AircraftScatterSharp – An Aircraft Scatter Assistance program for Datahounds

--by Roger Rehr, W3SZ

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I wrote AircraftScatterSharp to assist those wanting to do aircraft scatter. This text highlights improvements that I have made to the software both recently and over the past several years. AircraftScatterSharp has several important capabilities:

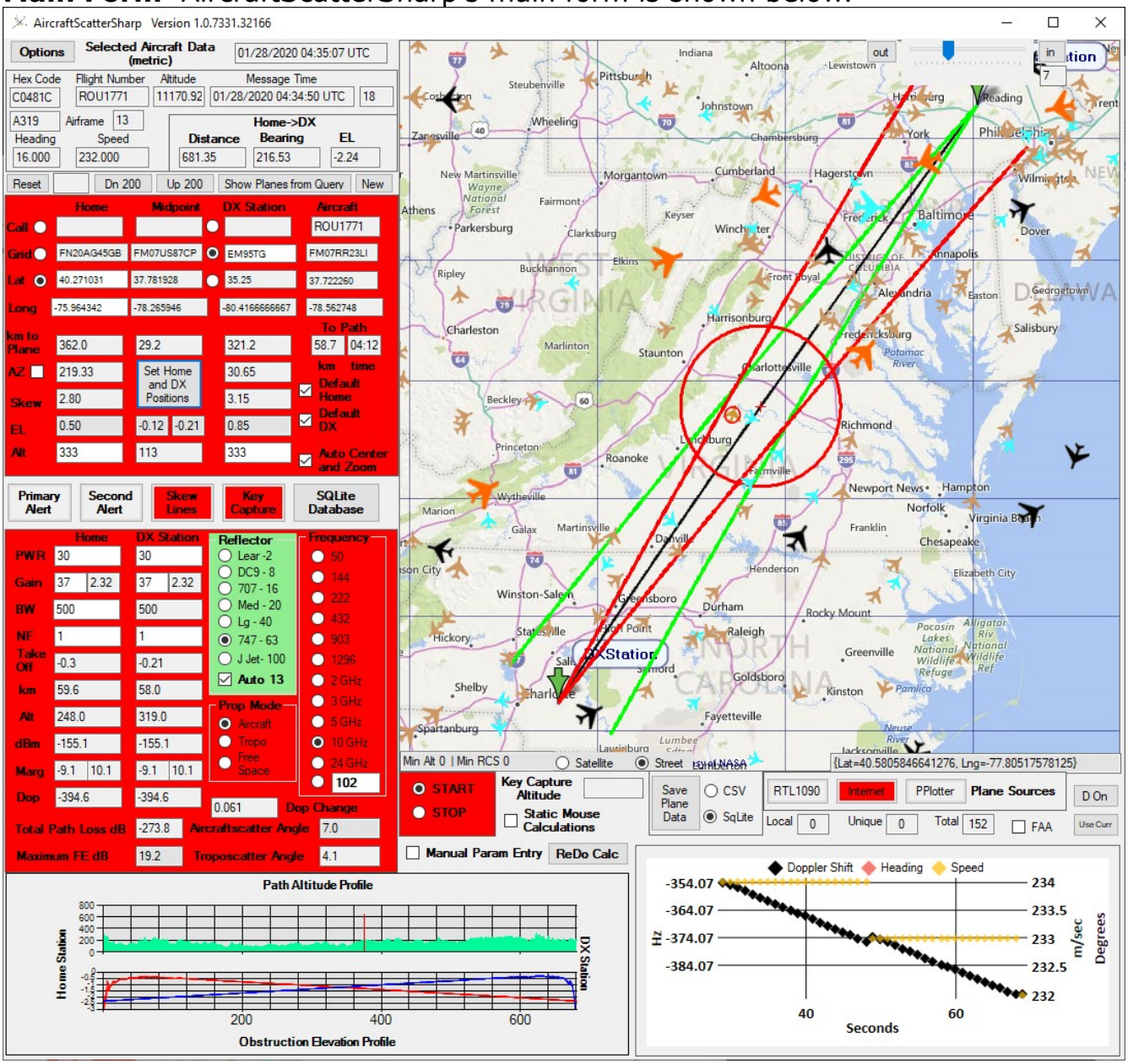
1. Real-time capture and display of plane position data derived from internet plane servers, from a local RTL1090 server, or both
2. Display of the direct path line between two stations, along with skew lines to allow a quick assessment of the angular deviation of an aircraft's position from the direct path between the stations, and a midpoint circle to show when an aircraft is within a specified distance from the midpoint of the path. Path altitude and elevation/obstruction profiles are also shown.
3. Highlighting of aircraft near the ideal position for scatter, based both on distance from the path midpoint and angular deviation from the path.
4 Real-time calculation of path loss, received signal strength, and signal margin at both stations based on plane location and user-adjustable station parameters, using either bistatic aircraft scatter, Yeh troposcatter [1] or free path formulas. Radar Cross Section may either be selected from a list or set automatically based on the aircraft's airframe type, which is determined from the ADS-B ICAO code value.
5. Real-time estimation of Doppler shift and its rate of change
6. An integrated SQLite database that allows you [1] to save information on all planes appearing on your screen for however long you want [minutes, hours, days, weeks, months] and [2] to then analyze that data to determine when aircraft scatter opportunities will most likely occur. You can analyze the data without interrupting its collection, and powerful SQL search functions are automatically included and easily selectable using only mouse-clicks to generate the SQL query statements.
7. An Experimenters' Mode where you can manually set various parameters and use the mouse to vary "plane" position and see the effects of those settings on RF signal parameters, troposcatter angle, aircraft scatter angle, etc.

The SQLite database provides something that has been missing from previous aircraft-scatter software (except for my earlier program mentioned above, which also included this feature). For EME we have software predictors of when the moon will be "available" to us as a reflector and for rain-scatter we have RainScatter, by Andy Flowers, K0SM [2] to give us this information. But there has been nothing similar for aircraft scatter until AircraftScatterSharp came along.

Below I will describe the program in some detail. For detailed "Getting Started" instructions on installing and using it, go to the appendix.

Getting Started In order to start an aircraft-scatter session, one needs to enter the Home and DX station position information. This can be done in several ways which will be detailed below. After this has been done the user then left-clicks the "Set Home and DX Positions" button. That sets the Home and DX station locations and sets up the path. If one wants to see the midpoint circle and the skew lines, one then clicks the "Skew Lines" button to place the direct path line and the midpoint circle and skew lines onto the map. One then selects either the local or the internet plane server or both, and clicks "Start" to start the real-time aircraft display. Before doing all of this for the first time, there are some options that should be set as described in the appendix to this document. More details about all of this will be explained more fully in the text below.

Main Form AircraftScatterSharp's main form is shown below.



On the right side of the display is a map which contains a real-time display of all aircraft positions downloaded from the server[s] that meet certain criteria set by the user. The aircraft icons shown on the map represent real-time aircraft positions and headings. The size of each aircraft's icon is indexed to its Radar Cross Section (RCS) using the formula Size = 15 + RCS/3. Icon color also gives an indication of size, with planes with RCS = 1 - 9 being colored light blue, those with RCS = 10 - 29 being colored beige, those with RCS = 30-49 being colored black, and those with RCS greater than or equal to 50 being colored red. Planes from a local ADS-B server will be colored bright green. If you over over a plane's icon the icon size will change to 35 and the icon will turn a yellow-green color and a black ring will be placed around the icon. If a plane is selected for in-depth analysis by left-clicking on it, then a black ring will be placed around it, except for "black" planes which will have a red ring placed around their icons. If manual mode is selected, a hot-pink aircraft icon will be placed at the manually-selected point on the map.

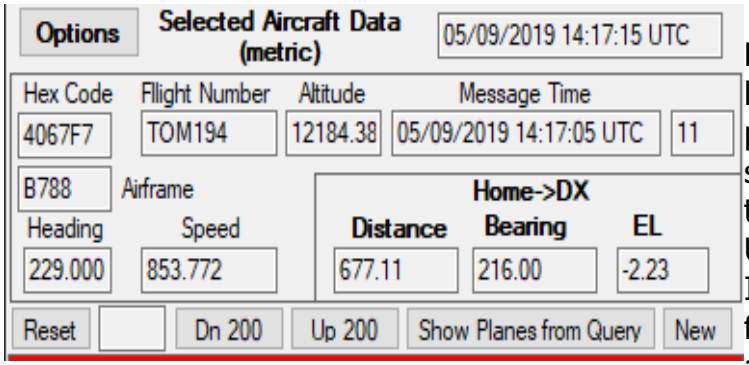
Below the map on the left is a path altitude profile and a path elevation profile for the path between the home and DX stations. The path altitude profile will only appear if SRTM3 data files have been installed [3] [4]. To the right of these profile displays is the Doppler display.

To the left of the map is the data display area. This section of the display shows data for an aircraft that has been selected by left-clicking its marker on the map display. Selecting an aircraft in this fashion puts a black ring around the plane icon for easier identification, as noted above. In the image above you can see the selected plane slightly below the center of the map. It is located near the inter-station line well inside the red "Secondary Alert" circle, between Lynchburg and Charlottesville. The plane is colored beige because its RCS is 13.

The path between W3SZ and W4DEX (the Home and DX stations) shown on the map above was selected by clicking the "Grid" radio buttons for each station and then entering their 6-10 digit grids in the adjacent text boxes, and finally clicking the "Set Home and DX Positions" button. The program then calculated and displayed the latitude and longitude values for each station and set the path. If, instead, the "Lat" radio button for each station was clicked and the appropriate latitude and longitude values were entered into the corresponding text boxes, and finally the "Set Home and DX Positions" button clicked, the program would calculate and display the 10-digit grid locator for each station in the appropriate text boxes and then set the station locations and the path.

The Aircraft Scatter Sharp program package also contains a call3.txt file, and AircraftScatterSharp can use this call3.txt file to supply location information for stations included in the file. New stations can be added to the call3.txt file by AircraftScatterSharp or by manually editing the call3.txt file. As long as a given callsign is contained in the call3.txt file and that file is placed in the appropriate directory, you can also enter location information for either the Home or DX

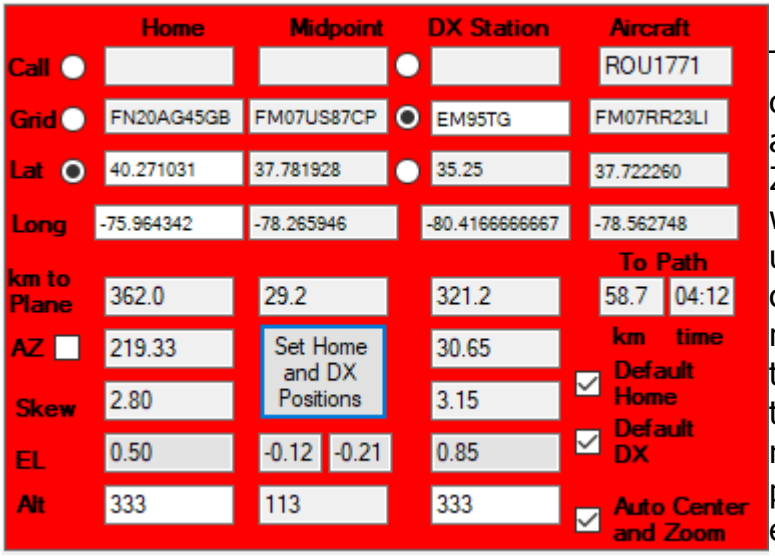
station by typing that station's call into the appropriate "Call" text box when the "Call" radio button has been clicked for that station and then clicking the "Set Home and DX Positions" button.



Basic Plane Data Area On the left is an image of the topmost portion of the data area on the left side of the main form. At the very top it shows the current time in UTC. Just below that, it shows the ICAO hexcode for the plane, its flight number, altitude, and the time at which its data was received. Just below that on the left is the selected plane's airframe type. Below that are aircraft heading and speed, and on the right is a description of the length and bearing of the path from the home station to the DX station, along with a notation of the elevation of each station relative to the horizon as seen from the other station.

As you can see above,the next portion of the form, just below this section, has five buttons, labeled "Reset", "Dn 200", "Up 200", "Show Planes from Query", and "New" and a text box. These are used to control the display of planes from the stored SQLite database, and they will be discussed more fully below.

Station and Aircraft Position Data Area The portion of the form just below the above sections of the form is colored red in this instance, and is shown below.



This section is colored red in this case because there is at least one aircraft within the Secondary Alert Zone. This alert zone is activated when a plane is within the red user-defined "optimal range circle" that is drawn around the midpoint of the path (the radius of this circle is user-adjustable via the "Options" "Alerts" page). The red color of this section of the program display provides an easily visible indication that the secondary alert has been activated. Although the likelihood of a successful aircraft scatter contact is less for planes in this zone than it is for those in the Primary Alert Zone (which will be described in the section titled "Path Loss and Signal Margin Display" below), the likelihood of success for planes in the Secondary Alert zone is higher than it is for planes that are not in either the Primary or Secondary Alert zones.

This section of the form contains 4 columns of text boxes. These respectively, from left to right, give positional information about [1] the Home Station, [2] the midpoint of the path between the Home and DX stations, [3] the DX Station, and [4] the selected aircraft. Checking the check box to the right of "AZ" activates the N1MM Rotor Controller interface. Then the antenna tracks the selected plane.

This information includes for the Home and DX stations callsign (optional), grid square, latitude, longitude, km to plane, azimuth to plane, elevation of the selected aircraft as seen from that station, skew angle of the selected aircraft's position relative to the direct path as seen from that station, and altitude of the station location's antenna above sea level in meters (which can either be entered by user or populated from the SRTM3 data if is available and should be the sum of the terrain's elevation above sea level plus the tower and mast height).

Callsign, grid square, latitude, longitude, and altitude are user-adjustable by entering these values into the text boxes. As was noted above, radio buttons allow the user to select whether station location is specified by callsign look-up, grid square, or latitude and longitude. If Key Capture is turned on, one can also use the latitude and longitude of a point on the map to position the Home station location at that point by selecting manual lat/long entry by clicking the "Lat" radio button and then positioning the mouse cursor over the desired location on the map and then hitting <Ctl>F1. One can similarly position the DX station by positioning the mouse cursor over the desired location on the map and then hitting <Ctl>F2 after the "Lat" radio button has been selected. When <Ctl>F1 or <Ctl>F2 is used in this manner to automatically locate either the Home or DX station location, the program will also calculate the elevation of that location if SRTM3 data has been downloaded by the user and placed in the appropriate file location, using that SRTM3 data. To this value the user must manually add his and the DX station mast heights unless he has entered those values on the Options>>Home Location page. If these values have been entered on the appropriate Options page, then they will be automatically added to the elevation values obtained by using <Ctl>F1 and/or <Ctl>F2. Note that if either the "Grid" or "Call" radiobutton has been selected for either the Home or DX station, then this method of setting the location for that station is disabled, by design.

The "Aircraft" column at the extreme right side of this portion of the display contains two small text boxes under the label "To Path". The small box on the left is labeled "km" and gives the distance from the selected aircraft to the inter-station path along the heading that the aircraft is currently following. The small box on the right is labeled "time" and gives the time in minutes and seconds that it will take the plane to reach the inter-station path, flying along its current heading at its current speed. These values, as well as the other "aircraft-related" values in this section of the display are updated once each second.

This section of the display also contains 3 check boxes in its lower right corner.

