued by ATC.

<u>Scenario A:</u> Arrival to Sea-Tac Runway 16L and departure from BFI Runway 13R on the proposed JEFFW1 RNAV SID:

a. Sea-Tac arrivals and departures would be separated by the 2 increasing to 3 rule.[10]
b. An arrival to Sea-Tac Runway 16L would execute a missed approach. Initial climb would be on a 165-degree heading.
c. A departure from BFI would climb out on an initial track of 133-degrees – more than 30-degrees divergence from the Sea-Tac missed approach aircraft's 165-degree track.
d. At the point the aircraft departing BFI would turn further south, the tracks would already be 1.89NM apart and diverging.
e. When the BFI departure would turn to a track of 151-degrees, the aircraft would be separated by at least 10-degrees from the Sea-Tac missed approach aircraft, which would be joining the SEA 161-R or on an RNAV missed approach on a 163-degree track.

<u>Scenario B:</u> Departure off of Sea-Tac Runway 16R and departure off of BFI Runway 13R on the JEFFW1 RNAV SID: *NOTE- Runway 16R departures are the worst case divergence scenario between SEA and BFI due to the initial heading being 161-degrees as opposed to departures off of Runways 16C/L initial heading of 163-degrees.*

a. Sea-Tac arrivals and departures would be separated by the 2 increasing to 3 rule.

[10] The 2 increasing to 3 rule is contained in FAA Order JO 7110.65, Para **5−8−4. DEPARTURE AND ARRIVAL -** *TERMINAL.*- Except as provided in para 5−8−5, Departures and Arrivals on Parallel or Nonintersecting Diverging Runways, separate a departing aircraft from an arriving aircraft on final approach by a minimum of *2 miles* if separation will increase to a minimum of 3 miles (5 miles when 40 miles or more from the antenna) within 1 minute after takeoff.

b. A Sea-Tac departure from Runway 16R that would execute the proposed SUMMA7 SID. Initial climb would be on a 161-degree heading and then via the SEA 161-R (R is a radial from the SEA VOR).
c. A departure from BFI would climb out on an initial track of 133-degrees then turn further south to a track of 151-degrees; the tracks would be 1.89NM apart and diverging.
d. When the BFI departure would turn to a track of 151-degrees, the aircraft tracks would be separated by at least 1.89 NM and 10-degrees divergence from the Sea-Tac departure aircraft which would be joining the SEA 161-R.

<u>Scenario C:</u> Departure from BFI Runway 13R on the proposed JEFFW1 RNAV SID and departure from RNT Runway 16 on the proposed ALLAR1 RNAV SID:

a. BFI Runway 13R departures on a track of 133-degrees would initially converge towards RNT airport. However, parallel to the departure end of RNT Runway 16, the BFI departure would turn further to the south to a 151-degree track and would never get closer to the RNT departure track than 1.89NM (11,340 feet).

NOTE- Aircraft using the ELSO Concept can be as close at 2,500 feet on parallel headings before beginning a turn to diverge by at least 10-degrees.

b. RNT Runway 16 departures would initially climb out on a 157-degree heading until reaching 500 feet AGL, approximately 1.0NM from the Departure End of the Runway (DER). At this point, the RNT departure would turn southeast to a 117-degree track.

<u>Scenario D:</u> South flow departures from Sea-Tac and departures from RNT Runway 16 on the ALLAR1 RNAV SID: These airports are more than 3-miles apart and their SID tracks diverge by more than 40-degrees immediately after departure. These airports could operate independently without a waiver.

North Flow. Departures in north flow are grouped into two primary scenarios: 1) RNT vs BFI/Sea-Tac and 2) BFI vs. Sea-Tac. These are shown visually in the bottom portion of **Figure 3.2**, *RNAV SIDs for General Aviation Airports.*

<u>Scenario E</u>: North departures from Sea-Tac/BFI and departures from RNT Runway 34 on the proposed DNHTR1 RNAV SID: The DER at both Sea-Tac and BFI are more than 3-miles from the DER of Runway 34 at RNT. Additionally, the departure track off of RNT is always more than 3-miles from the departure tracks off of Sea-Tac and BFI. RNT departures could also turn to the northeast immediately after departure, further increasing separation from the other two airports' departures. RNT could operate independently of Sea-Tac and BFI without a waiver.

<u>Scenario F</u>: North departures from Sea-Tac and BFI are routed through Elliot Bay for noise reasons. Considering the proposed KTSAP4 RNAV SID off of Sea-Tac for northbound departures and the proposed WILLM1 RNAV SID off of BFI Runway 31, both SIDs would use approximately the same initial route. Implementing RNAV SIDs with built-in altitude restrictions could accomplish both a noise abatement role and de-conflict the departures vertically. This would enable the two airports to operate independently in all weather conditions, thereby reducing departure delays without compromising safety or adversely affecting the environment.

Benefits

1. *Access and Efficiency:* Departure delays to general aviation activity would be greatly reduced.
2. *De-confliction:* Airports could operate independently.
3. *Data/Comm*: Pilot/Controller communication would be reduced due to pilots automatically flying predictable, repeatable RNAV paths.
4. *Safety*: Separation of aircraft would be ensured by RNAV SIDs instead of radar vectors. Pilot/Controller workload would be reduced and situational awareness increased.
5. *Environment*: RNAV routes can be designed to minimize noise impact to avoid overflying residential areas.

The primary benefits of the RNAV departure scenarios would be that the three airports could operate independently. The proposed notional RNAV SIDs off of BFI and RNT would be separated from arrivals and departures at Sea-Tac.

The notional RNAV SIDs would reduce workload for both pilots and controllers by automating the route structure. This would result in reduced communications between pilots and controllers, reduced possibility of read-back[11] errors, and enhanced situational awareness. All of this would contribute to an overall enhancement of safety in the airspace within the region.

Technical Factors

Scenario: A, B, C. In Scenarios A, B, and C, the most significant issue to implementing these concepts would be the ability to leverage the ELSO concept in a south flow to de-conflict the three airports. It seems a natural progression for ELSO; however, it will require a Safety Risk Management Panel (SRM Panel) to be convened and a waiver and/or a Facility Specific Safety Standard (FSSS) to be approved.

In Scenario C, the primary technical factor would be the initial convergence of the departure tracks. This is the reason that these airports do not conduct independent operations today. However, with the use of RNAV SIDs, a window of opportunity would be open to use the proven, predictable, repeatable, and accurate performance of RNAV to mitigate the risk associated with the initial convergence of these routes. As stated above, the closest proximity of these procedures is 1.89NM or 11,340 feet. At that point, the procedures would diverge by over 40-degrees. A SRM Panel will have to review this scenario to ensure that it meets an equivalent level of safety to a parallel runway operation at 2,500 feet with divergence of 10-degrees or more after departure. Given that the closest proximity of the procedures is 11,340 feet, if an aircraft would blunder at that point, the controller would have at least as much time to correct the blunder as an aircraft departing a parallel runway 2,500 feet away. Additionally, in Scenario 3, the BFI departure would have been climbing for over 2NM. This would add a vertical component of separation that is not present in parallel runway departures from the same airport.

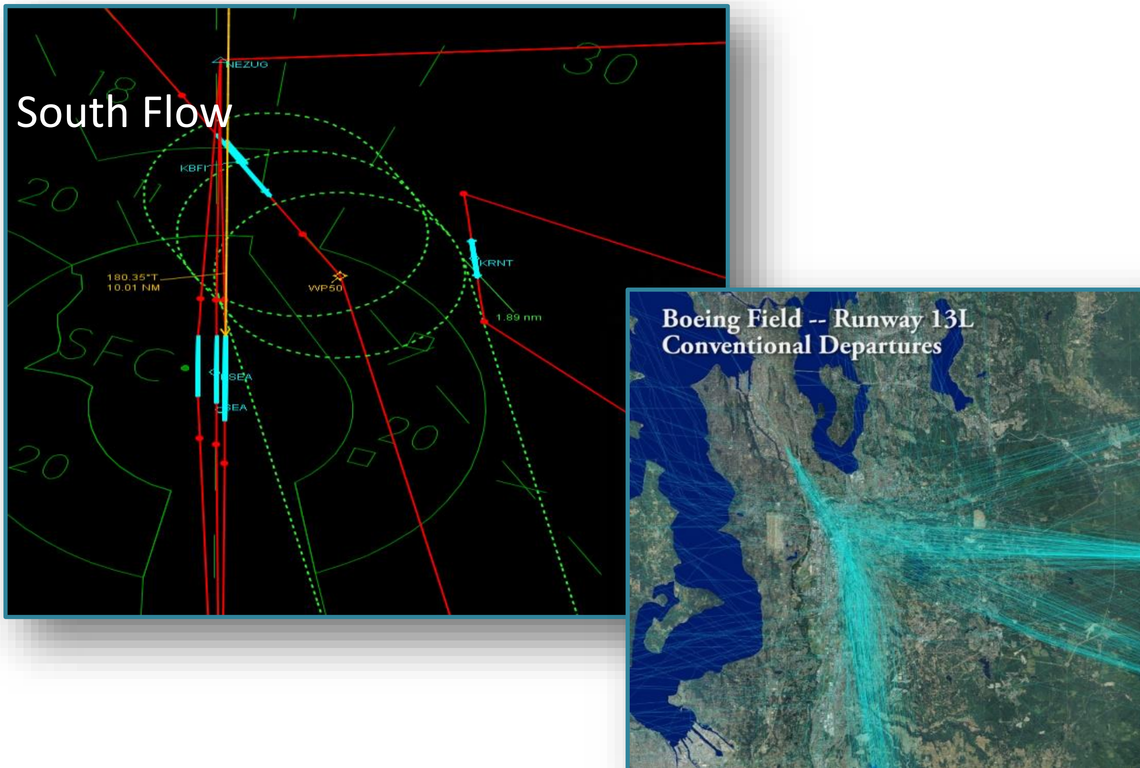
[11] According to Federal Aviation Regulation Aeronautical Information Manual 4-4-7A: Pilots of airborne aircraft should read back those parts of ATC clearances and instructions containing altitude assignments vectors, or runway assignments as a means of mutual verification.

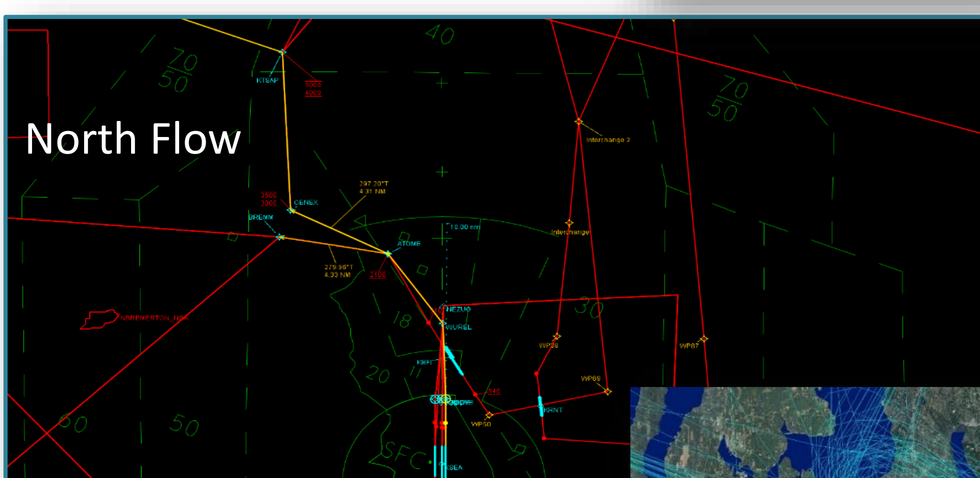
NOTE- The above Technical Factors were calculated using headings adjusted for a Magnetic Variation of 17E. When conducting a SRM Panel, either a Magnetic Variation (MagVar) study needs to be completed, or the Sea-Tac area of the SRM Panel should use True North heading s/tracks as the basis of comparison.

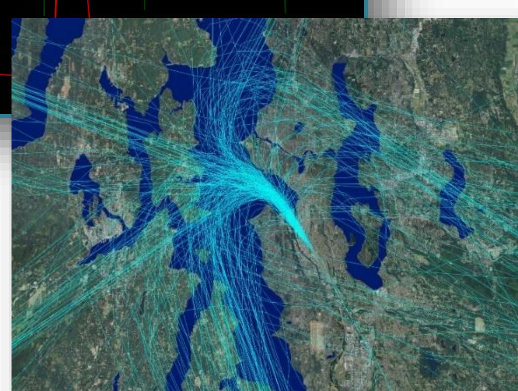
Scenario: D, E. In Scenarios D and E, the only technical issues of concern would be the ability to place aircraft on the most preferable noise path due to criteria, including leg length and turn angle. Leg length and turn angle criteria sometimes reduce the ability to design the most noise friendly routes. This could be addressed through waivers to design criteria, by evaluating the types of aircraft that would typically use the procedures and getting approval from Flight Standards to modify the criteria for the SIDs showing that an equivalent level of safety is maintained by the reduced leg length. This would enable the SIDs to be designed in the most noise friendly way while maintaining a high level of safety and efficiency.

Scenario F. Scenario F would require specific climb gradients for aircraft departing Sea-Tac to the north, as well as close in altitude restrictions for aircraft departing BFI. This scenario would require a review by a SRM Panel and by Flight Standards to ensure that aircraft can perform the maneuvers required safely. An ATC separation waiver would also be required due to the fact that standard separation of either 1000 feet vertical or 3 miles lateral cannot be guaranteed in this scenario. As aircraft depart Sea-Tac, they would be climbing to an altitude at least 1,000 feet above the BFI departures. However, the Sea-Tac departures would not have achieved 1,000 feet vertical separation before losing the required 3-mile lateral separation. As vertical separation would increase lateral separation would decrease and there may be a point at which an aircraft could be in a situation with less than 1,000 feet vertical, less than 3-miles lateral, and not have achieved divergence. The window for such an occurrence would be very small and that is why it is expected that a waiver could be obtained.

Figure 3.2
RNAV SIDs for General Aviation Airports







Source: BridgeNet International

3.4 King County Airport

3.4.1 RNAV (GPS) Approach during Plan C

Issue

Due to the close proximity of BFI to Sea-Tac, in poor weather north flow conditions (Plan C), access to BFI is constrained because its airspace conflicts with Sea-Tac operations. New NextGen procedures may allow for increased access by de-conflicting the BFI airspace from Sea-Tac airspace.

