Automatic Dependent Surveillance – Broadcast (ADS-B)

Service Availability Prediction Tool (SAPT) /

Receiver Autonomous Integrity Monitoring (RAIM)

User Guide

Version 3.0.1

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En Route & Oceanic Second Level Engineering Group
Federal Aviation Administration
William J. Hughes Technical Center
Atlantic City International Airport, New Jersey 08405

REVISION HISTORY

Revision No.	Date	Summary of Changes
1.0	May 2013	Create draft for baseline release 1.3
2.0	May 2014	Update draft for RAIM Integration release 2.0
Not published	May 2015	Update draft for SAPT release *Note: This draft was not released.*
3.0	February 2016	Update draft for SAPT Enhancement release 3.0
3.0.1	May 2016	AIMS 157995; AJM¬-25 Baseline Release. Transfer of Configuration Management from Volpe to AJM-25.

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1 INTRODUCTION

The Automatic Dependent Surveillance – Broadcast (ADS-B) Service Availability Prediction Tool (SAPT) was developed by the U.S. Department of Transportation (USDOT), 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 two interfaces (graphical and eXtensible Markup Language (XML)). The ADS-B SAPT predicts 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

An ADS-B prediction is based on the ability of the aircraft avionics to meet performance requirements along a given route of flight, as specified in the Technical Standard Orders (TSOs) listed below as well as the predicted status of the Global Positioning System (GPS) constellation:

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

The availability of Wide Area Augmentation System (WAAS) under TSO C145c/C146c is not provided by the SAPT, however, predictions for TSO C145c/C146c will be available both with WAAS and outside WAAS coverage. 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.

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. 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. 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.

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 Code of Federal Regulations (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[1], hereafter referred to as the "Final Rule."

The ADS-B prediction is based on the TSOs— C129, C129 with SA Aware, C129 with FDE, C129 with SA Aware & FDE, C145/146 with WAAS, C145/146 outside WAAS coverage, C196—of the Global Positioning System (GPS) avionics on the aircraft and on the predicted status of the GPS constellation.

WAAS coverage information will be used for predictions for TSO-C145/C146 equipment.

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's requirements for 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

1 The Federal Register, Vol. 75, No. 103 / Friday, May 28, 2010 / Rules and Regulations.

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.

Users who want to review the instructions on how to use the RAIM tool, may jump directly to Section 9. RAIM Prediction Tool in this user guide.

2 BACKGROUND

ADS-B is a surveillance technology in which avionics broadcast an aircraft's identification, position, altitude, velocity, and other information, to support Air Traffic Control (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 (and air-to-air) broadcast links:

- One such link is 1090ES. This refers to aircraft broadcasts using a 1090 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.
- Another, UAT, 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…." (Aviation Rulemaking Committee, 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:

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

3 SCOPE

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

Note: Please refer to Advisory Circular (AC) 90-114A CHG 1, dated 7 March 2016.

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)

Three additional major releases are planned:

- Tech Refresh (FY 2016)
- Google Earth™ replacement (December 2016)
- New requirements (FY 2017)

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 is now deprecated.

This latest enhancement release includes the following features:

- Provides the FAA with the ability to define different NIC and NACp requirements for a defined airspace.
- Availability of alternate surveillance sources such as Secondary Surveillance Radar (SSR) and Wide Area Multilateration (WAM).
- An improved web form response that highlights results at each waypoint with a traffic light graphic and includes alerts for planned potential GPS Jamming & Interference.
- An interface with the SBS compliance monitor.

Future releases are planned for new hardware; to replace Google Earth™ with a new graphical display technology; and to incorporate any additional requirements required by 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, operational help and full system-crash recovery will be limited to regular business hours. There is no requirement to track users; i.e., no user names or passwords are required to use the tool.

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. 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 FAA-approved 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. Notices to Airmen (NOTAMs) 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 U.S. airspace as defined in the FAA SBS Service Volume Definition Document (SVDD). The SVDD definition of U.S. airspace includes Alaska, Hawaii, Puerto Rico, Guam and the Gulf of Mexico.

6.1 INTERFACE REQUIREMENTS

The SAPT supports the following desktop browsers:

- Internet Explorer 8 and higher
- Chrome
- Firefox
- Safari

Users must install JavaScript on their computer in order to use the graphical user interface (GUI).

The Google Earth™ plug-in was turned off on December 12, 2015. It may continue to work for a while depending on which browser is used.

Note: Users will be prompted to install the Google Earth™ plug-in the first time they generate a prediction.

6.2 INTERFACE TYPES

SAPT has two interface mechanisms, both available over the Internet:

- A GUI built on interactive hypertext markup language (HTML) for users who require information for a few flights.
- A Web service-enabled automated interface (i.e., computer-to-computer) in XML

format, 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.[2]

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 minimum operational performance standards (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).

[2] 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.

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
- C145/146 with WAAS
- C145/146 outside WAAS Coverage
- C196

Selective Availability (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 barometric aiding.

Note that RAIM availability demands that a minimum number of satellites be received. Barometric aiding 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 Google Earth™, 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 sections 9 and 10 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 United States (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 Google Earth™ plug-in[3] to navigate to a particular region, and then display outages for that region at a higher resolution. The areas within which outages

[3] Unfortunately, the Google Earth™ plug-in has been deprecated. We will find a replacement as soon as possible. Meanwhile, users who still have Google Earth™ can follow these instructions. Users can also generate and download a KML file of the outages and load that file into the full Google Earth™ application.

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 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. 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 7.8.1.1. 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: This figure applies to ADS-B predictions only. RAIM users should refer to Sections 9 and 10 in this guide for more information.

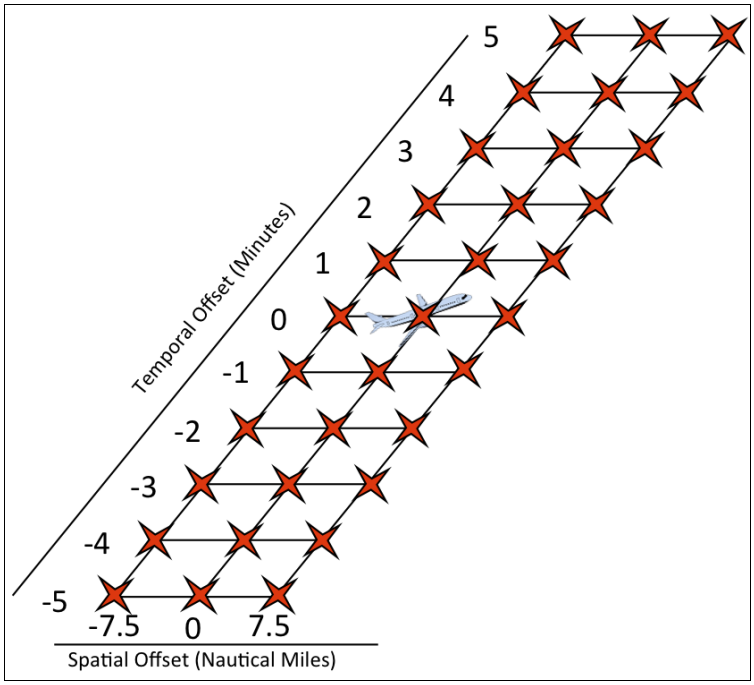


Figure 6-1: ADS-B SAPT 33-Point Algorithm

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-145/146 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-145/146 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-129, with and without SA Awareness and/or FDE capabilities, and TSO-196:
  - 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 Backup 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 'backupCoverage = true,' and a waypoint on the Flight Plan Form web response will show a yellow traffic light and the text: "Backup Only".

6.7 RAIM Sufficiency

RAIM users submit XML, which supplies the required 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 nautical mile, which is required for terminal airspace), throughout the route of flight.

7 INTERACTIVE GUI

The SAPT and RAIM Prediction Tool can be accessed from http://sapt.faa.gov or from http://www.sapt.faa.gov.

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

A user who clicks **I Do Not Agree** will not be able to access the site.

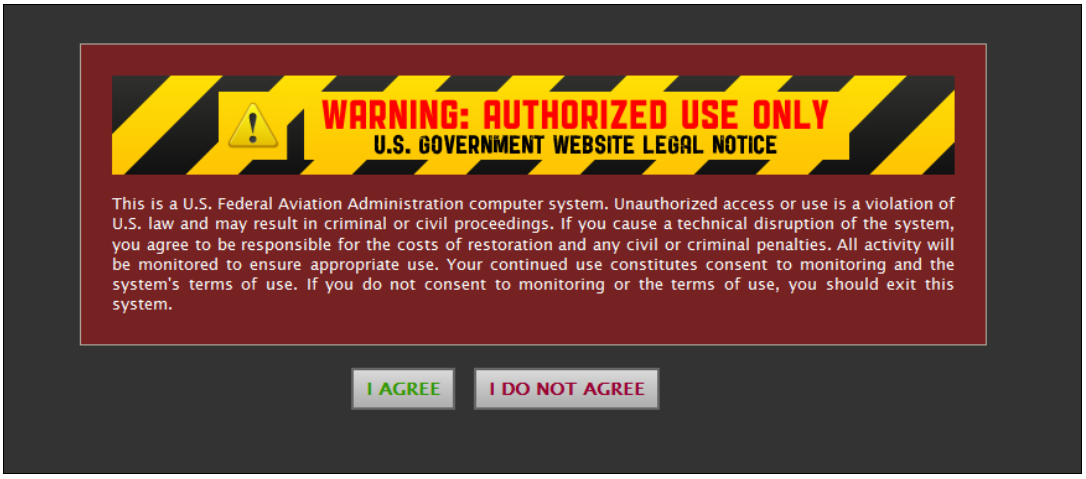


Figure 7-1: SAPT Warning Page

7.1 ADS-B Home Page

The main page of the website, shown in Figure 7-2, 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 Service Availability Prediction Tool
- RAIM Prediction Tool

- RAIM Summary Pages

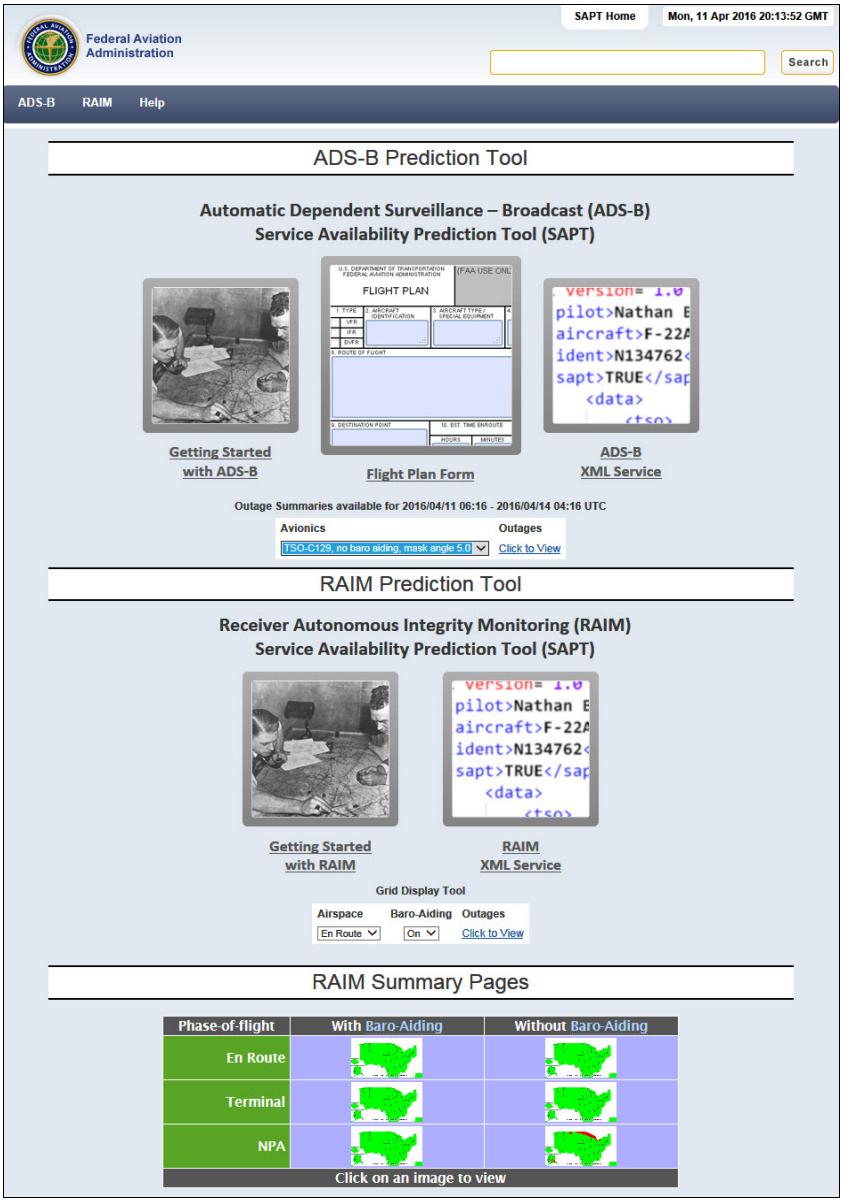


Figure 7-2: SAPT Main Page

7.1.1 Service Availability Prediction Tool

The Service Availability Prediction Tool is displayed at the top of the home page:

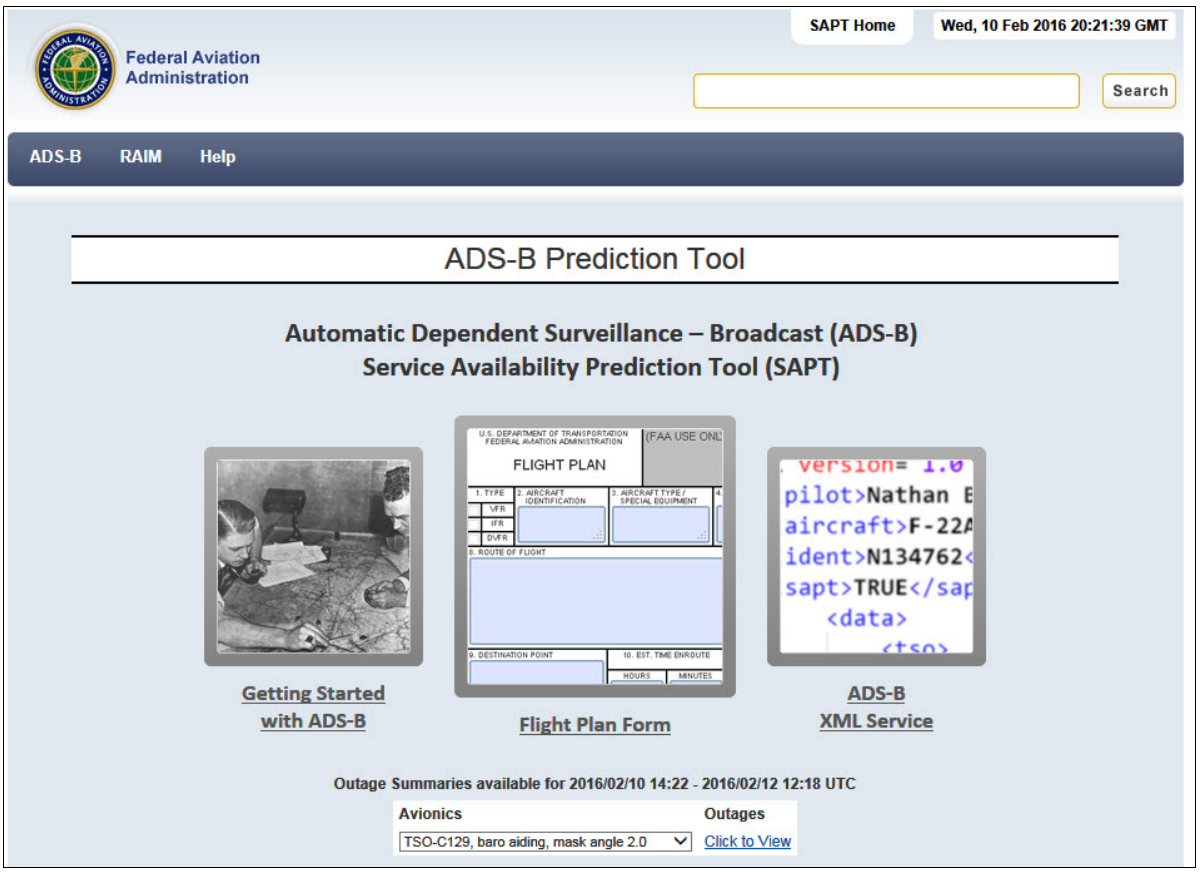


Figure 7-3: ADS-B Home Page - SAPT Section

You have three options if you want to use the 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.

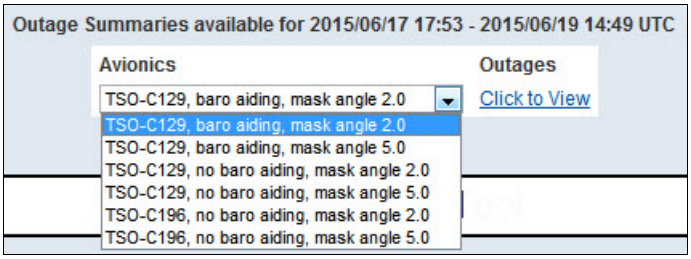


Figure 7-4: ADS-B Home Page - Outage Summary

Press Click to View to display the map for the avionics you selected from the drop-down list.

Note: It takes a few moments for the map to load and develop.

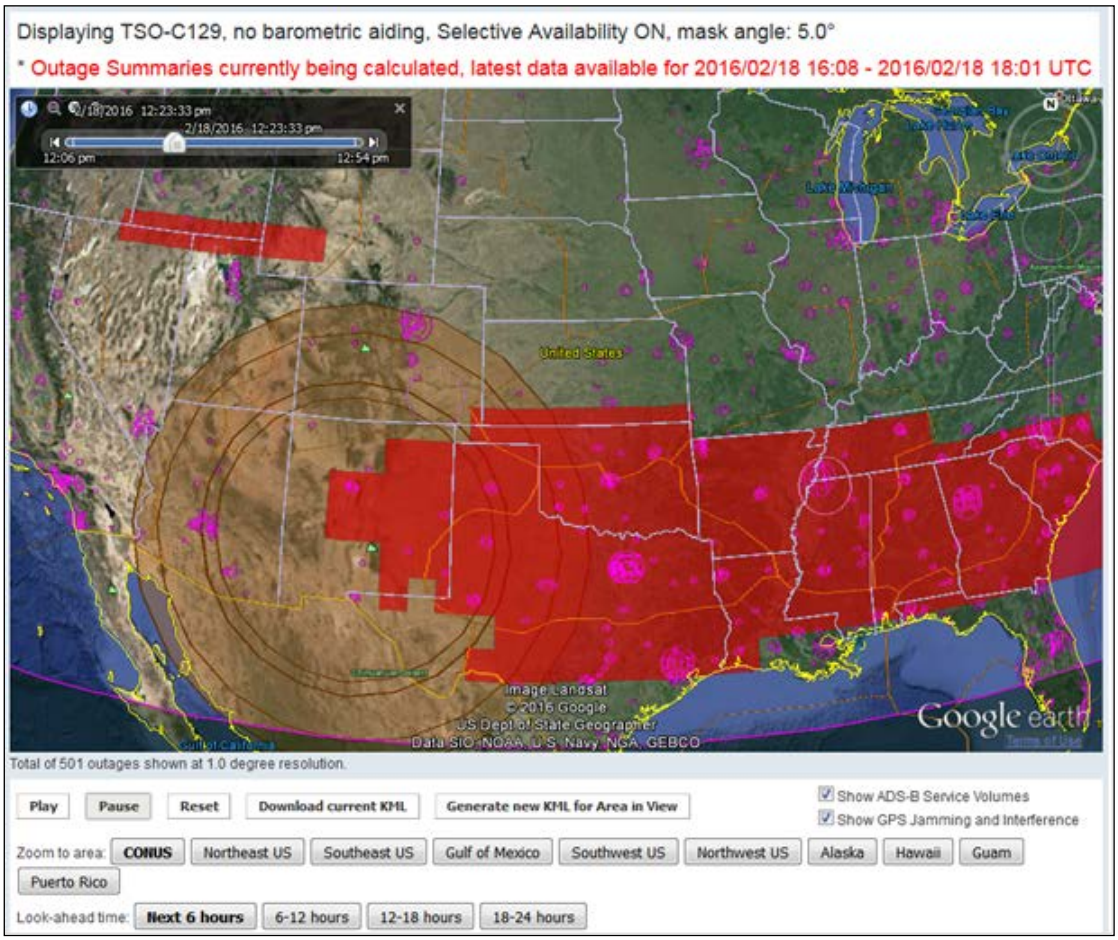


Figure 7-5: SAPT Graphical Display With Outages

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 "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 WDSL 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:

