Automatic Dependent Surveillance – Broadcast (ADS–B)

Service Availability Prediction Tool (SAPT)/Receiver Autonomous Integrity Monitoring (RAIM)

User Guide

Version 4.2

February 28, 2019

En Route & Oceanic Second Level Engineering Group
Federal Aviation Administration
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Atlantic City International Airport, New Jersey 08405
# Revision History

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February 28, 2019
<table>
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<th>Revision Level</th>
<th>Date</th>
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</tr>
</tbody>
</table>
Contents

Revision History ........................................................................................................ i

1 Introduction ................................................................................................................. 1–1
  1.1 ADS–B Prediction ...................................................................................... 1–1
  1.2 RAIM SAPT .............................................................................................. 1–2

2 Background .............................................................................................................. 2–1

3 Scope ...................................................................................................................... 3–1

4 Development Cycle .............................................................................................. 4–1

5 Limitations and Restrictions ............................................................................... 5–1

6 SAPT Use .............................................................................................................. 6–1
  6.1 Interface Requirements ............................................................................... 6–1
  6.2 Interface Types ......................................................................................... 6–1
  6.3 Required Information .................................................................................. 6–1
    6.3.1 GPS TSOs .......................................................................................... 6–2
    6.3.2 Mask Angle ....................................................................................... 6–3
    6.3.3 Barometric Aiding ............................................................................. 6–3
  6.4 Prediction Window ....................................................................................... 6–3
    6.4.1 Prediction for the XML and Flight Form Interface ......................... 6–3
    6.4.2 Prediction for the Graphical Display ............................................... 6–4
  6.5 ADS–B SAPT Algorithm ........................................................................... 6–4
  6.6 Alternate Surveillance Coverage .............................................................. 6–6
  6.7 RAIM Sufficiency ...................................................................................... 6–6

7 Interactive GUI ...................................................................................................... 7–1
  7.1 ADS–B Home Page ................................................................................... 7–1
  7.1.1 ADS–B Service Availability Prediction Tool .................................. 7–3
  7.2 Getting Started with ADS–B SAPT ...................................................... 7–6
  7.2.1 User Feedback ................................................................................... 7–7
  7.3 SAPT Header .............................................................................................. 7–8
    7.3.1 Header Layout .................................................................................. 7–8
    7.3.2 Search Feature ................................................................................ 7–8
    7.3.3 FAA Logo ......................................................................................... 7–9
    7.3.4 ADS–B Menus ................................................................................ 7–9
  7.4 SAPT Footer ............................................................................................... 7–11
7.5 Flight Plan Form ........................................................................................................ 7–12
7.5.1 Required Fields ..................................................................................................... 7–13
7.5.2 Field-Entry Help and Suggestions ........................................................................ 7–20
7.6 Saving and Loading a Flight Plan Form ................................................................ 7–22
7.6.1 Saving a Flight Plan Form ..................................................................................... 7–22
7.6.1.1 Save to My Browser Option ............................................................................. 7–23
7.6.1.2 Save to Uniform Resource Locator (URL) Option ........................................ 7–24
7.6.1.3 Save As A Computer File Option ..................................................................... 7–25
7.6.2 Loading Saved Data .............................................................................................. 7–26
7.6.2.1 Load Data From Browser .................................................................................. 7–27
7.6.2.2 Load Data From File ....................................................................................... 7–28
7.6.2.3 Load Data From ICAO Flight Plan ................................................................. 7–30
7.7 Prediction Output ...................................................................................................... 7–30
7.7.1 Flight Plan Results ............................................................................................... 7–30
7.7.1.1 Sufficiency ....................................................................................................... 7–32
7.7.1.1.1 FAA SAPT Policy with Exemption 12555 ...................................................... 7–33
7.7.1.1.2 Considerations: Departure and ETO Timing .............................................. 7–36
7.7.1.1.3 Considerations: When to Run a Prediction ................................................. 7–36
7.7.1.2 Insufficiency and Suggested Flight Times ..................................................... 7–36
7.7.1.3 Inserted/Redundant Route Points .................................................................... 7–37
7.7.2 Graphical Display ............................................................................................... 7–37
7.7.2.1 Large Area Display ......................................................................................... 7–38
7.7.2.2 Route-Specific Display .................................................................................... 7–42
7.8 Printing a Request .................................................................................................... 7–45
8 ADS–B XML Interface .................................................................................................. 8–1
8.1 WSDL .................................................................................................................... 8–1
8.2 Classes and Types ..................................................................................................... 8–3
8.3 Request and Response Example ............................................................................ 8–9
8.4 Interpreting the Results .......................................................................................... 8–17
8.5 Error Conditions ...................................................................................................... 8–18
9 RAIM Prediction Tool ................................................................................................ 9–1
9.1 Getting Started with RAIM ...................................................................................... 9–1
9.2 RAIM XML Service ................................................................................................. 9–2
9.2.1 Request the SAPT WSDL and SDK ................................................................. 9–3
9.2.2 Software Connectivity ....................................................................................... 9–5
9.2.3 SAPT Announcement Subscription ..................................................................... 9–7
10 RAIM Summary Pages .............................................................................................. 10–1

List of Acronyms and Abbreviations ........................................................................... LOA–1

February 28, 2019
List of Figures

Figure 6–1. ADS–B SAPT 33-Point Algorithm ............................................................. 6–5
Figure 7–1. SAPT Warning Page ............................................................................. 7–1
Figure 7–2. SAPT Main Page .................................................................................. 7–2
Figure 7–3. ADS–B Home Page — SAPT Section ..................................................... 7–3
Figure 7–4. ADS–B Home Page — Outage Summary ............................................... 7–4
Figure 7–5. SAPT Graphical Display With Outages .................................................. 7–5
Figure 7–6. Getting Started with ADS–B SAPT Page .............................................. 7–6
Figure 7–7. Feedback Form ................................................................................... 7–7
Figure 7–8. SAPT Header ....................................................................................... 7–8
Figure 7–9. SAPT Search Text-box (Single Character) ............................................. 7–9
Figure 7–10. SAPT Search Text-box (Full Word) .................................................... 7–9
Figure 7–11. ADS–B Menu .................................................................................. 7–10
Figure 7–12. Save & Load Menu ............................................................................ 7–10
Figure 7–13. Help Menu ....................................................................................... 7–11
Figure 7–14. SAPT Footer .................................................................................... 7–12
Figure 7–15. Flight Plan Form ............................................................................... 7–13
Figure 7–16. Flight Plan Form with Errors: Pop-up Example ................................... 7–18
Figure 7–17. Flight Plan Form with Errors: Example ............................................. 7–19
Figure 7–18. Flight Plan Form with Prediction ....................................................... 7–20
Figure 7–19. Field and Overlaid Suggestion Tip Box .............................................. 7–21
Figure 7–20. Save & Load Menu Pop-up Tip .......................................................... 7–22
Figure 7–21. Flight Plan Saving Options ................................................................. 7–23
Figure 7–22. Flight Plan Form Saved to a Browser — Notification Message ......... 7–24
Figure 7–23. Flight Plan Form Written to a URL — Notification Message ............ 7–25
Figure 7–24. Flight Plan Form Saved to a File — Notification Message ............... 7–26
Figure 7–25. Flight Plan Form Loading Options ................................................... 7–27
Figure 7–26. Flight Plan Form Loading Options — Browser .................................. 7–28
Figure 7–27. Flight Plan Form Loading Options — File .......................................... 7–29
Figure 7–28. Flight Plan Form Loading a File — Choose a File to Upload ............. 7–29
Figure 7–29. Flight Plan Prediction Request ............................................................ 7–30
Figure 7–30. Sufficiency Suggestion .................................................................... 7–32
Figure 7–31. Large Area Graphical Display ............................................................ 7–39
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7–32.</td>
<td>Northeast Region — Illustrated Selection</td>
<td>7–41</td>
</tr>
<tr>
<td>7–33.</td>
<td>Create Route-Specific Flight Plan Form</td>
<td>7–43</td>
</tr>
<tr>
<td>7–34.</td>
<td>Route-Specific Graphical Display</td>
<td>7–45</td>
</tr>
<tr>
<td>7–35.</td>
<td>Print a Prediction Menu</td>
<td>7–46</td>
</tr>
<tr>
<td>7–36.</td>
<td>Sample Printed Prediction</td>
<td>7–47</td>
</tr>
<tr>
<td>8–1.</td>
<td>WSDL Request Link</td>
<td>8–1</td>
</tr>
<tr>
<td>8–2.</td>
<td>Download the SAPT SDK Pop-up</td>
<td>8–1</td>
</tr>
<tr>
<td>8–3.</td>
<td>Save the SAPT SDK</td>
<td>8–2</td>
</tr>
<tr>
<td>8–4.</td>
<td>Open the SAPT SDK</td>
<td>8–2</td>
</tr>
<tr>
<td>8–5.</td>
<td>XML Web Service — Classes and Types</td>
<td>8–3</td>
</tr>
<tr>
<td>9–1.</td>
<td>Getting Started with RAIM SAPT Page</td>
<td>9–2</td>
</tr>
<tr>
<td>9–2.</td>
<td>RAIM XML Service Page</td>
<td>9–3</td>
</tr>
<tr>
<td>9–3.</td>
<td>Download the SAPT SDK</td>
<td>9–4</td>
</tr>
<tr>
<td>9–4.</td>
<td>Download the SAPT SDK Pop-up Window</td>
<td>9–4</td>
</tr>
<tr>
<td>9–5.</td>
<td>Save the SAPT SDK</td>
<td>9–5</td>
</tr>
<tr>
<td>9–6.</td>
<td>Open the SAPT SDK</td>
<td>9–5</td>
</tr>
<tr>
<td>9–7.</td>
<td>SAPT E-mail Subscription Page</td>
<td>9–7</td>
</tr>
<tr>
<td>10–1.</td>
<td>RAIM Summary Section</td>
<td>10–1</td>
</tr>
<tr>
<td>10–2.</td>
<td>RAIM Summary — NPA Airspace, SA On and Baro-aiding Enabled</td>
<td>10–2</td>
</tr>
<tr>
<td>10–3.</td>
<td>RAIM Summary — NPA Airspace, with SA On and No Baro-aiding</td>
<td>10–3</td>
</tr>
<tr>
<td>10–4.</td>
<td>RAIM Summary — NPA Airspace, SA On and Baro-aiding</td>
<td>10–4</td>
</tr>
<tr>
<td>10–5.</td>
<td>RAIM Summary — GPS Test Outage Detail, NPA Airspace, SA On and No Baro-aiding</td>
<td>10–6</td>
</tr>
<tr>
<td>10–6.</td>
<td>RAIM Summary — RAIM Outage Detail, NPA Airspace, SA On and No Baro-aiding</td>
<td>10–7</td>
</tr>
</tbody>
</table>
List of Tables

Table 7–1. Required SAPT Fields ................................................................. 7–14  
Table 7–2. Interpreting Results for SAPT Preflight Availability Predictions .......... 7–35  
Table 8–1. ADSB Sufficiency for Route Request ............................................ 8–4  
Table 8–2. ADSB Sufficiency for Route Response .......................................... 8–4  
Table 8–3. ADS–B SAPT Transaction Information ........................................... 8–4  
Table 8–4. Constellation Information .............................................................. 8–5  
Table 8–5. Route Information ......................................................................... 8–5  
Table 8–6. Waypoint Information ................................................................. 8–6  
Table 8–7. Disposition Information ................................................................. 8–7  
Table 8–8. ADS–B SAPT Exception ................................................................. 8–8  
Table 8–9. Sample ADS–B SAPT Request ...................................................... 8–9  
Table 8–10. Sample ADS–B SAPT Response with Alternate Surveillance .......... 8–11  
Table 8–11. Sample ADS–B SAPT Response with One Expired and One Sufficient Route ................................................................. 8–12  
Table 8–12. ADS–B SAPT Exception Error Information ................................... 8–18
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1. INTRODUCTION

The Automatic Dependent Surveillance – Broadcast (ADS–B) Service Availability Prediction Tool (SAPT) was developed by the United States (US) Department of Transportation (DOT), John A. Volpe National Transportation Systems Center (Volpe Center) for the Surveillance and Broadcast Services (SBS) organization within the Federal Aviation Administration (FAA).

The Receiver Autonomous Integrity Monitoring (RAIM) SAPT is intended mainly for situational awareness for pilots, dispatchers, and commercial operators to check their predicted navigation horizontal protection level.

In this document, the term SAPT refers to the system that includes both the ADS–B and RAIM prediction capability. When ADS–B SAPT is specified, the requirement applies only to the ADS–B-related predictions. When RAIM SAPT is specified, the requirement applies only to the RAIM part of the SAPT.

The SAPT is an Internet-accessible application with multiple interfaces. There are maps of predicted RAIM and ADS-B outages; downloadable files containing the outage information from the maps; and an eXtensible Markup Language (XML) interface that will accept planned routes of flight and return predictions. The ADS–B SAPT also provides a flight plan-like web form that will predict the ability of an aircraft to meet ADS–B airspace performance requirements along a given route of flight.

REMINDER: The SAPT provides maps of wide area outages as an informational flight planning aid for situational awareness only.

1.1 ADS–B Prediction

The ADS–B SAPT predicts the ability of an aircraft’s avionics to meet performance requirements along a given route of flight based on the predicted status of the Global Positioning System (GPS) constellation and a model of the aircraft’s avionics. Avionics specified in the Technical Standard Orders (TSO) listed below are modeled by the SAPT:

- C129
- C129 with Selective Availability (SA) Aware
- C129 with FDE
- C129 with SA Aware & FDE
- C145/146 with WAAS\(^1\)
- C145/146 outside WAAS coverage
- C196

The SAPT will also provide users with dispatch information based on the availability of other surveillance sources, such as Wide Area Multilateration (WAM) and Secondary Surveillance Radar (SSR) when ADS–B performance is predicted to be below requirements along a specified route of flight.

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\(^1\) The availability of Wide Area Augmentation System (WAAS) under TSO–C145c/146c is not provided by the SAPT; however, predictions for TSO–C145c/146c are available both with WAAS and outside WAAS coverage.
The ADS–B prediction computes Navigation Integrity Category (NIC) and Navigation Accuracy Category for Position (NACp) and compares the results to the required values for each point within the indicated flight plan. SSR and WAM availability will be based on coverage volumes in the Service Volume Definition Document (SVDD), as modeled by Technologies Service Corporation (TSC), FAA-defined airspace definitions, and status feeds. It is the responsibility of the user to know whether a point is in rule airspace defined in Title 14 Code of Federal Regulations (14 CFR) Part 91 § 91.227, Automatic Dependent Surveillance-Broadcast (ADS-B) Out equipment performance requirements.

The ADS–B SAPT is primarily intended for pilots, dispatchers, and commercial operators to verify their predicted surveillance availability before flight; it is also accessible to others.

For ADS–B, if the aircraft avionics meet the requirements of 14 CFR § 91.227, but unexpected GPS degradations during the flight inhibit the position source from providing adequate accuracy and integrity for ADS–B, Air Traffic Control (ATC) will be alerted from the aircraft broadcasted data, and may provide services to that aircraft using the back-up strategy.

This information is in accordance with 14 CFR Part 91, Paragraph H.2, Automatic Dependent Surveillance–Broadcast (ADS–B) Out Performance Requirements to Support ATC Service, hereafter referred to as the “Final Rule.”

In addition, the ADS–B SAPT will allow the FAA to define different NIC and NACp requirements for a defined airspace. The changed NIC and NACp requirements for this airspace will be applied based on guidance from the FAA.

### 1.2 RAIM SAPT

The RAIM SAPT provides situational awareness to users planning flights which are predicated on TSO–C129 GPS being the primary navigational aid supporting Area Navigation (RNAV) operations. The RAIM SAPT provides users with TSO–C129 GPS availability predictions along the desired route of flight and compares the results to the user-supplied Horizontal Alert Limit (HAL).

