Automatic Dependent Surveillance – Broadcast (ADS-B)

Service Availability Prediction Tool (SAPT) /

Receiver Autonomous Integrity Monitoring (RAIM)

User Guide

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DRAFT

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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.

1.1 ADS-B PREDICTION

An ADS-B prediction is based on the ability of the aircraft avionics to meet performance requirements specified in Technical Standard Orders (TSOs) C129, C129a, C145c/C146c, and C196, as well as the predicted status of the Global Positioning System (GPS) constellation.

Included within this prediction is the availability of Wide Area Augmentation System (WAAS) under TSO C145c/C146c. 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 use reduced NIC and NACp requirements for en route airspace and 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 Flight Standards and Aviation Safety (AVS). SSR and WAM availability will be based on coverage volumes in the Service Volume Definition Document (SVDD), 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 will 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, C129a, C145/C146, 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 its users for planning flights which are predicated upon 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 along the requested route, a sufficiency value of "false" is returned. Conversely, if predicted integrity levels meet or exceed these operational limits, a sufficiency value of "true" is returned.

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.

If you want to review the instructions on how to use the RAIM tool, please skip directly to Section 9. RAIM Prediction Tool in this user guide.

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

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 will require that aircraft operating in certain airspace have ADS-B Out capabilities in 2020.

The FAA ADS-B implementation involves two air-to-ground (and air-to-air) broadcast links:

- 1090ES 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.
- UAT refers to aircraft broadcasts on 978 MHz that conform 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…." (International Civil Aviation Organization, 2011).

The SAPT addresses the ARC recommendation. In making ADS-B predictions, the SAPT will take into account the status of both the GPS satellite constellation and the WAAS.

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 (forthcoming) for more information.

4 DEVELOPMENT CYCLE

The ADS-B SAPT development will include the following releases:

- RAIMprediction.net Release (June 2009)
- Test Release (September 2011)

- Baseline Release (May 2013)
- RAIM Integration Release (April 2014)
- Enhancement Release (Fiscal Year (FY) 14-15)

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 is planned for April 2014 and will incorporate TSO-C129 GPS RAIM predictions, thus satisfying the operational requirement to check the availability of GPS RAIM for flights in which TSO-C129 equipment will be used to satisfy the RNAV requirement.

An Enhancement Release is planned for FY 2014-2015. It will provide users with the following features:

- A reduced level of ADS-B performance (Navigation Integrity Category (NIC) of 5 and Navigation Accuracy Category for Position (NACp) of 7) that meets the needs of separation services provided en route.
- Availability of alternate surveillance sources such as Secondary Surveillance Radar (SSR) and Wide Area Multilateration (WAM).
- An interface with the SBS compliance monitor.

5 LIMITATIONS

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 does not make predictions for navigational use because the RNP for ADS-B does not employ the same standard as navigation.

> REMINDER: SAPT users who want to use certain GPS TSOs for navigation must check for that availability separately.

The SAPT makes predictions based on ADS-B performance thresholds of a NIC of 7 or better and a NACp of 8 or better. These thresholds meet the needs of separation services throughout ADS-B airspace.

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 or intended 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, and Safari.

Users must install JavaScript on their work-station in order to make use of the graphical user interface (GUI).

The Google Earth™ plug-in is required in order to use the graphical display for a prediction. 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

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 flight plan, 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.

6.3.1 GPS TSOs

The SAPT follows four TSOs:

- TSO–C129/129a
  Note: For SAPT purposes, 129a is 129 plus Selective Availability (SA) Aware.
- TSO–C145c/146c with SBAS GEO coverage
- TSO–C145c/146c outside of SBAS GEO coverage
- TSO–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 does not exclude satellites from the solution; i.e., this receiver is not equipped with fault detection and exclusion (FDE) capability.

TSO C145c/146c 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 C145c/146c 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 C145c/146c avionics which employ FDE. TSO C145c/146c 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
- C129a (see Section 6.3.2)
- C145c/146c with WAAS
- C145c/146c without WAAS
- C196

6.3.2 Selective Availability

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.

SA Awareness is only an issue for TSO 129/129a.

Note: The TSO-129a menu designation has no significance other than "TSO 129 with SA Awareness."

Note: FDE is not used for TSO 129a in this Baseline SAPT Release.

REMINDER: Users should select "TSO C129" from the Navigation Source drop-down menu if their TSO C129 avionics are set to SA "unaware"/SA "ON."

REMINDER: Users should select "TSO C129a" from the Navigation Source drop-down menu if their TSO C129 avionics are set to SA "aware"/SA "OFF."

6.3.3 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.

6.3.4 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. 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 every 12 hours for a 40-hour period, but only for TSOs C129 and C196 and for mask angles 2.5 and 5.0.

While loading, the graphical display will report the total number of outages and the degree if resolution. By default the graphical display will show outages for the continental United States (CONUS) at a low resolution. The user can select a region from a drop-down menu, or use the features of Google Earth™ to navigate to a particular region, and then display outages for that region at a higher resolution. The areas within which outages are searched are highlighted within a box. While the graphical display recalculates its position it reports zero (“0”) outages.

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

6.5 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 as to the aircraft's actual location versus the operator's best-laid plans. The user may wish to submit additional requests for predictions with different departure times to account for anticipated 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: Please refer to Section 7.8.2.1 for details.

For TSO-C129a, the Horizontal Figure of Merit (HFOM) is calculated using the same weighting algorithm. The HFOM is transformed into a NACp value. In some instances, such as a latitude and longitude near zero degrees, the HFOM calculation causes the NACp to go to zero. In these cases, the SAPT will transform the HPL to the NACp.

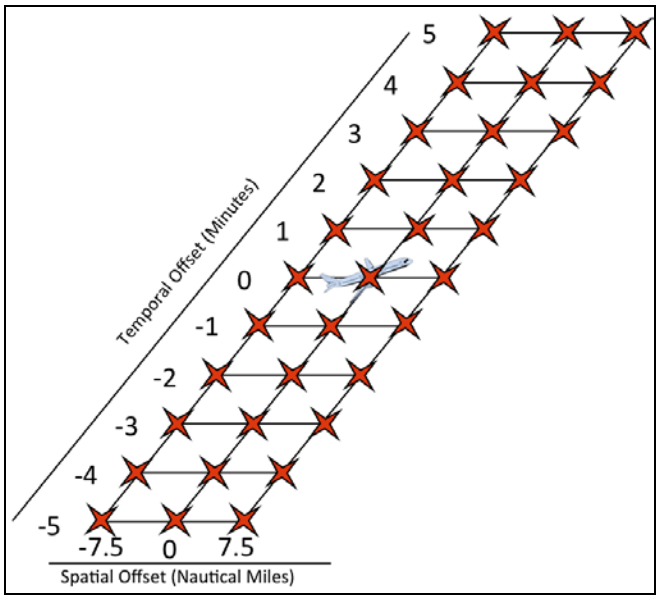


Figure 6-1: SAPT Weighting Algorithm

7 INTERACTIVE GUI

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

Users must accept the warning message, depicted below 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.

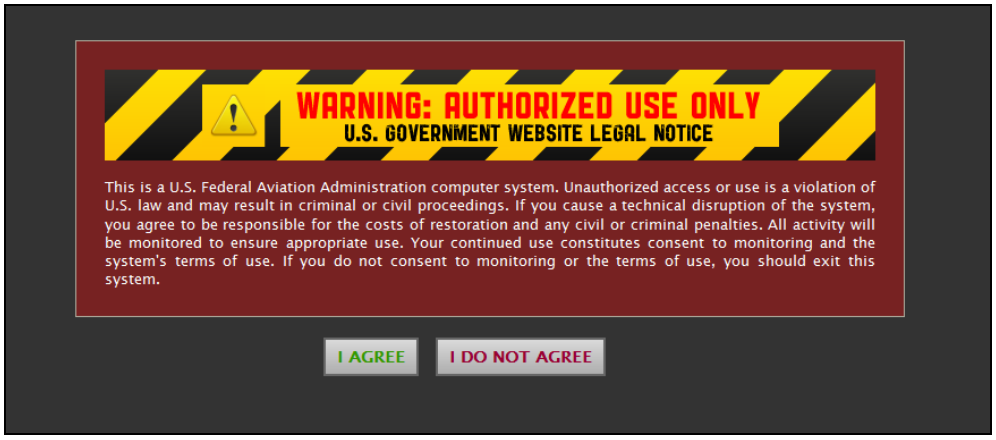


Figure 7-1: SAPT Warning Page

7.1 ADS-B HOME PAGE

The main page of the website offers users the three primary selections:

- ADS-B Service Availability Prediction Tool
- RAIM Prediction Tool
- RAIM Summary Pages

The main page is shown in Figure 7-2 on the next page:

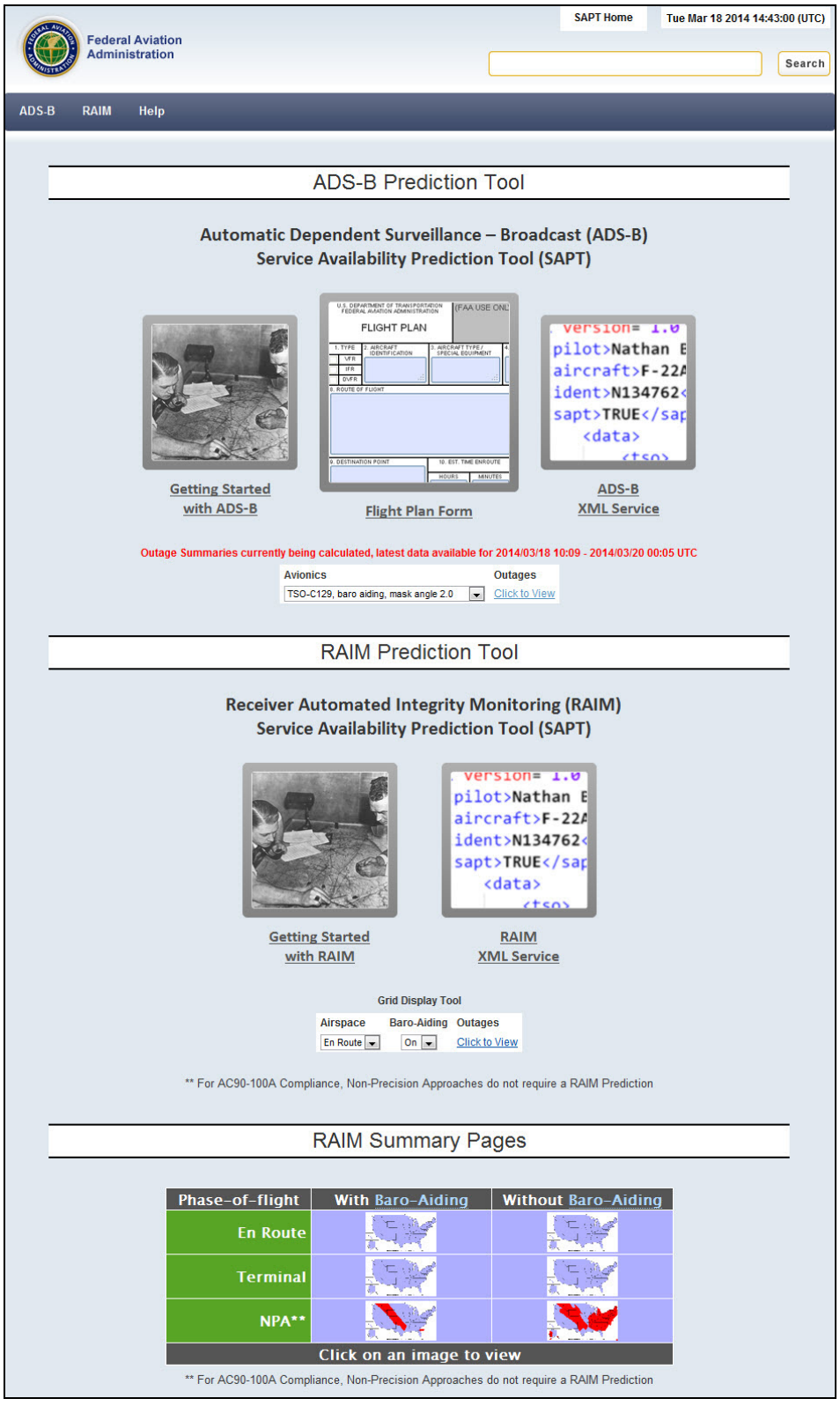


Figure 7-2: SAPT Main Page

7.1.1 Service Availability Prediction Tool

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

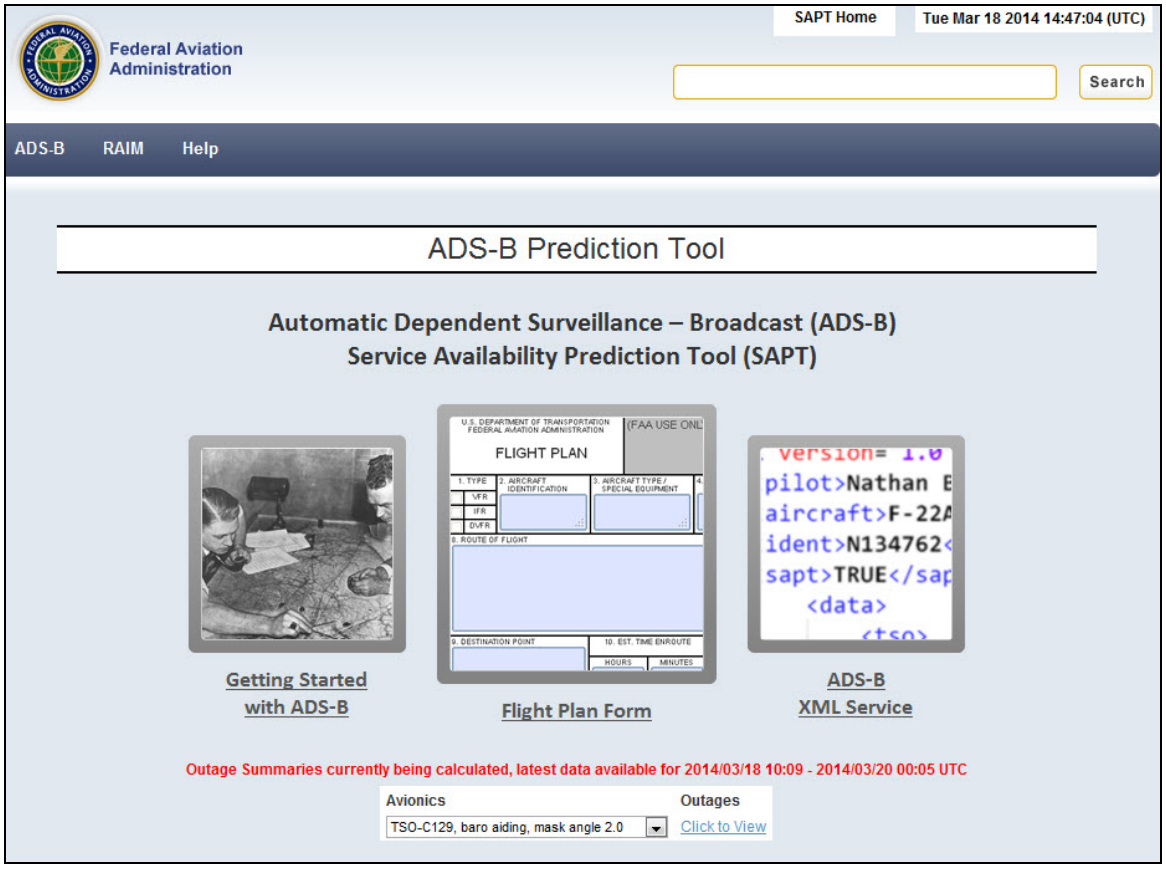


Figure 7-3: ADS-B Home Page - SAPT Section

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.

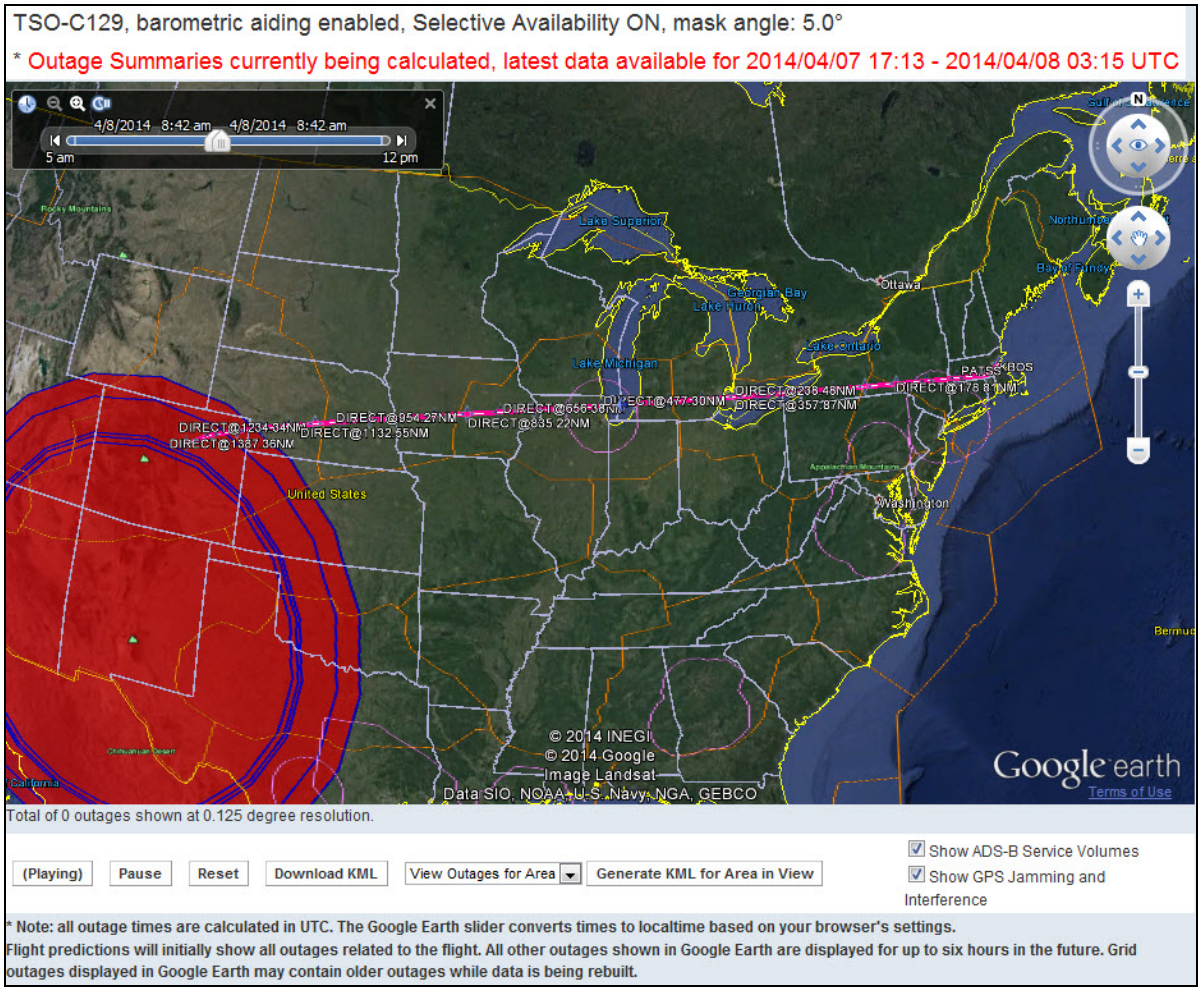


Figure 7-5: SAPT Flight Plan With Outages

The “Getting Started” Section informs users of how to make a prediction and which fields are required. It explains the entry fields on the SAPT-modified Flight Plan Form, and includes examples of how to complete the fields.