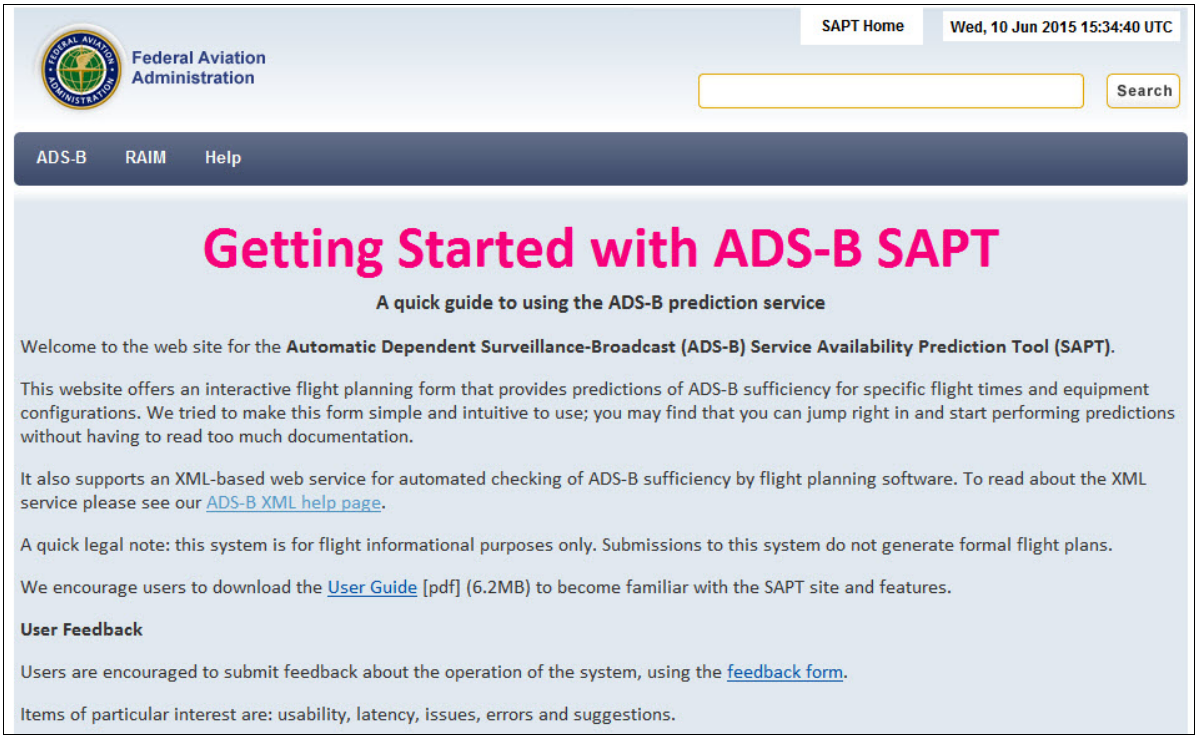


Figure 7-6: Getting Started with ADS-B SAPT Page

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 work-station 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, either 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 of this document) in order to open the form, which is shown below:

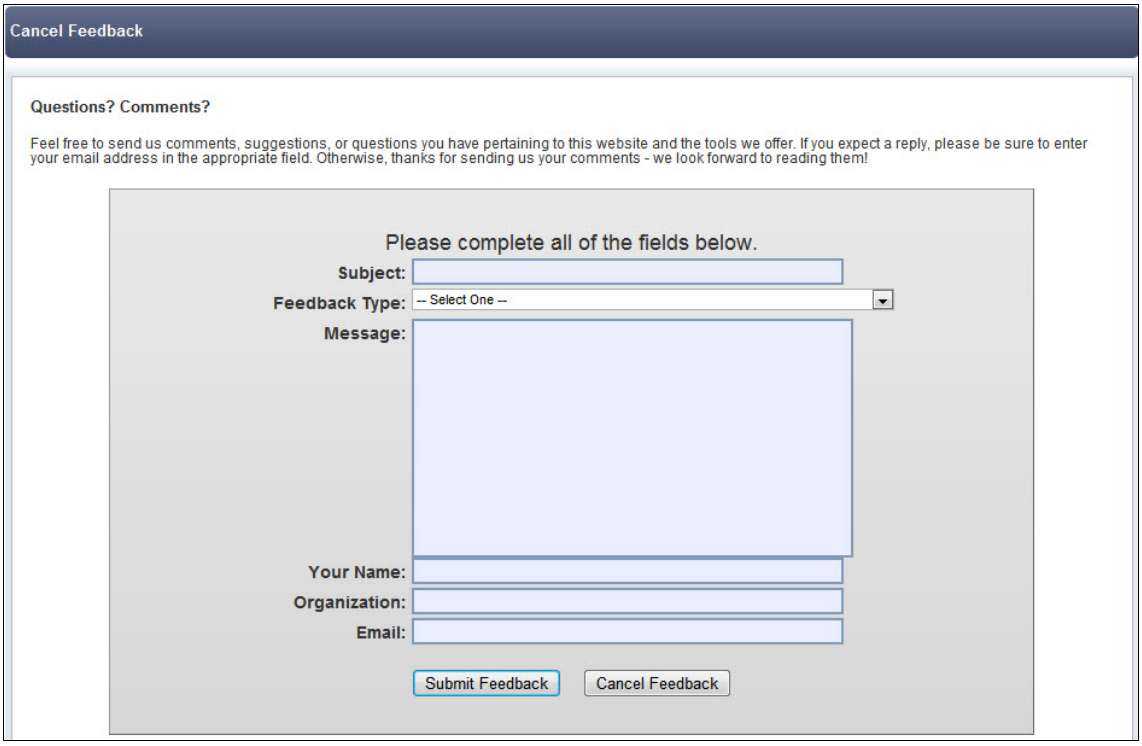


Figure 7-7: Feedback Form

Please specify the subject of your feedback, enter your question or comment, and add your name and email address so you can receive an answer to your message.

Click **SUBMIT FEEDBACK** to deliver your message or click **CANCEL FEEDBACK** if you change your mind. You can also click the Cancel Feedback link in the header.

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 below:

Figure 7-8: SAPT Header

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 Figures 7-9 and 7-10:

In this example, the user only entered one character in the search box:

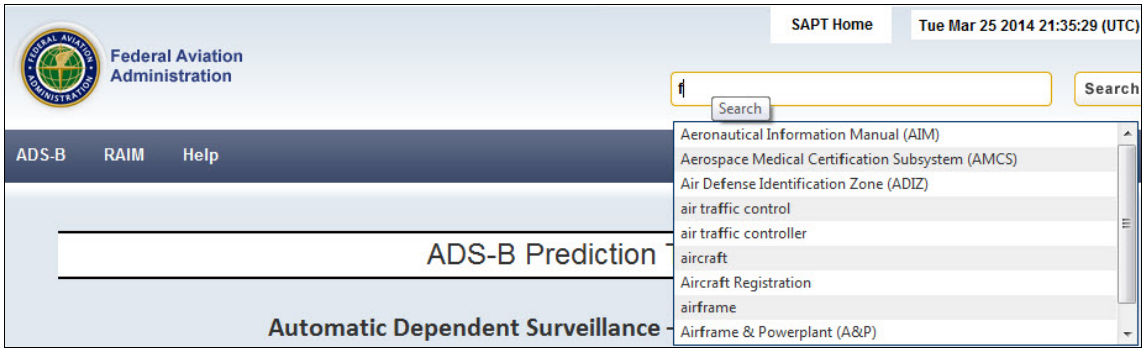


Figure 7-9: SAPT Search Text-box (single character)

By adding more characters this user targeted the subject of interest more closely:

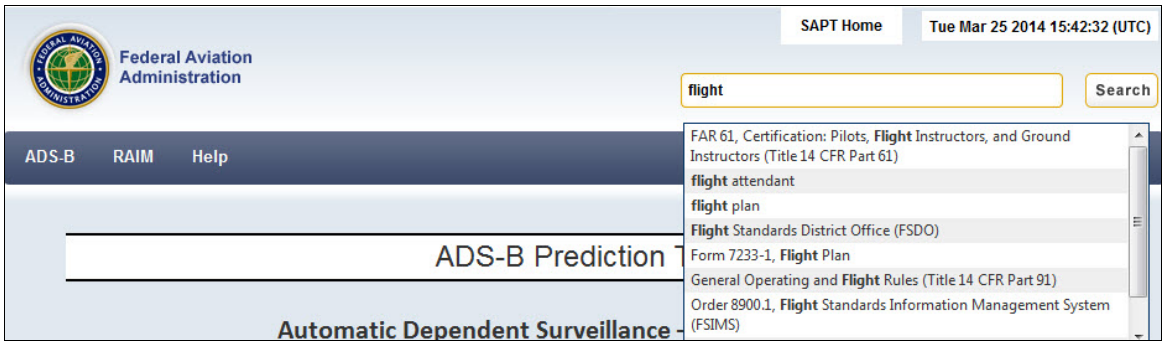


Figure 7-10: SAPT Search Text-box (full word)

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: Hold your cursor over the menu and click the page name in order to navigate directly to it:

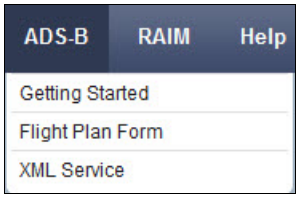


Figure 7-11: ADS-B Menu

- Step 2: On the Flight Plan Form, hold your cursor over the 'Save & Load' menu to display the options:

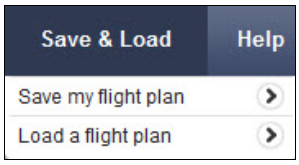


Figure 7-12: Save & Load Menu

Saving or importing pre-filled flight plan forms can be done in multiple ways. When you hold your cursor over the 'Save my flight plan' option, illustrated below, the three available methods are shown on the right in a separate menu:

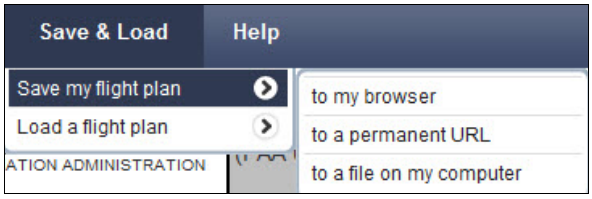


Figure 7-13: Save My Flight Plan Sub-menu

- Step 1: Click the option that suits you and save the flight plan form as defined in section 7.7.1 of this document.
  - To my browser
  - To a permanent URL
  - To a file on my computer
- Step 2: To load a flight plan that you saved, hold your cursor over the 'Load a flight plan' option to display the two methods, as shown here:

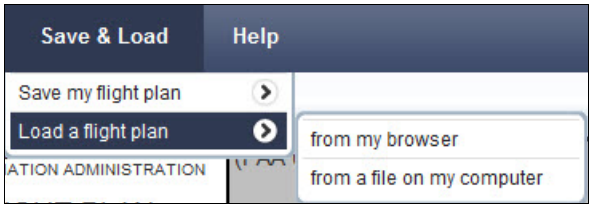


Figure 7-14: Load A Flight Plan Sub-menu

- Step 3: Click the option that suits you and import the saved flight plan form as defined in section 7.7.2 of the user guide.

  Note: You will import the flight plan form from wherever you saved it – either in a browser or in a file on your computer.

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:

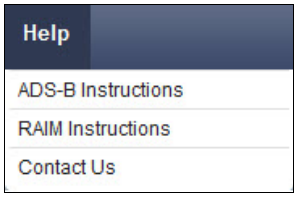


Figure 7-15: Help Menu

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., above.

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 here:

Figure 7-16: SAPT Footer

7.5 Download Google Earth™ Plug In

The Google Earth™ plug-in is required in order to display the large area or route-specific display that illustrates the predictions.

You must download the plug-in the first time you submit a route request. The plug-in will open shortly thereafter and will show the route of flight and any outages.

Note: The Google Earth plug-in has been deprecated, and was turned off on December 12, 2015. It may continue to work for a while depending on which browser is used.

Note: If you cannot download the plug-in, please refer to section 7.8.3 of this guide for another option.

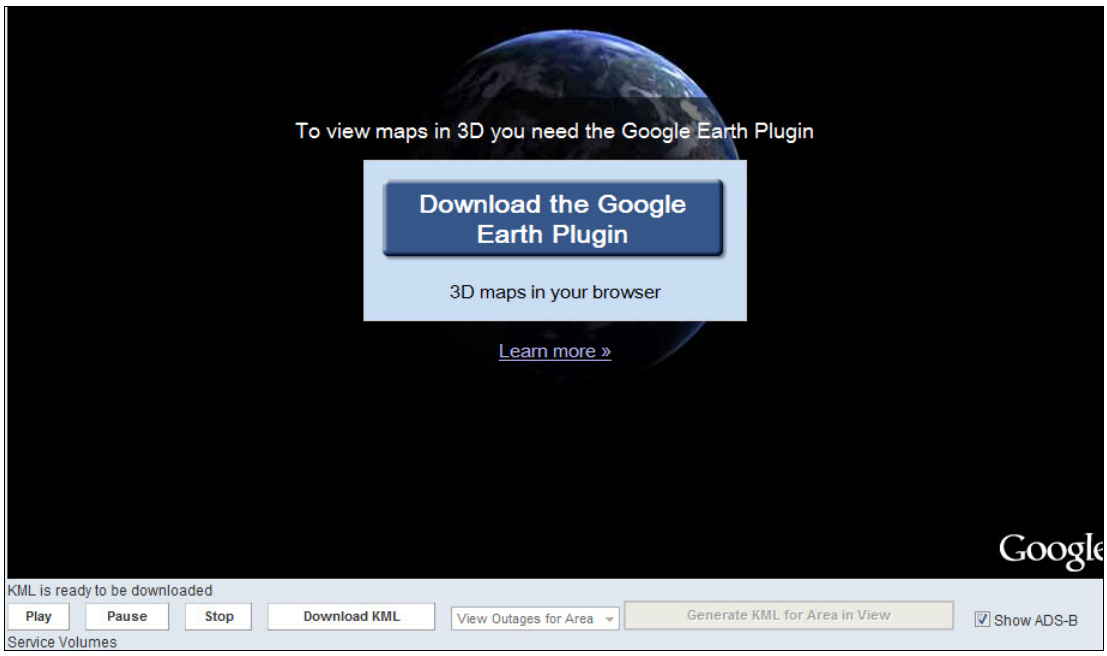


Figure 7-17: Download Google Earth™ PlugIn

7.6 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 18: Flight Plan Form below:

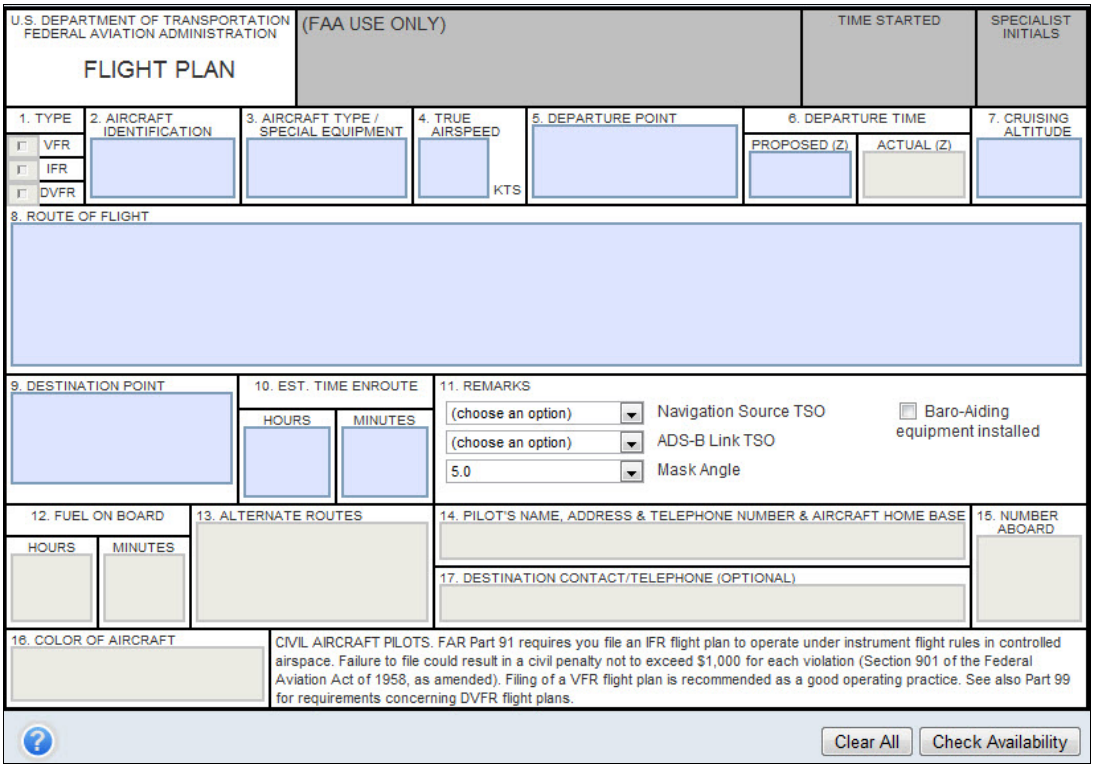


Figure 7-18: Flight Plan Form

7.6.1 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.

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

Table 7-1 defines the user-entered fields on the Flight Plan Form page:

Table 7-1: Required SAPT Fields

Field	Description	Units	Example of Field Value
Aircraft Identification	Flight ID of the aircraft that will be flown.	None	UPS1234
Aircraft Type / Special Equipment	The International Civil Aviation Organization (ICAO) identifier for the type of aircraft that will be flown. *Note: Small, Medium and Large aircraft types are supported in the enhancement release.*	None	C172 sml, med, lrg *Note: Aircraft Type/Special Equipment is case insensitive.*
True Airspeed	The aircraft's cruising speed.	Knots	110

Field	Description	Units	Example of Field Value
	Note: This value is currently not used in the final prediction calculation.		
Departure Point	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.	Decimal latitude, decimal longitude	KBOS or [43.3389,-79.6194] Latitude/longitude pairs should be in the form "[42.3630,-71.0064]" where latitude and longitude are in decimal degrees. *Note: There are no spaces in the latitude/longitude string.*
Departure Time Proposed (Z)	The time within the next 24 hours that the aircraft is expected to depart.	Zulu 24-hour notation	1800
Cruising Altitude	The expected cruising flight level.	Flight Level (FL)	This value must be between 10 and 510, e.g., 200 (20,000).
Route of Flight	The anticipated route of flight from departure to arrival.	See example.	Enter waypoints, routes, or standard departure or arrival procedures. 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]") *Note: See Departure Point for more information.* Waypoints should be separated by spaces; the form will automatically replace the spaces with an ellipsis (…). Routes 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). Standard Procedures (Standard Instrument Departures (SIDs)/Standard Terminal Arrivals (STARs)) should be specified with their fully-qualified name, if the user intends to join the procedure (e.g., "ORW3.JFK"), or simply with the SID (e.g., "ORW3"), if the user wants the system to determine

Field	Description	Units	Example of Field Value
			the join point. The system will automatically add the waypoints along the procedure. *Note: If you are flying from one airport to another, simply press the space bar. This field cannot be blank*
Destination Point	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.	None	KJFK or [43.3389,-79.6194] *Note: See Departure Point for more information.*
Estimated Time En Route Hours / Minutes	The length of the flight from departure to destination.	Hour and minutes	01 45 *Note: The user must account for wind and other weather factors in this calculation.*
Navigation Source TSO	The TSO number corresponding to the aircraft's GPS navigation source.	None	C129 *Note: For results to be valid, this entry must accurately reflect the aircraft equipage.*
ADS-B Link TSO	The TSO number corresponding to the aircraft's ADS-B transponder	None	260B *Note: This entry currently is not used in the prediction.*
Mask Angle	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.	Degree	5.0 *Note: If unsure, the user should set this value to 5.0.*
Baro-Aiding equipment installed	Barometric aiding equipment, if installed, augments the GPS by using a non-satellite input for altitude.	None	Check the box or remove the checkmark to indicate if baro aiding is present. *Note: This box should be checked only if the user is certain that barometric aiding equipment is installed in the aircraft.*

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, such as the following, for each incorrect data-point, which is identified by name (e.g., in this illustration the user forgot to specify a Navigation Source TSO):

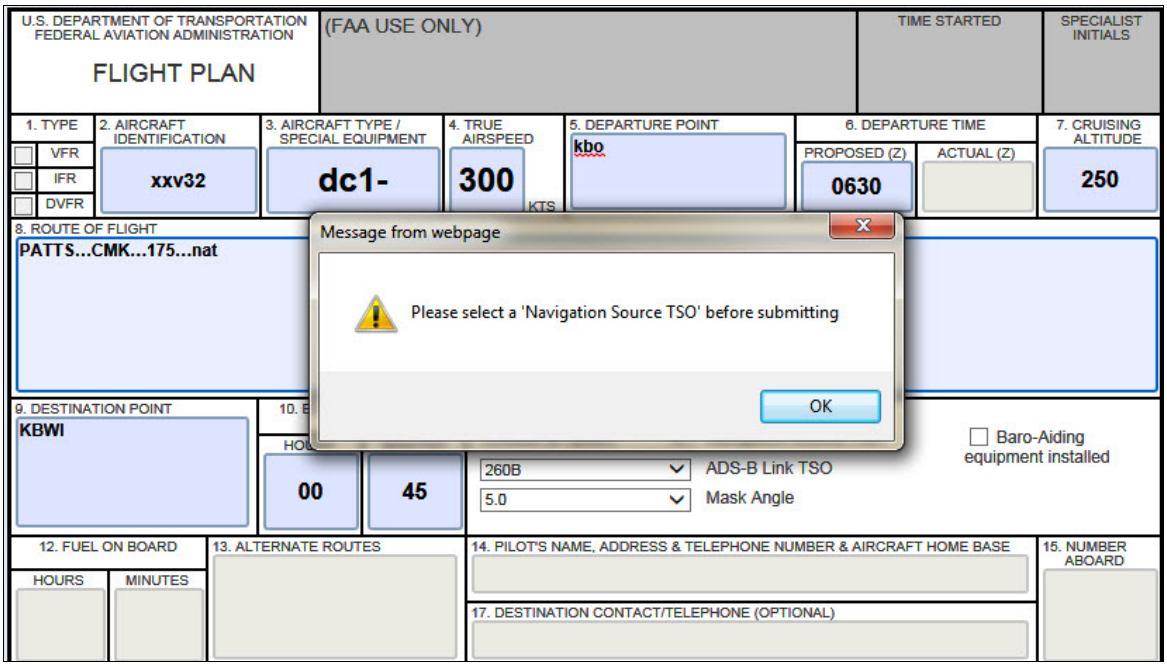


Figure 7-19: Flight Plan Form with Errors: Example

In this example (illustrated on the next page) the SAPT could not parse the waypoints which the user chose:

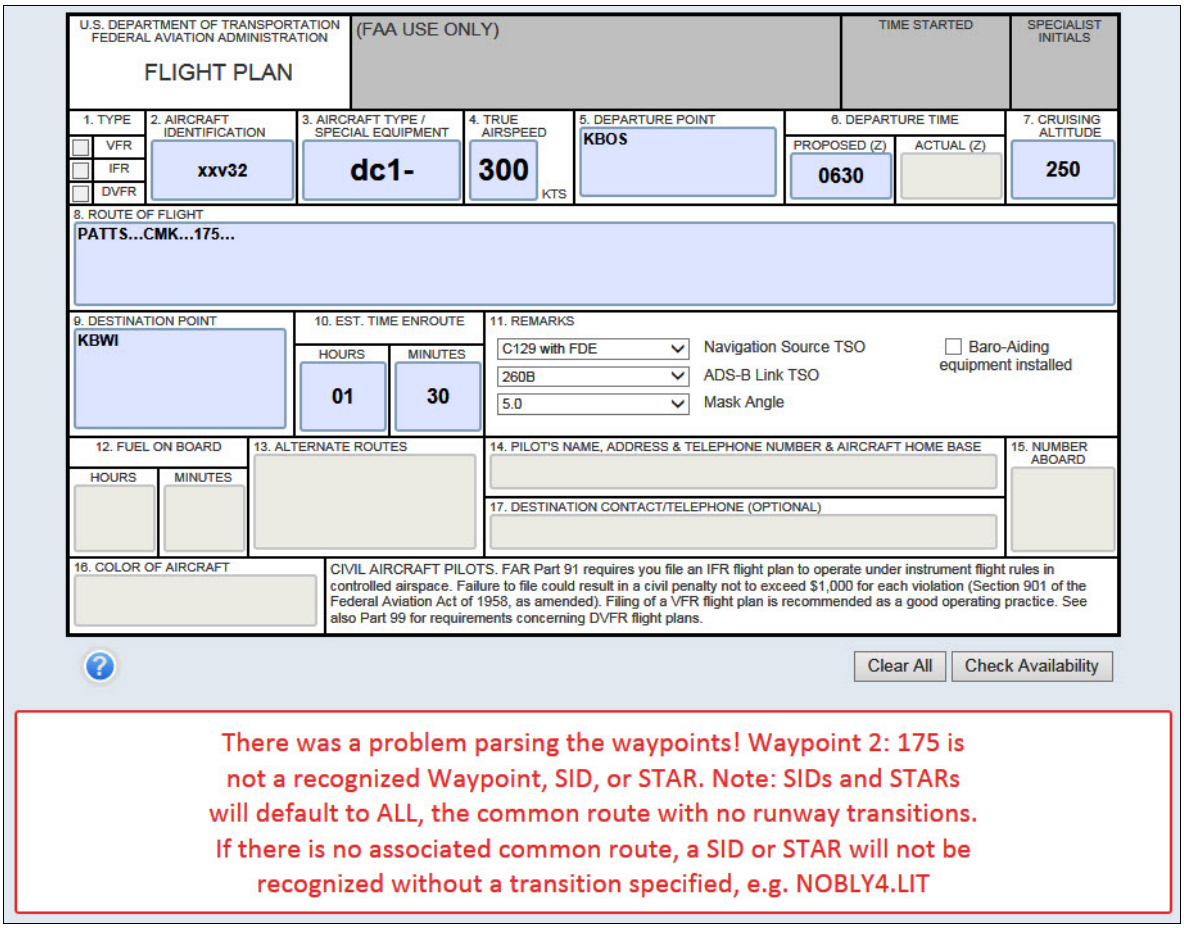


Figure 7-20: Flight Plan Form with Errors: Example

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 7-21 below.