The intent is for users to submit requests that use the FAA required values for Required Navigation Performance (RNP) and RNAV in the En Route and Terminal environments, or better. If the predicted integrity does not meet the requested integrity for a five-minute period anywhere along the requested route, the SAPT returns a sufficiency value of “false”. Conversely, if predicted integrity levels meet or exceed these operational limits, the SAPT returns a sufficiency value of “true”.

The SAPT provides maps of wide area outages as a flight planning aid. Wide area outage maps are available for a limited subset of supported avionics for both ADS–B and RAIM.

Instructions for using the RAIM tool are found in Section 9, RAIM Prediction Tool, of this user guide.

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2. BACKGROUND

ADS–B is a surveillance technology in which avionics broadcast an aircraft’s identification, position, altitude, velocity, and other information, to support ATC services in Terminal and En Route airspace, and in airport surface operations.

The FAA ADS–B Final Rule requires that aircraft operating in certain airspace have ADS–B Out capabilities by January 1, 2020.

The FAA ADS–B implementation involves two Air-to-Ground (A/G) (and Air-to-Air (A/A)) broadcast links:

- **1090ES.** This refers to aircraft broadcasts using a 1090 Megahertz (MHz) carrier that conforms to the Mode S Extended Squitter signal protocol. Primary standards for aircraft equipment are FAA TSO–C166b and RTCA, Inc., Minimum Operational Performance Standards (MOPS) DO–260B.

- **UAT.** This refers to aircraft broadcasts on a 978 MHz carrier that conforms to the Universal Access Transceiver (UAT) signal protocol. Primary standards for aircraft equipment are FAA TSO–C154c and RTCA MOPS DO–282B.

Because radar and ADS–B determine position so differently, an ADS–B Aviation Rulemaking Committee (ARC) was formed to advise the FAA on the adoption of ADS–B.

The ARC recommended that:

“The FAA should create a function for centralized, expert calculation and reporting of predicted continuity of the required navigation performance (RNP) parameters....” (ARC, 2008).

The SAPT addresses the ARC recommendation. In making predictions, the SAPT will take into account the status of the GPS satellite constellation.

In addition, the FAA determined SAPT should include the availability of surveillance, such as WAM and SSR, to provide an encompassing picture of surveillance coverage. The following list outlines prediction capabilities of ADS–B SAPT:

- ADS–B integrity/accuracy for Terminal and En Route separation services (NIC 7, NACp 8; or better)
- ADS–B integrity/accuracy for separation services different than Terminal and En Route
- SSR coverage
- WAM coverage
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3. SCOPE

This document has been developed to aid users to operate the SAPT under SAPT 4.0, the Industry Eval Release. Where known, FAA policy about interpreting SAPT results is presented.

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4. DEVELOPMENT CYCLE

The ADS–B SAPT development includes the following releases:

- RAIMPrediction.net Release (June 2009)
- Test Release (September 2011)
- Baseline Release (May 2013)
- RAIM Integration Release (April 2014)
- Enhancement Release (May 2016)
- Tech Refresh (FY 2016)
- SAPT 3.1 Google Earth™ Replacement (May 2017)
- SAPT 3.2 Industry Eval Prep (September 2017)
- SAPT 4.0 Industry Eval (the current release) (September 2018)

One additional major release is planned:

- SAPT 4.1 (new requirements follow-on) (September 2019)

The Test Release of the SAPT system was delivered to the FAA in September 2011 to allow users and developers the opportunity to test and improve the system.

The Baseline Release was delivered in May 2013 and included changes based on user feedback, discovered bugs, algorithm changes, and additional levied requirements. The system is now fully operational and officially available for pre-flight predictions.

The RAIM Integration Release was delivered in August 2014. It incorporates TSO–C129 GPS RAIM predictions satisfying the operational requirement to check the availability of GPS RAIM for flights where TSO–C129 equipment will be used to satisfy the RNAV requirement per AC 90–100A, Paragraph 10(5)). That release established the baseline for the RAIM prediction system in the FAA inventory and allowed users to migrate from RAIMPrediction.net, which has been deprecated.

This Enhancement Release included the following features:

- Provided the FAA with the ability to define different NIC and NACp requirements for a defined airspace.
- Availability of alternate surveillance sources, such as SSR and WAM.
- An improved web form response that highlights results at each waypoint with a traffic light graphic and includes alerts for planned potential GPS Interference Tests.
- An interface with the SBS performance monitor.

The Tech Refresh Release updated the software to run on a different operating system and hardware.

SAPT 3.1, the Google Earth™ Replacement release changed to a new graphical display technology: the maps on the webpage now use Cesium.
SAPT 3.2, the Industry Eval Prep release, incorporated changes related to security, including a secure transaction key. It also added backup capability to the SAPT Validator. The Hypertext Transfer Protocol Secure (HTTPS) conversion was planned for SAPT 4.0, but was accomplished in February 2018, between releases.

SAPT 4.0, the Industry Eval release, adds features requested by the Equip 2020 SAPT Industry Evaluation, including a simplified Go/No ADS-B response and the ability to paste in an International Civil Aviation Organization (ICAO) Flight Plan Form. It also includes a number of improvements to the airspace model and maps. This is planned to be the last release that includes changes to the XML form.

At least one future release is planned to incorporate a few outstanding planned changes, such as the ability to issue a Notice to Airmen (NOTAM) when SAPT itself is down, as well as any additional requirements from the FAA.
5. LIMITATIONS AND RESTRICTIONS

The SAPT is a prediction service that is freely available over the Internet. While the system will be available 24/7, and the Contact Us link on the website will open a ticket with 24/7 phone coverage, operational help and full system-crash recovery will be limited to regular business hours. In the future there will be a NOTAM issued in the event of a SAPT product outage. There is no requirement to track users; i.e., no user names or passwords are required to use the tool. Predictions, however, will be stored in the database.

The pre-flight requests will be limited to a 72-hour prediction window. A prediction for a given flight should be done before the scheduled departure. For restrictions on when the prediction should be made relative to departure, refer to the policy in Exemption 12555. A prediction may be applied to a flight that does not deviate significantly from the scheduled departure time (i.e., ±5 minutes) or geographically from the predicted route of flight (i.e., ±7 Nautical Miles (NM) perpendicular to the route of flight).

Operators must ensure that they have the most up-to-date information. Operators are allowed to run more than one prediction with different scheduled departure times before their flight.

If an operator’s system exceeds the minimum performance specified in the Final Rule for ADS–B aircraft equipage, the operator may achieve higher availability than predicted by the SAPT. Operators may use an alternative prediction tool to take advantage of this increased availability. Operators and manufacturers are also free to build their own prediction tool based on their needs and requirements.

The SAPT will not be integrated with Flight Service Stations, and its use may constitute an additional step in the pre-flight routine. NOTAM are issued for a variety of reasons, so the requirement to “check for NOTAMs” will remain.

Users who choose to employ the XML interface, who are designated as “XML users,” and those designated as “Automated Users,” must develop and implement their own interface into SAPT through the Internet.

The SAPT web form is ADS–B only, and does not make predictions for navigational use because the RNP for ADS–B does not employ the same standard as navigation. RAIM prediction for a route of flight is available in XML format only.

**REMINDER:** SAPT users who want to use certain position sources for navigation must check for that availability separately.
6. SAPT USE

The ADS–B SAPT is primarily intended for use by pilots, dispatchers, and commercial flight operators when they plan flights for which ADS–B is required as a source of the surveillance information that controllers use for any part of the flight.

The SAPT provides surveillance availability for the entire US airspace as defined in the FAA SBS SSVDD. The SVDD definition of US airspace includes Alaska, Hawaii, Puerto Rico, Guam, and the Gulf of Mexico.

6.1 Interface Requirements

The SAPT has updated website security since the previous release to: HTTPS Secure Socket Layer (SSL)/Transport Layer Security (TLS) V1.2; HTML 4.01 Transitional; CSS 2.1; and JavaScript 1.8.5. The SAPT website and services will function in web browsers and clients which implement these standards. Minimum versions of popular client software include: Java 8; .NET 4.6, and Python V2.7.9/3.4.

NOTE: Java 8 implements TLS 1.2 by default, and is the only supported runtime environment for SAPT.

The SAPT HTTP Strict Transport Security (HSTS) implementation may not be recognized by all clients for automatic redirection of Hypertext Transfer Protocol (HTTP) to HTTPS. (All that means is that you may need to type the HTTPS at the beginning of the website name yourself.)

You will need JavaScript on your computer in order to use the Graphical User Interface (GUI).

We have implemented a few features to make navigation easier on mobile devices. Provided you have a recent version, SAPT should now work on most desktop and mobile browsers.

6.2 Interface Types

The SAPT has two interface mechanisms to perform a prediction for a route of flight and both are available over the Internet:

• ADS–B Only: A GUI Flight Plan Form built on interactive Hypertext Markup Language (HTML) for users who require information for a few flights. In addition to direct data entry, the Flight Plan Form supports saving and loading flight and aircraft information, and pasting in ICAO flight plans.

• A Web service-enabled automated interface (i.e., computer-to-computer) in XML format, intended for commercial aircraft operators and third-party flight-planning service providers.

6.3 Required Information

In addition to the standard information required on the FAA flight plan (FAA Form 7233–1 (8–82)), the interactive user interface includes the following fields:

• Navigation Source TSO — this is required information

• ADS–B Link TSO — this is required information
• Mask Angle — the default value is 5.0
• Barometric Aiding — this is required information. Users must indicate if baro-aiding is present or not. If the user does not check the box it means that baro-aiding is not present.

The SAPT employs this information to suggest routes.\(^3\)

**NOTE:** Users may contact the manufacturer of their aircraft for detailed information about its avionics.

### 6.3.1 GPS TSOs

The SAPT supports the following avionics MOPS:

- C129
- C129 with SA Aware
- C129 with FDE
- C129 with SA Aware & FDE
- C145/146 with WAAS
- C145/146 outside WAAS Coverage
- C196

A TSO–C129 GPS receiver’s availability will not always meet the ADS–B final rule requirement of NIC 7 and NACp 8. This type of receiver includes Fault Detection (FD) but may not be equipped with Fault Detection and Exclusion (FDE) capability.

If you do not know if the receiver supports FDE, choose C129 without FDE (this is similar to SA Aware).

TSO–C145/146 augmented with WAAS will always provide the required availability as defined by the ADS–B Final Rule. This type of TSO uses FDE; accuracy deviations are corrected with the aid of WAAS ground stations.

When WAAS is unavailable most TSO–C145/146 avionics will use FDE only. In these situations, avionics can detect and exclude satellites from the solution but accuracy deviations are not corrected. TSO C196 is essentially the same as TSO–C145/146 avionics which employ FDE.

TSO–C145/146 without WAAS and TSO–C196 will both provide much higher accuracy and availability than TSO–C129, but could still encounter periods of degraded performance.

You can select one of the following TSOs from the Navigation Source drop-down menu:

- C129
- C129 with SA Aware
- C129 with FDE
- C129 with SA Aware & FDE

---

\(^3\) The page uses Asynchronous JavaScript and Xml (AJAX) to send the user’s keystrokes to the Form Support Web Service so that the application can return suggestions to the user. Once the user submits the prediction request, a message below the form will indicate that the request is being processed. Once the matching results are returned, the message will be updated to display them.
ADS–B SAPT/RAIM User Guide

SA adds error to a GPS solution, thus degrading its accuracy. If avionics equipment has SA set to “ON” (or “unaware”), an error of 33.3 meters is added to the prediction. If avionics are set to SA “OFF” (or “aware”), the error is not added to the prediction. The SAPT only supports the addition of the error for TSO–C129 avionics.

6.3.2 Mask Angle

The GPS mask angle is the angle from the horizon that the receiver uses to eliminate potential satellites from the solution. Users may select values between 0 and 5 degrees using half-degree increments from the Mask Angle drop-down menu.

6.3.3 Barometric Aiding

Barometric Aiding (BA), or barometric altimeter, gives an additional altitude source which helps reduce the error when it is used in conjunction with GPS. It approximates the addition of a satellite in the view. SAPT users may check the BA box on the Flight Plan Form if their associated avionics includes BA.

Note that RAIM availability demands that a minimum number of satellites be received. BA reduces this number by one.

6.4 Prediction Window

The Satellite Service Level Prediction Model (SSLPM) enables SAPT to calculate the level of service that can be expected for a given time, including three-dimensional aircraft location (latitude, longitude and altitude) and the expected status of the GPS satellite constellation.

REMINDER: The predictions for the outages shown on the graphical display are generated differently from the predictions for individual flights.

6.4.1 Prediction for the XML and Flight Form Interface

Through the SSLPM, the SAPT implements several GPS accuracy and integrity prediction algorithms, as specified in the FAA TSOs listed in Section 6.3.1 of this guide.

The available satellite constellation is modeled every 24 hours or upon a change to the status of any of the satellites. The model projects the position of each available GPS satellite every minute for 72 hours into the future.

The SSLPM algorithm employs all satellites in view without requiring the user to specify the number of satellites that should be tracked.
The prediction for an individual route of flight is calculated in real time for each waypoint in the route of flight based on the pre-computed constellation.

### 6.4.2 Prediction for the Graphical Display

The graphical display is represented in an interactive map and can be generated from the Flight Plan Form to display a summary of outages over a six-hour period.

Data on the graphical display are calculated in advance for a configurable length of time and frequency for TSOs C129 and C196 and for mask angles 2.0 and 5.0.

**NOTE:** RAIM users should consult Section 9, *RAIM Prediction Tool*, and Section 10, *RAIM Summary Pages*, of this guide for more information.

While the graphical display is loading, it will report the total number of outages and the degree of resolution. By default, the graphical display will show outages for the Continental US (CONUS) at a low resolution.

Users can select a smaller specific region from the View Outages for Area drop-down menu, or they can employ the features of the interactive map to navigate to a particular region, and then display outages for that region at a higher resolution by clicking *Generate new KML for Area in View*. The areas within which outages are searched are highlighted within a box. While the graphical display recalculates its position, it reports zero ("0") outages.

**REMINDER:** Outages are only predicted within the airspace defined in the FAA SBS SVDD. An area outside this airspace may be highlighted but no outages will be shown.

### 6.5 ADS–B SAPT Algorithm

For each point along the route a maximum Horizontal Protection Limit (HPL) is calculated based on a 33-point grid. The grid scheme is illustrated in Figure 6–1, ADS–B SAPT 33-Point Algorithm. The grid scheme evaluates 33 points and applies the maximum HPL to the requested point on the route at the associated Estimated Time Over (ETO).

The grid is based on ± 5 minutes and ± 7.5 NM to project an aircraft’s possible location in both space and time.

**NOTE:** This projection accounts for only five minutes of variation in the departure time or other sources of uncertainty about the aircraft’s actual location compared to the operator’s plans. Users may wish to submit additional requests for predictions with different departure times to account for variations in departure times and in estimated times over later waypoints.

Once an HPL has been calculated, it is transformed into NIC and NACp values and is compared to the threshold for ADS–B sufficiency.

**NOTE:** For further information please refer to Section 7.7.1.1, Sufficiency.

The Horizontal Figure of Merit (HFOM) is calculated and the result converted into the NACp for TSO–C129, TSO–C196 and TSO–C145/146 outside WAAS coverage. For TSO–C145/146 w/ WAAS the horizontal confidence bounds are scaled to the containment radius.
NOTE: Figure 6–1 applies to ADS–B predictions only. RAIM users should refer to Section 9, RAIM Prediction Tool, and Section 10, RAIM Summary Pages, in this guide for more information.