Current Conventional Conditions

When the Puget Sound airspace is operating in north flow and there is incremental weather, ATC refer to this condition as Plan C. While this condition only occurs about 5% of the time, when it does occur, it puts severe constraints on access to BFI because approaches to BFI conflict with operations at Sea-Tac departing to the north. Operations from the two airports must be separated by ATC in a manner that generally reduces operations and creates delay. To allow an aircraft to land at BFI, ATC must hold operations at Sea-Tac, thereby resulting in delays where BFI arrivals are reduced to four an hour from the capacity for nearly 100 an hour in good weather. An example of this current operational scenario is presented in **Figure 3.3**, *Plan C North Flow***.**

Preliminary NextGen Concept

NextGen technology could be used to de-conflict the two airports, thereby allowing simultaneous and independent operations. This technology is called procedural separation in that the procedure the aircraft is flying provides for the necessary separation requirements. With NextGen procedures, the area of required separation would be less than with conventional procedures. A potential NextGen procedure would provide for a procedure that flies to a point in space, and when the aircraft reaches that point, and can see the runway at BFI, the pilot would cancel the instrument approach and land at BFI using visual conditions. If the pilot is unable to see the airport, then he would perform a go-around. An example of this concept is also presented in **Figure 3.3.**

Waiver 11-T-23A was approved along with a Facility Specific Safety Standard on 12/3/2013 by Air Traffic and on 12/19/2013 by the FAA'S office of Air Traffic Safety Oversight, AOV, for simultaneous approaches to be conducted between Los Angeles International Airport and the nearby Hawthorne Airport (Hawthorne is a GA facility located approximately 1.5 miles east of LAX under the predominant arrival path to LAX). A combination of new RNAV (GPS) and waiver may provide for the separation standards necessary to provide independent approaches between SEA and BFI, which are similarly situated in close proximity to one another.

Benefits

1. *De-confliction* – Would improve access to both airports by allowing them to operate independently.
2. *Safety* – Would provide a new approach procedure to BFI in poor weather conditions.
3. *Access* – Would enable increased access at low minimums in poor weather conditions to BFI.
4. *Environment* – Would reduce delays, minimizing operations in holding patterns and vectoring that results in unnecessary emissions.

Technical Factors

There are no limiting factors to implementation.

Figure 3.3
RNAV (GPS) Approach during Plan C

Source: BridgeNet International

3.5 Renton Municipal Airport

3.5.1 RNAV (GPS) Approach, Runway 34

Issue

When Sea-Tac and the airports of the region are in north flow and the weather is poor, there currently is not a north flow instrument approach procedure to RNT. Aircraft must approach from the north and land to the south or perform a circle-to-land. While this situation only occurs approximately 5% of the time, it does increase the complexity of the airspace operations and access to RNT when these conditions occur.

Current Conventional Conditions

The optimum flow configuration for the Puget Sound Region is driven by the flow that is optimum for Sea-Tac operations, given the volume of operations and aircraft performance. The surrounding airports generally operate in that same flow. Under north flow poor weather, where an instrument approach procedure is required to land at RNT, aircraft must be radar vectored north of the airport to land on Runway 16 or circle to perform a circle-to-land procedure into RNT Runway 34. These procedures require controllers to direct aircraft counter to flows of the other airports' arriving aircraft, thereby increasing workloads, the resulting in potential delays and access reduction. An example of the flight path for an aircraft arriving from the southwest is presented in **Figure 3.4**, *RNAV GPS Approach, Runway 34*. This shows an aircraft entering the region on the Olympia STAR, then radar vectored to the northeast of Renton to circle back to approach the runway from the south.

Preliminary NextGen Concept

The potential alternative would be to develop an RNAV (GPS) procedure for approaches to RNT Runway 34. This procedure would allow for aircraft flying to RNT during conditions when the airspace is operating in north flow and poor weather, to approach and land at RNT in north flow instead of flying around to land from the south. This would provide a more direct approach to RNT and would reduce the amount of controller-directed radar vectoring. An example of this potential procedure for aircraft arriving from the southwest is also presented in **Figure 3.4**. RNAV (GPS) approaches (e.g., LPV) could provide instrument approach access to a large percentage of the equipped GA aircraft that operate at RNT. An RNAV (GPS) approach procedure from the south to RNT Runway 34 is presently constrained due to terrain changes and obstacle conditions. Therefore, the procedure may require a high approach slope, or have higher minimums. The minimums were estimated to be similar to those with the current south flow approaches. In addition, the type of poor weather that is common in this flow consists of a higher cloud cover condition that does not require a low minimum approach altitude.

Benefits

1. *Safety* – Would provide a north flow instrument approach procedure.
2. *Access* – Would increase access to RNT at low minimums in north flow conditions.
3. *Environment* – Would reduce total population overflown compared to an approach from the north. This potential RNAV (GPS) procedure would result in a 31% reduction in population overflown by the procedure and could achieve a 32% reduction in fuel consumption.

Technical Factors

There are no limiting factors to implementation.

Figure 3.4
RNAV (GPS) Approach, Runway 34

Source: BridgeNet International

3.5.2 RNP-AR Approach, Runway 16

Issue

Current RNT approaches from the north to Runway 16 require a straight-in path from the north over Mercer Island that has terrain constraints as well as noise sensitivity. An RNP-AR approach that follows the east side of Lake Washington could provide reduced terrain elevation capability and reduced total population overflown.

Current Conventional Conditions

The primary configuration for landing at RNT is south flow. This is also the flow under which poor weather typically occurs. The airport has a conventional Non-Directional Beacon (NDB) approach procedure and two NextGen approaches that require use of different navigation technology. All three approaches generally land straight-in from the north over Mercer Island, with a minimum decision altitude ranging from 600 to 1,000 feet MSL. The path of the NDB procedure is presented in **Figure 3.5**, *RNT RNP-AR Approach***.**

Preliminary NextGen Concept

RNP approach procedures allow for curved approach paths that can potentially follow precise, desired paths that avoid high terrain/obstacles or noise sensitive land uses. The proposed RNP-AR path would follow the east channel of Lake Washington, east of Mercer Island. The location of that procedure is also presented in **Figure 3.5.** This RNP-AR approach procedure may not yet provide a large increase in access due to the fleet mix and lack of equipage to conduct RNP-AR approaches. The AR stands for "Authorization Required," which means the aircraft, operator, and pilot must be equipped and authorized to fly the procedure. This alternative may be considered a medium-term option that is presented to illustrate the potential benefits of these procedures as criteria evolves and/or more aircraft become RNP-AR capable. Additional access for non-RNP-AR aircraft may be gained by applying AC-90-105 RNP criteria which would allow for RNP approaches with a radius-to-fix, or RF Turns (curved paths), without the AR requirements. This would enable many more aircraft to fly the procedure. Given the predominant GA fleet operating at this airport, the RF turns may be the preferred option.

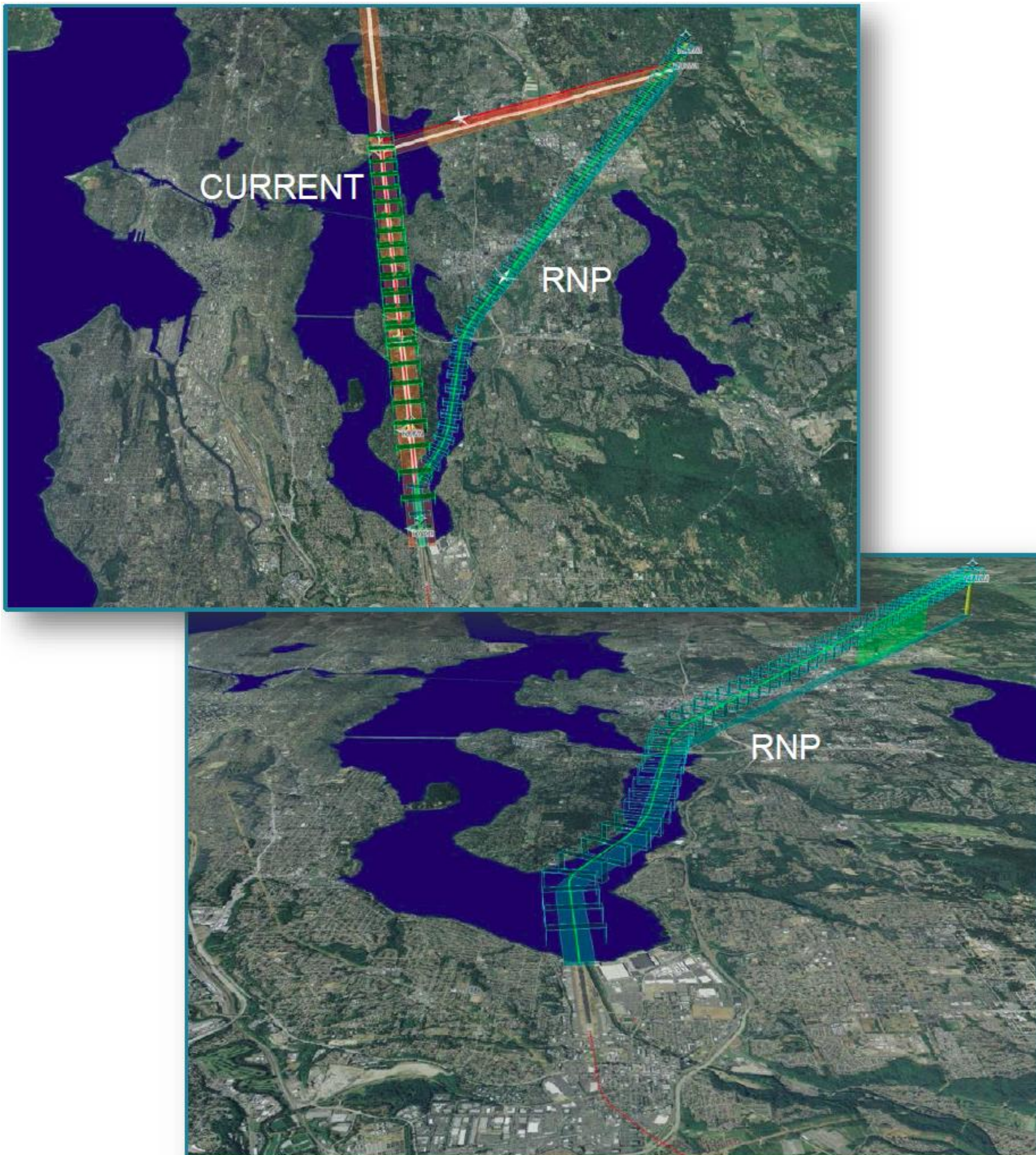
Benefits

1. *Safety* – Would provide an RNP-AR procedure that provides for stabilized approaches.
2. *Access* – Would enable increased access at low minimums in poor weather conditions to RNP-AR capable aircraft.
3. *Environment* – would reduce population overflown during approaches from the north. The potential RNP-AR procedure could result in a 17% reduction in population overflown by the procedure and a 14% reduction in fuel consumption.

Technical Factors

There are no limiting factors to implementation.

Figure 3.5
RNP-AR Approach, Runway 16



Source: BridgeNet International

3.6 Paine Field

3.6.1 T or Y Transitions for RNAV (GPS) Arrival, Runway 34R

Issue

While Sea-Tac and PAE are both within the Puget Sound area, there are times that these two airports experience different weather patterns. For example, there are times when Sea-Tac is in south flow and wind conditions north of the city in what is known locally as the weather convergence zone, dictate that PAE is in north flow. Under these conditions, arrivals into Sea-Tac and arrivals into PAE share the same airspace and require additional separation by controllers to de-conflict traffic utilizing the same airspace. This can lead to delays at both airports and less efficient operations.

Current Conventional Conditions

During certain wind conditions that occur around 20% of the time, aircraft are operating in south flow into Sea-Tac and north flow into PAE. As a result, aircraft are radar vectored into the same airspace that can result in delays and reduced efficiency.

Preliminary NextGen Concepts

The RNAV (GPS) approach procedures for north flow PAE (Runway 34R) could be updated to allow for transitions that intersect the final approach further to the north and closer to PAE, allowing transitions from both the east and west. These transitions could be connected to the RNAV STARS presented that would provide more direct routes into PAE, with minimal need for controller intervention and a reduction or possible elimination of interaction with Sea-Tac traffic. This concept is presented in **Figure 3.6**, *Paine Field T or Y Routes*.