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.

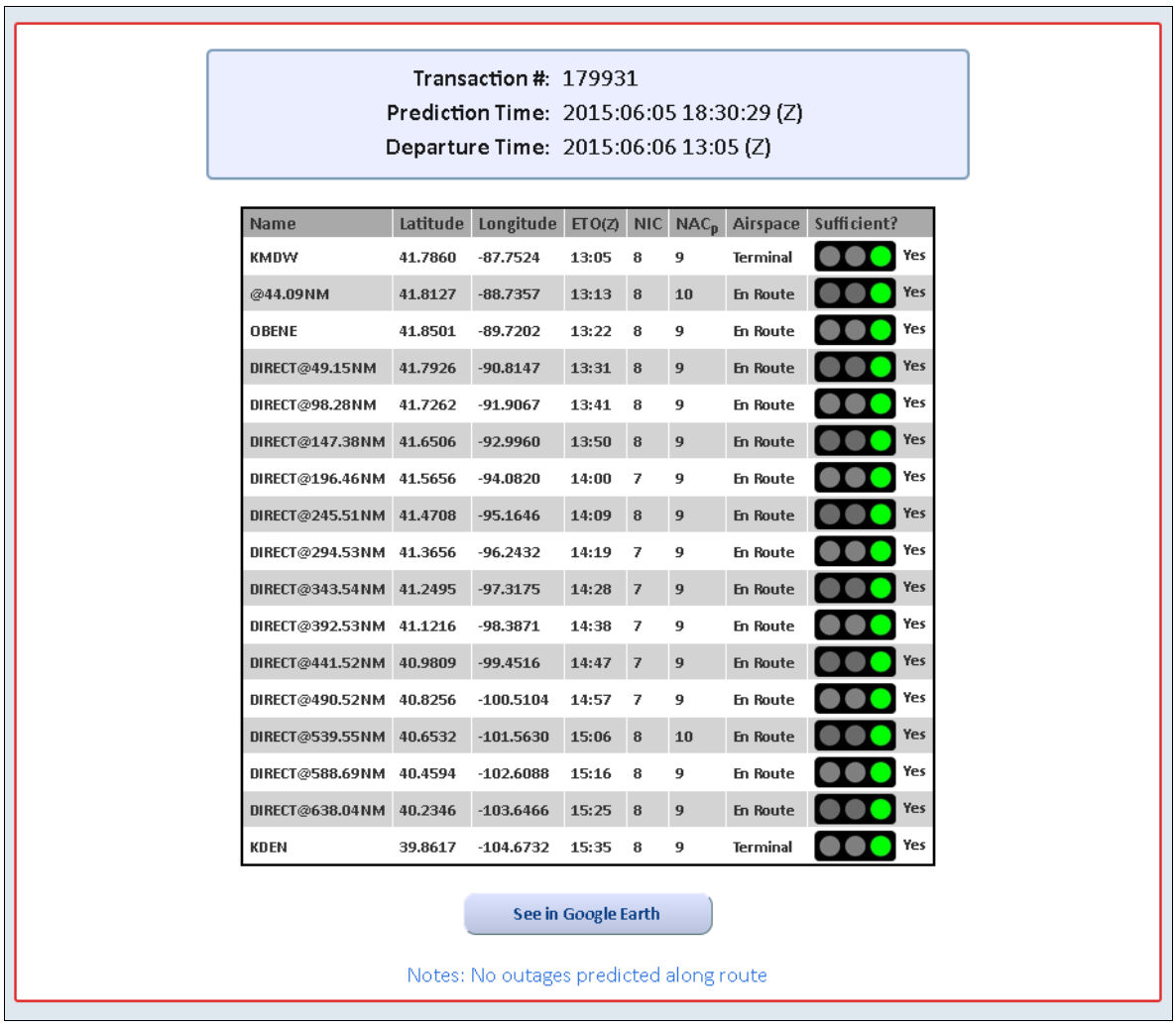


Figure 7-21: Flight Plan Form with Prediction

7.6.2 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 below:

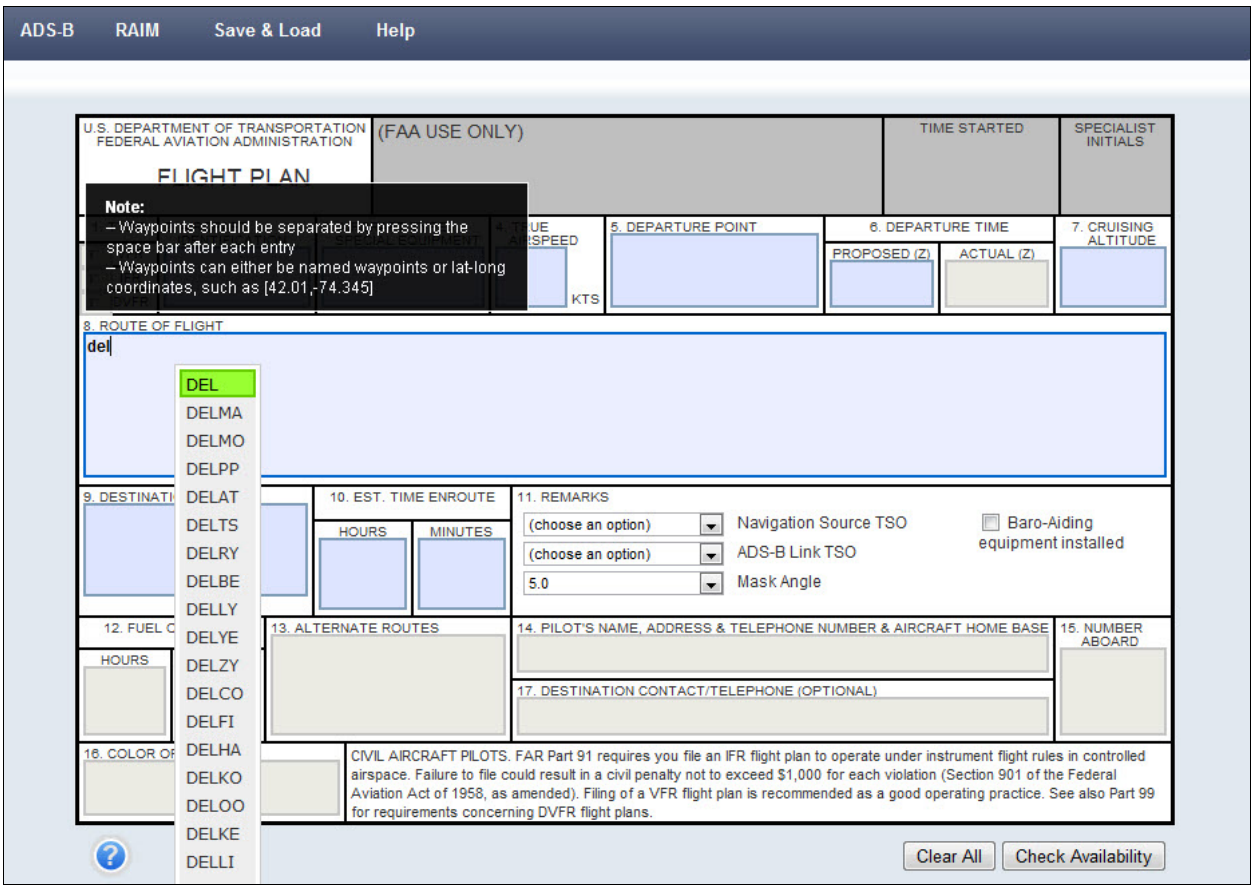


Figure 7-22: Field and Overlaid Suggestion Tip Box

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. Click the blue question mark in the bottom left corner [ ] to launch it:

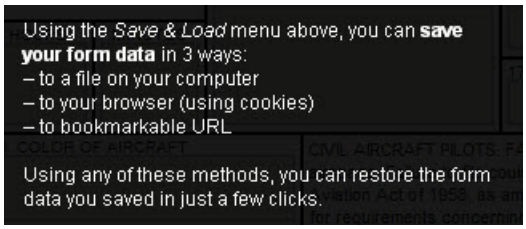


Figure 7-23: Save & Load Menu Pop-up Tip

7.7 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.

7.7.1 Saving a Flight Plan Form

You can save populated fields in the Flight Plan Form to a browser, to a uniform resource locator (URL), or to a computer file, as shown in Figure 7-24: Flight Plan Saving Options:

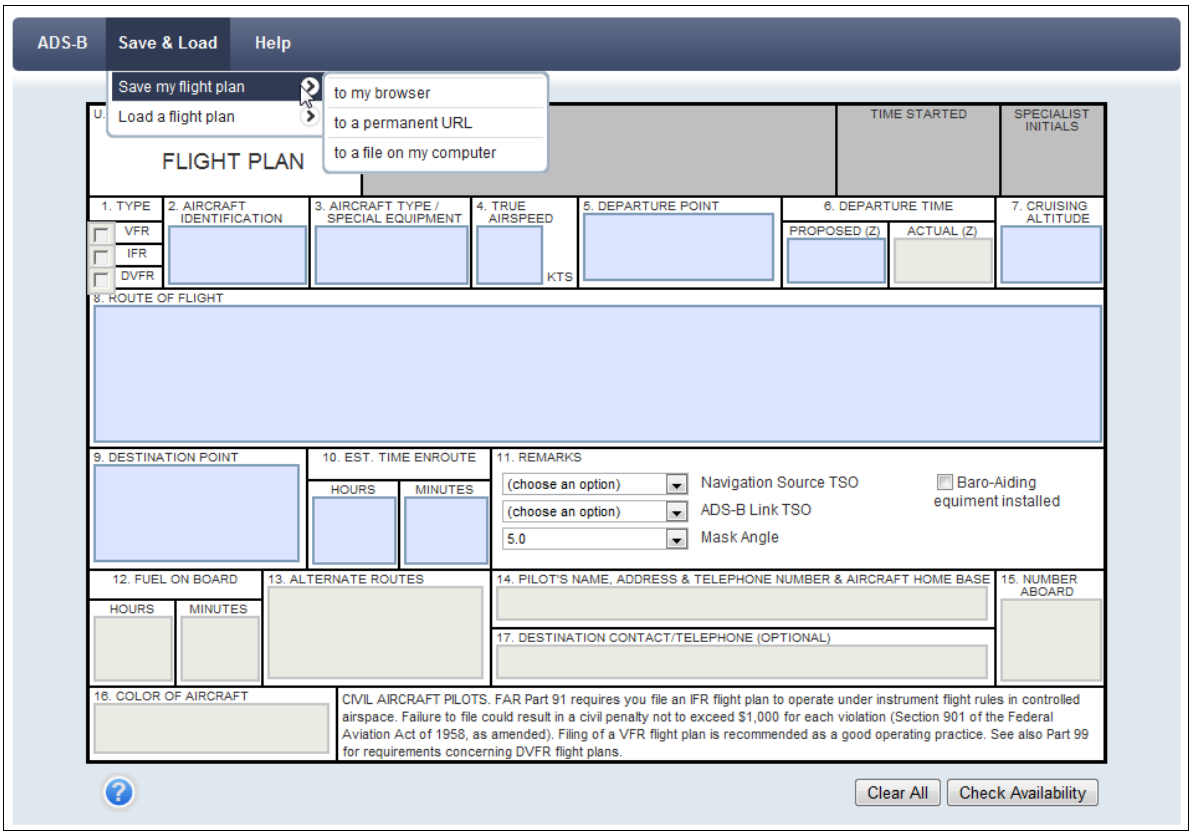


Figure 7-24: Flight Plan Saving Options

7.7.1.1 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 7-25: 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."

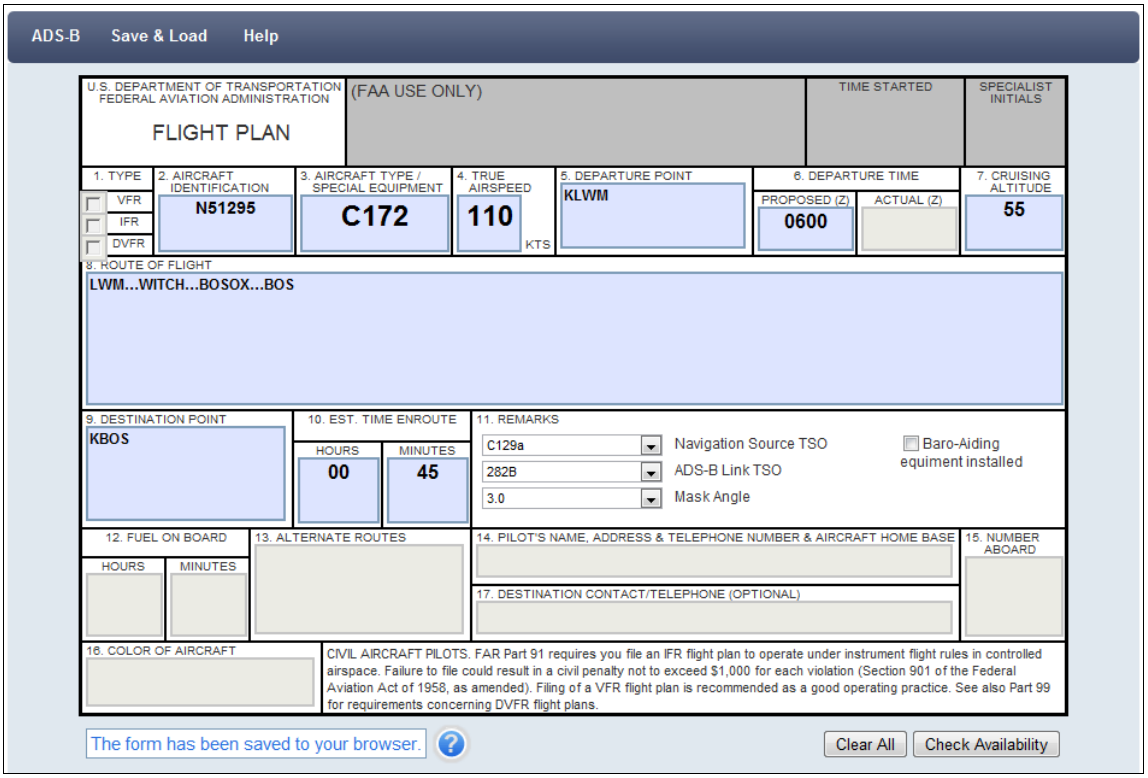


Figure 7-25: Flight Plan Form Saved to a Browser Notification Message

7.7.1.2 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 7-26: 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 Google Earth™ by pressing **BACK** on the browser. You can save the URL as a favorite in the browser for quick access to the form:

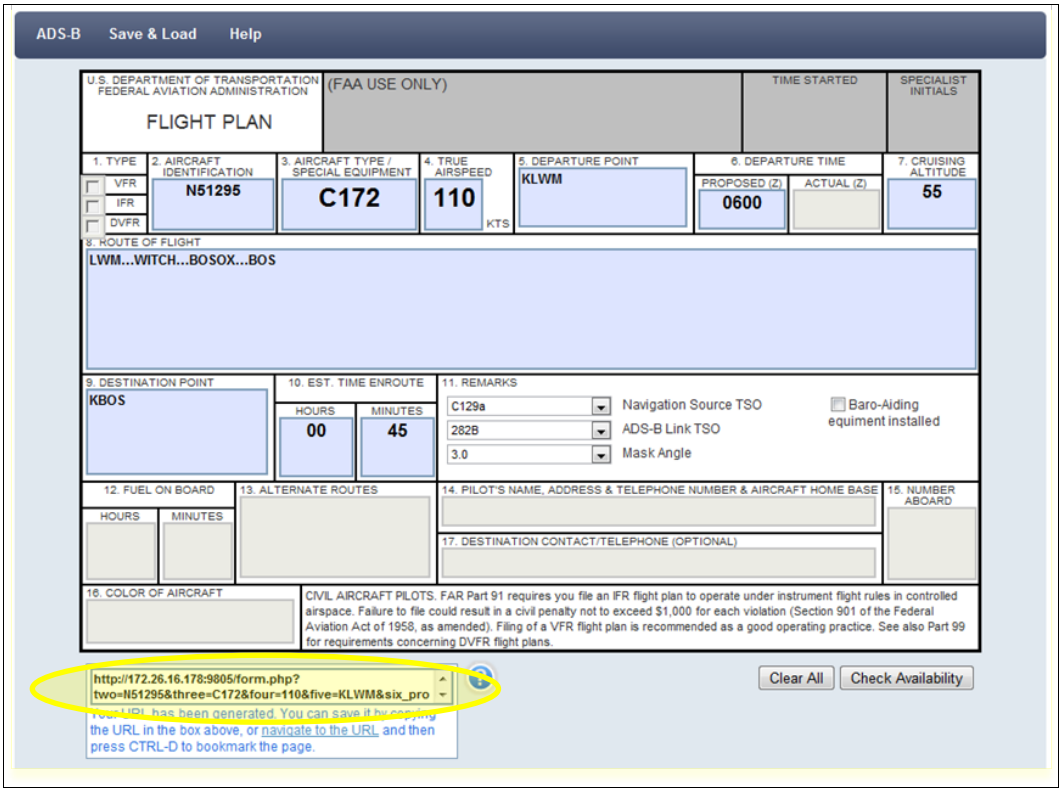


Figure 7-26: Flight Plan Form Written to a URL Notification Message

7.7.1.3 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 -27: Flight Plan Form Saved to a File—Notification Message.

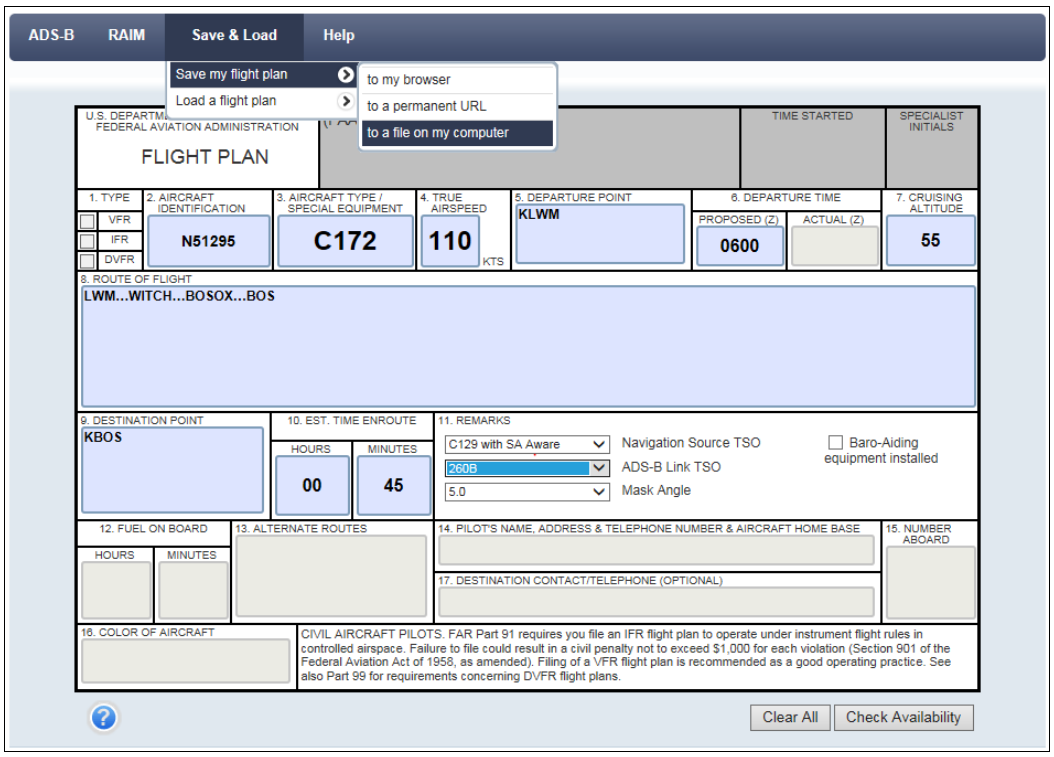


Figure 7-27: Flight Plan Form Saved to a File—Notification Message

- This action will open a new browser page, shown in Figure 7-27: Flight Plan Form Saved to a Computer File—File Download Box, with a pop-up message asking, "Do you want to open or save this file?"