The SSLPM evaluates ADS–B predictions based on the following configurations, using one-minute GPS constellation intervals, and taking the maximum HPL of the 33 sample points:

- TSO–C145/146 with WAAS:
  - Time-window limits: -5 to +5 minutes
  - Position offsets: -7.5 to +7.5 NM
  - Scale the maximum HPL of the 33 sample points to approximate an HFOM
- TSO–C145/146 outside WAAS coverage:
  - Time window limits: -5 to +5 minutes
  - Position offsets: -7.5 to +7.5 NM
  - Take the maximum HFOM of the 33 sample points
- TSO–C129, with and without SA Awareness and/or FDE capabilities, and TSO–C196:
  - Time window limits: -5 to +5 minutes
  - Position offsets: -7.5 to +7.5 NM
  - Take the maximum HFOM of the 33 sample points
6.6 Alternate Surveillance Coverage

The SAPT maintains a composite coverage profile of backup surveillance (from SSR and WAM stations) in the form of a grid of five (5) NM by five (5) NM squares. Each square has an associated indexing key to determine available coverage above that area based on altitude.

If a waypoint does not meet the rule performance requirements, SAPT will check to see if it is covered by backup surveillance. If backup is available, an XML transaction will set “disposition = AlternateSurveillance”, and a waypoint on the Flight Plan Form web response will show a yellow traffic light and the text “AltSurveillance”.

6.7 RAIM Sufficiency

RAIM users submit XML, which supplies a requested HAL.

RAIM users can ensure compliance without identifying the required HAL at each point by submitting the request with the most stringent required value, i.e., 1852 meters (one NM, which is required for Terminal airspace), throughout the route of flight for AC90-100 compliance. RNAV values are more strict.
7. INTERACTIVE GUI

The SAPT can be accessed from https://sapt.faa.gov.

Users must accept the warning message, depicted in Figure 7–1, SAPT Warning Page, in order to proceed to the SAPT site.

A user who clicks I DO NOT AGREE will not be able to access the site.

![Figure 7–1. SAPT Warning Page](image)

7.1 ADS–B Home Page

The main page of the website, shown in Figure 7–2, SAPT Main Page, offers users the three primary selections:

**NOTE:** You must scroll down the screen to display the full web page that is illustrated here. The footer that is on every ADS–B SAPT web page has been omitted from this screenshot.

- ADS–B SAPT
- RAIM Prediction Tool
- RAIM Summary Pages
ADS-B Prediction Tool

Automatic Dependent Surveillance – Broadcast (ADS-B)
Service Availability Prediction Tool (SAPT)

RAIM Prediction Tool

Receiver Autonomous Integrity Monitoring (RAIM)
Service Availability Prediction Tool (SAPT)

RAIM Summary Pages

Figure 7–2. SAPT Main Page
7.1.1 ADS–B Service Availability Prediction Tool

The ADS–B SAPT is displayed at the top of the home page (refer to Figure 7–3, ADS–B Home Page — SAPT Section).

![ADS–B SAPT Image]

You have three options, if you want to use the ADS–B SAPT:

- Getting Started with ADS–B
- Flight Plan Form
- ADS–B XML Service

The selectors and links to view outages on the large area display are shown below the three primary selections (refer to Figure 7–4, ADS–B Home Page — Outage Summary).
Figure 7–4. ADS–B Home Page — Outage Summary

Press **Click to View** to display the map for the avionics you selected from the drop-down list (refer to Figure 7–5, SAPT Graphical Display With Outages).

**NOTE:** It takes a few moments for the map to load and develop.
Displaying TSO-C129, no barometric aiding, Selective Availability ON, mask angle: 5.0°

* Outage Summaries currently being calculated, latest data available for 2018/03/15 00:50 - 2018/03/15 01:50 UTC

Total of 7865 outages shown at 1.0 degree resolution.

<table>
<thead>
<tr>
<th>Download current KML</th>
<th>Generate new KML for Area in View</th>
</tr>
</thead>
<tbody>
<tr>
<td>iShow ADS-B Service Volumes</td>
<td></td>
</tr>
<tr>
<td>iShow GPS Interference Tests</td>
<td></td>
</tr>
</tbody>
</table>


Look-ahead time: Next 6 hours | 6-12 hours | 12-18 hours | 18-24 hours

Outages for Cesium display are precomputed from a small list of avionics configurations. Outage Summaries are shown in Cesium for their entire duration and include outages with any impact in the next six hours. Display may contain older outages while recalculating with a newer GPS almanac.

**Figure 7–5.** SAPT Graphical Display With Outages

The “Getting Started” section of the home page introduces the SAPT and links users to the user guide, which informs them of how to make a flight prediction.

The “Flight Plan Form” is where users can request predictions for actual flight plans. The page presents a standard FAA Flight Plan Form, which has been modified for SAPT use. All of the active fields require the user to enter relevant data. The user may save and load field information as well. The “Flight Plan Form” will accept some information via the cut and paste interface from an ICAO Flight Plan.
The “XML Service” section provides information on how to use the XML interface. A user who wants to employ the XML interface must download the Web Service Description Language (WSDL) file. Please refer to Section 8.1, WSDL, for details on downloading the WSDL. This file outlines the required fields and their structures for the XML interface.

The following sections of this document describe the SAPT in detail.

## 7.2 Getting Started with ADS–B SAPT

The Getting Started page provides a summary introduction to the SAPT and explains what users can accomplish in the Web pages. It also lays out the limitations of the tool (refer to Figure 7–6, Getting Started with ADS–B SAPT Page).

![Federal Aviation Administration Logo](image)

### Getting Started with ADS-B SAPT

**A quick guide to using the ADS-B prediction service**

Welcome to the graphical web interface for the Automatic Dependent Surveillance-Broadcast (ADS-B) Service Availability Prediction Tool (SAPT).

This website offers an interactive flight planning form that provides predictions of ADS-B sufficiency for specific flight times and equipment configurations. We tried to make this form simple and intuitive to use; you may find that you can jump right in and start performing predictions without having to read too much documentation. It also supports an XML-based web service for automated checking of ADS-B sufficiency by flight planning software. To read about the XML service please see our ADS-B XML help page.

**A quick legal note:** this system is for flight informational purposes only. Submissions to this system do not generate formal flight plans.

**We encourage users to download the User Guide [pdf](4.0MB) to become familiar with the SAPT site and features.**

**User Feedback**

Users are encouraged to submit feedback about the operation of the system, using the feedback form. Items of particular interest are:

- Usability
- Latency
- Issues
- Errors
- Suggestions

Users who are interested in the XML service can access it from the link on this page as well as directly from the home page.

Users may download this user guide in a .pdf file from the SAPT/RAIM web site if they wish.

**NOTE:** Users must have Adobe Reader installed on their workstation in order to download the user guide.

Users may submit any questions or comments to the development team.
7.2.1 User Feedback

Users are encouraged to submit feedback about the operation of the ADS–B SAPT or RAIM portions of the application, using the feedback form found at https://enroutesupport.faa.gov/sapt/feedback.aspx.

Items of particular interest to the development team include:

- Usability
- Latency
- Issues
- Errors
- Suggestions

To submit a question or suggestion, please click the feedback form link on the Getting Started with ADS–B or Getting Started with RAIM pages (scroll to the middle of the page to see this section, which is illustrated and discussed in Section 9, RAIM Prediction Tool, of this document) in order to open the form (refer to Figure 7–7, Feedback Form).

Figure 7–7. Feedback Form
7.3 SAPT Header

The home page and Flight Plan Form display headers and footers, which are described in the following sections. The ADS–B SAPT header is illustrated in Figure 7–8, SAPT Header.

![SAPT Header](image)

7.3.1 Header Layout

The header provides direct paths to other information and sites:

- The FAA logo is in the top-left corner.
- The current day and time are shown in the top-right corner.
- Beneath the date and time is the search text box.
- Along the banner are menus to open sections of the Web site.
  - On the home page, these menus are ADS–B, RAIM and Help.
  - On the Flight Plan Form page, the menus are ADS–B, RAIM, Save & Load, and Help.

Click the menu item of interest to open that page.

7.3.2 Search Feature

When you start typing in the Search field to query the official FAA site, the application will suggest results that include the letters you have entered.

The more characters you enter, the fewer matches will be retrieved, as illustrated below in Figure 7–9, SAPT Search Text-box (Single Character), and Figure 7–10, SAPT Search Text-box (Full Word).

In Figure 7–9, the user only entered one character in the search box.
By adding more characters this user targeted the subject of interest more closely.

7.3.3 FAA Logo

Click the FAA logo in the top-left corner to open the FAA government site.

7.3.4 ADS–B Menus

The menus and sub-menus on the banner at the top of each page are illustrated below. To open a particular page, hold your cursor over a menu to display its sub-menus, and click the item of interest.

The ADS–B menu on the Home page, Flight Plan Form, and XML Service pages lists the pages within that specific portion of the Web site.

- Step 1: Click the top menu item and use the sub-menu to the left, or hold your cursor over the top menu and click the page name in order to navigate directly to it (refer to Figure 7–11, ADS–B Menu).
• Step 2: On the Flight Plan Form, click the **Save & Load** menu and use the sub-menu to the left, or hold your cursor over the **Save & Load** menu to display the options (refer to Figure 7–12, Save & Load Menu).

**Figure 7–11. ADS–B Menu**

**Figure 7–12. Save & Load Menu**

Saving or importing pre-filled Flight Plan Forms can be done in multiple ways.

• Step 1: Click the option that suits you and save the Flight Plan Form as defined in Section 7.7.1, Flight Plan Results, of this document.
— To my browser
— To a permanent Uniform Resource Locator (URL)
— To a file on my computer
— If you saved the flight plan to a URL, you will be able to copy and paste it into the address bar of your browser to bring up a pre-populated Flight Plan Form.

• Step 2: To load a flight plan that you saved, choose one of the options in Figure 7–12.

**NOTE:** You can only use option 1 or 2, load from your browser, or a file on your computer, if you had previously saved to the corresponding option. To use option 3, from a pasted ICAO form, you will need an ICAO flight plan in plain text format.

• Step 3: Click the option that suits you and import the saved Flight Plan Form.

**NOTE:** You will import the Flight Plan Form from wherever you saved it – either in a browser or in a file on your computer. The ICAO form import will prefill many, but not all, of the fields in the SAPT Flight Plan Form for you.

If you need to consult the help file, hold your cursor over the Help menu item to display sub-menu items and pick the one you want to see (refer to Figure 7–13, Help Menu).

![Figure 7–13. Help Menu](image)

The ADS–B Instructions link opens the ‘Getting Started with ADS–B’ page.

The RAIM Instructions link opens the ‘Getting Started with RAIM SAPT’ page.

The ‘Contact Us’ option leads to the Feedback form, which is discussed in Section 7.2.1.

### 7.4 SAPT Footer

The SAPT footer contains links to official government sites as well as information about Web policies and a way to contact the SAPT/RAIM developers.
The footer is illustrated in Figure 7–14, SAPT Footer.

![Figure 7–14. SAPT Footer](image)

### 7.5 Flight Plan Form

The SAPT-modified FAA Flight Plan Form allows you to make an interactive flight prediction.

Required text-boxes have blue borders. To see what information is required in each field, click anywhere in the field to display a tool tip. Enter all of the required information and press **CHECK AVAILABILITY** to submit your request.

To clear the fields, press **CLEAR ALL** and then click **OK** on the pop-up confirmation window. The form is shown in Figure 7–15, Flight Plan Form.
7.5.1 Required Fields

A prediction will not be accepted and submitted unless all of the required fields are populated. If a text field is blank or if the entry is invalid, the relevant field border will turn red and/or an error message will be displayed to alert you to fix that entry.

NOTE: Fields that are grayed out do not need to be completed.

REMEMBER: You can display a field description by placing the cursor in the field.

Table 7–1, Required SAPT Fields, defines the user-entered fields on the Flight Plan Form page.
<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Units</th>
<th>Example of Field Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft Identification</td>
<td>Flight ID of the aircraft that will be flown.</td>
<td>None</td>
<td>UPS1234</td>
</tr>
<tr>
<td>Aircraft Type/Special Equipment</td>
<td>The ICAO identifier for the type of aircraft that will be flown.</td>
<td>None</td>
<td>C172</td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong>: Small, Medium, and Large aircraft types are supported in the enhancement release.</td>
<td></td>
<td>sml, med, lrg</td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong>: Aircraft Type/Special Equipment is case insensitive.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>True Airspeed</td>
<td>The aircraft’s cruising speed.</td>
<td>Knots</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong>: This value is currently not used in the final prediction calculation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departure Point</td>
<td>This is either the four-character ICAO identifier for the departure airport OR the latitude and longitude (in square brackets) for airports outside the supported area.</td>
<td>Decimal latitude, decimal longitude</td>
<td>KBOS or [43.3389,-79.6194]</td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong>: Latitude/longitude pairs should be in the form “[42.3630,-71.0064]” where latitude and longitude are in decimal degrees.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong>: There are no spaces in the latitude/longitude string.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Departure Time Proposed (Z)</td>
<td>The time within the next 24 hours that the aircraft is expected to depart.</td>
<td>Zulu 24-hour notation</td>
<td>1800</td>
</tr>
<tr>
<td>Cruising Altitude</td>
<td>The expected cruising Flight Level (FL).</td>
<td>FL</td>
<td>This value must be between 10 and 600.</td>
</tr>
<tr>
<td>Field</td>
<td>Description</td>
<td>Units</td>
<td>Example of Field Value</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------</td>
<td>-----------</td>
<td>---------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Route of Flight</td>
<td>The anticipated route of flight from departure to arrival.</td>
<td>See example.</td>
<td>Enter waypoints, routes, or standard departure or arrival procedures.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Waypoints may be specified by name (e.g., “BOSOX”), by radial (e.g., “IGN265”), or by latitude/longitude pairs in the correct form (e.g., “[42.3630,- 71.0064]”)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> See Departure Point for more information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Waypoints should be separated by spaces; the form will automatically replace the spaces with an ellipsis (...).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Routes</strong> must follow, and be followed by, a named waypoint on the route, e.g., “NEWES…J225 …PVD”. The system will automatically add the points along the route between the start and end points (“J225” automatically added between NEWES, the start point, and PVD, the end point, in the example).</td>
</tr>
</tbody>
</table>
Table 7–1. Required SAPT Fields (Continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Units</th>
<th>Example of Field Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Procedures</td>
<td>(Standard Instrument Departures(SID)/Standard Terminal Arrivals (STAR))</td>
<td>None</td>
<td>Standard Procedures (Standard Instrument Departures(SID)/Standard Terminal Arrivals (STAR)) should be specified with their fully-qualified name, if the user intends to join the procedure (e.g., “ORW3.JFK”), or simply with the Standard Instrument Departure (SID) (e.g., “ORW3”), if the user wants the system to determine the join point. The system will automatically add the waypoints along the procedure. <strong>Note:</strong> If you are flying from one airport to another, simply press the space bar. This field cannot be blank.</td>
</tr>
<tr>
<td>Destination Point</td>
<td>This is either the four-character ICAO identifier for the destination airport OR the latitude and longitude (in square brackets) for airports outside the supported area.</td>
<td>None</td>
<td>KJFK or [43.3389,-79.6194]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> See Departure Point for more information.</td>
</tr>
<tr>
<td>Estimated Time En Route Hours/Minutes</td>
<td>The length of the flight from departure to destination.</td>
<td>Hours and minutes: HHmm</td>
<td>01 45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> The user must account for wind and other weather factors in this calculation.</td>
</tr>
</tbody>
</table>
Table 7–1. Required SAPT Fields (Continued)

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Units</th>
<th>Example of Field Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navigation Source TSO</td>
<td>The TSO number corresponding to the aircraft’s GPS navigation source.</td>
<td>None</td>
<td>C129</td>
</tr>
<tr>
<td></td>
<td>Note: For results to be valid, this entry must accurately reflect the aircraft equipage. If you are unsure, select C129.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADS–B Link TSO</td>
<td>The TSO number corresponding to the aircraft’s ADS–B transponder</td>
<td>None</td>
<td>260B</td>
</tr>
<tr>
<td></td>
<td>Note: This entry currently is not used in the prediction.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mask Angle</td>
<td>The mask angle (minimum elevation below which satellite signals will not be used) employed by the aircraft’s GPS equipment. The range is 0 to 5.0 in half-degree increments.</td>
<td>Degrees</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>Note: If unsure, the user should set this value to 5.0.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baro-Aiding equipment installed</td>
<td>BA equipment, if installed, augments the GPS by using a non-satellite input for altitude.</td>
<td>None</td>
<td>Check the box or remove the checkmark to indicate if baro-aiding is present.</td>
</tr>
<tr>
<td></td>
<td>Note: This box should be checked only if the user is certain that BA equipment is installed in the aircraft.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Click CLEAR ALL to erase your entries or click CHECK AVAILABILITY to generate a prediction.

