SkyRoof

software for Hams and satellite enthusiasts

User's Guide

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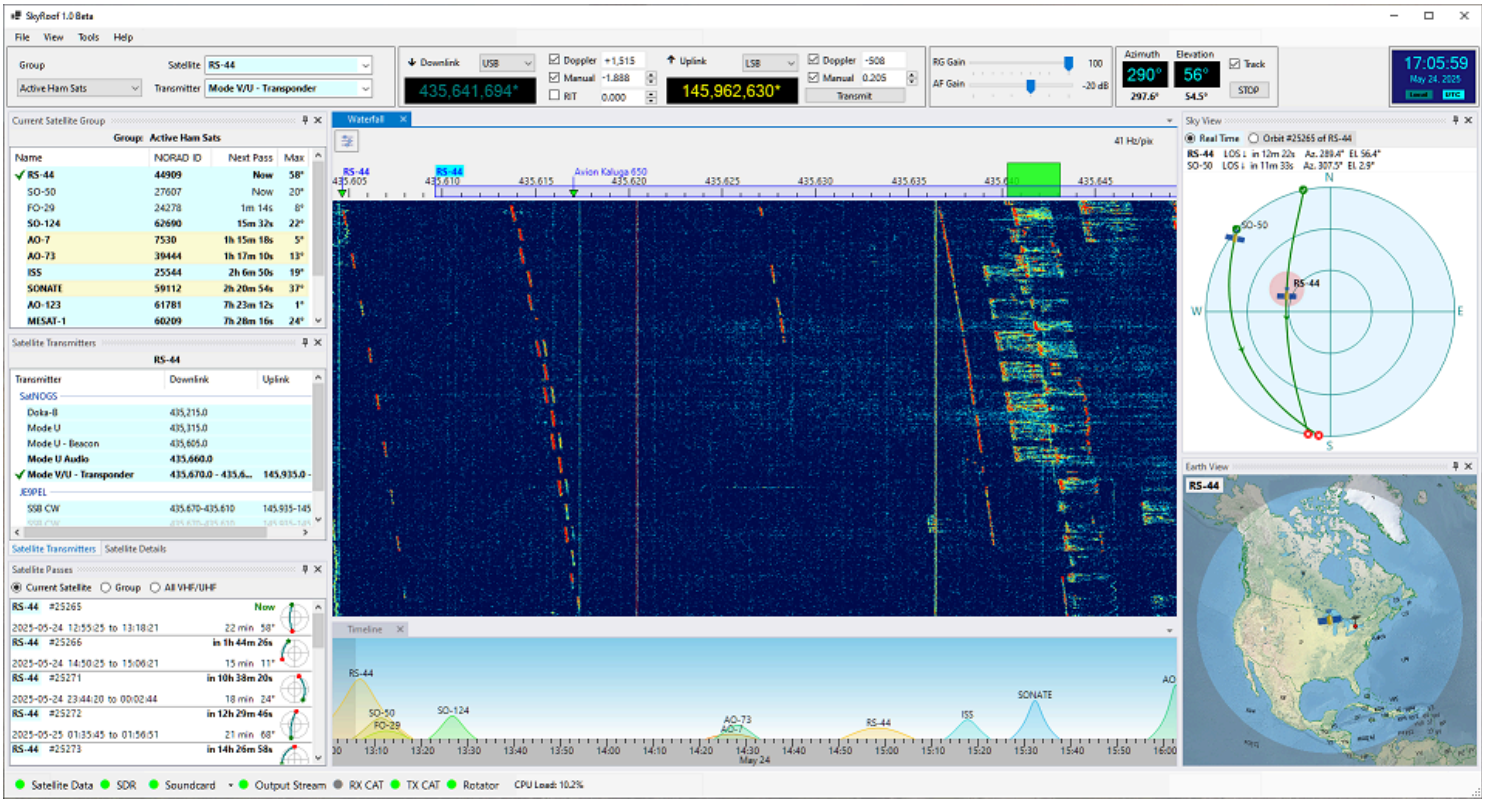
Overview

SkyRoof is an open source, 64-bit Windows application for Hams and satellite enthusiasts, available on the terms of the GPL v.3 license. It combines satellite tracking and SDR functions in one program, which opens some interesting possibilities. For example, all satellite traces on the waterfall are labeled with satellite names, the boundaries of the transponder segments follow the Doppler shift, and all frequency tuning is done visually, with a mouse.



Features

The main features of SkyRoof are:

- detailed information about all satellites that transmit in the Ham bands;
- satellite tracking in real time;
- pass prediction for the selected satellites;
- visual representation of the current satellite position and future passes, using:
  - Sky View - the view of the sky from your location;
  - Earth View - the view of the Earth from the satellite;
  - Time Line - the satellite passes on the time scale;
  - Pass List - the details of the predicted passes;
- SDR-based waterfall display that covers the whole satellite segments on the VHF and UHF bands, with zoom and pan;
- SDR-based SSB/CW/FM receiver with RIT and Doppler tracking;

- audio and I/Q output to external programs via VAC;
- frequency scale with satellite names and transponder segments, Doppler-corrected;
- CAT control of an external transceiver;
- antenna rotator control.

The program can work without an SDR, or even without any radio at all, but many useful functions are not available in this mode.

System Requirements

Hardware

- **Computer**: 64-bit PC. 3-GHz Quad-core CPU is recommended;
- **Video Card**: OpenGL 3.3 or higher, 512 Mb of texture memory;
- **Monitor**: screen resolution 1900x1280 or higher, 4K recommended;
- **Internet**: required, to download satellite data;
- **SDR**: optional, but highly recommended. Supported models:
  - Airspy Mini;
  - SDRplay;
  - RTL-SDR.

  Contact me for other models;
- **Transceiver**: optional. The beta version was tested with IC-9700, please try it with other models;
- **Antenna rotator** - optional, any rotator supported by HamLib, please test with yours and let me know.

Software

- **OS**: Windows 10 or Windows 11, 64-bit only;
- **HamLib**: optional, for CAT and rotator control.

Quick Start

Installation

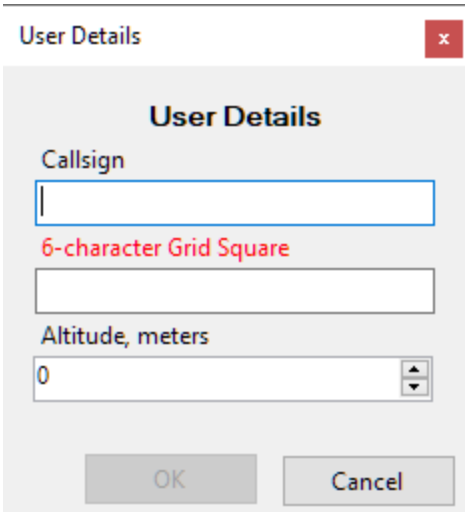
To install SkyRoof, download the installer from the Download page, run it, and follow the on-screen instructions.

First Run

When you run SkyRoof for the first time, the program performs several important, but somewhat lengthy steps. Fortunately, they need to be done only once.

User Information Input

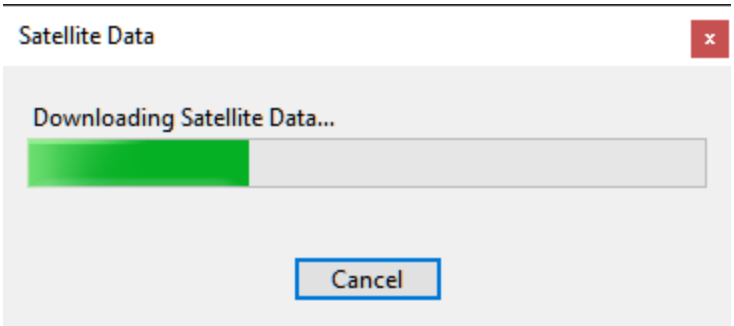
You will be presented with the User Details dialog:



Enter your callsign, 6-character grid square and your altitude above the sea level. The grid square is required, the program cannot proceed without that information. The other two values are optional.

Satellite Data Download

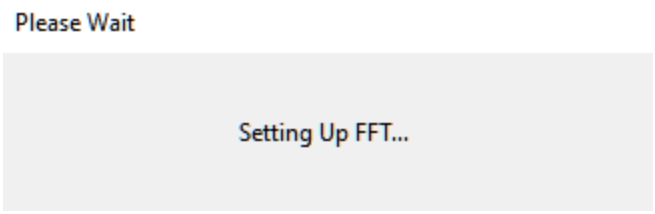
Then SkyRoof downloads the satellite data: make sure that your computer is connected to the Internet.



Wait until the data are downloaded and imported. Again, SkyRoof cannot proceed without this data downloaded at least once, so if you click on Cancel, the program terminates.

FFT Setup

Wait for SkyRoof to try different ways of computing the FFT transform and to find the one that works best on your system. This may take quite some time!

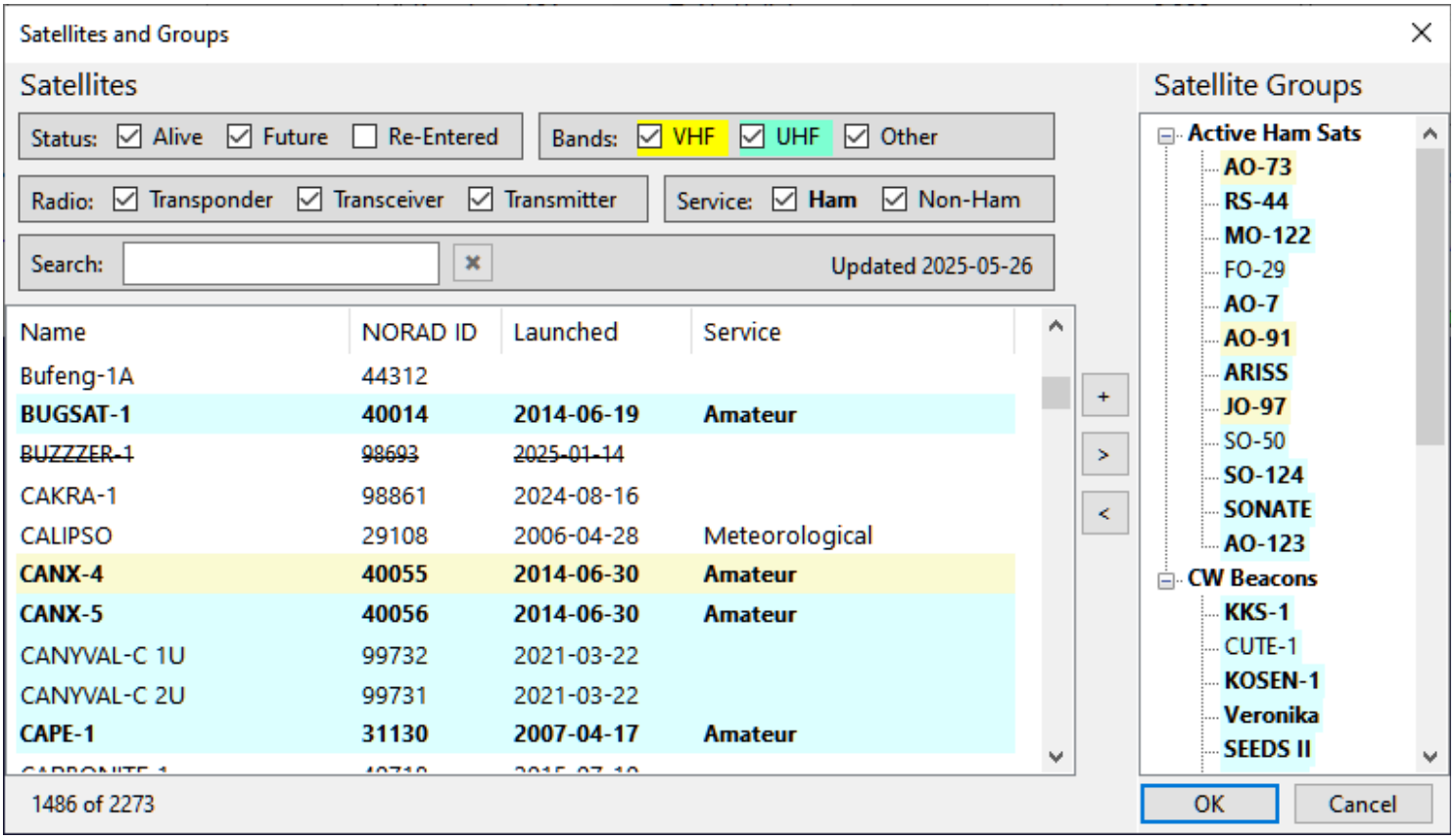


That's all for the quick start! Now you can use the program for tracking the satellites in frequency and space, and for predicting the satellite passes over your location. To do more than that, you have to perform the rest of the setup steps described in the next sections.