The “Flight Plan Form” section is where users can request predictions for actual flight plans. The page presents a standard FAA Flight Plan Form, 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 employ the XML interface. A XML interface user must contact sapthelpdesk@faa.gov to request the Web Service Description

Language (WSDL) file. 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

This page provides a summary introduction to the SAPT and explains what users can accomplish in the Web pages. It also lays out the limitations on the tool. This page is shown here:

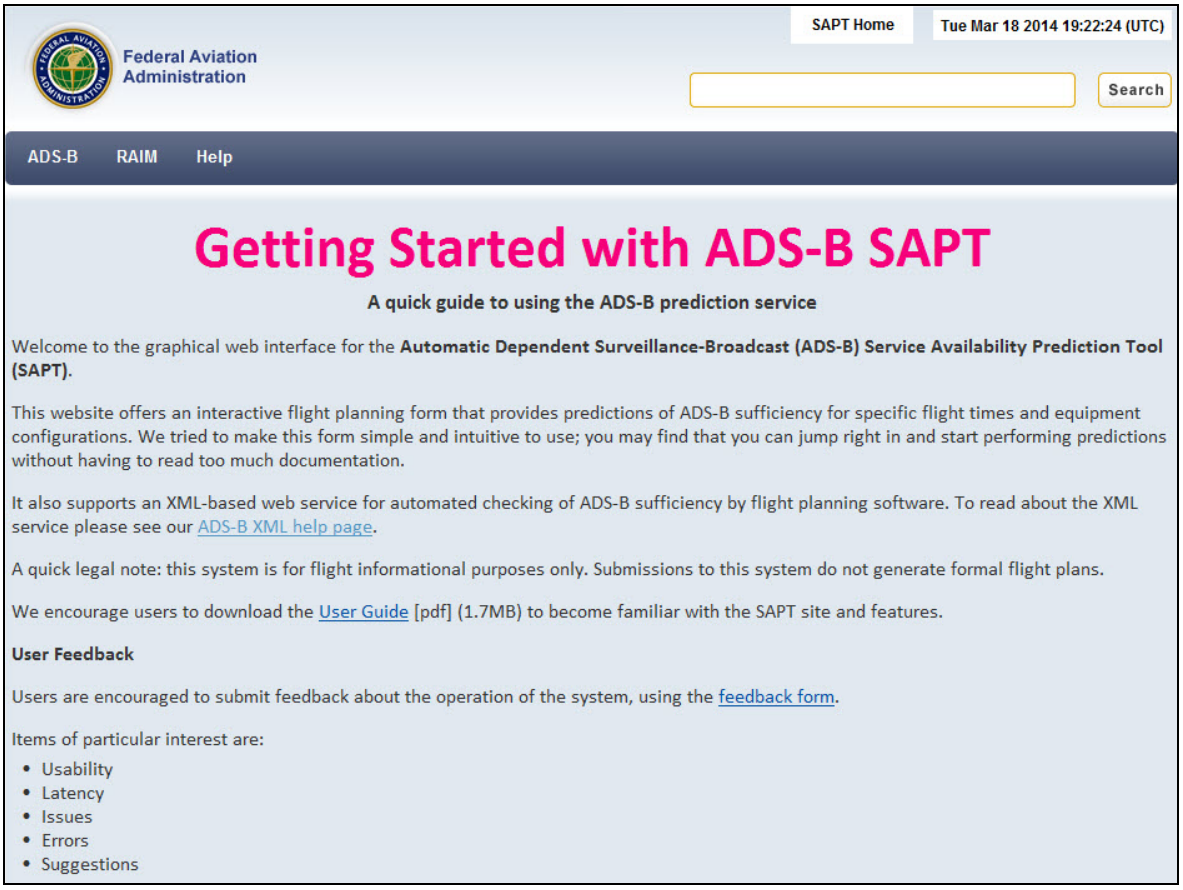


Figure 7-6: Getting Started Page

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 http://sapt.faa.gov/feedback.php or by email to sapthelpdesk@faa.gov.

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 in order to open the form, which is shown below:

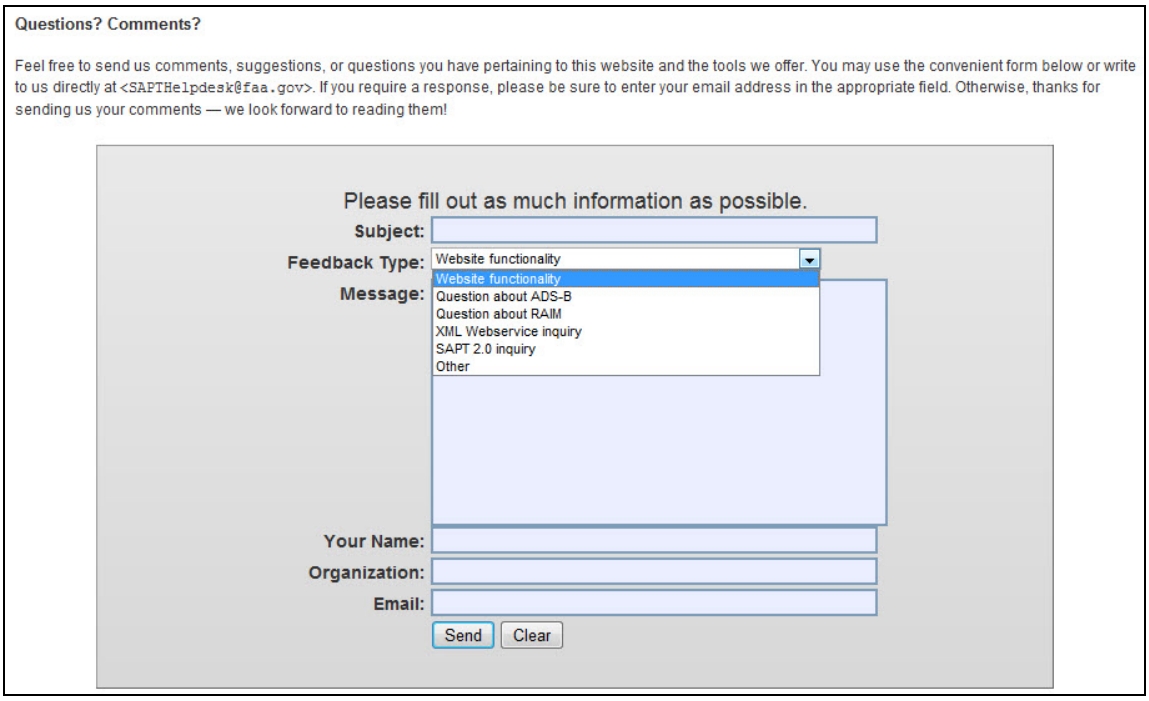


Figure 7-7: Feedback Form

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 **SEND** to deliver your message or click **CLEAR** if you change your mind.

7.3 SAPT Header

The home page and flight plan 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 jump directly to sections of the Web site.
- On the home page, these menus are ADS-B, RAIM and Help.
- On the Flight Plan 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:

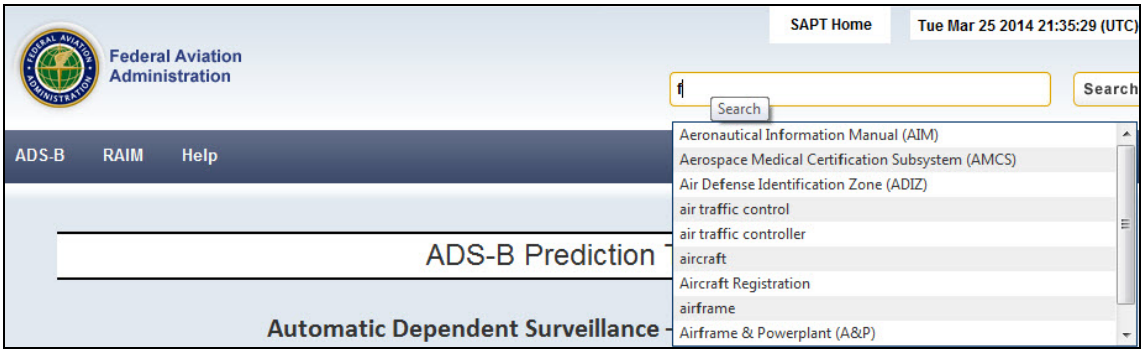


Figure 7-9: SAPT Search Text-box (one character)

By adding more characters the user can target their subject of interest more closely:

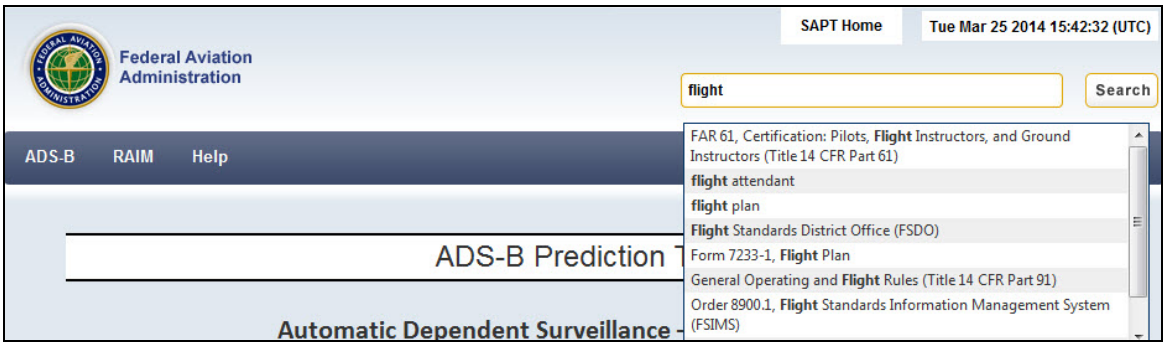


Figure 7-10: SAPT Search Text-box (full word)

7.3.3 FAA Logo

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

7.3.4 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, Flight Plan and XML Service pages lists the pages within that portion of the Web site. Hold your cursor over the menu and click the page name in order to navigate directly to it:

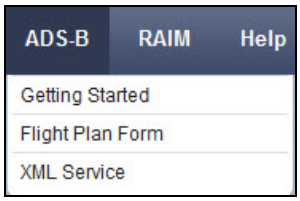


Figure 7-11: ADS-B Menu

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

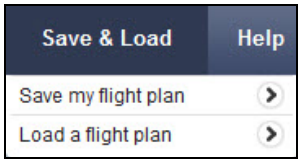


Figure 7-12: Save & Load Menu

Saving or importing flight plans 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:

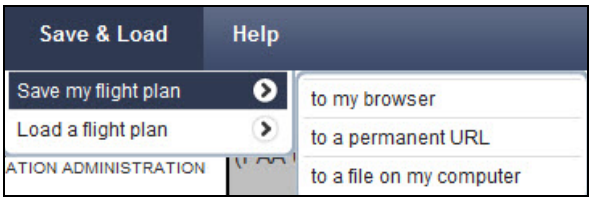


Figure 7-13: Save My Flight Plan Sub-menu

Click the option that suits you and save the flight plan as defined in section 7.6.1 of this document.

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:

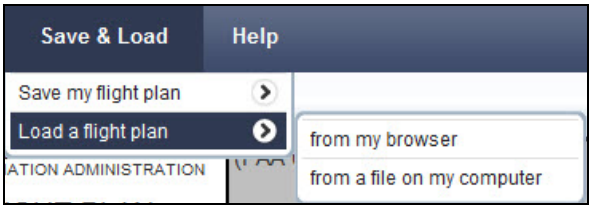


Figure 7-14: Load A Flight Plan Sub-menu

Click the option that suits you and import the saved flight plan as defined in section 7.6.2 of this document.

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:

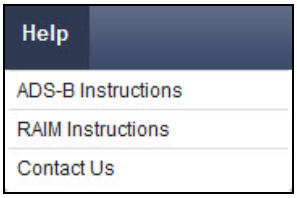


Figure 7-15: Help Menu

The application navigates to the help file that you want to consult.

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™ PLUGIN

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: If you do cannot download the plug-in, please refer to section 7.8.3 for another option.

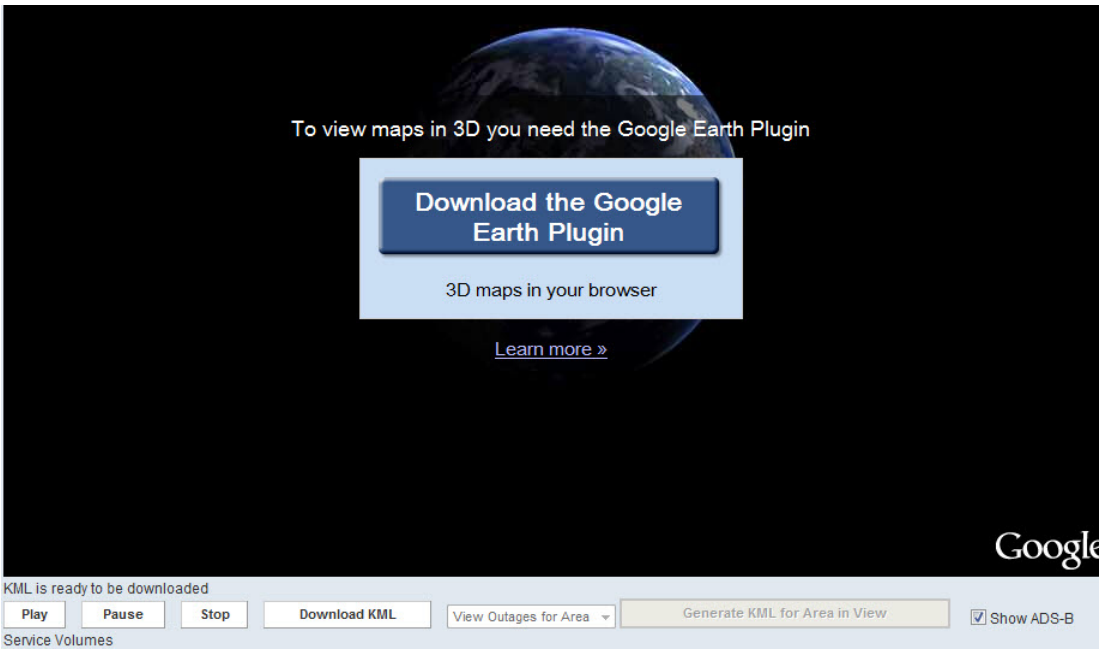


Figure 7-17: Download Google Earth™ PlugIn

7.6 FLIGHT PLANNING FORM

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

Required fields are tinted blue. To see what information is required in each field place your cursor in the field. The application displays a tool tip. Enter 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:

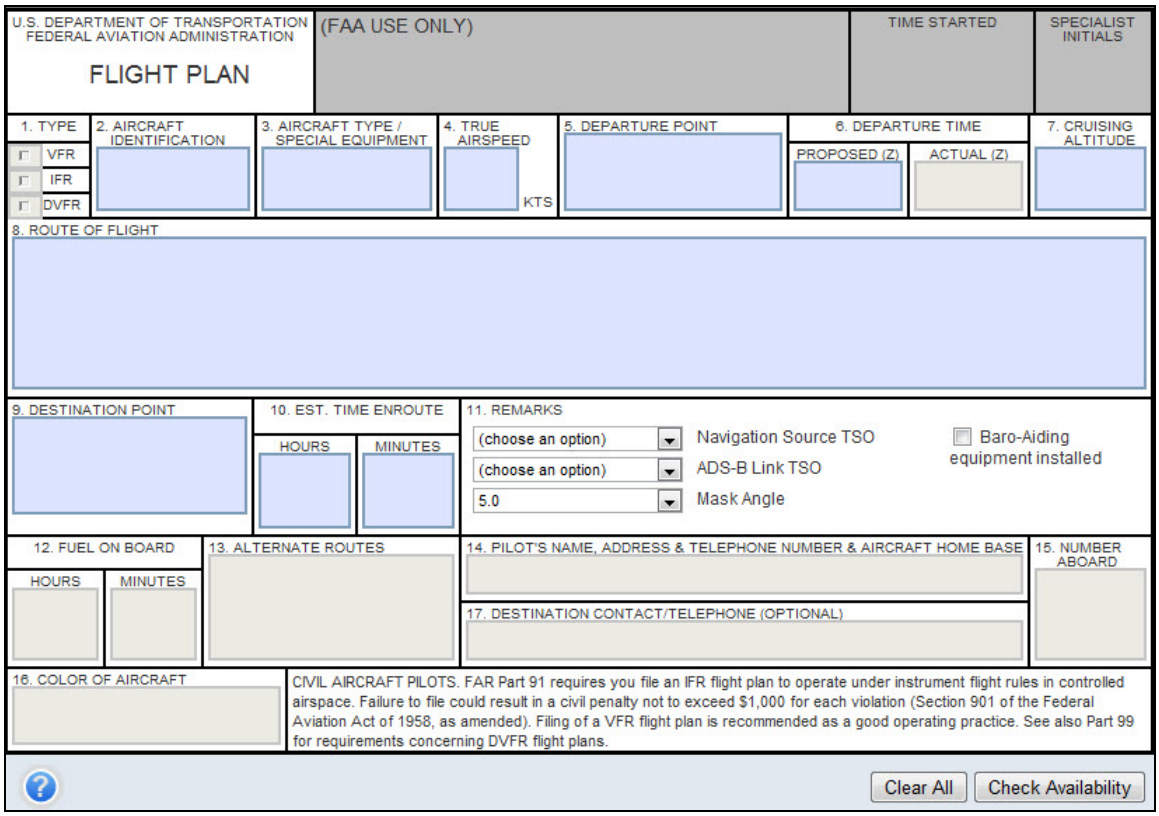


Figure 7-18: Flight Plan Form

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 tool will turn the relevant field red to alert you to fix that entry.