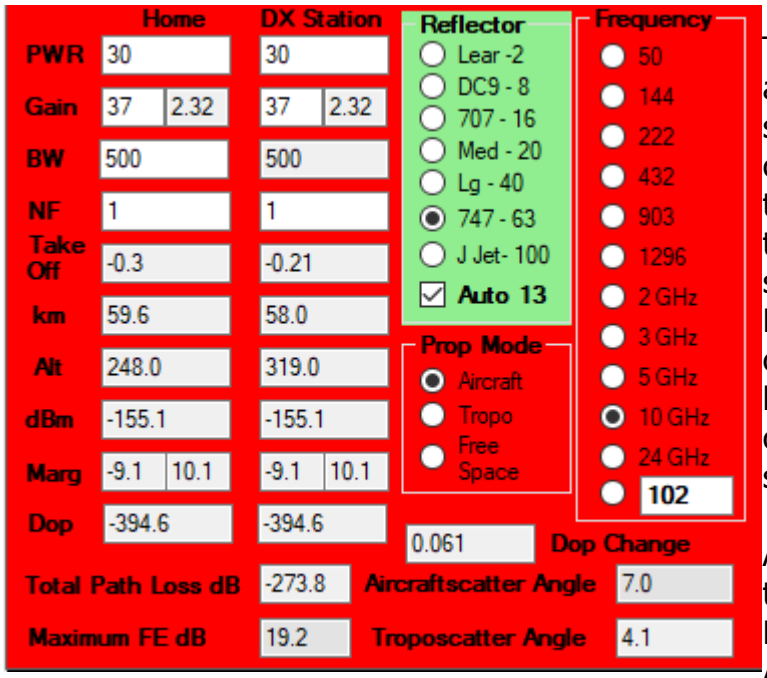
Checking the box labeled "Default Home" will cause the program to use for the Home Station location the latitude and longitude entered on the "Home Location" Options page, if the "Lat" radio button for the Home Station is also selected. The "Default DX" check box provides an identical function for the DX Station. The box labeled "Auto Center and Zoom" will cause the map display to recenter and resize any time a new location is chosen for either the Home or the DX Station, centering the display on the midpoint of the inter-station path. I check this box when first setting up a path, but then leave it unchecked thereafter.

Alert, Skew, Key Capture and SQLite Database Buttons Moving further down the data portion of the form the next portion of the display, shown immediately above, contains buttons that [1] activate or deactivate the audio primary and [2] secondary alarms but do not affect the panel color changes that accompany these audio alerts, [3] display or hide the skew lines and midpoint circle display, [4] activate or deactivate key capture, and [5] bring up the SQLite database query and analysis page. As noted above, the secondary alert, if activated, sounds when any plane enters the midpoint circle. The primary alert, if activated, sounds if at least one of those planes is also within both sets of skew lines. There are multiple functions that can be activated by Control Key combinations when the "Key Capture" button is activated. These will be listed if one hovers over the Key Capture button and are also listed on the Options page labeled "Key Capture", and can also be displayed by typing <Ctl>F9 if Key Capture has been activated. These functions include:

<Ctl>F1 will place the latitude and longitude of the point under the mouse cursor in the Home Station position boxes, **if** the manual entry "Lat" radio button is selected for the Home Station.
<Ctl>F2 will place latitude and longitude of the point under the mouse cursor in the DX Station position boxes, **if** the manual entry "Lat" radio button is selected for the DX Station.
<Ctl>F3 will place the altitude of the point under the mouse cursor into the Key Capture Altitude text box beneath the map.
<Ctl>F4 Displays a message box showing Latitude, Longitude, Altitude, and Grid for the point chosen when the F3 key was last used as described above.
<Shift>F4 is equivalent to **<Ctl>F3** followed immediately by **<Ctl>F4**.
<Ctl>F5 Activates ToolTips for all forms.
<Ctl>F6 Deactivates ToolTips for all forms.
<Ctl>F7 Brings up a web page showing information for the selected plane's ICAO 6-digit hexadecimal identifier. For this you need to register at airFrames.org. This will be described below.
<Ctl>F8 Brings up a Flight Aware web page showing both current and historical information for the selected plane's Flight Number.
<Ctl>F9 Shows a list of all Key Capture functions.

<Alt>A Allows user to set a lower altitude limit for planes displayed.
<Alt>R Allows user to set a lower RCS limit for planed displayed.
<Alt>E Allows user to set a lower elevation limit for aircraft elevation as seen from either end of the inter-station path.
<Alt>M Turns on or off the display in the "Key Capture Altitude" box of the elevation of the map point under the mouse cursor. This is useful for determining the best location to site an antenna, and also in looking for local path obstructions.
<Ctl>Home Used on the SQLite database page to center a database query around a geographic point on the map.
<Ctl>Insert and **<Ctl>Delete** Used on the SQLite database page to set two ends of a Great Circle path along which a database query will return planes.
<Ctl>Up-Down-Right-Left Arrows Used on the SQLite database page to set North/South/East/West boundaries for a rectangular query box.

Path Loss and Signal Margin Display Area Located immediately below these buttons, the next section of the display is shown below and is used for entry and display of RF-related information: expected path loss and resultant signal strengths and signal margins at both the Home and the DX stations and Doppler shift and its rate of change. This section will be colored red if a plane is both within the midpoint circle and also within the skew lines (i.e., if the primary alert is activated). This section will have a gray background if no planes are within the primary alert zone.



To perform the RF calculations for a selected aircraft, the user first selects the desired aircraft by left-clicking on it, and then selects in the section labeled "Reflector" (see the image on the left) the plane size category (Lear, DC-9, 707, Med, Lg, 747,or J Jet) by left-clicking the appropriate radio button. These select RCS values of 2, 8, 16, 20, 40, 63, and 100 sq. m respectively.

Alternatively, the user may click the "Auto" checkbox in the Reflector section, and AircraftScatterSharp will then automatically select the RCS based on the 4-digit ICAO airframe type designator displayed in the text box described above and labeled "Airframe". Not all airframe types are in the database, and if the selected aircraft is not in the database then the RCS value selected by the radio buttons above this checkbox will be used to determine the RCS value used in the calculations. In the case illustrated here the

airframe is in the database and so the "Reflector" box has a light green background, the estimated RCS of 41 m^2 is displayed as shown, and the value of 41 is used for the RCS in the program calculations.

The user then selects the desired frequency band by clicking on the appropriate radio button in the box labeled "Frequency". Next the user enters into the appropriate text boxes the power ("PWR" in watts), antenna gain ("Gain" in dBi), receiver bandwidth ("BW" in Hz), and receiver noise figure ("NF" in dB) for both the Home and DX stations (except that the receiver bandwidth is entered only for the Home Station and identical bandwidth for the DX station is assumed). Once this has been done, the program continuously calculates and displays the expected received signal level, signal margin, and total path loss for both Home and DX stations in real time, as well as Doppler shift and its rate of change if there is adequate data available for the selected aircraft. The station information is remembered between sessions, so it only needs to be entered once unless it changes.

Under these text boxes are text boxes which display for both Home and DX stations [1] the Take Off angle in the text boxes labeled "Take Off", [2] the distance in km to the first path obstruction in the text boxes labeled "km", and [3] the altitude (in meters) of that obstruction in the text boxes labeled "Alt". These values are derived from the station location and the SRTM3 datasets.

Below those text boxes are the expected received signal level at each station in the text boxes labeled "dBm", and just below that there are two text boxes for each station on the line labeled "Marg". The first box for each station on this line shows the value of the receive signal margin without considering the effects of Forward Scattering Enhancement. The second box shows the signal margin that will occur if maximum FSE for the extant plane/station geometry is obtained. This value thus equals the value shown in the first "Marg" box for that station plus the value in the "Maximum FE" text box shown at the very bottom of this section of the display.

Beneath the signal margin text boxes are the text boxes that report the Doppler shift of the signal scattered from the selected aircraft as well as its rate of change. The Doppler shift is reported in Hz and its rate of change is reported as Hz/second. These text boxes are complemented by the Doppler graphic display which is below the map on the right side of the display and which will be discussed more below.

At the bottom of this section of the display, below the Doppler text boxes, are text boxes for the "Total Path Loss dB" excluding FSE effects, the "Aircraftscatter Angle" in degrees, the "Maximum FE dB" and the "Troposcatter Angle" in degrees.

The "Total Path Loss dB' box and the "Marg" and "dBm" boxes will display the values for either aircraft scatter, troposcatter, or free space propagation,

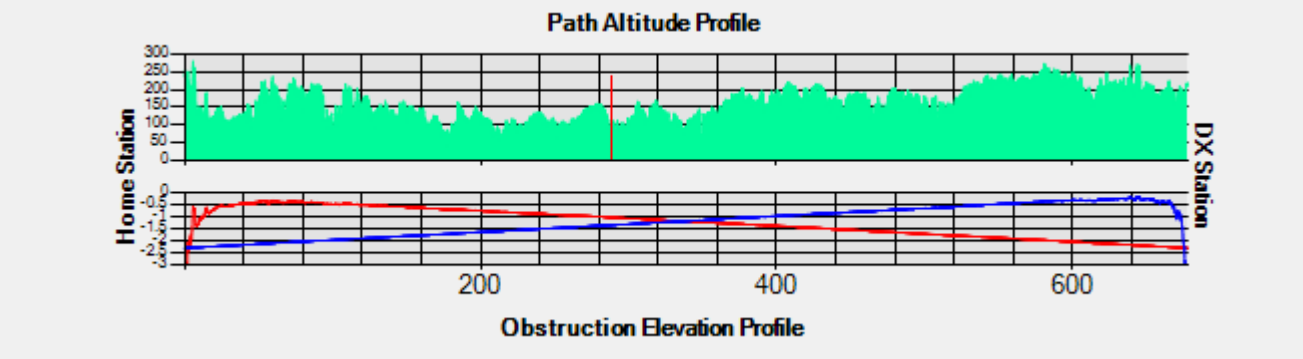
depending upon which radio button in the "Prop Mode" group box is selected. In this way one can easily compare signal levels and signal margins for aircraft scatter vs troposcatter for any situation, and compare both to what the free-space loss would be for a similar station path if a line of sight were present between the two stations.

"Static Mouse Calculations" Check Box The check box located beneath the map and just to the right of the "Start" and "Stop" buttons and labeled "Static Mouse Calculations" is provided so that the calculations just described can be made for a theoretical aircraft that is positioned statically at a user-selected point on the map. If one <Ctrl>-left-clicks (left-clicks while holding down the <Ctrl> key) on any map point, then a hot-pink aircraft icon will be placed at that point and all calculations will be performed for a theoretical aircraft located at that point rather than using an aircraft position downloaded from one of the plane servers as the scattering object (see the first illustration in this article or the illustration on the next page to see this control).

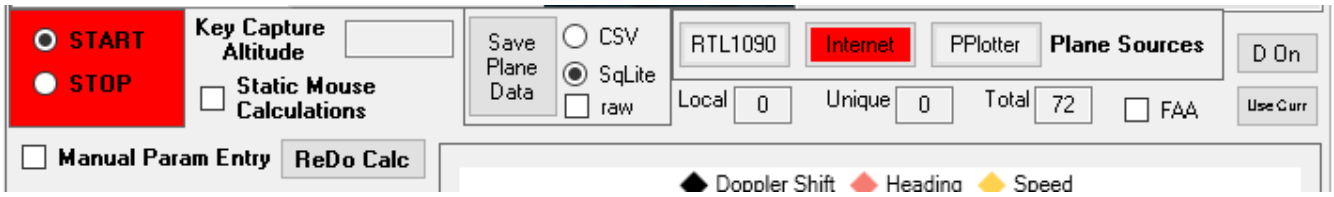
However, unless this "Static Mouse Calculations" box is checked, then the plane location and parameters derived from this location will be updated each second using the values for speed, heading, and altitude given in the text boxes in the "Basic Plane Data Area" described above. Activating this check box allows path analysis to be performed for any given map position even in the absence of any aircraft at the desired position.

<Ctrl>-left-clicking in this manner "opens" the Altitude, Heading, and Speed text boxes in the "Basic Plane Data Area" so that the user can enter specific values into these boxes in order to evaluate the effect of changes in these parameters. If one enters these parameters in this fashion with the "Static Mouse Calculations" box checked, and then unchecks it, a dynamic evaluation will be done beginning at the selected location and then for those points updated each second based on the altitude, heading,and speed data entered by the user in these boxes. If one subsequently selects a "real" aircraft from the map display, then these text boxes are again "closed" to user entry.

Path Altitude Profile and Obstruction Elevation Profile Immediately below this section of the form are the the "Path Altitude Profile" and the "Obstruction Elevation Profile" graphs, both of which will be displayed only if the SRTM3 files have been downloaded and properly installed. If an aircraft has been selected, it will appear as a vertical red line superimposed on the Path Altitude Profile. Such a red line is near the midpoint of the Path Altitude Profile shown below.



Start and Stop Buttons To the right of the RF calculations section of the display, beneath the map, are the "Start" and "Stop buttons that start or stop the real-time display of aircraft on the map, as shown in the image immediately below. It is necessary to click on "Start" to initiate downloading of plane information.



Just to the right of the "Start" and "Stop" buttons is the "Static Mouse Calculations" check box that we discussed above.

Key Capture Altitude Text Box Below the "Use Mouse Position for Calculations" check box is a text box labeled "Key Capture Altitude", as you can see in the illustration above. This text box will display the altitude for any point on the map if one has key capture enabled and hits <Ctl>F3 while the mouse is over the selected point. Alternatively, one can type <Ctl>E and the elevation for the map point under the cursor will be continuously displayed as one moves the cursor over the map. This feature is useful for determining the elevation of either the Home or DX station, or of any point on the map when looking for local obstructions or for the best location to site an antenna. This feature, like the path altitude profile feature, requires that SRTM3 files be installed in the appropriate directory. The details of getting and using these SRTM3 files is described by the tool tip obtained by hovering over the "Path Altitude Profile" display, which is labeled as such on the form, and also in the appendix to this document. Hitting <Ctl>F4 will cause a Message Box containing the position and altitude of the point last referenced by hitting <Ctl>F3 to pop up. This is useful if you are cataloging the elevations of several locations on the map.

Manual Parameter Entry Check Box and ReDoCalc Button Beneath the Key Capture Altitude text box are a check box labeled "Manual Param Entry" and a button labeled "ReDo Calc", also seen in the illustration above. Checking the

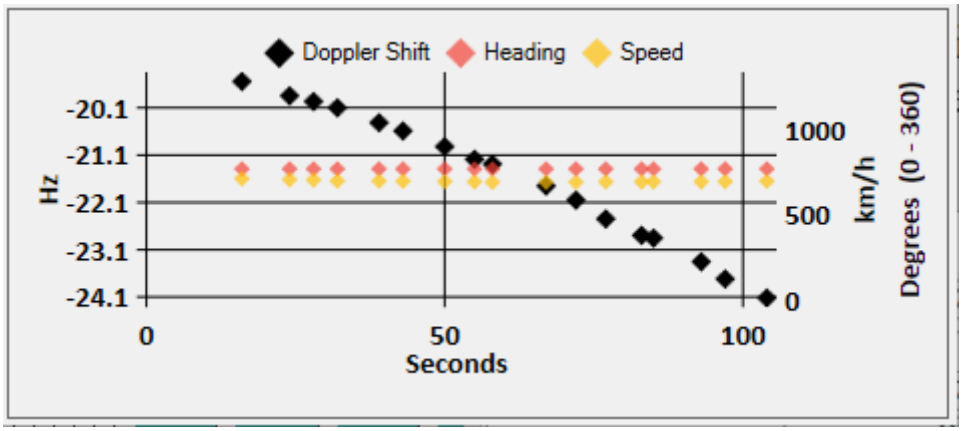
Manual Param check box will allow you to manually enter values for Home and DX Station take-off angles for the inter-station path as well as for the path from each station to the aircraft and also to manually enter parameters for aircraft speed and heading. This is generally done in association with using the mouse to enter theoretical "aircraft" position for calculations. If you check the "Static Mouse Calculations" check box but do not check the "Manual Param Entry" box, then the values for these parameters will be those calculated by the program using the SRTM-3 data and whatever speed, heading, and altitude data were left from the last aircraft selected rather than using manually entered parameters as would be the case if this "Manual Param Entry" box were checked. Because this function is often used for detailed path / location analysis, the results of calculations performed when this box is checked are automatically written to a CSV file at ../Users/your_user_name/AppData/Local/W3SZ/AS_TS_Data.csv, in order to make further analysis easier for the user.