Creating Satellite Groups

SkyRoof comes with two pre-defined groups of satellites created for your convenience, **Active Ham Sats** and **CW Beacons**. The first group lists the satellites carrying the linear transponders, FM repeaters or digital systems that were available to Hams at the time of this writing. The second group includes the satellites that send beacon signals or telemetry in Morse Code, or just transmit an unmodulated carrier (a.k.a. Continuous Wave, CW). Most likely, you will want to modify or delete these groups and add your own ones. Here is how to do this.

Click on **Tools / Satellites and Groups** in the main menu to open the **Satellites and Groups window**:



The left panel lists all satellites known to SkyRoof, the right panel shows the groups.

- to create a group, click on the **[+]** button, then enter the group name;
- to add a satellite to the group, drag it from the satellite list onto the group, or click on the **[>]** button;
- to delete a group, or a satellite from the group, select it in the right panel and press the Delete key, or click on the **[<]** button.
- click on OK to save the changes.

The **Satellites and Groups window** has many commands to filter and search satellites, to rename them, and to view detailed information about the satellites and their transmitters. These commands are described in the Satellites and Groups Window section of this document.

Configuring the Window Layout

The layout of SkyRoof's main window is under your full control. Any panel may be shown or hidden, docked anywhere in the window, or left floating.

Show and Hide

Show the panels using the menu commands in the **View** section, hide them using the same command again, or by clicking on the Close button on panel's caption bar.

Docking

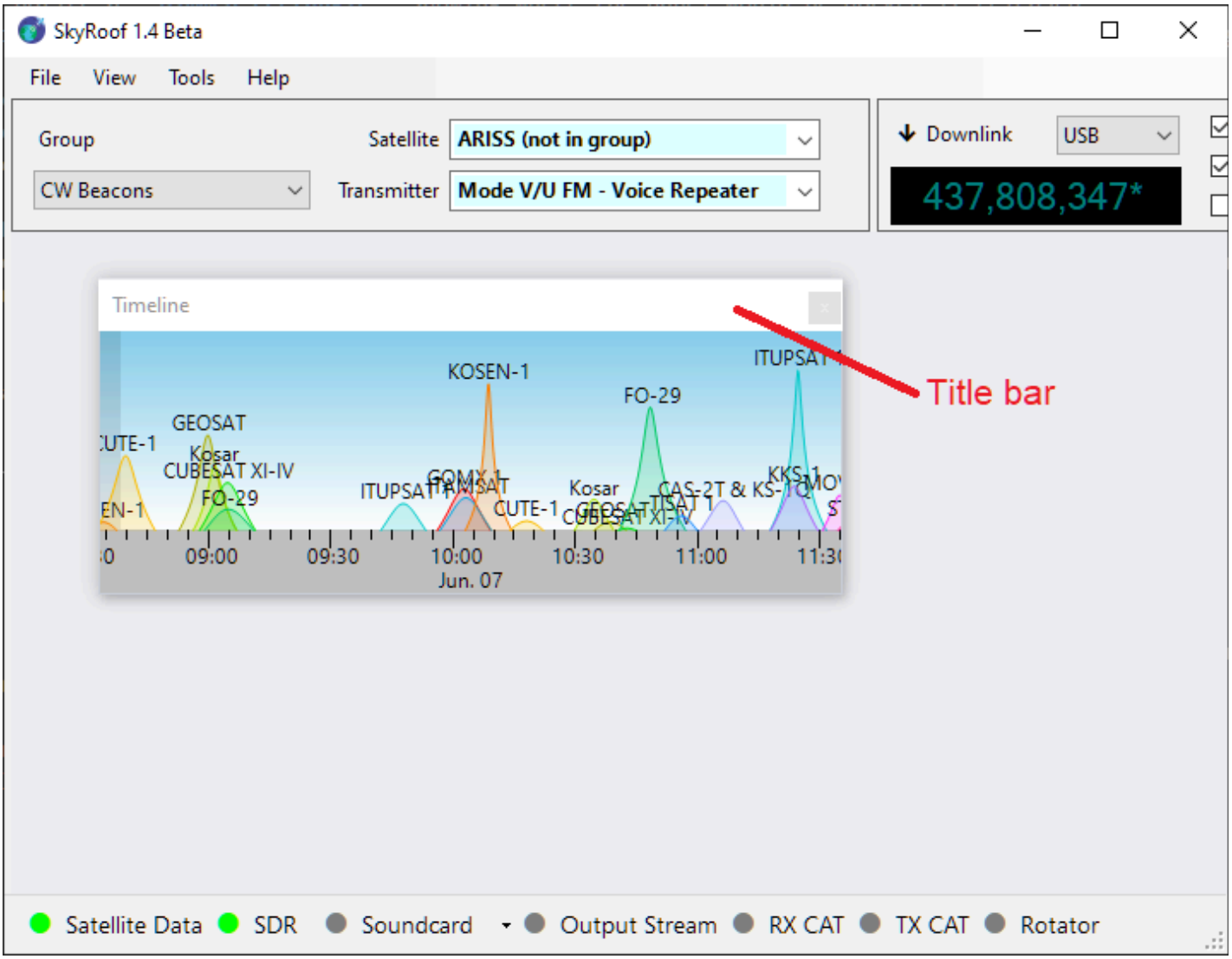
The panels you open are initially in the floating state. This is not very convenient as you cannot move or resize the main window without breaking your panel arrangement. You can dock the panels so that they move and resize when you move/resize the main window.

How to Dock a Floating Panel

The Timeline panel in the screenshot below is floating. Let us dock it to the bottom of the main window.

1. **Find the Panel's Title Bar**

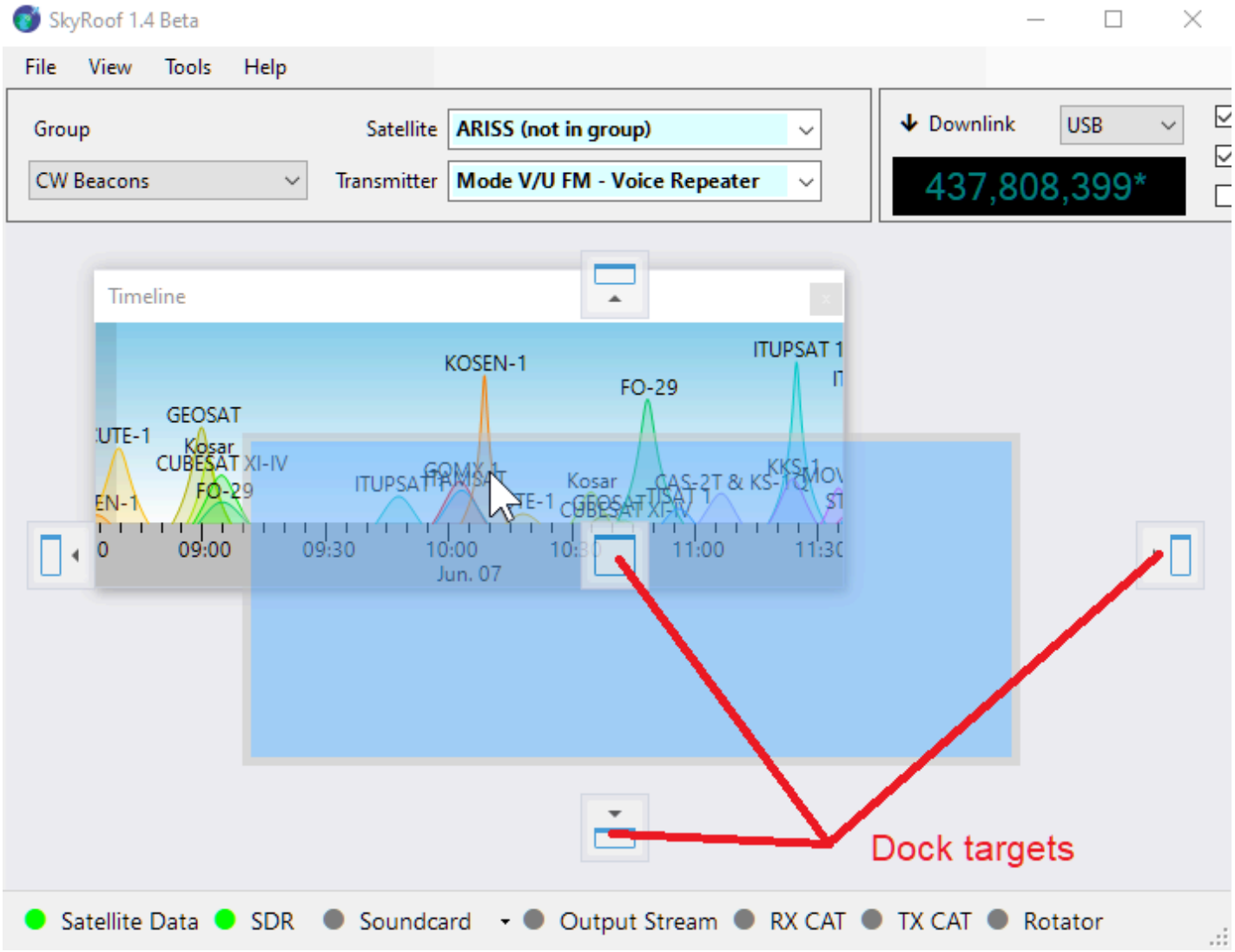
   Locate the top bar of the floating panel labeled "*Timeline*". This is known as the **title bar**.