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

Table 7-1 describes required fields on the Flight Plan Form page:

Table 7-1: Required SAPT Fields

Field	Description	Units	Example
Aircraft Identification	Flight ID of the aircraft that will be flown.	None	UPS01234
Aircraft Type /	The International Civil Aviation	None	C172

Field	Description	Units	Example
Special Equipment	Organization (ICAO) identifier for the type of aircraft that will be flown.		
True Airspeed	The aircraft's cruising speed. *Note: This value is currently not used in the final prediction calculation.*	Knots	110
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 anywhere within 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 along 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

Field	Description	Units	Example
			(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 the join point. The system will automatically add the waypoints along the procedure.
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	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 or remove checkmark *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.

If you neglect to enter required information the system will display an error message such as the following:

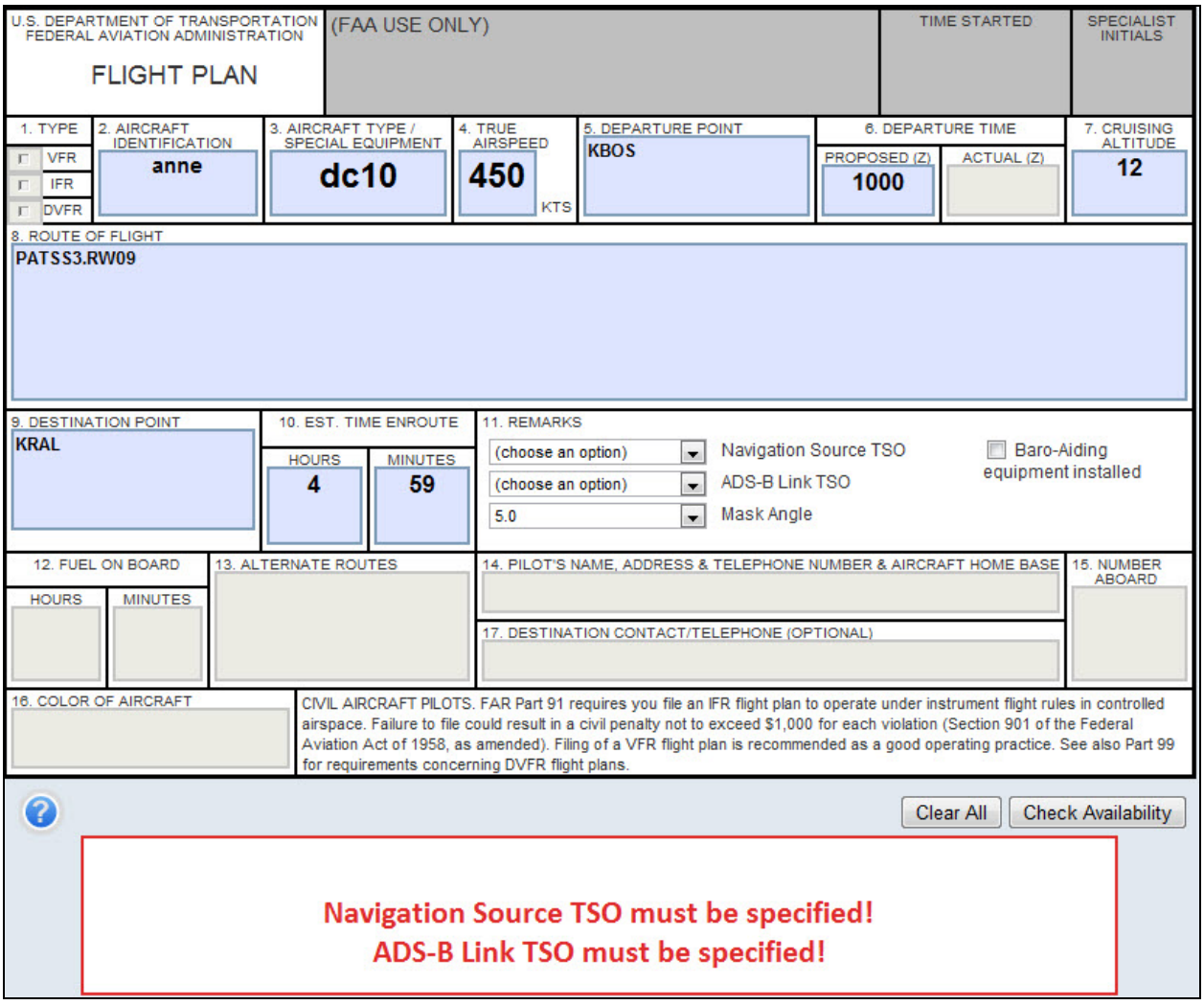


Figure 7-19: Flight Plan Form with Errors

When the flight plan is correctly filled in, the system displays the prediction beneath the form:

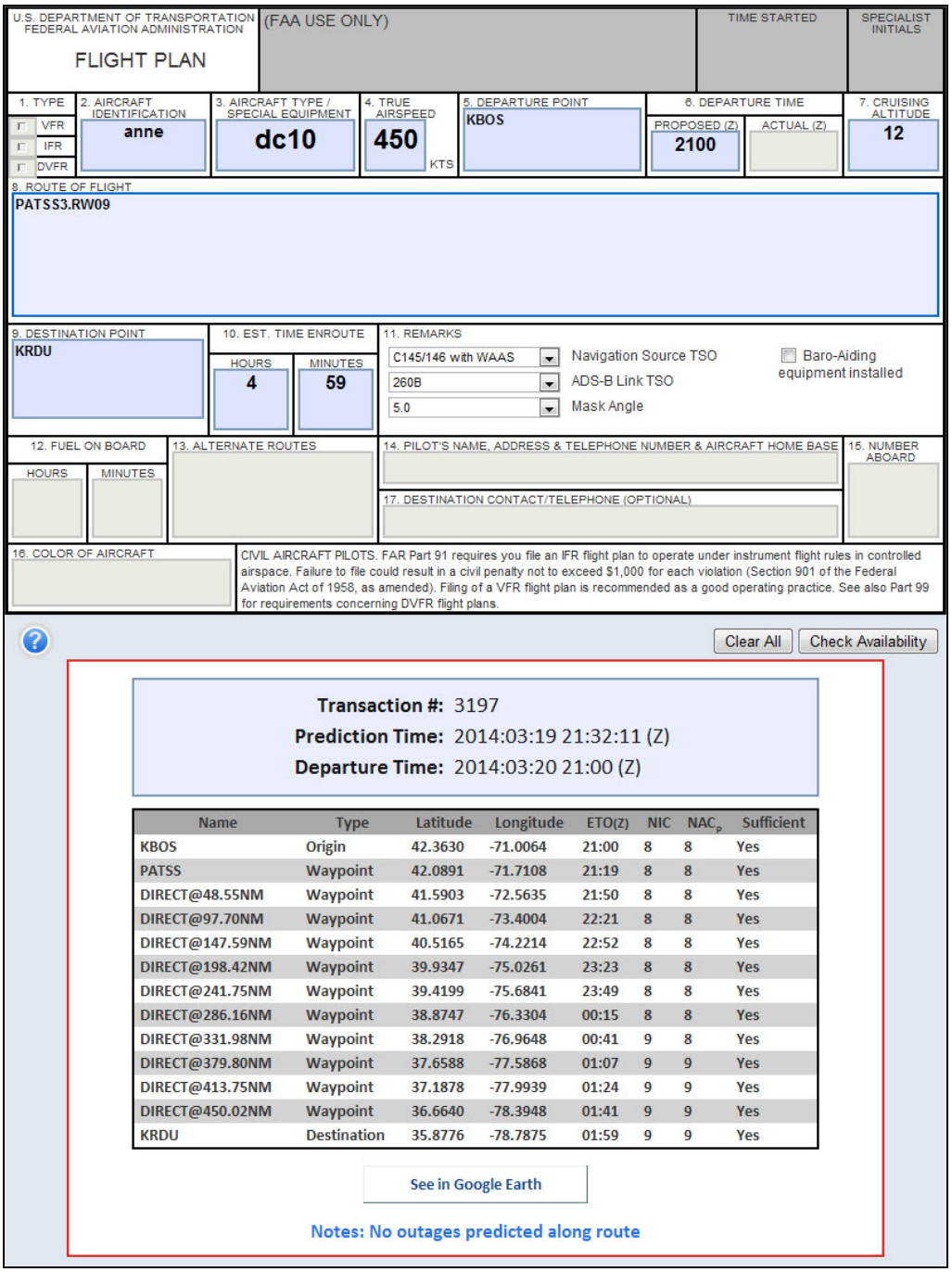


Figure 7-20: Flight Plan Form with Prediction

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 which you enter. The tip box appears where you last clicked the left mouse button. 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:

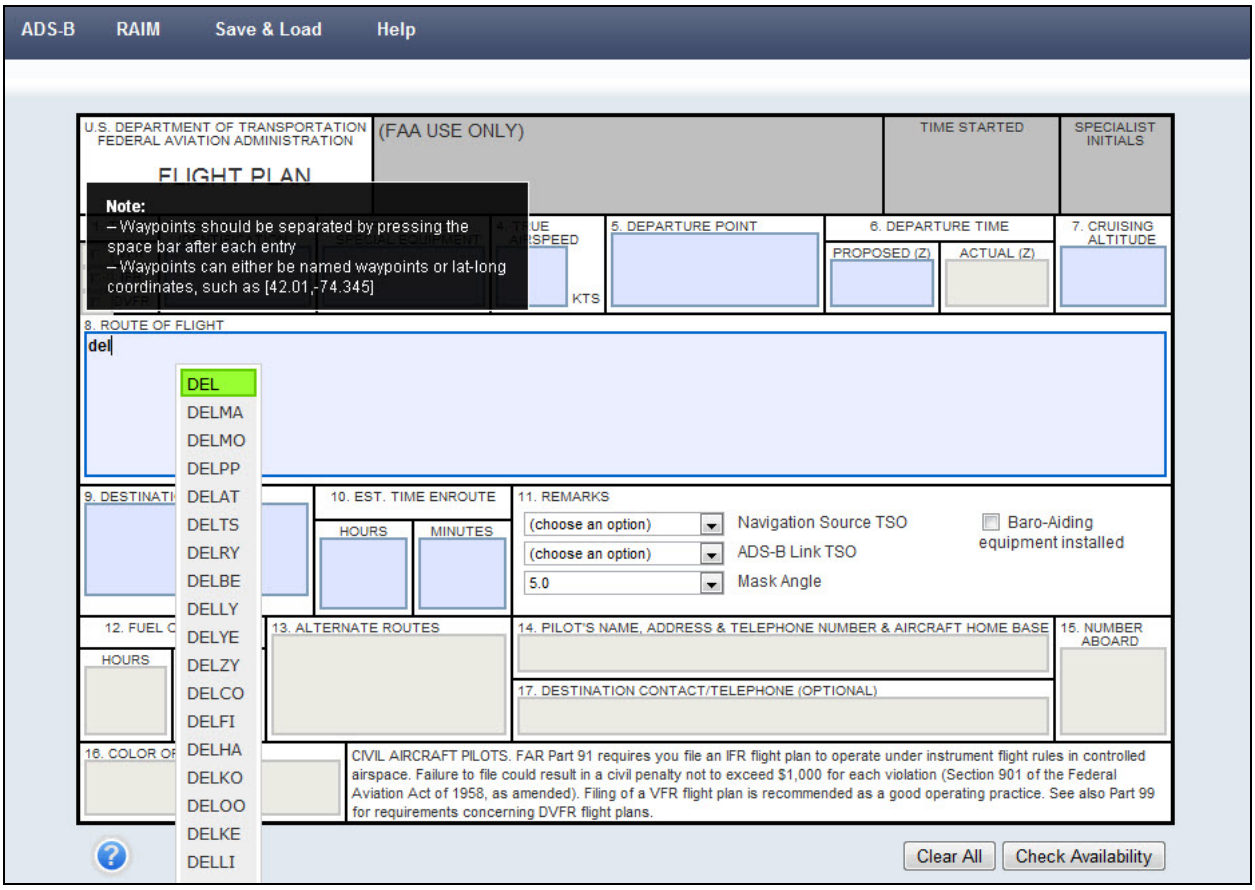


Figure 7-21: Field and Suggestion Tip Box

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 on the list of nearby suggestions.

There is a further pop-up tool tip on how to save a flight plan. Click the blue question mark in the bottom left corner [ ] to launch it:

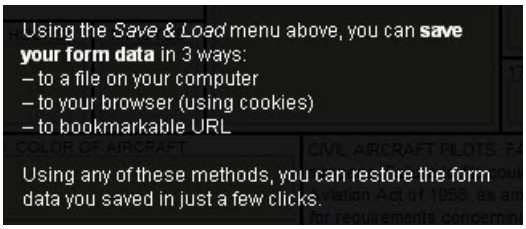


Figure 7-22: Save & Load Menu Pop-up Tip

7.7 SAVING AND LOADING A FLIGHT PLAN

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

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 7-23: Flight Plan Saving Options:

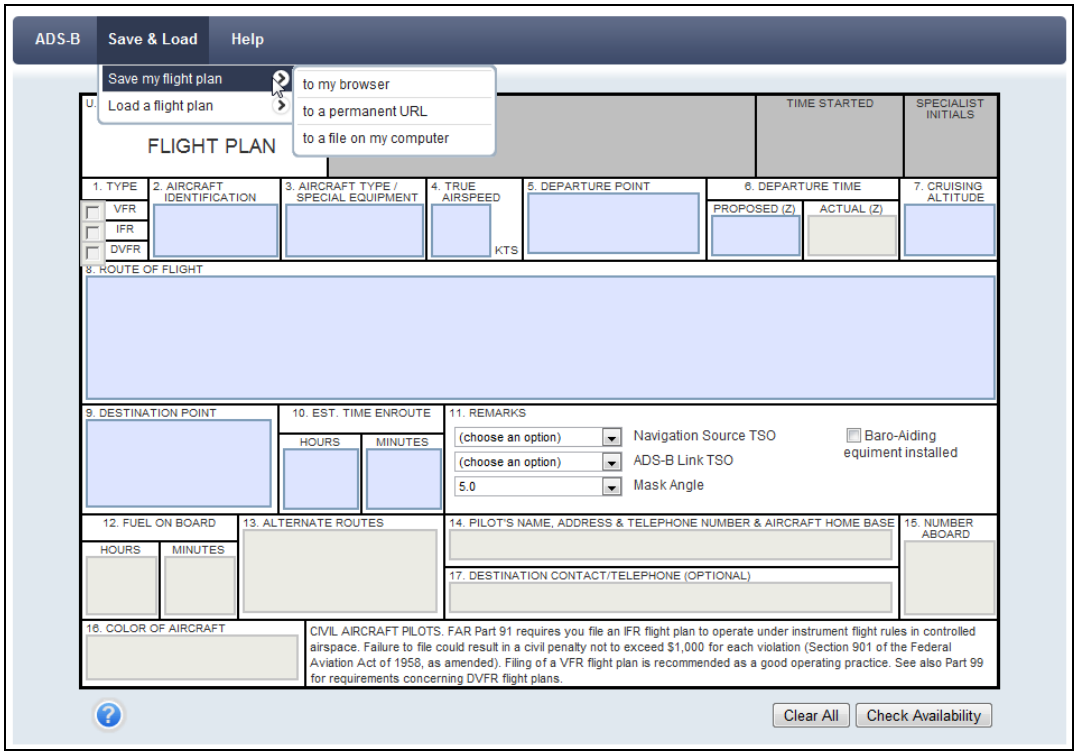


Figure 7-23: Flight Plan Saving Options

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 7-24: 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."

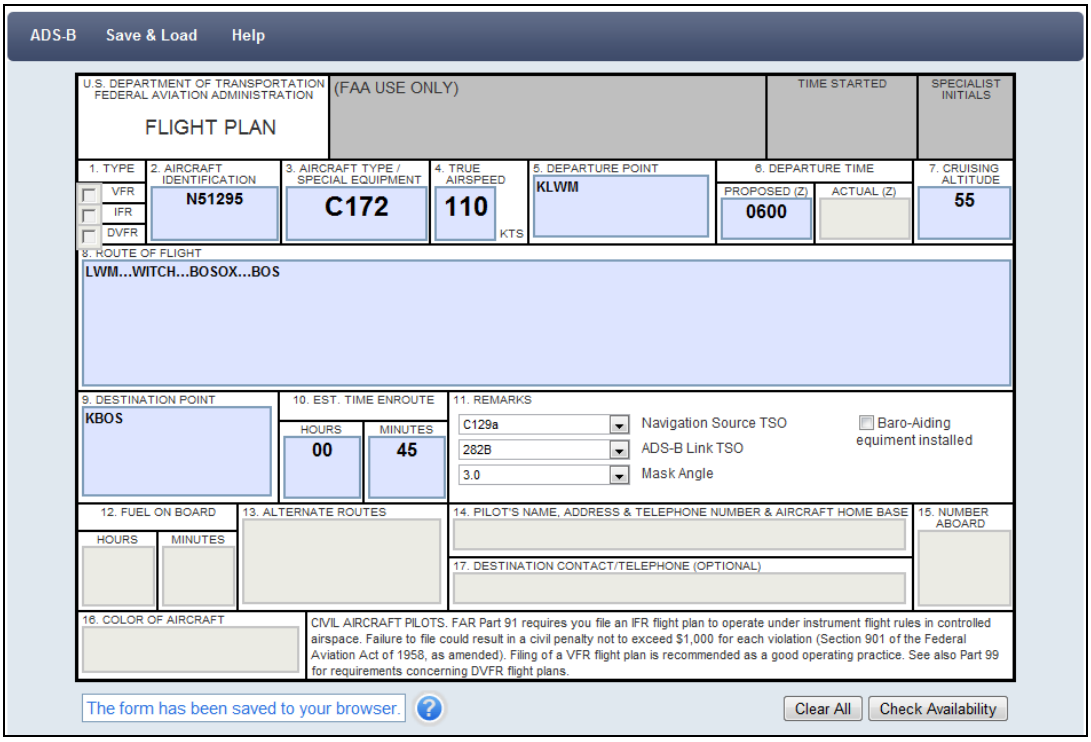


Figure 7-24: Flight Plan Form Saved to a Browser Notification Message

7.7.1.2 Save to Uniform Resource Locator 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 7-25: 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's 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:

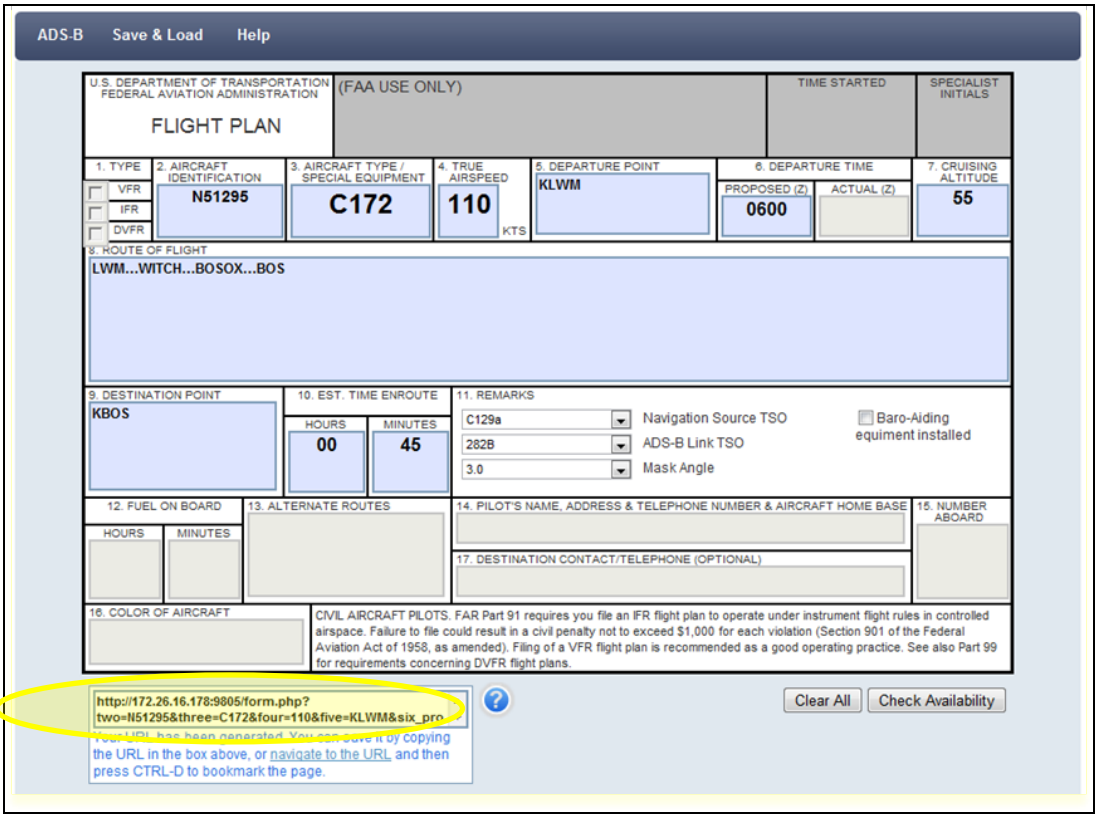


Figure 7-25: Flight Plan Form Written to a URL Notification Message

7.7.1.3 Save As A Computer File Option

When you elect to save your flight plan ‘to a file on my computer’, the field information is saved to a text file on your computer.