REMINDER: If you neglect to enter required information the system will display an error message (refer to Figure 7–16, Flight Plan Form with Errors: Pop-up Example) for each incorrect data-point, which is identified by name (e.g., in this illustration the user forgot to specify a Navigation Source TSO).
In Figure 7–17, Flight Plan Form with Errors: Example, the SAPT could not parse the waypoints which the user chose.
Figure 7–17. Flight Plan Form with Errors: Example

The SAPT does not return a prediction until the form is correctly filled in. When the flight plan is correctly filled in, the system displays the prediction beneath the form, as shown in Figure 7–18, Flight Plan Form with Prediction.

A transaction number and the date and time when the prediction was completed are shown at the top of the notification box. The transaction number is a unique identifier to facilitate a reference to the request and provides proof that a prediction was run for that flight.
7.5.2 Field-Entry Help and Suggestions

When you place your cursor in a field, the Flight Plan Form will provide information on that field in a black floating tip box. The tip includes information such as required format and character limits.

The tip boxes for the Departure Point, Route of Flight, and Destination Point fields offer suggestions to populate these fields based on the leading characters you enter. The tip box appears at the point where you stopped typing. You may type in the desired value, or accept the suggestion that matches your desired selection from a drop-down list.

A tip box for the Route of Flight text-box is depicted in Figure 7–19, Field and Overlaid Suggestion Tip Box.

Figure 7–18. Flight Plan Form with Prediction
The SAPT determines suggestions through the following process:

- If an entry is the first waypoint, the SAPT checks if a departing airport was entered; if so, it uses the airport to find SID fixes within 100 NM.
- If the entry is not the first waypoint, the SAPT uses the last waypoint to find a nearby route. If an arrival airport was entered, the SAPT will also attempt to find a STAR.
- If the last waypoint entered was a route, the SAPT only looks for fixes along that route.

You may enter a waypoint that is not in the list of nearby suggestions.

There is a further pop-up tool tip on how to save a Flight Plan Form (refer to Figure 7–20, Save & Load Menu Pop-up Tip). Click the blue question mark in the bottom-left corner [?] to launch it.
7.6 Saving and Loading a Flight Plan Form

You may save and load entries on the Flight Plan Form for later use.

This feature allows users who use the same aircraft or route to save information which they can recall in the future, thereby saving time in the pre-flight planning process.

7.6.1 Saving a Flight Plan Form

You can save populated fields in the Flight Plan Form to a browser, to a URL, or to a computer file, as shown in Figure 7–21, Flight Plan Saving Options.
7.6.1.1 Save to My Browser Option

When you select the ‘Save my flight plan’ → ‘to my browser’ option, all of the information is saved to your browser in a cookie. Each time you select this feature, you over-write previously saved field entries. If multiple users save information with the “to my browser” feature on the same computer, they risk changing or losing information that was saved earlier by someone else. Also, note that the saved information will be lost if you erase the browser cookies.

As depicted in Figure 7–22, Flight Plan Form Saved to a Browser — Notification Message, a successful save will be identified at the bottom of the Flight Plan Form by the message, “The form has been saved to your browser.”
7.6.1.2 Save to Uniform Resource Locator (URL) Option

When you save the flight plan to a permanent URL, the field information is saved as an Internet web address that you can copy from the notification box at the bottom of the Flight Plan Form.

**NOTE:** This option is shown in the yellow highlighted area in Figure 7–23, Flight Plan Form Written to a URL — Notification Message.

You can paste the URL into a browser — URL entry field and save it to the browser favorites file to use again later. You can also click the link, as identified in the notification box. When you do so you will open the URL, which will enable you to navigate back to the request after reviewing the request in the interactive map by pressing BACK on the browser. You can save the URL as a favorite in the browser for quick access to the form.
Figure 7–23. Flight Plan Form Written to a URL — Notification Message

7.6.1.3 Save As A Computer File Option

When you save your flight plan ‘to a file on my computer’, the field information is saved to a text file on your computer, as shown in Figure 7–24, Flight Plan Form Saved to a File — Notification Message.
7.6.2 Loading Saved Data

You can load previously saved field information in three ways:

- From your browser favorites
- From browser cookies
- From a file

You can also load from an ICAO flight plan in text format.

If you employ a browser favorite, you must remember its name and select the correct entry. This action can be performed without first navigating to the Flight Plan Form.

In the other loading options, which are displayed in Figure 7–25, Flight Plan Form Loading Options, you must open the Flight Plan Form.
7.6.2.1 Load Data From Browser

If you want to load field information from the browser cookie, select the ‘Load a flight plan’ → ‘from my browser’ option. The fields will automatically be populated with the most recent entries.

The application will display a notification at the bottom of the Flight Plan Form that “All existing flight data loaded,” as shown in Figure 7–26, Flight Plan Form Loading Options — Browser.
7.6.2.2 Load Data From File

Loading field information using the ‘Load a flight plan’ \(\rightarrow\) ‘from a file on my computer’ option will load data from a text file to the Flight Plan Form.

- Choose “Select a saved flight plan from your computer to load” when a pop-up box is displayed in the middle of the Flight Planning Form, as shown in Figure 7–27, Flight Plan Form Loading Options — File.
When you click **BROWSE**, the SAPT opens a pop-up box containing the ‘Choose File to Upload’ prompt, as displayed in Figure 7–28, Flight Plan Form Loading a File — Choose a File to Upload.
NOTE: The file manager on your device may differ in appearance from this example.

- Select the desired file and click OPEN. This action will enter the file name and location in the box at the bottom of the Flight Planning Form.
- Click LOAD to populate the fields with the information in the file.

7.6.2.3 Load Data From ICAO Flight Plan

The final option for loading a Flight Plan Form is not from previously saved data, but from an ICAO flight plan in text format.

7.7 Prediction Output

After you submit a prediction request via the Flight Plan Form (refer to Figure 7–29, Flight Plan Prediction Request), the SAPT will issue a response outlined in red.

This result will be shown at the bottom of the form, as illustrated in Figure 7–30, Sufficiency Suggestion.

![Figure 7–29. Flight Plan Prediction Request](image)

7.7.1 Flight Plan Results

The results issued by the SAPT Flight Plan Form will include the following information for each point in the route of flight. These points can be entered in the form or they can be intermediate points that were inserted automatically by the SAPT:

7–30 February 28, 2019
• Name of the point
• Latitude
• Longitude
• ETO (in Greenwich Mean Time (GMT))
• NIC
• NACp
• Airspace
• Sufficient?

In addition, a transaction number and the date and time when the prediction was completed are returned at the top of the notification box. The transaction number is a unique identifier that you can use to reference the request and it is also proof that a prediction was run for that flight.
Figure 7–30. Sufficiency Suggestion

Users must interpret the flight information that is returned in order to determine if the route and time will be adequate to support ADS–B surveillance. The primary SAPT indicator in that determination is the sufficiency value, which is described in the following section of this guide.

7.7.1.1 Sufficiency

Under the Sufficient heading, a point will be considered sufficient if the NIC and NACp values are equal to, or higher than, the required minimum values as defined in the ADS–B Final Rule: NIC≥7 and NACp≥8. If a point falls outside US-controlled rule airspace, the SAPT will return “N/A”.

NOTES: Try again with your departure time offset by 15 minutes.
NOTE: The SAPT approximates rule airspace. You are responsible for knowing whether a waypoint in your flight plan is in rule airspace.

If any point has a sufficiency value of “No,” users should not take that route. In that case, users must find another route and time that meets sufficiency rules. A sufficiency value of “N/A” can be treated as a “Yes,” since that airspace falls outside US control and is irrelevant.

A prediction that denotes that all sufficiency values are “Yes” or “N/A,” means that all points meet the required accuracy. You may accept the route and time for the flight. You may want to print the form and prediction for your records.

The stoplight icons shown in Figure 7–30 indicate sufficiency:

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Red Green Yellow]</td>
<td>ADS–B performance is sufficient at the waypoint. The flight may proceed, as per the rules.</td>
</tr>
<tr>
<td>![Yellow Green]</td>
<td>ADS–B performance is NOT sufficient at the waypoint but alternate surveillance is predicted to be available. Operators holding Exemption 12555 may be approved to conduct the flight. Refer to FAA policy, including the conditions of Exemption 12555.</td>
</tr>
<tr>
<td>![Red Green]</td>
<td>ADS–B performance is NOT sufficient at the waypoint and NO adequate alternative surveillance is predicted to be available. The flight may NOT proceed, unless authorized by ATC (refer to 14 CFR Part 91 § 91.225).</td>
</tr>
<tr>
<td>![Gray Gray Gray]</td>
<td>ADS–B coverage is not computed for points outside of supported airspace. This point has no bearing on ADS–B sufficiency or on whether the flight may proceed.</td>
</tr>
</tbody>
</table>

For more information, please refer to Table 7–2, Interpreting Results for SAPT Pre-flight Availability Predictions.

7.7.1.1.1 FAA SAPT Policy with Exemption 12555

Publication of FAA regulation and policy is outside the scope of this guide. However, correct interpretation of SAPT results requires some mention of Exemption 12555 and FAA policy in this document. Users are cautioned to refer to the published Final Rule on ADS–B (Docket No. FAA–2007–29305; Amdt. No. 91–314), specified in 14 CFR §§91.225 and 91.227, the Grant of Exemption 12555 (Docket No. FAA-2015-0971) and FAA Advisory Circular (AC) 90–114A CHG 1, for authoritative information.

The FAA has issued a limited grant of exemption (viz. Exemption 12555) from specific performance requirements of the ADS–B Out rule during certain periods of GPS satellite constellation performance. A fact-sheet on the exemption is available here:

[https://www.faa.gov/nextgen/equipadsb/research/exemption/media/Exemption12555.pdf](https://www.faa.gov/nextgen/equipadsb/research/exemption/media/Exemption12555.pdf)

NOTE: Operators must follow the procedures described in FAA Information for Operators (InFO) 16003, Exemption 12555 Process to obtain the exemption.

Exemption 12555 does not amend or change 14 CFR §§91.225 or 91.227. Beginning January 1, 2020, operators must still be equipped with ADS–B Out, as specified in 14 CFR §§91.225 and 91.227 to fly in rule airspace.
Whether an operator holds Exemption 12555 will affect the following factors:

- When the operator needs to run a prediction
- Whether an operator needs to contact ATC for a deviation
- The interpretation of the SAPT response

In summary:

- GPS performance to TSO–C129, SA ON (Jan 1, 2020 – Dec 31, 2024)
  - With Exemption 12555, pre-flight prediction required:
    - When EVERY point in the route of flight that does not meet the ADS–B Rule performance requirements is predicted to have alternate surveillance, a deviation is authorized by the FAA when using SAPT.
  - No Exemption 12555, pre-flight prediction required:
    - When ANY point in the route of flight does not meet the ADS–B Rule performance requirements the operator must contact ATC to obtain authorization.

- GPS performance to TSO–C129/C196, SA–AWARE (Jan 1, 2020 – Dec 31, 2024)
  - With Exemption 12555, flight authorized without pre-flight prediction.
  - NO Exemption 12555, pre-flight prediction required:
    - When ANY point in the route of flight does not meet the ADS–B Rule performance requirements the operator must contact ATC to obtain authorization.

Table 7–2 outlines the expected SAPT response for these conditions.
### Table 7–2. Interpreting Results for SAPT Preflight Availability Predictions

<table>
<thead>
<tr>
<th>Equipment</th>
<th>2020–2024</th>
<th>After 2024</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exemption required?</td>
<td>Yes</td>
</tr>
<tr>
<td>SA ON (TSO-C129)</td>
<td><strong>Condition</strong></td>
<td><strong>XML disposition</strong></td>
</tr>
<tr>
<td></td>
<td>No Action</td>
<td>Unregulated or Expired</td>
</tr>
<tr>
<td></td>
<td>Fails*, No Authorized Deviation from SAPT</td>
<td>Insufficient</td>
</tr>
<tr>
<td>SA AWARE (ITSO-C129 or C196)</td>
<td>Prediction required?</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Exemption authorizes flight without the need for Preflight Prediction</td>
<td></td>
</tr>
<tr>
<td>SBAS (TSO-C145 or 146)</td>
<td>Prediction required?</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>No Preflight Availability Prediction Required</td>
<td>No Preflight Availability Prediction Required</td>
</tr>
</tbody>
</table>

*NOTE: These XML values are returned for each waypoint. A Fail at any waypoint fails the route.*
7.7.1.1.2 Considerations: Departure and ETO Timing

The following considerations must be taken into account for departure and ETO timing:

- Each waypoint that the SAPT checks.
- ETO and each minute for 5 minutes forward and backward.
- Waypoint and one point 7.5 NM to either side.
- The worst values are used for the waypoint.

This means an SAPT prediction applies to a ten-minute window at each waypoint.

NOTE: This is not the same as the RAIM prediction algorithm.

7.7.1.1.3 Considerations: When to Run a Prediction

The questions and considerations that must be taken into account when running a prediction are:

- How far in advance should I run the prediction?
- The GPS constellation model is built at least once a day for 72 hours.
- The SAPT should always cover the next 48 hours.
- XML transactions can be entered 48 hours before arrival.

NOTE: Refer to AC 90–114A CHG 1 and Exemption 12555 to determine the required timeframe to submit a transaction and obtain an authorized deviation.

7.7.1.2 Insufficiency and Suggested Flight Times

When the SAPT returns a prediction request with a sufficiency value of “No,” it will suggest a better time to fly the requested route if it can find one within an hour of the proposed time. A sample of this type of notification is provided in Figure 7–30.

Since TSO–C129 provides near worst-case results with regards to availability with a low computational overhead, the system will use TSO–C129 SA–ON to search for a time that may provide better results. The system search pattern uses the following times, and stops if it finds a combination that works:

- +15 (fifteen minutes later)
- -15 (fifteen minutes earlier)
- +30 (thirty minutes later)
- -30 (thirty minutes earlier)
- +45 (forty-five minutes later)
- -45 (forty-five minutes earlier)
- +60 (sixty minutes later)
- -60 (sixty minutes earlier)
Please keep in mind that when the SAPT returns a suggested time, the suggested time may not work. While the suggestion process uses a quick algorithm intended to save you time, it is your responsibility to verify that suggestion by modifying your prediction request – either forward or backward in time – and re-running the SAPT to make sure your actual avionics pass. If the system cannot provide a suggestion, it will issue a notification. In such cases, a change of route may be advised.

### 7.7.1.3 Inserted/Redundant Route Points

The system will add points to the route of flight as required in order to guarantee that the distance between the points is never more than 60 NM. If the sum of the distances between a mid-point and its two neighboring points is less than five NM, the mid-point will be marked as redundant and NIC/NACp values will not be calculated separately for it.

The system will not mark two consecutive points as redundant.

All points, whether ones that you have specified or ones that have been added by the system, will be returned in the SAPT response. Points that are marked as redundant (and are removed from the calculation) are included in the results, with the estimated NIC and NACp taken from the previous point.

When a point is added, the name of that point will either be “Direct@,” “<Route Name>@,” or “<Radial>@” (depending on the type of the previous point) followed by the distance from the previous point.