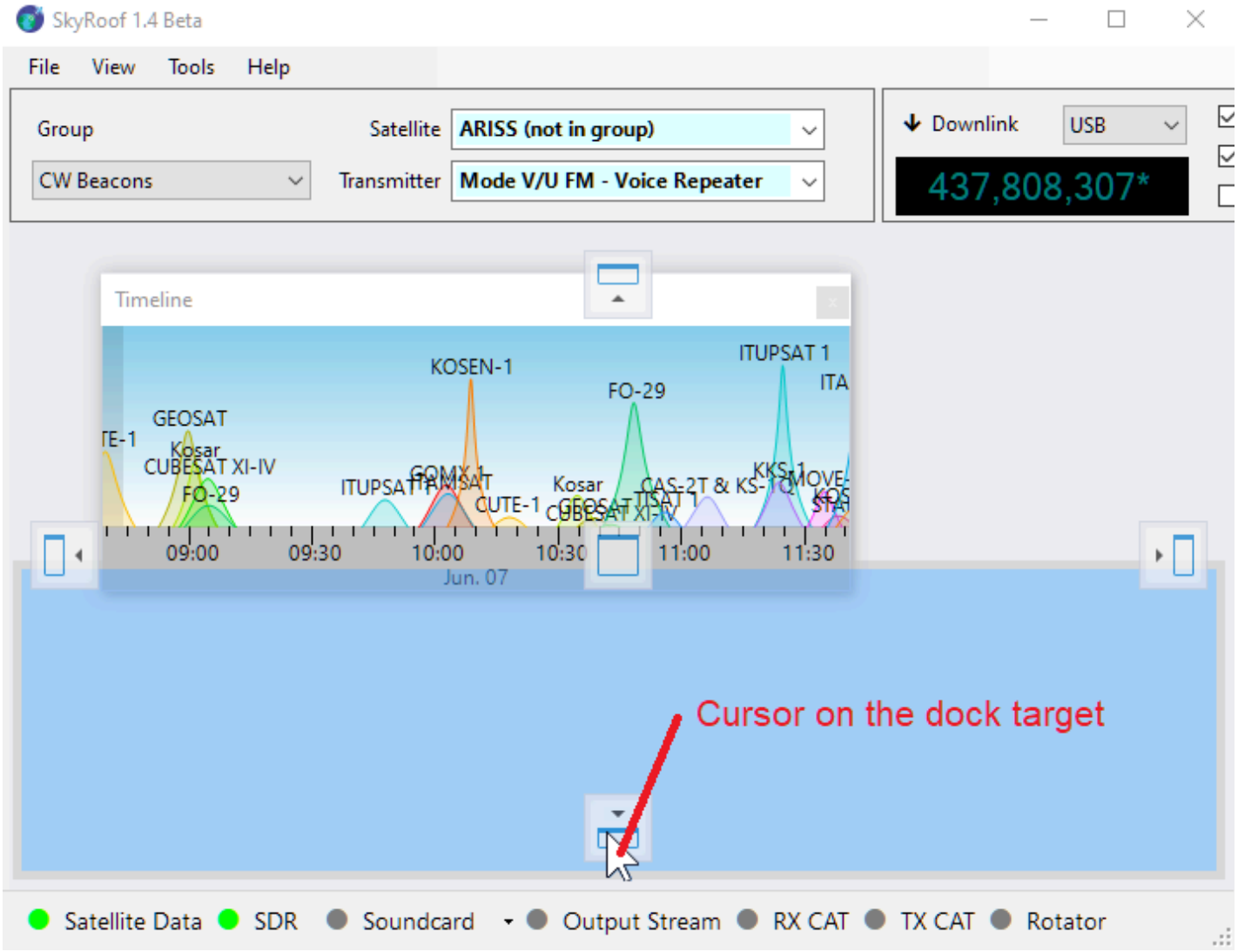
2. **Click and Hold**
   Move your mouse cursor to the title bar and press the **left mouse button**. Keep holding the button down.

3. **Drag the Panel**
   While holding the mouse button, move the panel by dragging it with the mouse. As you begin to drag, you will see **dock target icons** appear in the main window—these icons represent the available docking positions.
   You will also notice a **dimmed rectangle** showing where the panel would be docked if released.

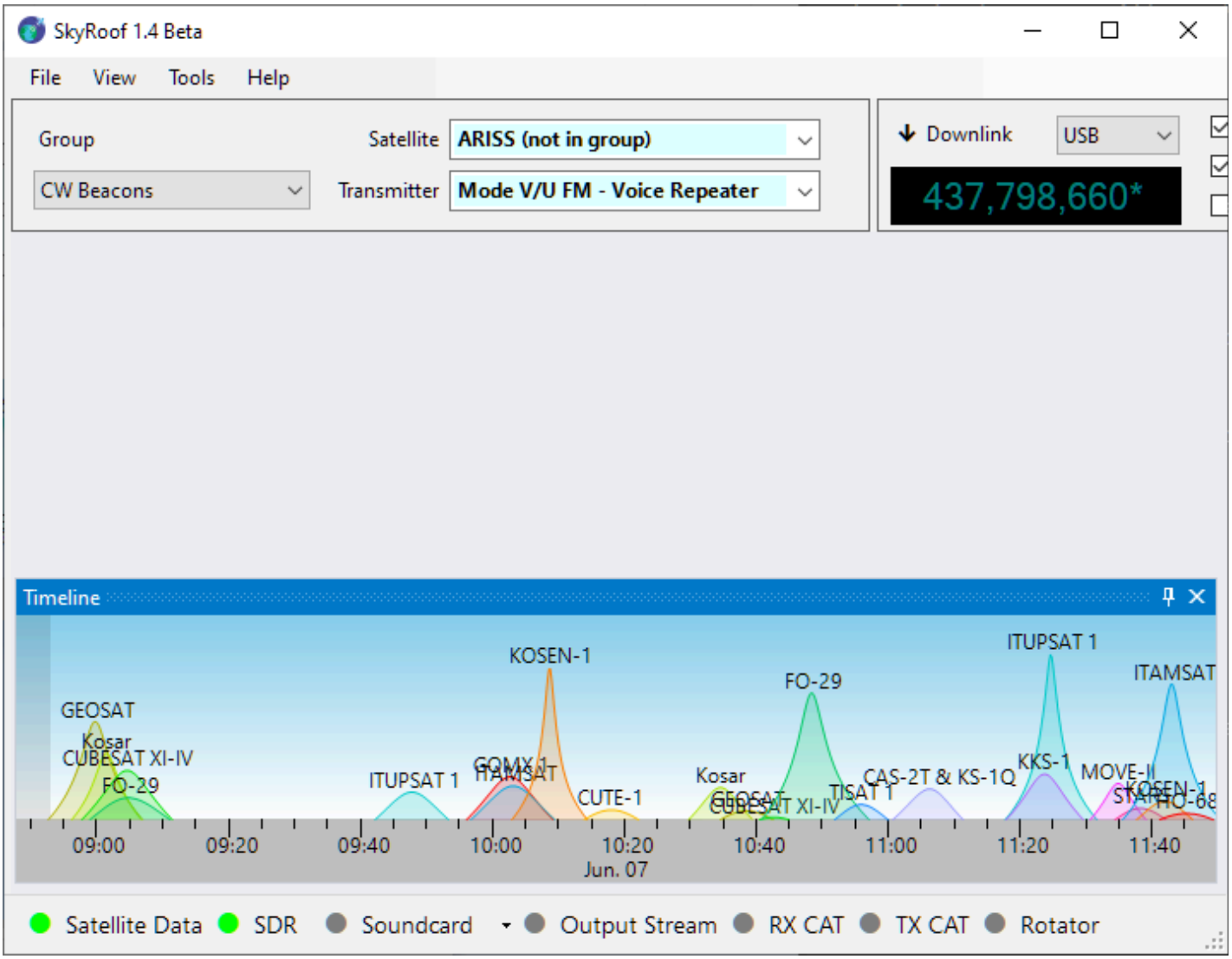
> ⚠️ **Important:** This rectangle is only a visual preview. Do **not** try to align it with the dock target icon. Instead, focus on where your mouse cursor is.



4. **Position the Mouse Cursor Over a Dock Target Icon**
   Move your **mouse cursor** over one of the dock target icons (not the rectangle). The docking location will update automatically. The panel will only dock if the cursor is directly over the icon.

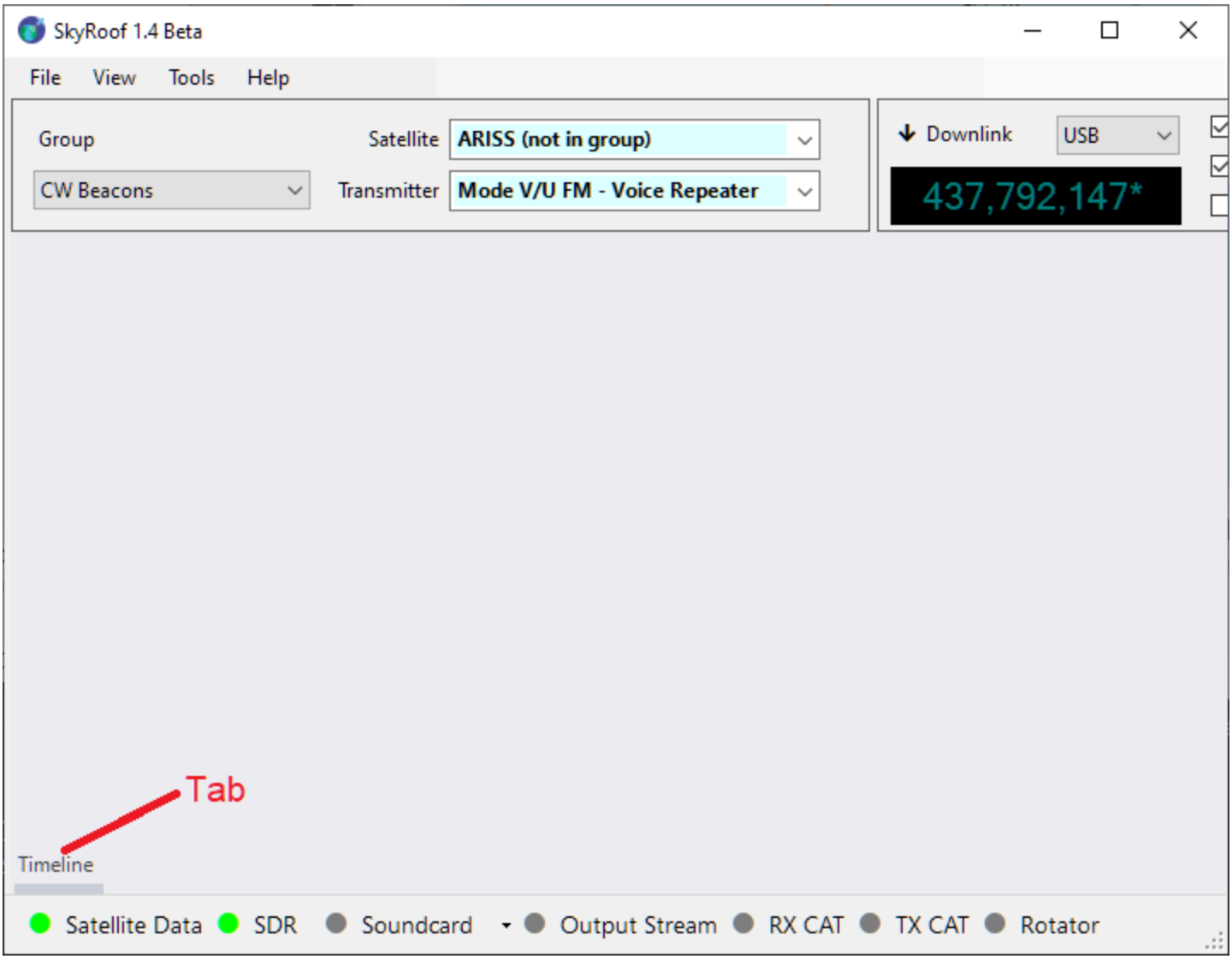


5. **Release to Dock**
   Once the cursor is over your desired dock target icon, **release the mouse button**. The panel will snap into place — either at the side, in the center, or nested inside another panel, depending on the selected icon. Once docked, the panel becomes part of the main window layout, helping keep your workspace clean and organized.