- Step 1. You will be requested to “Click here to download the save file” at the bottom of the Flight Plan Form, as shown in Figure -26: Flight Plan Form Saved to a File—Notification Message.

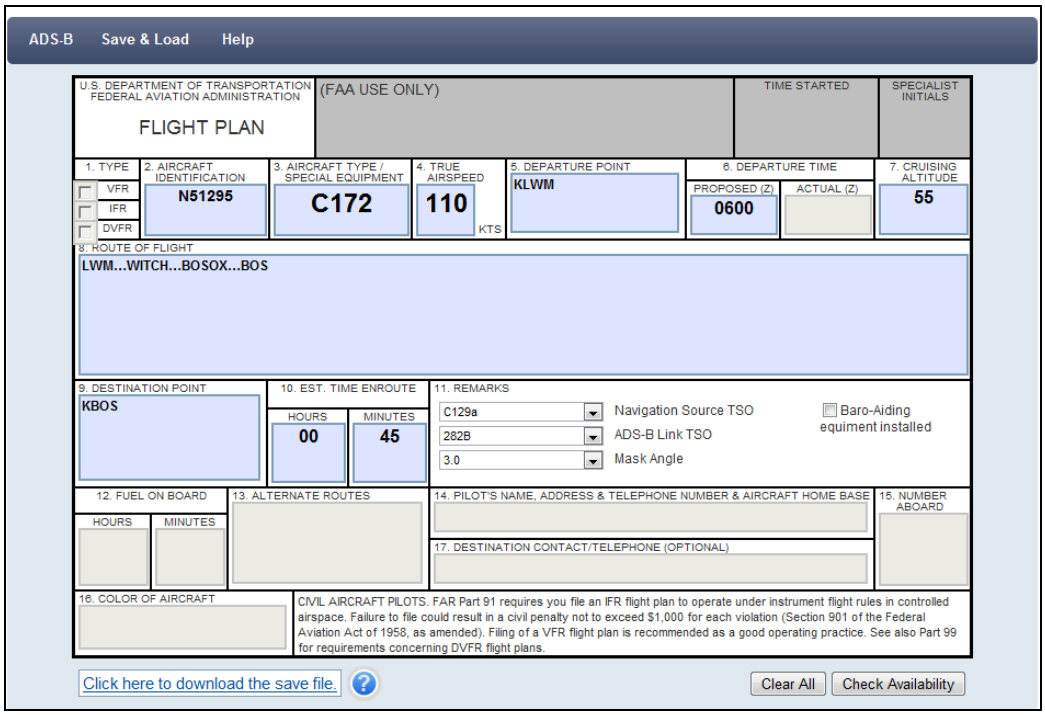


Figure 7-26: Flight Plan Form Saved to a File—Notification Message

- Step 2. 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?"

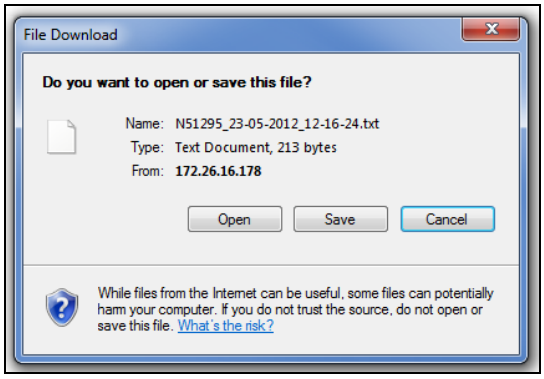


Figure 7-27: Flight Plan Form Saved to a Computer File—File Download Box

- Step 3. 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 7-28: Flight Plan Form Saved to a Computer File—Save As Box.

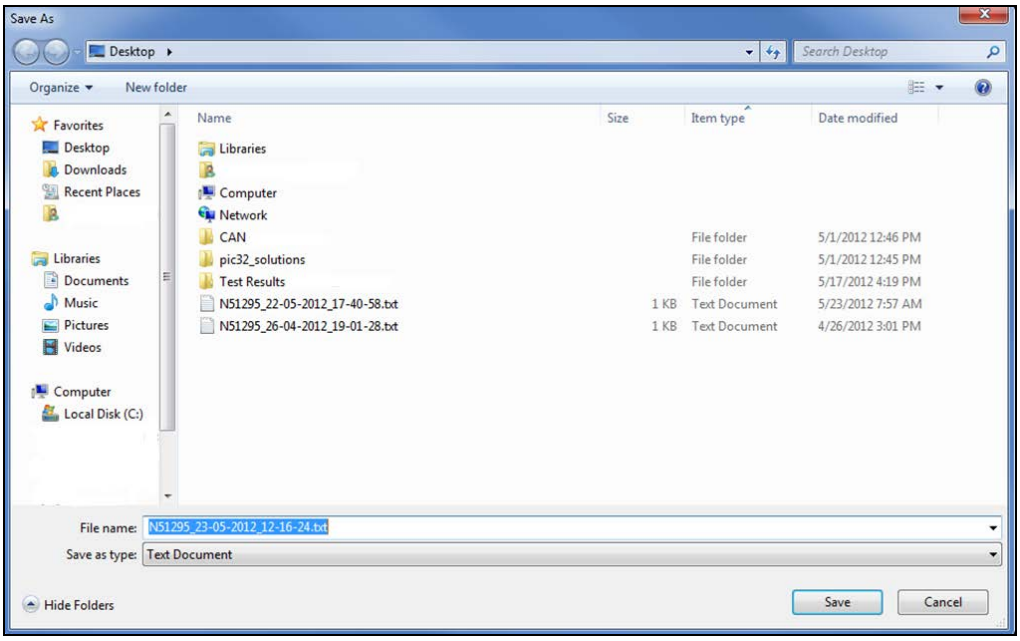


Figure 7-28: Flight Plan Form Saved to a Computer File—Save As Box

- Step 4. Enter that information and then click **SAVE**.

7.7.2 Loading Saved Data

You can load previously saved field information in three ways:

- From 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 7-29: Flight Plan Form Loading Options, you must first navigate to the Flight Plan Form.

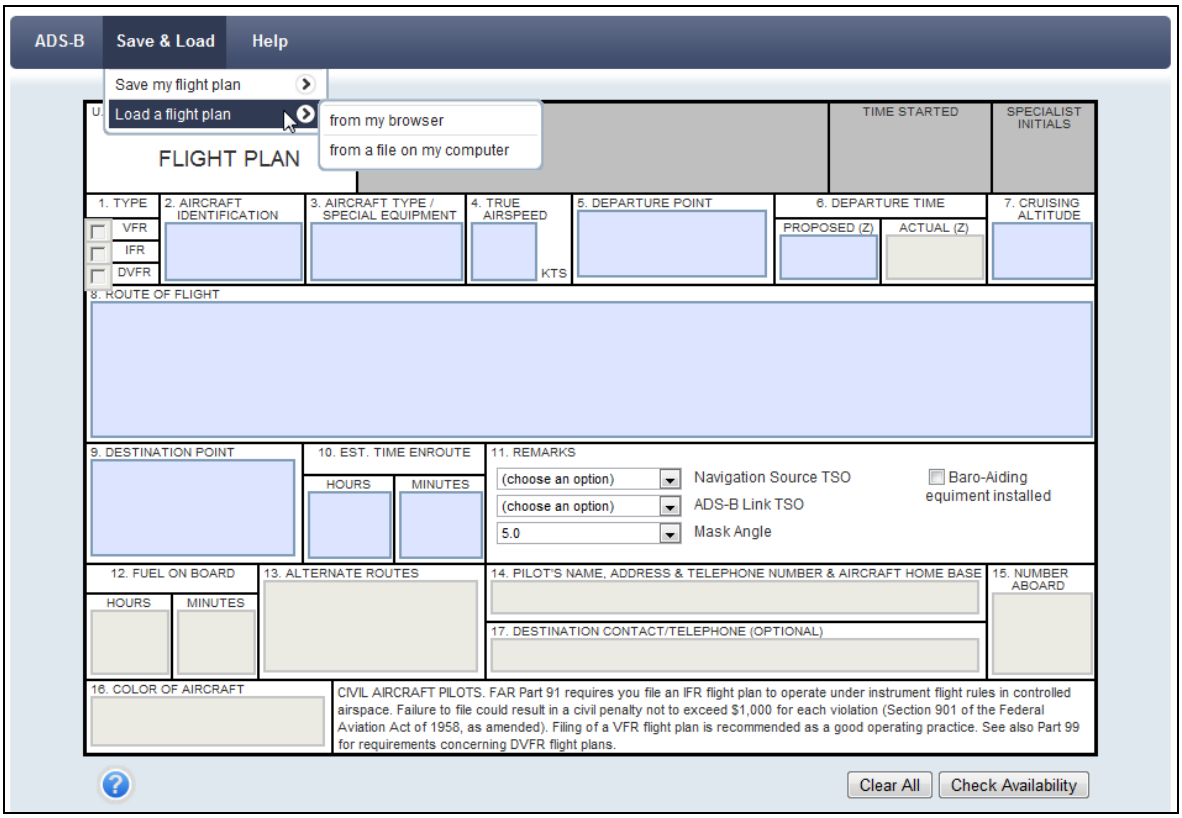


Figure 7-29: Flight Plan Form Loading Options

7.7.2.1 Load Data From Browser

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 7-30: Flight Plan Form Loading Options--Browser below:

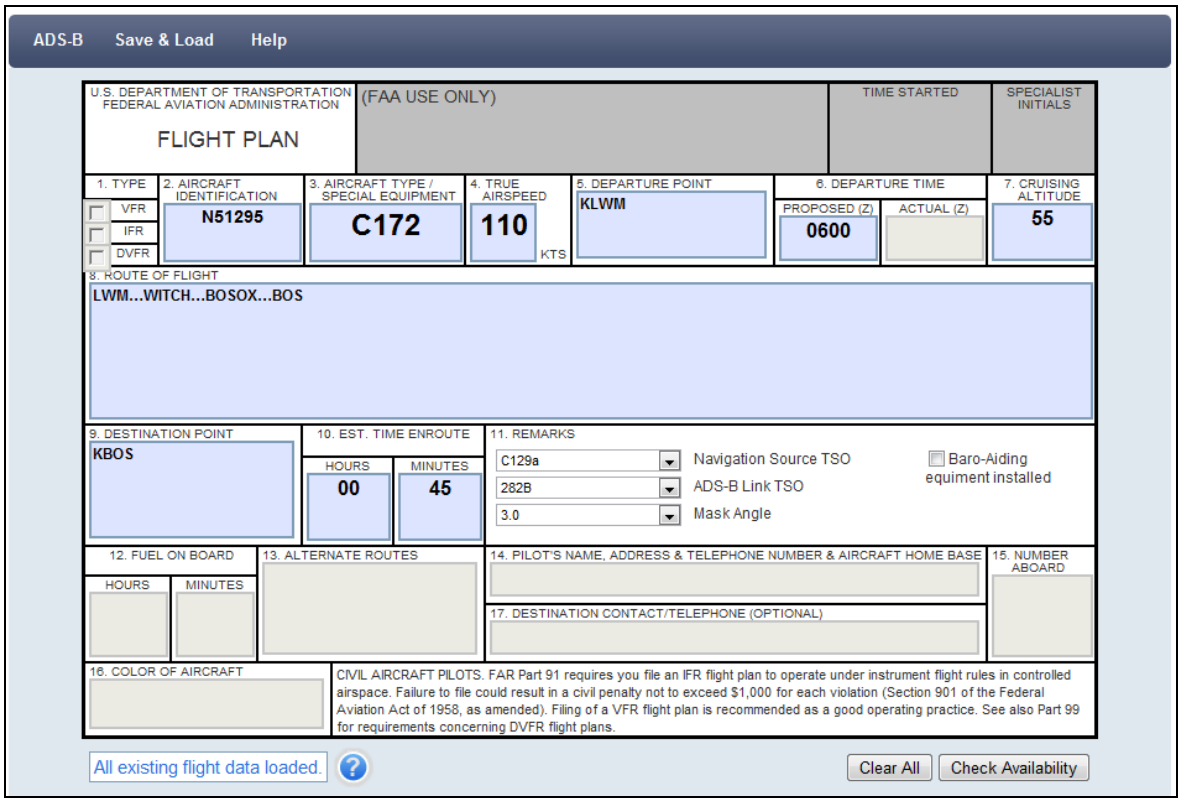


Figure 7-30: Flight Plan Form Loading Options--Browser

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 saved data from a text file to the Flight Plan Form.

- Step 1. Choose "Select the file on your computer to load" at the bottom of the Flight Planning Form, as shown in Figure 7-31: Flight Plan Form Loading Options—File.

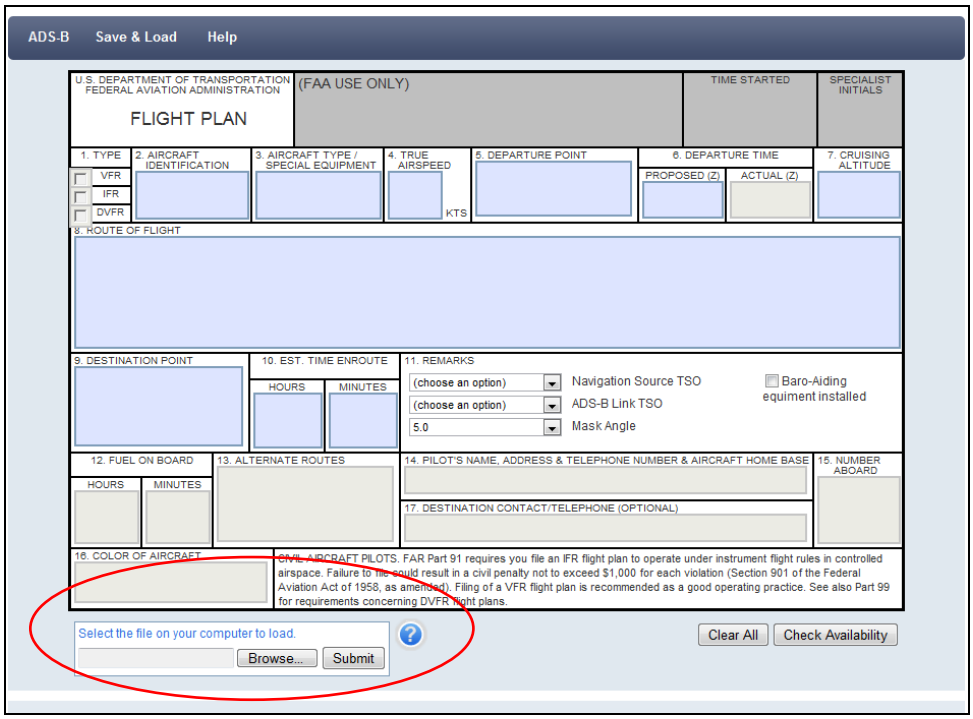


Figure 7-31: Flight Plan Form Loading Options—File

- Step 2. When you click **BROWSE** a pop-up box opens with the prompt, "Choose File to Upload," as displayed in Figure 7-32: Flight Plan Form Loading a File—Choose a File to Upload:

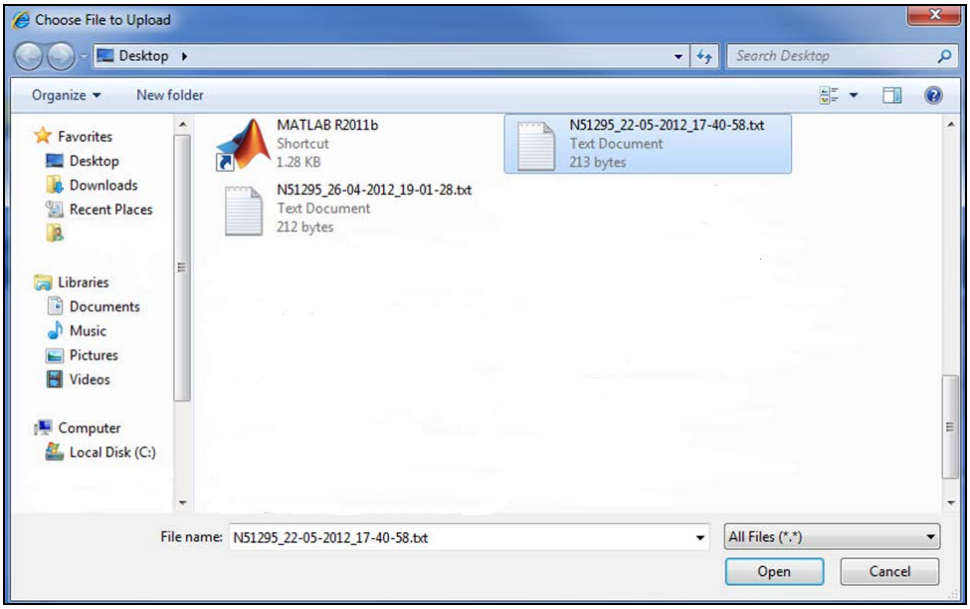


Figure 7-32: Flight Plan Form Loading a File—Choose a File to Upload

- Step 3. Select the desired file and click **OPEN**, which will enter the file name and location

in the box at the bottom of the Flight Planning Form.