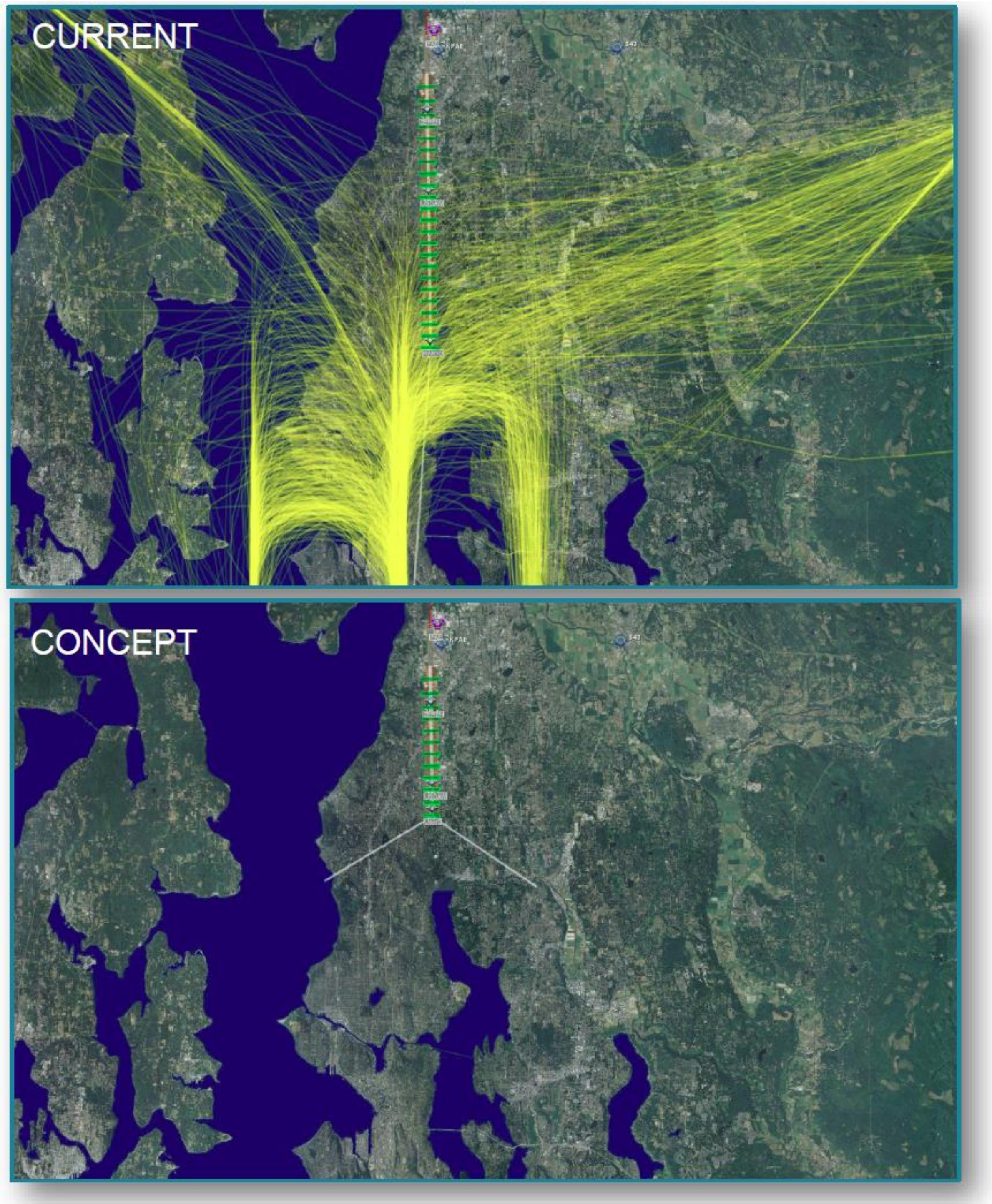
Benefits

1. *Safety* – Would improve when airports are de-conflicted.
2. *Access and Efficiency* – Would increase access and efficiency of PAE by removing de-confliction and direct access from the RNAV STAR to the RNAV (GPS) instrument approach procedure.
3. *Environment* – Would reduce potential noise and fuel consumption by reducing the need for radar vectoring aircraft.

Technical Factors

There are no limiting factors to implementation.

Figure 3.6
T or Y Transitions for RNAV (GPS) Arrival, Runway 34R



Source: BridgeNet International

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Chapter 4 – Evaluate Airspace Actions

Chapter 3 presented the potential NextGen concepts for general aviation operations within the Study Area. These concepts were generated to address the issues and their causes presented in Chapter 1, Table 1.3 and Table 1.4. The NextGen concepts were reviewed from the ability to fly the procedure with existing or short-term technology, however they were not assessed with regard to ground-based constraints. As noted in Chapter 3, obstacles within the region represent one of the issues that would need to be addressed before implementing any of the recommendations. Chapter 4 elaborates on the ground-based, physical obstacles at each of the study airports; this chapter will present the obstacle evaluation analysis, and note any locations that obstacle removal would be required.

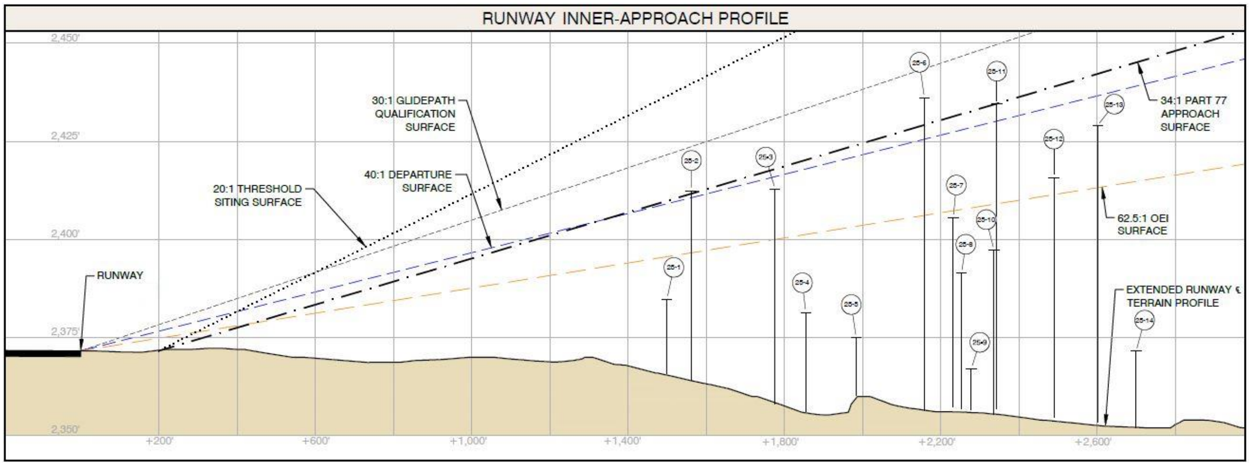
An obstacle evaluation considers three obstacle identification surface types that are critical to NextGen instrument procedure implementation: Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5300-13A runway threshold siting surfaces (TSS); U.S. Standard for Terminal Instrument Procedures (TERPS) surfaces included in AC 150/5300-13A; and one engine inoperative (OEI) surfaces that were removed through-150/5300-13A revision to AC 150/5300-13. Obstacle identification surfaces play a key role in instrument procedure design, and keeping these surfaces clear of obstructions may allow development of instrument procedures with lower minima. Lower minima will keep airports open during periods of inclement weather, and improve airport operational utility. Obstacle identification surfaces are analyzed by each runway end, therefore each airport may have multiple threshold siting surfaces to be identified.

Obstacle identification surfaces include:

- 20:1 threshold siting surface
- 30:1 glide path qualification surface
- 40:1 departure surface
- 34:1 FAR Part 77 approach surface
- 62.5:1 One Engine Inoperative (OEI) surface

Applicable surfaces described above were evaluated for each of the airports included in this study. The type of obstacle identification surface at an airport is dependent on the type of procedures in place. Airports that do not have vertically guided instrument approaches and high minimums do not have as restrictive surfaces as airports with approach procedures that feature vertical guidance and low visibility minimums that have more restrictive surfaces. In some instances, airports with multiple runways have different surfaces that apply to each runway end. The study evaluated the potential for vertically guided approach procedures in locations where none currently exist. The analysis identified known obstacles within the identification surface boundaries, and evaluated whether or not the obstacle penetrates the identification surface. In cases, where identification surfaces would be penetrated, a recommendation was made on how to address the penetration. Example obstacle identification surfaces are shown in **Figure 4.1**, *Example Obstacle Identification Surfaces*.

Figure 4.1: Example Obstacle Identification Surfaces



Source: Mead & Hunt, June 2015

4.1 Obstacle Sources & Terminology

Obstacle: An object that has the potential to penetrate airspace surfaces.

Obstruction: An object that penetrates airspace surfaces.

Hazard: An object that penetrates airspace surfaces and negatively impacts navigable airspace.

This study considered known obstacles from two FAA data sources: 1) the FAA's digital obstacle file, and 2) the database from the FAA Airport GIS Surface Analysis and Visualization (SAV) 20:1 visual approach surface analysis tool (20:1 Tool) and 30:1 glideslope qualifying surface tool (30:1 Tool). Research for this study considered ongoing FAA Airports GIS (AGIS) airport airspace analysis projects (such as the one underway for RNT); however, none were complete in time to be included in this analysis. Despite efforts made to obtain the most comprehensive and current data available, it is possible that obstacles exist that are not included in the two databases used in this study. ***Therefore, it is recommended that airport sponsors considering a feasibility study for any type of instrument approach first complete an airport airspace analysis per the requirements of AC 150/5300-18B***. This will provide airport sponsors with up-to-date information on obstacles that may impact instrument procedure feasibility and minima.

In FAA terminology, obstacles are objects included in FAA databases, and not necessarily obstructions or hazards. Obstacles can be a fixed object, such as a building, tree or land mark; they can also be a fixed object such as road with a moving object. Obstacles are obstructions when they penetrate FAA obstruction identification surfaces (such as those in FAA Advisory Circular 150/5300-13A and TERPS), and obstructions are hazards when they can negatively affect navigable airspace. The FAA further classifies obstructions for certain TSS types in terms of risk, as shown in **Table 4.1**. The lower the criteria, e.g. 20 feet, the steeper the slope; for example, for every 20 feet along the ground, the slope moves up by one foot.

Table 4.1: **FAA Obstruction Risk Classification**

Risk	Criteria	Penetration	Description
Low ◆	20:1	>3 Feet	FAA is not required to take immediate action to restrict Instrument Approach Procedures (IAPs) for these penetrations.
Medium ■	20:1	≤3 feet to ≥11 feet	FAA is not required to take immediate action to restrict IAPs for these penetrations.
High ▲	20:1	≤11 feet	The FAA must take immediate action to restrict the IAP visibility to at least one statute mile (SM) and, if the object is not lit, restrict night operations.
Penetration ●	30:1	>0	When an object exceeds the height of the Glide Slope Qualifying Surface (GQS), the FAA will not authorize Approach Procedures with Vertical Guidance (Instrument Landing System (ILS), Precision Approach Radar (PAR), Lateral Navigation (LNAV), Vertical Navigation (VNAV), etc.).

Source: FAA Airports GIS 20:1 Surface Analysis Visualization Tool

The Digital Obstacle File (DOF) is a database of tall structures that may or may not be obstacles depending on what evaluation criteria are applied. Evaluation criteria are selected based on the instrument approach procedure capabilities of the runway. Analysis conducted as part of this Study determined if known obstacles are obstructions, but it did not make a determination of hazard. The FAA has the sole responsibility for making a determination of hazard to navigable airspace in the United States. The SAV Tool lists obstructions that penetrate the 20:1 Visual Approach Surface and 30:1 Glideslope Qualifying Surface. The FAA Airports GIS web portal automatically conducts an analysis of obstacles in its database, and returns only obstructions that penetrate the surfaces. The 20:1 and 30:1 Tools were functional for KBFI, KPAE, and KPWT airports only. No additional analysis is performed on these obstructions.

4.2 Runway Threshold Siting Surface Evaluation

There are nine Runway Threshold Siting Surface (TSS) criteria which guide the analysis; they are contained in FAA's Advisory Circular 150/5300-13A. Each fulfills a slightly different role depending on the user type and flight procedure for which it was designed as noted here:

- Type 1 through Type 7 TSS are used to site the runway threshold for approaching aircraft,
- Type 8 TSS is used to keep the approach glide slope clear only for runways with vertically guided approaches, and
- Type 9 TSS is used to establish climb gradient for instrument departure procedures.

In many cases, multiple TSS can be applied to a single runway; however, there will be one TSS that is lower and larger than the others which makes it "critical." TSS types and qualifying criteria are described in **Figure 4.2**, *Threshold Siting Surface Criteria* and **Figure 4.3**, *Threshold Siting Surface Scematic.* TSS by runway type included in the Study are shown in **Table 4.2**. One additional TSS is evaluated that is not included in Advisory Circular 150/5300-13A; is the 62.5:1 One Engine Inoperative (OEI) surface. This surface is used to assess obstacles should an engine on a multi-engine air carrier aircraft fail during departure. It is not a regulatory requirement, and OEI is used for advisory purposes only.

The following sections describe the applicable TSS for each runway in the study area and identify the associated critical TSS used for analysis. A summary of obstacles and obstructions within the TSS boundary is presented. Analysis includes a review of the Type 8 TSS for runways that do not have existing vertically guided approach procedures. The purpose of this analysis is to provide a preliminary investigation on whether the airspace near one of the airports would support a vertically guided approach procedure. This analysis is the first step in determining feasibility of vertically guided instrument approach procedure design.

Graphics for this evaluation will be available on the project website. The project website is located at www.airportnetwork.com/psrc, using the password NEXTGEN in all caps.