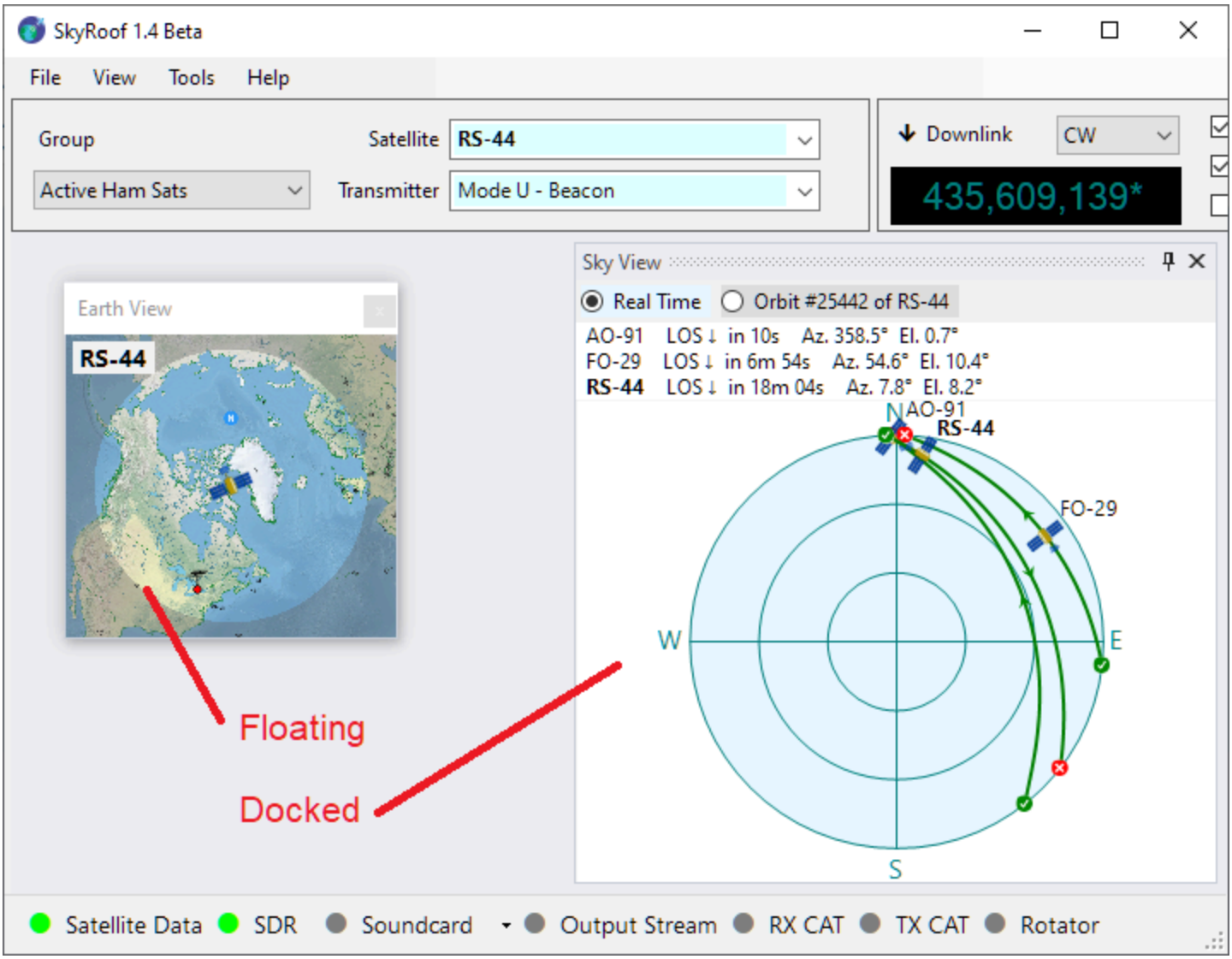
Auto-Hide

A panel can be switched to the **auto-hide mode**, which allows it to stay hidden until you click on its tab. In the screenshot below, notice the **"Timeline" tab** in the bottom-left corner. Clicking this tab temporarily slides the **Timeline** panel into view. To enable auto-hide mode, click the **Auto-Hide** button located on the panel's title bar.

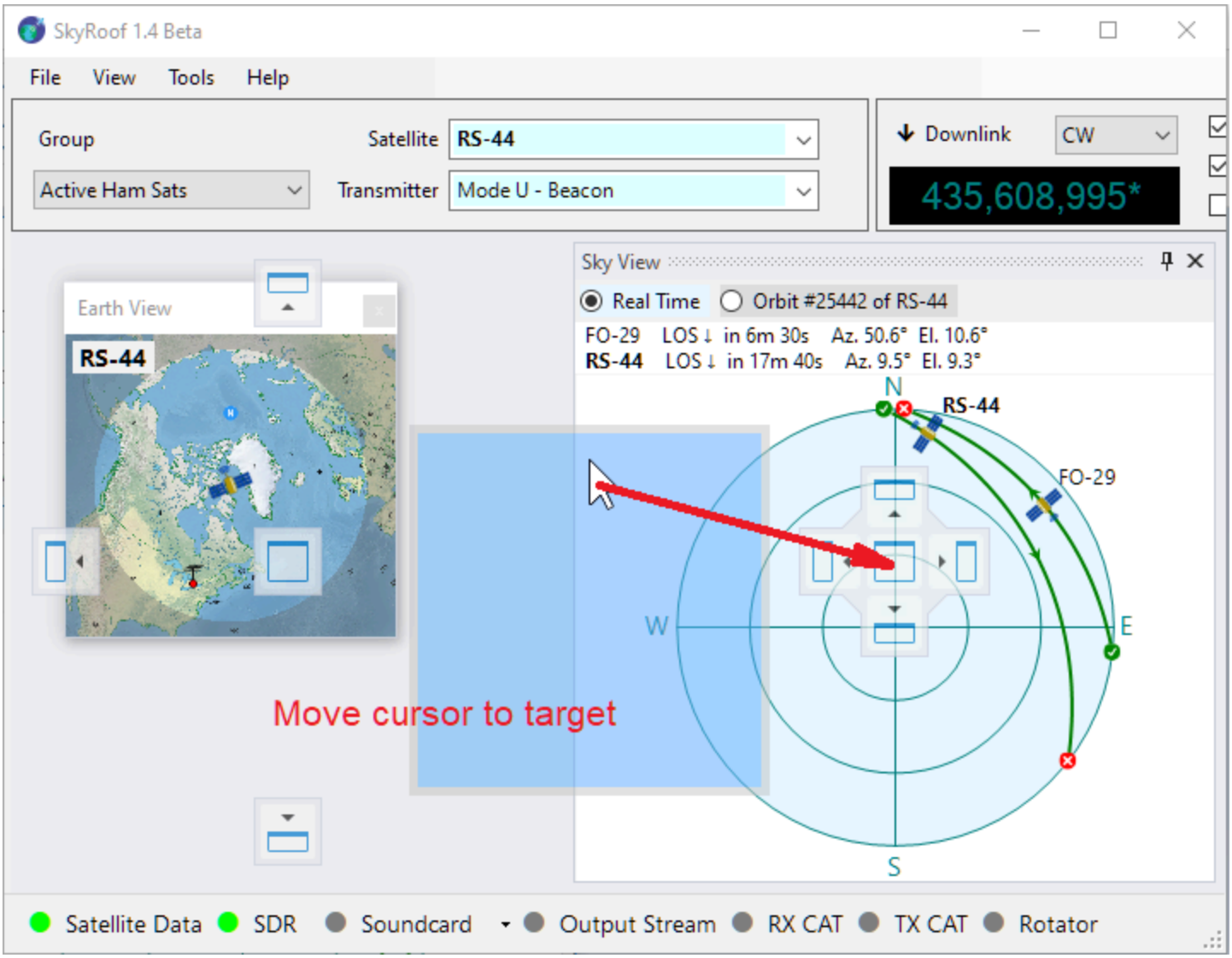


Tabbing

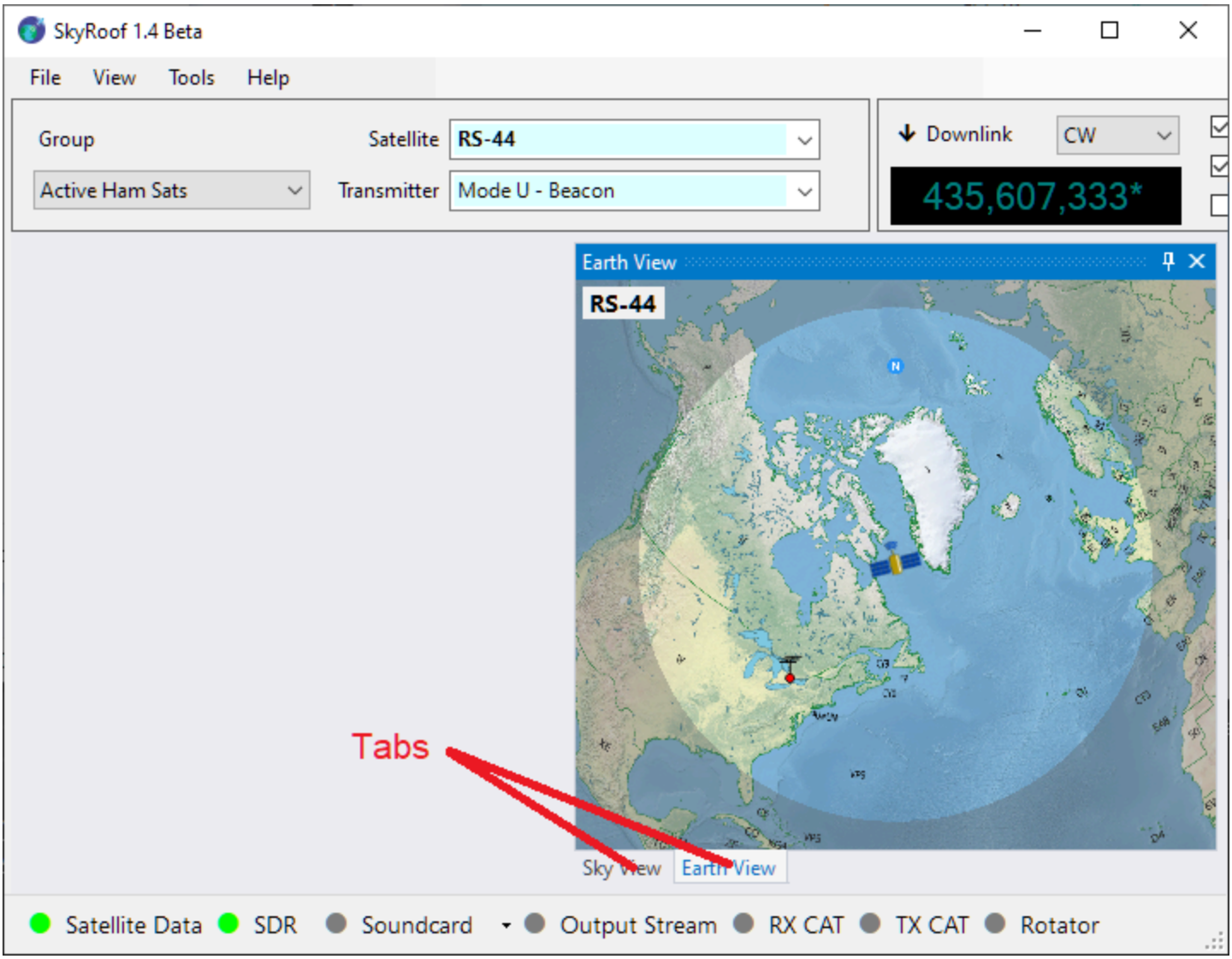
You can also organize panels as **tabs**.



If you drop one panel directly onto another, they will be grouped into a tabbed interface.