- Step 4. Click **SUBMIT** to populate the fields with the information in the file.

7.8 PREDICTION OUTPUT

After you submit a flight plan request, the SAPT will issue a response outlined in red. This result will be shown at the bottom of the form, as illustrated in Figure 7-33: Flight Plan Prediction Results.

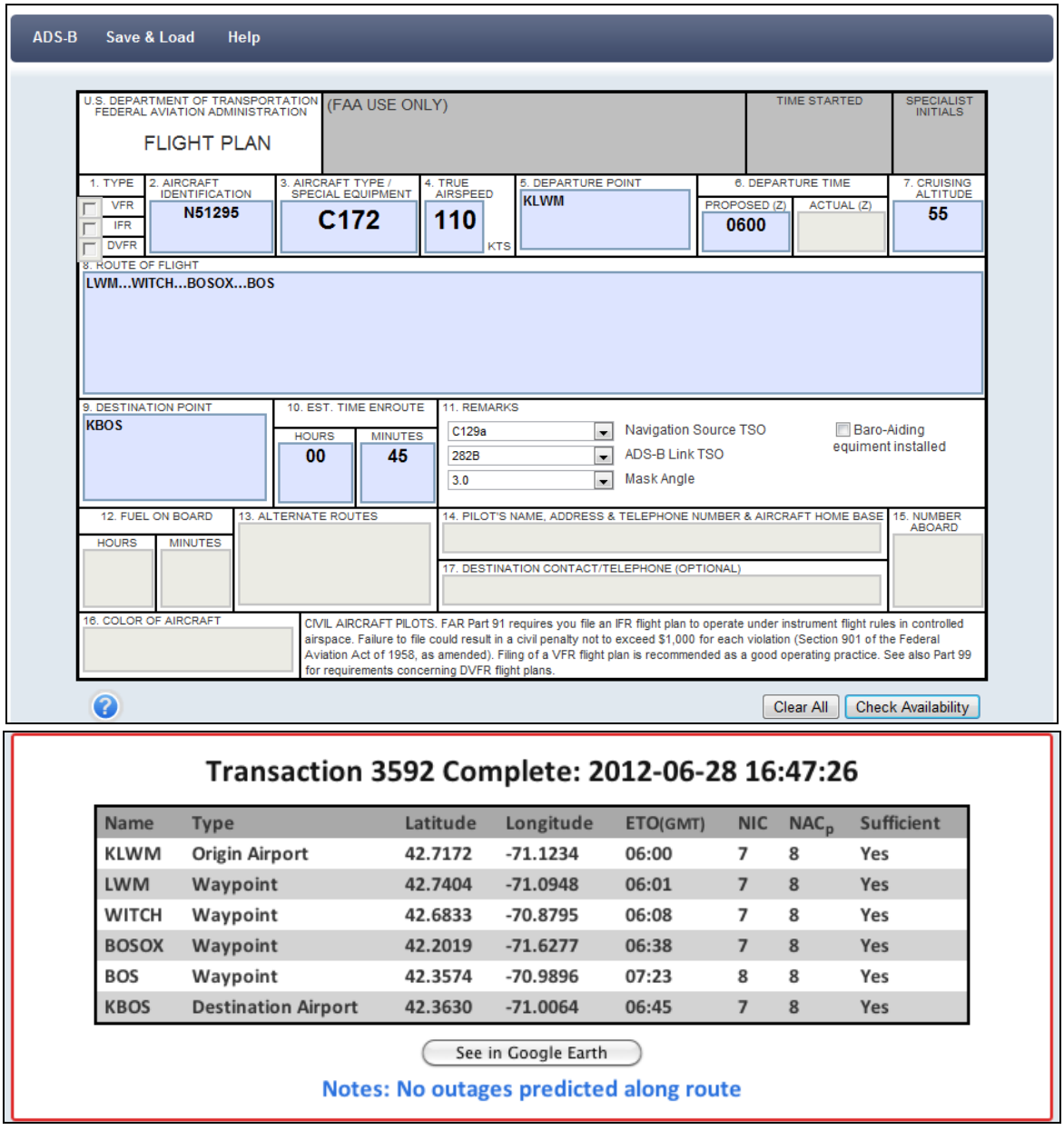


Figure 7-33: Flight Plan Prediction Results

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:

- Name of the point
- Type of waypoint
- Latitude
- Longitude
- ETO (in Greenwich Mean Time (GMT))
- NIC
- NACp
- Sufficiency

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.

7.8.2 Interpreting the Results

You must interpret the flight information that is returned. You must determine if the route and time that you chose will be adequate to support ADS-B surveillance. The primary SAPT indicator in that determination is the sufficiency value.

7.8.2.1 Sufficiency

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

Under the Baseline 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,” do not use that route. In this case you 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 therefore 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. While the SAPT does not generate a formal flight plan, you may want to print the form and prediction for your records.

7.8.2.2 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 the hour. A sample of this type of notification is provided in Figure 7-34: Sufficiency Suggestion.

Since TSO-C129 provides the worst-case results with respect to availability, the system will use TSO-C129 SA-ON, and search for a time that may provide better results.

Figure 7-34: Sufficiency Suggestion

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)

If the tool returns a suggested time, it does not mean that the suggested time will definitely work. While the suggestion process uses a quick algorithm intended to save you time, it is your responsibility to verify that suggested time by modifying your prediction request – either forward or backward in time – and re-running the SAPT. If the system cannot provide a suggestion, it will notify you of that fact. In such cases, a change of route may be advised.

7.8.2.3 Inserted/Redundant Route Points

The system will add points to the route of flight as required to guarantee that the distance between points is never greater than 60 NM. If the sum of the distances between a middle point (i.e., a point between two other points) and its two neighboring points is less than five NM, the

middle point will be marked as redundant and NIC/NACp values will not be calculated separately for that point.

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.

7.8.3 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 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.

7.8.3.1 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 7-35: Large Area Graphical Display, includes four configurations:

- Configuration 1: TSO-C129, 5-degree mask angle
- Configuration 2: TSO-C129, 2-degree mask angle
- Configuration 3: TSO-C196, 5-degree mask angle
- Configuration 4: TSO-C196, 2-degree mask angle

Configuration 1 represents the worst-case scenario that you might encounter. Configuration 4 represents the best-case scenario, other than WAAS.

Note: Since WAAS has been identified as always meeting the required availability as defined by the ADS-B Final Rule, it was not recommended for inclusion. Configuration 2 will be slightly better than 1 but typically worse than 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.

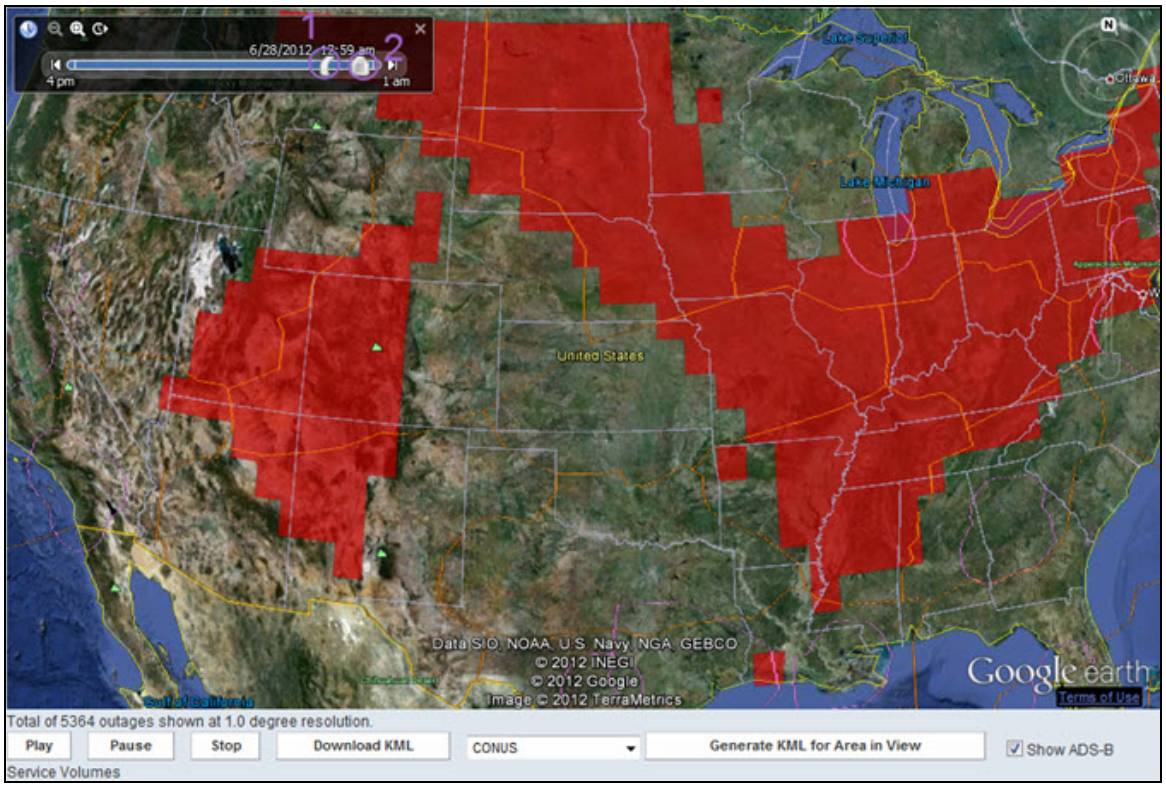


Figure 7-35: Large Area Graphical Display

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 7-35: Large Area Graphical Display, all outages over the next nine hours of the prediction window are shown.

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

A status message is shown below the lower left corner of the map, above **PLAY**. It will report when it is generating and retrieving the KML file, and it will report the total number of outages and the resolution when it is finished. A status message indicating that there are no outages is displayed while the map is rebuilding. The status message in Figure 7-35: Large Area Graphical Display is "Total of 5364 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 a drop-down menu or use the features of Google Earth™ to navigate to a custom region and display outages for that area 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" checkbox in the lower right corner allows you to show or hide the ADS-B Service Volume outlines.

A number of controls are available on this window:

- The large area display will play outages (in red) 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 7-35: 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 'Stop' are set at the lower left corner beneath the map.
  Clicking **PLAY** moves 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.
Clicking **PAUSE** halts the time slider at its current position, while clicking **STOP** resets it to its original position.

- A drop-down list to the right of **STOP** allows you to select a regional view for a more detailed view at a higher resolution. When you select a region, you must wait for the outages to be retrieved and displayed again. In Figure 7-36: 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.

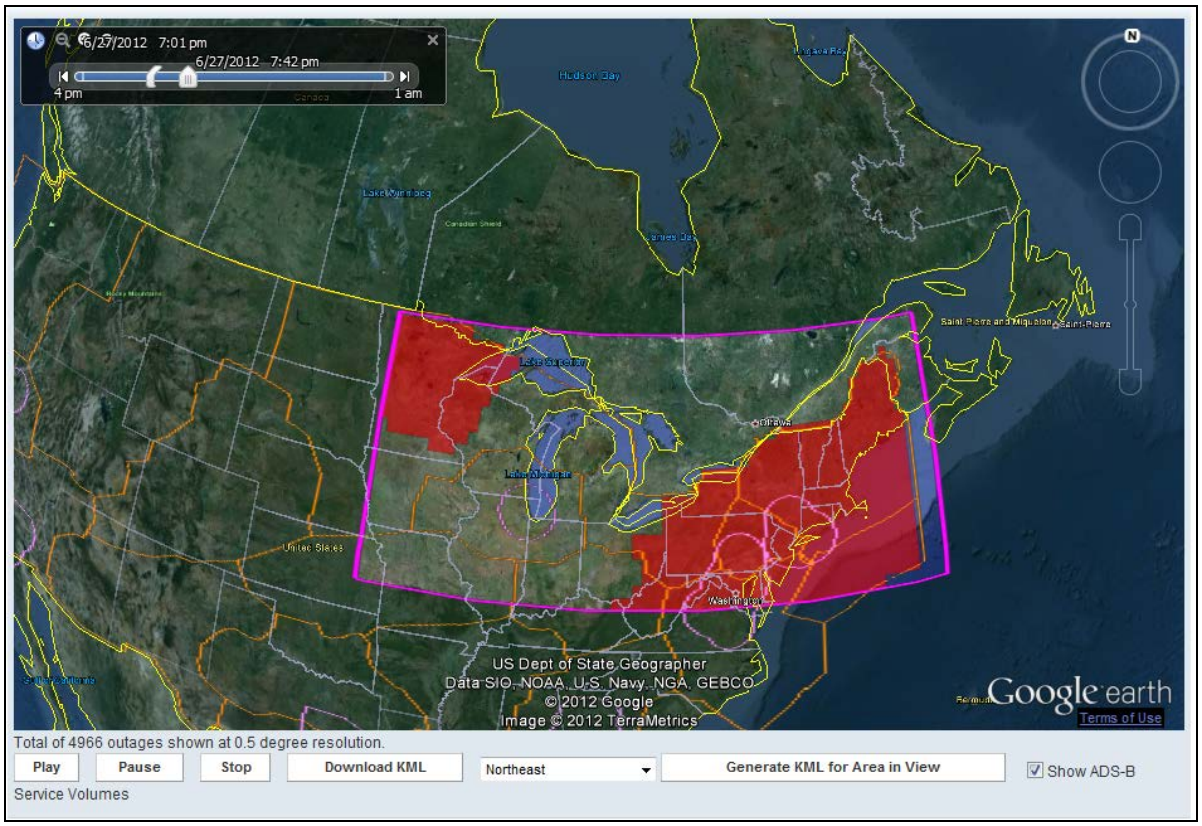


Figure 7-36: Northeast Region – Illustrated Selection

- 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 Kmlservlet.kml by default.
You may rename the file, but do not change the file extension from "kml." If you open the file in the browser, it should be displayed in the Google Earth™ plug-in application.

7.8.3.2 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.

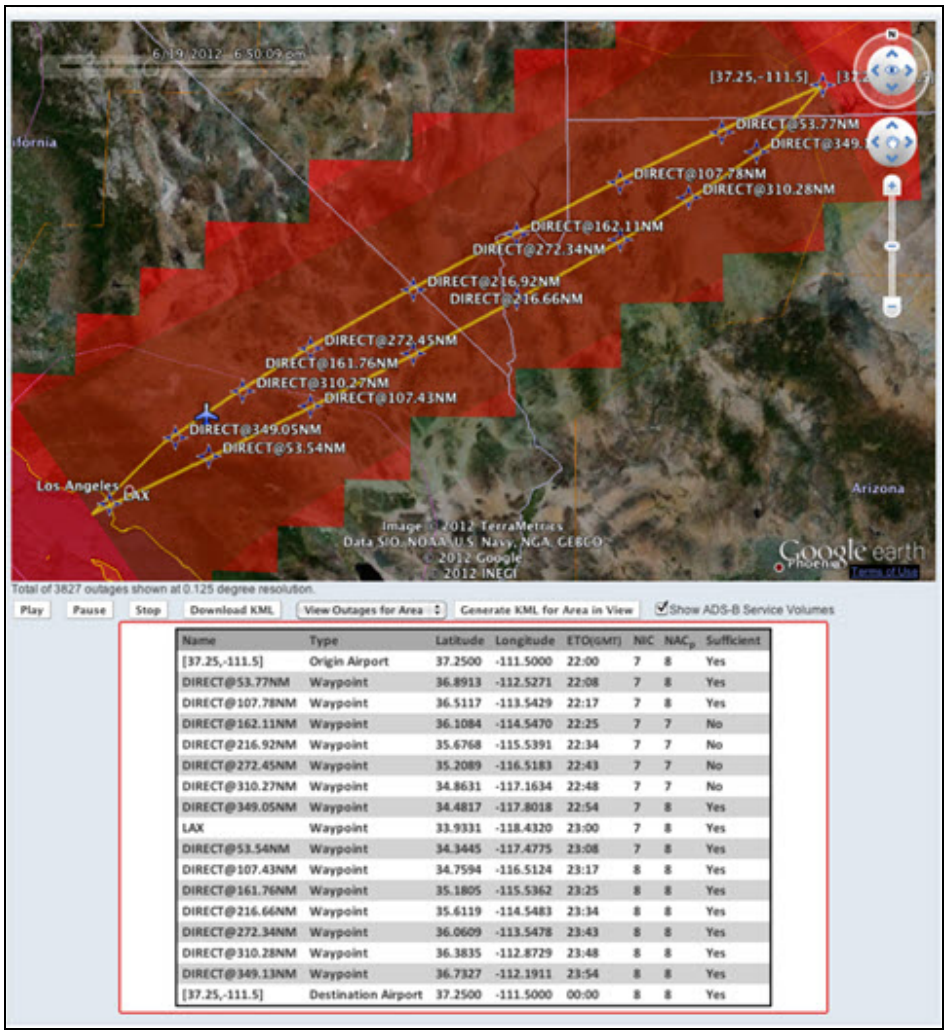
When you click **SEE IN GOOGLE EARTH** in the response on the Flight Plan Form, the route of flight will be superimposed on the Google Earth™ map above the list of route-points with Name, Type, Latitude, Longitude, ETO, NIC, NACp and Sufficiency.

The waypoints on the map will be labeled and hyperlinked. Click the hyperlinked waypoints to display the named route-point and ETO. The route-specific display includes standard 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 7-37: Route-Specific Graphical Display shows an example of a route-specific display:



Name	Type	Latitude	Longitude	ETO(GMT)	NIC	NAC_p	Sufficient
[37.25,-111.5]	Origin Airport	37.2500	-111.5000	22:00	7	8	Yes
DIRECT@53.77NM	Waypoint	36.8913	-112.5271	22:08	7	8	Yes
DIRECT@107.78NM	Waypoint	36.5117	-113.5429	22:17	7	8	Yes
DIRECT@162.11NM	Waypoint	36.1084	-114.5470	22:25	7	7	No
DIRECT@216.92NM	Waypoint	35.6768	-115.5391	22:34	7	7	No
DIRECT@272.45NM	Waypoint	35.2089	-116.5183	22:43	7	7	No
DIRECT@310.27NM	Waypoint	34.8631	-117.1634	22:48	7	7	No
DIRECT@349.05NM	Waypoint	34.4817	-117.8018	22:54	7	8	Yes
LAX	Waypoint	33.9331	-118.4320	23:00	7	8	Yes
DIRECT@53.54NM	Waypoint	34.3445	-117.4775	23:08	7	8	Yes
DIRECT@107.43NM	Waypoint	34.7594	-116.5124	23:17	8	8	Yes
DIRECT@161.76NM	Waypoint	35.1805	-115.5362	23:25	8	8	Yes
DIRECT@216.66NM	Waypoint	35.6119	-114.5483	23:34	8	8	Yes
DIRECT@272.34NM	Waypoint	36.0609	-113.5478	23:43	8	8	Yes
DIRECT@310.28NM	Waypoint	36.3835	-112.8729	23:48	8	8	Yes
DIRECT@349.13NM	Waypoint	36.7327	-112.1911	23:54	8	8	Yes
[37.25,-111.5]	Destination Airport	37.2500	-111.5000	00:00	8	8	Yes

Figure 7-37: Route-Specific Graphical 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 found under the browser “File” menu, as shown in Figure 7-38: Print a Prediction.