Clicking on the "ReDo Calc" button will redo calculations after parameters have been manually changed as described above.

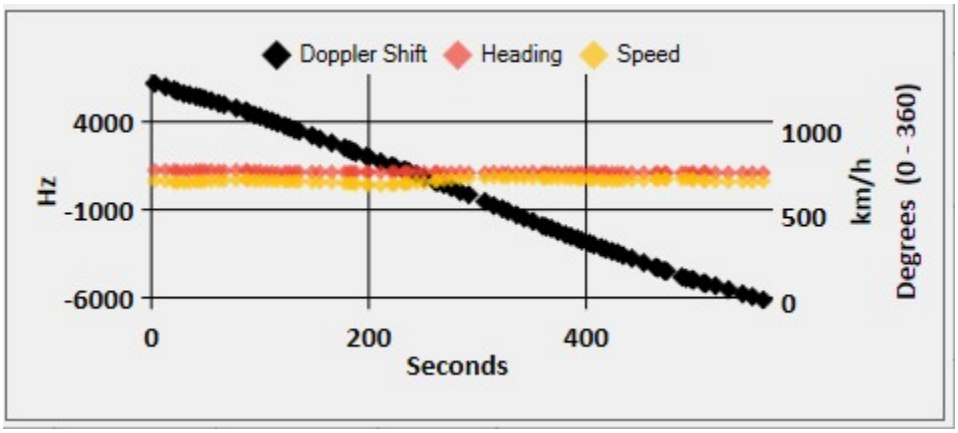
Database Entry Controls To the right of this section are the "Save Plane Data" button which is used to activate or deactivate the saving of all plane data to a file and the "CSV", and "SQLite" radio buttons and the "raw" checkbox. The CSV and SQLite buttons are used respectively to select between CSV file or SQLite database file types for this storage. Saving data to an SQLite database file is the default choice and is strongly recommended. Checking the raw checkbox will save the raw json plane data to a date-and-time-labeled text file in the ...AppData/Local/W3SZ directory.

Local and Remote Plane Server Buttons To the right of this button group, in the "Plane Sources" group box are the buttons used to select whether plane data downloads are from the local RTL1090 server, from a remote internet plane server, or via OLE/COM from PlanePlotter. These buttons as well as the text boxes described below are also visible in the illustration above.

Below these buttons in the Plane Sources group box are three text boxes. The leftmost text box, labeled "Local", displays the total number of planes currently "seen" by the local RTL1090 receiver. To the right of this box, the box labeled "Unique" shows the number of these local planes that are "unique" and not "seen" by the internet plane server. The box to the right of this box displays the total number of unique aircraft seen by both the internet and the local plane servers. To the right of this text box is a check box labeled "FAA". Checking this box will add FAA-sourced-time-delayed data to the real-time plane data if the internet plane server being used provides such data.



Doppler Shift Graph Below this area is the Doppler Shift graph, which is shown in the illustration immediately above. This display shows the value of the Doppler shift in Hz on the vertical axis and the time in seconds since the aircraft was selected by the user on the horizontal axis, and is updated each second. Both the X and Y axes for the Doppler Shift display are autoscaling. In this case shown here, the selected aircraft was flying along and parallel to the inter-station path and the frequency band selected for analysis was 10 GHz. You can see in the graph that this geometry results in a very small Doppler shift, ranging from -20 to -24 Hz during the period shown, and also a very small rate of change of the Doppler shift.



Contrast the geometry just described with the Doppler display shown above, obtained from a plane that was flying perpendicular to the direct path between the Home and DX stations Note that the Doppler shift ranges between +6000 and -6000 Hz, and both the shift and its rate of change are far greater than the values shown for the aircraft flying down the inter-station path.

Additional Map Features The map portion of the form has a few features that should be noted. Boundary lines for the Maidenhead grid squares which cover the globe are shown by default. These can be turned off using one of the tabs on the Options form, which is accessed by clicking the Options button at the top left of the main form. A grid square label pop-up for a given grid is activated by

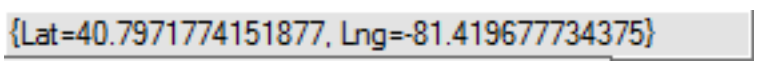
hovering the mouse over the marker placed in the center of that grid. A tab on the options form allows one to turn this function on or off, and to make the grid square center markers more or less visible.

At the top right of the map are controls for zooming the map in and out, labeled "in" and "out", as shown above.

At the lower left edge of the map, shown above, are two boxes that display the minimum elevation, minimum altitude, and minimum RCS selections that the user has made. The default for the minimum altitude and minimum RCS parameters is zero, meaning that no planes will be excluded from display because of their RCS or altitude values In this case the minimum altitude has been set to 10000 feet, so that no planes with altitude less than 10000 feet will be displayed. The minimum RCS in this case has been set to 10, so no aircraft with radar cross sections of less than 10 sq meters will be displayed. When these values are reset, any planes that no longer meet the new limits will be removed from the map, and no new planes that do not meet the new criteria will be displayed. The default value for minimum elevation is minus 10 degrees, making it very unlikely that any planes of interest will be excluded from display by this parameter's value.

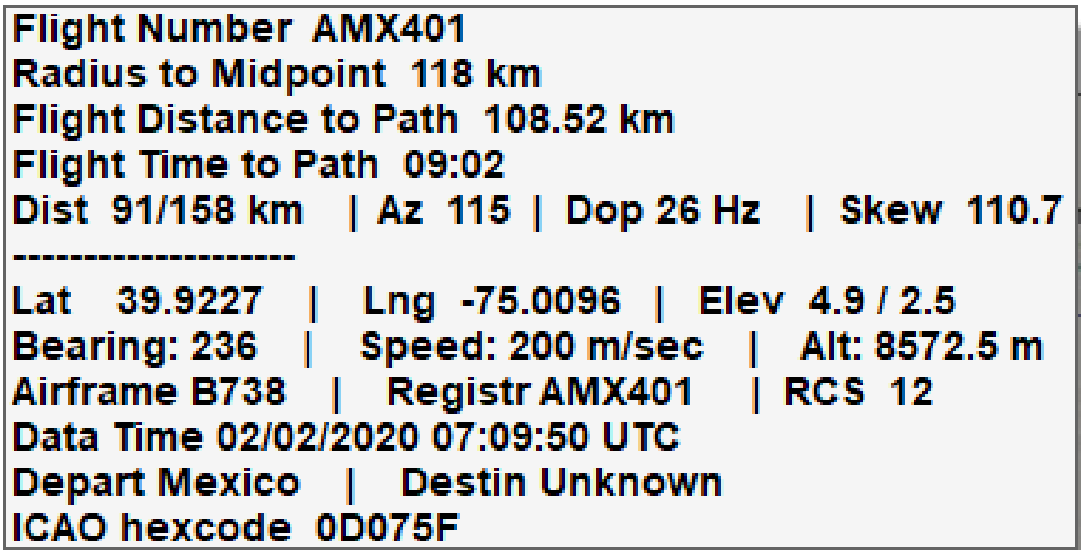
These parameters may be set either on the Options page labeled "Limits" or by typing "Alt-A" to reset the altitude limit, "Alt-R" to reset the RCS limit, or "Alt-E" to set the elevation limit. As with other Alt-key and control-key functions in AircraftScatterSharp, the Key Capture button must be active for these keys to perform their functions as just described.

These functions allow the user to "hide" the chaff of smaller planes that will not return a useful signal due to their small RCS, or which are likely flying too low to be able to provide a reflection point that will be above the horizon at both stations, or both.



At the lower right edge of the map, shown above, is a box that displays the latitude and longitude for the point on the map over which the mouse is hovering.

If one uses the mouse to hover over an aircraft on the map, information for that plane will pop up in a "ToolTip", whether or not that plane is the "selected" plane. An example of this information is shown above. The displayed information includes:



Airline flight number on the first line

Radius to the midpoint on the second line

Flight distance to the interstation path on the third line

Flight time to the interstation path on the fourth line

Distances from Home/DX QTH to the aircraft, Azimuth from Home QTH to the aircraft, Doppler shift, and Skew angle on the fifth line.

Plane latitude and longitude and plane elevation from Home/DX locations on the sixth line

Bearing, Speed, and Altitude on the seventh line

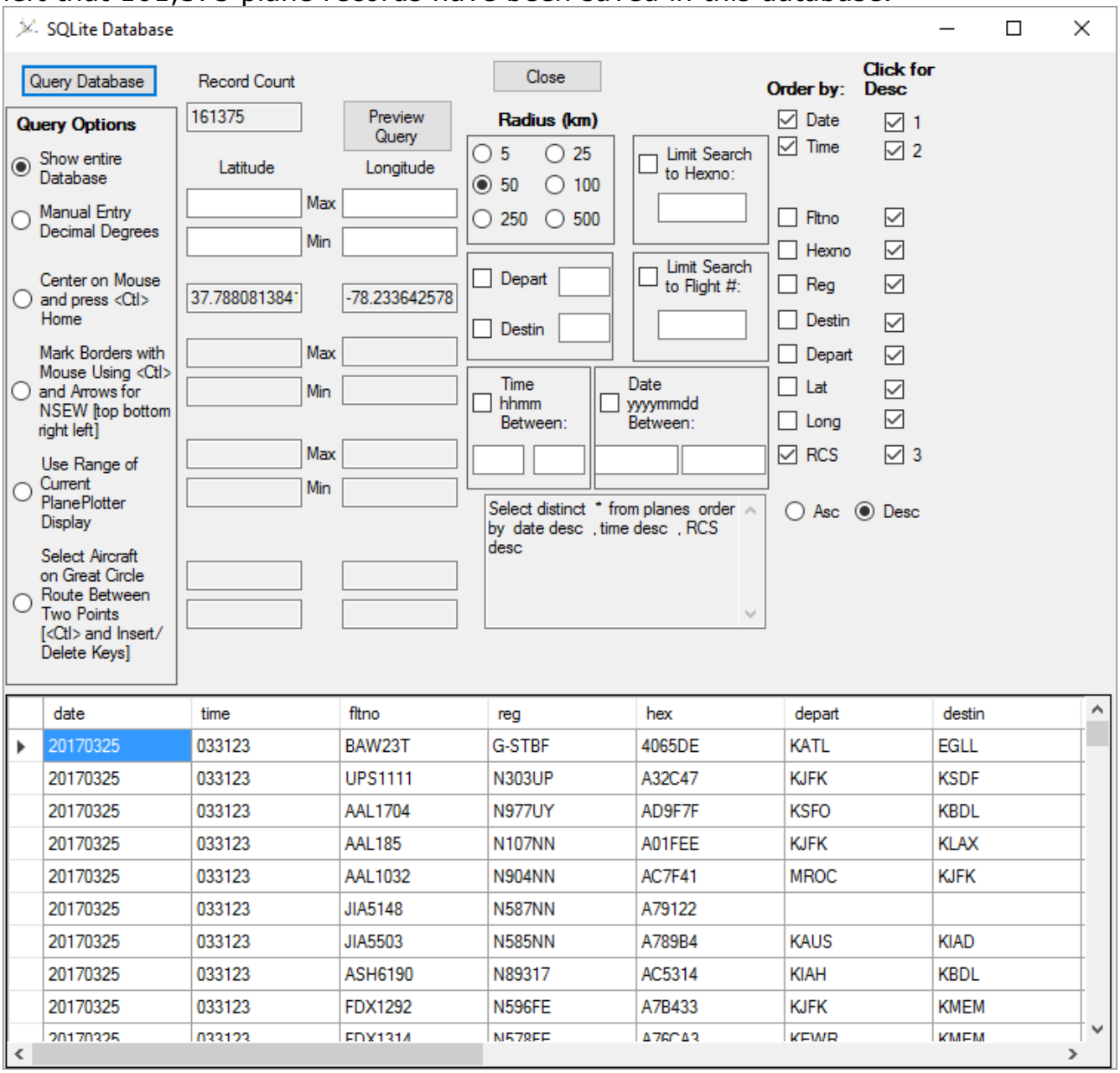
Airframe, Registration, and the estimated RCS for the aircraft, if known on the eighth line

Timestamp for the ADS-B data on the ninth line

Departure Country if using the remote internet plane server, or Departure and Destination airports if using PlanePlotter input on the tenth line

6 digit ICAO Hex Number on the eleventh and final line

VII. Getting Historical Aircraft Position Data. If you are unfortunate enough to live in an area where there is not a constant stream of aircraft between your QTH and that of your QSO partner, making use of the historical aircraft position data that can be acquired by this program may be of great use to you. Below is the SQLite database analysis form that is accessed by clicking on the "SQLite Database" button on the main form of the program. This form shows at the top left that 161,375 plane records have been saved in this database.



Information about each plane that is recorded in the database includes date, time, flight number, registration (whether FAA or other), ICAO hexcode, departing airport, destination airport, latitude of plane, longitude of plane, altitude, bearing, speed, airframe type, squawk, vertical speed, RCS (radar cross section), whether the data is from a local receiver or downloaded from the internet, and the

database ID number of the aircraft. You can see by the check boxes near the top right of this form that the entries in the search that is displayed here were specified to be ordered by date, then time, and then by RCS. The "Query Options" box on the left shows that "show entire database" has been selected, so the table contains all 161,375 planes.

The database is also useful for teaching and demonstration purposes, and for investigational use.