In the screenshot below the Sky View Panel and Earth View Panel have been combined into a tabbed view. You can switch between these panels by clicking on their respective tabs.


SkyRoof 1.4 Beta
File
View
Tools
Help
Group
Active Ham Sats
Satellite
RS-44
Transmitter
Mode U - Beacon
Downlink
CW
435,607,333*
Earth View
RS-44
Tabs
Sky View
Earth View
Satellite Data
SDR
Soundcard
Output Stream
RX CAT
TX CAT
Rotator

Setting Up SDR

Supported Radios

SkyRoof uses the Soapy SDR engine to interface with the SDR radios. Currently it supports:

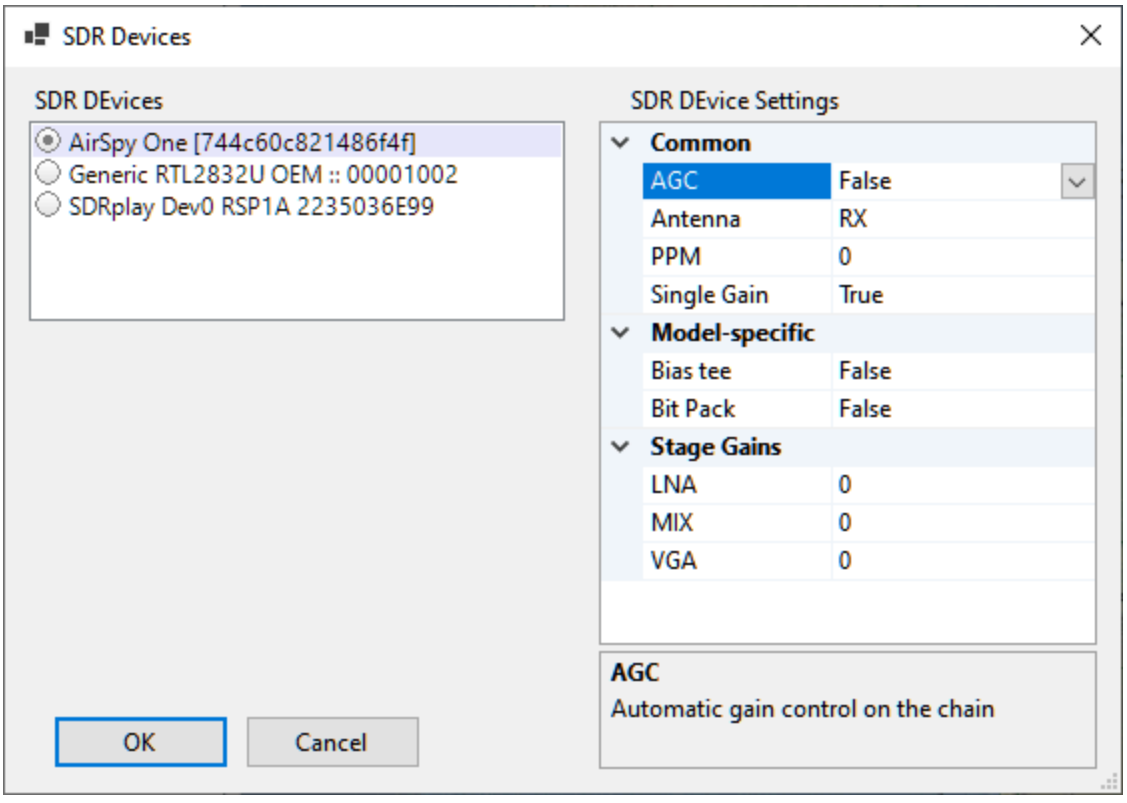
- Airspy Mini;
- SDRplay;
- RTL-SDR.

> **NOTE**
> It may be possible to add support of other SDR devices to SkyRoof. Contact me if you have an unsupported SDR and are willing to do extensive testing.

If you plan on using one of the SDRplay radios with SkyRoof, download the latest SDRplay API from their web site and install it on your system before starting the program.

Selecting an SDR device

Connect your SDR device to the computer, then click on **Tools / SDR Devices** in the main menu. This will open the **SDR Devices dialog**:



All active SDR devices are listed on the left panel. Click on the one that you want to use.

Configuring the device

The right panel shows all settings that the device driver understands. The setting names and descriptions (shown on the bottom panel) come from the driver, with two exceptions described below. For information about these settings see the documentation that comes with the radio.

The two settings, common to all radios, are:

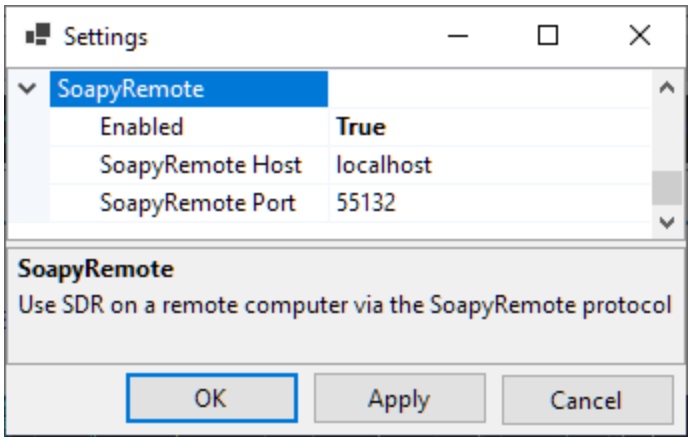
- **PPM** - the correction factor for the SDR clock frequency, expressed in parts per million. This setting is important for the correct operation of the Doppler tracking algorithm, see the Calibrating PPM Correction section for details;

- **Single Gain** - when set to true (**and AGC is off**), the SDR gain is controlled by the **RF Gain** slider on the toolbar. This is the recommended setting. When it is set to false, the settings in the **Stage Gains** are applied to the individual stages of the SDR, and the gain slider is disabled.

Using Remote SDR

SkyRoof can use SDR devices connected to a remote computer via the SoapyRemote driver. To enable remote access to SDR:

- **On the remote computer:**
  - install the **SoapySDRServer** that comes with SoapySDR and run it.
- **In SkyRoof:**
  - enable **SoapyRemote** in the **Settings** dialog;
  - enter the **host** and **port number** of the remote computer.



  - Open the **SDR Devices** dialog and select one of the remote SDR devices from the list.

Calibrating PPM Correction

Motivation

The clock frequency of an SDR, as it comes from the factory, is rarely accurate. Typical errors are in the range of a few PPM (parts per million), which translates to a tuning error of 1-2 Khz on the 70 cm band. For accurate tracking of the satellite signals this error must be calibrated out. The calibration process is simple, we just find a signal of known frequency, check on what frequecy it appears on the waterfall, and compute the PPM correction factor from the difference between the two.

There are plenty of signals on the air that may be used for calibration, if one knows what to look for. One of such signals is the FCCH channel of a GSM downlink. This channel is located 67,708 Hz above the center frequency of a GSM channel, and the accuracy of its frequency is claimed to be better than 0.05 PPM.

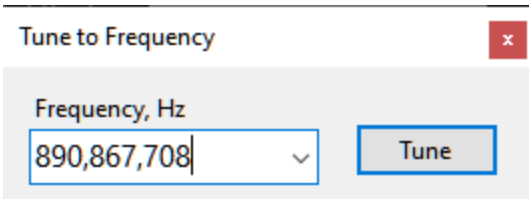
3-rd Party Software

For the RTL-SDR dongles you can use the Kalibrate utility that performs such calibration automatically. For other radios follow the steps below.

Steps

1. Find a strong GSM signal, or any other signal of known frequency. In my area one of such signals is present on 890.8 MHz.

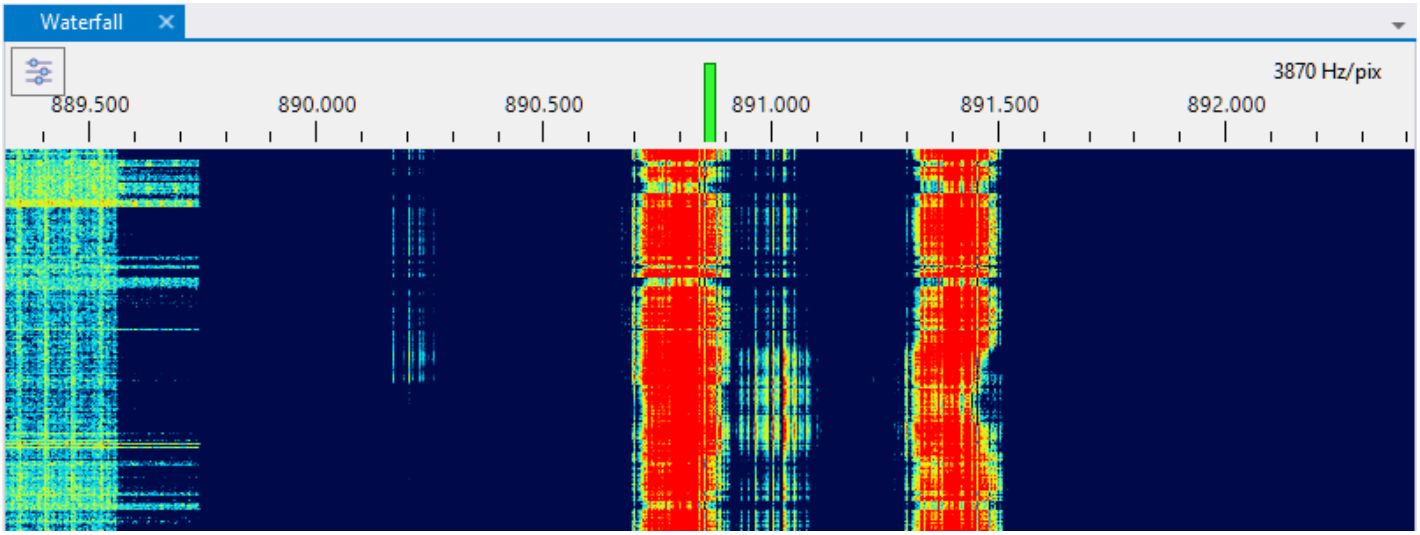
2. Click on the Downlink frequency display in the Frequency Control panel on the toolbar to open the frequency entry dialog:



3. Enter the frequency of the channel plus the FCCH offset:

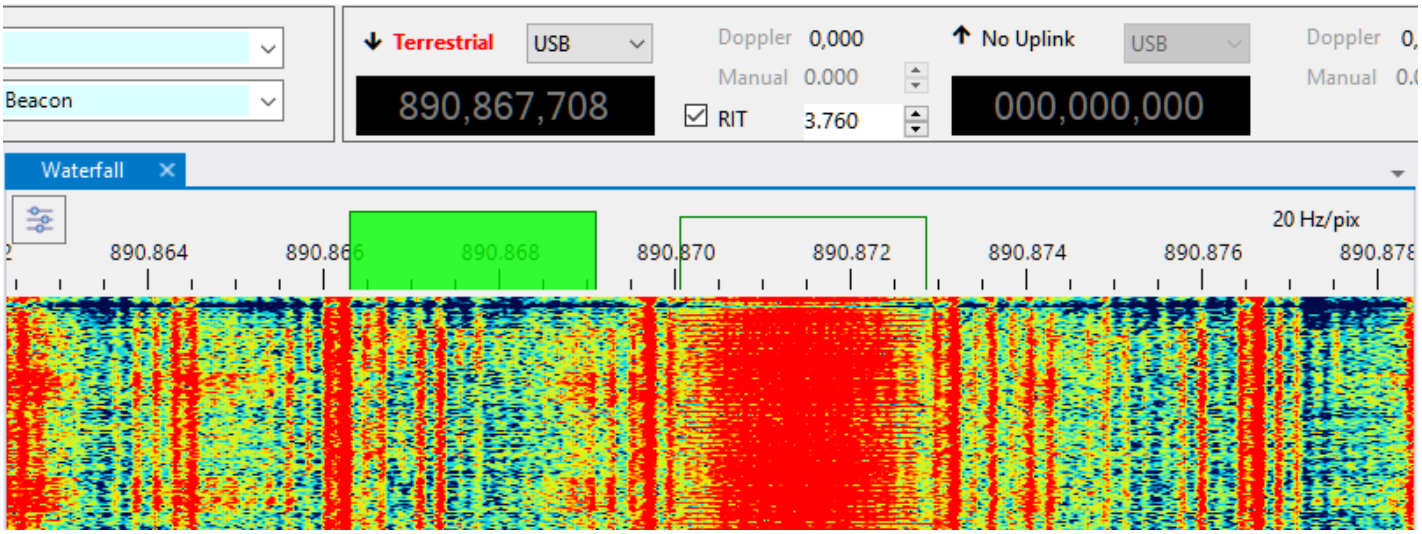
```
890,800,000 + 67,708 = 890,867,708 Hz
```