When you select a printer and click **PRINT**, the form should resemble the example shown in Figure 7-39: Sample Printed Prediction.

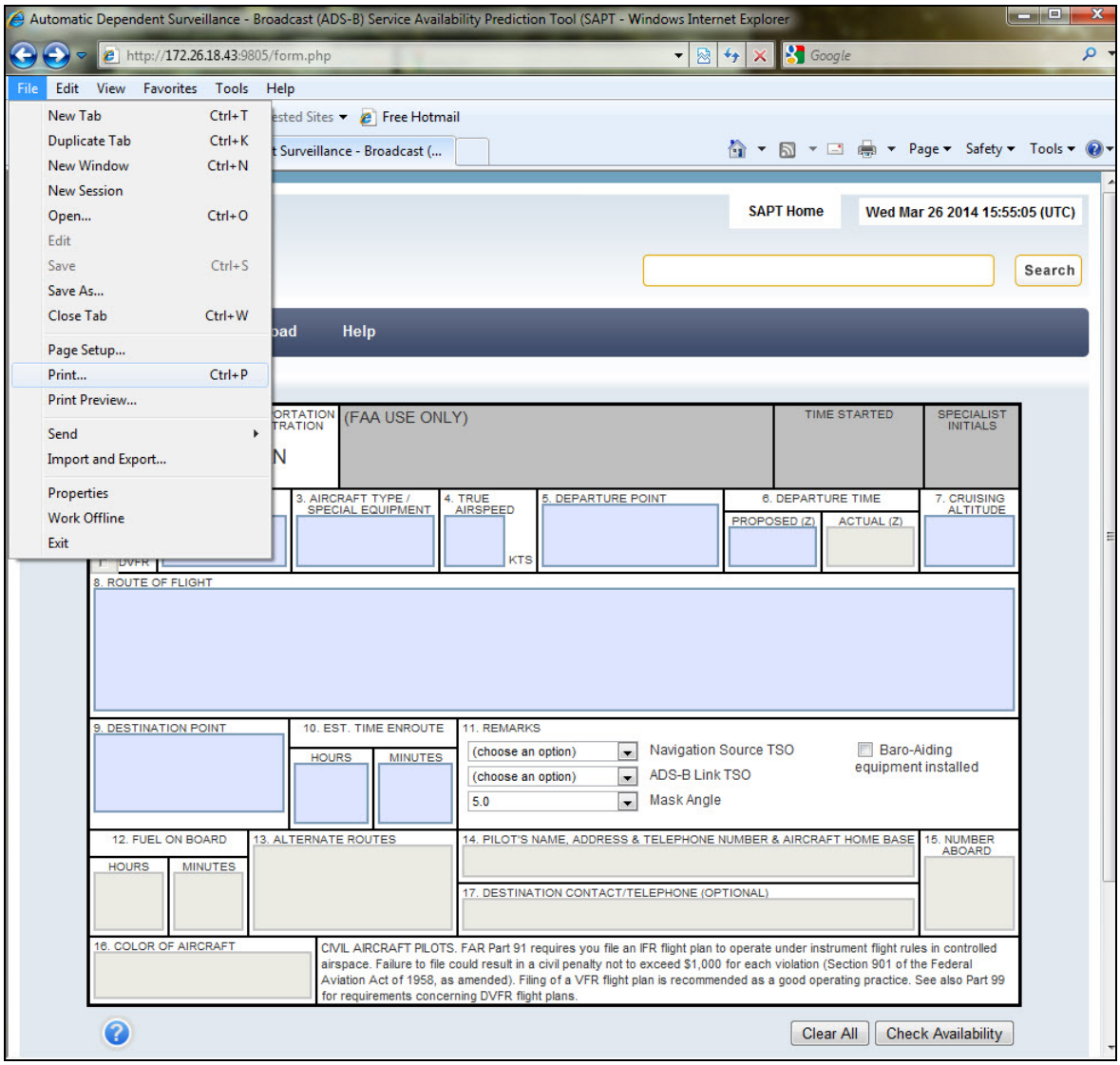
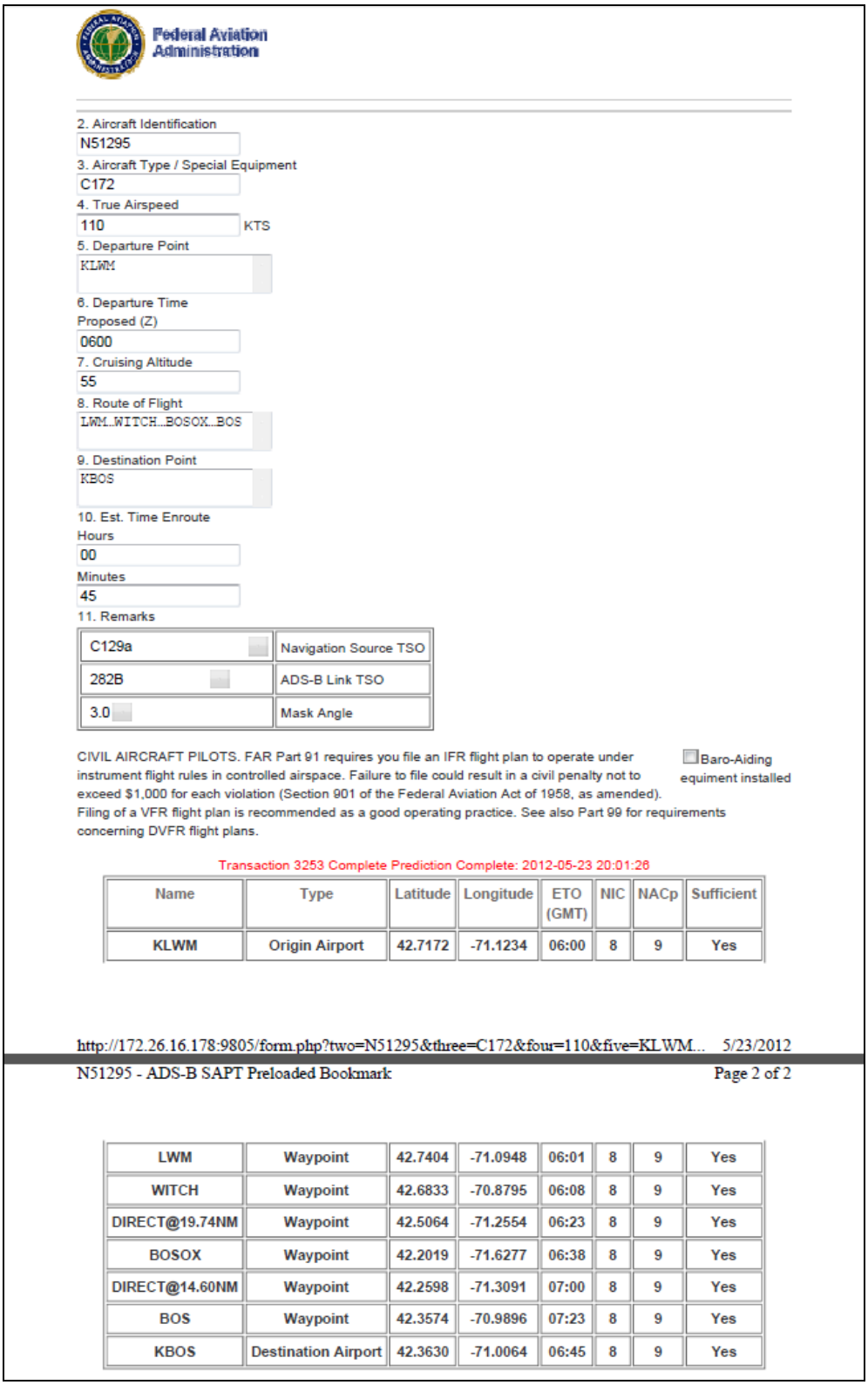


Figure 7-38: Print a Prediction Menu

A sample printed prediction is shown in the following illustration:



Federal Aviation Administration

2. Aircraft Identification
N51295
3. Aircraft Type / Special Equipment
C172
4. True Airspeed
110 KTS
5. Departure Point
KLWM
6. Departure Time
Proposed (Z)
0600
7. Cruising Altitude
55
8. Route of Flight
LWM..WITCH..BOSOX..BOS
9. Destination Point
KBOS
10. Est. Time Enroute
Hours
00
Minutes
45
11. Remarks

C129a	Navigation Source TSO
282B	ADS-B Link TSO
3.0	Mask Angle

CIVIL AIRCRAFT PILOTS. FAR Part 91 requires you file an IFR flight plan to operate under instrument flight rules in controlled airspace. Failure to file could result in a civil penalty not to exceed $1,000 for each violation (Section 901 of the Federal Aviation Act of 1958, as amended). Filing of a VFR flight plan is recommended as a good operating practice. See also Part 99 for requirements concerning DVFR flight plans.

Baro-Aiding equiment installed

Transaction 3253 Complete Prediction Complete: 2012-05-23 20:01:26

Name	Type	Latitude	Longitude	ETO (GMT)	NIC	NACp	Sufficient
KLWM	Origin Airport	42.7172	-71.1234	06:00	8	9	Yes
LWM	Waypoint	42.7404	-71.0948	06:01	8	9	Yes
WITCH	Waypoint	42.6833	-70.8795	06:08	8	9	Yes
DIRECT@19.74NM	Waypoint	42.5064	-71.2554	06:23	8	9	Yes
BOSOX	Waypoint	42.2019	-71.6277	06:38	8	9	Yes
DIRECT@14.60NM	Waypoint	42.2598	-71.3091	07:00	8	9	Yes
BOS	Waypoint	42.3574	-70.9896	07:23	8	9	Yes
KBOS	Destination Airport	42.3630	-71.0064	06:45	8	9	Yes

http://172.26.16.178:9805/form.php?two=N51295&three=C172&four=110&five=KLWM... 5/23/2012
N51295 - ADS-B SAPT Preloaded Bookmark Page 2 of 2

Figure 7-39: Sample Printed Prediction

8 ADS-B XML INTERFACE

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

If you use flight planning software from a third-party vendor, please contact the vendor and request that the XML web service be incorporated into the software. If you have more control over their flight planning software, please continue reading about the web service and then contact the SAPT Help Desk to get a copy of the WSDL file. 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 'SAPT20'. It updates the interface for ADS-B with some new features and also integrates the RAIM Prediction service.

You may request the 'SAPT20' WSDL through the ADS-B or RAIM XML pages. Please note that the ADS-B portion will not be fully functional until approximately mid-2015 when the 2.0 update is complete.

To request the WSDL from the ADS-B XML page, scroll to the bottom of the page and click the ‘I’d like a copy of the WSDL please!’ link, shown here:

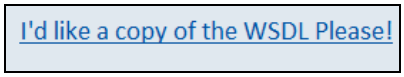


Figure 8-1: WSDL Request Link

Error! Reference source not found. is a Unified Modeling Language (UML) diagram of the various information classes and types employed by the web service.

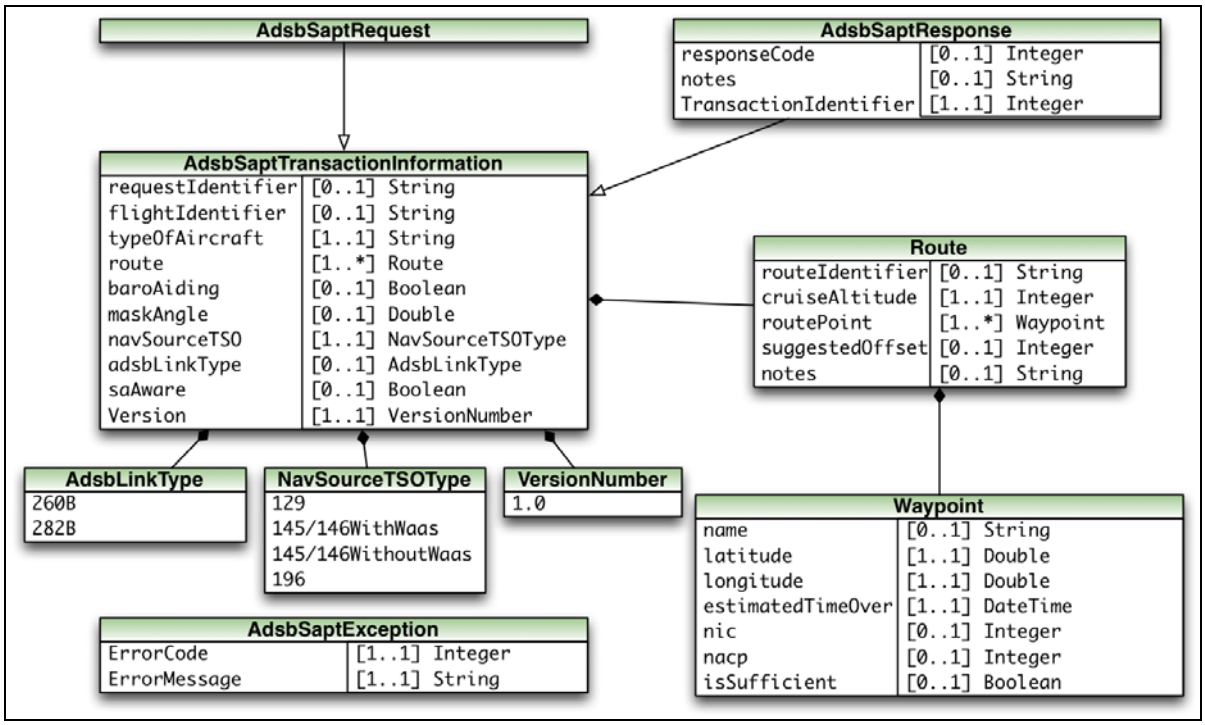


Figure 8-2: XML Web Service—Classes and Types

8.2 CLASSES AND TYPES

The primary class is the AdsbSaptTransactionInformation class, shown in Table 8-1, which contains all the information that requests and responses have in common.

The AdsbSaptRequest (refer to Table 8-6) contains only what is in AdsbSaptTransactionInformation, while the AdsbSaptResponse, shown in Table 8-2, contains more fields.

Table 8-3, Table 8-4, and Table 8-5 provide details about the Route, Waypoint, and AdsbSaptException information classes utilized by the XML web service:

Table 8-1: 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.
baroAiding	Boolean	No	True if the aircraft is equipped with a GPS-based navigation source that

Field Name	Type	Required?	Definition
			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	NavSourceTSOType	Yes	The TSO number for the navigation source.
adsbLinkType	AdsbLinkType	Yes	The TSO number for the aircraft's ADS-B transponder.
saAware	Boolean	No	True if the aircraft is equipped with a TSO-C129a navigation source. False otherwise. *Note: This field is ignored for any NavSourceTSOType other than "129."*
Version	VersionNumber	Yes	The version of the web service the user wants to use. *Note: This field is intended for future use; only version 1.0 is currently available.*

Table 8-2: ADS-B SAPT Response

Field Name	Type	Required?	Definition
responseCode	Integer	No	0 If the request was successfully processed, a negative number otherwise.
Notes	String	No	An explanation for a failed request and/or information about upcoming system outages/changes.
TransactionIdentifier	Integer	Yes	The transaction number assigned to the request by the system.

Table 8-3: Route

Field Name	Type	Required?	Definition
routeIdentifier	String	No	An optional string to identify the route.
cruiseAltitude	Integer	Yes	The cruising altitude of the flight between 0-51000 feet.
routePoint	Waypoint	Yes	A sequence of waypoints that make up the route.
suggestedOffset	Integer	No	Used only for the HTML flight planning form.
Notes	String	No	Any route-specific notes from the system.

Table 8-4: Waypoint

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	The NIC as predicted by the system. Anything provided by the user is overwritten by the system.
Nacp	Integer	No	The NACp as predicted by the system. *Note: Anything provided by the user is overwritten by the system.*
isSufficient	Boolean	No	Whether or not the NIC and NACp meet the requirements for the airspace containing the waypoint.

Table 8-5: 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 EXAMPLES

Table 8-6 and Table 8-7 provide examples of a valid AdsbSaptRequest and AdsbSaptResponse in XML form, respectively.