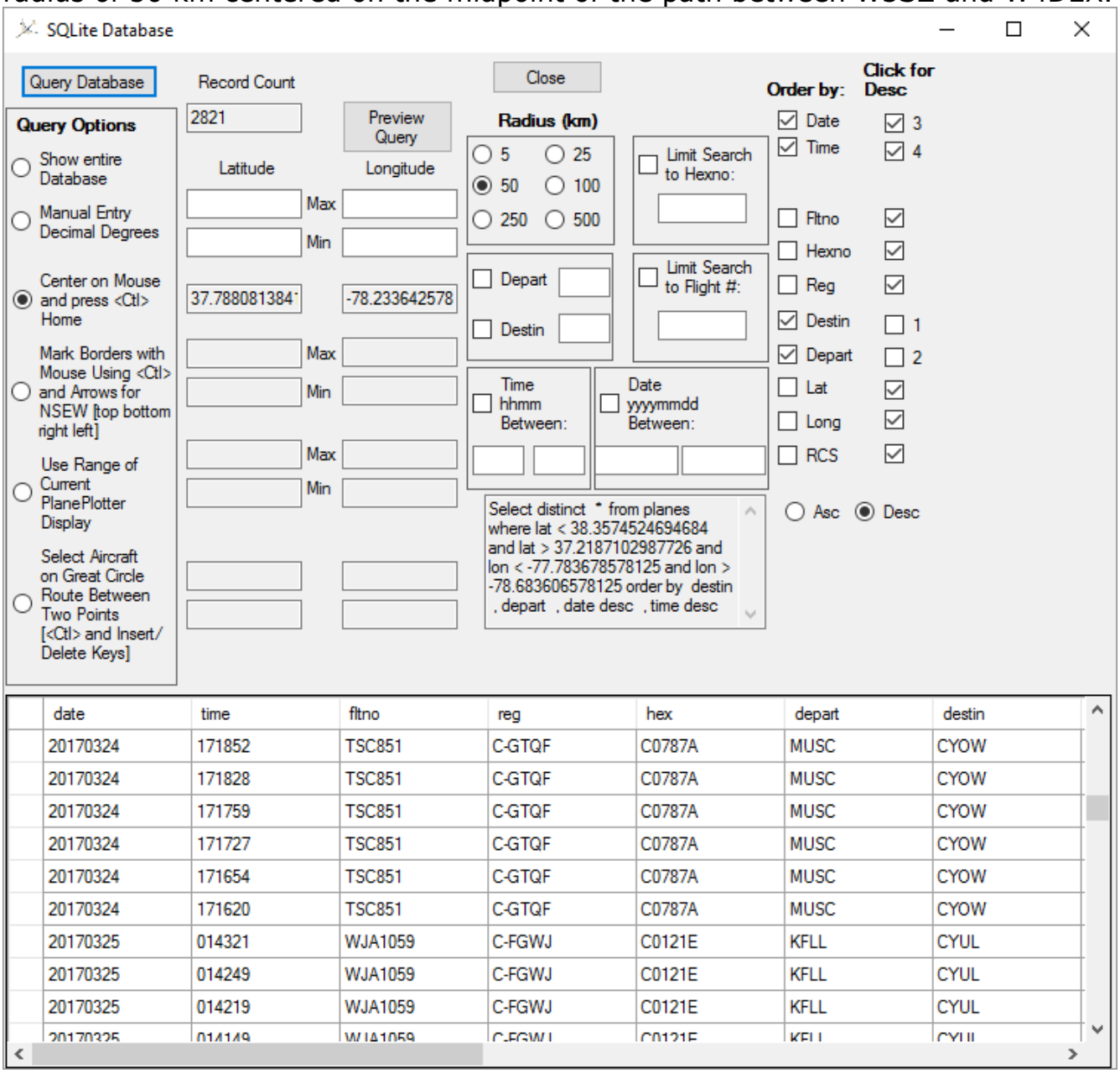
In order to plan an aircraft-scatter session using previously acquired SQL data, one enters the Home and DX station 6-10 digit grid squares into the appropriate text boxes on the primary form and left-clicks the "Set Home and DX Positions" button. That places the direct path line and the midpoint circle and skew lines onto the map, to help one decide on exactly what geographical area to explore with the database. One then opens the SQLite database form by either left-clicking the "SQLite Database" button, thus bringing up the SQLite database form, or by clicking on the "Show Planes from Query on Map" button, which will bring up the SQLite database form and also display the first 200 planes in the selected dataset on the map, where they can be analyzed and viewed just as if they were "live" planes. From the SQLite database form, one can then select a region from which to display aircraft records in one of several ways.

If one wants to see when aircraft are likely to be within a 5, 25, 50, 100, 250, or 500 km square centered on the midpoint of the direct path, one clicks the appropriate radio button on the SQLite database page to set the radius desired. With the key capture function activated, one uses the mouse to place the cursor over the midpoint of the direct path and hits <Ctl>HOME on the keyboard. This puts the coordinates for the midpoint into the appropriate text boxes on the SQLite database page, as shown in the illustration below. One then left clicks the radio button labeled "Center on Mouse and press Home Key" on the database page to choose this method of location selection for the database query, and finally one left clicks the "Query Database" button. This sends the appropriate query to the database, and the data returned to the data grid includes only planes that are within this region. One can order the display of these planes by date, time, etc. as described below and quickly see what aircraft are likely to be available for use, and when.

There are 4 other methods of limiting the geographic region from which planes are returned in the query. These are also contained in the "Query Options" panel and include (1) manual entry of the maximum and minimum latitude and longitude for a rectangle from within which all planes will be selected, (2) setting the borders of a rectangle using the map and the mouse, (3) using the display area of the map itself to set the boundaries, or (4) selecting a great circle route between any two points (such as the Home and DX stations) and using the "Radius" radio buttons to specify a distance from that path from within which planes will be selected.

One can also, and simultaneously, limit the search query by date and/or time, by the ICAO hexno, which is a unique identifier assigned to every plane that is put into service worldwide, and which stays with the plane for its entire life, and by departure or destination airport, and by flight number.

The searches can also have the data returned by the query ordered by up to 10 additional parameters, as you can see on the right side of the Database form. In the second example shown below we have limited the search to an area with radius of 50 km centered on the midpoint of the path between W3SZ and W4DEX.



This query returns 2821 flight records, and in this case I ordered the query by alphabetically ascending destination, then by alphabetically ascending departure airport, then by descending date, and finally by descending time. Reviewing the

data, you can quickly see that flights crossing this point in this time span included flights from MUSC to CYOW and from KFLL to CYUL. A careful inspection of the "Query Options" portion of the form will show the choices I made to direct the geographic area of the query, and the text box below the time and date check boxes shows the query that the program automatically formed based on the selections I made with just a few clicks of the mouse.

The order of the plane record display can also be changed after the query results have been obtained by clicking on the heading for any column of the display itself.

Viewing SQL Database Planes on the Map Once you have gotten your SQL search organized and sorted in the manner just described, you are ready to view the planes on the map.

To do that, go to the row of buttons between the Selected Aircraft Data area at the top left of the form and the Home and DX Station position entry portion of the display below that. This row of buttons is pictured below:

Then click on the "Show Planes from Query on Map" and the program will display up to 200 planes at a time on the map.

If there are more than 200 planes in the query results, how you sorted the planes in your query becomes important. For example, if you want to follow the course of a single plane in the SQLite database during a single flight, then you would want to do a search with hex number ("hexno") as the first search term, date as the second search term, and time as the third search term. This would make it most likely that all of the plane entries for each flight would be shown on the same map page.

When there are more than 200 planes you can view successive sets of 200 planes by clicking on the "Up 200" button, as shown above. If, after doing this, you want to return to a map page that you had previously viewed that is nearer to the beginning of your query than your current map view, you would click the "Dn 200" button.

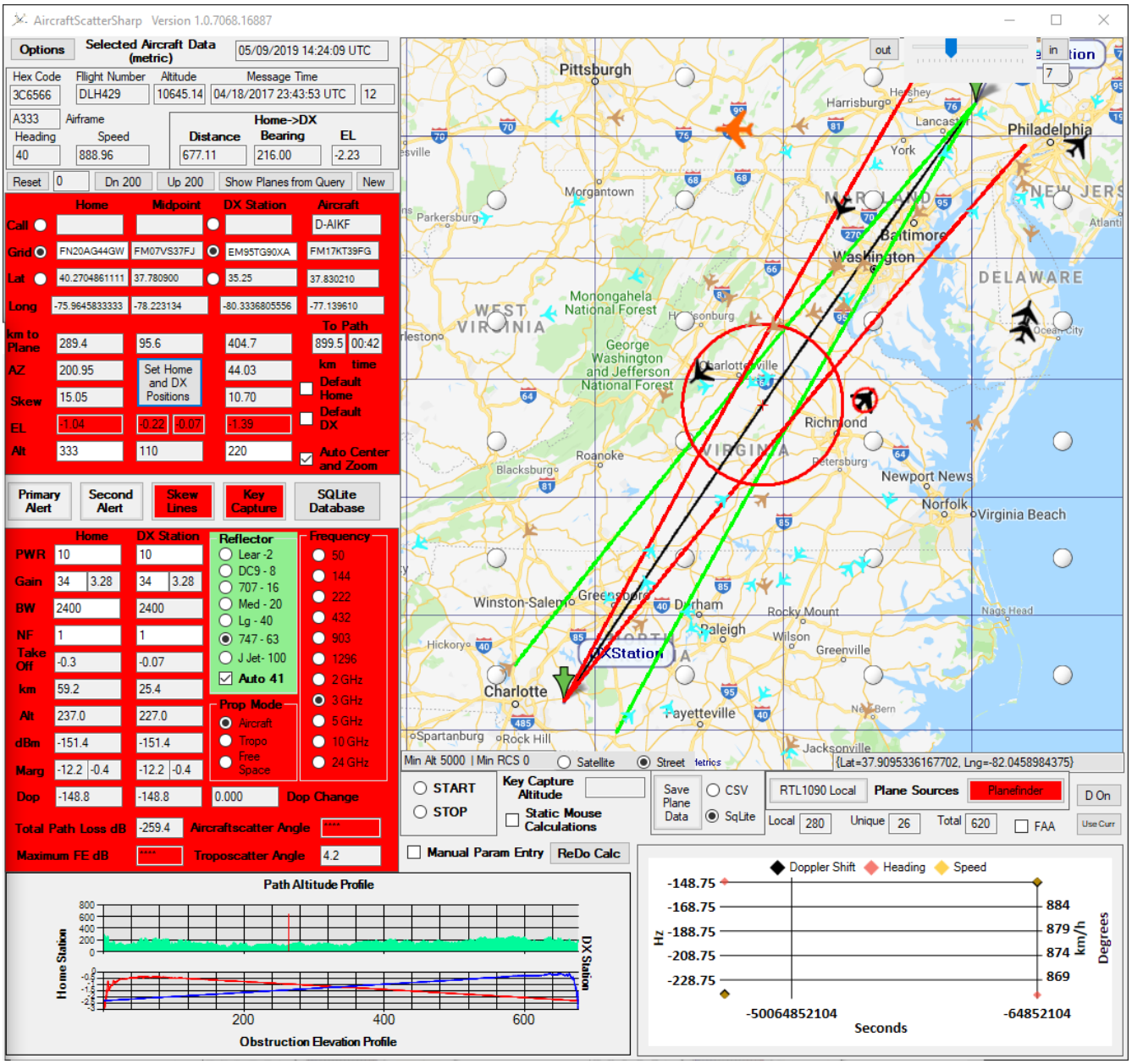
As you cycle through the multiple map displays available for a large query result, you can tell where you are in the data set by looking at the number displayed in the text box between the "Reset" button and the "Dn 200" button. This number represents the index of the first plane on the currently displayed map; if the number is 0, then you are looking at the first 200 planes in your query. If the number is 200, then you are looking at the second 200 planes, etc.

Clicking the "Reset" button returns the display index back to zero and initiates a

new query. If you have entered a new query before you click this button, then the first 200 planes in the new query result will be immediately displayed when you click this button.

At the extreme right end of this row of buttons is the “New” button. Clicking this button signals that a new plane is going to be used for Doppler calculations using planes data from the SQLite database. Clicking this clears the Doppler graph and ensures that the time stamp of the next plane marker to be clicked will be used as the "start" time for subsequent Doppler calculations.

Now lets review in more detail the results of clicking the “Show Planes from Query” button in this case.



The display looks just like a live plane display, but you can see that the selected

plane has an ADS-B timestamp that is 2 years prior to the time displayed in the current time display.
In the data and calculation area to the left you can see all of this plane's position and RF calculation parameters and even the Doppler data, just as if it were a "live" plane.

You can get more information about a plane on the map that you have selected, whether it is "live" or a plane from the SQLite database, by typing <Ctl>F7, which will bring up information for its hexno from the web pages at airframes.org. Such a result is shown immediately below. To do this you need to register with a user name and password at http://www.airframes.org/signup. Then click the "Options" button at the top left corner of the main AircraftScatter# window. Next click the "URLs/IPs" tab and enter your airFrames.org user name and password and click "OK". Once you have entered this data it will be remembered by AircraftScatter# and you never need to re-enter it unless your airFrames.org account expires due to 45 days or more of non-use.

The first time you type <Ctl>F7 during a session after having selected an aircraft, AircraftScatter# will log on to airFrames.org and present a browser window. Keep that window open so that you stay logged on, and the next time you select a new aircraft and then type <Ctl>F7 and thereafter the aircraft information will be displayed on this web page.

ICAO24 Hexcode Information

Aircraft Registration Database Lookup

Passenger airliners, cargo airplanes, business jets, helicopters, private aircraft, civil and military, showing common registry data as well as mode-S radar transponder addresses. The database is still **under development and construction.**

Aircraft database

Registration: [e.g. D-AIXA or daixa]

Selcal: [e.g. AS-DR or asdr]

ICAO24 address: [Mode-S address, default hex, or dec oct bin]

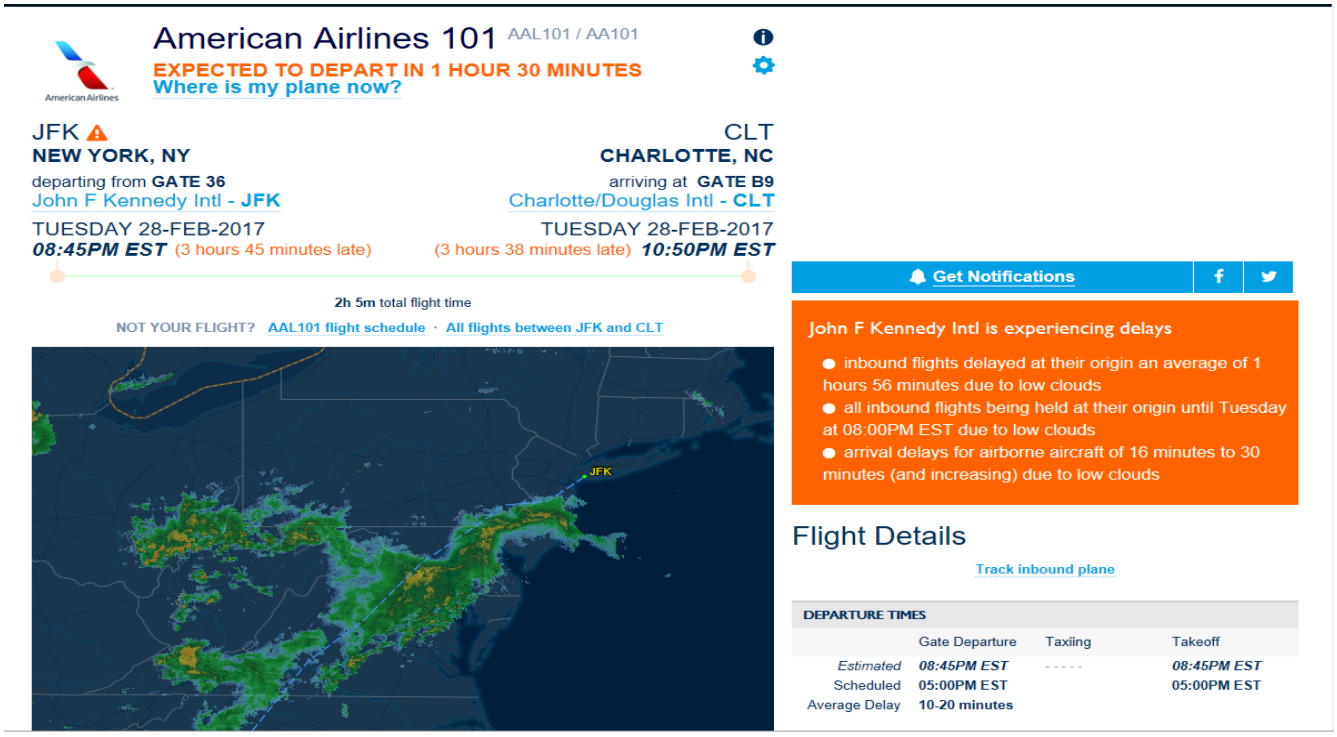
submit reset ... no bots ...