4. Click on the Tune button in the dialog and verify that the SDR is tuned to the desired frequency:



5. Zoom in by spinning the mouse wheel over the waterfall display:

6. Find the FCCH signal. On the screenshot below it is about 4 kHz above the expected frequency:



7. Now let us measure the offset between the receiver frequency (the center of the green rectangle that represents the receiver passband) and the FCCH frequency. Tick the **RIT** checkbox on the **Frequency Control panel** and adjust the RIT offset until the RIT passband (the clear rectangle) aligns with the signal. You can tune RIT in many different ways, as described in the Frequency Control and Frequency Scale sections. For now, just use the up/down buttons in the RIT offset box, or spin the mouse wheel over that box.

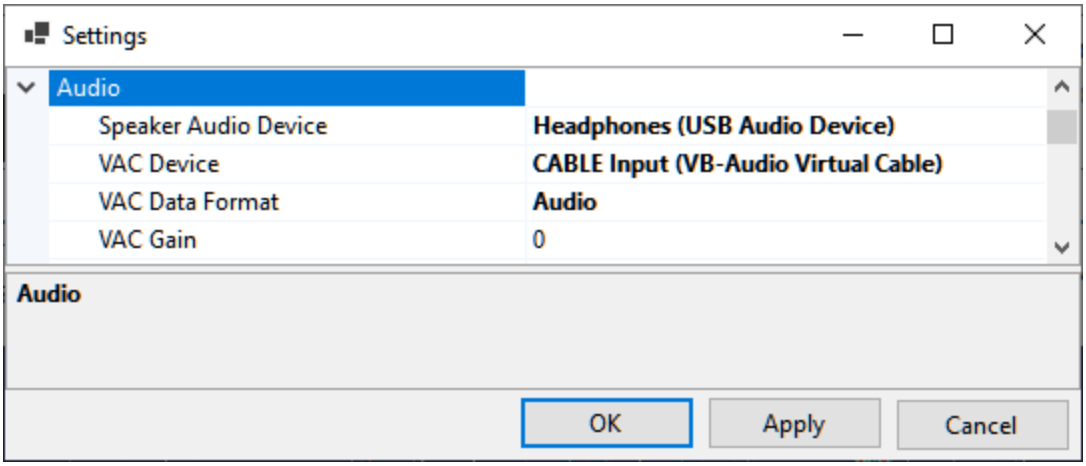
8. Compute the PPM correction. The frequency error measured in the previous step is 3,760 Hz, so the PPM is:

```
3,760 / 890,867,708 * 1e6 = 4.22 PPM
```

9. Now enter this value in the SDR Devices dialog, and you are done.

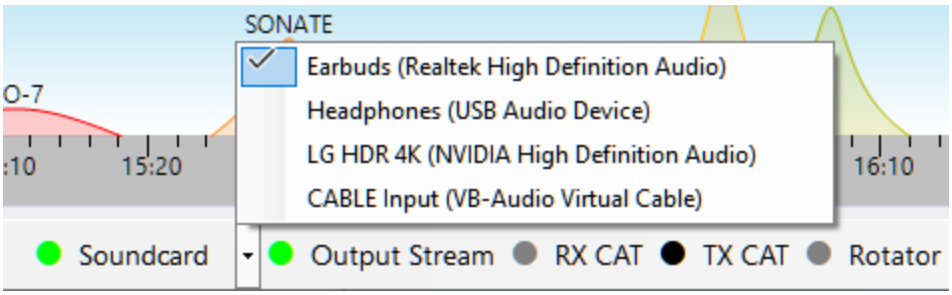
Setting Up Audio

Click on **Tools** / **Settings** in the main menu to open the Settings window:



- **Speaker Audio Device** - select the audio device that will be used to output the audio received with SDR;
- **VAC Device** - the same audio or I/Q stream may be also sent to the external software via a Virtual Audio Cable (VAC). Select the VAC device here;
- **VAC Data Format** - the format of the output stream, either audio or I/Q data sampled at 48 kHz;
- **VAC Gain** - gain or attenuation, in dB, that will be applied to the VAC output.

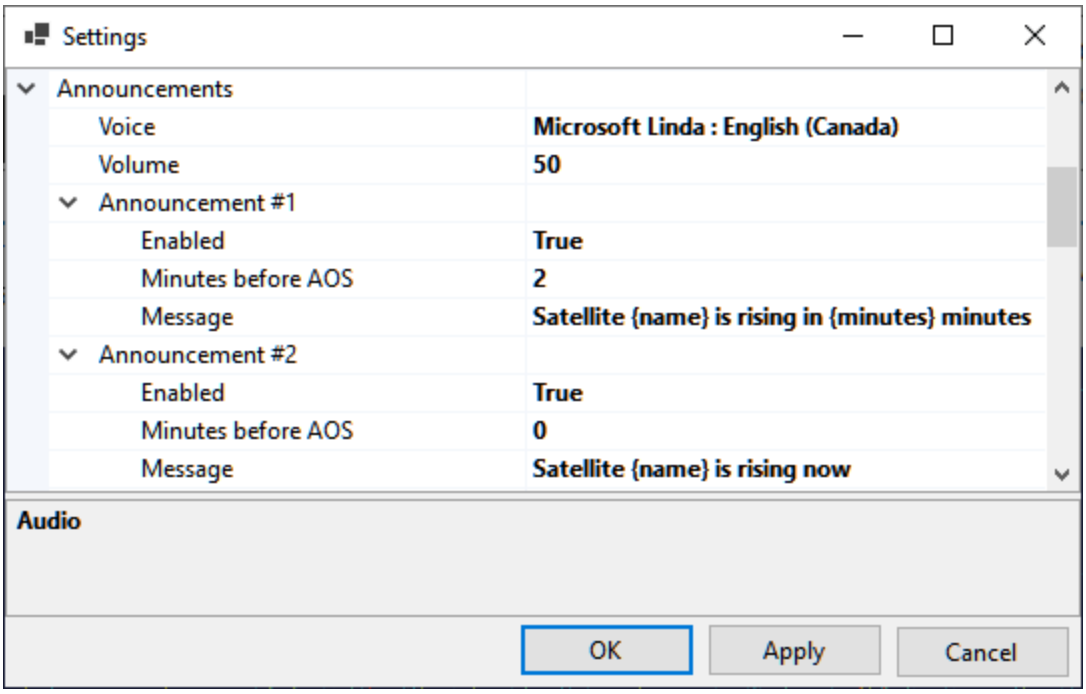
The output to the soundcard and VAC can be toggled by clicking on the **Soundcard** and **Output Stream** labels on the status bar. A drop-down list next to **Soundcard** allows switching between the audio devices:



Setting Up Voice Announcements

SkyRoof can make voice announcements of the the satellite AOS events. Up to two announcements may be enabled.

Click on **Tools / Settings** in the main menu to open the Settings window:



- **Voice** - select one of the voices available on your system. To install a new voice package in Windows, go to **Settings > Time & language > Speech** and then select **Add voices** to download and install the desired voice package.
- **Volume** - set the volume between 1 and 100;
- **Enable** - enable or disable the announcement;
- **Minutes Before AOS**: enter 0 to 5 minutes;
- **Message** - enter the announcement message. For the satellite name enter `{name}`, for the number of minutes enter `{minutes}`.

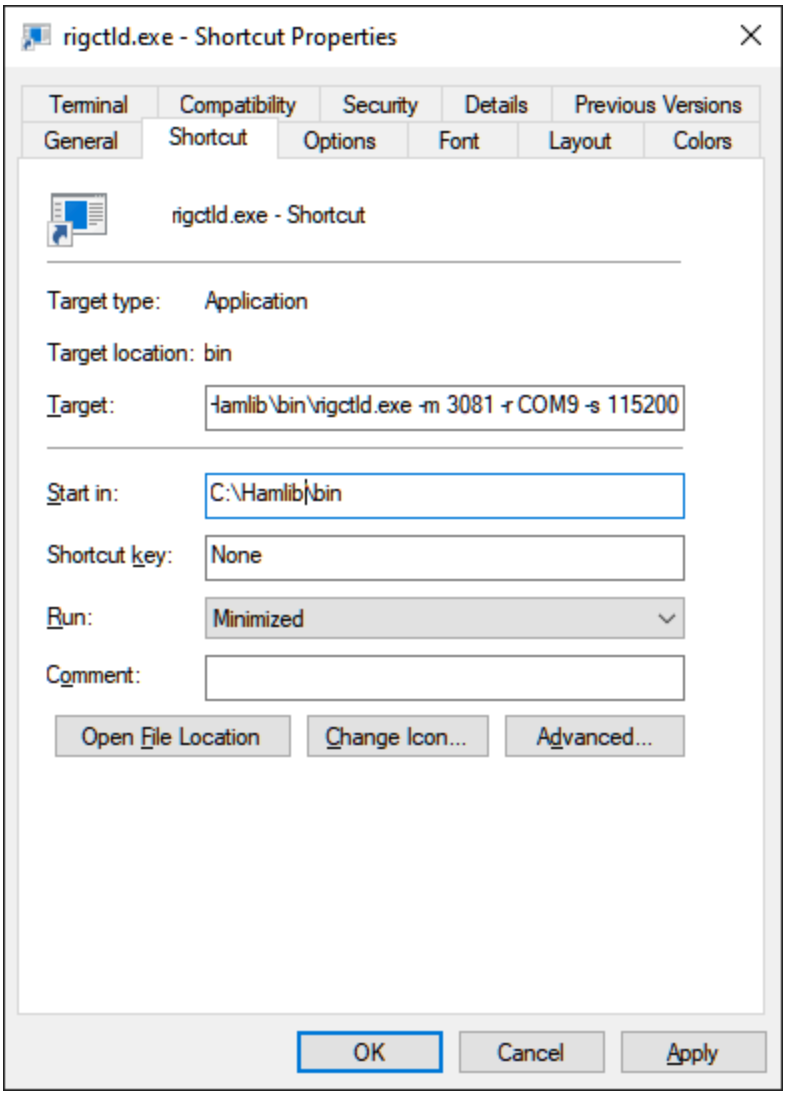
Setting Up CAT Control

> **WARNING**
>
> The initial release of the beta version was tested only with an IC-9700 radio. The code for other radio models is present but has not been tested. If you have a different radio and are willing to do extensive testing, please send me an email.

rigctld.exe

SkyRoof uses **rigctld.exe**, a HamLib-based CAT control daemon, to control the radio.