Figure 4.2: Threshold Siting Surface Criteria

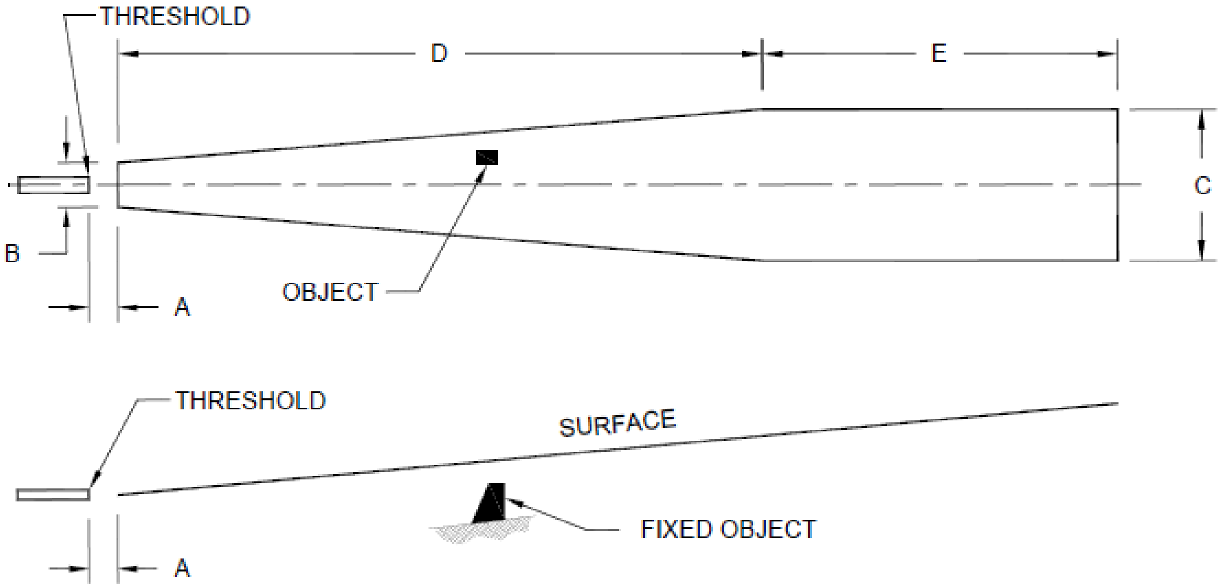
AC 150/5300-13A 9/28/2012

Approach/departure standards table

Runway Type		DIMENSIONAL STANDARDS* Feet (Meters)					Slope/ OCS
		A	B	C	D	E	
1	Approach end of runways expected to serve small airplanes with approach speeds less than 50 knots. (Visual runways only, day/night)	0 (0)	120 (37)	300 (91)	500 (152)	2,500 (762)	15:1
2	Approach end of runways expected to serve small airplanes with approach speeds of 50 knots or more. (Visual runways only, day/night)	0 (0)	250 (76)	700 (213)	2,250 (686)	2,750 (838)	20:1
3	Approach end of runways expected to serve large airplanes (Visual day/night); or instrument minimums ≥ 1 statute mile (1.6 km) (day only).	0 (0)	400 (122)	1000 (305)	1,500 (457)	8,500 (2591)	20:1
4	Approach end of runways expected to support instrument night operations, serving approach Category A and B aircraft only. [1]	200 (61)	400 (122)	3,800 (1158)	10,000 [2] (3048)	0 (0)	20:1
5	Approach end of runways expected to support instrument night operations serving greater than approach Category B aircraft. [1]	200 (61)	800 (244)	3,800 (1158)	10,000 [2] (3048)	0 (0)	20:1
6	Approach end of runways expected to accommodate instrument approaches having visibility minimums ≥ 3/4 but <1 statute mile (≥ 1.2 km but < 1.6 km), day or night.	200 (61)	800 (244)	3,800 (1158)	10,000 [2] (3048)	0 (0)	20:1
7	Approach end of runways expected to accommodate instrument approaches having visibility minimums < 3/4 statute mile (1.2 km).	200 (61)	800 (244)	3,800 (1158)	10,000 [2] (3048)	0 (0)	34:1
8[3,5,6,7]	Approach end of runways expected to accommodate approaches with vertical guidance (Glide Path Qualification Surface [GQS]).	0 (0)	Runway width + 200 (61)	1520 (463)	10,000 [2] (3048)	0 (0)	30:1
9	Departure runway ends for all instrument operations.	0 [4] (0)	See Figure 3-4.				40:1

Source: FAA AC 150/5300-13A, Airport Design

Figure 4.3: Threshold Siting Surface Schematic



Source: FAA AC 150/5300-13A, Airport Design

Table 4.2: PSRC NextGen Study Airports – Threshold Siting Surfaces by Runway

			Runway Type											
		→ Non-TERPS Surfaces →	1 (15:1 Slope)	2 (20:1 Slope)	3 (20:1 Slope)	4 (20:1 Slope)	5 (20:1 Slope)	6 (20:1 Slope)	7 (34:1 Slope)	→ TERPS Surfaces →	8 (30:1 Slope)	9 (40:1 Slope)	→ Advisory Surface →	AC (62.5:1 Slope)
Airport	**Runway**		Sml,V<50kts	Sml,V>50kts	Lrg, ≥1sm	Night, Cat A/B	Night >B	≥ 3/4sm but <1sm	< 3/4sm		GQS	Departure		OEI
BFI	13R		YES	YES	YES	YES	CRITICAL	NO	NO		YES	YES		Yes
BFI	31L		YES	YES	YES	YES	CRITICAL	NO	NO		YES	YES		Yes
BFI	13L		YES	YES	CRITICAL	NO	NO	NO	NO		POTENTIAL	NO		NO
BFI	31R		YES	YES	CRITICAL	NO	NO	NO	NO		POTENTIAL	NO		NO
S36	15		YES	CRITICAL	NO	NO	NO	NO	NO		POTENTIAL	NO		NO
S36	33		YES	CRITICAL	NO	NO	NO	NO	NO		POTENTIAL	NO		NO
PLU	16		YES	YES	CRITICAL	NO	NO	NO	NO		POTENTIAL	YES		NO
PLU	34		YES	YES	YES	YES	CRITICAL	NO	NO		POTENTIAL	YES		NO
TIW	17		YES	YES	YES	YES	YES	YES	CRITICAL		YES	YES		NO
TIW	35		YES	YES	YES	YES	YES	CRITICAL	NO		YES	YES		NO
S43	15L		YES	YES	YES	CRITICAL	NO	NO	NO		POTENTIAL	YES		NO
S43	33R		YES	YES	YES	CRITICAL	NO	NO	NO		POTENTIAL	YES		NO
S43	15R		CRITICAL	NO	NO	NO	NO	NO	NO		NO	NO		NO
S43	33L		CRITICAL	NO	NO	NO	NO	NO	NO		NO	NO		NO
RNT	16		YES	YES	YES	CRITICAL	NO	NO	NO		POTENTIAL	YES		Yes
RNT	34		YES	YES	YES	NO	NO	NO	NO		POTENTIAL	YES		Yes
S50	16		YES	YES	NO	CRITICAL	NO	NO	NO		POTENTIAL	YES		NO
S50	34		YES	YES	NO	CRITICAL	NO	NO	NO		POTENTIAL	YES		NO
PWT	2		YES	YES	YES	YES	CRITICAL	NO	NO		YES	YES		NO
PWT	20		YES	YES	YES	YES	YES	YES	CRITICAL		YES	YES		NO
PAE	16R		YES	YES	YES	YES	YES	YES	CRITICAL		YES	YES		Yes
PAE	34L		YES	YES	CRITICAL	NO	NO	NO	NO		POTENTIAL	YES		Yes
PAE	16L		YES	CRITICAL	NO	NO	NO	NO	NO		POTENTIAL	NO		NO
PAE	34R		YES	CRITICAL	NO	NO	NO	NO	NO		POTENTIAL	NO		NO

Source: FAA AC 150/53001-13A, Airport Design, ***except*** *"OEI 62.5:1", which comes from Canceled FAA AC 150/5300-13, Airport Design*

SML = Small aircraft less than 12,500 pounds, Lrg = Large Aircraft 12,500 pounds or greater, CAT A/B = FAA approach category A / B, etc., determined by aircraft approach speed, SM = Statute Mile

GQS = Glideslope Qualifying Surface, OEI = One Engine Inoperative Surface

Runway type determined by evaluating instrument approach procedures valid May 2015. "Critical" indicates that Non-TERPS TSS is most restrictive for a certain area. "Potential" indicates that runway was analyzed for a vertically guided approach – assumed to be a WAAS LPV.

Runway type criteria are defined in **Exhibit 5.2**.

4.2.1 Auburn Municipal Airport (S50)

Existing Conditions

Auburn Municipal Airport uses the airport code S50. S50 has one runway in a 16/34 orientation, and accommodates small aircraft and night-time approaches for small aircraft. Applicable Runway Threshold Siting Surface (TSS) are Type 1, Type 2, Type 4, and Type 9. The critical approach TSS is Type 4. S50 does not serve air carrier aircraft; therefore, the OEI surface does not apply at S50. S50 is not yet included in the AGIS 20:1 database, therefore only obstacles found in the FAA DOF were used in this analysis.

The Type 9 surface begins at the end of pavement and has a 40:1 slope, making it the shallowest of the TSS applicable to S50. Unlike the other TSS that are used for approach procedures, the Type 9 TSS is used for departure procedures, and was evaluated separately.

The DOF has one obstacle in the Type 4 surface and two obstacles in the Type 9 surface (one of which is the same as included in the Type 4 surface). Analysis shows that these obstacles do not penetrate any of the surfaces evaluated, and are therefore not considered obstructions.

S50 Potential Procedure Improvements

Runway 16/34 was screened for penetrations to the airspace surfaces using the Type 8 TSS. The DOF shows no obstacles within the Type 8 TSS at S50, and the FAA Airport GIS SAV Tool is not configured for S50. Based on this information, a vertically guided approach may be feasible at S50. However, this analysis did not include an assessment of instrument minimums that would be possible. The lowest minimums for a vertically guided approach, associated with the NextGen concepts, would require runway lighting and marking improvements, and the installation of an approach lighting system.

4.2.2 Boeing Field – King County International Airport (BFI)

Existing Conditions

BFI has two runways (13R/31L and 13L/31R) and accommodates most aircraft types with approach minimums below one mile. BFI currently has a vertically guided instrument approach procedure. Applicable TSS are Type 1, Type 2, and Type 3 for both runways, and Type 4, Type 5, Type 8, and Type 9 for Runway 13R/31L only. BFI has air carrier operations which use Runway 13R/31L; therefore an OEI analysis was performed on this runway. Both obstacles in the DOF and the AGIS 20:1 database were used in the analysis. The critical TSS for Runway 13L/31R is Type 3 and the critical TSS for Runway 13R/31L is Type 5.

The Type 8 TSS has the shallowest slope of the approach TSS and was analyzed separately because it only applies to runways with vertically guided procedures. Penetrations to the Type 8 TSS could be mitigated by changing the glide path angle, or decommissioning vertically guided approaches. The TERPS 9 departure TSS applies to Runway 13R/31L only.

Due to the number of surfaces and runways at BFI, three layers of analysis were prepared: A) Non-TERPS TSS (Type 3 and Type 5), B) TERPS TSS (Type 8 and Type 9), and C) the OEI. The DOF included 45 obstacles in the non-TERPS TSS, 14 obstacles in the TERPS Type 8 TSS, 46 obstacles in the TERPS Type 9 TSS, and 38 obstacles in the OEI. A summary of penetrations is included in **Table 4.3**.

Table 4.3: BFI Threshold Siting Surface Analysis (Numbers of Obstacles)				
Runway	**Type 3/Type 5**	**Type 8**	**Type 9***	**OEI***
13R	0	0	9	14
31L	2	0	5	24
13L	0	N/A	N/A	N/A
31R	0	N/A	N/A	N/A
** = Type 9 and OEI are departure surfaces – the obstacles identify those found in the departure path from the specified runway, not those beyond the runway end.*				

Source: FAA Airports SAV Tool

Penetrations to the Type 5 TSS could be mitigated by removing the obstruction, or displacing the threshold. Penetrations to the Type 9 TSS could be mitigated by raising the minimum climb rate on departure from the standard 200 feet per nautical mile. BFI currently has a minimum climb rate of 504 feet per nautical mile from Runway 13R and 480 feet per nautical mile from Runway 31L to meet required obstacle separation requirements.

The SAV 20:1 Tool found one obstacle beyond Runway End 13L – a pole that penetrates the surface by 7.72 feet. This obstacle is defined as a "medium" risk by the FAA, which means that the FAA is not required to take immediate action to restrict instrument procedures for this penetration.

BFI Potential Procedure Improvements

Runway 13R/31L has instrument procedures and did not receive additional screening. The SAV Tool found two obstructions in the 30:1 surface for Runway End 13L, shown in **Table 4.4**. These obstacles must be removed prior to authorization of an approach with vertical guidance such as the recommendations of this study. The 30:1 Tool did not identify penetrations to the 30:1 surface beyond Runway End 31R.

Table 4.4: BFI 30:1 SAV Tool Penetration Report						
Obstacle ID	**Type**	**Latitude**	**Longitude**	**RWY**	**Risk**	**Penetration**
53-021827	Pole	47 32 20.33	122 18 31.46	13L	High	9.58 feet
53-021828	Tower	47 32 20.88	122 18 31.97	13L	High	0.39 feet

Source: FAA Airports SAV Tool

This analysis did not include an assessment of instrument minimums that would be possible. The lowest minimums would require runway lighting and marking improvements, and the installation of an approach lighting system.

4.2.3 Bremerton National Airport (PWT)

Existing Conditions

PWT has one runway (2/20) and accommodates most aircraft types with approach minimums below one mile. PWT currently has a vertically guided instrument approach procedure. Applicable TSS are Type 1, Type 2, Type 3, Type 4, Type 5, Type 8, and Type 9. KPWT does not have air carrier operations; therefore an OEI analysis was not performed. Both obstacles in the DOF and the AGIS 20:1 database are used in the KPWT analysis. The critical TSS is Type 5.

The Type 8 TSS has the shallowest slope of the approach TSS and was analyzed separately because it only applies to runways with vertically guided procedures. Penetrations to the Type 8 TSS could be mitigated by changing the glide path angle, or decommissioning vertically guided approaches. The Type 9 TSS is a departure surface, and was also analyzed because PWT has instrument departure procedures.

Analysis of the DOF database found eight obstacles in the TSS; however none of these obstacles are high enough to penetrate the surface and be classified as obstructions. The SAV 30:1 Tool found two obstructions in the approach to Runway End 2. Both obstructions are trees and mitigation (topping or removal of the tree) would be required. Penetrations to the 30:1 surface are not given a priority – however, removal would be required before vertically guided procedures could be authorized.

PWT Potential Procedure Improvements

Runway End 20 has a vertically guided approach, so it was not evaluated for approach procedure improvements. Runway End 2 is not currently authorized for vertically guided approaches because of the two trees in the 30:1 surface. PWT may be able to get a vertically guided approach into Runway End 2 if the obstructions are removed.

4.2.4 Crest Airpark (S36)

Existing Conditions

S36 has one runway, 15/33, and accommodates small aircraft only with no instrument procedures. Applicable TSS are Type 1 and Type 2. S36 does not presently serve air carrier aircraft; therefore, the OEI surface does not apply. S36 is not yet included in the AGIS 20:1 database, therefore, only obstacles found in the FAA DOF were used in this analysis.

Type 1 surfaces have a 15:1 slope starting at runway end, and are entirely included within the boundaries and slope of the 20:1 Type 2 surface, which also starts at runway end. The Type 9 surface does not apply because S36 does not have instrument procedures. The Type 2 surface is the critical surface for S36.

The DOF has no obstacles in the Type 2 TSS; therefore, no obstructions were detected.

S36 Potential Procedure Improvements

Runway 15/33 was screened for obstacles using the Type 8 TSS. The DOF has no obstacles within the Type 8 TSS at S50, and the SAV Tool is not configured for S36. Based on this information, a vertically guided LPV approach may be feasible at S36. This analysis does not include an assessment of instrument minimums that would be possible. The lowest minimums would require runway lighting and marking improvements, and the installation of an approach lighting system.