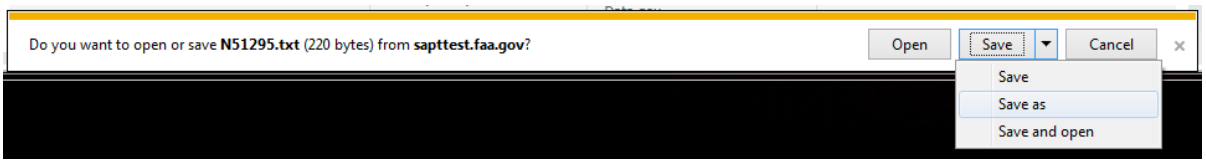


Figure 7-28: Flight Plan Form Saved to a Computer File—File Download Box

- When you click **SAVE**, the browser will either save the plan to the default download folder or open a Save As pop-up window that prompts you to pick a location and file name for the information, as displayed in Figure 7-29: Flight Plan Form Saved to a Computer File—Save As Box.

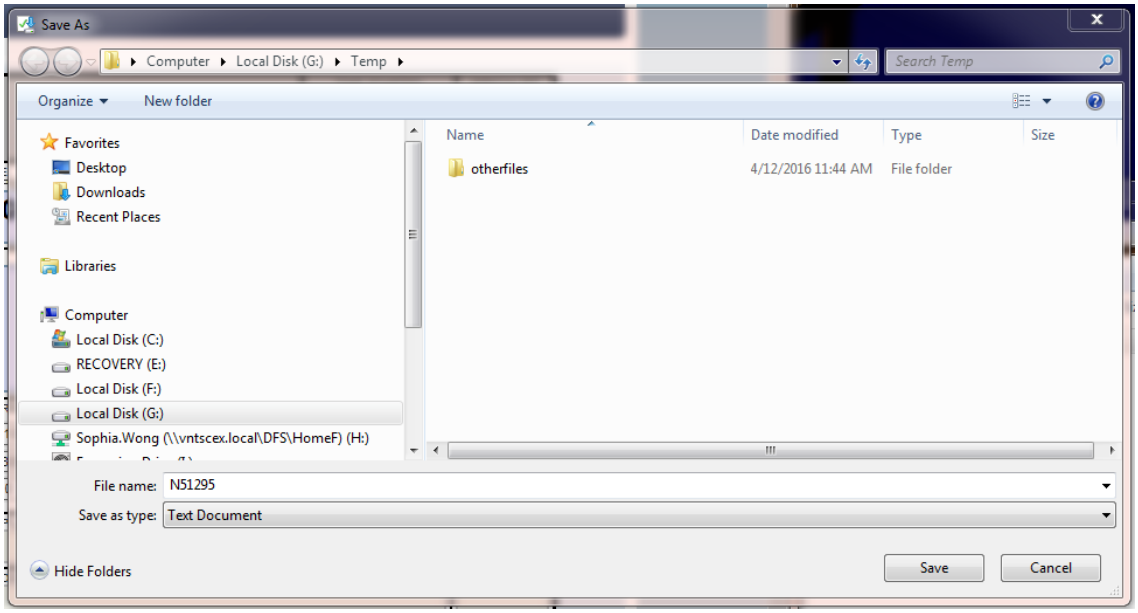


Figure 7-29: Flight Plan Form Saved to a Computer File—Save As Box

Enter that information and then click **SAVE**.

7.7.2 Loading Saved Data

You can load previously saved field information in three ways:

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

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 two other loading options, which are displayed in Figure 7-30: Flight Plan Form Loading Options, you must open the Flight Plan Form.

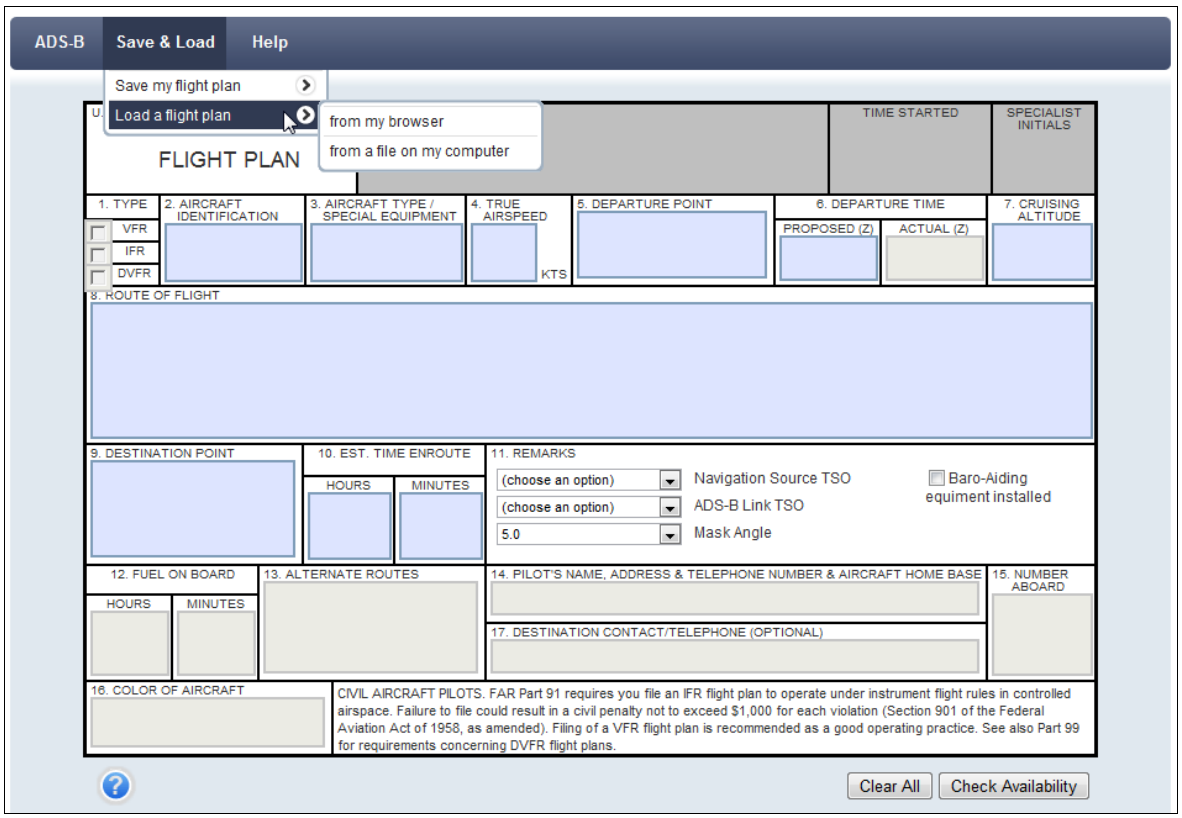


Figure 7-30: Flight Plan Form Loading Options

7.7.2.1 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 7-31: Flight Plan Form Loading Options--Browser below:

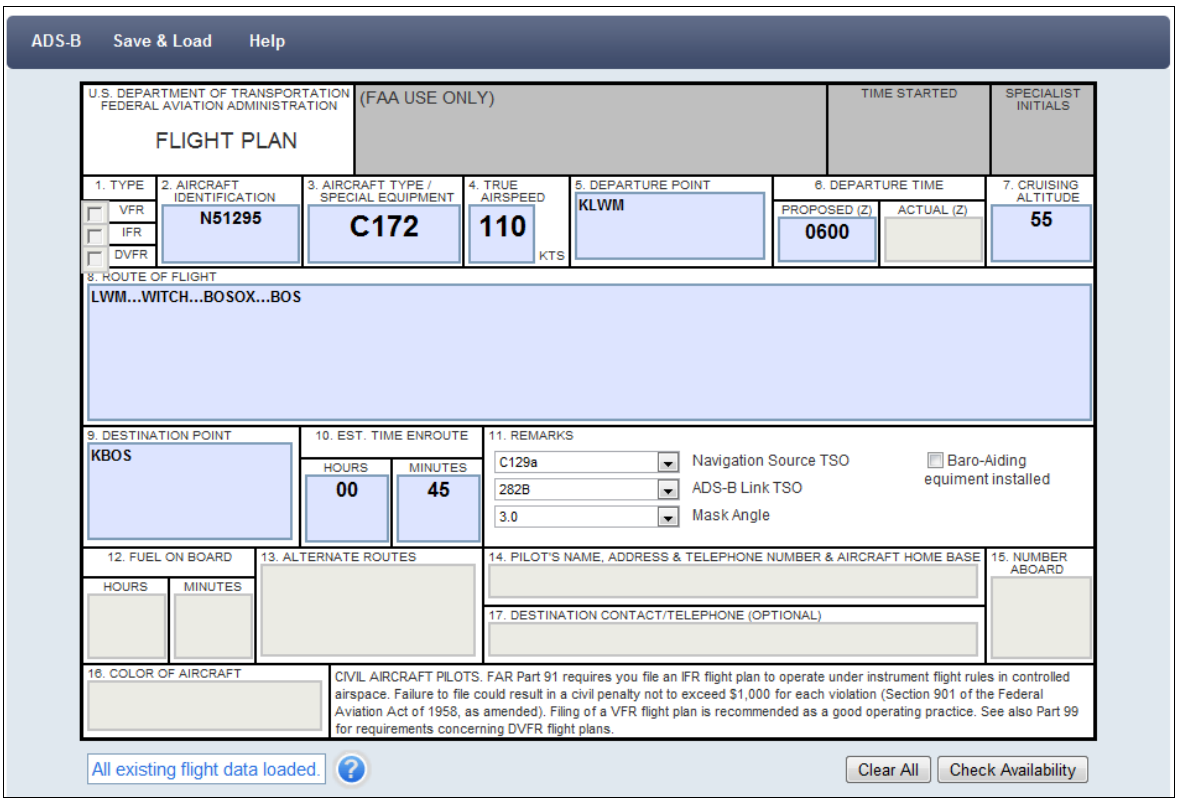


Figure 7-31: Flight Plan Form Loading Options--Browser

7.7.2.2 Load Data From File

Loading field information using the 'Load a flight plan' → '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 7-32: Flight Plan Form Loading Options—File:

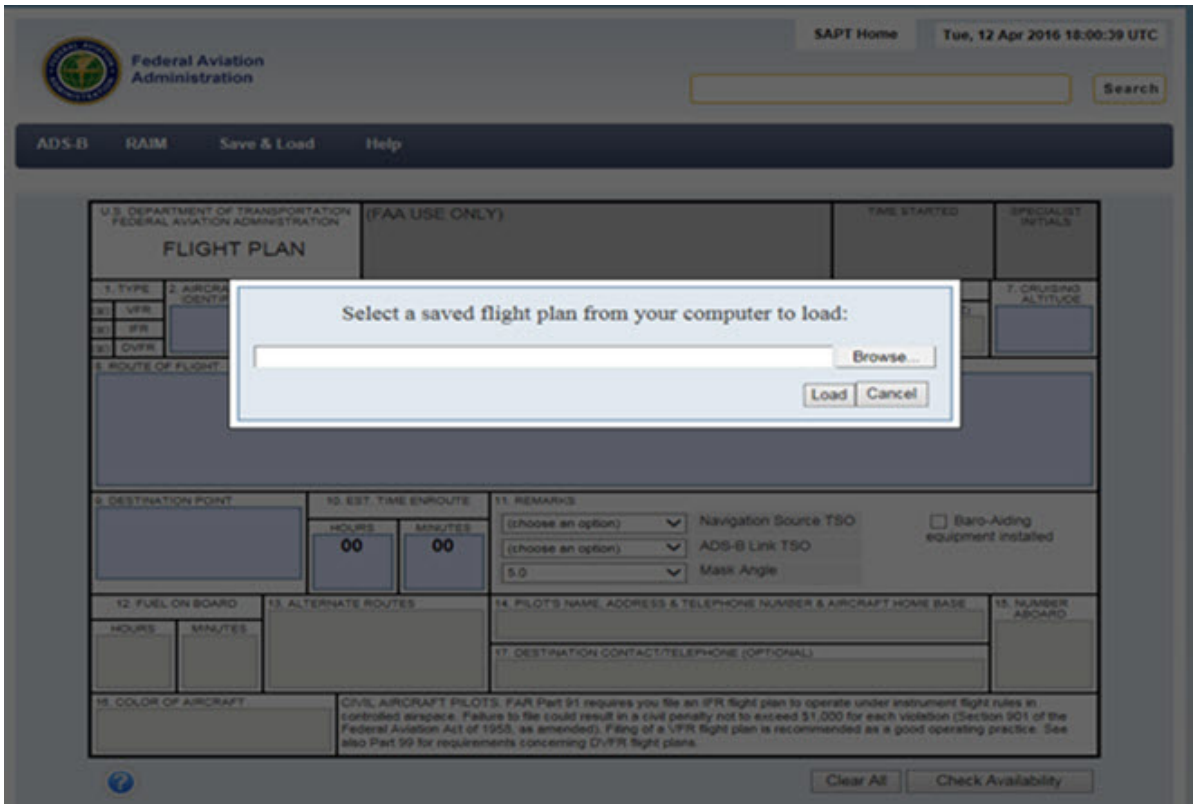


Figure 7-32: Flight Plan Form Loading Options—File

- When you click **BROWSE** the SAPT opens a pop-up box containing the "Choose File to Upload" prompt, as displayed in Figure 7-33: Flight Plan Form Loading a File—Choose a File to Upload:

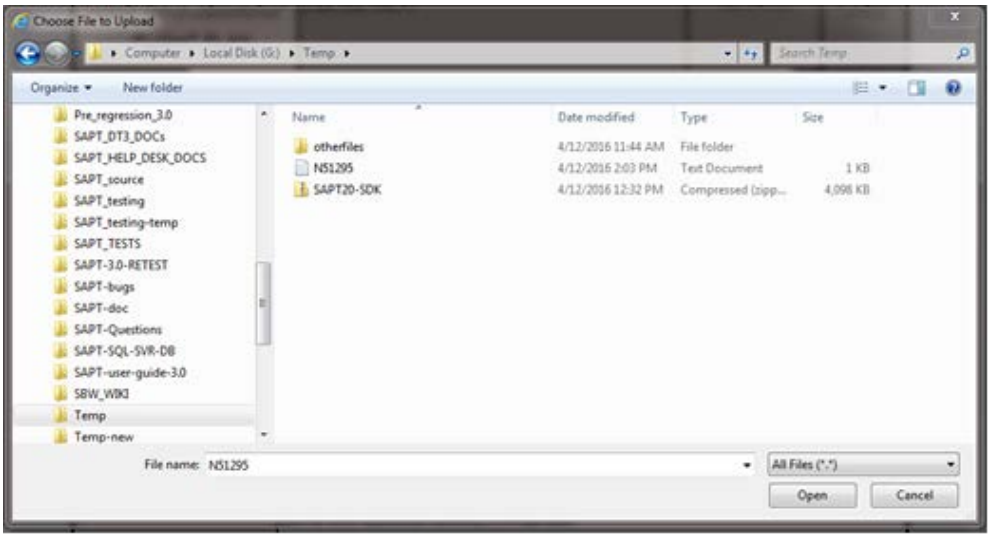


Figure 7-33: Flight Plan Form Loading a File—Choose a File to Upload

- 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.

7.8 PREDICTION OUTPUT

After you submit a prediction request via the flight plan form, the SAPT will issue a response outlined in red.

This result will be shown at the bottom of the form, as illustrated in Figure 7-34: Flight Plan Sufficiency Suggestion.

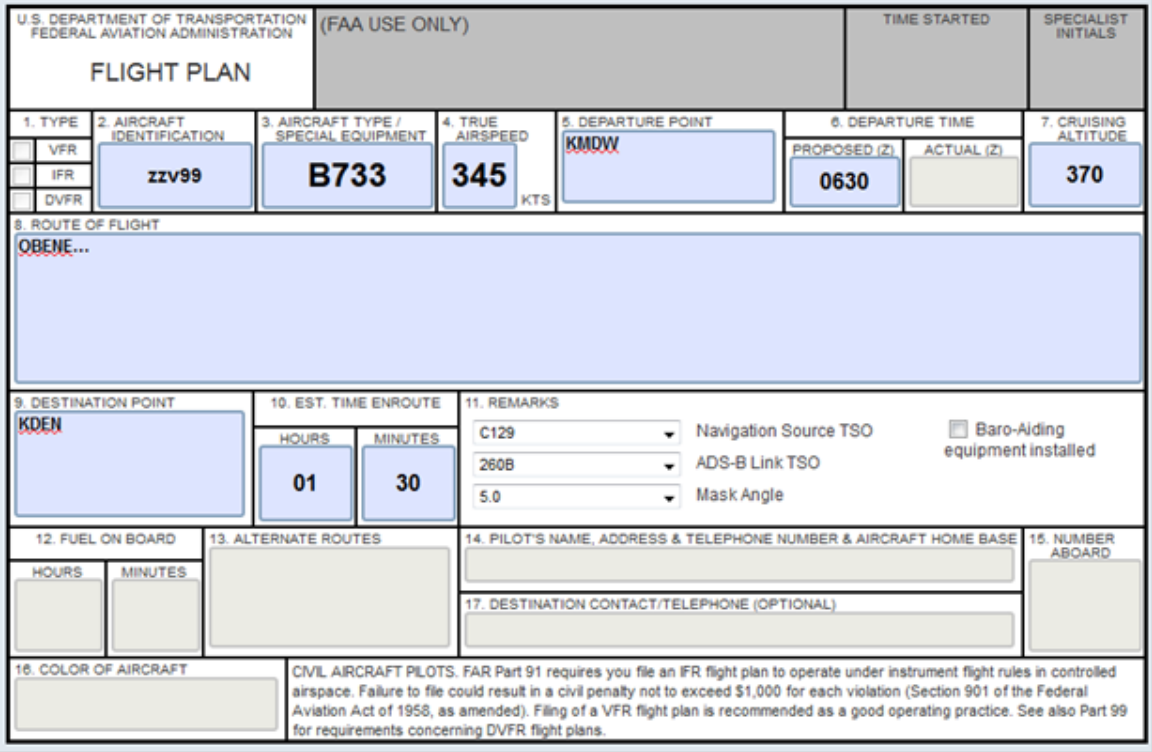


Figure 7-34: Flight Plan Prediction Request

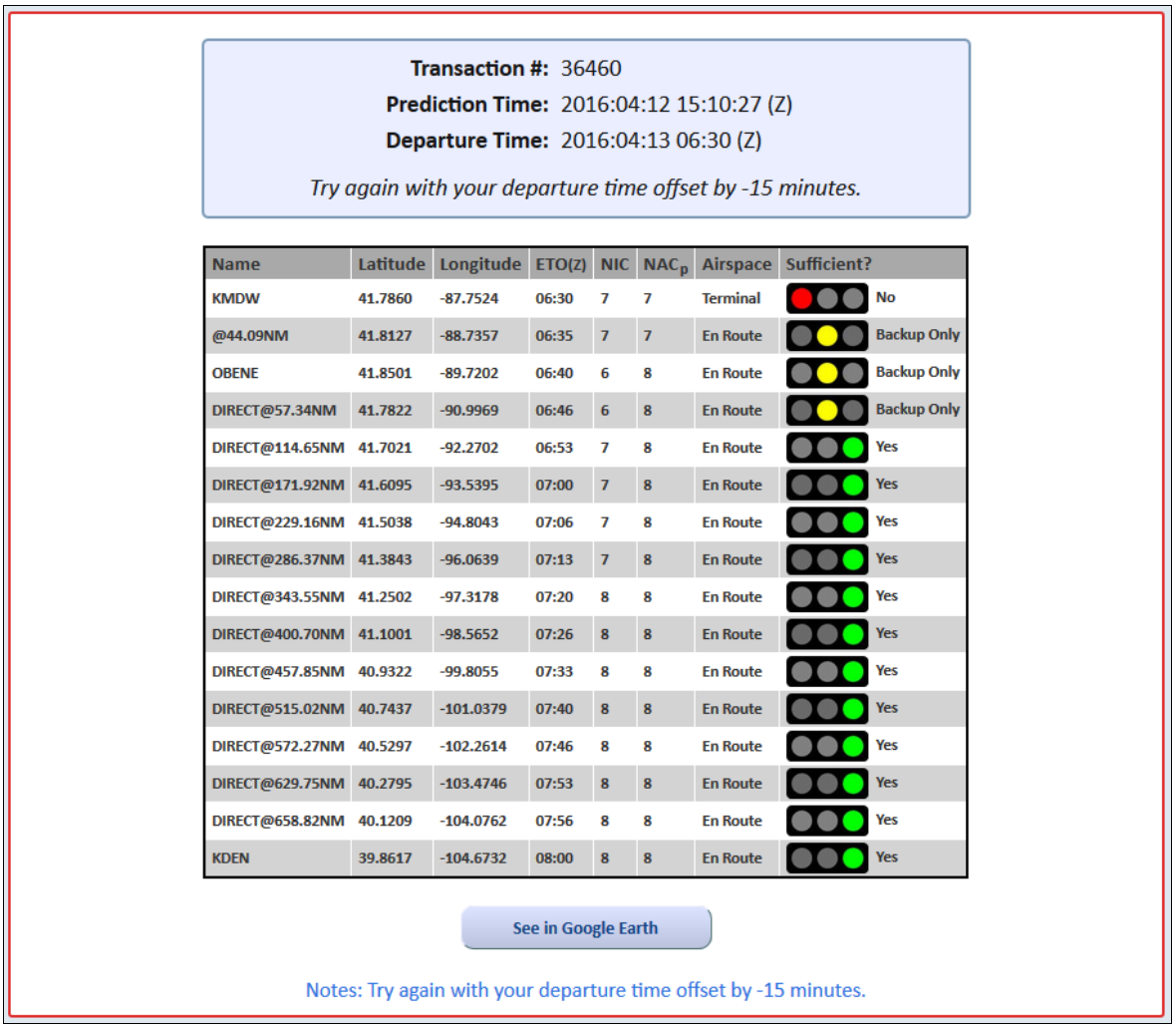
7.8.1 Flight Plan Results

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:

- 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.