1. Download **hamlib-w64-4.5.5.exe** from GitHub. Other versions may not work correctly.
2. Run the downloaded file to install HamLib, note the folder where it is installed.
3. Create a shortcut to start **rigctld.exe*, with command line arguments:



The arguments on the command line must be tailored for your specific radio and COM port settings. Refer to the [rigctld documentation] for a complete description of the arguments.

Assuming that HamLib is installed in the default location, here is an example string for the shortcut:

```
"C:\Program Files\hamlib-w64-4.5.5\bin\rigctld.exe" -m 3081 -r COM9 -s 115200
```

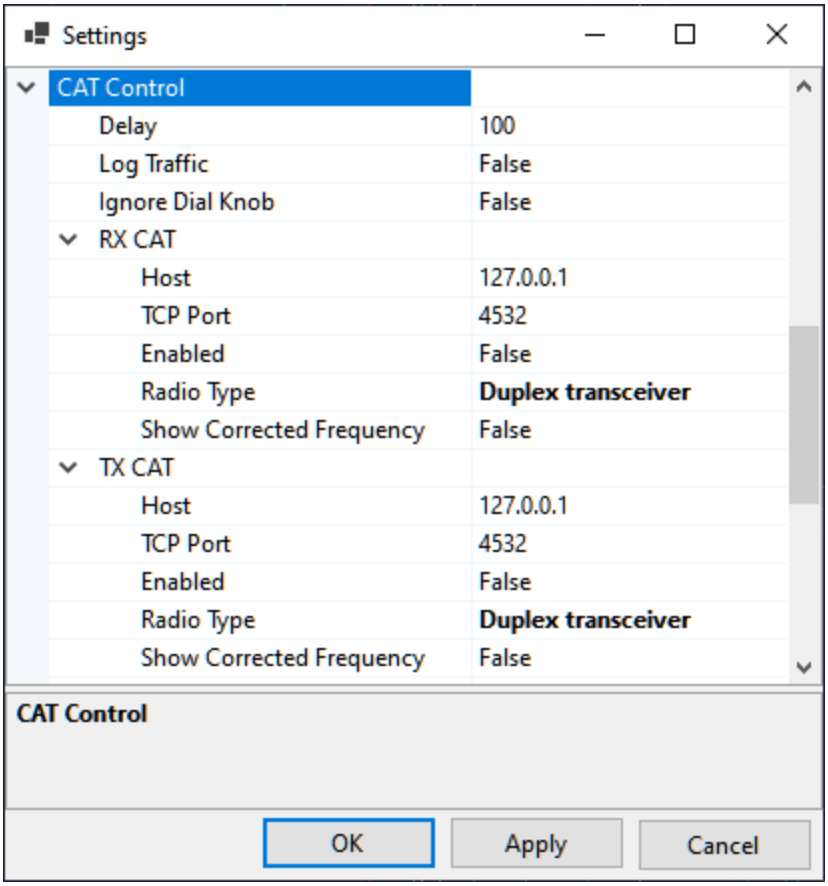
In the string above the following arguments are used:

- **-m 3081** - the radio model is IC-9700;
- **-r COM9** - the COM port used by the radio. In this case, the USB connection to IC-9700 creates two virtual COM ports, COM9 and COM10. The port with the lower number is used for CAT;
- **-s 115200** - use the highest available COM port speed.

4. Run rigctld.exe using this shortcut before you enable CAT control in SkyRoof.

Settings

Click on **Tools** / **Settings** in the main menu to open the Settings dialog:



- **Delay** determines how often SkyRoof sends commands to the radio. The default delay of 100 ms is good in most cases. Increase the delay if your radio is slow;
- **Log Traffic** should be set to False and enabled only for debugging;
- **Ignore Dial Knob** - by default, CAT control allows you to change the frequency both in the program and by spinning the dial knob. If for some reason this causes trouble, change this setting to True, then the dial knob will be ignored.

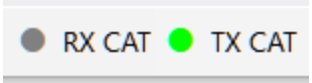
The two sections in the Settings, **RX CAT** and **TX CAT**, allow you to use either the same radio for RX and TX, or two different radios. You can also enable only one of those, or disable both. The recommended configuration is to use an SDR for reception and a transceiver for transmission, in this case RX CAT should be disabled.

To use the same radio for RX and TX, set **Host**, **TCP Port** and **Radio Type** to the same values in both sections.

To use two different radios, create a second shortcut for the second radio, and specify a different port number on the command line. Enter this port number in the settings as well, and run two instances of **rigctld.exe** using both shortcuts.

The settings in the RX and TX sections are:

- **Host** - should be "127.0.0.1" or "localhost" if rigctld is running on the same computer as SkyRoof. It may be changed to a different address for remote control;
- **TCP Port** - 4532 is the default port used by rigctld. Use a different port in one of the sections to control different radios for RX and TX;
- **Enabled** - enable or disable CAT. Another way to toggle CAT is to click on the CAT labels on the status bar:



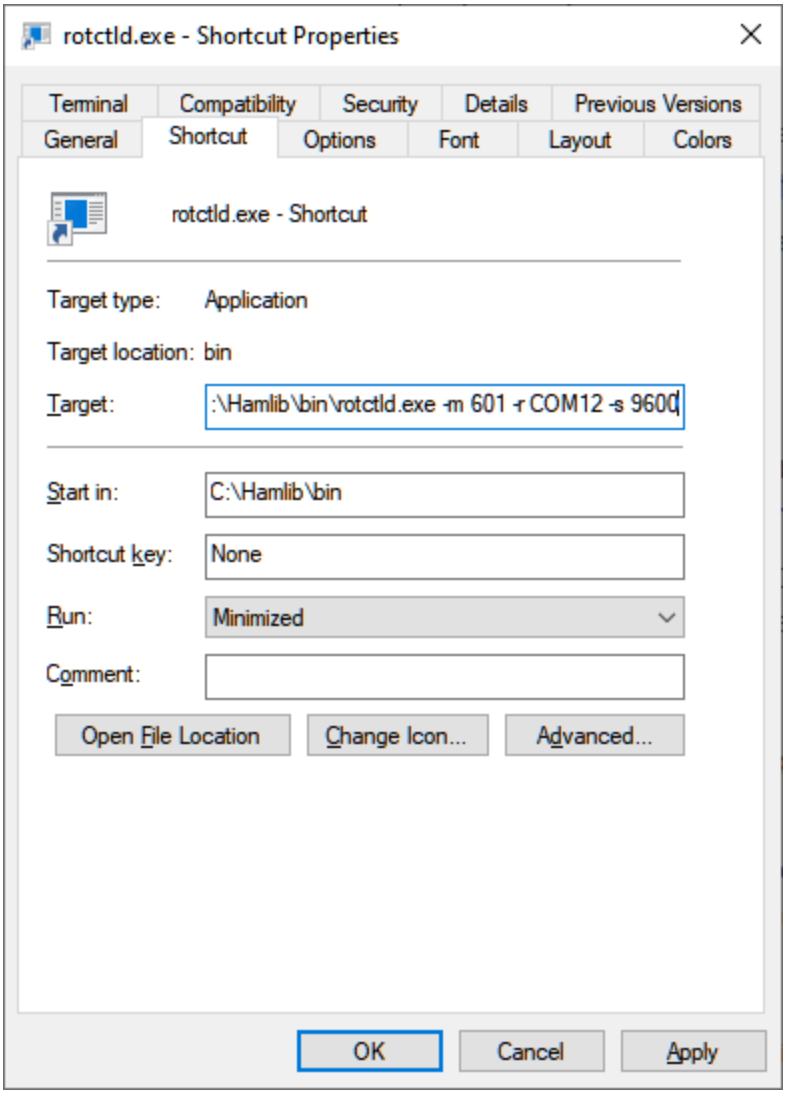
- **Radio Type** - as mentioned above, the beta version has been tested only with IC-9700, which is a duplex transceiver. Change this setting if you want to test a radio of a different type;
- **Show Corrected Frequency** - The SkyRoof can display either the nominal frequency of the satellite transmitter, or the frequency with all corrections applied. Another way to toggle this setting is via a right-click menu on the frequency display on the toolbar.

Setting Up Rotator Control

rotctld.exe

SkyRoof uses **rotctld.exe**, a HamLib-based rotator control daemon, to control the antenna rotator. See the Setting Up CAT Control section for the instructions how to download and install HamLib.

Create a shortcut to start **rotctld.exe*, with command line arguments:



The arguments on the command line must be tailored for your specific rotator and COM port settings. Refer to the rotctld documentation for a complete description of the arguments.

Assuming that HamLib is installed in the default location, here is an example string for the shortcut:

```
"C:\Program Files\hamlib-w64-4.5.5\bin\rotctld.exe" -m 601 -r COM12 -s 9600
```

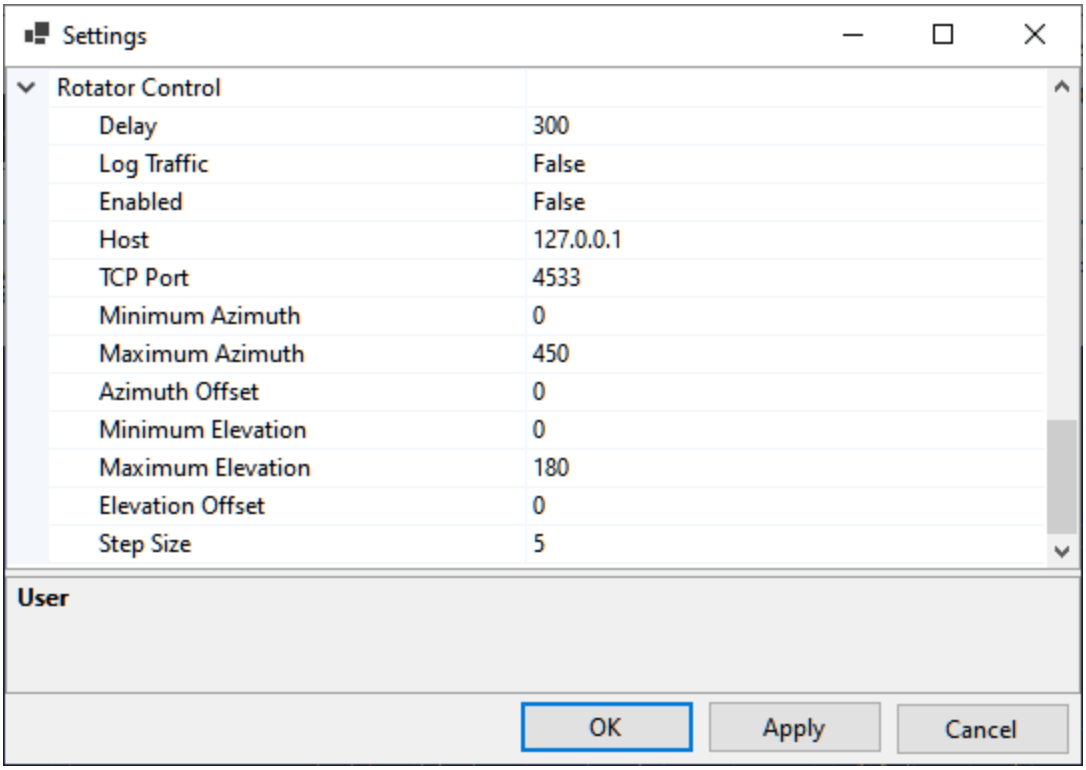
In the string above the following arguments are used:

- **-m 601** - the rotator model is Yaesu GS-232A;
- **-r COM12** - the COM port used by the rotator;
- **-s 9600** - the COM port speed.