4.2.5 Harvey Field (S43)

Existing Conditions

S43 has two runways (15L/33R and 15R/33L) and presently accommodates small aircraft types. Applicable TSS are Type 1 for both runways, and, Type 2, Type 3, Type 4, and Type 9 for Runway 15L/33R only. S43 does not serve air carrier aircraft; therefore, the OEI surface does not apply. S43 is not yet included in the AGIS 20:1 database, therefore, only obstacles found in the FAA DOF were used in this analysis. The critical approach TSS for Runway 15L/33R is Type 4. The critical approach TSS for Runway 15R/33L is Type 1. The Type 9 departure TSS applies to Runway 15L/33R only.

The DOF has no obstacles in the Type 1 TSS for Runway 15R/33L; therefore, no obstructions were detected. The DOF had no obstacles in the Type 4 approach TSS for Runway 15L/33R, and had four obstacles in the Type 9 departure TSS: three for departures on Runway 33R and one for departures on Runway 15L. All four obstacles penetrate the Type 9 departure TSS, and are considered obstructions. Penetrations to the Type 9 TSS could be mitigated by raising the minimum climb rate on departure from the standard 200 feet per nautical mile. Most aircraft can climb in excess of 500 feet per nautical mile under normal operating conditions. Aircraft that cannot meet the climb gradient requirements would not be allowed to depart under instrument meteorological conditions. S43 has a minimum climb rate of 355 feet per nautical mile from Runway 15L and 480 feet per nautical mile from Runway 33R to meet required obstacle separation requirements.

S43 Potential Procedure Improvements

Runway 15R/33L is a turf runway and not eligible for instrument procedures so it was not analyzed for future improvements. Runway 15L/33R was screened using the Type 8 TSS. The DOF presently has no obstacles within the Type 8 TSS at S43, and the SAV Tool was not configured for S43. Based on this information, a vertically guided LPV approach may be feasible at S43. This analysis did not include an assessment of instrument minimums that would be possible. The lowest minimums would require runway lighting and marking improvements, and the installation of an approach lighting system.

4.2.6 Renton Municipal Airport (RNT)

Existing Conditions

RNT has one runway (16/34) and accommodates small aircraft types on approach and large aircraft on departure. Applicable TSS are Type 1, Type 2, Type 3, Type 4, and Type 9. RNT has non-scheduled air carrier operations; therefore an OEI analysis was performed. Both obstacles in the DOF and the AGIS 20:1

database were used in the RNT analysis. The critical approach TSS is Type 4. The TERPS Type 9 TSS is a departure surface.

The DOF presently has one obstacle in the Type 4 TSS which would not be tall enough to penetrate the TSS, and is not considered an obstruction. The DOF has 11 obstacles in the Type 9 departure TSS, all beyond Runway End 34 (associated with aircraft departing using Runway 16). Eight of these nine penetrate the TSS and are considered obstructions. Penetrations to the Type 9 TSS could be mitigated by raising the minimum climb rate on departure from the standard 200 feet per nautical mile, which has already been done at RNT. A steeper climb rate gets aircraft to an altitude where they can safely pass over obstructions during instrument meteorological conditions. The 200 feet per nautical mile ratio is the default ratio used for TERPS departure clearance analysis, although many airports have steeper ratios in order to keep the surface clear of obstructions. RNT has a minimum climb rate of 405 feet per nautical mile from Runway 16 to meet required obstacle separation requirements.

There are no obstacles in the OEI surface for departures on Runway End 34, and 10 obstacles in the OEI surface for departures on Runway End 16. No mitigation would presently be necessary for the penetrations to the OEI surface because the surface is not regulatory; however, it is recommended that the location and height of these penetrations be included on airport charts for flight planning purposes. The 20:1 SAV Tool did not identify any obstacles for RNT.

RNT Potential Procedure Improvements

The DOF found no obstacles in the Type 8 TSS for both runways. The SAV tool found one obstruction in the 30:1 surface for Runway End 34, shown in **Table 4.5.** This obstacle must be removed prior to authorization of an approach with vertical guidance, such as the procedures noted in Chapter 3. The 30:1 Tool did not identify penetration to the 30:1 surface beyond Runway End 16, which means that a vertically guided approach may be feasible.

Table 4.5: RNT 30:1 SAV Tool Penetration Report

Obstacle ID	Type	Latitude	Longitude	RWY	Risk	Penetration
Not Included	Blast Shield	47 29 7.04	122 15 52.34	34	High	0.98 feet

Source: FAA Airports SAV Tool

This analysis did not include an assessment of instrument minimums that would be possible. The lowest minimums would require runway lighting and marking improvements, and the installation of an approach lighting system.

4.2.7 Snohomish County Airport – Paine Field (PAE)

Existing Conditions

PAE has two runways (16R/34L and 16L/34R) and accommodates most aircraft types with minimums below 3/4 mile. PAE has a vertically guided instrument approach procedure into Runway End 16R. Applicable TSS are Type 1, Type 2 for all runway ends; Type 3 and Type 9 for Runway Ends 16R and 34L; and Type 4, Type 5, Type 6, Type 7, and Type 8 for Runway End 16R only. PAE has air carrier operations that use Runway 16R/34L; therefore an OEI analysis was performed on this runway. Both obstacles in the DOF and the AGIS 20:1 database were used in the PAE analysis. The critical TSS for Runway 16L/34R is Type 2, and the critical TSS for Runway 16R/34L is Type 7.

The Type 8 TSS presently has the shallowest slope of the approach TSS and is analyzed separately because it only applies to runways with vertically guided procedures. Penetrations to the TERPS Type 8 TSS can be mitigated by changing the glide path angle, or decommissioning vertically guided approaches. The TERPS Type 9 departure surface applies to Runway 16R/34L only.

Due to the number of surfaces and runways at PAE, three layers of analysis were conducted: A) Non-TERPS TSS (Type 2 and Type 7), B) TERPS TSS (Type 8 and Type 9), and C) the OEI. The DOF included 10 obstacles in the non-TERPS TSS, 1 in the TERPS Type 8 TSS, and 4 in the TERPS Type 9 TSS. None of these obstacles penetrate the surfaces; therefore, no obstructions were identified. There are two penetrations in the OEI surface for departures on Runway End 16R.

The 20:1 SAV Tool identified three obstacles beyond Runway 34R, shown in **Table 4.6**. Two obstacles are defined as a medium risk by the FAA, which means that the FAA is not required to take immediate action to restrict instrument procedures for these penetrations. The third obstacle was defined as a high risk by the FAA, which means that the FAA is required to take immediate action to restrict approaches into 34R to at least one statute mile of visibility, and to restrict night operations if the obstacle is not lit. The Airport should work with FAA Flight Procedures and the property owner to light or lower this obstruction and restore full instrument procedure capability to Runway 34R.

Table 4.6: PAE 20:1 SAV Tool Penetration Report

Obstacle ID	Type	Latitude	Longitude	RWY	Risk	Penetration
53-022193	Tower	47 53 47.68	122 16 21.26	34R	High	12.87 feet
53-022191	Tower	47 53 47.73	122 16 14.49	34R	Medium	9.12 feet
KPAET000096	Pole	47 53 47.69	122 16 14.32	34R	Medium	8.92 feet

Source: FAA Airports SAV Tool

PAE Potential Procedure Improvements

Runway 16R currently has vertically guided instrument procedures and did not receive additional screening in this study. The SAV tool found five current obstructions in the 30:1 surface for Runway End 34L, and two obstructions in the 30:1 surface for Runway End 34R, shown in **Table 4.7.** These obstacles must be removed prior to authorization of an approach with vertical guidance. The 30:1 Tool did not identify penetration to the 30:1 surface beyond Runway End 16L.

Table 4.7: PAE 30:1 SAV Tool Penetration Report

Obstacle ID	Type	Latitude	Longitude	RWY	Risk	Penetration
KPAET000292	Tree	47 53 18.11	122 17 11.27	34L	High	19.85 feet
KPAET000289	Tree	47 53 19.11	122 17 9.23	34L	High	16.15 feet
KPAET000295	Tree	47 53 17.21	122 17 9.38	34L	High	9.74 feet
KPAE0061	Tree	47 53 16.75	122 17 8.74	34L	High	4.16 feet
KPAET000232	Rwy. Light	47 53 47.80	122 17 7.31	34L	High	0.96 feet
KPAE0071	Tree	47 53 38.68	122 16 15.26	34R	High	5.28 feet
KPAET000184	Tree	47 53 36.45	122 16 15.93	34R	High	1.75 feet

Source: FAA Airports SAV Tool

This analysis did not include an assessment of instrument minimums that would be possible. The lowest minimums would require runway lighting and marking improvements, and the installation of an approach lighting system.

4.2.8 Tacoma Narrows (TIW)

Existing Conditions

TIW has one runway (17/35) and accommodates most aircraft types with minimums below 3/4 of a mile. TIW has a vertically guided instrument approach procedure. All TSS are applicable to Runway End 17 and all except Type 7 are applicable to Runway End 35. TIW presently does not have air carrier operations; therefore an OEI analysis has not been performed. Both obstacles in the DOF and the AGIS 20:1 database are used in the TIW analysis. The critical TSS for Runway End 17 is Type 7 and the critical TSS for Runway End 35 is Type 6.

The DOF currently has three obstacles in the Type 6 approach TSS, two obstacles in the Type approach 7 TSS, and four obstacles in the Type 9 departure TSS. None of these obstacles are tall enough to penetrate the approach and departure TSS, and are not considered obstructions. The 20:1 SAV Tool did not pick-up any obstacles at TIW.

TIW Potential Procedure Improvements
Runway 17/35 has vertically guided instrument procedures as did not receive additional screening.

4.2.9 Pierce County Airport – Thun Field (PLU)

Existing Conditions

PLU has one runway (16/34) and accommodates most aircraft types with minimums greater than one mile. PLU has a non-vertically guided instrument approach procedure into Runway End 34. Applicable TSS are Type 1, Type 2, Type 3 and Type 9 into both runway ends, and Type 4 and Type 5 into Runway End 34 only. TIW does not presently have air carrier operations; therefore an OEI analysis was not performed.

The AGIS SAV database is not configured for PLU; therefore only the DOF was used in this analysis. The critical approach TSS is Type 3 for Runway End 16 and Type 5 for Runway End 34.

The DOF has seven obstacles in the Type 5 approach TSS, three obstacles in the Type approach 7 TSS, and 11 obstacles in the Type 9 departure TSS. None of these are tall enough to penetrate the approach TSS, and are not considered obstructions. There are two penetrations to the Type 9 TSS for aircraft departing on Runway End 34. Penetrations to the Type 9 TSS could be mitigated by raising the minimum climb rate on departure from the standard 200 feet per nautical mile. Raising the climb rate means that aircraft will reach a safe altitude to clear the obstacle on takeoff, even when the obstacle may not be visible due to inclement weather. PLU has a departure procedure, but maintains a standard climb rate. Obstacles are noted on the procedure.

PLU Potential Procedure Improvements

The DOF found no current obstacles in the Type 8 TSS for Runway End 16, and four obstacles in the Type 8 TSS for Runway End 34. The obstacles are too low to penetrate the Type 8 TSS; therefore, a vertically guided approach procedure may be possible at PLU. This analysis did not include an assessment of instrument minimums that would be possible. The lowest minimums would require runway lighting and marking improvements, and the installation of an approach lighting system.

4.2.11 Airspace Analysis Summary

A summary of the findings of this analysis is included in **Figure 4.4**.

		Approach Analysis Summary			
		Surface Clearance			Vertically Guided
Airport	Runway	Approach	Departure	OEI	Potential
BFI	13R	YES	NO	NO	EXISTS
BFI	31L	NO	NO	NO	EXISTS
BFI	13L	YES	N/A	N/A	MITIGATION
BFI	31R	YES	N/A	N/A	YES
S36	15	YES	N/A	N/A	YES
S36	33	YES	N/A	N/A	YES
PLU	16	YES	YES	N/A	YES
PLU	34	YES	NO	N/A	YES
TIW	17	YES	YES	N/A	EXISTS
TIW	35	YES	YES	N/A	EXISTS
S43	15L	YES	NO	N/A	YES
S43	33R	YES	NO	N/A	YES
S43	15R	YES	N/A	N/A	N/A
S43	33L	YES	N/A	N/A	N/A
RNT	16	YES	NO	NO	YES
RNT	34	YES	YES	YES	MITIGATION
S50	16	YES	YES	N/A	YES
S50	34	YES	YES	N/A	YES
PWT	2	NO	YES	N/A	MITIGATION
PWT	20	YES	YES	N/A	EXISTS
PAE	16R	YES	YES	NO	EXISTS
PAE	34L	YES	YES	YES	MITIGATION
PAE	16L	YES	YES	N/A	YES
PAE	34R	YES	YES	N/A	MITIGATION

KEY	
YES	Surface type applies to this runway end, and is clear of obstructions.
NO	Surface type applies to this runway end, and is not clear of obstructions.
N/A	Surface type does not apply to this runway end.
MITIGATION	Obstacle mitigation is required in order for vertically guided procedures to be implemented.
EXISTS	Runway already has vertically guided procedures.

Source: Mead & Hunt

Several runways at airports in the study area may benefit from exploration of instrument approach procedures with vertical guidance, such as the procedures described in Chapter 3. At Boeing Field (BFI), Renton Municipal (RNT), Bremerton (PWT), and Paine Field (PAE), new vertically guided procedures would not be possible without mitigation of current detected obstructions. Further – there may be obstacles that exist and are not captured by the DOF or FAA SAV Tool databases. It is recommended that airports complete an airport airspace analysis per the requirements of FAA Advisory Circular AC 150/5300-18B to check for obstructions and to provide a more detailed analysis of vertically guided approach procedure applicability.