Transaction #: 36460
Prediction Time: 2016:04:12 15:10:27 (Z)
Departure Time: 2016:04:13 06:30 (Z)

Try again with your departure time offset by -15 minutes.

Name	Latitude	Longitude	ETO(Z)	NIC	NAC_p	Airspace	Sufficient?
KMDW	41.7860	-87.7524	06:30	7	7	Terminal	No
@44.09NM	41.8127	-88.7357	06:35	7	7	En Route	Backup Only
OBENE	41.8501	-89.7202	06:40	6	8	En Route	Backup Only
DIRECT@57.34NM	41.7822	-90.9969	06:46	6	8	En Route	Backup Only
DIRECT@114.65NM	41.7021	-92.2702	06:53	7	8	En Route	Yes
DIRECT@171.92NM	41.6095	-93.5395	07:00	7	8	En Route	Yes
DIRECT@229.16NM	41.5038	-94.8043	07:06	7	8	En Route	Yes
DIRECT@286.37NM	41.3843	-96.0639	07:13	7	8	En Route	Yes
DIRECT@343.55NM	41.2502	-97.3178	07:20	8	8	En Route	Yes
DIRECT@400.70NM	41.1001	-98.5652	07:26	8	8	En Route	Yes
DIRECT@457.85NM	40.9322	-99.8055	07:33	8	8	En Route	Yes
DIRECT@515.02NM	40.7437	-101.0379	07:40	8	8	En Route	Yes
DIRECT@572.27NM	40.5297	-102.2614	07:46	8	8	En Route	Yes
DIRECT@629.75NM	40.2795	-103.4746	07:53	8	8	En Route	Yes
DIRECT@658.82NM	40.1209	-104.0762	07:56	8	8	En Route	Yes
KDEN	39.8617	-104.6732	08:00	8	8	En Route	Yes

See in Google Earth

Notes: Try again with your departure time offset by -15 minutes.

Figure 7-35: 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.

7.8.1.1 Sufficiency

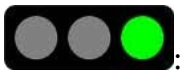
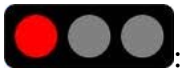
Under the Sufficient heading, a point will be considered sufficient if the NIC and NACp values are equal to, or higher than, the required values for that airspace, as defined in the ADS-B Final Rule.

In the Enhancement Release, the SAPT will use NIC7 and NACp8 as minimum values. If a point falls outside U.S.-controlled airspace, the SAPT will return "N/A".

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 do meet sufficiency rules. A sufficiency value of "N/A" can be treated as a "Yes," since that airspace falls outside U.S. 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 7-35 indicate sufficiency:

-  : ADS-B performance is sufficient at the waypoint. The flight may proceed, as per the rules.
-  : ADS-B performance is NOT sufficient at the waypoint but backup surveillance is predicted to be available. Operators holding Exemption 12555 may be approved to conduct the flight. Refer to the conditions of Exemption 12555.
-  : ADS-B performance is NOT sufficient at the waypoint and NO backup surveillance is predicted to be available. The flight may NOT proceed, unless an ATC deviation is authorized (Refer to 14 CFR 91.225).
-  : 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.

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

7.8.1.1.1 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, specified in 14 CFR §§91.225 and 91.227, the Grant of Exemption 12555 and 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/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 SAPT will grant a deviation without ATC intervention
- 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 ANY point in the route of flight does not meet the ADS-B Rule performance requirements but does indicate the existence of backup 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 below outlines the expected SAPT response for the conditions specified above.

Table 7-2: Interpreting Results for SAPT Pre-flight Availability Predictions

Equipment	2020-2024								After 2024
	Exemption 12555				No Exemption 12555				Exemption Expires
SA ON (ISO-C129)	Prediction required? **YES**				**YES**				**YES**
	SAPT will determine backup surveillance & convey ATC authorization	**Condition**	**XML**	**Web Form: "Traffic Light"**	Operator must contact ATC to obtain authorization if they don't meet the rule	**Condition**	**XML**	**Web Form: "Traffic Light"**	Operator must contact ATC to obtain authorization. **Same "Conditions" appply as do for "No Exemption 12555"**
		No Action	isSufficientForAdsb – unspecified backupCoverage = unspecified	Traffic light: gray Text: "N/A"		No Action	isSufficientForAdsb – unspecified backupCoverage = unspecified	Traffic light: gray Text: "N/A"	
		Meets Rule	isSufficientForAdsb = true backupCoverage – unspecified	Traffic light: green Text: "Yes"		Meets Rule	isSufficientForAdsb = true backupCoverage – unspecified	Traffic light: green Text: "Yes"	
		Authorized Deviation from SAPT	isSufficientForAdsb – false backupCoverage = true	Traffic light: yellow Text: "Backup Only"		Fails*, No Authorized Deviation from SAPT	isSufficientForAdsb – false backupCoverage = true	Traffic light: yellow Text: "Backup Only"	
		Fails*, No Authorized Deviation from SAPT	isSufficientForAdsb = false backupCoverage – false	Traffic light: red Text: "No"		Fails*, No Authorized Deviation from SAPT	isSufficientForAdsb = false backupCoverage – false	Traffic light: red Text: "No"	
SA AWARE (ISO-C129 or C196)	Prediction required? **NO**				**YES**				**YES**
	Exemption authorizes flight without the need for Preflight Prediction				Operator must contact ATC to obtain authorization. **Same "Conditions" appply as do for "No Exemption 12555" under SA ON.**				Operator must contact ATC to obtain authorization. **Same "Conditions" apply as do for "No Exemption 12555" under SA ON**
SBAS (TSO-C145 or 146)	Prediction required? **NO**				**NO**				**NO**
	No Preflight Availability Prediction Required				No Preflight Availability Prediction Required				No Preflight Availability Prediction Required
*NOTE: These XML values are returned for each waypoint. A Fail at any waypoint fails the route.									

7.8.1.1.2 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.

7.8.1.1.3 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: Please refer to AC 90-114A CHG1 in order to determine the required timeframe to submit a transaction and obtain an authorized deviation.

7.8.1.2 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 7-35: Sufficiency Suggestion.

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)

When the SAPT returns a suggested time, please keep in mind that that 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.

7.8.1.3 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.

7.8.2 Graphical Display

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

- Large area display
- Route-specific display

Both displays use the Google Earth™ plug-in. If the Google Earth™ plug-in[4] has not been installed on your computer, you will be prompted to download and install it the first time you access the large area or route-specific display. If you cannot, or do not want, to install Google Earth™, you may still download the keyhole markup language (KML) by pressing **DOWNLOAD KML**.

Although iOS and Android are not officially supported, early testing indicates that they may 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 KML file.

7.8.2.1 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 7-36: Large Area Graphical Display, includes six configurations:

[4] Unfortunately, the Google Earth™ plug-in has been deprecated. We will find a replacement as soon as possible. Meanwhile, users who still have Google Earth™ can follow these instructions. Users can also generate and download a KML file of the outages and load that file into the full Google Earth™ application.

- 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.

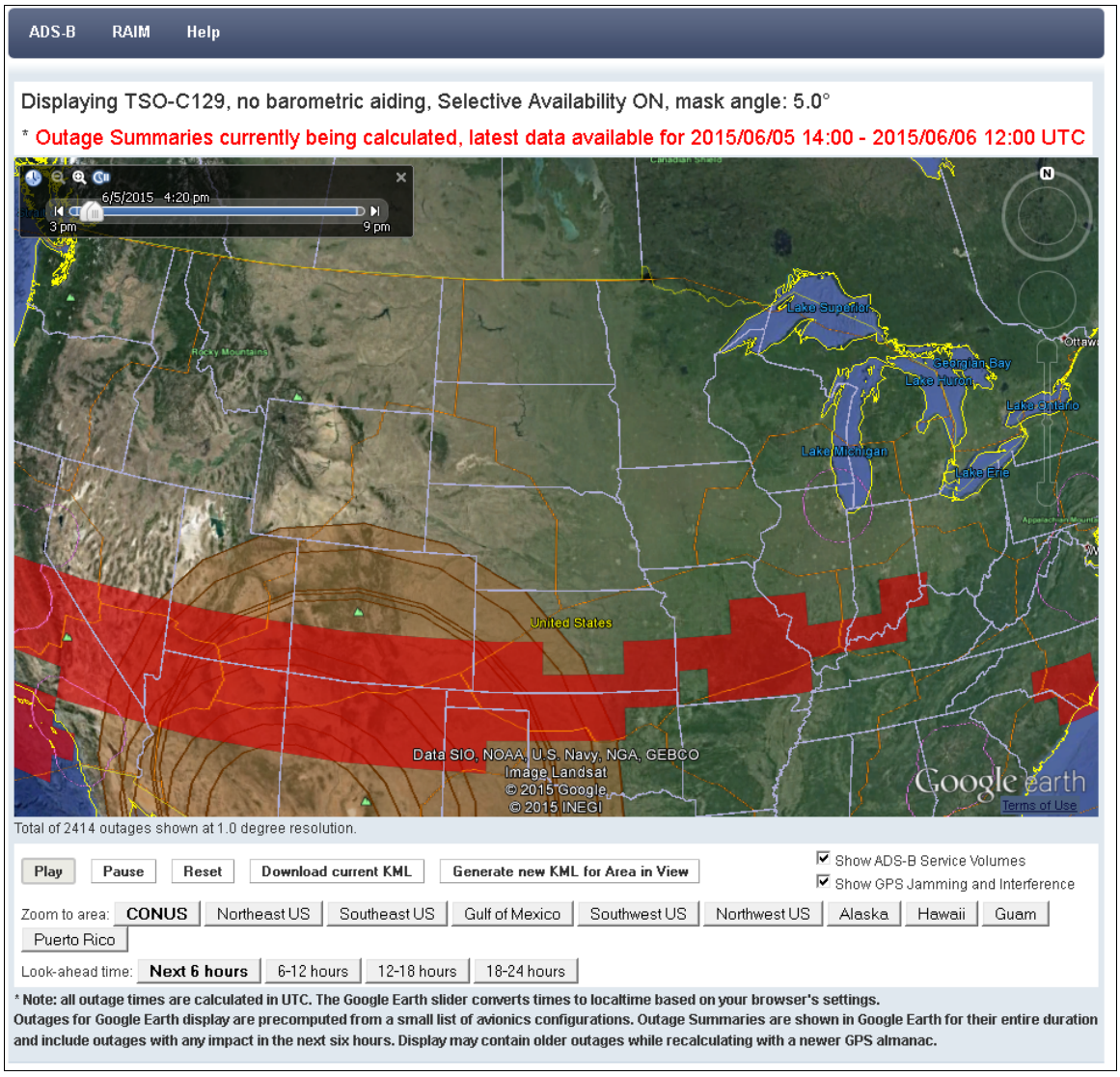


Figure 7-36: Large Area Graphical Display

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". Follow these steps:

- Step 1. Select either TSO-C129 or TSO-C196 from the TSO drop-down box.
- Step 2. Select either a mask angle of 2.0 or 5.0 from the Mask angle drop-down box.
- Step 3. Click the "Click to View" link in the Outages column to open a Google Earth™ outage display, as in the example shown above.

The display identifies all of the outages under the selected configuration. In Figure 7-36: Large Area Graphical Display, 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, above **PLAY**, 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 7-36: Large Area Graphical Display is "Total of 2414 outages shown at 1.0 degree resolution."

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 Google Earth™ features to navigate to a custom region and display outages at a higher resolution. 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 pink (terminal).
A "Show ADS-B" box in the lower right corner allows you to display or hide the ADS-B Service Volume outlines.
Check the "Show GPS Jamming and Interference" box 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 Google Earth™ time slider at the top left corner. Due to a limitation in the Google Earth™ application programming interface (API), the time slider is in your local time zone as set by your system. 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. The purple circle labeled "1" in Figure 7-36: Large Area Graphical Display identifies the starting time slider and purple circle "2" indicates the ending time slider. The starting time slider may be moved to the left away from the ending time slider or to the right toward the ending time slider to create an outage window.
  Any outages that are active within the time between the two sliders will be shown. Overlapping outages may be created at a location by moving the sliders; the effect of such overlaps is the presence of a higher-intensity red cell on the display.
  You can click the outages to display the latitude and longitude of the outage and its starting and ending times.
- Buttons labeled **PLAY**, **PAUSE**, and **RESET** are set at the lower left corner beneath the map. Click **PLAY** to move the time slider to the right; subsequent clicks increase the playback rate.
  A limitation in the Google Earth™ API prevents the slider from automatically stopping when it hits the end of the slide bar.
  Click **PAUSE** to stop the time slider at its current position. Click **RESET** to reset the

slider to its original position.

- 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.
- Buttons labeled **CONUS, NORTHEAST US, SOUTHEAST US, GULF OF MEXICO, SOUTHWEST US, NORTHWEST US, ALASKA, HAWAII, GUAM AND PUERTO RICO** are set before the Look-ahead time allows user to select a region. When you select a region, you must wait for the outages to be retrieved and displayed again. In Figure 7-37: Northeast Region – Illustrated Selection, outages are not searched for Ottawa or other parts of southern Canada even though they are included in the highlighted region. Need to change (Zoom to area:)

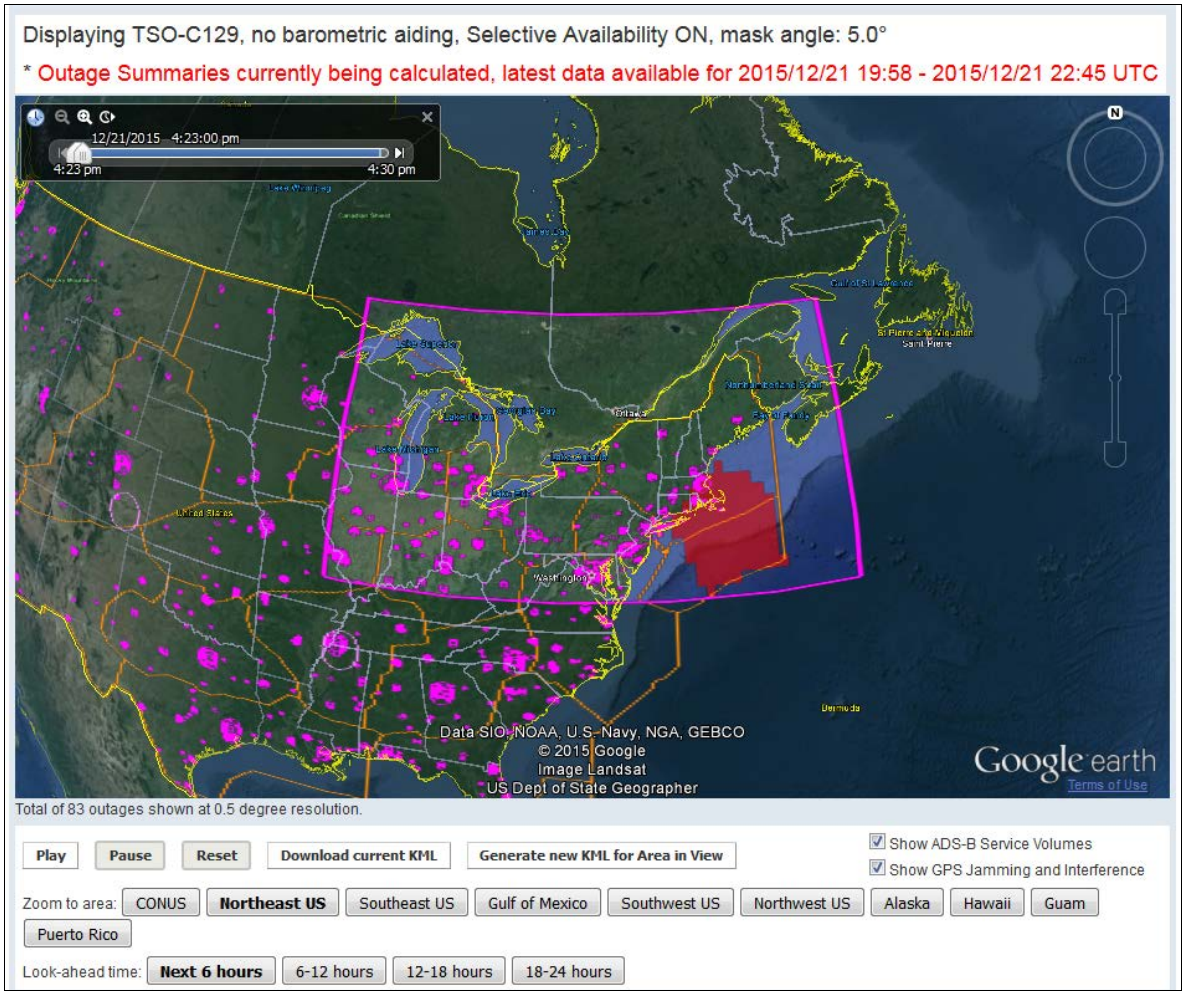


Figure 7-37: Northeast Region – Illustrated Selection

- 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 file in the browser, it should be displayed in the Google Earth™ plug-in application.

7.8.2.2 Route-Specific Display

The route-specific display provides the submitted route-of-flight superimposed on a map in Google Earth™. Outages will be displayed along the route-of-flight when predicted to be present at the indicated ETO.

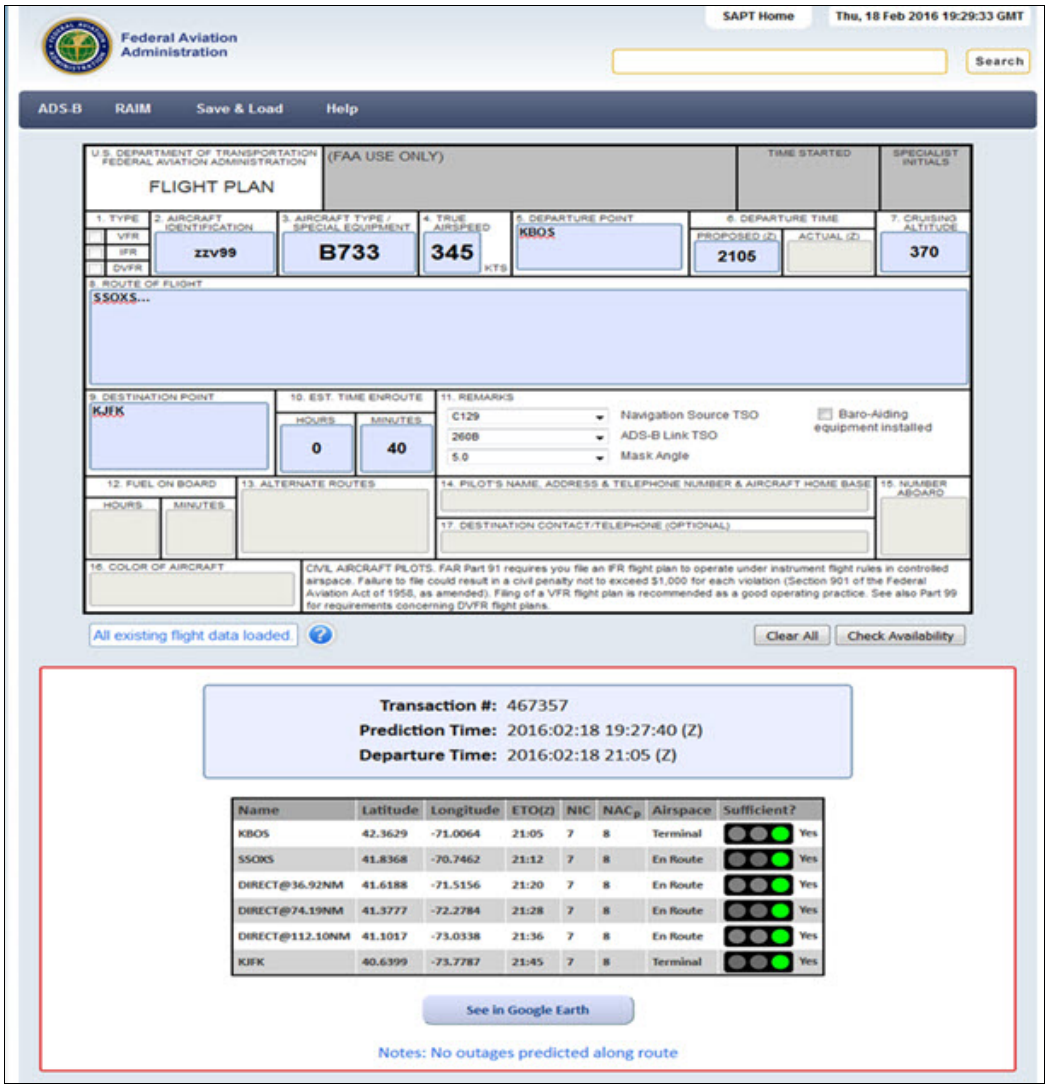


Figure 7-38: Create Route-Specific Flight Plan Form

When you click **SEE IN GOOGLE EARTH** in the response on the Flight Plan Form, the route of flight will be superimposed on the Google Earth™ map above the list of route-points with Name, Latitude, Longitude, ETO, NIC, NACp and Sufficiency.

Figure 7-38: Route-Specific Graphical Display

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 Google Earth™ 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) every five minutes and compares the NIC and NACp that are generated to the threshold for the given airspace. If the predicted NIC or NACp is insufficient for the airspace, the time is marked as an outage.

These differences occasionally lead to instances in which the grid display and the route-of-flight prediction disagree, typically near the beginning or end of an outage. Figure 7-38: Route-Specific Graphical Display shows an example of a route-specific display:

7.9 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 7-39: Print a Prediction. When you click the icon the form should resemble the example shown in Figure 7-40: Sample Printed Prediction.