Your query for aircraft ICAO24-address AB2C04. Result: 1 row.

ICAO24-address AB2C04 is from United States of America [US] : A00000...AFFFFF (1048576 allocations, 1010---- -------- --------)
AB2C04 hex = 11217924 decimal = 52626004 octal = 10101011 00101100 00000100 binary.

Registration	Manuf.	Model	Type	c/n	l/n	i/t	Selcal	ICAO24	Reg / Opr	built	test reg	delivery	prev.reg	until	next reg	status	
N819NN	Boeing	737-823	B738	31083	3118	L2J	BMCH	AB2C04	AAL [AA] American Airlines	2009		2009-12-15				active	edit
	Remarks:	[MODE-S] [ACARS]															

By clicking <Ctl>F8 you can bring up flight information for the selected aircraft from FlightAware.com, as shown below. This gives you a history of several weeks of arrival and departure times that you can use to get an idea of how much variability there is in flight times, to supplement the data you acquired with Aircraft Scatter Sharp. Note that if you are using a plane that was captured by the SQL database a really long time ago, that the airline might have reassigned the flight number to a different route.



American Airlines 101 AAL101 / AA101

EXPECTED TO DEPART IN 1 HOUR 30 MINUTES

Where is my plane now?

JFK
NEW YORK, NY
departing from GATE 36
John F Kennedy Intl - JFK
TUESDAY 28-FEB-2017
08:45PM EST (3 hours 45 minutes late)

CLT
CHARLOTTE, NC
arriving at GATE B9
Charlotte/Douglas Intl - CLT
TUESDAY 28-FEB-2017
(3 hours 38 minutes late) 10:50PM EST

2h 5m total flight time

NOT YOUR FLIGHT? AAL101 flight schedule · All flights between JFK and CLT

Get Notifications

John F Kennedy Intl is experiencing delays

- inbound flights delayed at their origin an average of 1 hours 56 minutes due to low clouds
- all inbound flights being held at their origin until Tuesday at 08:00PM EST due to low clouds
- arrival delays for airborne aircraft of 16 minutes to 30 minutes (and increasing) due to low clouds

Flight Details

Track inbound plane

DEPARTURE TIMES

	Gate Departure	Taxiing	Takeoff
Estimated	08:45PM EST	-----	08:45PM EST
Scheduled	05:00PM EST		05:00PM EST
Average Delay	10-20 minutes		

Airline Flight Information

Activity Log

UPCOMING FLIGHTS

Date		Departure	Arrival	Aircraft	Duration
Thursday	02-Mar-2017	05:10PM EST John F Kennedy Intl - JFK	07:04PM EST Charlotte/Douglas Intl - CLT	B738	1 hour 54 minutes
Thursday	02-Mar-2017	10:25AM GMT London Heathrow - LHR	01:20PM EST John F Kennedy Intl - JFK	B772	7 hours 55 minutes
Wednesday	01-Mar-2017	05:10PM EST John F Kennedy Intl - JFK	07:04PM EST Charlotte/Douglas Intl - CLT	B738	1 hour 54 minutes
Wednesday	01-Mar-2017	10:25AM GMT London Heathrow - LHR	01:20PM EST John F Kennedy Intl - JFK	B772	7 hours 55 minutes
Tuesday	28-Feb-2017	08:45PM EST John F Kennedy Intl - JFK	10:50PM EST Charlotte/Douglas Intl - CLT	B738	2 hours 5 minutes

PAST FLIGHTS

Date		Departure	Arrival	Aircraft	Duration
Tuesday	28-Feb-2017	10:04AM GMT London Heathrow - LHR	12:38PM EST John F Kennedy Intl - JFK	B772	7 hours 34 minutes
Monday	27-Feb-2017	05:07PM EST John F Kennedy Intl - JFK	07:07PM EST Charlotte/Douglas Intl - CLT	B738	2 hours
Monday	27-Feb-2017	10:07AM GMT London Heathrow - LHR	12:49PM EST John F Kennedy Intl - JFK	B772	7 hours 42 minutes
Sunday	26-Feb-2017	04:53PM EST John F Kennedy Intl - JFK	06:55PM EST Charlotte/Douglas Intl - CLT	B738	2 hours 2 minutes
Sunday	26-Feb-2017	10:14AM GMT London Heathrow - LHR	01:18PM EST John F Kennedy Intl - JFK	B772	8 hours 4 minutes
Saturday	25-Feb-2017	07:55PM EST John F Kennedy Intl - JFK	10:56PM EST Charlotte/Douglas Intl - CLT	B738	3 hours 1 minute
Saturday	25-Feb-2017	10:10AM GMT London Heathrow - LHR	01:24PM EST John F Kennedy Intl - JFK	B772	8 hours 14 minutes
Friday	24-Feb-2017	05:08PM EST John F Kennedy Intl - JFK	07:00PM EST Charlotte/Douglas Intl - CLT	B738	1 hour 52 minutes
Friday	24-Feb-2017	09:59AM GMT London Heathrow - LHR	01:09PM EST John F Kennedy Intl - JFK	B772	8 hours 10 minutes
Thursday	23-Feb-2017	05:01PM EST John F Kennedy Intl - JFK	06:44PM EST Charlotte/Douglas Intl - CLT	B738	1 hour 43 minutes
Thursday	23-Feb-2017	10:01AM GMT London Heathrow - LHR	01:05PM EST John F Kennedy Intl - JFK	B772	8 hours 4 minutes
Wednesday	22-Feb-2017	05:08PM EST John F Kennedy Intl - JFK	07:27PM EST Charlotte/Douglas Intl - CLT	B738	2 hours 19 minutes

Because plane schedules are NOT like clockwork, using only published schedules to estimate when a plane will be in a given area can be unreliable. But using Aircraft Scatter Sharp to gather large amounts of data over a period of days or weeks or longer allows one to make statistically based decisions on when aircraft of appropriate RCS and altitude are most likely to be in the region of interest, by examining the historical data obtained using this program. Using the various functions on the database form, one can select which data is to be displayed, and by analyzing that data, one can then devise operating schedules that will be most likely to be productive. Also, the data in the SQLite dataset is useful for quickly testing experimental hypotheses about the effects of various aircraft parameters on various dependent variables, and for teaching and demonstration purposes.

Further suggestions on how to setup and use Aircraft Scatter Sharp are contained in the appendix, which immediately follows this page.

If you have any questions, please contact me by email at mycall at comcast dot net. You may download a copy of the program from the web page listed below.

There is also a copy of this talk plus additional information at
http://www.nitehawk.com/w3sz/AircraftScatter.htm

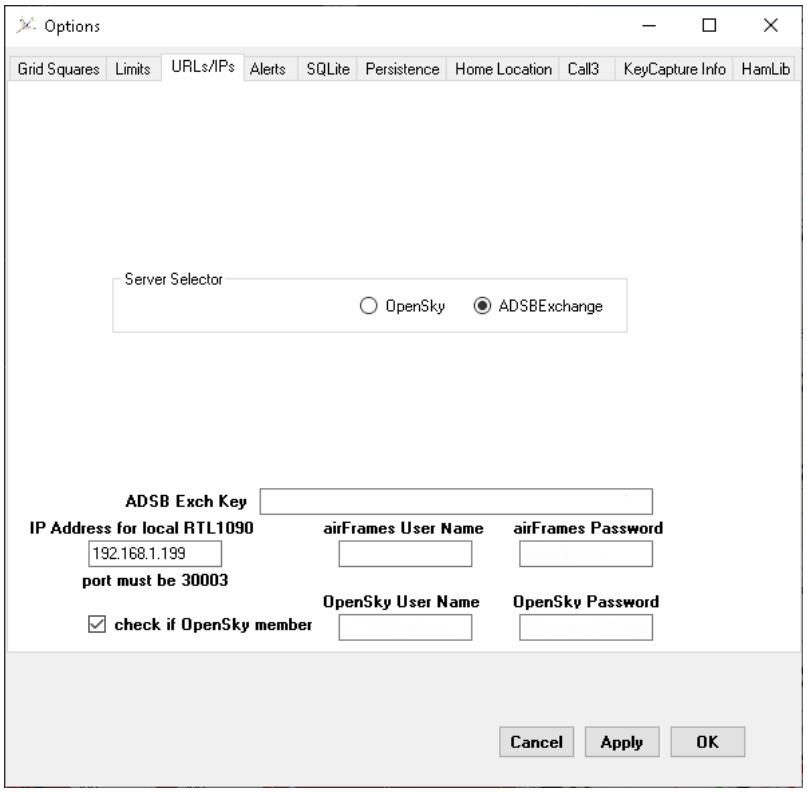
Roger Rehr W3SZ
02-03-2022

Appendix. Suggestions for getting started.

1. The program has been tested and works with Windows 7, 8, 8.1, 10, and 11, both 32 and 64 bit versions. It has not been tested with other operating systems.
2. Download Aircraft Scatter Sharp from: https://w3sz.com/updates/AircraftScatterSharp.exe
3. Double-left-click the file to start the installation process.
4. Make the usual appropriate responses to prompts that apppear to install the program.
5. When the program starts it will tell you that it is writing to disk the initial dBplanes.sqlite database file and the call3.txt file. It will also check to see if you are running the newest version of the program and if not, it will ask you if you want to install the newest version.
6. Go to Options by clicking the button at the top left of the main form. If you are using an RTL 1090 for input, enter its URL on the URLs/IPs page. On that page also enter your airFrames user name and password so that you can use Cntl-F7. On that page also enter your username and password for the OpenSky Network and check the OpenSky member box. If you aren't already registered as an OpenSky user, then set up a (free) account there now at https://opensky-network.org/ If you aren't a registered user, then you are limited to 100 API downloads per day. If you are a regular user, then you are granted 1000 API downloads per day. If you are a contributing user with at least 30% onine percentage in the past month, then you are granted 2000 API downloads per day. How long these allotments of API downloads will last you depends on the download interval that you specified on the Options >> Persistence tab. If you set the download interval to 10 seconds, then 100 downloads will last you about 17 minutes, 1000 downloads will last you about 2 and ¾ hours, and 2000 downloads will last you about 5 and a half hours. If you set the download interval to 60 seconds, then 100 downloads will last you an hour and 40 minutes, 1000 downloads will last you about 16 hours and 40 minutes, and 2000 downloads will last you about 33 hours and 20 minutes. Since the download counter resets every 24 hours, if you are a contributing user and set the download interval to 60 seconds then you will never run out of downloads. If you aren't a registered OpenSky user, you will quickly run out of API downloads regardless of the download interval that you choose.

In February 2023 I added a second server option, ADSBExchange https://www.adsbexchange.com/. It is just as fast as OpenSky, and shows at least as many planes in my region. And it gives all of the necessary "live" information that you need to track planes when you are operating. ADSBExchange, unlike OpenSky, does not provide the aircraft's country of origin or an on-ground flag. However, ADSBExchange provides Airfame Type information for downloaded aircraft, which OpenSky does not do. This is a major point in favor of ADSBExchange. To use ADSBExchange with AircraftScatterSharp you need to sign up for the ADSBExchange RapidAPI, which you can do from https://rapidapi.com/adsbx/api/aircraftscatter/. There is additional information

on how to get your key at this url: https://w3sz.com/obtainADSBExchAPI_AirScatterSharp.html Signing up will give you 60,000 downloads per month, which is equivalent to you get from OpenSky when you upload enough planes per month to put you in OpenSky's "Active Contributing User" class. When you sign up with ADSBexchange you will be assigned an X-RapidAPI-Key which is a roughly 50-digit alphnumeric string that you will need to enter into the text box labeled "ADSB Exch Key" on the AircraftScatterSharp Options tab labeled "URLs/IPs" in order to access the ADSBexchange planeserver. This tab is shown below



7. While on the Options form, you should also go to the "Home Location" tab and set the home latitude, longitude, and altitude for your QTH, and a DX station if you have a regular DX partner. After you have entered the appropriate data, click the "Set Home Station" button and also the "Set DX Station" if you have entered location and altitude data for the DX station. You should also enter the mast heights for both your station and the DX station, if known. Then click "OK" to close the Options form. The default values for the parameters on the other Options pages will be suitable until you gain more experience. Images of the Options pages with additional information regarding their use appear at the end of this appendix.
8. There are numerous tool tips which appear when you hover over the various controls, text boxes, etc. to guide you as you learn the program.
9. After you have selected your plane server(s), you can start downloading plane data from the internet by left-clicking the "START" button near the center of the main form below the map.
10. Buttons turn RED when activated, and return to their baseline color when

deactivated.
11. Using the internet plane server is selected by default. You can deselect it by clicking on the "Internet Servers" button. When you exit the program, your choice will be remembered. If you select "Internet", it will deselect "Pplotter", and vice versa. You can run RTL1090 while running one of the other two choices too.
12. You can additionally select to display local plane data, sent using the port 30003 server of your RTL dongle software, by clicking on the "RTL1090 Local" button.
13. To save plane data to the SQLite database, click the "Save Plane Data" button.
14. Hover over a plane with the mouse to see its tool tip data. You need to hover near the "3 o'clock" to "6 o'clock" quadrant below the plane to activate the tool tip, and this is also where you need to left-click to select an aircraft. It takes some practice to select the correct aircraft when the planes are clustered close together.
15. Left-click a plane to make it the "selected" plane and put all of its data into the data/calculation portion of the main form. As just noted, you need to click near the "3 o'clock" to "6 o'clock" quadrant below the plane to select it.
16. In order to use the Hotkeys, you need to turn on key capture, using the "KeyCapture" button near the middle of the data/calculation portion of the main form. The hotkeys are F1-F9 combined with the <Ctl> key and do the following:

<Ctl>F1 will place the latitude and longitude of the point under the mouse cursor in the Home Station position boxes, **if** the manual entry "Lat" radio button is selected for the Home Station.

<Ctl>F2 will place latitude and longitude of the point under the mouse cursor in the DX Station position boxes, **if** the manual entry "Lat" radio button is selected for the DX Station.

<Ctl>F3 will place the altitude of the point under the mouse cursor into the Key Capture Altitude text box beneath the map.

<Ctl>F4 Displays a message box showing Latitude, Longitude, Altitude, and Grid for the point chosen when the F3 key was last used as described above.

<Shift>F4 is equivalent to **<Ctl>F3** followed immediately by **<Ctl>F4**.

<Ctl>F5 Activates ToolTips for all forms.

<Ctl>F6 Deactivates ToolTips for all forms.

<Ctl>F7 Brings up a web page showing information for the selected plane's ICAO 6-digit hexadecimal identifier. For this you need to register at airFrames.org.

<Ctl>F8 Brings up a Flight Aware web page showing both current and historical information for the selected plane's Flight Number.

<Ctl>F9 Shows a list of all Key Capture functions.

<Alt>A Allows user to set a lower altitude limit for planes displayed.

<Alt>E Allows user to set a lower limit for the elevation as seen by either station for the planes displayed.

<Alt>R Allows user to set a lower RCS limit for planes displayed.