The SAPT considers route requests that contain 35 waypoints or fewer (including system-added ones) to be conforming by default.

### 7.7.2 Graphical Display

The following two types of graphical displays have been implemented in the SAPT:

- Large area display
- Route-specific display

The interactive map is built on Cesium, an open-source JavaScript library for world-class 3D globes and maps. Cesium is based on the WebGL engine. Web Graphics Library (WebGL) is a JavaScript Application Programming Interface (API) for rendering interactive 3D and 2D graphics within any compatible web browser without the use of plug-ins. WebGL does so by introducing an API that closely conforms to Open Graphics Library for Embedded Systems (OpenGL ES) 2.0 that can be used in HTML5 <canvas> elements.

WebGL 1.0 is supported in the stable releases of most major browsers on both desktop and mobile platforms. Chrome, Firefox, Internet Explorer, Opera, and Safari are all known to have good WebGL support on both desktop and mobile browsers.

Although iOS and Android are not officially supported, early testing indicates that they work with reduced functionality.

- On an iOS product, pressing DOWNLOAD KML should automatically open the Google Earth™ application if it has been installed.
• On an Android product, you must first download and then open the Keyhole Markup Language (KML) file.

7.7.2.1 Large Area Display

The large area display has been developed to allow you to see configuration-specific degradations in ADS–B performance based on the GPS constellation, navigation TSO, and time.

This display, depicted in Figure 7–31, Large Area Graphical Display, includes six configurations:

• Configuration 1: TSO–C129, no baro-aiding, mask angle 5.0
• Configuration 2: TSO–C129, no baro-aiding, mask angle 2.0
• Configuration 3: TSO–C129, baro-aiding, mask angle 5.0
• Configuration 4: TSO–C129, baro-aiding, mask angle 2.0
• Configuration 5: TSO–C196, no baro-aiding, mask angle 5.0
• Configuration 6: TSO–C196, no baro-aiding, mask angle 2.0

Configuration 1 represents the worst-case scenario that you might encounter. Configuration 6 represents the best-case scenario, other than WAAS.

**NOTE:** WAAS was not recommended for inclusion because it always meets the required availability defined in the ADS–B Final Rule. Configuration 2 will be slightly better than Configuration 1 but typically worse than Configuration 3.

If you have a different configuration, choose the one that most closely represents the aircraft you will use.

**REMINDER:** The large area display should only be used as a reference as it does not replace the need for an actual route-specific prediction request.
To select a large area display, open the main SAPT web page (please refer to Figure 7–2) and scroll to the Outage Summaries section below the “Flight Plan Form”. Perform the following steps:

1. Select either TSO–C129 or TSO–C196 from the TSO drop-down box.
2. Select either a mask angle of 2.0 or 5.0 from the Mask angle drop-down box.
3. Click the Click to View link in the Outages column to open an interactive map outage display, as shown in Figure 7–31.
The display identifies all of the outages under the selected configuration. In Figure 7–31, all outages over the next six hours of the prediction window are shown.

**NOTE:** Depending on the number of outages, the large area display may take some time to initialize and display.

A status message below the lower-left corner of the map reports when the tool is generating and retrieving the KML file, and reports the total number of outages and the resolution when the file is finished. A status message indicating that there are no outages is displayed while the map is rebuilding. The status message in Figure 7–31 is “Total of 4703 outages shown at 1.0 degree resolution.”

The predicted outages are displayed in red and yellow. Both red and yellow highlighted areas are regions where ADS-B performance with the specified avionics is not predicted to be sufficient to meet the Final Rule. Some of the regions are yellow because the SAPT graphical display was able to confirm that there would be alternate surveillance available for the area. However, the graphical display does not have access to all the acceptable sources of alternate surveillance, so a specific flight prediction may well turn yellow where the map shows red, or even green, if it is at a higher altitude.

The large area display defaults to show the CONUS outages at a low resolution. You may select a region from the buttons on the right to zoom to an area or use the interactive map features to navigate to a custom region and display outages at a higher resolution. Once you have selected the desired region, click **Generate new KML for area in view** to see the outages for the new view. The area within which outages are searched will be highlighted within a box.

**NOTE:** Outages are NOT generated for the entire world, but even inside the highlighted search box are only predicted within the airspaces inside the ADS–B Service Volumes. To help distinguish airspace that is free of outages from airspace that is outside the relevant ADS–B-required volume, the ADS–B Service Volumes are also marked on the map, outlined in orange (En Route) and cyan (Terminal). These service volumes do not correspond directly to rule airspace. It is your responsibility to know if you are in rule airspace. A “Show ADS–B” checkbox in the lower-right corner allows you to display or hide the ADS–B Service Volume outlines. Click the **Show GPS Interference Tests** checkbox in the lower-right corner in order to display or hide it.

A number of controls are available on this window:

- The large area display will play outages (in brown using a standard Cesium™ time slider at the bottom. All outages and route-point ETOs are displayed in GMT. You can move the time slider forward and backward to determine outages at specific times. Any outages that are active within the time will be shown. You can click the outages to display the latitude and longitude of the outage and its starting and ending times.

- **PLAY, PAUSE, and REVERSE** controls are set at the lower-left corner of the map. These controls function as follows:
  - Click ➤ to allow the timeline slider to play.
  - Click ✋ to stop the timeline slider.
  - Click ⬅️ to reverse the play of the timeline slider.

- A limitation in the Cesium API prevents the slider from automatically stopping when it hits the end of the slide bar. The timeline controller will reset to the beginning when it reaches the end and continue to play. Click **PAUSE** to stop the time slider at its current position.
• Drag the arrow located in outer ring of the timeline controller to change the speed of the timeline animation.

• Buttons labeled NEXT 6 HOURS, 6–12 HOURS, 12–18 HOURS and 18–24 HOURS are set at the bottom allows user to select the look-ahead time for outage.

• The Zoom to Area buttons labeled CONUS, NORTHEAST US, SOUTHEAST US, GULF OF MEXICO, SOUTHWEST US, NORTHWEST US, ALASKA, HAWAII, GUAM, and PUERTO RICO allow the user to select a region quickly. After you select a region, you must still wait for the new outages to be retrieved and displayed.

**NOTE:** As shown in Figure 7–32, Northeast Region – Illustrated Selection, outages are not searched for Ottawa or other parts of southern Canada even though they are selected and included in the highlighted region outlined in pink; they are outside the US service volumes outlined in orange.

---

**Figure 7–32. Northeast Region — Illustrated Selection**

• When network performance is slow, it may be difficult to display outages. By clicking **DOWNLOAD KML** you can download the outage file using the browser’s download function. The file is named...
“outages-<number>.kml” (<number> is either the transaction ID or an internal number for non-route specific outages). You may rename the file, but you should not change the “kml” file extension. If you open the downloaded file, it should be displayed in the Google Earth™ desktop application.

• Please note that the downloaded KML file will include the GPS Interference Tests, but not the Service Volume information. The interactive map contains checkboxes that allow users to show or hide the GPS Interference Tests, as well as the Service Volume layers. These checkboxes do not affect the downloaded KML file.

7.7.2.2 Route-Specific Display

The route-specific display (refer to Figure 7–33, Create Route-Specific Flight Plan Form) provides the submitted route-of-flight superimposed on a map in the interactive map. Outages will be displayed along the route-of-flight when predicted to be present at the indicated ETO.
When you click View in Interactive Map in the response on the Flight Plan Form, the route of flight will be superimposed on the Interactive map above the list of route-points with Name, Latitude, Longitude, ETO, NIC, NACp, and Sufficiency.
The waypoints on the map will be labeled and hyperlinked. Click the hyperlinked waypoints to display the named route-point and ETO. The route-specific display includes standard controls, including a zoom feature and a time slider.

Outages will be displayed in red along the route of flight as you progress through the route ETOs. Subsequently, a plane icon will also move along the route of flight. The route display only shows outages within a 60 NM-wide corridor along the planned route of flight. A green band will indicate the distance from the route of flight for which the outages are displayed.

Outages for the grid display do not use the weighting algorithm, specified in Section 6.5 of this guide, as used in the prediction. The grid display calculates the HPL (and HFOM for TSO–C129 and TSO-C196) once per minute and compares the NIC and NACp that are generated to rule values. If the predicted NIC or NACp is insufficient, the time is marked as an outage. The map will give you a good idea of where and when to expect outages, but these values may not be identical to the values in a prediction for a specific route of flight. In addition, the map knows about some, but not all, backup surveillance. If backup surveillance is expected to be available in an outage, the region is marked yellow on the map. Otherwise the outage will be red.

**NOTE:** A prediction done for a specific flight is more precise, and also uses additional sources for backup surveillance. A point in a prediction will often be yellow when the corresponding point on the map shows red.

These differences occasionally lead to instances in which the grid display and the route-of-flight prediction disagree. Figure 7–34, Route-Specific Graphical Display, shows an example of a route-specific display where the background outages on the map are red, but the waypoints are yellow.
7.8 Printing a Request

After you have submitted a prediction and have received a result, you can print the web page using the standard print options with the printer icon on the menu bar, as shown in Figure 7–35, Print a Prediction Menu. When you click the icon the form should resemble the example shown in Figure 7–36, Sample Printed Prediction.
Figure 7–35. Print a Prediction Menu

A sample printed prediction is shown in Figure 7–36.
### Figure 7–36. Sample Printed Prediction

<table>
<thead>
<tr>
<th>Route of Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPEAK...DONIL...ACY...PANZE...CAMRN...</td>
</tr>
</tbody>
</table>

**Table**

<table>
<thead>
<tr>
<th>Arrival Time</th>
<th>Departure Time</th>
<th>Equipment Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>00 45</td>
<td>23:10</td>
<td>Terminal</td>
</tr>
</tbody>
</table>

**Notes:** No outages predicted along route.
This page intentionally left blank.


8. ADS–B XML INTERFACE

The SAPT is primarily an XML-based web service. For users who periodically need to check if their GPS-based navigation source will be adequate for ADS–B along their route of flight, the HTML front end will work well. Many users employ flight planning software, however, which may be developed in-house or from a third-party vendor. The XML web service is recommended for these users.

If you use flight planning software from a third-party vendor, please contact that vendor to request that the XML web service be incorporated into the software. If you have more control over your flight planning software, please follow the procedure in Section 8.1 to request a copy of the SAPT WSDL and Software Development Kit (SDK). Most Integrated Development Environments (IDE) can build a skeleton structure from the WSDL and streamline the development process.

8.1 WSDL

The ADS–B web service is being updated and the present WSDL, which is documented here, is being replaced. The new version is referred to as 'sapt-2.2'. This version incorporates changes for SAPT 4.0, including the new “disposition” keyword. Another change is that waypoints in the past at the beginning of a route of flight will no longer be grounds for erroring the route. This is intended to make it easy to run a SAPT check mid-flight to validate a potential route change.

You may request the 'SAPT20-SDK' WSDL through the RAIM or ADS–B XML pages. To request the WSDL from the ADS–B XML page, scroll to the bottom of the page and click the Request a copy of the SAPT WSDL and SDK link (refer to Figure 8–1, WSDL Request Link).

![Figure 8–1. WSDL Request Link](image)

When you click DOWNLOAD, the application generates a pop-up dialog (refer to Figure 8–2, Download the SAPT SDK Pop-up).

![Figure 8–2. Download the SAPT SDK Pop-up](image)

Click SAVE AS to choose the location where you want to save it on your computer (refer to Figure 8–3, Save the SAPT SDK).
Click **OPEN** to save the file to the temporary internet files folder on your computer (refer to Figure 8–4, Open the SAPT SDK).

The SDK archive contains the WSDL and other files that might be useful for developing software to interface with SAPT.

Figure 8–5, XML Web Service — Classes and Types, is a Unified Modeling Language (UML) diagram of the various information classes and types employed by the web service.
8.2 Classes and Types

The primary class is the ‘AdsbSaptTransactionInformation’ class, shown in Table 8–3, ADS–B SAPT Transaction Information, which contains all the information that requests and responses have in common.

The ADSB Sufficiency for Route Request (refer to Table 8–1) contains only what is in AdsbSaptTransactionInformation, while the ADSB Sufficiency for Route Response shown in Table 8–2 contains more fields.

Table 8–5, Route Information, and Table 8–6, Waypoint Information, provide more details about the Route and Waypoint. Table 8–8, ADS–B SAPT Exception, describes AdsbSaptException information classes used by the XML web service. Table 8–7, Disposition Information, describes the results returned in the Disposition keyword.

For samples, refer to Table 8–9, Sample ADS–B SAPT Request and Table 8–10, Sample ADS–B SAPT Response with Alternate Surveillance and Table 8–11, Sample ADS–B SAPT Response with One Expired and One Sufficient Route for sample responses.

Table 8–9, Table 8–10, and Table 8–11 provide examples of a valid AdsbSaptRequest and valid AdsbSaptResponses in XML form.
### Table 8–1. ADSB Sufficiency for Route Request

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>Required?</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>transaction</td>
<td>Information</td>
<td>Yes</td>
<td>The requested transaction information (refer to Table 8–3).</td>
</tr>
<tr>
<td>Information</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 8–2. ADSB Sufficiency for Route Response

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>Required?</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>constellation</td>
<td>Constellation</td>
<td>No, Response</td>
<td>Constellation build information (refer to Table 8–4, Constellation Information).</td>
</tr>
<tr>
<td>responseCode</td>
<td>Integer</td>
<td>No, Response</td>
<td>0 If the request was successfully processed, a negative number otherwise.</td>
</tr>
<tr>
<td>Notes</td>
<td>String</td>
<td>No, Response</td>
<td>An explanation for a failed request and/or information about upcoming system outages/changes.</td>
</tr>
<tr>
<td>transaction</td>
<td>Transaction</td>
<td>No, Response</td>
<td>The requested transaction information (refer to Table 8–3).</td>
</tr>
<tr>
<td>Identifier</td>
<td>Information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>disposition</td>
<td>Disposition</td>
<td>No, Response</td>
<td>Describes the prediction result for the transaction (see Disposition).</td>
</tr>
<tr>
<td>transaction</td>
<td>Transaction</td>
<td>No, Response</td>
<td>The requested transaction information (refer to Table 8–3).</td>
</tr>
<tr>
<td>Information</td>
<td>Information</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 8–3. ADS–B SAPT Transaction Information

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>Required?</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>requestIdentifier</td>
<td>String</td>
<td>No</td>
<td>Optional string to identify a user’s request.</td>
</tr>
<tr>
<td>flightIdentifier</td>
<td>String</td>
<td>No</td>
<td>Optional string to identify the flight to which the request pertains (either tail number or flight Identification (ID)).</td>
</tr>
<tr>
<td>typeOfAircraft</td>
<td>String</td>
<td>Yes</td>
<td>The ICAO identifier of the aircraft.</td>
</tr>
<tr>
<td>route</td>
<td>Route</td>
<td>Yes</td>
<td>One or more routes on which to perform the prediction (refer to Table 8–5).</td>
</tr>
<tr>
<td>baroAiding</td>
<td>Boolean</td>
<td>No</td>
<td>True if the aircraft is equipped with a GPS-based navigation source that utilizes BA. False otherwise. Default is False.</td>
</tr>
<tr>
<td>maskAngle</td>
<td>Double</td>
<td>No</td>
<td>The mask angle (in degrees) utilized by the GPS-based navigation source. Default is 5.0 (degrees).</td>
</tr>
<tr>
<td>navSourceTSO</td>
<td>NavSourceTSO Type</td>
<td>Yes</td>
<td>The TSO number for the navigation source.</td>
</tr>
</tbody>
</table>
Table 8–3. ADS–B SAPT Transaction Information (Continued)