Table 8-6: 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>
      <getAdsbSaptPrediction>
         <requestIdentifier>RQSTID01</requestIdentifier>
         <flightIdentifier>TSTFLT1</flightIdentifier>
         <typeOfAircraft>AC10</typeOfAircraft>
         <route>
            <routeIdentifier>TSTRT1</routeIdentifier>
            <cruiseAltitude>35000</cruiseAltitude>
            <cruiseSpeed>450</cruiseSpeed>
            <routePoint>
               <name>KLWM</name>
```

```
            <latitude>42.71719</latitude>
            <longitude>-71.12341</longitude>
            <estimatedTimeOver>2013-05-08T23:41:08.986Z</estimatedTimeOver>
         </routePoint>
         <routePoint>
            <name>COTEE</name>
            <latitude>42.49506</latitude>
            <longitude>-71.11886</longitude>
            <estimatedTimeOver>2013-05-08T23:48:08.986Z</estimatedTimeOver>
         </routePoint>
         <routePoint>
            <name>SOSYO</name>
            <latitude>42.48734</latitude>
            <longitude>-71.43215</longitude>
            <estimatedTimeOver>2013-05-08T23:59:08.986Z</estimatedTimeOver>
         </routePoint>
         <routePoint>
            <name>BOSOX</name>
            <latitude>42.20188</latitude>
            <longitude>-71.62767</longitude>
            <estimatedTimeOver>2013-05-09T00:06:08.986Z</estimatedTimeOver>
         </routePoint>
         <routePoint>
            <name>GRIPE</name>
            <latitude>42.13579</latitude>
            <longitude>-71.90901</longitude>
            <estimatedTimeOver>2013-05-09T00:14:08.986Z</estimatedTimeOver>
         </routePoint>
         <routePoint>
            <name>GRAYM</name>
            <latitude>42.10118</latitude>
            <longitude>-72.03152</longitude>
            <estimatedTimeOver>2013-05-09T00:19:08.986Z</estimatedTimeOver>
         </routePoint>
         <routePoint>
            <name>WITNY</name>
            <latitude>42.04939</latitude>
            <longitude>-72.23665</longitude>
            <estimatedTimeOver>2013-05-09T00:24:08.986Z</estimatedTimeOver>
         </routePoint>
         <routePoint>
         <name>BDL</name>
            <latitude>41.94101</latitude>
            <longitude>-72.68857</longitude>
            <estimatedTimeOver>2013-05-09T00:29:08.986Z</estimatedTimeOver>
         </routePoint>
```

```
            <routePoint>
            <name>BRISS</name>
               <latitude>41.70129</latitude>
               <longitude>-73.01558</longitude>
               <estimatedTimeOver>2013-05-09T00:33:08.986Z</estimatedTimeOver>
            </routePoint>
            <routePoint>
               <name>K4B8</name>
               <latitude>41.69037</latitude>
               <longitude>-72.86482</longitude>
               <estimatedTimeOver>2013-05-09T00:38:08.986Z</estimatedTimeOver>
            </routePoint>
            <suggestedOffset>0</suggestedOffset>
            <notes/>
         </route>
         <baroAiding>false</baroAiding>
         <maskAngle>2.5</maskAngle>
         <navSourceTso>145/146WithWaas</navSourceTso>
         <adsbLinkType>260B</adsbLinkType>
         <Version>1.0</Version>
      </getAdsbSaptPrediction>
   </soapenv:Body>
</soapenv:Envelope>
```

Table 8-7: 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>
<getAdsbSaptResponse xmlns="">
<requestIdentifier>RQSTID01</requestIdentifier>
<flightIdentifier>TSTFLT1</flightIdentifier>
<typeOfAircraft>AC10</typeOfAircraft>
<route>
<routeIdentifier>TSTRT1</routeIdentifier>
<cruiseAltitude>35000</cruiseAltitude>
<cruiseSpeed>450.0</cruiseSpeed>
<routePoint>
<name>KLWM</name>
<latitude>42.71719</latitude>
<longitude>-71.12341</longitude>
<estimatedTimeOver>2013-05-08T23:41:00.000Z</estimatedTimeOver>
<nic>10</nic>
```

```
<nacp>10</nacp>
<isSufficientForAdsb>true</isSufficientForAdsb>
</routePoint>
<routePoint>
<name>COTEE</name>
<latitude>42.49506</latitude>
<longitude>-71.11886</longitude>
<estimatedTimeOver>2013-05-08T23:48:00.000Z</estimatedTimeOver>
<nic>10</nic>
<nacp>10</nacp>
<isSufficientForAdsb>true</isSufficientForAdsb>
</routePoint>
<routePoint>
<name>SOSYO</name>
<latitude>42.48734</latitude>
<longitude>-71.43215</longitude>
<estimatedTimeOver>2013-05-08T23:59:00.000Z</estimatedTimeOver>
<nic>10</nic>
<nacp>10</nacp>
<isSufficientForAdsb>true</isSufficientForAdsb>
</routePoint>
<routePoint>
<name>BOSOX</name>
<latitude>42.20188</latitude>
<longitude>-71.62767</longitude>
<estimatedTimeOver>2013-05-09T00:06:00.000Z</estimatedTimeOver>
<nic>10</nic>
<nacp>10</nacp>
<isSufficientForAdsb>true</isSufficientForAdsb>
</routePoint>
<routePoint>
<name>GRIPE</name>
<latitude>42.13579</latitude>
<longitude>-71.90901</longitude>
<estimatedTimeOver>2013-05-09T00:14:00.000Z</estimatedTimeOver>
<nic>10</nic>
<nacp>10</nacp>
<isSufficientForAdsb>true</isSufficientForAdsb>
</routePoint>
<routePoint>
<name>GRAYM</name>
<latitude>42.10118</latitude>
<longitude>-72.03152</longitude>
<estimatedTimeOver>2013-05-09T00:19:00.000Z</estimatedTimeOver>
<nic>10</nic>
<nacp>10</nacp>
```

```
<isSufficientForAdsb>true</isSufficientForAdsb>
</routePoint>
<routePoint>
<name>WITNY</name>
<latitude>42.04939</latitude>
<longitude>-72.23665</longitude>
<estimatedTimeOver>2013-05-09T00:24:00.000Z</estimatedTimeOver>
<nic>10</nic>
<nacp>10</nacp>
<isSufficientForAdsb>true</isSufficientForAdsb>
</routePoint>
<routePoint>
<name>BDL</name>
<latitude>41.94101</latitude>
<longitude>-72.68857</longitude>
<estimatedTimeOver>2013-05-09T00:29:00.000Z</estimatedTimeOver>
<nic>10</nic>
<nacp>10</nacp>
<isSufficientForAdsb>true</isSufficientForAdsb>
</routePoint>
<routePoint>
<name>BRISS</name>
<latitude>41.70129</latitude>
<longitude>-73.01558</longitude>
<estimatedTimeOver>2013-05-09T00:33:00.000Z</estimatedTimeOver>
<nic>10</nic>
<nacp>10</nacp>
<isSufficientForAdsb>true</isSufficientForAdsb>
</routePoint>
<routePoint>
<name>K4B8</name>
<latitude>41.69037</latitude>
<longitude>-72.86482</longitude>
<estimatedTimeOver>2013-05-09T00:38:00.000Z</estimatedTimeOver>
<nic>10</nic>
<nacp>10</nacp>
<isSufficientForAdsb>true</isSufficientForAdsb>
</routePoint>
<suggestedOffset>0</suggestedOffset>
<notes>null</notes>
</route>
<baroAiding>false</baroAiding>
<maskAngle>2.5</maskAngle>
<navSourceTso>145/146WithWaas</navSourceTso>
<adsbLinkType>260B</adsbLinkType>
<Version>1.0</Version>
```

```
<responseCode>0</responseCode>
<notes> Prediction Complete: 2013-05-08 19:41:09</notes>
<transactionIdentifier>401802</transactionIdentifier>
</getAdsbSaptResponse>
</soapenv:Body>
</soapenv:Envelope>
```

One difference between the Response and the Request is that the Response has seconds in all the DateTime fields set to zero. The system predicts at one-minute resolution and thus truncates seconds.

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, refer to Section 7.8.2.1. If a point does not have the 'isSufficientForAdsb' field it means the point is not within the defined ADS-B Service volume, and therefore 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 useful to the user, such as any planned system downtime. The XML response will also include a transaction ID unique to that specific transaction.

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.

Table 8-8 lists the error code, error message, and corrective actions a user should take for the less obvious error conditions.

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

Error Code	Error Message	Corrective Actions
-1	Unable to process request due to unknown Version Number Available version is 1.0	The version number currently must be set to 1.0. In future releases, the number will be incremented, as appropriate. The older version will remain set to 1.0 for backward compatibility purposes.
-2	Request must contain at least one route	An ADSB SAPT prediction must contain at least one route containing at least one point. The user should add a valid route to the request.
-3	Error Communicating with the Satellite Service Level Prediction Module	The user should retry the request. If the second request fails, the user should contact the helpdesk at sapthelpdesk@faa.gov.
-4	Error in processing transaction:	The user should correct any errors listed in the

Error Code	Error Message	Corrective Actions
	<further details>	further details. If the correction fails, the user should contact the helpdesk at sapthelpdesk@faa.gov.
-5	Time-out occurred waiting for response from Prediction Services	This error means the SSLPM was unable to process the request in a reasonable amount of time. This error could occur for the following reasons: ▪ A non-compliant request made during peak hours; ▪ A communication error on the server; or ▪ The server is experiencing a very heavy load. The user should retry the request. If the second request fails, the user should contact the helpdesk at sapthelpdesk@faa.gov.
-6	Unexpected Error Occurred	The user should first verify that the XML request is valid, and then retry the request. If the second request fails, the user should contact the helpdesk at sapthelpdesk@faa.gov.

9 RAIM PREDICTION TOOL

The TSO-C129 class of GPS receivers provides an integrity algorithm known as RAIM. RAIM is a form of integrity monitoring performed within the avionics themselves: it ensures available satellite signals meet the integrity requirements for a given phase of flight. The receiver performs the RAIM function in real-time, using the current constellation, excluding any satellite whose signal is broadcasting an "Unhealthy" (Do Not Use) condition. By comparing the pseudorange measurements of a number of satellites, the RAIM function can identify a satellite failure and issue an alert to the pilot. A minimum of five satellites is required to detect a bad satellite. TSO-C129 receivers also provide a prediction function that allows a pilot during pre-flight to predict RAIM availability for an intended GPS-based procedure. RAIM SAPT users can get information on satellite outages through the Notice to Airmen (NOTAM) system; the SAPT shows the effect of an outage on the intended operation by excluding satellites which are predicted to be out-of-service.

There are limitations in the receiver's prediction capability, some of which gave rise to Advisory Circular (AC) 90-100A. This circular outlines performance and functional criteria that should be met to conduct an RNAV procedure. The ability to predict compliance with these criteria during the flight pre-planning phase allows for greater flexibility and can potentially increase the use of GPS-based RNAV procedures (RNAV-GPS).

The website offers two RAIM interfaces. The first is through XML and the second through summary pages.

9.1 GETTING STARTED WITH RAIM

This page provides a summary introduction to the RAIM prediction tool and explains what users can accomplish in the web pages. It also lays out the limitations on the tool. This page is shown in the following image:

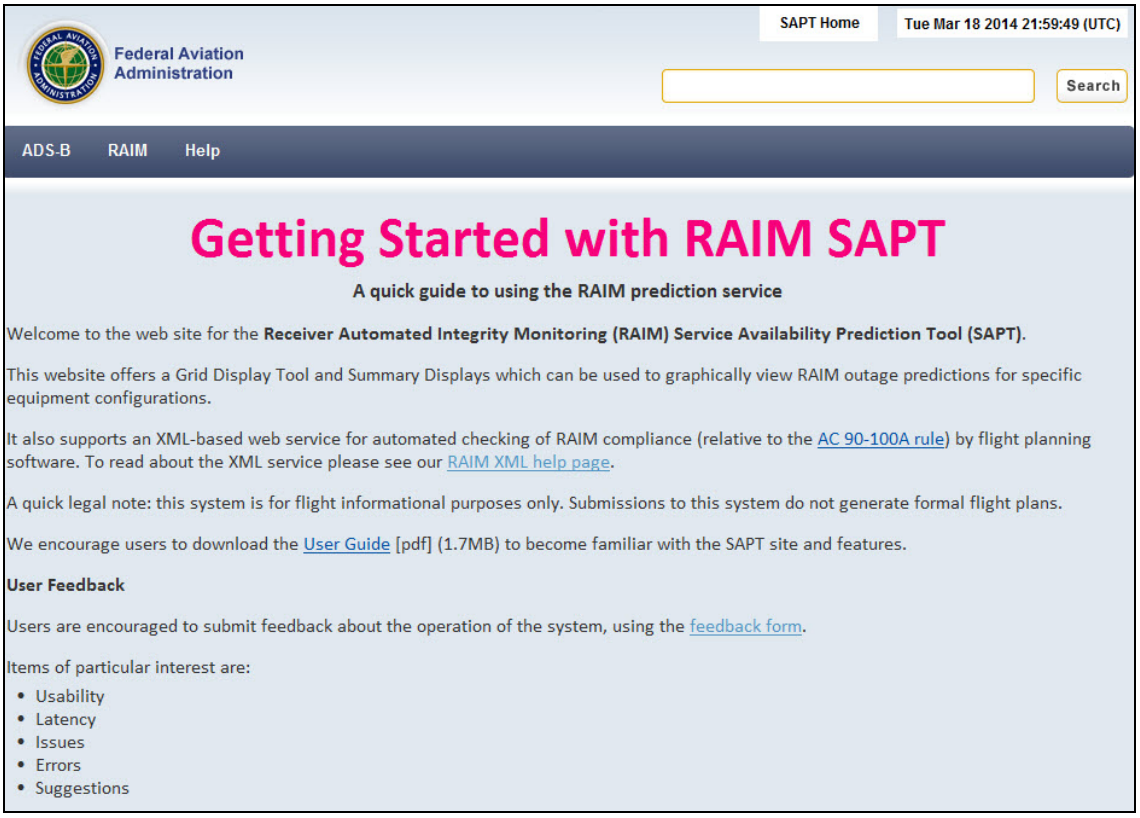


Figure 9-1: Getting Started with RAIM SAPT

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).

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 user's software supplies a desired HPL in the request XML and the RAIM model ensures that, within the specified confidence level, the user's actual position is within the HPL radius of the calculated position.

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.

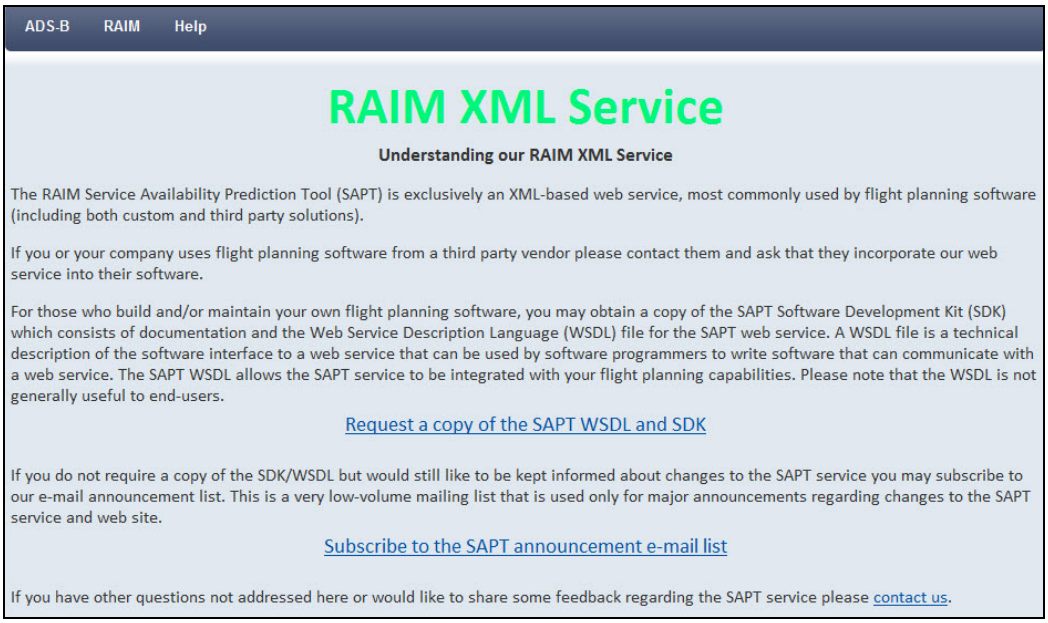


Figure 9-2: RAIM XML Service Page

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:

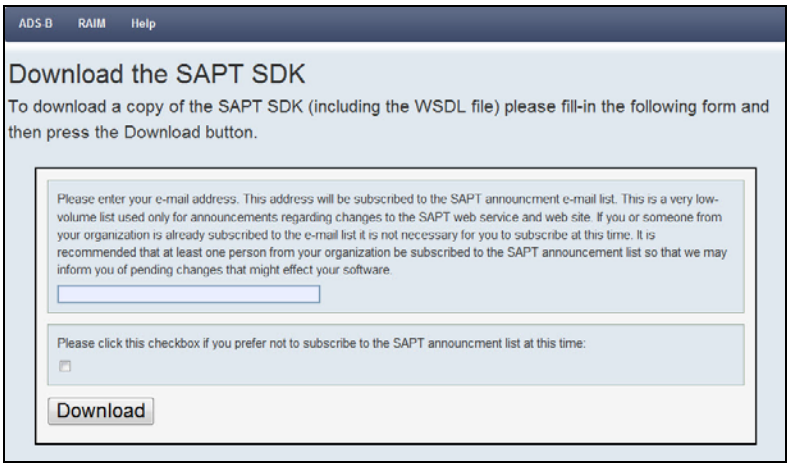


Figure 9-3: Download the SAPT SDK

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

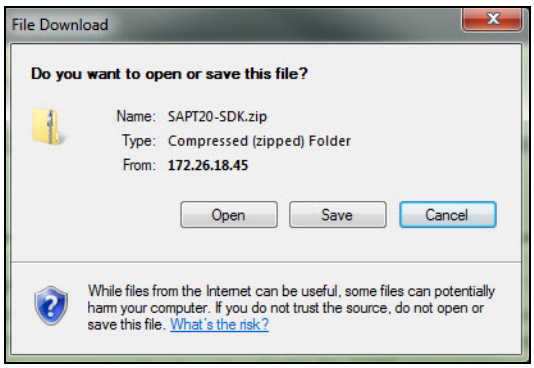


Figure 9-4: Download the SAPT SDK Pop-up

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

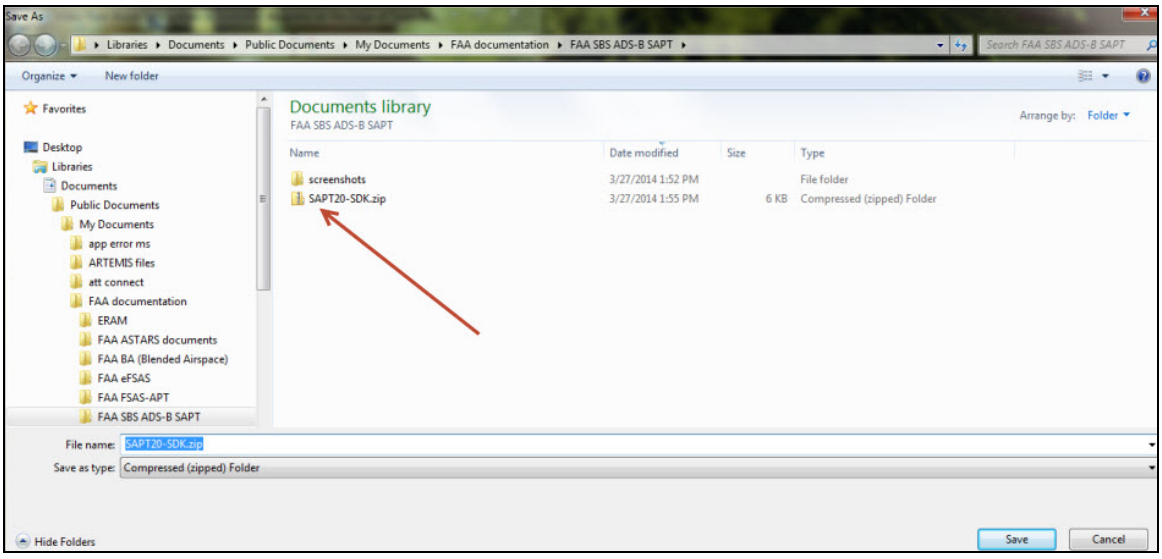


Figure 9-5: Save the SAPT SDK

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

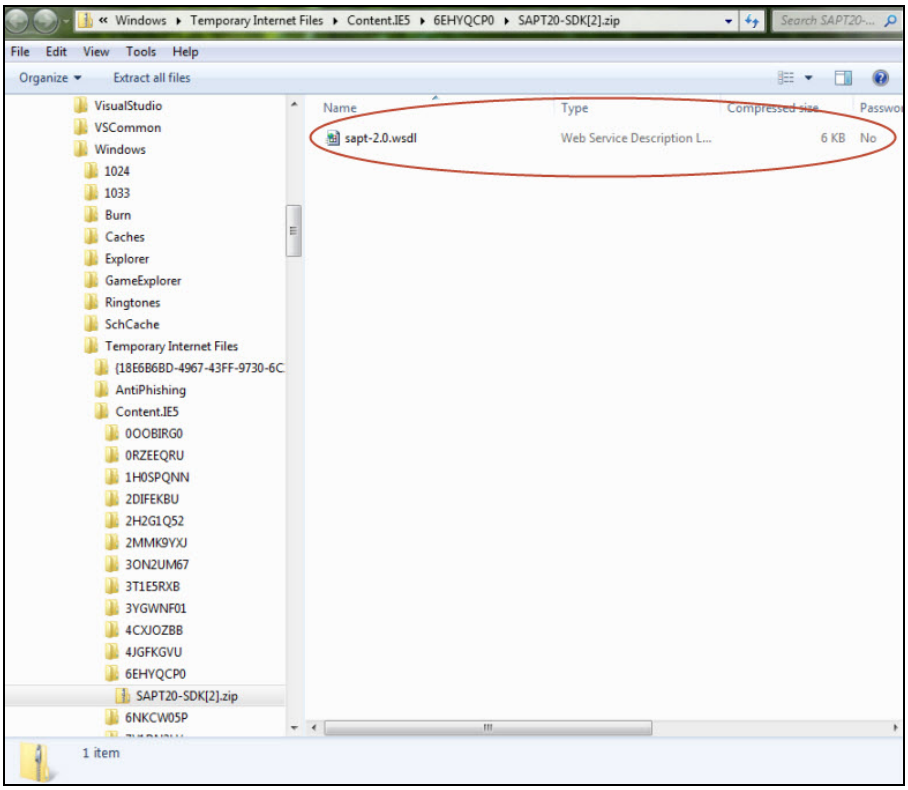


Figure 9-6: Download the SAPT SDK

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:

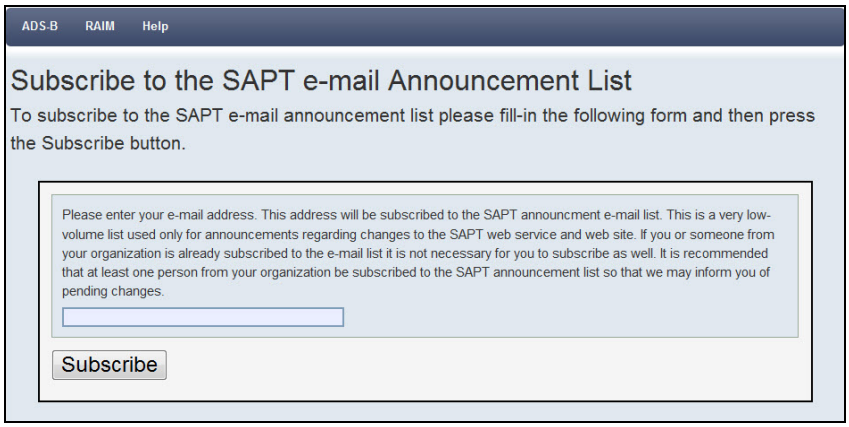


Figure 9-7: Download the SAPT SDK

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:

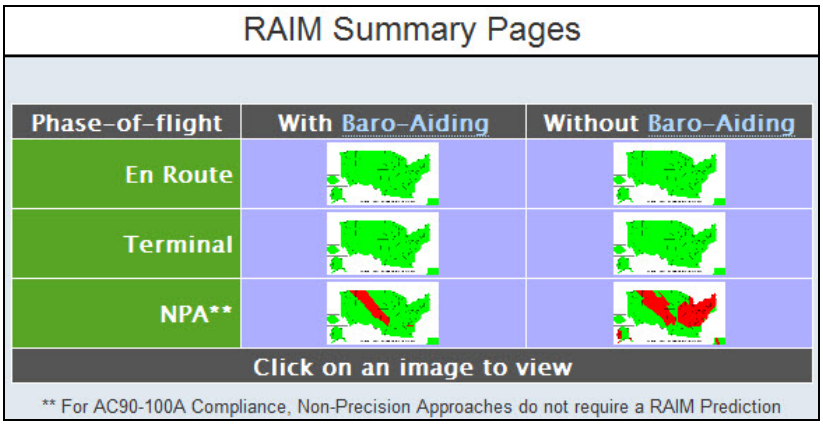


Figure 10-1: RAIM Summary Section

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:

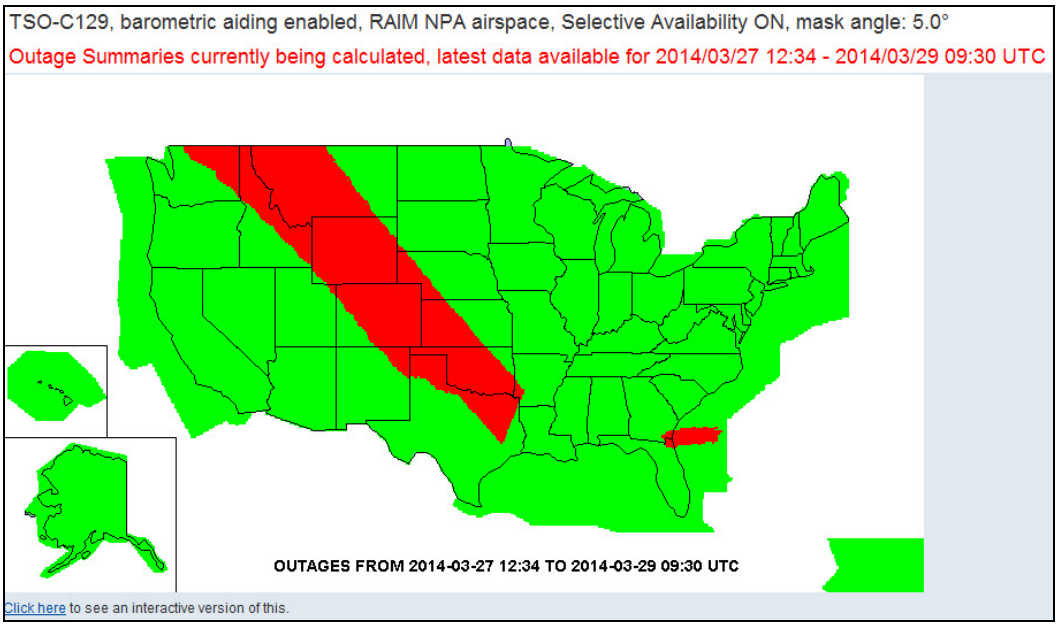


Figure 10-2: RAIM Summary – NPA Airspace, SA On & Baro-aiding Enabled

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 enabled and no barometric aiding:

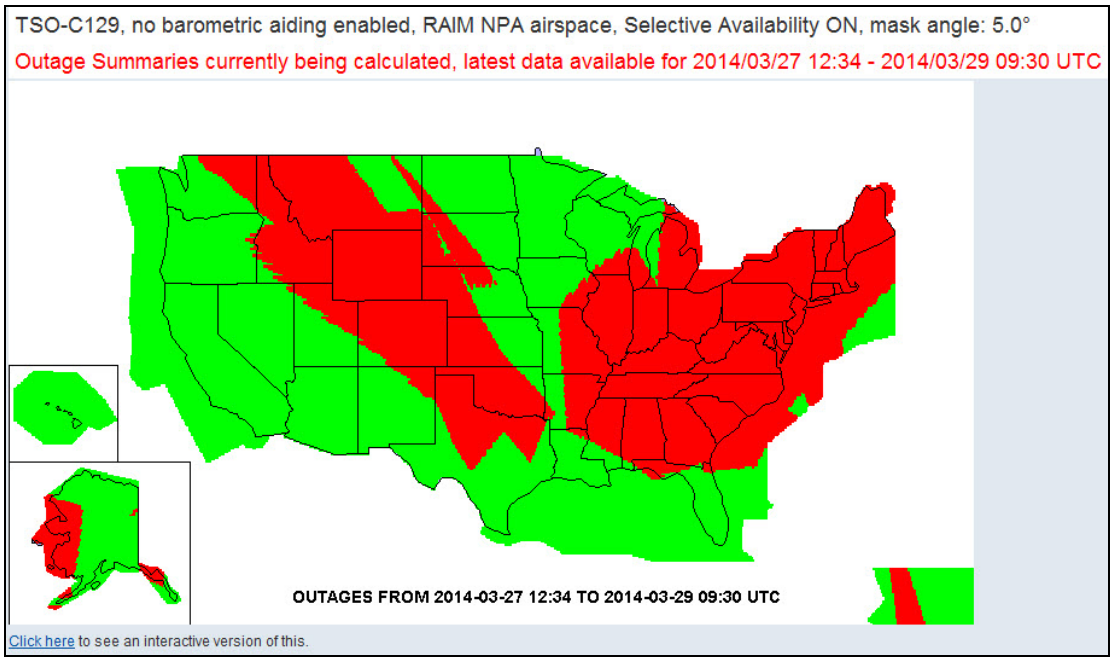


Figure 10-3: RAIM Summary – NPA Airspace, SA On & No Baro-aiding

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.

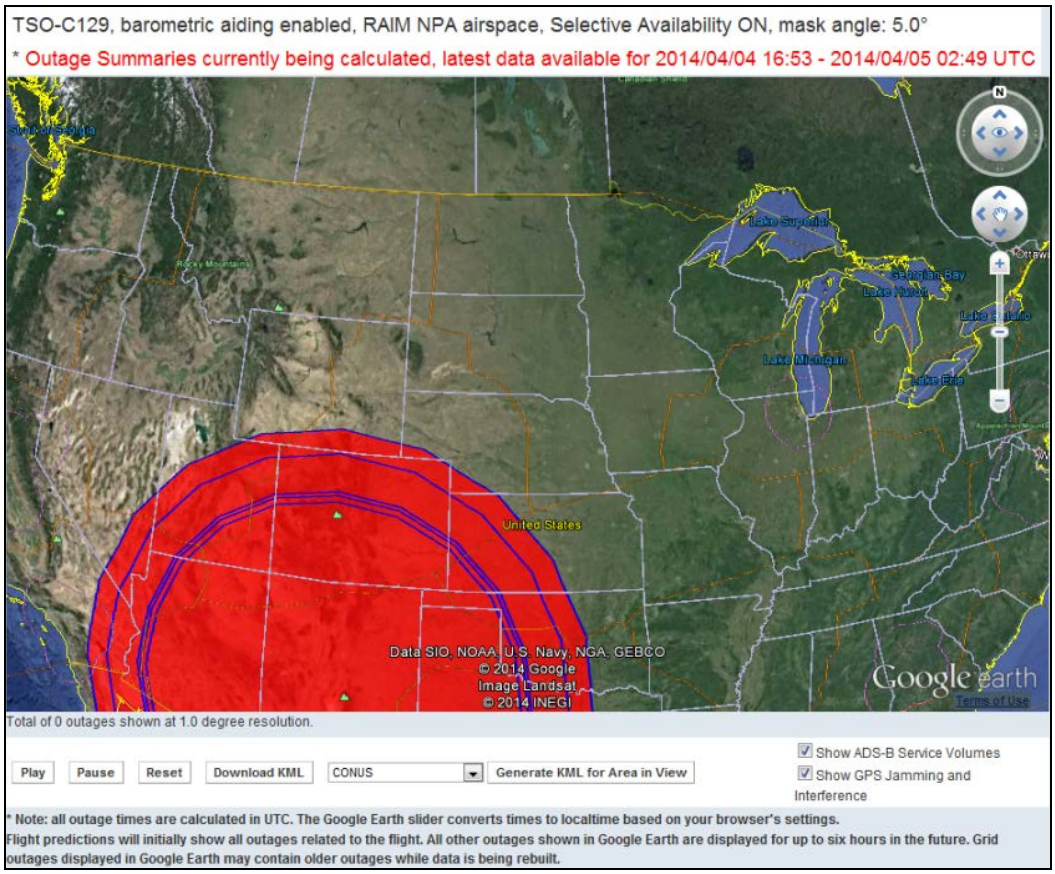


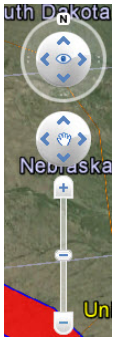
Figure 10-4: RAIM Summary -- NPA Airspace, SA On & No Baro-aiding

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

- 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.
- Select the area of interest from the drop-down list.
- 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 your route of flight you can use three different methods.

- Method 1: Select an area from the drop-down list in the center of the applet.
  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:

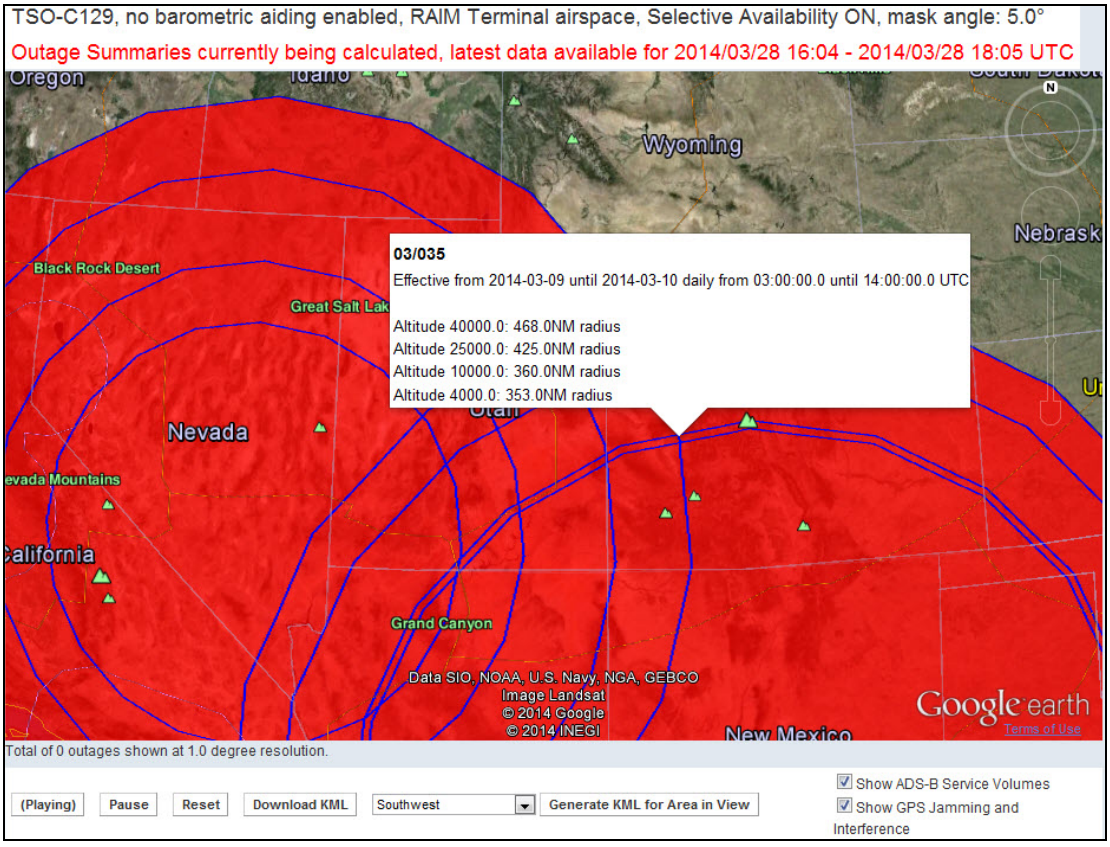


Figure 10-5: RAIM Summary – NPA Airspace, SA On & No Baro-aiding

APPENDIX A. ACRONYMS

The following acronyms may be found in this document.

Acronym	Definition
3D	Three-dimensional
AC	Advisory Circular
AC 90-100A	Advisory Circular "U.S. Terminal and En Route Area Navigation (RNAV) Operations"
ACY	FAA Technical Center in Atlantic City
ADS-B	Automatic Dependent Surveillance-Broadcast
AEEC	Airlines Electronic Engineering Committee
API	Application Programming Interface
ARC	(ADS-B)Aviation Rulemaking Committee
ARINC	Aeronautical Radio Incorporated
ATC	Air Traffic Control
CFR	Code of Federal Regulations
CIFP	Coded Instrument Flight Procedures (formerly the National Flight Database (NFD))
CONUS	Continental United States
DAFIF	Digital aeronautical flight information file
DoD	Department of Defense
ETO	Estimated time over
FAA	Federal Aviation Administration
FD	Fault detection
FDE	Fault Detection and Exclusion
FL	Flight level
GA	General aviation
FY	Fiscal year
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
HTML	Hypertext markup language
ICAO	International Civil Aviation Organization
ID	Identification number
IDE	Integrated Development Environment
ILS	Instrument landing system
IP	Internet protocol
IT	Information technology
J2EE	Java 2 Platform, Enterprise Edition
KML	Keyhole Markup Language

Acronym	Definition
LAAS	Local Area Augmentation System
LAN	Local area network
MHz	Megahertz
MOPS	Minimum Operational Performance Standards
MSL	Mean sea level
NACp	Navigation Accuracy Category for Position
NAS	National Airspace System
Navaids	Aids to Navigation
NAVCEN	USCG Navigation Center
NextGen	Next Generation Air Transportation System
NIC	Navigation Integrity Category
NM	Nautical miles
NOTAM	Notices to Airmen
QRO	Quality and Reliability Officer
RADAR	Radio Detection and Ranging
RAIM	Receiver Autonomous Integrity Monitoring
RNAV	Area navigation *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
SA	Selective Availability
SAPT	ADS-B SAPT Service Availability Prediction Tool
SBAS	Satellite-Based Augmentation System
SBS	Surveillance and Broadcast Services
SID	Standard Instrument Departure
SSLPM	Satellite Service Level Prediction Model
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival
SV	Satellite vehicle
SVDD	Service Volume Definition Document
TCP/IP	Transfer Control Protocol/ Internet Protocol
TSO	Technical Standard Order
UAT	Universal Access Transceiver
UML	Unified Modeling Language
URL	Uniform Resource Locator
USCG	U.S. Coast Guard
US DOT	U.S. Department of Transportation
UTC	Coordinated Universal Time
VHF	Very high frequency
WAAS	Wide Area Augmentation System
WAM	Wide Area Multilateration
WAN	Wide Area Network

Acronym	Definition
WJHTC	William J. Hughes Technical Center
WSDL	Web Service Description Language
XML	eXtensible Markup Language

APPENDIX B. BIBLIOGRAPHY

- International Civil Aviation Organization, A. S. (2011). Service Availability Prediction Tool Information Paper (IP ASP11-12). Montreal, Canada.