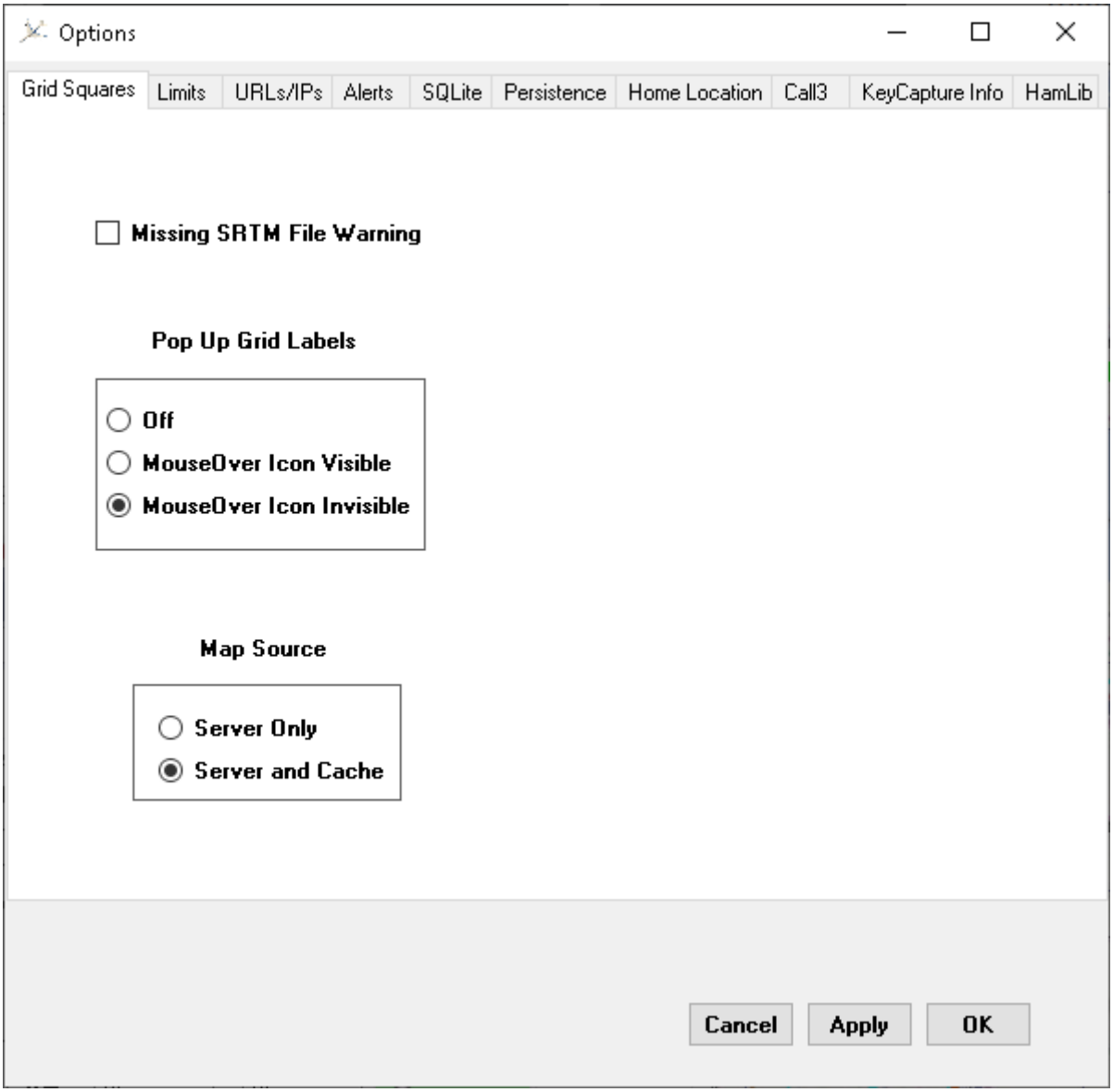
<Alt>M Turns on or off display in the Key Capture Altitude box of the elevation in meters of the map point under the mouse cursor.

<Ctl>Home Used on the SQLite database page to center a database query around a geographic point on the map.

<Ctl>Insert and **<Ctl>Delete** Used on the SQLite database page to set two ends of a Great Circle path along which a database query will return planes.

<Ctl>Up-Down-Right-Left Arrows Used on the SQLite database page to set North/South/East/West boundaries for a rectangular query box.

17. Zoom the map in and out using the "in" and "out" buttons at the top right of the map.
18. You may drag the map to a new center by holding down the right mouse button while you are dragging the map with the mouse pointer.
19. If you have "Auto Center and Zoom" checked [the default] then each time you click "Set Home and DX Positions", the map will center itself on the midpoint of the path you have created.
20. You can enter Home and DX station position data one of 3 ways:
    - Click on the "Call" radio button and type in a call. If that call is contained in the call3.txt database, its grid and Lat/Long information will be entered.
    - Click on the "Grid" radio button and type a 4-10 digit grid locator
    - Click on the "Lat" radio button and enter the latitude and longitude values
21. Once you have entered the position data for Home and DX stations as described above, left-click the "Set Home and DX Positions" button to calculate the path between the home and DX stations.
22. The Path Altitude Profile will only be displayed if you have downloaded all of the necessary SRTM3 data files from https://srtm.kurviger.de/SRTM3/North_America/index.html and put it into the %localAppData%/W3SZ/ElevationData/SRTM3 directory. This is most likely of the form x:/Users/your_user_name/AppData/Local/W3SZ/ElevationData/SRTM3/.
23. If you check the checkbox next to the "AZ" label in the Station and Aircraft Position Data area, and if you have configured the rotor settings properly in the Options "HamLib" tab, then your antenna will track the position of the selected plane. You can set the rotor "time out" or "dead zone" to be any number of degrees greater than 0.1. This feature uses the N1MM Rotor Control App, and you can read about setup for that in the N1MM documentation.
24. Read the tool tips and the Options pages for more useful information.
25. I have reproduced the Options pages from my installation below, in case you have trouble reading them at your site:

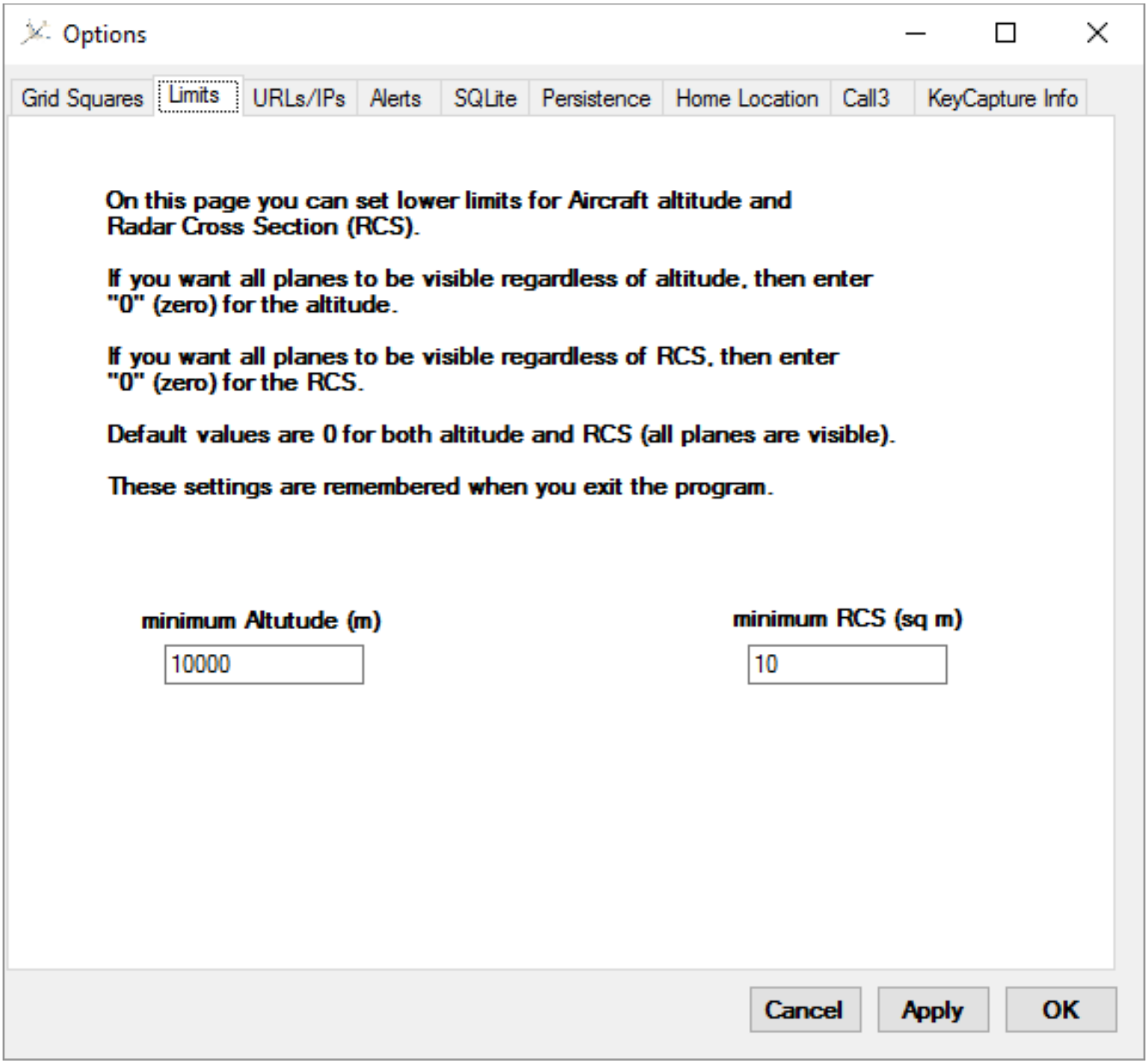


If you don't have the SRTM3 files mentioned on pages 9 and 27 above, then you will get Message Boxes with errors of the sort "SRTM3 File N3xxWyyy required for this path is missing for BW3". To prevent such error messages from appearing, either uncheck the box on this page that is labeled "Missing SRTM File Warning" or download the SRTM3 files as described on pages

You can choose to turn off pop-up grid labels, and you can choose to make the mouse-over icon in the middle of each grid visible or invisible.

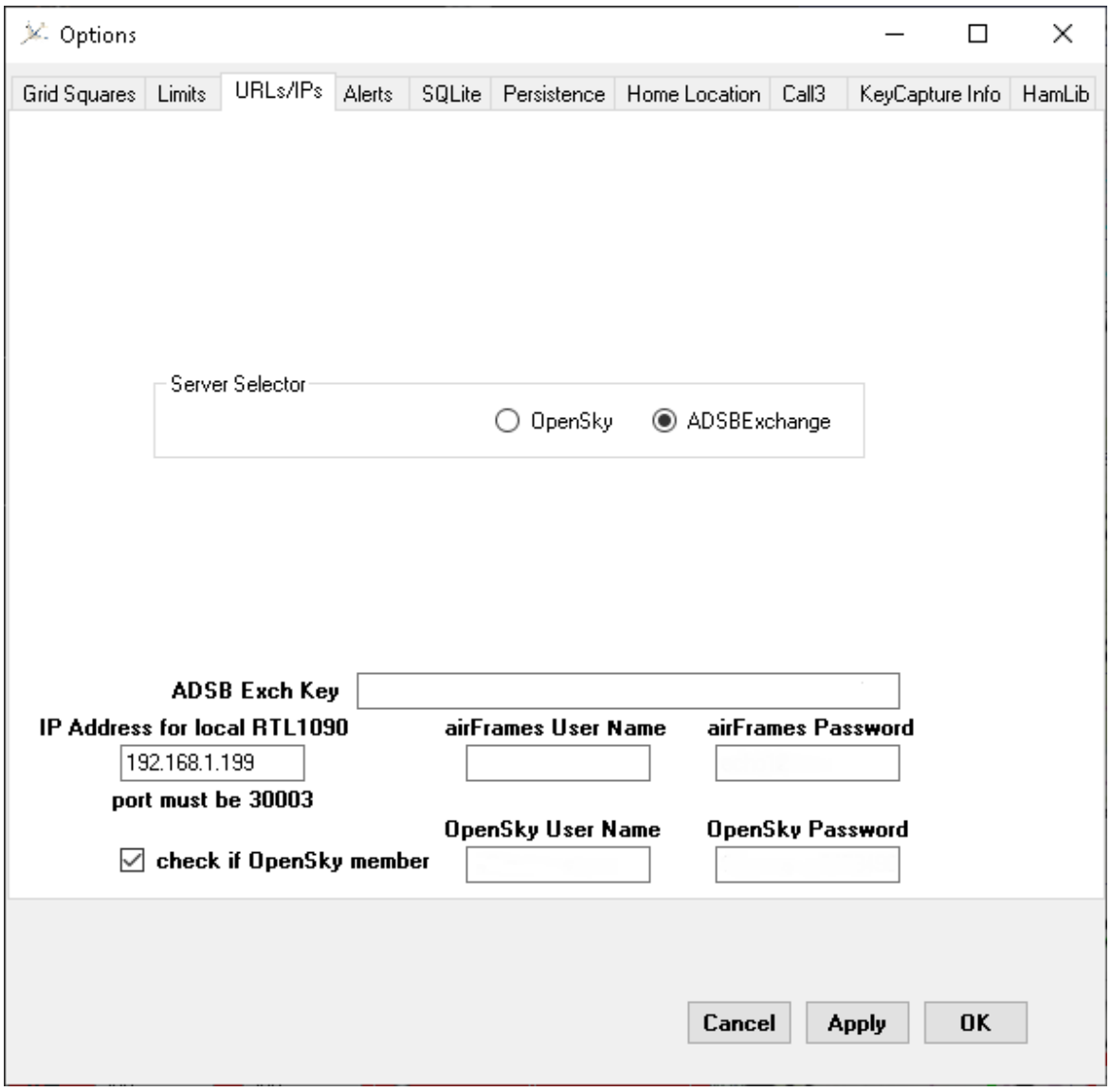
By default, maps for the aircraft display are obtained from an internet map server. If you wish to save maps to your hard drive so that they will be available to this program if you are operating without internet access, then click the "Server and Cache" button while connected to the internet and maps you view will be saved to your hard drive and available to this program when internet access is not available, as long as the "Server and Cache" radio button is

checked. The map cache resides at
../Users/your_user_name/AppData/Local/Gmap.NET/TileDBv5/en/Data.gmdb