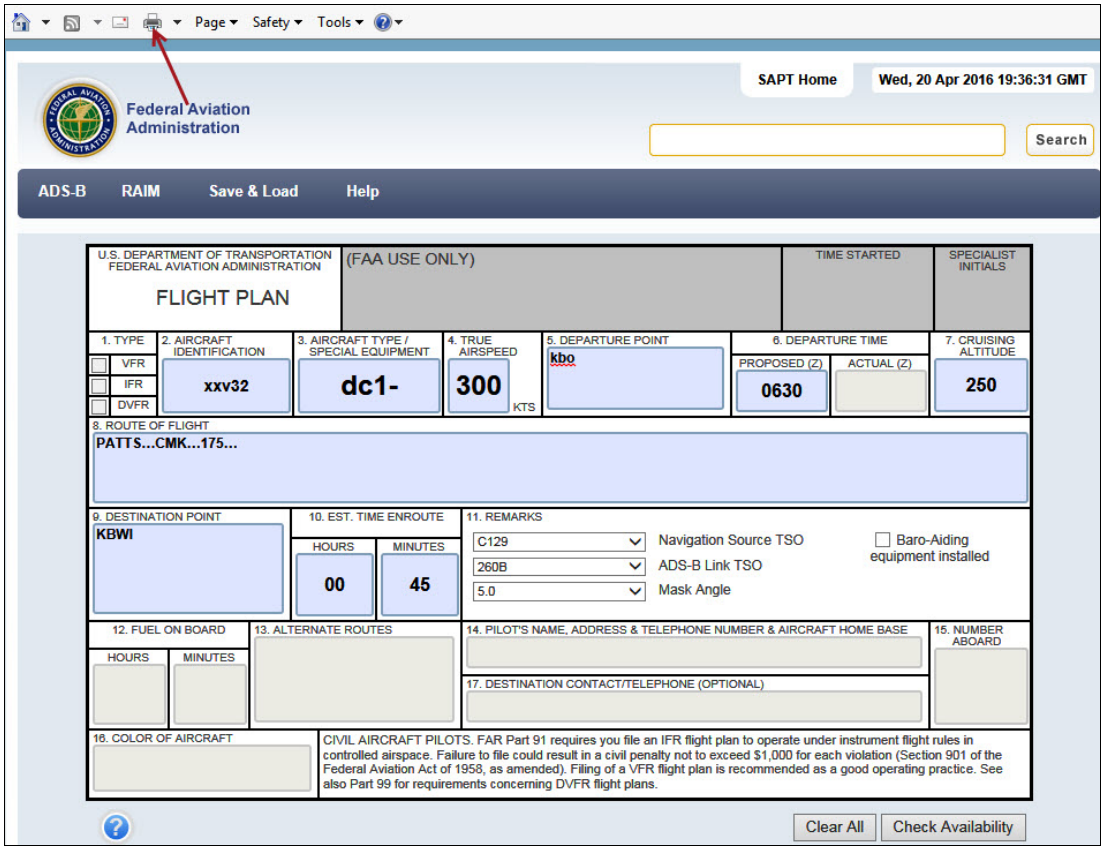
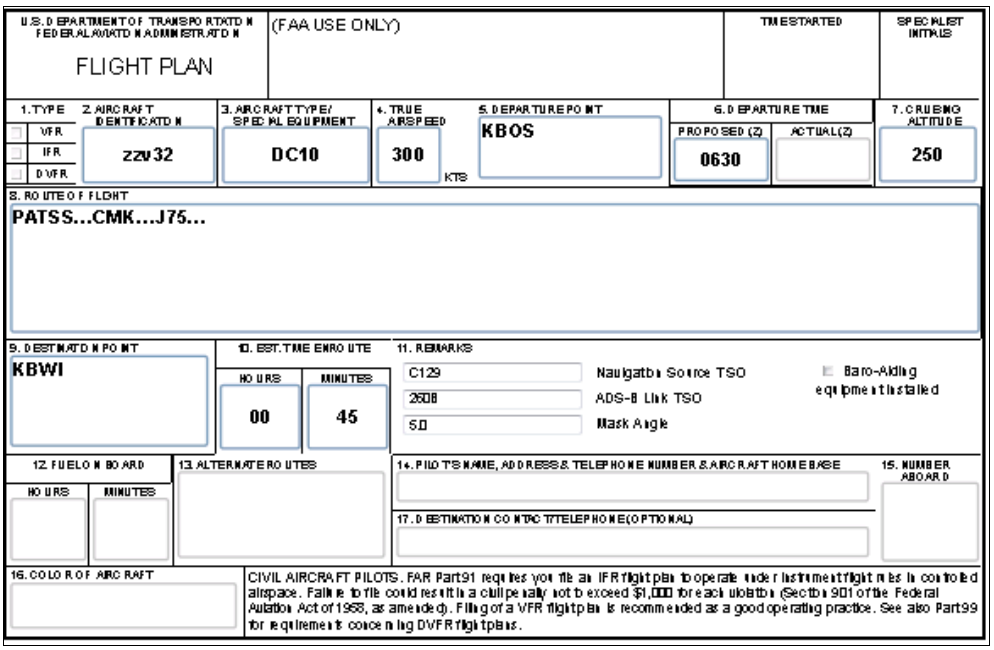


Figure 7-39: Print a Prediction Menu

A sample printed prediction is shown in the following illustration:



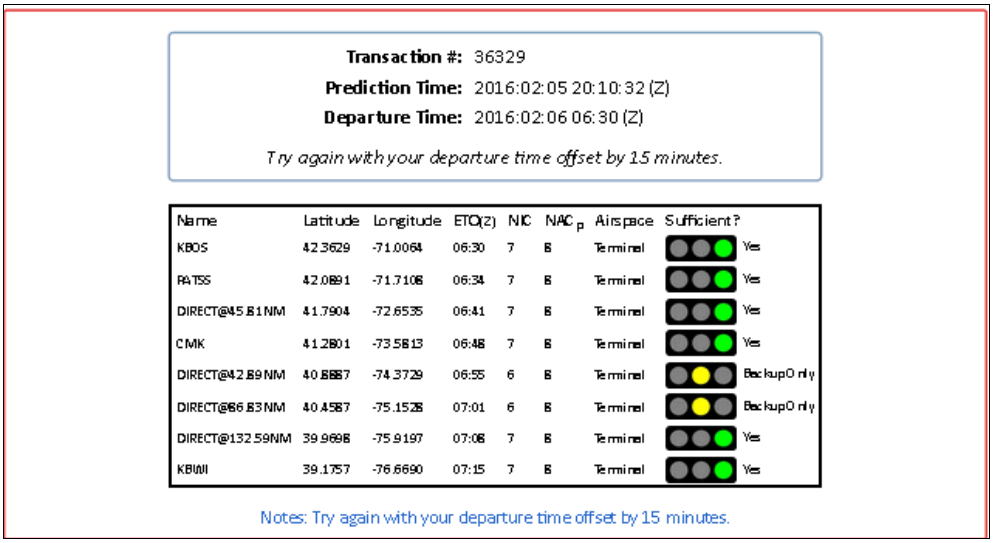


Figure 7-40: Sample Printed Prediction

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 section 8.1 WSDL to request a copy of the

SAPT WSDL and SDK. Most integrated development environments (IDEs) 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-2.1'. It updates the interface for ADS-B with some new features and also integrates the RAIM Prediction service.

You may request the 'SAPT20-SDK' WSDL through the RAIM and 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, shown here:

Figure 8-1: WSDL Request Link

When you click **DOWNLOAD** the application generates a pop-up dialog:

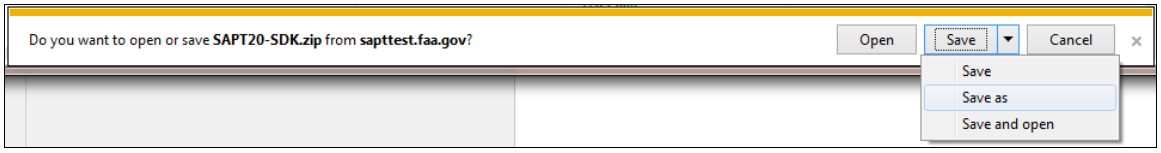


Figure 8-2: Download the SAPT SDK Pop-up

Click **SAVE AS** to choose the location where you want to save it on your computer:

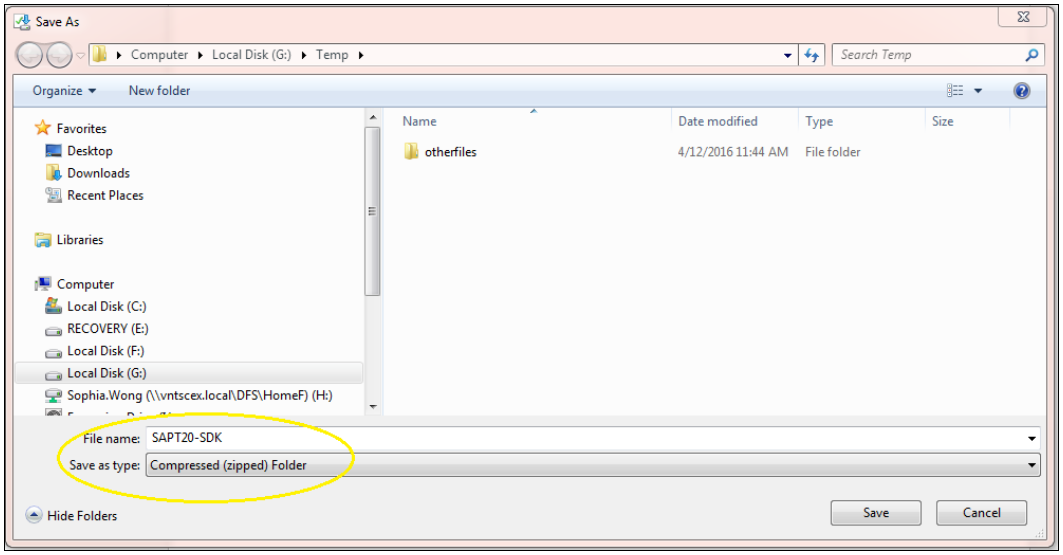


Figure 8-3: Save the SAPT SDK

Click **OPEN** to save the file to the temporary internet files folder on your computer:

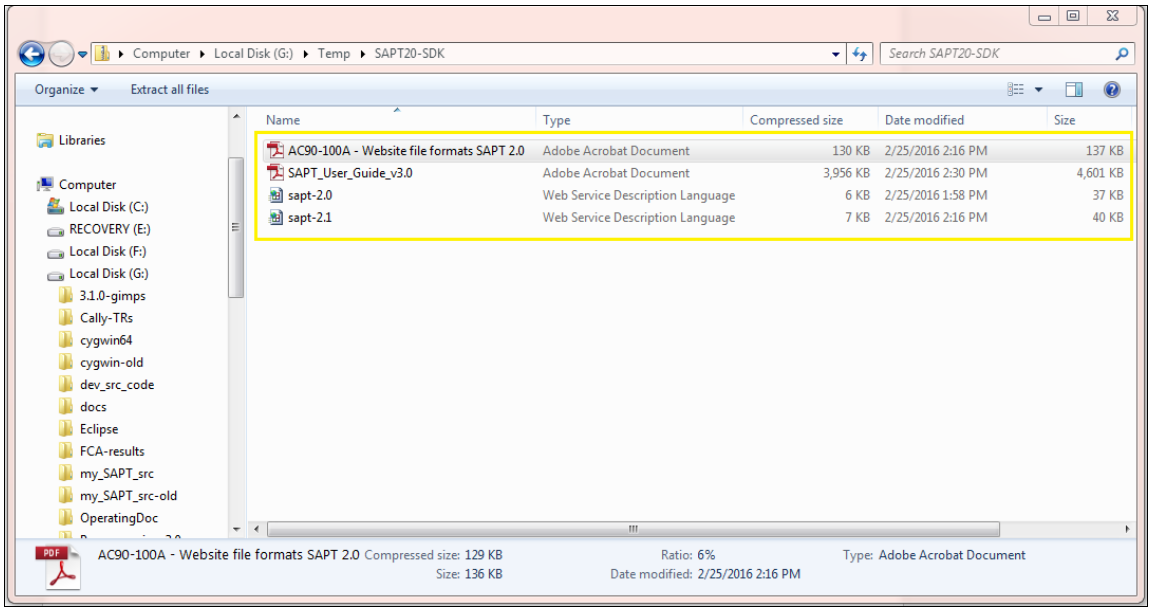


Figure 8-4: Open the SAPT SDK

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

Figure 8-5 is a Unified Modeling Language (UML) diagram of the various information classes and types employed by the web service.

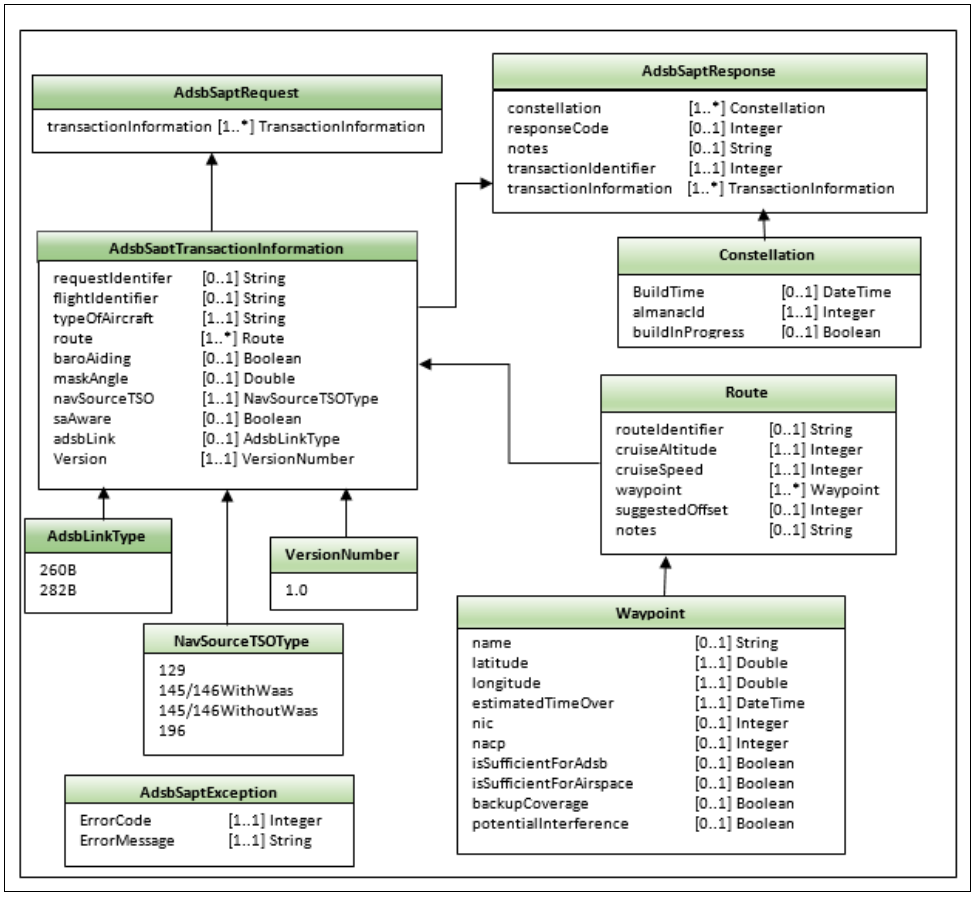


Figure 8-5: XML Web Service—Classes and Types

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 sample AdsbSaptRequest (refer to Table 8-8) contains only what is in AdsbSaptTransactionInformation, while the sample AdsbSaptResonse, shown in Table 8-9, contains more fields.

Table 8-5 and Table 8-6 provide more details about the Route, Waypoint, and Table 8-7 AdsbSaptException information classes used by the XML web service.

Table 8-1: ADSB Sufficiency for Route Request

Field Name	Type	Required?	Definition
Transaction Information	Transaction Information	Yes	The requested transaction information. See Table 8-3

Table 8-2: ADSB Sufficiency for Route Response

Field Name	Type	Required?	Definition
constellation	Constellation	No, Response Only	Constellation build information. See Table 8-4
responseCode	Integer	No, Response Only	0 If the request was successfully processed, a negative number otherwise.
Notes	String	No, Response Only	An explanation for a failed request and/or information about upcoming system outages/changes.
TransactionIdentifier	Integer	No, Response Only	The transaction number assigned to the request by the system.
Transaction Information	Transaction Information	No, Response	The requested transaction information. See Table 8-3

Table 8-3: ADS-B SAPT Transaction Information

Field Name	Type	Required?	Definition
requestIdentifier	String	No	Optional string to identify a user's request.
flightIdentifier	String	No	Optional string to identify the flight to which the request pertains (either tail number or flight ID).
typeOfAircraft	String	Yes	The ICAO identifier of the aircraft.
route	Route	Yes	One or more routes on which to perform the prediction. See Table 8-5
baroAiding	Boolean	No	True if the aircraft is equipped with a GPS-based navigation source that utilizes barometric aiding. False otherwise. Default is False.
maskAngle	Double	No	The mask angle (in degrees) utilized by the GPS-based navigation source. Default is 5.0 (degrees).
navSourceTSO	NavSourceTSO Type	Yes	The TSO number for the navigation source.
adsbLink	AdsbLinkType	No	The TSO number for the aircraft's ADS-B transponder.
saAware	Boolean	No	True if the aircraft is equipped with a TSO-C129 with no saAware navigation source. False with saAware. *Note: This field is ignored for any NavSourceTSOType other than "129."*
enableWAAS	Boolean	No	A true or false value specifying whether "WAAS" is supported by the avionics
enableFDE	Boolean	No	A true or false value specifying whether "FDE" is supported by the avionics

Table 8-4: Constellation Information

Field Name	Type	Required?	Definition
buildTime	DateTime	No, Response Only	The time that the constellation is being built
almanacId	Integer	No, Response Only	To identify the GPS almanac that was used in the constellation build.
buildInProgress	Boolean	No, Response Only	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.

Table 8-5: Route Information

Field Name	Type	Required?	Definition
routeIdentifier	String	No	Optional for the waypoint.
cruiseAltitude	Integer	Yes	Aircraft Cruising Altitude specified in ft
cruiseSpeed	Double	No	Aircraft Cruising Speed specified in knots
waypoint	Waypoint information	Yes	Waypoint information See Table 8-6
suggestedOffset	Integer	No, Response Only	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).
notes	String	No, Response Only	Returned note on the route

Table 8-6: Waypoint Information

Field Name	Type	Required?	Definition
name	String	No	An optional name for the waypoint.
latitude	Double	Yes	The latitude of the waypoint in decimal degrees.
longitude	Double	Yes	The longitude of the waypoint in decimal degrees.
estimatedTimeOver	DateTime	Yes	The anticipated time the aircraft is expected to arrive at the waypoint.
nic	Integer	No, response	The NIC as predicted by the system. Anything provided by the user is overwritten

Field Name	Type	Required?	Definition
		only	by the system.
nacp	Integer	No, response only	The NACp as predicted by the system. *Note: Anything provided by the user is overwritten by the system.*
isSufficientForAdsb	Tribool	No, response only	Returns "true" if the waypoint has met either the ADS-B Final Rule (NIC >= 7 and NACp >= 8) or a custom airspace with a performance requirement that is *higher* than the ADS-B Final Rule. Returns "false" if the waypoint failed to meet the ADS-B Final Rule or a custom airspace with a *higher* performance requirement (note that such custom airspace takes precedent over the ADS-B Final Rule and is treated as the minimal requirement).If the waypoint fails to meet the ADS-B Final Rule but does meet a custom airspace with a performance requirement that is *lower* than the ADS-B Final Rule, this field returns "false" and the "isSufficientForAirspace" field returns "true". Returns "unspecified" for waypoints that are outside of US airspace.
isSufficientForAirspace	Tribool	No, response only	Returns "true" if the waypoint has met the performance requirement for the airspace that the waypoint falls within. Returns "false" if the waypoint failed to meet the airspace requirement. Returns "unspecified" for waypoints that are outside of US airspace.
backupCoverage	Tribool	No, response only	Returns a value indicating if the waypoint is predicted to have backup coverage (SSR,WAM). *Note that backup coverage is indicated only if the waypoint fails to meet any NIC/NACp requirement associated with it and the waypoint is in US Airspace. The value "unspecified" is returned in all other cases.*
potentialInterference	Tribool	No, response only	Returns "true" if the waypoint is predicted to be subject to potential GPS Jamming or Interference and "false" if not. Returns "unspecified" for waypoints that are outside of US airspace.

Table 8-7: ADS-B SAPT Exception

Field Name	Type	Definition
ErrorCode	Integer	This number should be included when requesting help.
ErrorMessage	String	A description of the error.