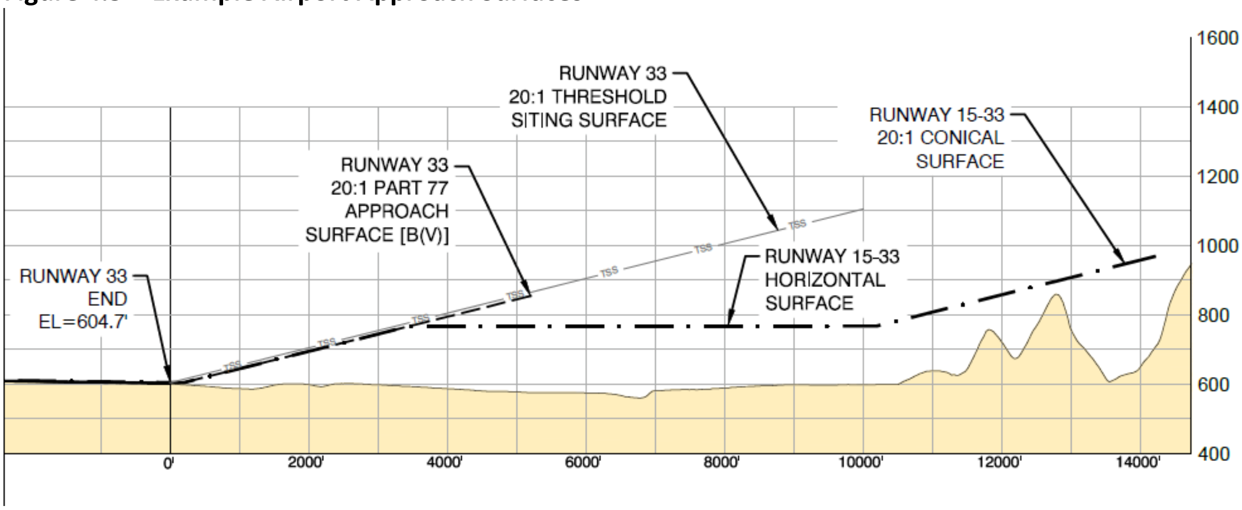
To achieve the lowest minimums possible, airport sponsors may need to invest in ground-based improvements such as runway lighting and marking, and approach lighting systems. Coordination with local land development entities such as cities and counties is essential to protect airspace from potential encroachment of would-be hazards, and protect the airport sponsor investment. Land use compatibility is addressed in the following section.

Recommended Land Uses

The encroachment of incompatible land uses can challenge the long-term viability of an airport. Coordinated planning for land use development in the vicinity of an airport, and specifically off the ends of runways can protect airports from encroaching incompatible uses. The approach areas beyond runway ends are the most critical to protect, as these areas dictate the ability for an airport to obtain and enable aircraft to use instrument approach procedures.

Areas beyond runway ends fall under the Approach Surface for the runway. The Approach Surface is a composite of several airspace surfaces which slope up and away from the runway end. An example is included in **Figure 4.5**. These surfaces are defined in Part 77 of the Federal Aviation Regulations (Part 77).

Figure 4.5 – Example Airport Approach Surfaces



Source: Mead & Hunt

Terrain, vegetation, and man-made penetrations of these approach surfaces can impact airport instrument approach procedures and the ability to improve approach procedures with lower visibility minimums. Efforts should be made to remove airspace obstructions, and to protect the airspace from future obstructions.

The Washington State Department of Transportation *Airports and Compatible Land Use Guidebook*[12] (the Guidebook) contains information for local jurisdictions to use in protecting their airports from encroaching incompatible land uses. Although the 2011 guidebook is several years old, it is the current version of the document and intended to guide long-term planning projects. Issues recognized in the Guidebook are:

[12] Available at http://www.wsdot.wa.gov/aviation/Planning/ACLUguide.htm

Washington's Growth Management Act (RCW 37.70.547) which requires towns, cities, and counties to discourage development of incompatible land uses adjacent to public use airports through adoption of comprehensive plan policies and development regulations.

According to RCW 14.12, an airspace hazard "endangers the lives and property of users of the airport and of occupants of land in its vicinity, and also, if of the obstruction type, in effect reduces the size of the area available for the landing, taking-off and maneuvering of aircraft thus tending to destroy or impair the utility of the airport and the public investment. Accordingly, it is hereby declared:

> (1) That the creation or establishment of an airport hazard is a public nuisance and an injury to the community served by the airport in question;
> (2) That it is therefore necessary in the interest of the public health, public safety, and general welfare that the creation or establishment of airport hazards be prevented; and
> (3) That this should be accomplished, to the extent legally possible, by exercise of the police power, without compensation."

The Guidebook also states the following.

"History shows us that incompatible development has the following consequences:

- Reduces the public's access to air transportation and the benefits it provides.
- Reduces the value of public investment in airport infrastructure.
- Reduces opportunity for economic development and diminishes a community's capacity to deal with natural and human caused disasters.
- Reduces quality of life for people living in developments located near airports."

Consequences of Incompatible Land Uses near Airports

Consequences to the aviation system and its users:

- Delays and constraints to airport development, leading to limitations on system capacity.
- Restrictions on aircraft operations, leading to system delays and travel time penalties.
- Constraints to runway approach protection, leading to runway capacity constraints and safety risks.
- Litigation and related costs.
- Increased development costs.
- Lost value of public investment.
- Increased risk of aviation accidents caused by the presence of tall structures, visual obstructions, and wildlife attractants.

Consequences to people who live near airports:

- Exposure to noise.
- Exposure to emissions.
- Exposure to aviation accident risk.
- Decline in transportation access.
- Consequences to concerned local and regional jurisdictions.
- Local and regional economic impacts due to constraints on airport growth.
- Irresolvable political disputes.

The following section highlights existing and recommended future development for the areas surrounding the study airports. A matrix containing land uses recommended, to be avoided, and to be prohibited is included as **Figure 4.7**, *Recommended Land Uses Near Airports*. For all airports and runway ends, land uses which would allow structures of sufficient height to penetrate the airport approach surfaces should be prohibited.

Auburn Municipal Airport
Areas under the approach surfaces to both runway ends are developed with a mix of industrial/ commercial, with residential uses farther out from the runway ends. Few vacant parcels remain in the immediate area under approach surfaces. Where additional development is possible, low intensity industrial infill is recommended land use. Officials controlling land use should continue to avoid residential uses on the extended runway centerlines.

Boeing Field – King County International Airport
Areas under the approach surfaces to both runway ends are developed or occupied by transit infrastructure (rail and highways). Residential uses exist east of the airport and I-5. Some residential exists to the northwest of the airport, under the approach surface. Where additional development is possible, low intensity industrial infill is the recommended land use as well as avoidance of further densifying the residential uses in the immediate vicinity of the approach surfaces.

Bremerton National Airport
Mostly open/undeveloped land under the approach surfaces. The undeveloped lands should remain undeveloped if possible. Residential should be avoided.

Crest Airpark
Large lot residential surrounds the airport with areas of open space scattered throughout. The close-in portion of the southern approach surface is mostly undeveloped and should remain so. The northern approach surface lies above large lot/rural residential close in to the runway, and undeveloped land farther out.

Harvey Field
The south approach surface lies over agriculture and rural residential. The north approach surface lies over large lot residential, a river, and then industrial and higher density residential on the north side of the river. Rural residential uses could be rezoned for low intensity industrial uses, but additional residential should not be allowed under the approach surfaces.

Renton Municipal Airport
The north approach surface generally lies almost entirely over lake Washington. The small piece of land at the north end of the north approach surface is occupied by existing residential uses. At the south end, the approach surface lies over a mix of industrial/commercial and residential. Very little vacant land exists in the immediate airport vicinity, but where possible industrial infill/redevelopment would be an acceptable use.

Snohomish County Airport – Paine Field

The extended centerline and approach surface for Runway 16L lies above Airport Road and industrial buildings associated with Boeing Aircraft and ancillary businesses. Very little vacant developable land exists in the area that which is available should be developed with similar low intensity industrial uses.

The approach for Runway 16R lies above primarily undeveloped open space with some parking and industrial uses on the outer edges. Open space is a preferable land use, but if development is inevitable, to protect encroachment, it should be low intensity industrial.

The approach for Runway 34L lies above a major highway and commercial uses at the close-in end. Further from the runway some residential uses exist. The areas which are undeveloped are within the commercial development areas and should be developed in a similar fashion to protect the runway from encroachment, focusing on low intensity development. Additional residential should not be encouraged.

The approach for Runway 34R lies above a major arterial road and industrial uses at the close-in end. Further from the runway some residential uses exist. The areas which are undeveloped are within the commercial development areas and should be developed in a similar fashion, focusing on low intensity development. Additional residential should not be encouraged.

Tacoma Narrows

The southern approach surface to Runway 35 lies entirely over water and undeveloped land. These lands should remain undeveloped preferably, however low intensity industrial would be a recommended use.

The approach from the north to Runway 17 lies over mostly vacant/undeveloped land with the exception of a golf course at the north end. Residential uses lie lateral to the approach surface. To protect the airport from encroachment, as much as practical these areas should remain undeveloped, however low intensity industrial or commercial would be an acceptable use. Additional residential should not be encouraged.

Pierce County Airport – Thun Field

The southern approach surface to Runway 34 falls over an old landfill, a rock quarry, and a golf course. Furthest to the south, the approach surface falls over some residential. No vacant usable land exists in the close-in half of the approach surface. The southern half of the approach surface does contain some vacant, buildable land. These areas could accommodate infill residential but to prevent noise conflicts, a more compatible use would be low intensity industrial or commercial.

The northern approach to Runway 16 lies above large commercial uses close in to the runway and residential uses under the remainder of the approach surface. Some vacant buildable lands exist near the commercial development. A compatible use for those areas would be low intensity industrial or commercial.

Summary

Where possible, areas under the approach surface should be designated to remain as vacant and undeveloped. Land uses such as industrial and low density commercial are acceptable for the types of procedures discussed in Chapter 3 if development must occur in under the approaches. Residential should always be avoided when possible. The attached matrix contained in **Figure 4.6** contains specific recommendations for each runway end of airports in this study. Additionally, the following table is used in the Guidebook for reference on recommended land uses for all areas surrounding an airport.

Figure 4.6 – Recommend Land Uses Near Airports

Table 2-5
Characteristics of Existing Influence Area Environs

Characteristics of Existing Influence Area Environs	**Rural** *Existing land use is agricultural or rural; few buildings; new development not anticipated.*	**Limited Development** *Existing development is scattered or low-intensity with little new development anticipated.*	**Developing** *Extensive vacant or underutilized land with urban development potential.*	**Developed** *Fully or mostly developed; potential redevelopment.*
Runway Protection Zone	• Airport should control land consistent with design standards. • Height restrictions. • Avoid new buildings. • Avoid new roads.	• Airport should control land consistent with design standards. • Height restrictions. • Avoid new buildings. • Avoid new roads.	• Airport should control land consistent with design standards. • Height restrictions. • Avoid new buildings. • Avoid new roads.	• Airport should control land consistent with design standards. • Height restrictions. • Infill uses if low intensity. • Avoid new roads.
Parallel to Runway	• Aviation-related development preferred. • No new residential tracts. • Non-residential uses acceptable, industry preffered. • No new schools, hospitals, nursing homes, etc. • Tall structures restricted to protect airspace. • Caution regarding land uses that attract birds or other wildlife. • Encourage keeping land agricultural, undeveloped, or in airport-related uses.	• Aviation-related development preferred. • No new residential tracts. • Low intensity non-residential uses acceptable. • No new schools, hospitals, nursing homes, etc. • Tall structures restricted to protect airspace. • Caution regarding land uses that attract birds or other wildlife. • Encourage keeping land agricultural, undeveloped, or in airport-related uses.	• Aviation-related development preferred. • Low/moderate intensity non-residential uses acceptable. • No new residential tracts. • No new schools, day care centers, nursing homes, etc. • No new shopping centers or places of public assembly*. • Tall structures restricted to protect airspace. • Caution regarding land uses that attract birds or wildlife. • Encourage light industrial and other low-intensity uses or airport-related uses.	• Aviation-related development preferred. • Low/moderate intensity non-residential uses acceptable. • No new residential tracts. • No new schools, day care centers, nursing homes, etc. • No new shopping centers or places of public assembly*. • Tall structures restricted to protect airspace. • Caution regarding land uses that attract birds or wildlife. • Encourage light industrial, commercial, and other low-intensity non-residential uses.
Approaches/ Extended Runway Centerline	• Aviation-related development preferred. • Low-intensity industry or other non-residential uses acceptable. • No new residential tracts. • No new schools, day care centers, nursing homes, hospitals, etc. • Tall structures restricted to protect airspace. • Caution regarding land uses that attract birds or wildlife. • Encourage continuation of agricultural and related uses.	• Low-intensity industrial or other non-residential uses acceptable. • No new residential tracts. • No new schools, day care centers, nursing homes, hospitals, etc. • Tall structures restricted to protect airspace. • Caution regarding land uses that attract birds or wildlife. • Encourage continuation of agricultural and related uses.	• Low/moderate-intensity industrial or other non-residential uses acceptable. • No new residential tracts; infill discouraged. • No new schools, day care centers, nursing homes, hospitals, etc. • No new shopping centers, industrial uses with high concentrations of people, places of public assembly*. • Tall structures restricted to protect airspace. • Caution regarding land uses that attract birds or wildlife. • Encourage light industrial, office, and other low-intensity uses.	• Low/moderate-intensity industrial or other non-residential uses acceptable. • Residential as infill acceptable. • No new schools, day care centers, nursing homes, hospitals, etc. • No new shopping centers, industrial uses with high concentrations of people, places of public assembly*. • Tall structures restricted to protect airspace. • Caution regarding land uses that attract birds or wildlife • Encourage light industrial, office, and other low-intensity uses.
Traffic Pattern	• Maintain existing minimal development conditions to maximum extent practical. • No new schools, day care centers, nursing homes, hospitals, etc. • Encourage continued agricultural uses, and industrial uses.	• No new residential subdivisions. • No new schools, day care centers, nursing homes, hospitals, etc. • Encourage continued agricultural and agriculture-related commercial or industrial or other low-intensity commercial uses.	• No new residential subdivisions. • Encourage nonresidential uses except for ones with very high intensities (such as sports arenas). • Favor moderate to high-density or mixed use development if residential is necessary. • Caution regarding land uses that attract birds or wildlife.	• No new residential subdivisions. • Encourage nonresidential uses except for ones with very high intensities (such as sports arenas). • Favor high-density residential or as infill or mixed use redevelopment. • Caution regarding land uses that attract birds or wildlife.