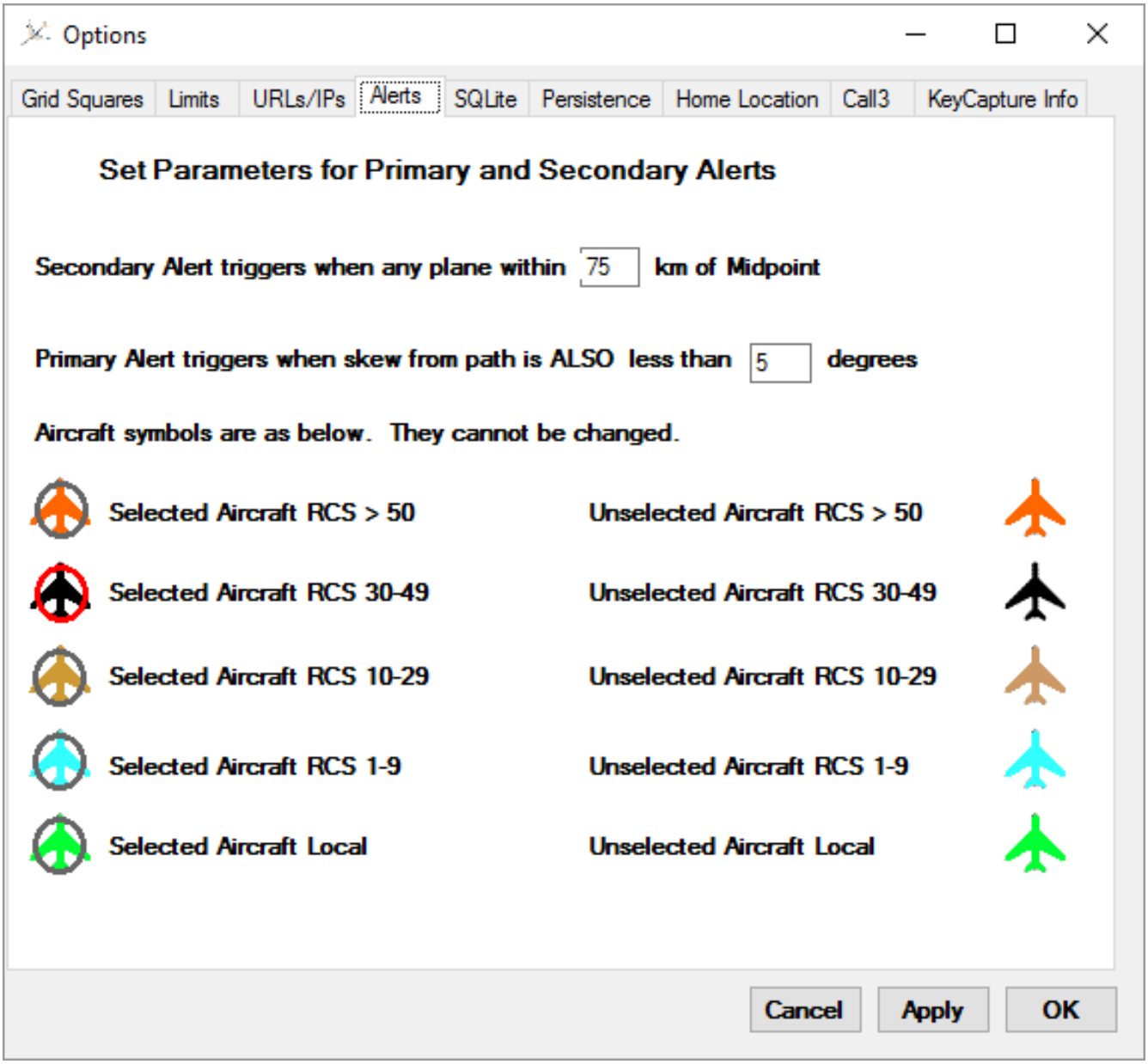
This page is used to set the minimum altitude (in meters) and minimum RCS (in sq. meters). Alternatively, these values can be set using Alt-A for altitude and Alt-R for RCS. Aircraft with values for these parameters below these limits will not be displayed. Once set, these values are remembered from session to session.

As with all AircraftScatterSharp functions that make use of the Alt key or the Control key, the Key Capture button must be enabled for Alt-A and Alt-R to function for this purpose.

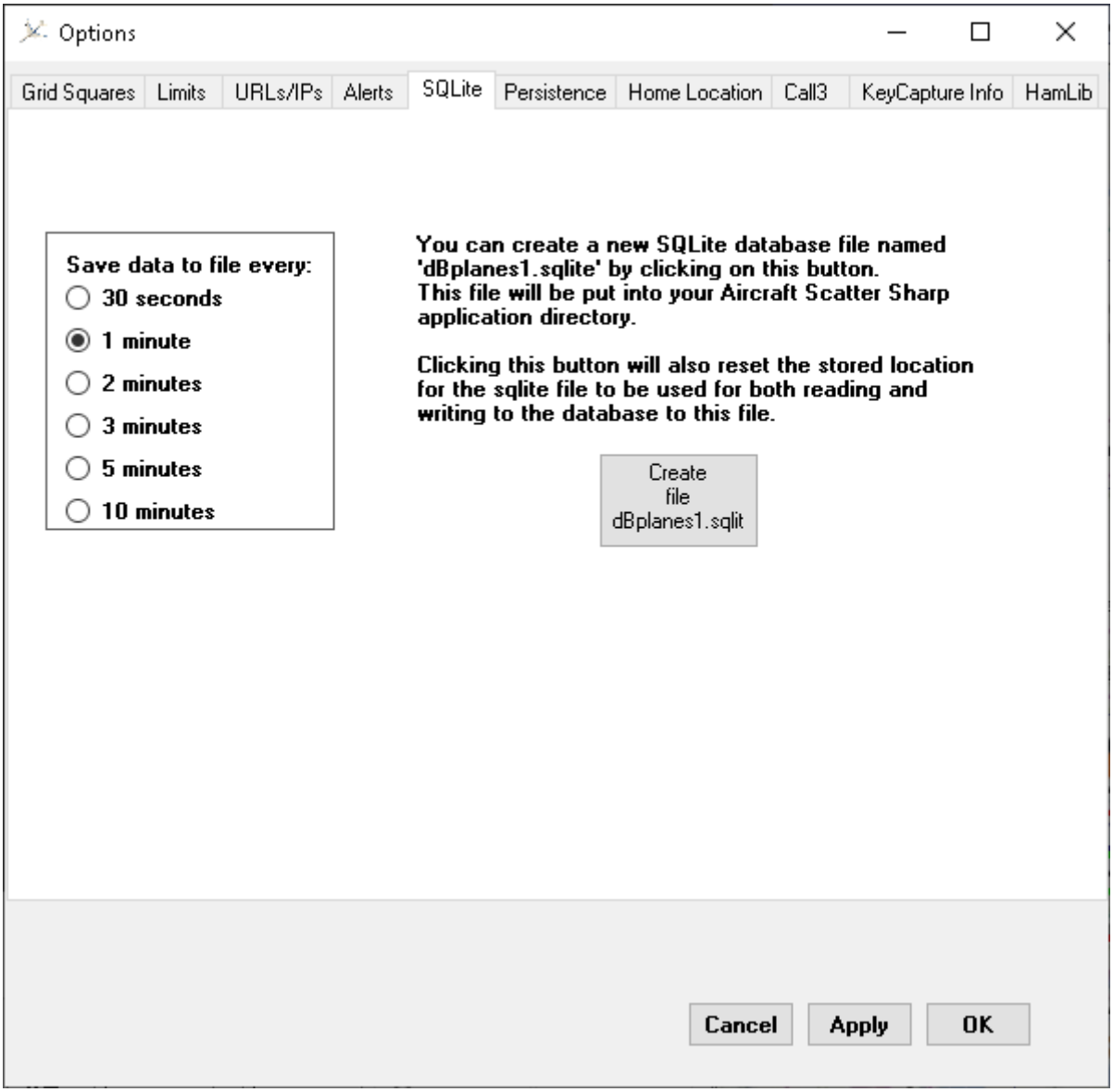


If you are using a local RTL1090 as a plane server, place its IP address here. Its port must be 30003. Also, make sure that you register as an OpenSky user at https://opensky-network.org/ and then check the "check if OpenSky member" checkbox on this page and also enter your OpenSky username and OpenSky password. Otherwise, your ability to download planes from the OpenSky planeserver will be extremely limited. Signing up as a user is free. Signup and other info for ADSBexchange is given in the Appendix section 6 above.

To use <Ctl>F7 to get aircraft information,you need to register with a user name and password at http://www.airframes.org/signup and enter your airFrames.org user name and password aon this form. Once you have entered this data it will be remembered by AircraftScatter# and you never need to re-enter it unless your airFrames.org account expires due to 45 days or more of non-use. The first time you type <Ctl>F7 you will be logged onto airFrames.org and when you subsequently select new planes and then type <Ctl>F7 you will be presented with the aircraft data for the aircraft that you have selected.

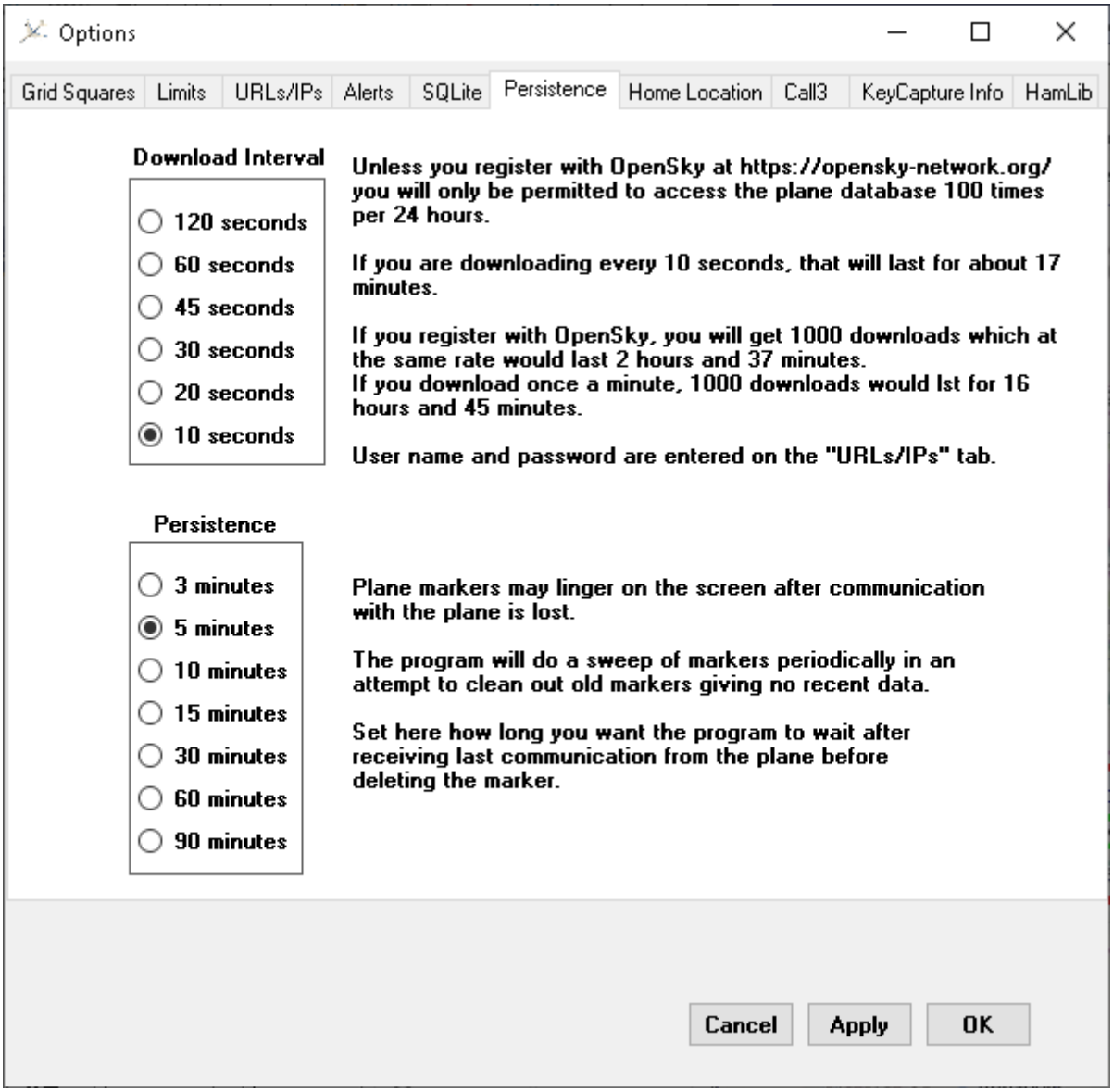


I have found that values of 75 km for the Secondary Alert circle and 5 degrees for the Primary Alert skew angle trigger work well for alerting me as to when aircraft are in a position to give a high likelihood of successful aircraft scatter contacts.



For general database collection I have found that adding data to the database every 3 minutes works well. When I want to collect data for analysis of Doppler rates of change or to closely track and record plane parameters, I collect data every 30 seconds.

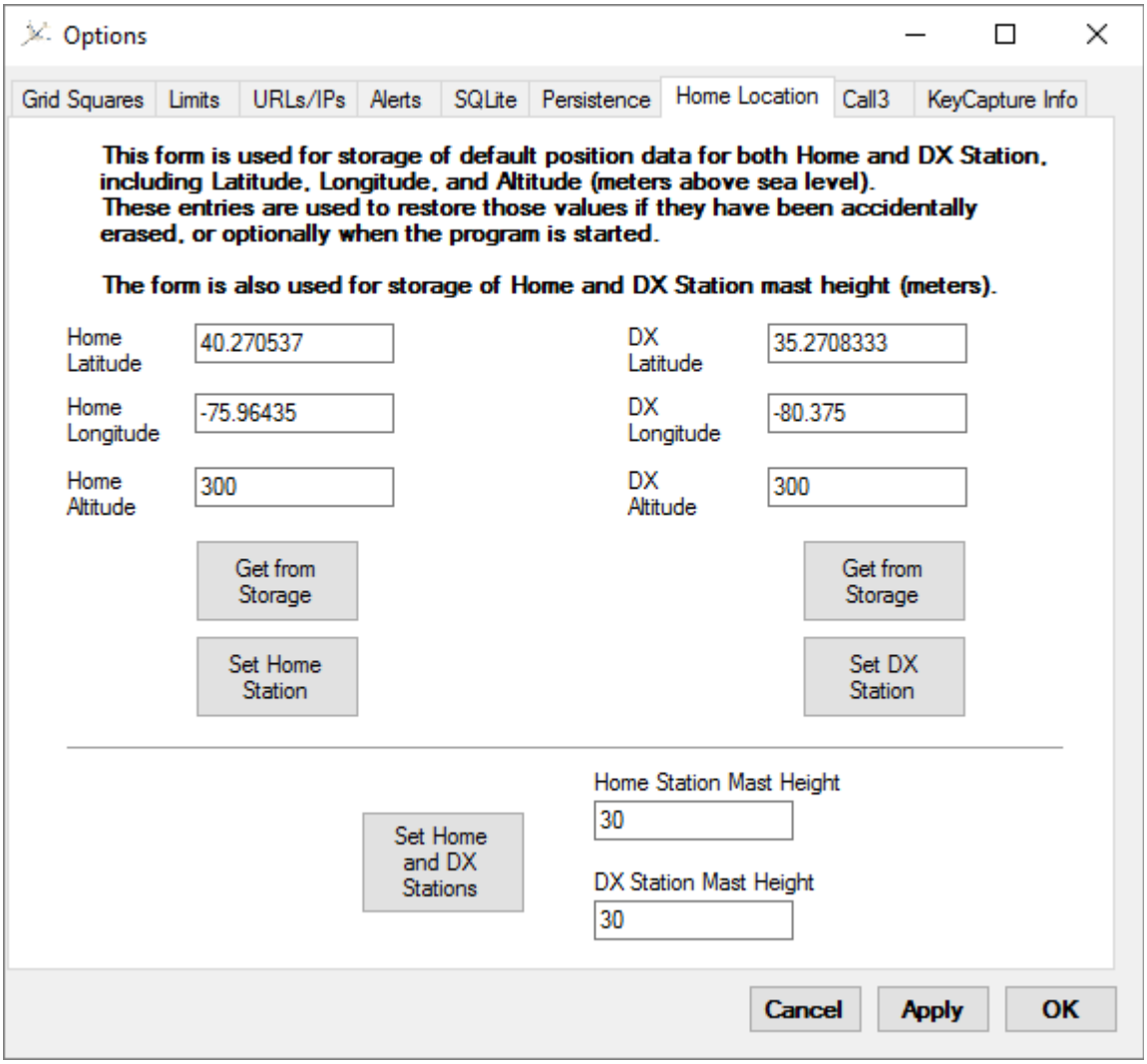
I have never needed to create a new SQLite file after one has been created automatically during program installation, but the capability to create a new one is available on this tab by clicking the "Create file dBplanes1.sqlit" button. Be careful and back up your old file before creating a new one! The dBplanes.sqlite file is typically found in the directory ../Users/your_user_name/AppData/Local/W3SZ.