8.3 REQUEST AND RESPONSE EXAMPLE

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

Table 8-8: Sample ADS-B SAPT Request

```
<?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>REQTODO1</requestIdentifier>
              <flightIdentifier>ZZVTSTFLT1</flightIdentifier>
              <typeOfAircraft>DC10</typeOfAircraft>
              <baroAiding>false</baroAiding>
              <maskAngle>2.5</maskAngle>
              <navSourceTso>129</navSourceTso>
              <saAware>false</saAware>
              <adsbLink>260B</adsbLink>
              <route>
              <routeIdentifier>TSTRT1</routeIdentifier>
                     <cruiseAltitude>35000</cruiseAltitude>
                     <cruiseSpeed>450</cruiseSpeed>
                     <suggestedOffset>0</suggestedOffset>
                     <notes/>
                     <waypoint>
                            <name>KLWM</name>
                            <latitude>42.71719</latitude>
                            <longitude>-71.12341</longitude>
                            <estimatedTimeOver>2015-12-
23T02:59:19.112Z</estimatedTimeOver>
                     </waypoint>
                     <waypoint>
                            <name>COTEE</name>
                            <latitude>42.49506</latitude>
                            <longitude>-71.11886</longitude>
                            <estimatedTimeOver>2015-12-
23T03:06:19.112Z</estimatedTimeOver>
                     </waypoint>
                     <waypoint>
                            <name>SOSYO</name>
                            <latitude>42.48734</latitude>
                            <longitude>-71.43215</longitude>
                            <estimatedTimeOver>2015-12-
23T03:17:19.112Z</estimatedTimeOver>
                     </waypoint>
                     <waypoint>
                            <name>BOSOX</name>
                            <latitude>42.20188</latitude>
                            <longitude>-71.62767</longitude>
                            <estimatedTimeOver>2015-12-
23T03:24:19.112Z</estimatedTimeOver>
                     </waypoint>
```

```
                    <waypoint>
                           <name>GRIPE</name>
                           <latitude>42.13579</latitude>
                           <longitude>-71.90901</longitude>
                           <estimatedTimeOver>2015-12-
23T03:32:19.112Z</estimatedTimeOver>
                    </waypoint>
                    <waypoint>
                           <name>GRAYM</name>
                           <latitude>42.10118</latitude>
                           <longitude>-72.03152</longitude>
                           <estimatedTimeOver>2015-12-
23T03:37:19.112Z</estimatedTimeOver>
                    </waypoint>
                    <waypoint>
                           <name>WITNY</name>
                           <latitude>42.04939</latitude>
                           <longitude>-72.23665</longitude>
                           <estimatedTimeOver>2015-12-
23T03:42:19.112Z</estimatedTimeOver>
                    </waypoint>
                    <waypoint>
                           <name>BDL</name>
                           <latitude>41.94101</latitude>
                           <longitude>-72.68857</longitude>
                           <estimatedTimeOver>2015-12-
23T03:47:19.112Z</estimatedTimeOver>
                    </waypoint>
                    <waypoint>
                           <name>BRISS</name>
                           <latitude>41.70129</latitude>
                           <longitude>-73.01558</longitude>
                           <estimatedTimeOver>2015-12-
23T03:51:19.112Z</estimatedTimeOver>
                    </waypoint>
                    <waypoint>
                           <name>K4B8</name>
                           <latitude>41.69037</latitude>
                           <longitude>-72.86482</longitude>
                           <estimatedTimeOver>2015-12-
23T04:26:19.112Z</estimatedTimeOver>
                    </waypoint>
             </route>
      </getAdsbSufficiencyForRoute>
      </soapenv:Body>
</soapenv:Envelope>
```