Places of worship, auditoriums, outdoor sports arenas, etc.

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CHAPTER 5 - NEXT STEPS

The next step is to implement the concepts in this report regionally and nationally. Successful implementation of the concepts in this report rely on outreach at the local and national level. Throughout this study, the project team, PSRC, and the FAA worked with airports and users to make sure the report captured what is truly needed and can advance the Puget Sound GA experience to include NextGen. There are four areas of implementation:

1. Airport Approach surfaces,
2. Promotion of NextGen and General Aviation in Puget Sound,
3. NextGen Enhancements for Implementation Package Submittal to the FAA, and
4. Promotion of other available options.

5.1 Implementation One: Airport Approach Surfaces

The implementation of the concepts requires airports to collect up to date obstruction information. If obstruction information isn't current, the FAA procedures division that creates NextGen procedures must base their procedure design on a set of generic standards that may not represent the true obstruction landscape. Airports that have current obstruction information give the FAA the best information to create new procedures.

Chapter 4 of this report detailed the requirements for ensuring the approach surfaces at each applicable airport are ready for NextGen. Each airport should coordinate with the State of Washington Department of Transportation to complete required obstacle surveys and secure funding to mitigate any hazards.

5.2 Implementation Two: Promotion of NextGen and General Aviation in Puget Sound

The outreach will be to local pilots, airport operators, and the FAA. The focus of the outreach will be to achieve independent operations between the GA airports and SEA-TAC. PSRC will also provide outreach and resources to help local jurisdictions with outreach; these resources will include a website, PowerPoint presentations, and a project brochure.

Local Pilots: This implementation includes promoting GA aircraft to equip in the Puget Sound region; PSRC will work with the FAA and study area airports on pilot outreach. This message platform will be done through an iPad application developed as part of this study and as part of outreach efforts by the PSRC. The iPad application information will be disseminated to the pilot communities through known stakeholders, airport owners/operators, and local pilot groups. The iPad application will contain information regarding advantages to equipping and animations of the concept procedures.

FAA ATC: The flight procedure concepts that were identified in this study should be submitted to the FAA flight procedure implementation process for future evaluation and design. These concepts can be vetted and presented for the next step of becoming a procedure through the FAA submittal process. It is important that the procedures are submitted into this system along with the supporting information relative to the proposed design.

5.3 Implementation Three: NextGen Enhancements for Implementation Package Submittal to the FAA

As detailed in Chapter 3, this report created numerous concepts of operations for many of the study area airports to solve issues related to airport access. Many of these concepts included flight procedures for the GA Airports that allow these aircraft to operations independent of Sea-Tac operations. These primarily involve the following general categories of operational concepts and will be packaged for submittal to the FAA.

- Focus on achieving independent operations with SEA-TAC:
    - North/South Flow RNAV SIDs for GA airports – BFI, RNT, PAE
    - North/South Flow RNAV STARs for GA airports – BFI, RNT, PAE
    - T-route over the Cascades connecting to the new RNAV SIDs
    - Updated North Flow IAPs – BFI, RNT, and PAE
- Options with minimal controversy/environmental issues

5.4 Implementation Four: Promote Other Available Options

There are procedures that could be implemented but would only be used by a small percentage of operators due to their advanced technology, aircraft equipage, and pilot training. One of the proposed concept of operations is an RNP-AR arrival at Renton Municipal Airport. The airport has started the process of submitting this procedure for approval by the FAA. This procedure, while projected to be used initially by a small number of aircraft, has the potential to be used by many more as more aircraft equip with RNP-AR capabilities.

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Appendix A– Glossary

Above Ground Level Altitude, AGL. Altitude expressed in feet measured above ground level. *(FAA Pilot/Controller glossary)*

Advisory Circular, AC. Advisory Circulars (ACs) provide guidance such as methods, procedures, and practices for complying with regulations and grant requirements. ACs may also contain explanations of regulations, other guidance material, best practices, or information useful to the aviation community. They do not create or change a regulatory requirement. *(FAA RGL Library)*

Aircraft Operation. An aircraft arrival or departure from an airport with FAA airport traffic control service. There are two types of operations: local and itinerant. *(FAA)*

Air Traffic. (FAA FAR Sec. 1.1) Aircraft operating in the air or on an airport surface, exclusive of loading ramps and parking areas.

Air Traffic Control, ATC. A service operated by appropriate authority to promote the safe, orderly, and expeditious flow of air traffic. *(FAA FAR Sec. 1.1)*

Airport. Any areas of land or water that is used, or intended for use, for the landing and takeoff of aircraft. Any appurtenant areas that are used, or intended for use, for airport buildings, other airport facilities, or rights-of-way; and all airport buildings and facilities located on the areas specified in this definition. *(FAA FAR Sec. 152.3)*

Airport Operations. The total number of movements in landings (arrivals) plus take-offs (departures) from an airport. *(FAA website)*

Airport Geographic Information Systems, AGIS. The Airports Surveying Geographic Information System (AGIS or Airport GIS) helps the FAA collect airport and aeronautical data to meet the demands of NextGen. *(FAA website)*

Airspace. The space lying above the earth or above a certain area of land or water that is necessary to conduce aviation operations. *(FAA website)*

Approach Slopes. The ratios of horizontal to vertical distance indicating the degree of inclination of the Approach Surface. The various ratios include:

- **20:1.** For all utility and visual runways extended from the primary surface a distance of 5,000 feet.

- **34:1.** For all non-precision instrument runways extended from the primary surface for a distance of 10,000 feet.

- **50:1/40:1.** For all precision instrument runways extending from the primary surface for a distance of 10,000 feet at an approach slope of 50.1 and an additional 40,000 feet beyond this at a 40:1 Approach Slope. *(FAR Part 77)*

Approach Surface. A surface longitudinally centered on the extended runway centerline, extending outward and upward from the end of the primary surface and at the same slope as the approach zone height limitation slope set forth in this Ordinance. In plan the perimeter of the approach surface coincides with the perimeter of the approach zone. *(FAA AC 150/5190-4A)*

Area Navigation, RNAV. A method of navigation that permits aircraft operations on any desired flight path within the coverage of ground – or space- based navigation aids or within the limits of the capability of sel-contained aids, or a combination of these. Note: Area navigation includes performance-based navigation as well as other operations that do not meet the definition of performance-based navigation. *(FAA Pilot/Controller Glossary)*

Automated Dependent Surveillance- Broadcast, ADS-B. A surveillance system that continuously broadcasts GPS position information, aircraft identification, altitude, velocity vector, and direction to all other aircraft and air traffic control facilities within a specific area. ADS-B information is displayed in the flight deck via a flight deck display of traffic information unit, providing the pilot with greater situational awareness. *(FAA website)*

Automatic Dependent Surveillance Rebroadcast, ADS-R. This takes position information received on the ground from Universal Access Transceivers (UAT)-equipped aircraft and rebroadcasts it on the 1090 megahertz (MHz) frequency. Likewise, ADS-R rebroadcasts 1090 MHz data to UAT users. In concert with TIS-B, airborne data exchange and ADS-R provide all ADS-B In-equipped aircraft with a comprehensive airspace and airport surface traffic picture. ADS-R delivers traffic data within a 15-nm radius 5,000 feet above or below relative to the receiving aircraft's position. *(FAA website)*

Decision Altitude, DA. A specified altitude or height in the precision approach at which a missed approach must be initiated if the required visual reference to continue the approach has not been established. *(FAA Pilot/Controller Glossary)*

Departure End of Runway, DER. The end of runway available for the ground run of an aircraft departure. The end of the runway that is opposite the landing threshold, sometimes referred to as the stop end of the runway. *(pilotscareer.com)*

Digital Obstacle File, DOF. The DOF describes all known obstacles of interest to aviation users in the United States, with limited coverage of the Pacific, the Caribbean, Canada, and Mexico. The obstacles are assigned unique numerical identifiers, accuracy codes, and are listed in order by state.

Distance Measuring Equipment, DME. Equipment (airborne and ground) used to measure, in nautical miles, the slant range distance of an aircraft from the DME navigational aid. *(FAA Pilot/Controller Glossary)*

DME/DME/IRU – Refers to navigation using DME ranging from at least two DME facilities to determine position along with the use of an inertial reference unit to provide sufficient position information during limited DME gaps. *(FAA AC 90-100A)*

Equivalent Lateral Spacing Operations, ELSO. Allows aircraft to depart simultaneously from parallel runways separated by 2,500 feet or more while diverging by as little at 10-degrees. ELSO SIDs are standard instrument departures that are published and use ELSO separation. *(PSRC Chapter 3 and Consultant Team)*

Facility Specific Safety Standard, FSSS. FSSS – An FAA ATC Facility Specific Safety Standard is a wavier/authorization to a Directive/Order (i.e., JO 7110.65), that allows a 'specific facility' to conduct authorized operations under special provisions, conditions and limitations." *(Consultant Team)*

Federal Aviation Administration, FAA. A federal agency charged with regulating air commerce to promote its safety and development; encourage and develop civil aviation, air traffic control, and air navigation; and promoting the development of a national system of airports. *(FAA website)*

Flight Information Service – Broadcast, FIS-B. A ground broadcast service provided through ADS-B Broadcast Service network over the UTA data link that operates on 978 MHz. The FIS-B system provides pilots and flight crews of properly equipped aircraft with a cockpit display of certain aviation weather and aeronautical information. *(FAA Pilot/Controller Glossary)*

General Aviation, GA. Refers to all civil aircraft and operations that are not classified as air carrier, commuter or regional. The types of aircraft used in general aviation activities cover a wide spectrum from corporate multi-engine jet aircraft piloted by professional crews to amateur-built single engine piston acrobatic planes, balloons and dirigibles. *(FAA website)*

General Aviation Airport. Any airport that is not an air carrier airport, or a military facility. *(FAA)*

Glide Slope Qualifying Surface, GQS. The GQS extends from the runway threshold along the runway centerline extended to the decision altitude point. It limits the height of obstructions between decision altitude and runway threshold. When obstructions exceed the height of the GQS, an approach procedure with positive vertical guidance (ILS, VNAV, Etc) is not authorized. *(FAA)*

Global Navigation Satellite System, GNSS. GNSS refers collectively to the worldwide positioning, navigation, and timing determination capability available from one or more satellite constellation in conjunction with a network of ground stations. *(FAA Pilot/Controller Glossary)*

Global Positioning System, GPS. GPS refers to the worldwide positioning, navigation and timing determination capability available from the U.S. satellite constellation. *(FAA Pilot/Controller Glossary)*

Height Above Touchdown, HAT. The height of the Decision Height or Minimum Descent Altitude above the highest runway elevation in the touchdown zone (first 3,000 feet of the runway). HAT is published on instrument approach charts in conjunction with all straight-in minimums. *(FAA Pilot/ Controller Glossary)*

Instrument Approach Procedure. A series of predetermined maneuvers for the orderly transfer of an aircraft under instrument flight conditions from the beginning of the initial approach to a landing or to a point from which a landing may be made visually. It is prescribed and approved for a specific airport by competent authority. *(FAA Pilot/Controller Glossary)*

Instrument Flight Rules, IFR. Rules governing the procedure for conducting instrument flight. In addition, it is a term used by pilots and controllers to indicate a type of flight plan**.** *(FAA Pilot/Controller Glossary)*

Instrument Landing System, ILS. A precision instrument approach system which normally consists of the following electronic components and visuals aids: localizer, glideslope, outer marker, middle marker, and approach lights. *(FAA Pilot/Controller Glossary)*

ILS Category (CAT I, II, III). There are three categories of ILS equipment which support similarly named categories of approach/landing operation. CAT I has the highest minimums (the pilot must be able to see the runway at a point 200 feet above the runway), while Cat III has the lowest minimums, meaning aircraft can land in near zero visibility conditions and doesn't require visual identification of the runway prior to landing. Special categories of ILS approach are defined which allow qualified pilots flying equipped aircraft to equipped runways using appropriately qualified ILS systems to continue an ILS approach without acquiring visual reference to a lower decision height than the Category I standard of 200 feet above runway threshold elevation. *(Adapted from skybrary.com and Wikipedia.org)*

Internal Reference Unit, IRU. An IRU is an internal navigation system used on large aircraft. It is a type of inertial sensor which uses gyroscopes and accelerometers to determine a moving aircraft's or spacecraft's change in rotational attitude (angular orientation relative to some reference frame) and translational position (typically latitude, longitude and altitude) over a period of time. *(adapted from PSRC Working Paper Chapter 1 and Wikipedia.org)*

Itinerant Operation. Takeoff or landing operations of airplanes going from one airport to another airport that involves a trip of at least 20 miles. Local operations are excluded. *(FAA AC 150/5325-4B)*

Land Use Compatibility. The coexistence of land uses surrounding the airport with airport-related activities. *(FAA website)*

Lateral Navigation, LNAV. A function of RNAV equipment which calculates, displays, and provides lateral guideance to a profile or path. *(FAA Pilot/Controller Glossary)*

Local Operation. Any operation performed by an aircraft that (a) operates in the local traffic pattern or within sight of the tower or airport, or (b) is known to be departing for, or arriving from, flight in local practice areas located within a 20-mile radius of the control tower or airport, or (c) executes a simulated instrument approach or low pass at the airport. *(FAA website)*

Localizer Performance, LP. LP is an arrival that requires a WAAS-approved GPS to fly the localizer-based procedure; it does not provide vertical guidance. LPs are published at locations where the terrain or obstructions do not allow publication of LPV procedures. *(airfactsjournal.com and FAA website)*

Localizer Performance with Vertical Guidance, LPV. LPV is one of the four lines of approach minimums found on an RNAV (GPS) approach chart. Lateral guidance accuracy is equivalent to a localizer. The height above touchdown is published as a decision altitude since it uses an electronic glide path that is not dependent on any ground equipment or barometric aiding and may be as low as 200 feet and ½ statute mile visibility depending on the airport terrain and infrastructure. WAAS avionics approved for LPV is required. *(FAA website)*

Magnetic Variation Study, MagVar Study. The magnetic variation is the difference between magnetic north and true north. When a navigational aid is out of tolerance by a certain number of degrees from magnetic north, a MagVar Study is conducted. *(FAA)*