The persistence tab allows you to set the download interval and also how long a plane will persist on the display after its data is last downloaded. Frequent aircraft position updates are nice, but unless you are an OpenSky registered user you will quickly run out of downloads if you have the download interval set to 10 seconds. On the other hand, if you are a contributing OpenSky user (one who sends them regular aircraft data uploads), you can afford to set a shorter download interval without using up your API download allotment.

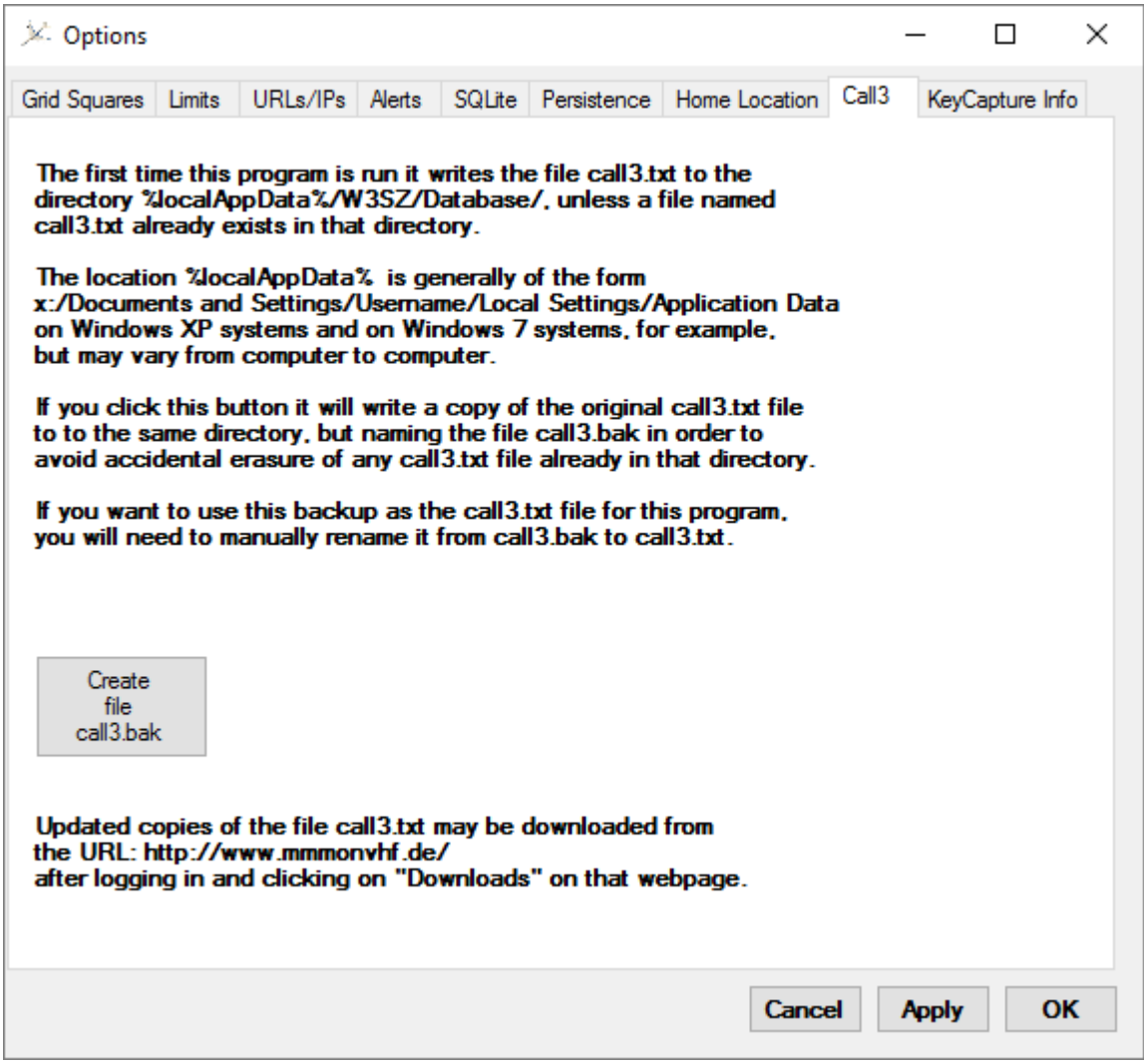
Airplane servers typically contain a number of "dead" planes that are in the database download but no longer sending any new data. Additionally, planes that were initially sending data may move out of range of the plane feeders and stop sending new data. The persistence setting determines how long after the last received message such planes will be scrubbed from the plane display.

I have found that a setting of 10 minutes for this parameter works well for me.



This page allows you to save (if you click "Set Home Station" or "Set DX Station") default locations and altitude for the Home Station and the DX Station, or to retrieve such data if you click "Get from Storage" for either the Home Station or the DX Station. If [1] values are entered here and saved, and if [2] the "Default Home" or "Default DX" check box in the "Station and Aircraft Position Data Area" of the main form are checked and [3] the "Lat" radio button is checked for the Home or DX Station or both, then this data will be used to populate the latitude and longitude for the respective station(s).

At the bottom of this page you can set the default mast height for the Home and the DX stations by clicking the "Set Home and DX Stations" button. This data will then be used to populate the Home and DX Station "Alt" (altitude) text boxes in the "Station and Aircraft Position Data Area" of the main form by adding it to the altitude for that location.

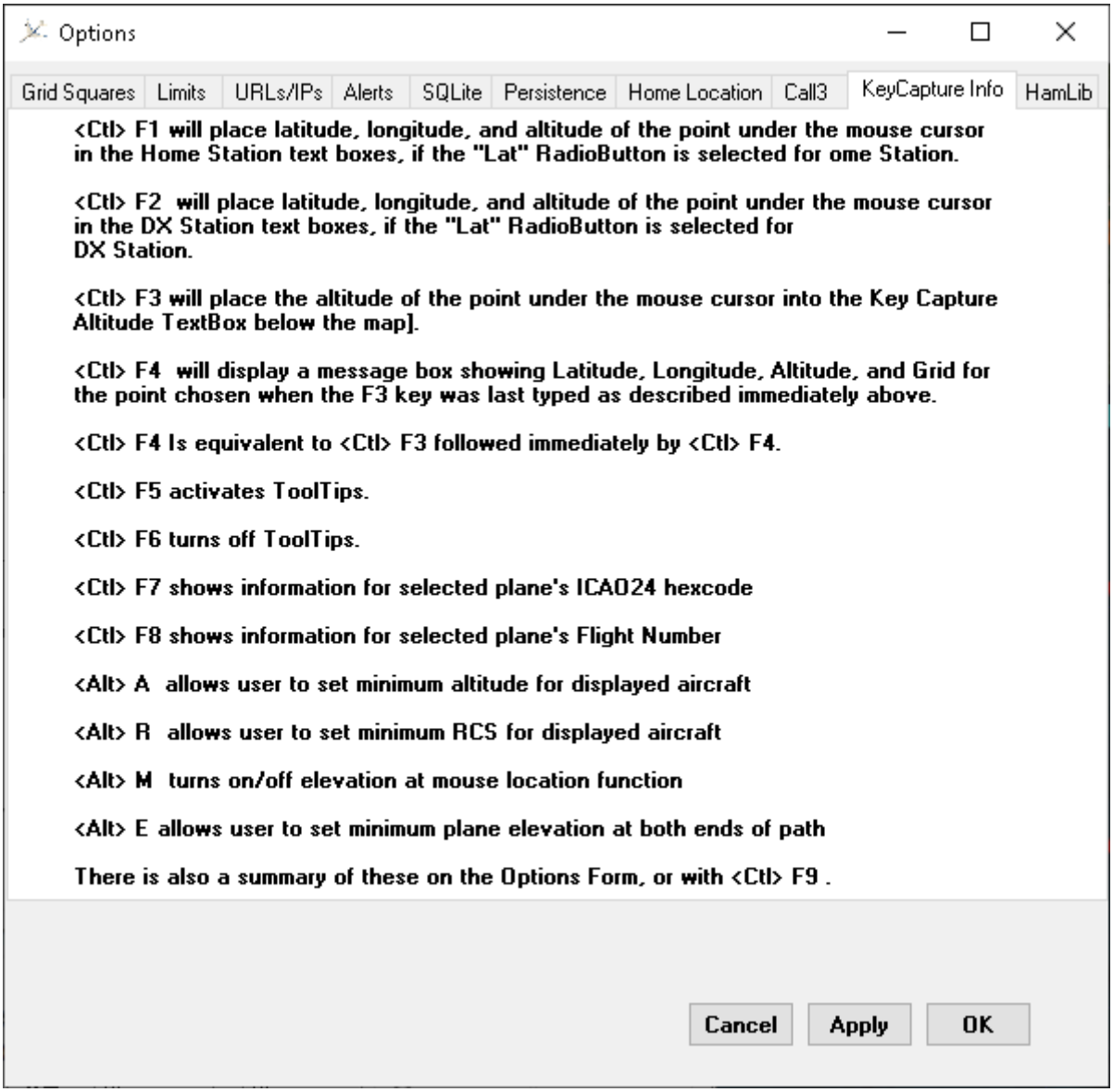


Optionally, a call3.txt file can be used to obtain grid information and thus latitude and longitude for the Home and DX stations. A copy of a call3.txt file is included with this program download but the user is advised to download an updated version when installing this program.

One location from which the call3.txt file can be downloaded is http://www.mmmonvhf.de/download.php

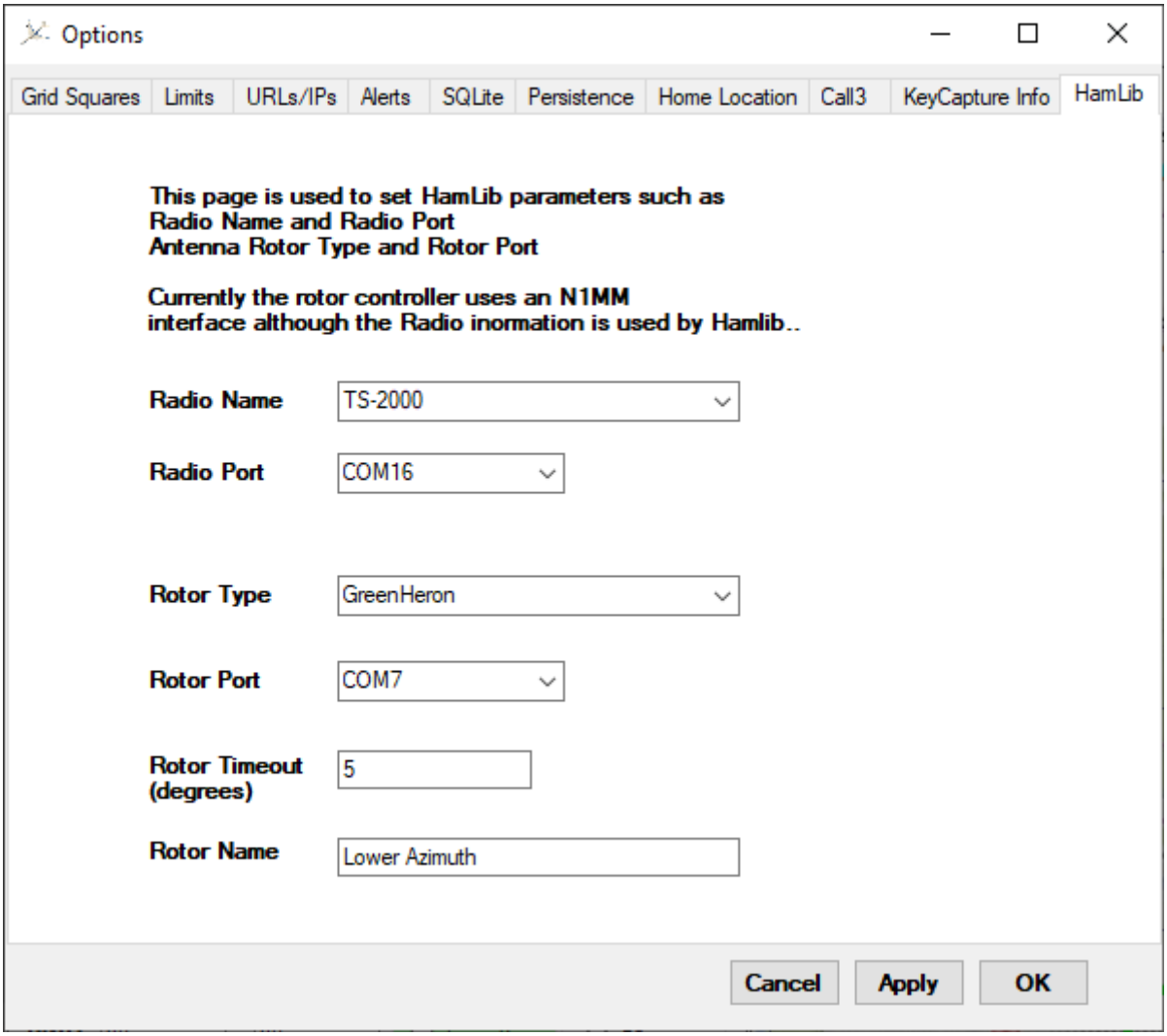
You need to be registered and logged in to that site to download the call3.txt file which is updated daily at this location.

On modern versions of Windows this file is typically located at ../Users/your_user_name/AppData/Local/W3SZ/Database.



Key Capture will not function unless you have activated it by clicking the “Key Capture” button, which will have a red background when the key capture function is active.

In addition to the Function-Key related items, <Alt> A, <Alt>E, and <Alt> R will set the minimum display altitude, elevation, and RCS when key capture is activated, and <Alt> M will turn on and off the display in the Key Capture Altitude text box of the elevation of the map point under the mouse cursor.



The final tab is for setting up radio and rotor control.

Antenna control is obtained via the N1MM Rotor Control application, and one needs to set the rotor type, rotor port, and rotor name so that they are identical to the settings in the N1MM Rotor Control application. Plane tracking is not useful in making QSOs but I use this function in some of the experimental work that I am doing.

The rotor timeout can be set to be any number of degrees greater than 0.1.

Plane tracking is in general not sufficiently predicable for useful Doppler control. This feature, which uses HamLib, is not supported. If you use it you are on your own.

References

1 Rehr R,Tropospheric Scatter (Troposcatter) Propagation for VHF, UHF, and Microwave Frequencies. Mid-Atlantic States VHF Conference 2014. Also http://www.nitehawk.com/w3sz/W3SZ-PackRatsConference2014.pdf

2 Flowers, A. RainScatter 1.61. http://www.frontiernet.net/~aflowers/rainscatter/

3 Jet Propulsion Laboratory, California Institute of Technology. http://www2.jpl.nasa.gov/srtm/

4 SRTM3 files for North America can be downloaded from https://srtm.kurviger.de/SRTM3/index.html