Table 8-9: Sample ADS-B SAPT Response

```
<?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>
<AdsbSufficiencyForRoute_Response xmlns="">
```

```
<requestIdentifier>REQTODO1</requestIdentifier>
        <constellation>
                <BuildTime>2015-12-22T06:35:00.724Z</buildTime>
                <almanacId>1450771164150      </almanacId>
                <buildInProgress>false</buildInProgress>
        </constellation>
        <flightIdentifier>ZZVTSTFLT1</flightIdentifier>
        <typeOfAircraft>DC10</typeOfAircraft>
        <navSourceTso>129</navSourceTso>
        <adsbLink>260B</adsbLink>
        <maskAngle>2.5</maskAngle>
        <baroAiding>false</baroAiding>
        <saAware>false</saAware>
        <route>
                <routeIdentifier>TSTRT1</routeIdentifier>
                <cruiseAltitude>35000</cruiseAltitude>
                <cruiseSpeed>450.0</cruiseSpeed>
                <waypoint>
                        <name>KLWM</name>
                        <latitude>42.71719</latitude>
                        <longitude>-71.12341</longitude>
                        <estimatedTimeOver>2015-12-23T02:59:19.112Z</estimatedTimeOver>
                        <nic>7</nic>
                        <nacp>8</nacp>
                        <isSufficientForAdsb>true</isSufficientForAdsb>
                        <isSufficientForAirspace>true</isSufficientForAirspace>
                        <backupCoverage>false</backupCoverage>
                        <potentialInterference>false</potentialInterference>
                </waypoint>
                <waypoint>
                        <name>COTEE</name>
                        <latitude>42.49506</latitude>
                        <longitude>-71.11886</longitude>
                        <estimatedTimeOver>2015-12-23T03:06:19.112Z</estimatedTimeOver>
                        <nic>7</nic>
                        <nacp>8</nacp>
                        <isSufficientForAdsb>true</isSufficientForAdsb>
                        <isSufficientForAirspace>true</isSufficientForAirspace>
                        <backupCoverage>false</backupCoverage>
                        <potentialInterference>false</potentialInterference>
                </waypoint>
                <waypoint>
                        <name>DIRECT@6.95NM</name>
                        <latitude>42.49228473180492</latitude>
                        <longitude>-71.27551712206126</longitude>
                        <estimatedTimeOver>2015-12-23T03:11:49.112Z</estimatedTimeOver>
                        <nic>7</nic>
                        <nacp>8</nacp>
                        <isSufficientForAdsb>true</isSufficientForAdsb>
                        <isSufficientForAirspace>true</isSufficientForAirspace>
                        <backupCoverage>false</backupCoverage>
                        <potentialInterference>false</potentialInterference>
                </waypoint>
                <waypoint>
                        <name>SOSYO</name>
```

```
            <latitude>42.48734</latitude>
            <longitude>-71.43215</longitude>
            <estimatedTimeOver>2015-12-23T03:17:19.112Z</estimatedTimeOver>
            <nic>7</nic>
            <nacp>8</nacp>
            <isSufficientForAdsb>true</isSufficientForAdsb>
            <isSufficientForAirspace>true</isSufficientForAirspace>
            <backupCoverage>false</backupCoverage>
            <potentialInterference>false</potentialInterference>
        </waypoint>
        <waypoint>
            <name>BOSOX</name>
            <latitude>42.20188</latitude>
            <longitude>-71.62767</longitude>
            <estimatedTimeOver>2015-12-23T03:24:19.112Z</estimatedTimeOver>
            <nic>7</nic>
            <nacp>8</nacp>
            <isSufficientForAdsb>true</isSufficientForAdsb>
            <isSufficientForAirspace>true</isSufficientForAirspace>
            <backupCoverage>false</backupCoverage>
            <potentialInterference>false</potentialInterference>
        </waypoint>
        <waypoint>
            <name>GRIPE</name>
            <latitude>42.13579</latitude>
            <longitude>-71.90901</longitude>
            <estimatedTimeOver>2015-12-23T03:32:19.112Z</estimatedTimeOver>
            <nic>7</nic>
            <nacp>7</nacp>
            <isSufficientForAdsb>false</isSufficientForAdsb>
            <isSufficientForAirspace>true</isSufficientForAirspace>
            <backupCoverage>false</backupCoverage>
            <potentialInterference>false</potentialInterference>
        </waypoint>
        <waypoint>
            <name>GRAYM</name>
            <latitude>42.10118</latitude>
            <longitude>-72.03152</longitude>
            <estimatedTimeOver>2015-12-23T03:37:19.112Z</estimatedTimeOver>
            <nic>7</nic>
            <nacp>7</nacp>
            <isSufficientForAdsb>false</isSufficientForAdsb>
            <isSufficientForAirspace>true</isSufficientForAirspace>
            <backupCoverage>false</backupCoverage>
            <potentialInterference>false</potentialInterference>
        </waypoint>
        <waypoint>
            <name>WITNY</name>
            <latitude>42.04939</latitude>
            <longitude>-72.23665</longitude>
            <estimatedTimeOver>2015-12-23T03:42:19.112Z</estimatedTimeOver>
            <nic>7</nic>
            <nacp>7</nacp>
            <isSufficientForAdsb>false</isSufficientForAdsb>
            <isSufficientForAirspace>true</isSufficientForAirspace>
```

```
                <backupCoverage>false</backupCoverage>
                <potentialInterference>false</potentialInterference>
            </waypoint>
            <waypoint>
                <name>BDL</name>
                <latitude>41.94101</latitude>
                <longitude>-72.68857</longitude>
                <estimatedTimeOver>2015-12-23T03:47:19.112Z</estimatedTimeOver>
                <nic>7</nic>
                <nacp>8</nacp>
                <isSufficientForAdsb>true</isSufficientForAdsb>
                <isSufficientForAirspace>true</isSufficientForAirspace>
                <backupCoverage>false</backupCoverage>
                <potentialInterference>false</potentialInterference>
            </waypoint>
            <waypoint>
                <name>BRISS</name>
                <latitude>41.70129</latitude>
                <longitude>-73.01558</longitude>
                <estimatedTimeOver>2015-12-23T03:51:19.112Z</estimatedTimeOver>
                <nic>7</nic>
                <nacp>8</nacp>
                <isSufficientForAdsb>true</isSufficientForAdsb>
                <isSufficientForAirspace>true</isSufficientForAirspace>
                <backupCoverage>false</backupCoverage>
                <potentialInterference>false</potentialInterference>
            </waypoint>
            <waypoint>
                <name>K4B8@1.70NM</name>
                <latitude>41.69926503102991</latitude>
                <longitude>-72.97788480054906</longitude>
                <estimatedTimeOver>2015-12-23T04:00:04.112Z</estimatedTimeOver>
                <nic>7</nic>
                <nacp>8</nacp>
                <isSufficientForAdsb>true</isSufficientForAdsb>
                <isSufficientForAirspace>true</isSufficientForAirspace>
                <backupCoverage>false</backupCoverage>
                <potentialInterference>false</potentialInterference>
            </waypoint>
            <waypoint>
                <name>K4B8@3.39NM</name>
                <latitude>41.697059921648616</latitude>
                <longitude>-72.94019262211877</longitude>
                <estimatedTimeOver>2015-12-23T04:08:49.112Z</estimatedTimeOver>
                <nic>8</nic>
                <nacp>8</nacp>
                <isSufficientForAdsb>true</isSufficientForAdsb>
                <isSufficientForAirspace>true</isSufficientForAirspace>
                <backupCoverage>false</backupCoverage>
                <potentialInterference>false</potentialInterference>
            </waypoint>
            <waypoint>
                <name>K4B8@5.09NM</name>
                <latitude>41.694566425175424</latitude>
                <longitude>-72.90250385492524</longitude>
```

```
                        <estimatedTimeOver>2015-12-23T04:17:34.112Z</estimatedTimeOver>
                        <nic>8</nic>
                        <nacp>8</nacp>
                        <isSufficientForAdsb>true</isSufficientForAdsb>
                        <isSufficientForAirspace>true</isSufficientForAirspace>
                        <backupCoverage>false</backupCoverage>
                        <potentialInterference>false</potentialInterference>
                </waypoint>
                        <waypoint>
                        <name>K4B8</name>
                        <latitude>41.69037</latitude>
                        <longitude>-72.86482</longitude>
                        <estimatedTimeOver>2015-12-23T04:26:19.112Z</estimatedTimeOver>
                        <nic>8</nic>
                        <nacp>8</nacp>
                        <isSufficientForAdsb>true</isSufficientForAdsb>
                        <isSufficientForAirspace>true</isSufficientForAirspace>
                        <backupCoverage>false</backupCoverage>
                        <potentialInterference>false</potentialInterference>
                </waypoint>
                <suggestedOffset>-1</suggestedOffset>
                <notes>Unable to suggest an alternative time.</notes>
        </route>
        <transactionIdentifier>389854</transactionIdentifier>
        <responseCode>0</responseCode>
        <notes> Prediction Complete: 2015-12-22 19:14:58</notes>
</AdsbSufficiencyForRoute_Response>
</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.

Lists the error code, error message, and corrective actions a user should take for the less obvious error conditions.

Table 8-10: ADS-B SAPT Exception Error Information

Error Code	Error Message	Corrective Actions
-2	Invalid number of routes submitted	Invalid number of routes submitted. Fix the number of routes to be sent to process.
-3	Invalid typeOfAircraft value (SAPT)	Fix the aircraft type that is supported by SAPT.
-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 – 510.
-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.
-10	Invalid longitude value	Change the waypoint longitude value. Longitude must be between +/-180.0 degrees.
-11	Missing estimatedTimeOver value	Make sure the estimatedTimeOver value is entered.
-12	EstimatedTimeOver value is in the past	Make sure the estimatedTimeOver value is in the future.
-13	Timed-out due to maxWaitAccepted	Set the maxWaitAccepted value to a larger number.
-14	Validator configuration error (SAPT)	Contact us at https://enroutesupport.faa.gov/sapt/feedback.aspx
-15	Timeout from prediction servers	Try again in a couple of minutes. If you get the error again, contact us at https://enroutesupport.faa.gov/sapt/feedback.aspx
-17	Invalid avionics options (TSO + SA,FDE,WAAS) (SAPT)	Make sure the avionics options are correct. ▪ C129 ▪ C129 with SA Aware ▪ C129 with FDE ▪ C129 with SA Aware & FDE ▪ C145/146 with WAAS ▪ C145/146 outside WAAS Coverage ▪ C196

Error Code	Error Message	Corrective Actions
-18	Invalid maskAngle value (SAPT)	Make sure the maskAngle value is between 0 to 5.0 using half-degree increments
-19	HAL input is out of valid range (RAIM)	Make sure the HAL value is within range.
-99	Internal exception	None of the above errors. Contact us at https://enroutesupport.faa.gov/sapt/feedback.aspx

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 the following image:

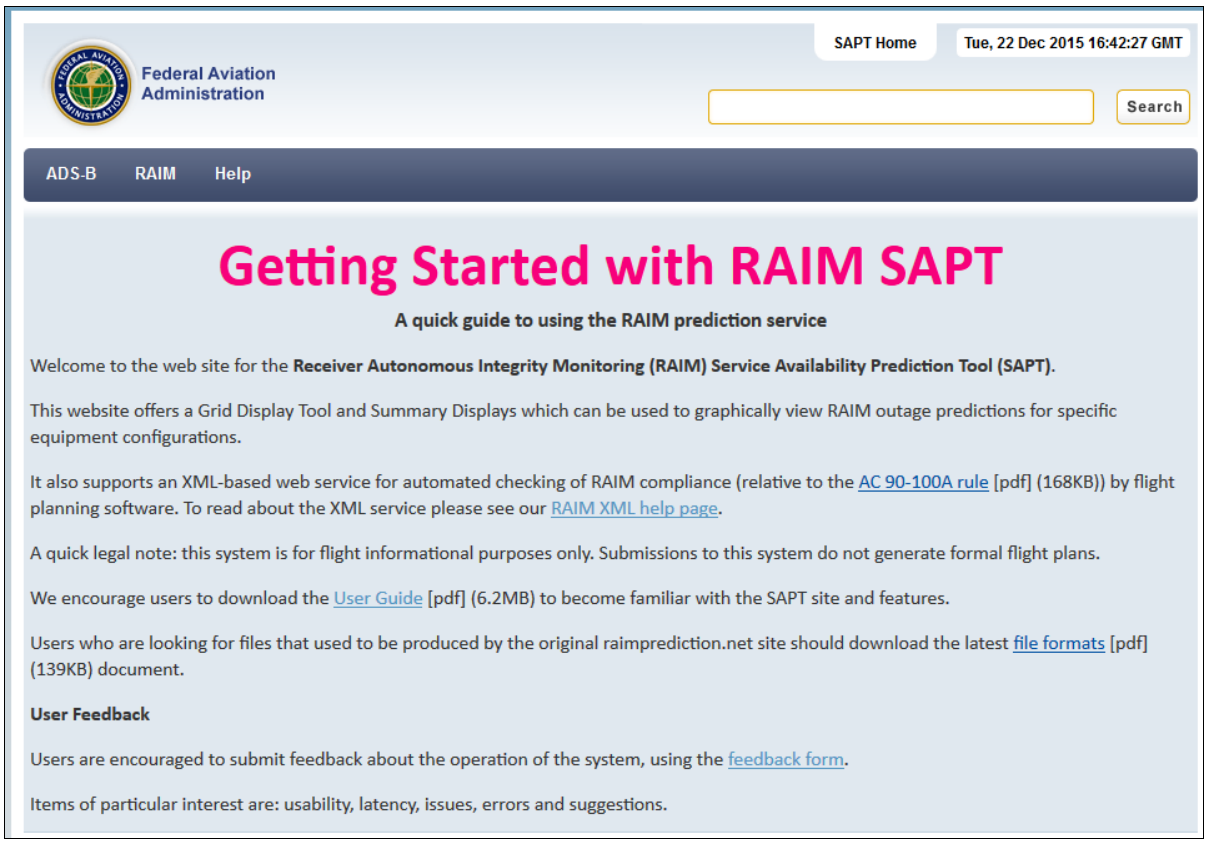


Figure 9-1: Getting Started with RAIM SAPT Page

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 Software Development Kit (SDK) 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 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.

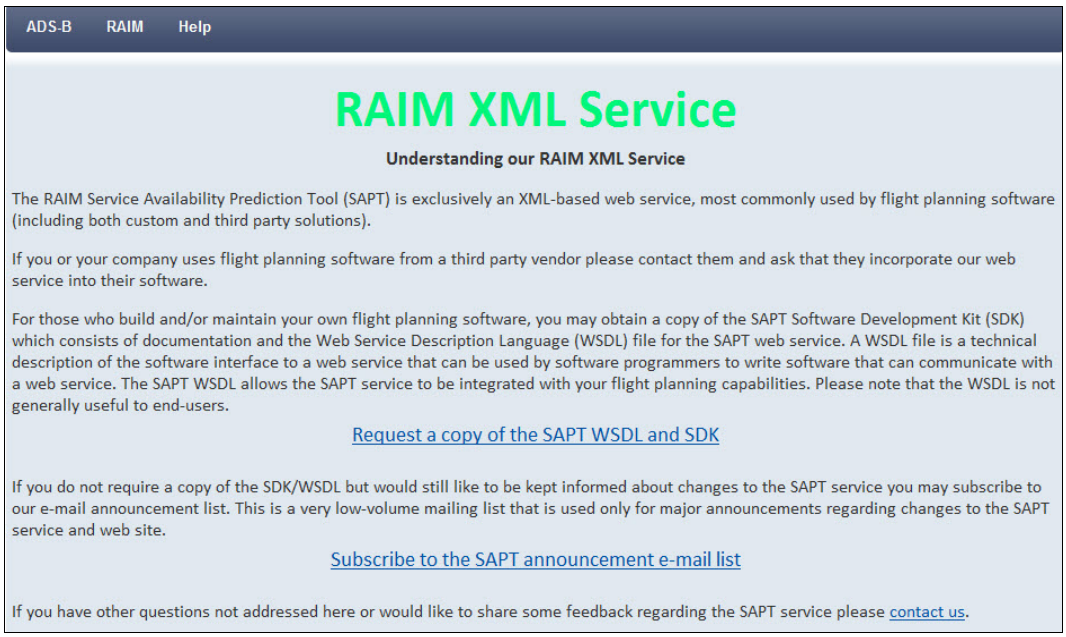


Figure 9-2: RAIM XML Service Page

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:

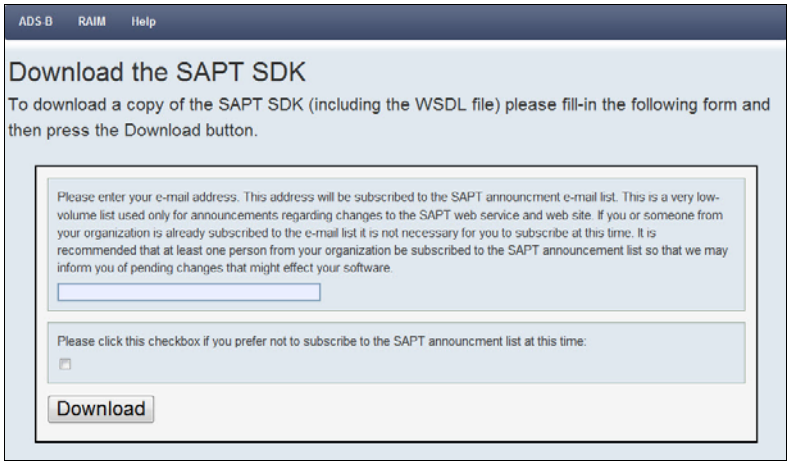


Figure 9-3: Download the SAPT SDK

When you click **DOWNLOAD** the application generates a pop-up dialog:

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:

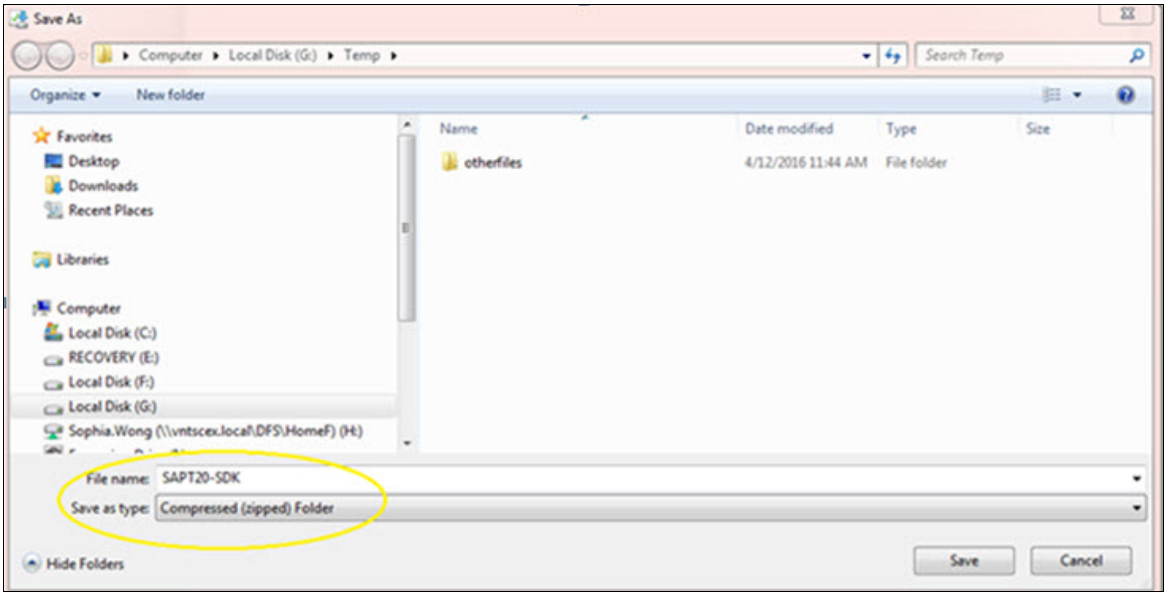


Figure 9-5: Save the SAPT SDK

Click **OPEN** to save the file to the temporary internet files folder on your computer:

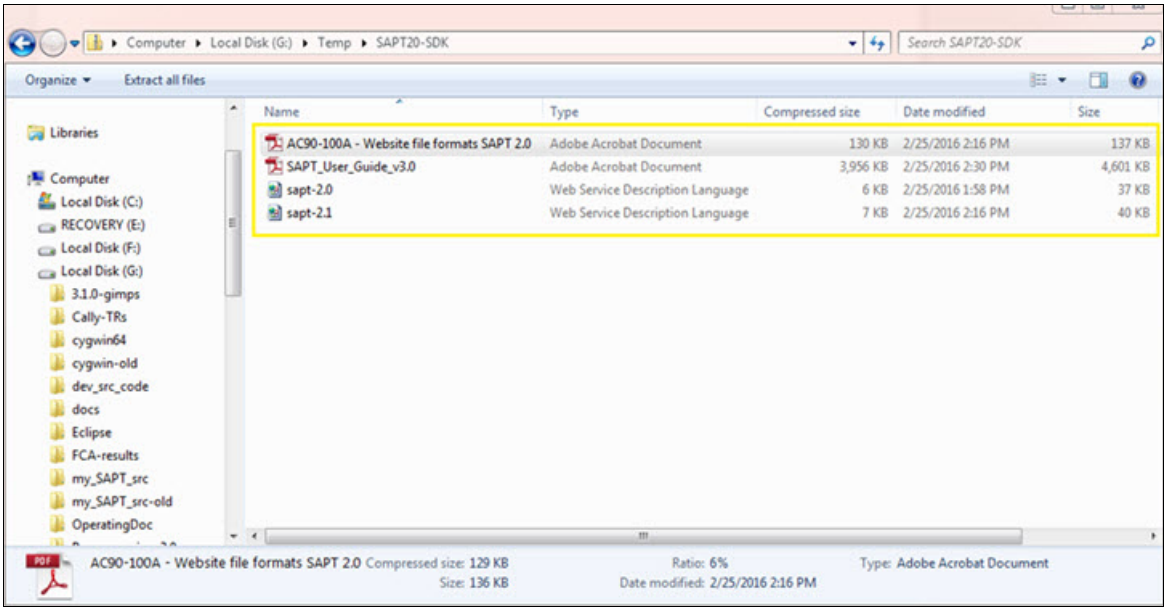


Figure 9-6: Open the SAPT SDK

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

9.2.2 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 announcement e-mail list link to open the subscription page:

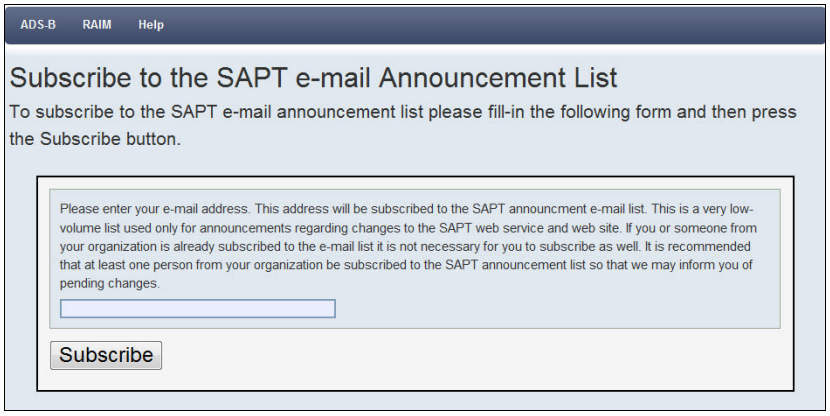


Figure 9-7: Download the SAPT SDK

Enter your e-mail address and press **SUBSCRIBE**.

10 RAIM SUMMARY PAGES

Scroll down the ADS-B- SAPT home page to see the RAIM Summary Pages section of the site:

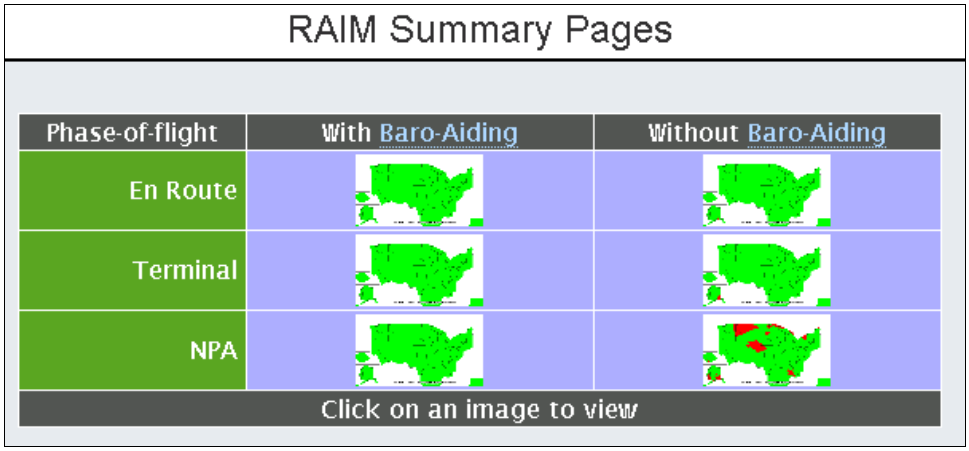


Figure 10-1: RAIM Summary Section

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 following image illustrates the summary for NPA airspace with selective availability and barometric aiding both enabled:

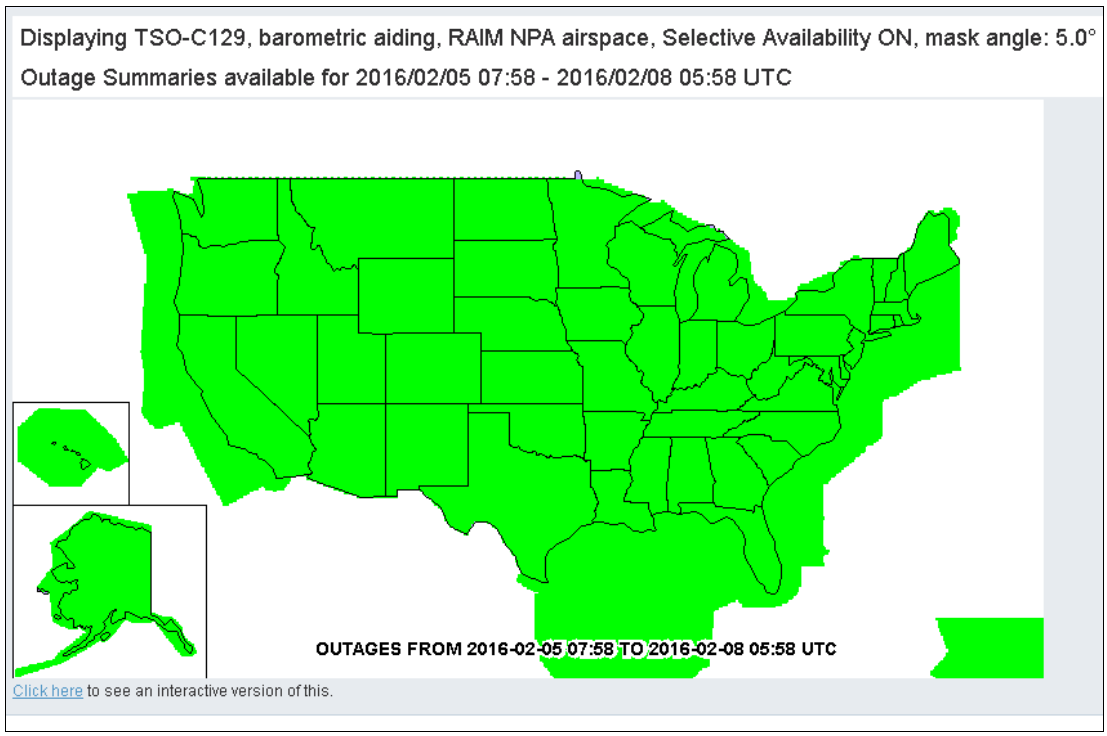


Figure 10-2: RAIM Summary – NPA Airspace, SA On and Baro-aiding Enabled

Your parameters are displayed at the top of the screen. The outage summary beneath them is a quick review of the activity within the 24-hour prediction window.

The snapshots offer a 24-hour window on the CONUS. If the area where you intend to fly is colored green there are no predicted RAIM outages in that area for the next 24 hours 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, please employ the SAPT to get a more detailed forecast.

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 selective availability ON and no barometric aiding:

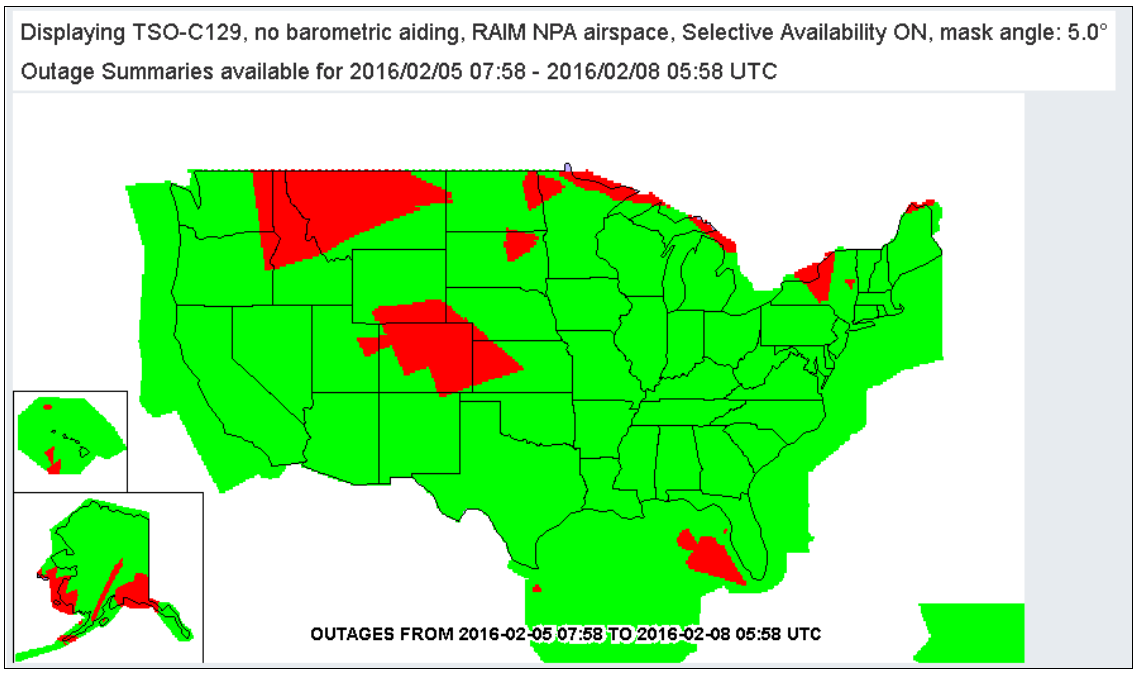


Figure 10-3: RAIM Summary – NPA Airspace, With SA On and No Baro-aiding

To see the Google Earth™ 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 Google Earth™ representation of Figure 10-3 above:

Note: In the interactive presentation you see outages over the next six hours only. Please review the summary pages again later or use the SAPT Flight Plan Form for more information.

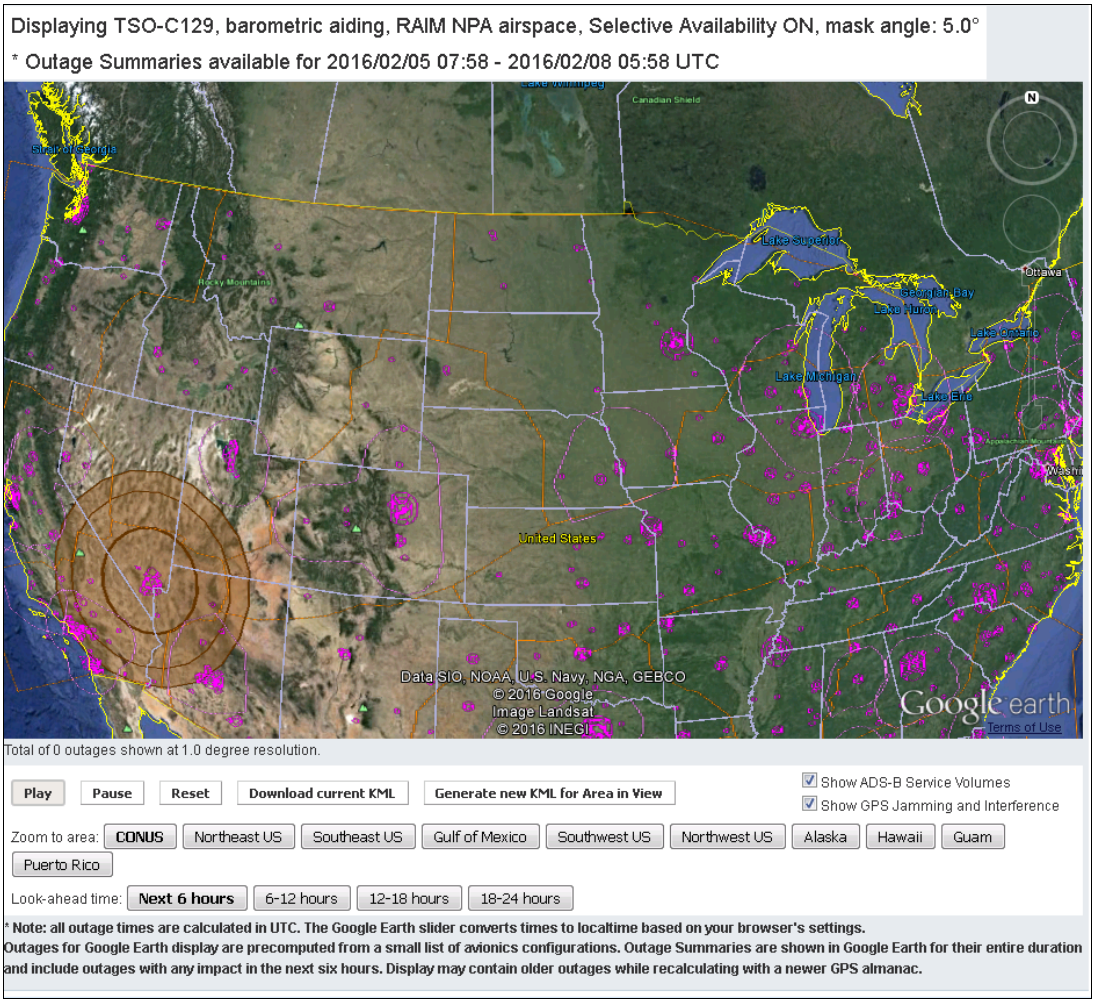


Figure 10-4: RAIM Summary -- NPA Airspace, SA On and Baro-aiding

Some of the features of this tool are displayed at the bottom of the Google Earth™ applet. They are described briefly here:

Notes: The graphical display is provided through the Google Earth™ API and functionality consistent with the SAPT ADS-B requirements.

Outages are shown in red for en route, terminal and NPA areas, and are available both with and without baro aiding.

GPS jamming and interference outages are shown in brown.

- Press **PLAY** to run the simulation and review the prediction window.
- Press **PAUSE** to stop the simulation.
- Click **RESET** to set the simulation to the starting point again.
- Press **DOWNLOAD KML** to download the KML servlet.
- Zoom to area: Press **CONUS, NORTHEAST US, SOUTHEAST US, GULF OF MEXICO, SOUTHWEST US, NORWEST 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.
- Press **GENERATE KML FOR AREA IN VIEW** to see the entire area you have chosen.
- Check the boxes for Show ADS-B Service Volumes and Show GPS Jamming and Interference if you want to see that information.

To zoom in on the area of interest you can use any of these three different methods:

- Method 1: Select an area by pressing one of the buttons right to Zoom to area.
  Note: The region defaults to the entire continental United States.
- Method 2. Employ the slider tool on the right side of the screen, illustrated here:

- Method 3. Use the hand tool in Google Earth™ to 'grab' a section of the map and move it in the desired direction.

To zoom back out reverse whichever of the above methods you used: i.e., select a different region from the drop-down list, use the slider tool or use the Google hand icon.

For details of an outage, position the mouse over an area and press the left mouse button. The information appears as a pop-up window, as illustrated here:

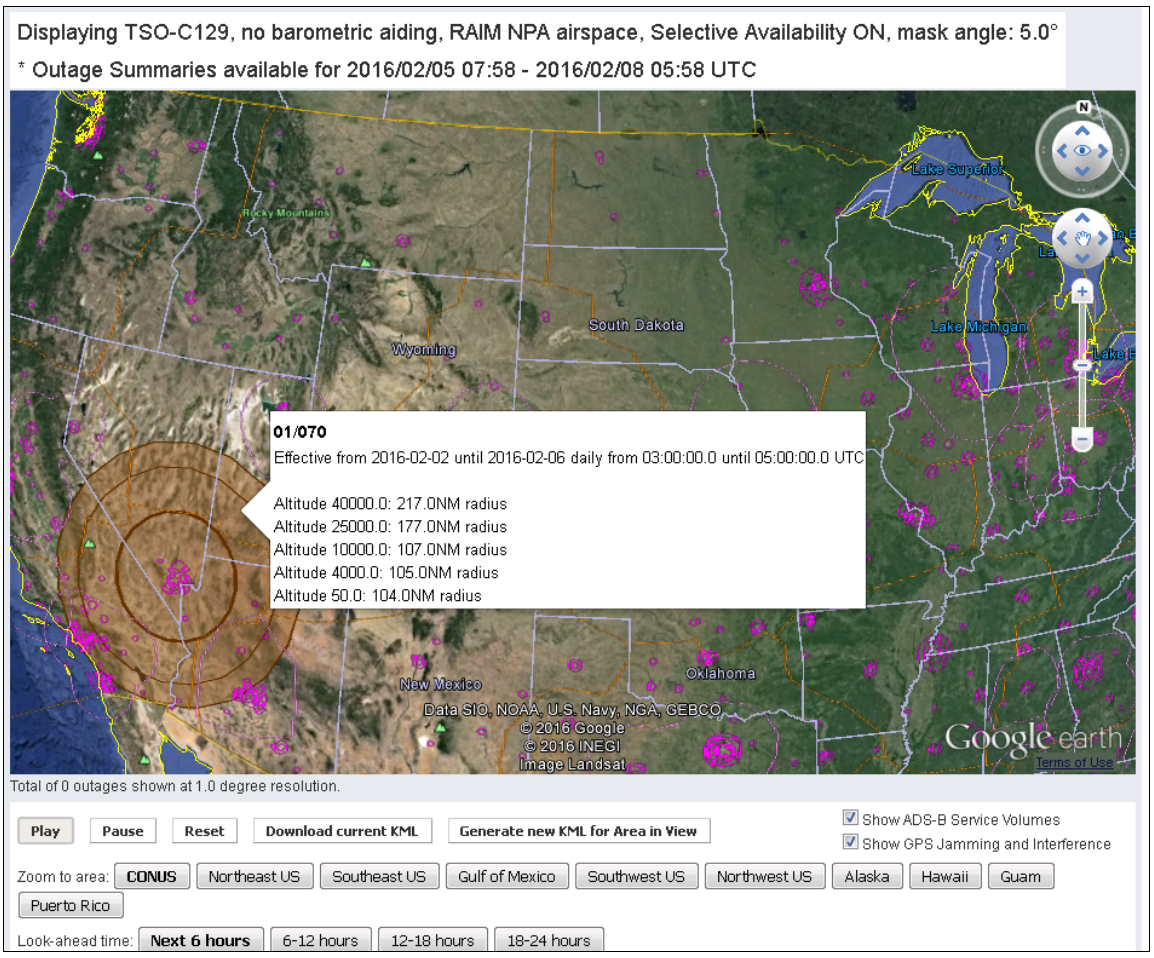


Figure 10-5: RAIM Summary – NPA Airspace, SA On and No Baro-aiding

APPENDIX A. ACRONYMS AND GLOSSARY

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

Acronym	Definition
3D	Three-dimensional
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 "U.S. 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.
API	Application Programming Interface
ARC	(ADS-B)Aviation Rulemaking Committee
ATC	Air Traffic Control
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.
CIFP	Coded Instrument Flight Procedures (formerly the National Flight Database (NFD))
CONUS	Continental United States
DoD	Department of Defense
DOT	Department of Transportation
ETO	Estimated Time Over
FAA	Federal Aviation Administration
FD	Fault detection
FDE	Fault Detection and Exclusion
FL	Flight level
GA	General aviation
GMT	Greenwich Mean Time
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GUI	Graphical user interface
HFOM	Horizontal Figure of Merit
HPL	Horizontal Protection Limit
ICAO	International Civil Aviation Organization
IDE	Integrated Development Environment
IP	Internet protocol

Acronym	Definition
IT	Information technology
J2EE	Java 2 Platform, Enterprise Edition
KML	Keyhole Markup Language
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
NIC	Navigation Integrity Category The NIC specifies the radius of containment for the aircraft's horizontal position.
NM	Nautical miles
NOTAM	Notices to Airmen Notices 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 advisories 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).
QRO	Quality and Reliability Officer
RADAR	Radio Detection and Ranging
RAIM	Receiver Autonomous Integrity Monitoring
RNAV	Area navigation (RNAV) 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.
RNP	Required Navigation Performance: Accuracy, Integrity, Continuity, Availability
SA	Selective Availability 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

Acronym	Definition
	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.
SAPT	ADS-B SAPT Service Availability Prediction Tool
SBAS	Satellite-Based Augmentation System
SBS	Surveillance and Broadcast Services
SID	Standard Instrument Departure
SIL	Source Integrity Level 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.
SSR	Secondary Surveillance Radar Secondary surveillance radar (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.
STAR	Standard Terminal Arrival
TCP/IP	Transfer Control Protocol/ Internet Protocol
SVDD	Service Volume Definition Document
TSO	Technical Standard Order 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.
UAT	Universal Access Transceiver
UML	Unified Modeling Language
URL	Uniform Resource Locator
UTC	Coordinated Universal Time
WAAS	Wide Area Augmentation System 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.
WAM	Wide Area Multilateration 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.
WAN	Wide Area Network
WJHTC	William J. Hughes Technical Center
WSDL	Web Service Description Language
XML	eXtensible Markup Language

APPENDIX B. BIBLIOGRAPHY

- Report from the ADS–B Aviation Rulemaking Committee to the Federal Aviation Administration, September 26, 2008. https://www.faa.gov/nextgen/programs/adsb/media/arcReport2008.pdf