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>Required?</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>adsbLink</td>
<td>AdsbLinkType</td>
<td>No</td>
<td>The TSO number for the aircraft’s ADS–B transponder.</td>
</tr>
<tr>
<td>saAware</td>
<td>Boolean</td>
<td>No</td>
<td>True if the aircraft is equipped with a TSO–C129 with no saAware navigation source. False with saAware.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> This field is ignored for any NavSourceTSOType other than “129.”</td>
</tr>
<tr>
<td>enableWAAS</td>
<td>Boolean</td>
<td>No</td>
<td>A true or false value specifying whether “WAAS” is supported by the avionics.</td>
</tr>
<tr>
<td>enableFDE</td>
<td>Boolean</td>
<td>No</td>
<td>A true or false value specifying whether “FDE” is supported by the avionics.</td>
</tr>
<tr>
<td>disposition</td>
<td>Disposition</td>
<td>No,</td>
<td>Describes the prediction result for the transaction (see Disposition).</td>
</tr>
<tr>
<td></td>
<td>Response Only</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8–4. Constellation Information

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>Required?</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>buildTime</td>
<td>DateTime</td>
<td>No,</td>
<td>The time that the constellation is being built.</td>
</tr>
<tr>
<td></td>
<td>Response Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>almanacId</td>
<td>Integer</td>
<td>No,</td>
<td>To identify the GPS almanac that was used in the constellation build.</td>
</tr>
<tr>
<td></td>
<td>Response Only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>buildInProgress</td>
<td>Boolean</td>
<td>No,</td>
<td>True if the constellation is currently being rebuilt. This indicates that the data used for the prediction may be obsolete and that the prediction should be retried after a short delay.</td>
</tr>
<tr>
<td></td>
<td>Response Only</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8–5. Route Information

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>Required?</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>routeIdentifier</td>
<td>String</td>
<td>No</td>
<td>Optional for the waypoint.</td>
</tr>
<tr>
<td>cruiseAltitude</td>
<td>Integer</td>
<td>Yes</td>
<td>Aircraft Cruising Altitude specified in ft</td>
</tr>
<tr>
<td>cruiseSpeed</td>
<td>Double</td>
<td>No</td>
<td>Aircraft Cruising Speed specified in knots</td>
</tr>
<tr>
<td>waypoint</td>
<td>Waypoint</td>
<td>Yes</td>
<td>Waypoint information (refer to Table 8–6).</td>
</tr>
</tbody>
</table>
### Table 8–5. Route Information (Continued)

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>Required?</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>suggestedOffset</td>
<td>Integer</td>
<td>No, Response Only</td>
<td>Returns a value of zero when all waypoints in the route have sufficient coverage and a value of -1 when at least one waypoint does not have sufficient coverage. Any other non-zero integer indicates a suggested change to departure time (specified in minutes) that may result in an increased chance of meeting the rule (however this is not supported for XML-based requests).</td>
</tr>
<tr>
<td>notes</td>
<td>String</td>
<td>No, Response Only</td>
<td>Returned note on the route</td>
</tr>
</tbody>
</table>

### Table 8–6. Waypoint Information

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>Required?</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>String</td>
<td>No</td>
<td>An optional name for the waypoint.</td>
</tr>
<tr>
<td>latitude</td>
<td>Double</td>
<td>Yes</td>
<td>The latitude of the waypoint in decimal degrees.</td>
</tr>
<tr>
<td>longitude</td>
<td>Double</td>
<td>Yes</td>
<td>The longitude of the waypoint in decimal degrees.</td>
</tr>
<tr>
<td>estimatedTimeOver</td>
<td>DateTime</td>
<td>Yes</td>
<td>The anticipated time the aircraft is expected to arrive at the waypoint.</td>
</tr>
<tr>
<td>nic</td>
<td>Integer</td>
<td>No, Response only</td>
<td>The NIC as predicted by the system. Anything provided by the user is overwritten by the system. NIC is not computed or returned for expired waypoints.</td>
</tr>
<tr>
<td>nacp</td>
<td>Integer</td>
<td>No, Response Only</td>
<td>The NACp as predicted by the system.</td>
</tr>
<tr>
<td>disposition</td>
<td>Disposition</td>
<td>No, Response Only</td>
<td>Describes the prediction result for the transaction (see Disposition).</td>
</tr>
<tr>
<td>potentialInterference</td>
<td>Tribool</td>
<td>No, Response Only</td>
<td>Returns &quot;true&quot; if the waypoint is predicted to be subject to potential GPS Interference Tests and &quot;false&quot; if not. Returns &quot;unspecified&quot; for waypoints that are outside of US airspace.</td>
</tr>
</tbody>
</table>

**NOTE:** Anything provided by the user is overwritten by the system. NACp is not computed or returned for expired waypoints.
### Table 8–7. Disposition Information

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>Required?</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>disposition</td>
<td>String</td>
<td>No, Response Only</td>
<td>Describes the prediction result:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>On the Waypoint, returns a value determined by the first matching condition as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Expired</strong>: If the waypoint ETO is in the past (no prediction was performed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Unregulated</strong>: If the waypoint is outside controlled US airspace</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Sufficient</strong>: If the waypoint is predicted to meet the required integrity and accuracy, i.e., if NIC is predicted to be ( \geq 7 ) and NACp is predicted to be ( \geq 8 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>AlternateSurveillance</strong>: If the position fix at the waypoint is predicted not to meet the required integrity or accuracy, but to be covered by another form of surveillance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Insufficient</strong>: None of the above, i.e., if the position fix at the waypoint is predicted not to meet the required integrity or accuracy, or to be covered by another form of surveillance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>On the Route, returns a value determined by the first matching condition as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Expired</strong>: If all waypoints in the route are either unregulated or expired</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Unregulated</strong>: If all waypoints in the route are unregulated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Sufficient</strong>: If all waypoints in the route are sufficient, unregulated or expired</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Insufficient</strong>: If any waypoint in the route was insufficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>AlternateSurveillance</strong>: If one or more waypoints in the route returns AlternateSurveillance and no points are insufficient</td>
</tr>
</tbody>
</table>
Table 8–7. Disposition Information (Continued)

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>Required?</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>On the Transaction, returns a value determined by the first matching condition as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Expired:</strong> If all routes in the transaction are either unregulated or expired</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Unregulated:</strong> If all routes in the transaction are unregulated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Sufficient:</strong> If all regulated, unexpired routes in the transaction are sufficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>Insufficient:</strong> If any route in the transaction is insufficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• <strong>AlternateSurveillance:</strong> If any routes in the transaction returned AlternateSurveillance and none returned insufficient</td>
</tr>
</tbody>
</table>

Table 8–8. ADS–B SAPT Exception

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ErrorCode</td>
<td>Integer</td>
<td>This number should be included when requesting help.</td>
</tr>
<tr>
<td>ErrorMessage</td>
<td>String</td>
<td>A description of the error.</td>
</tr>
</tbody>
</table>
### 8.3 Request and Response Example

Table 8–9 and provide examples of a valid AdsbSaptRequest and AdsbSaptResponse in XML form, respectively.

**Table 8–9. Sample ADS–B SAPT Request**

```xml
<?xml version="1.0" encoding="utf-8"?>
<soapenv:Envelope
xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/"
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <soapenv:Body>
    <getAdsbSufficiencyForRoute>
      <requestIdentifier>REQ2COD01</requestIdentifier>
      <flightIdentifier>ZZVSST1T1</flightIdentifier>
      <typeOfAircraft>DC10</typeOfAircraft>
      <baroAiding>false</baroAiding>
      <maskAngle>2.5</maskAngle>
      <navSourceTso>129</navSourceTso>
      <saAware>false</saAware>
      <adslLink>260</adslLink>
      <route>
        <routeIdentifier>1D2STRT1</routeIdentifier>
        <cruiseAltitude>35000</cruiseAltitude>
        <cruiseSpeed>450</cruiseSpeed>
        <suggestedOffset>0</suggestedOffset>
        <notes/>
        <waypoint>
          <name>KLMM</name>
          <latitude>42.71719</latitude>
          <longitude>-71.12341</longitude>
          <estimatedTimeOver>2015-12-02 23T02:59:19.112z</estimatedTimeOver>
        </waypoint>
        <waypoint>
          <name>COTEE</name>
          <latitude>42.49506</latitude>
          <longitude>-71.11886</longitude>
          <estimatedTimeOver>2015-12-02 23T03:06:19.112z</estimatedTimeOver>
        </waypoint>
        <waypoint>
          <name>SOSYO</name>
          <latitude>42.48734</latitude>
          <longitude>-71.43215</longitude>
          <estimatedTimeOver>2015-12-02 23T03:17:19.112z</estimatedTimeOver>
        </waypoint>
      </route>
    </getAdsbSufficiencyForRoute>
  </soapenv:Body>
</soapenv:Envelope>
```
<table>
<thead>
<tr>
<th>Time</th>
<th>Waypoint</th>
<th>Name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Estimated Time Over</th>
</tr>
</thead>
<tbody>
<tr>
<td>23T03:32:19.112Z</td>
<td>&lt;waypoint&gt;</td>
<td>GRAYM</td>
<td>42.10118</td>
<td>-72.03152</td>
<td>2015-12</td>
</tr>
<tr>
<td>23T03:37:19.112Z</td>
<td>&lt;waypoint&gt;</td>
<td>WITNY</td>
<td>42.04939</td>
<td>-72.23665</td>
<td>2015-12</td>
</tr>
<tr>
<td>23T03:42:19.112Z</td>
<td>&lt;waypoint&gt;</td>
<td>BDL</td>
<td>41.94101</td>
<td>-72.68857</td>
<td>2015-12</td>
</tr>
<tr>
<td>23T03:47:19.112Z</td>
<td>&lt;waypoint&gt;</td>
<td>BRIS</td>
<td>41.70129</td>
<td>-73.01558</td>
<td>2015-12</td>
</tr>
<tr>
<td>23T03:51:19.112Z</td>
<td>&lt;waypoint&gt;</td>
<td>K4B8</td>
<td>41.69037</td>
<td>-72.86482</td>
<td>2015-12</td>
</tr>
<tr>
<td>23T04:26:19.112Z</td>
<td>&lt;waypoint&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 8–10. Sample ADS–B SAPT Response with Alternate Surveillance

```xml
<soapenv:Envelope xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/"
 xmlns:xsd="http://www.w3.org/2001/XMLSchema"
 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <soapenv:Body>
    <AdsbSufficiencyForRoute_Response xmlns="">
      <requestIdentifier>ZZV_Sally#3</requestIdentifier>
      <constellation>
        <buildTime>2018-03-29T08:05:00.000Z</buildTime>
        <almanacId>1522310700000</almanacId>
        <buildInProgress>false</buildInProgress>
      </constellation>
      <flightIdentifier>N1234</flightIdentifier>
      <typeOfAircraft>A321</typeOfAircraft>
      <navSourceIso>129</navSourceIso>
      <adsbLink>260B</adsbLink>
      <maskAngle>5.0</maskAngle>
      <baroAiding>true</baroAiding>
      <saAware>false</saAware>
      <enableEAS>false</enableEAS>
      <enableFD>false</enableFD>
      <route>
        <routeIdentifier>Cally#3</routeIdentifier>
        <cruiseAltitude>35000</cruiseAltitude>
        <cruiseSpeed>520.0</cruiseSpeed>
        <waypoint>
          <name>KPHX</name>
          <latitude>33.4342778</latitude>
          <longitude>-112.0115833</longitude>
          <estimatedTimeOver>2018-03-30T01:15:00.000Z</estimatedTimeOver>
          <nic>7</nic>
          <nacp>8</nacp>
          <disposition>Sufficient</disposition>
          <potentialInterference>true</potentialInterference>
        </waypoint>
        <waypoint>
          <name>ESTWD</name>
          <latitude>33.9051389</latitude>
          <longitude>-114.1135833</longitude>
          <estimatedTimeOver>2018-03-30T01:40:07.440Z</estimatedTimeOver>
          <nic>7</nic>
          <nacp>8</nacp>
          <disposition>Sufficient</disposition>
          <potentialInterference>false</potentialInterference>
        </waypoint>
        <waypoint>
          <name>HLWMD</name>
          <latitude>34.1042361</latitude>
          <longitude>-116.2987861</longitude>
          <estimatedTimeOver>2018-03-30T02:02:57.920Z</estimatedTimeOver>
          <nic>7</nic>
          <nacp>7</nacp>
          <disposition>AlternateSurveillance</disposition>
          <potentialInterference>false</potentialInterference>
        </waypoint>
      </route>
    </AdsbSufficiencyForRoute_Response>
  </soapenv:Body>
</soapenv:Envelope>
```
Table 8–11. Sample ADS–B SAPT Response with One Expired and One Sufficient Route

```xml
<?xml version="1.0" encoding="utf-8"?>
<soapenv:Envelope xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema"
    xmlns:soap="http://www.w3.org/2001/XMLSchema-instance">
  <soap:Body>
    <AdsbSufficiencyForRoute_Response xmlns="">
      <requestIdentifier>ZZV_Cally#2</requestIdentifier>
      <constellation>
        <buildTime>2018-03-29T08:05:00.000Z</buildTime>
        <almanacId>15223107000000</almanacId>
        <buildInProgress>false</buildInProgress>
      </constellation>
      <flightIdentifier>112345</flightIdentifier>
      <typeOfAircraft>DC10</typeOfAircraft>
      <navSourceTso>129</navSourceTso>
      <adsbLink>2608</adsbLink>
      <maskAngle>2.5</maskAngle>
      <baroAiding>false</baroAiding>
      <saAware>true</saAware>
      <enableWAAS>false</enableWAAS>
      <enableFDE>false</enableFDE>
    </AdsbSufficiencyForRoute_Response>
  </soap:Body>
</soapenv:Envelope>
```

route

```xml
<routeIdentifier>Callly#2A</routeIdentifier>
  <cruiseAltitude>35000</cruiseAltitude>
  <cruiseSpeed>450.0</cruiseSpeed>
  <waypoint>
    <name>KBOS</name>
    <latitude>42.363</latitude>
    <longitude>-71.0064</longitude>
    <estimatedTimeOver>2018-03-29T18:00:00.000Z</estimatedTimeOver>
    <nic>8</nic>
    <napc>9</napc>
    <disposition>Sufficient</disposition>
    <potentialInterference>false</potentialInterference>
  </waypoint>
  <waypoint>
    <name>DIRECT@14.28NM</name>
    <latitude>42.30371300403917</latitude>
    <longitude>-71.31753542173712</longitude>
    <estimatedTimeOver>2018-03-29T18:07:30.000Z</estimatedTimeOver>
    <nic>8</nic>
    <napc>9</napc>
    <disposition>Sufficient</disposition>
    <potentialInterference>false</potentialInterference>
  </waypoint>
  <waypoint>
    <name>BOSOY</name>
    <latitude>42.20188</latitude>
    <longitude>-71.62767</longitude>
    <estimatedTimeOver>2018-03-29T18:15:00.000Z</estimatedTimeOver>
    <nic>8</nic>
    <napc>9</napc>
    <disposition>Sufficient</disposition>
    <potentialInterference>false</potentialInterference>
  </waypoint>
</route>
```