Mean Sea Level Altitude, MSL. Altitude expressed in feet measured from seal level. *(FAA Pilot/Controller glossary)*

Military Operations Area, MOA. A MOA is airspace established outside of Class A airspace area to separate or segregate certain nonhazardous military activities from IFR traffic and to identify for VFR traffic where these activities are conducted. *(FAA Pilot/Controller glossary)*

National Airspace System, NAS. The common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas; aeronautical charts, information and services; rules, regulations and procedures, technical information, and manpower and material. Included are system components shared jointly with the military. *(FAA Pilot/Controller glossary)*

National Plan of Integrated Airport Systems, NPIAS. The Secretary of Transportation transmitted the 2007-2011 National Plan of Integrated Airport Systems (NPIAS) to Congress on September 29, 2006. The AIP-eligible development needs identified in this report were compiled as of December 2005 with selected updates through July 2006. *(FAA NPIAS Report)*

Nautical Mile. A measure of distance equal to one minute of arc on the earth's surface, which is approximately 6,076 feet. *(FAA website)*

Navigation Aids, NAVAID. Any facility used by an aircraft for guiding or controlling flight in the air or the landing or take-off of an aircraft. *(FAA website)*

Next Generation Air Transportation System, NextGen. Ongoing, wide-ranging transformation of the National Airspace System (NAS). NextGen represents an evolution from a ground-based system of air traffic control to a satellite-based system of air traffic management. *(FAA website)*

Non-Directional Beacon, NDB. An L/MF or UHF radio beacon transmitting nondirectional signals whereby the pilot of an aircraft equipped with direction finding equipment can determine his/her bearing to or from the radio beacon and “home” on or track to or from the station. When the radio beacon is installed in conjunction with Instrument Landing System marker, it is normally called a Compass Locator. *(FAA Pilot/Controller glossary)*

Non-Precision Instrument Runway. A runway having an existing instrument approach procedure utilizing air navigation facilities with only horizontal guidance, or area type navigation equipment, for which a straight-in nonprecision instrument approach procedure has been approved or planned. *(FAA AC 150/5190-4A)*

Notices to Airmen, NOTAM. A notice containing information (not known sufficiently in advance to publicize by other means) concerning the establishment, condition, or change in any component (facility, service, or procedure of, or hazard in the National Airspace System) the timely knowledge of which is essential to personnel concerned with flight operations. *(FAA Pilot/Controller Glossary)*

Object. Includes, but is not limited to above ground structures, NAVAIDSs, people, equipment, vehicles, natural growth, terrain, and parked aircraft. *(FAA AC 150/5300-13)*

Obstruction. Any structure, growth, or other object, including a mobile object, which exceeds a limiting height, specific to its geographic location relative to the runway/airport. *(FAA AC 150/5190-4A)*

One Engine Inoperative Surface, OEI Surface. OEI surface is based on TERPS IFR departure procedure climb requirements for an aircraft climbing with one engine inoperative. *(Consultant Team)*

Part 77. 14 CFR Part 77, *Objects Affecting Navigable Airspace,* establishes standards for determining obstructions in navigable airspace; defines the requirements for notice to the FAA Administrator of certain proposed construction or alteration; provides for aeronautical studies of obstructions to air navigation to determine their effect on the safe and efficient use of airspace; provides for public hearings on the hazardous effect of proposed construction or alteration on air navigation; and provides for establishing antenna farm areas. *(FAA FAR Sec. 77.31)*

Performance Based Navigation, PBN. Area navigation based on performance requirements for aircraft operating along ant ATS route, on an instrument approach procedure or in a designated airspace. *(FAA Pilot/Controller Glossary)*

Note: Performance requirements are expressed in navigation specifications (RNAV specification, RNP specification) in terms of accuracy, integrity, continuity, availability, and functionality needed for the proposed operation in the context of a particular airspace concept.

Precision Instrument Runway. A runway having an existing instrument approach procedure utilizing an Instrument Landing System (ILS) or a Precision Approach Radar (PAR). It also means a runway for which a precision approach system is planned and is so indicated on an approved airport layout plan or any other planning document. *(FAA AC 150/5190-4A)*

Q-Route – A jet route for aircraft navigating under IFR conditions above 18,000 feet mean sea level and require RNAV capability. *(FAA Instrument Procedures Handbook, Chapter 2)*

Required Navigation Performance, RNP. RNP is a statement of navigation performance necessary for operation within a defined airspace. On-board monitoring and alerting is required. RNP operations are RNAV procedures with a specified level of performance and capabilities. *(FAA website)*

Required Navigation Performance-Authorization Required, RNP-AR. RNP-AR approaches include unique capabilities that required special aircraft and aircrew authorization similar to CAT II/III instrument landing system operations. All RNP-AR approaches have reduced lateral obstacle evaluation areas and vertical obstacle clearance surfaces predicated on the aircraft and aircrew performance requirements of Advisory Circular 90-101A. *(FAA AC 90-101A)*

RNAV – see Area Navigation.

RNAV SID – A standard instrument departure that uses area navigation for guidance.

Runway Threshold Siting Surface, TSS. TSS are the approach and departure surfaces as defined in FAR AC 150/5300-13A. *(FAA website)*

Safety Risk Management Panel, SRM Panel. A formalized, proactive approach to system safety. SRM is a methodology applied to all NAS changes that ensures that hazards are identified and unacceptable risk is mitigated before a change is made. It provides a framework to ensure that once a change is made, it continues to be tracked throughout its lifecycle. An SRM Panel is a panel comprised of subject matter experts that make be required to conduct a Safety Assessment. *(FAA website)*

Standard Terminal Arrival, STAR. Provides a common method for departing the en route structure and navigating to your destination. A STAR is a preplanned instrument flight rule ATC arrival procedure published for pilot use in graphic and textual form to simplify clearance delivery procedures. STARs provide you with a transition from the en route structure to an outer fix or an instrument approach fix or arrival waypoint in the terminal area, and they usually terminate with an instrument or visual approach procedure. *(FAA website)*

Standard Instrument Departure, SID. An ATC requested and developed departure route designed to increase capacity of terminal airspace, effectively control the flow of traffic with minimal communication, and reduce environmental impact through noise abatement procedures. *(FAA website)*

Statute Mile, SM. A measure of distance equal to 5,280 feet. *(FAA website)*

Surface Analysis and Visualization Tool, SAV. The SAV tool analyzes object penetrations to the visual area surface of instrument approaches using a risk-based approach. The tool allows the FAA and airport owners and sponsors to discover, verify, and mitigate objects identified as penetrations to the 20:1 visual area surface. *(FAA website)*

Terminal Area. A general term used to describe airspace in which airport traffic control or approach control service is provided. *(FAA website)*

Terminal Area Forecast, TAF. The TAF is the official FAA forecast of aviation activity for U.S. airports. It contains active airports in the *National Plan of Integrated Airport Systems (NPIAS)* including FAA towered airports, Federal contract towered airports, nonfederal towered airports, and non-towered airports. *(FAA website)*

Terminal Area Route Generation, Evaluation and Traffic Simulation, TARGETS. TARGETS incorporates data visualization capabilities with readily accessible design elements to enable procedure designers to rapidly and easily develop [flight] procedures. The integrated capabilities of TARGETS enable quick assessment of alternative design concepts, leading to robust solutions that satisfy operation needs and co mply with design constrains. *(FAA Brochure)*

Terminal En Route Procedures, TERPS. TERPs prescribes standardized methods for use in designing instrument flight procedures. *(FAA Instrument Flying Handbook, Chapter 8)*

Traffic Information Service-Broadcast, TIS-B. An air traffic surveillance system that combines all available traffic information on a single display. *(PSRC Chapter 1)*

T-Route - A “T-Route” is a low altitude RNAV only route, identified by the “T” prefix, followed by a three digit number. T-routes are for aircraft operating below 18,000 feet mean sea level. *(FAA Instrument Procedures Handbook, Chapter 2)*

Wide Area Augmentation System, WAAS. The WAAS is a satellite navigation system consisting of the equipment and software which augments the GPS Standard Positioning Service (SPS). The WAAS provides enhanced integrity, accuracy, availability, and continuity over and above GPS SPS. The differential correction function provides improved accuracy required for precision approach. *(FAA Pilot/Controller Glossary)*

Vertical Navigation, VNAV. A function of RNAV equipment which calculates, displays, and provides vertical guidance to a profile or path. *(FAA Pilot/Controller Glossary)*

Very High Frequency Omnidirectional Range, VOR. A ground-based electronic navigation aid transmitting very high frequency navigation signals, 360 degrees in azimuth, oriented from magnetic north. Used as the basis for navigation in the National Airspace System. *(FAA Pilot/Controller Glossary)*

Visual Approach. An approach to an airport conducted with visual reference to the terrain. *(FAA website)*

Visual Runway. A runway without an existing or planned straight-in instrument approach procedure. *(FAA AC 150/5300-13)*

Visual Flight Rules, VFR. Rules that govern the procedures for conducting flight under visual conditions. The term "VFR" is also used in the United States to indicate weather conditions that are equal to or greater than minimum VFR requirements. In addition, "VFR" is used by pilots and controllers to indicate the type of flight plan. *(FAA FAR Sec. 170.3)*

V-Route – A system of established routes that run along specified VOR radials from one VOR station to another. *(FAA Instrument Procedures Handbook, Chapter 2)*

Zoning. An exercise of the police powers of the State, as delegated to local governments, designating the uses permitted on each parcel of land within the zoning jurisdiction. *(FAA AC 150/5020-1)*

Zoning Ordinance. Primarily a legal document that allows a local government effective and legal regulation of uses of property while protecting and promoting the public interest. *(FAA AC 150/5190-4A general definition)*

APPENDIX B: WEBSITE GUIDE

NEXTGEN AIRSPACE OPTIMIZATION STUDY

Tips for Surfing the Technical Website

We're building a technical website to display information for the airspace project in the study area within the Puget Sound region. It has a TON of data, including airports and navigation points; airspace structure; routes and procedures; flight tracks; and a flight replay function that's fun to watch. Here are some tips on accessing and using the website. The website is for use by the FAA, PSRC, and stakeholders; should you want to share the information beyond the stakeholder group, please call PSRC first, thanks!

NOTE: The website works BEST in Google Chrome, less well in Firefox, and it does NOT work in Internet Explorer.

WEBSITE: http://psrc.airportnetwork.com

PASSWORD: NEXTGEN (all CAPS)

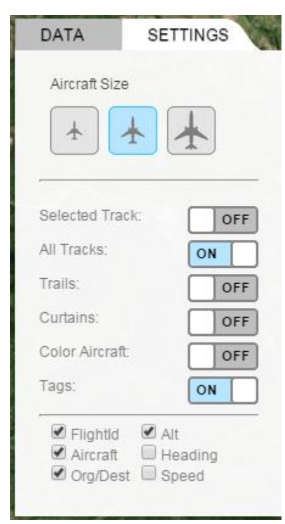
After you've logged in, you'll see icons and toolboxes that help you display various "layers" of information. First, there are 7 MAIN controls that let you change how the overall data is displayed.

MAIN Controls

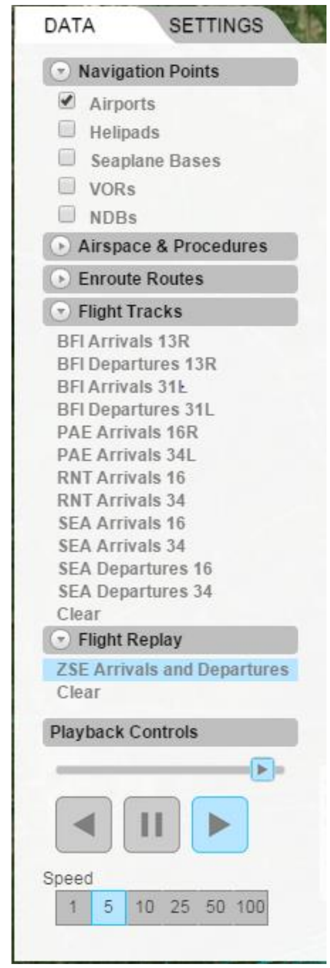
Display/hide - Allows you to display or hide the DATA and SETTINGS toolboxes.
Pilot view – Shows view from the cockpit in Flight Replay.
Flight profile – Displays a flight profile chart for selected aircraft in Flight Replay.
Map type - Lets you choose among three background maps.
Home – Takes you back to the original study area map.
Search – Allows you to search for an airport, etc.
Controls – Allows you to set mouse and arrow controls.

SETTINGS Toolbox

This tab allows you to change aircraft size, and display or hide flight tracks, aircraft trails, and aircraft color. This tab also allows you to display or hide aircraft tags. When tags are displayed, you can select an airline flight number, aircraft type, origin and destination, altitude, heading, and speed. These aircraft tags only show when in Flight Replay (described below).



DATA Toolbox



This tab contains most of the technical information, which you can access by clicking the grey box heading each section. You can open or close each section by clicking the grey title box at the top of each section. Under each grey box you can then click on the data you want to see, such as navigation points and airports, airspace structure and procedures, enroute routes, and flight tracks for each airport. Currently this website will only display one flight track at a time, but we're working to enable multiple tracks, so users can see interaction of flights to and from multiple airports. Stay tuned for this enhancement.

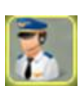
We've recently added STARS, SIDS, and approaches. To view these, click the airport symbol  on the map and the information will appear in the upper left corner of your screen.

Flight Replay

At the bottom of the DATA tab you'll see "Flight Replay" which shows a video of aircraft flying to and from Sea-Tac Airport based on radar data for a sample time period (2 hours) last September. Below this is a set of Playback Controls that allow you to play, stop, and back up. For those who like speed, you can control the playback (flight) speed by choosing a speed between 1 and 100.

Also, while in "Flight Replay" mode, the pilot view  icon lets you experience the actual flight as viewed by the pilot from the cockpit. To activate this feature:

1. Click on a plane. In the attached tag, and in the upper left corner of your screen, you'll see flight information: flight number, airline, aircraft type, altitude, origin, and destination. You can change what's displayed by using the settings toolbox (see above).

2. Click the pilot view  icon, and you'll be in the cockpit. Now sit back, relax, and enjoy your (short) flight.