Table 8–11. Sample ADS–B SAPT Response with One Expired and One Sufficient Route (Continued)

```xml
<route>
  <waypoint>
    <name>DIRECT@4.62NM</name>
    <latitude>42.131040335155916</latitude>
    <longitude>-71.58752461315876</longitude>
    <estimatedTimeOver>2018-03-29T18:23:48.000Z</estimatedTimeOver>
    <nic>8</nic>
    <nacp>9</nacp>
    <disposition>Sufficient</disposition>
    <potentialInterference>false</potentialInterference>
  </waypoint>
  <waypoint>
    <name>DIRECT@9.50NM</name>
    <latitude>42.0552224506438</latitude>
    <longitude>-71.54749138014013</longitude>
    <estimatedTimeOver>2018-03-29T18:32:36.000Z</estimatedTimeOver>
    <nic>8</nic>
    <nacp>9</nacp>
    <disposition>Unregulated</disposition>
    <potentialInterference>unspecified</potentialInterference>
  </waypoint>
  <waypoint>
    <name>DIRECT@14.74NM</name>
    <latitude>41.97340247502529</latitude>
    <longitude>-71.5075938218776</longitude>
    <estimatedTimeOver>2018-03-29T18:41:24.000Z</estimatedTimeOver>
    <nic>8</nic>
    <nacp>9</nacp>
    <disposition>Unregulated</disposition>
    <potentialInterference>unspecified</potentialInterference>
  </waypoint>
  <waypoint>
    <name>DIRECT@20.59NM</name>
    <latitude>41.8805979270309065</latitude>
    <longitude>-71.46780343313623</longitude>
    <estimatedTimeOver>2018-03-29T18:50:12.000Z</estimatedTimeOver>
    <nic>8</nic>
    <nacp>8</nacp>
    <disposition>Sufficient</disposition>
    <potentialInterference>false</potentialInterference>
  </waypoint>
  <waypoint>
    <name>FPVD</name>
    <latitude>41.724</latitude>
    <longitude>-71.428222</longitude>
    <estimatedTimeOver>2018-03-29T18:59:00.000Z</estimatedTimeOver>
    <nic>8</nic>
    <nacp>8</nacp>
    <disposition>Sufficient</disposition>
    <potentialInterference>false</potentialInterference>
  </waypoint>
  <waypoint>
    <disposition>Sufficient</disposition>
    <potentialInterference>false</potentialInterference>
  </waypoint>
  <suggestedOffset>0</suggestedOffset>
  <notes/>
</route>
```
Table 8–11. Sample ADS–B SAPT Response with One Expired and One Sufficient Route (Continued)

```xml
<route>
  <routeIdentifier>cally#28</routeIdentifier>
  <cruiseAltitude>35000</cruiseAltitude>
  <cruiseSpeed>450.0</cruiseSpeed>
  <waypoint>
    <name>BOSX</name>
    <latitude>42.363</latitude>
    <longitude>-71.0064</longitude>
    <estimatedTimeOver>2018-03-29T00:00:000Z</estimatedTimeOver>
    <disposition>Expired</disposition>
  </waypoint>
  <waypoint>
    <name>DIRECT@14.28NM</name>
    <latitude>42.30371300403917</latitude>
    <longitude>-71.31755342173712</longitude>
    <estimatedTimeOver>2018-03-29T00:07:30.000Z</estimatedTimeOver>
    <disposition>Expired</disposition>
  </waypoint>
  <waypoint>
    <name>BOSX</name>
    <latitude>42.28188</latitude>
    <longitude>-71.62767</longitude>
    <estimatedTimeOver>2018-03-29T00:15:00.000Z</estimatedTimeOver>
    <disposition>Expired</disposition>
  </waypoint>
  <waypoint>
    <name>DIRECT@6.72NM</name>
    <latitude>42.310051470233745</latitude>
    <longitude>-71.58967685038363</longitude>
    <estimatedTimeOver>2018-03-29T00:23:48.000Z</estimatedTimeOver>
    <disposition>Expired</disposition>
  </waypoint>
  <waypoint>
    <name>DIRECT@13.83NM</name>
    <latitude>42.425041531484375</latitude>
    <longitude>-71.55151991351367</longitude>
    <estimatedTimeOver>2018-03-29T00:32:36.000Z</estimatedTimeOver>
    <disposition>Expired</disposition>
  </waypoint>
  <waypoint>
    <name>DIRECT@21.52NM</name>
    <latitude>42.549301042505515</latitude>
    <longitude>-71.51318358134297</longitude>
    <estimatedTimeOver>2018-03-29T00:41:24.000Z</estimatedTimeOver>
    <disposition>Expired</disposition>
  </waypoint>
  <waypoint>
    <name>DIRECT@30.15NM</name>
    <latitude>42.696431618468</latitude>
    <longitude>-71.474642259012341</longitude>
    <estimatedTimeOver>2018-03-29T00:50:12.000Z</estimatedTimeOver>
    <disposition>Expired</disposition>
  </waypoint>
</route>
```
Table 8–11. Sample ADS–B SAPT Response with One Expired and One Sufficient Route (Continued)

```
<waypoint>
  <name>KMHT</name>
  <latitude>42.9328</latitude>
  <longitude>-71.4358</longitude>
  <estimatedTimeOver>2018-03-29T00:59:00.000Z</estimatedTimeOver>
  <disposition>Expired</disposition>
</waypoint>
<disposition>Expired</disposition>
<suggestedOffset>-1</suggestedOffset>
<notes>Unable to suggest an alternative time.</notes>
</route>
<translationIdentifier>3QEWHG3MKGK3N</translationIdentifier>
<disposition>Sufficient</disposition>
<responseCode>0</responseCode>
<notes>Prediction Complete: 2018-03-29 17:21:13</notes>
</AdsbSufficiencyForRoute_Response>
</soapenv:Body>
</soapenv:Envelope>
```
Table 8–11. Sample ADS–B SAPT Response with One Expired and One Sufficient Route (Continued)

```xml
<soapenv:Envelope xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/
xmlns:xsd="http://www.w3.org/2001/XMLSchema-instance">
  <soapenv:Body>
    <AddSufficiencyForRoute_Response xmlns=""/>
    <requestIdentifier>2V_Cally#2</requestIdentifier>
    <constellation>
      <buildTime>2018-03-29T08:05:00.000Z</buildTime>
      <almanacID>1527210700000</almanacID>
      <buildInProgress>false</buildInProgress>
    </constellation>
    <flightIdentifier>H12345</flightIdentifier>
    <typeOfAirCraft>DC10</typeOfAirCraft>
    <navSourceTso>129</navSourceTso>
    <adsLink>260B</adsLink>
    <maskAngle>2.5</maskAngle>
    <baroHeading>false</baroHeading>
    <saAware>true</saAware>
    <enableHAAS>false</enableHAAS>
    <enableFD>false</enableFD>
    <route>
      <routeIdentifier>Cally##2</routeIdentifier>
      <cruiseAltitude>35000</cruiseAltitude>
      <cruiseSpeed>450.0</cruiseSpeed>
      <waypoint>
        <name>BOS</name>
        <latitude>42.363</latitude>
        <longitude>-71.0064</longitude>
        <estimatedTimeOver>2018-03-29T18:00:00.000Z</estimatedTimeOver>
        <nic>8</nic>
        <nacp>9</nacp>
      </waypoint>
      <disposition>Sufficient</disposition>
      <potentialInterference>false</potentialInterference>
      <waypoint>
        <name>DIRECTO14.28NM</name>
        <latitude>42.3037300403617</latitude>
        <longitude>-71.31753542173712</longitude>
        <estimatedTimeOver>2018-03-29T18:07:30.000Z</estimatedTimeOver>
        <nic>8</nic>
        <nacp>9</nacp>
      </waypoint>
      <disposition>Sufficient</disposition>
      <potentialInterference>false</potentialInterference>
      <waypoint>
        <name>BOSOX</name>
        <latitude>42.20188</latitude>
        <longitude>-71.62767</longitude>
        <estimatedTimeOver>2018-03-29T18:15:00.000Z</estimatedTimeOver>
        <nic>8</nic>
        <nacp>9</nacp>
      </waypoint>
      <disposition>Sufficient</disposition>
      <potentialInterference>false</potentialInterference>
    </route>
  </soapenv:Body>
</soapenv:Envelope>
```
8.4 Interpreting the Results

The user is responsible for interpreting the results. The results will include most of the same information as submitted, with the addition of NIC, NACp, and Sufficiency.
A point that does not have the ‘isSufficientForAdsb’ field is not within the defined ADS–B Service volume, and sufficiency does not apply. This situation is analogous to being set to “N/A” in the graphical interface. The Notes section will include error information or other information that is useful to the user, such as any planned system downtime. The XML response will also include a transaction ID that is unique to that transaction.

The following fields have been added in the response .xml file for the Enhancement release:

- `isSufficientForAirspace=true/false/unspecified`
- `backupCoverage=true/false/unspecified`
- `potentialInterference=true/false/unspecified`

### 8.5 Error Conditions

Error conditions will typically be in the form of an AdsbSaptException.

An AdsbSaptException may be generated in the event of a malformed request or non-nullable field being null, but may also be generated for less obvious reasons.

List the error code, error message, and corrective actions a user should take for the less obvious error conditions (refer to Table 8–12, ADS–B SAPT Exception Error Information).

**Table 8–12. ADS–B SAPT Exception Error Information**

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Error Message</th>
<th>Corrective Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>Invalid number of routes submitted</td>
<td>Invalid number of routes submitted. Fix the number of routes to be sent to process.</td>
</tr>
<tr>
<td>-3</td>
<td>Invalid typeOfAircraft value (SAPT)</td>
<td>Fix the aircraft type that is supported by SAPT.</td>
</tr>
</tbody>
</table>
| -4         | Invalid value for navSourceTso (SAPT) | Fix the navSourceTso. Choose from this list:  
  - C129  
  - C129 with SA Aware  
  - C129 with FDE  
  - C129 with SA Aware & FDE  
  - C145/146 with WAAS  
  - C145/146 outside WAAS Coverage  
  - C196 |
| -6         | Invalid cruiseAltitude value (SAPT) | Fix the cruiseAltitude to be within the range of 10 – 600. |
| -7         | Too few waypoints submitted | Increase the number of waypoints to be submitted. |
| -9         | Invalid latitude value | Change the waypoint latitude value. Latitude must be between +/-90.0 degrees. |
### Table 8–12. ADS–B SAPT Exception Error Information (Continued)

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Error Message</th>
<th>Corrective Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10</td>
<td>Invalid longitude value</td>
<td>Change the waypoint longitude value. Longitude must be between +/-180.0 degrees.</td>
</tr>
<tr>
<td>-11</td>
<td>Missing estimatedTimeOver value</td>
<td>Make sure the estimatedTimeOver value is entered.</td>
</tr>
<tr>
<td>-12</td>
<td>EstimatedTimeOver value is in the past</td>
<td>Make sure the estimatedTimeOver value is in the future.</td>
</tr>
<tr>
<td>-13</td>
<td>Timed-out due to maxWaitAccepted</td>
<td>Set the maxWaitAccepted value to a larger number.</td>
</tr>
<tr>
<td>-14</td>
<td>Validator configuration error (SAPT)</td>
<td>Contact us at <a href="https://enroutesupport.faa.gov/sapt/feedback.aspx">https://enroutesupport.faa.gov/sapt/feedback.aspx</a></td>
</tr>
<tr>
<td>-15</td>
<td>Timeout from prediction servers</td>
<td>Try again in a couple of minutes. If you get the error again, contact us at <a href="https://enroutesupport.faa.gov/sapt/feedback.aspx">https://enroutesupport.faa.gov/sapt/feedback.aspx</a></td>
</tr>
<tr>
<td>-17</td>
<td>Invalid avionics options (TSO + SA,FDE,WAAS) (SAPT)</td>
<td>Make sure the avionics options are correct.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• C129</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• C129 with SA Aware</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• C129 with FDE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• C129 with SA Aware &amp; FDE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• C145/146 with WAAS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• C145/146 outside WAAS Coverage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• C196</td>
</tr>
<tr>
<td>-18</td>
<td>Invalid maskAngle value (SAPT)</td>
<td>Make sure the maskAngle value is between 0 to 5.0 using half-degree increments</td>
</tr>
<tr>
<td>-19</td>
<td>HAL input is out of valid range (RAIM)</td>
<td>Make sure the HAL value is within range.</td>
</tr>
<tr>
<td>-99</td>
<td>Internal exception</td>
<td>None of the above errors. Contact us at <a href="https://enroutesupport.faa.gov/sapt/feedback.aspx">https://enroutesupport.faa.gov/sapt/feedback.aspx</a></td>
</tr>
</tbody>
</table>
This page intentionally left blank.
9. RAIM PREDICTION TOOL

The RAIM prediction model constructs the GPS constellation from a given almanac. This almanac is usually the most recent but can also be an historic one in order to construct scenarios or for validation. The constellation is iterated over the prediction window using the specified time interval.

The RAIM algorithms implemented in the ADS–B SAPT have a confidence level of 99.99999 percent.

RAIM needs a minimum of five satellites in view, or four satellites and a barometric altimeter (baro-aiding), to detect an integrity anomaly. The GPS receiver verifies the usability of the signals received from the GPS constellation through RAIM to determine if a satellite is providing corrupted information.

In addition to the satellites required for navigation, at least one must be in view for the receiver to perform the RAIM function.

RAIM capability cannot be determined by simply counting the number of satellites in view. Since ADS–B reports rely primarily on GPS for information regarding aircraft position, the accuracy of the solution must be validated.

The HPL is calculated for each user’s time and location. The HPL is a radius in the horizontal (latitude-longitude) plane around the user’s calculated GPS position. The RAIM model ensures that, within the specified confidence level, the user’s actual position is within the HPL radius of the calculated position. The HPL is converted to the NIC value which is used to determine sufficiency.

The SAPT provides maps of wide area outages as a flight planning aid for informational situational awareness only. Wide area outage maps are available for a limited subset of supported avionics for both ADS–B and RAIM.

9.1 Getting Started with RAIM

This page provides a summary introduction to the RAIM prediction tool, explains what users can accomplish in the web pages, and lays out the limitations of the tool. This page is shown in Figure 9–1, Getting Started with RAIM SAPT Page.
### 9.2 RAIM XML Service

The RAIM SAPT is exclusively an XML-based web service, most commonly used by flight planning software (including both custom and third-party solutions).

If you use flight planning software from a third-party vendor, please contact the vendor and request that they incorporate our web service into their software.

If you build and/or maintain your own flight planning software, you may obtain a copy of the SAPT SDK and the WSDL file for the SAPT web service (refer to Figure 9–2, RAIM XML Service Page).

A WSDL file is a technical description of the software interface to a web service that programmers can use to write software that can communicate with a web service. The SAPT WSDL allows the SAPT service to be integrated with your flight planning capabilities.
RAIM XML Service

Understanding our RAIM XML Service

The RAIM Service Availability Prediction Tool (SAPT) is exclusively an XML-based web service, most commonly used by flight planning software (including both custom and third party solutions).

If you or your company uses flight planning software from a third party vendor please contact them and ask that they incorporate our web service into their software.

For those who build and/or maintain your own flight planning software, you may obtain a copy of the SAPT Software Development Kit (SDK) which consists of documentation and the Web Service Description Language (WSDL) file for the SAPT web service. A WSDL file is a technical description of the software interface to a web service that can be used by software programmers to write software that can communicate with a web service. The SAPT WSDL allows the SAPT service to be integrated with your flight planning capabilities. Please note that the WSDL is not generally useful to end-users.

Request a copy of the SAPT WSDL and SDK

If you do not require a copy of the SDK/WSDL but would still like to be kept informed about changes to the SAPT service you may subscribe to our e-mail announcement list. This is used only for major announcements regarding changes to the SAPT service and web site.

Subscribe to the SAPT announcement e-mail list

If you have other questions not addressed here or would like to share some feedback regarding the SAPT service please contact us.

Figure 9–2. RAIM XML Service Page

9.2.1 Request the SAPT WSDL and SDK

If you do not require a copy of the SDK/WSDL but would like to be informed about changes to the SAPT service, you may subscribe to our e-mail announcement list. This is used only for major announcements regarding changes to the SAPT service and web site.

Click the Request a copy of the SAPT WSDL and SDK link on the RAIM XML Service page to open the download page (refer to Figure 9–3, Download the SAPT SDK).
Download the SAPT SDK

To download a copy of the SAPT SDK (including the WSDL file) please fill-in the following form and then press the Download button.

When you click **DOWNLOAD**, the application generates a pop-up dialog (refer to Figure 9–4, Download the SAPT SDK Pop-up Window).

Click **SAVE AS** if you want to choose the location where you save the file on your computer (refer to Figure 9–5, Save the SAPT SDK).
Click **OPEN** to save the file to the temporary internet files folder on your computer (refer to Figure 9–6, Open the SAPT SDK).

The SDK archive contains the WSDL and other files that might be useful in developing software to interface with the SAPT.

### 9.2.2 Software Connectivity

The following ADS-B and RAIM files are available for download by navigating to [https://sapt.faa.gov/](https://sapt.faa.gov/) and appending the full filename to the URL in your address bar:

**RAIM Files** – Format descriptions can be found in **AC90-100A - Website file formats SAPT 2.0.pdf** (included in the SDK).

interference.dat
last_outages.dat
locations.dat
locations_highres.dat
outages.dat
outages_highres.dat
status.txt

**ADS-B Files** – Format descriptions can be found in **ADSB_Outage_File_Formats.txt** (included in the SDK).

- TSOC129_ADSB_BARO_FIVE_RES15.csv
- TSOC129_ADSB_BARO_FIVE_RES30.csv
- TSOC129_ADSB_BARO_FIVE_RES60.csv
- TSOC129_ADSB_BARO_FIVE_RES7.csv
- TSOC129_ADSB_BARO_TWO_RES15.csv
- TSOC129_ADSB_BARO_TWO_RES30.csv
- TSOC129_ADSB_BARO_TWO_RES60.csv
- TSOC129_ADSB_BARO_TWO_RES7.csv
- TSOC129_ADSB_NOBARO_FIVE_RES15.csv
- TSOC129_ADSB_NOBARO_FIVE_RES30.csv
- TSOC129_ADSB_NOBARO_FIVE_RES60.csv
- TSOC129_ADSB_NOBARO_FIVE_RES7.csv
- TSOC129_ADSB_NOBARO_TWO_RES15.csv
- TSOC129_ADSB_NOBARO_TWO_RES30.csv
- TSOC129_ADSB_NOBARO_TWO_RES60.csv
- TSOC129_ADSB_NOBARO_TWO_RES7.csv
- TSOC196_ADSB_FIVE_RES15.csv
- TSOC196_ADSB_FIVE_RES30.csv
- TSOC196_ADSB_FIVE_RES60.csv
- TSOC196_ADSB_FIVE_RES7.csv
9.2.3 SAPT Announcement Subscription

Announcements regarding changes to the SAPT web service and web site will be made periodically. At least one person from each organization should be subscribed to the SAPT announcement list so that all users at that organization can learn of pending changes.

If you are interested in receiving SAPT announcements, click the Subscribe to the SAPT e-mail Announcement List link to open the subscription page (refer to Figure 9–7, SAPT E-mail Subscription Page).

Figure 9–7. SAPT E-mail Subscription Page

Enter your e-mail address and press SUBSCRIBE.
This page intentionally left blank.
10. RAIM SUMMARY PAGES

Scroll down the ADS–B SAPT home page to see the RAIM Summary Pages section of the site (refer to Figure 10–1, RAIM Summary Section).

![RAIM Summary Pages Table]

<table>
<thead>
<tr>
<th>Phase-of-flight</th>
<th>With Baro-Aiding</th>
<th>Without Baro-Aiding</th>
</tr>
</thead>
<tbody>
<tr>
<td>En Route</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>Terminal</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>NPA</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

Click on an image to view

**Figure 10–1. RAIM Summary Section**

Click on the image that mirrors the avionics on your aircraft and the phase of flight you are interested in to see an overview.

The image shown in Figure 10–2, RAIM Summary — NPA Airspace, SA On and BA Enabled, illustrates the summary for NPA airspace with SA and BA both enabled.
Displaying TSO-C129, barometric aiding, RAIM NPA airspace, Selective Availability ON, mask angle: 5.0°

Outage Summaries available for 2018/05/03 22:42 - 2018/05/06 21:42 UTC

Click here to see an interactive version of this.

Figure 10–2. RAIM Summary — NPA Airspace, SA On and Baro-aiding Enabled

Your parameters are displayed at the top of the screen, along with the timeframe for which outages have been predicted and are available. The outage summary beneath them is a static map for quick review; It shows a cumulative summary of the predicted outages within the timeframe described by the caption, a prediction window of at least 24 hours. In other words, a ten minute outage an hour from now in Maine and a 20 minute outage tomorrow morning, and every other predicted outage in the prediction window would all show as red on the map,

The snapshots offer a 24-to-72 hour window on the airspace. If the area where you intend to fly is colored green there are no predicted RAIM outages in that area and you may proceed with your trip.

Red blocks indicate outages. If there are red sections of the map near where you plan to travel, or if you are unsure if the outages will affect your flight, you should get a more detailed forecast. You can see a detail map with a time slider by clicking the Click here link in the lower-left corner of the screen, or you can submit a transaction for your specific flight plan.

Please refresh the summary page each time you review it in case it has been cached in your browser.
The following image illustrates the summary for NPA airspace with SA ON and no barometric aiding (refer to Figure 10–3, RAIM Summary — NPA Airspace, with SA On and No Baro-aiding).

Displaying TSO-C129, no barometric aiding, RAIM NPA airspace, Selective Availability ON, mask angle: 5.0°

Outage Summaries available for 2018/05/03 22:42 - 2018/05/06 21:42 UTC

![Map of NPA Airspace with SA ON and No Baro-aiding](image)

Click here to see an interactive version of this.

Figure 10–3. RAIM Summary — NPA Airspace, with SA On and No Baro-aiding

To see the interactive map representation of a mapped route of flight, click the hyperlink in the bottom-left corner of the screen (“Click here to see an interactive version of this”). It will take a few moments to generate the map.

The following image is the Cesium™ representation, as show in Figure 10–4, RAIM Summary — NPA Airspace, SA On and Baro-aiding.

NOTE: In the interactive presentation you see outages over the next six hours only. Review the summary pages again later or use the SAPT Flight Plan Form for more information.
Displaying TSO-C129, no barometric aiding, RAIM NPA airspace. Selective Availability ON, mask angle: 5.0°

* Outage Summaries available for 2018/05/03 22:42 - 2018/05/06 21:42 UTC

Figure 10–4. RAIM Summary — NPA Airspace, SA On and Baro-aiding

Some of the features of this tool are displayed at the bottom of the interactive map. They are described briefly here:

**NOTE:**

- The graphical display is provided through Cesium and functionality consistent with the SAPT ADS–B requirements.
- Outages are shown in red for En Route, Terminal and Non-Precision Approach (NPA) areas, and are available both with and without baro-aiding
- GPS Interference Test outages are shown in brown

Press **DOWNLOAD KML** to download the KML servlet.

**NOTE:** The downloaded KML file will include the GPS Interference Tests, but not the Service Volume information. The interactive map contains checkboxes that allow users to show or hide the GPS...
Interference Tests, as well as the Service Volume layers. These checkboxes do not affect the downloaded KML file.

The most important feature of the tool is the time slider ruler at the bottom of the window. Using the blue slider, you can see the outages play across the map.

Check the boxes for Show ADS–B Service Volumes and Show GPS Interference Tests, if you want to see that information. The region defaults to the continental US outages at a low resolution. You may select a region from the buttons on the right to zoom to an area, or use the interactive map features to navigate to a custom region and display outages at a higher resolution. To zoom in on an area of interest you can use any of these four different methods:

Method 1. Select an area by pressing one of the buttons below the map to zoom to it.

Method 2. You can zoom using the plus/minus tool on the right side of the screen, illustrated here:

Method 3. Use the hand tool in the interactive map to ‘grab’ a section of the map and move it in the desired direction.

Method 4. Use the scroll wheel on your mouse to zoom in/out.

You can also Zoom to an area of interest to see the outages in more detail: Press CONUS, NORTHEAST US, SOUTHEAST US, GULF OF MEXICO, SOUTHWEST US, NORTHWEST US, ALASKA, HAWAII, GUAM and PUERTO RICO to select the area for viewing. Look-ahead time: Press NEXT 6 HOURS, 6–12 HOURS, 12–18 HOURS and 12–24 HOURS to select the look-ahead time for outage.

Once you have selected the desired region, click GENERATE KML FOR AREA IN VIEW to see the outages for the new view. The area within which outages are searched will be highlighted within a box.

**NOTE:** You must press GENERATE KML FOR AREA IN VIEW to refresh the outage detail for the area you have chosen. If you zoom in, you may see more detail of the outages.

**NOTE:** Outages are NOT generated for the entire world. Even outages inside the highlighted search box are only predicted within the airspace located inside the orange Service Volumes.
To zoom back out reverse whichever of the above methods you used: i.e., select a different region from the buttons, use the slider tool or use the hand icon.

**NOTE:** To return to the original region, use the CONUS button, not the refresh button on the plus/minus tool, which will attempt to show everything.

For details of an outage, position the mouse over an area and press the left mouse button. The information appears as a pop-out window. This works for both GPS Interference Test (Brown) outages and RAIM (Red) outages. Brown outages are shown in Figure 10–5, RAIM Summary — GPS Test Outage Detail, NPA On and No Baro-aiding, and Red outages are shown in Figure 10–6, RAIM Summary — RAIM Outage Detail, NPA On and No Baro-aiding.

Displaying TSO-C129, no barometric aiding, RAIM NPA airspace, Selective Availability ON, mask angle: 5.0°

* Outage Summaries available for 2018/05/04 12:09 - 2018/05/07 08:09 UTC

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**Figure 10–5.** RAIM Summary — GPS Test Outage Detail, NPA Airspace, SA On and No Baro-aiding
Figure 10–6. RAIM Summary — RAIM Outage Detail, NPA Airspace, SA On and No Baro-aiding
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List of Acronyms and Abbreviations

The following acronyms and terms may be found in this document.

3D Three-Dimensional
A/A Air-to-Air
A/G Air-to-Ground
AC Advisory Circular

ACs are publications offered by the FAA to provide guidance for compliance with aviation regulations. They define acceptable means, but not the only means, of accomplishing or showing compliance with aviation regulations.

Generally informative, ACs are neither binding nor regulatory yet some have the effect of de facto standards or regulations.

AC 90–100A Advisory Circular “US Terminal and En Route Area Navigation (RNAV) Operations”
ACY FAA Technical Center in Atlantic City, NJ
ADS–B Automatic Dependent Surveillance – Broadcast

ADS–B provides significant operational capabilities by addressing some of the limitations of the present surveillance system. The aircraft’s avionics system automatically transmits messages containing position and velocity information to the ATC. This makes the aircraft visible to the ATC and other appropriately equipped ADS–B aircraft. ADS–B allows ATC to monitor and separate aircraft with more precision. Because ADS–B uses GPS signals, it expands surveillance services into areas where little or no radar coverage exists.

AJAX Asynchronous JavaScript and XML
API Application Programming Interface
ARC (ADS–B) Aviation Rulemaking Committee
ATC Air Traffic Control
BA Barometric Aiding, baro-aiding

A method of augmenting the GPS integrity solution by using a non-satellite input source. To ensure that baro-aiding is available, the current altimeter setting must be entered as described in the operating manual.

CICA Convention on International Civil Aviation
CIFP Coded Instrument Flight Procedures (formerly the National Flight Database (NFD))
LAAS  Local Area Augmentation System

LAAS is an all-weather aircraft landing system based on real-time differential correction of the GPS signal. Local reference receivers located around the airport send data to a central location at the airport. The data are used to formulate a correction message, which is transmitted to users by VHF data link. A receiver on an aircraft uses this information to correct GPS signals, which then provide a standard ILS-style display to use while flying a precision approach.

LAN  Local Area Network

Mask angle  The minimum acceptable satellite elevation above the horizon to avoid blockage of line-of-sight.

MHz  Megahertz

MOPS  Minimum Operational Performance Standards

MSL  Mean sea level

NACp  Navigation Accuracy Category for Position

NACp specifies with 95 percent probability the accuracy limits for the horizontal position that is being broadcast.

NAS  National Airspace System

NavAids  Aids to navigation

NextGen  Next Generation Air Transportation System

NFD  National Flight Database

NIC  Navigation Integrity Category

The NIC specifies the radius of containment for the aircraft’s horizontal position.

NM  Nautical Miles

NOTAM  Notice to Airmen

NOTAM or NoTAM are filed with an aviation authority to alert pilots of potential hazards along a flight route or at a location that could affect the safety of the flight.

They are unclassified notices or advisorys distributed by means of telecommunication that contain information about the establishment, conditions or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel and systems concerned with flight operations.

NOTAMs are created and transmitted by government agencies and airport operators under guidelines specified by Annex 15: Aeronautical Information Services of the Convention on International Civil Aviation (CICA).
### Glossary

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPA</td>
<td>Non-Precision Approach</td>
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<tr>
<td>OpenGL ES</td>
<td>Open Graphics Library for Embedded Systems</td>
</tr>
<tr>
<td>QRO</td>
<td>Quality and Reliability Officer</td>
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<tr>
<td>RADAR</td>
<td>Radio Detection and Ranging</td>
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<tr>
<td>RAIM</td>
<td>Receiver Autonomous Integrity Monitoring</td>
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<tr>
<td>RNAV</td>
<td>Area Navigation</td>
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RNAV is a method of air navigation that allows an aircraft to choose any course within a network of navigation beacons, rather than navigating directly to and from the beacons. It can conserve flight distance, reduce congestion, and allow instrument flight plans into airports without beacons.

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<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>RNP</td>
<td>Required Navigation Performance, Accuracy, Integrity, Continuity, Availability</td>
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<tr>
<td>SA</td>
<td>Selective Availability</td>
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A function in the GPS navigation system that deliberately introduced random errors for civilian receivers. It was implemented to prevent enemy troops on foreign soil from using the GPS system to their advantage, while allowing friendly troops to obtain the true signals in GPS receivers that supported military encryption. SA was disabled permanently in 2000.

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<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>SAPT</td>
<td>(ADS–B) Service Availability Prediction Tool</td>
</tr>
<tr>
<td>SBAS</td>
<td>Satellite-Based Augmentation System</td>
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<tr>
<td>SBS</td>
<td>Surveillance and Broadcast Services</td>
</tr>
<tr>
<td>SDK</td>
<td>Software Development Kit</td>
</tr>
<tr>
<td>SID</td>
<td>Standard Instrument Departure</td>
</tr>
<tr>
<td>SIL</td>
<td>Source Integrity Level</td>
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The SIL defines the probability that the reported aircraft’s position is outside the radius of containment defined by the NIC parameter, without alarms and/or alerts.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>SSL</td>
<td>Secure Socket Layer</td>
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<tr>
<td>SSLPM</td>
<td>Satellite Service Level Prediction Model</td>
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<tr>
<td>SSR</td>
<td>Secondary Surveillance Radar</td>
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SSR is used in Air Traffic Control to not only detect and measure the position of aircraft, i.e., range and bearing, but also to request additional information from the aircraft itself, such as its identity and altitude.

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<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAR</td>
<td>Standard Terminal Arrival</td>
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<tr>
<td>TCP/IP</td>
<td>Transfer Control Protocol/ Internet Protocol</td>
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A TSO is a minimum performance standard for specified materials, parts, and appliances used on civil aircraft. When authorized to manufacture a material, part, or appliances to a TSO standard, this is referred to as TSO authorization. A separate FAA approval is required to install the article on an aircraft.

WAAS provides horizontal and vertical navigation for approach operations for all users at all locations. WAAS provides service for all classes of aircraft in all phases of flight, including En Route navigation and airport departures and arrivals.

In this technique several ground-receiving stations listen to signals from an aircraft and the aircraft location is mathematically calculated — typically in two dimensions, with the aircraft providing its altitude. Aircraft position, altitude and other data are ultimately transmitted, through an ATC automation system, to ATC for separation of aircraft.

WAM provides performance that is comparable to secondary surveillance radar (SSR) in terms of accuracy, probability of detection, update rate and availability/reliability. Performance varies as a function of the location of aircraft in relation to the ground sensors.