Run rotctld.exe using this shortcut before you enable rotator control in SkyRoof.

Settings

Click on **Tools / Settings** in the main menu to open the Settings dialog:



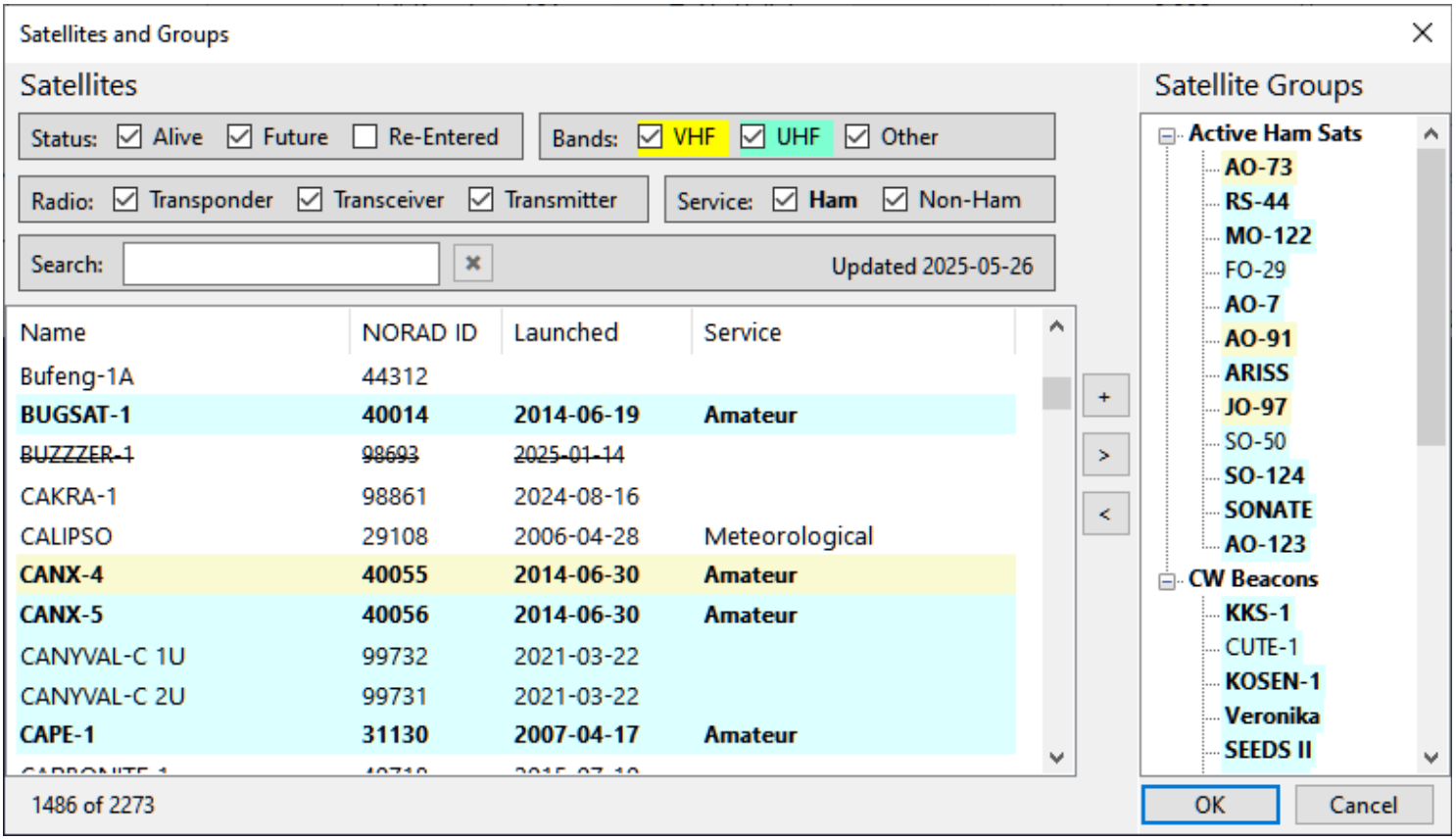
- **Delay** determines how often SkyRoof sends commands to the rotator. The default delay is 300 ms;
- **Log Traffic** should be set to False and enabled only for debugging;
- **Enabled** - enable or disable rotator control. Another way to toggle the rotator control is to click on the Rotator label on the status bar;
- **Host** - should be "127.0.0.1" or "localhost" if rotctld is running on the same computer as SkyRoof. It may be changed to a different address for remote control;
- **TCP Port** - 4533 is the default port used by rotctld;
- **Minimum Azimuth**, **Maximum Azimuth**, **Minimum Elevation**, **Maximum Elevation** - specify the range of values your rotator accepts;
- **Azimuth Offset**, **Elevation Offset** - if your rotator is not perfectly calibrated, these settings allow you to apply a correction;

- **Step Size** - to prevent the rotator from starting and stopping too often, change the bearing only when the required change is greater than the step size. The default value is 5 degrees.

If your rotator does not control elevation, set the MinimumElevation and MaximumElevation to the same value. With such settings, wrong elevation will not be considered a bearing error. Note that the bearing error is indicated with a pink color on the Rotator Control panel.

Satellites and Groups

Click on **Tools / Satellites and Groups** in the main menu to open the **Satellites and Groups** window:



Exploring the satellite data

This window is a great tool for browsing the information about the satellites that is available in SkyRoof. For a detailed description of the data see the Satellite Data section.

Highlighting

The satellites are highlighted based on their properties as described in the Satellite Highlighting section.

Filtering

Using the checkboxes at the top of the left panel, the satellites may be filtered by:

- **Status** - Alive, Future or Re-Entered. If you cannot find some satellite in the list, tick the Re-Entered checkbox, maybe this satellite has already re-entered the atmosphere;
- **Bands** - show only the satellites that have at least one transmitter working in the VHF (2m), UHF (70cm) or in any other band;

- **Radio** - the radio type: linear transponder, FM transceiver or a telemetry/beacon transmitter;
- **Service** - Ham or non-Ham, as marked in the database.

Searching

Use the **Search** box to search the satellites by name, callsign or NORAD Id. The search is case-insensitive, punctuation is ignored. If a satellite has multiple names, any name may be used. For example, the RS-44 satellite is found by entering "RS-44", "rs44" or "DOSAAF-85" in the search box.

The numbers on the bottom bar show the total number of satellites in the database and the number of those that match the filters and search string.

Viewing Details

Right-click on a satellite and click on **Satellite Details**, or press **Ctrl-D**, to open the Satellite Details window.

Renaming Satellites

To rename a satellite, press **F2**, or right-click on the satellite and click on **Rename** in the popup menu.

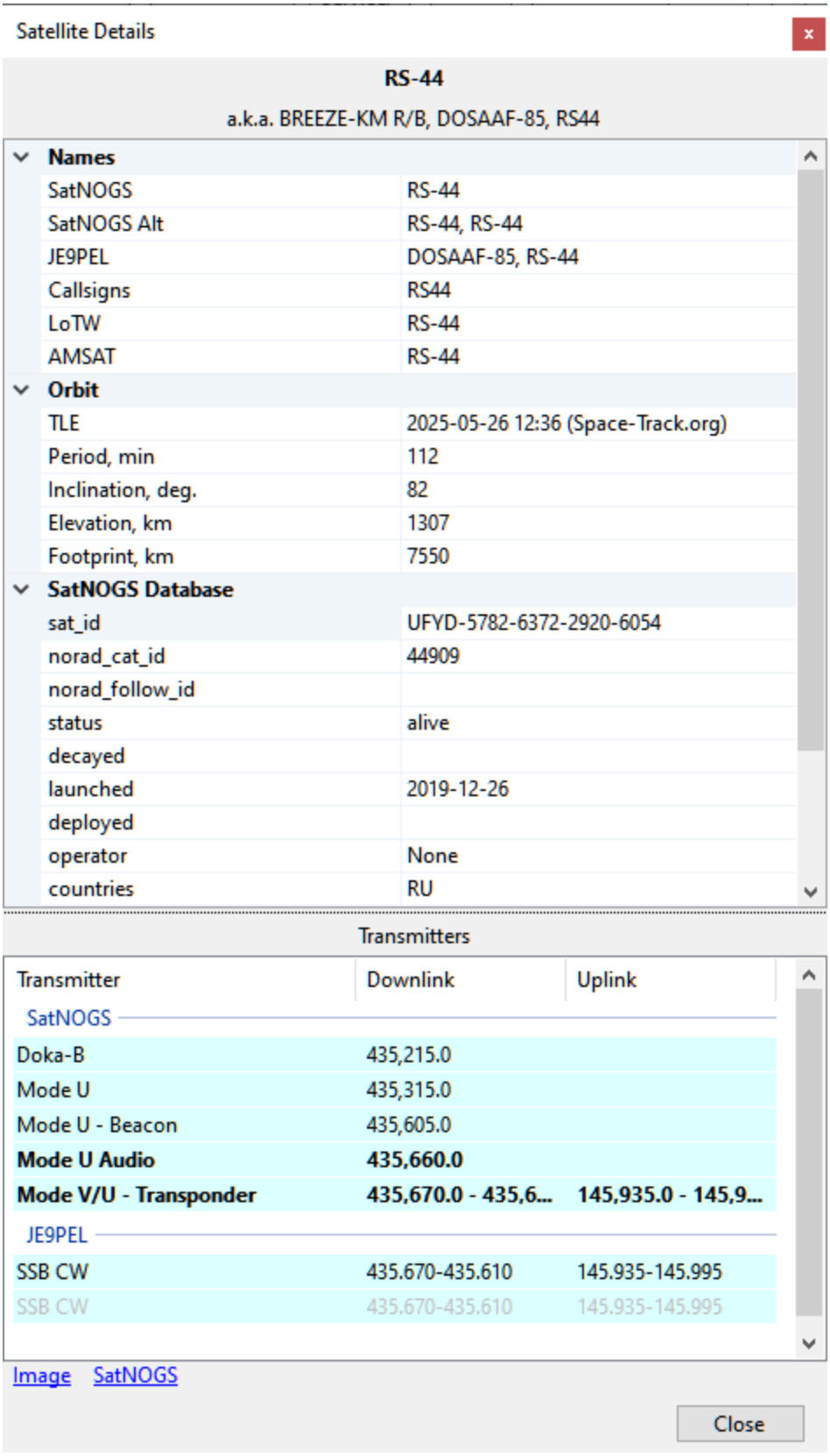
Editing Satellite Groups

The right panel of the window shows the satellite groups. See the Creating Satellite Groups section for information about creating and editing the satellite groups. The following editing commands are available:

- the **[+]** button creates a new group. Press **F2**, or use the popup menu, to rename the group;
- the **[>]** and **[<]** buttons add or remove the satellites to/from the group;
- drad-and-drop from the satellite list to the group adds the satellite to the group;
- drag-and-drop of a satellite between the groups moves it to another group;
- drag-and-drop with the **Ctrl** key down adds a copy of the satellite to another group;
- drad-and-drop re-orders the groups, or the satellites in the group;
- the Delete key deletes the group, or the satellite from the group;
- the popup menu of the group or satellite is an alternative way of accomplishing the same tasks.

Satellite Details Window

The Satellite Details window is available via the right-click menu in many panels, including the Satellites and Groups window, Current Group panel and Frequency Scale.



The transmitters are highlighted according to the downlink band. Ham transmitters are bold, inactive ones are grayed.

The blue links at the bottom of the window open the web pages with extra information about the satellite.

See the Satellite Data section for the description of the satellite data available in SkyRoof.

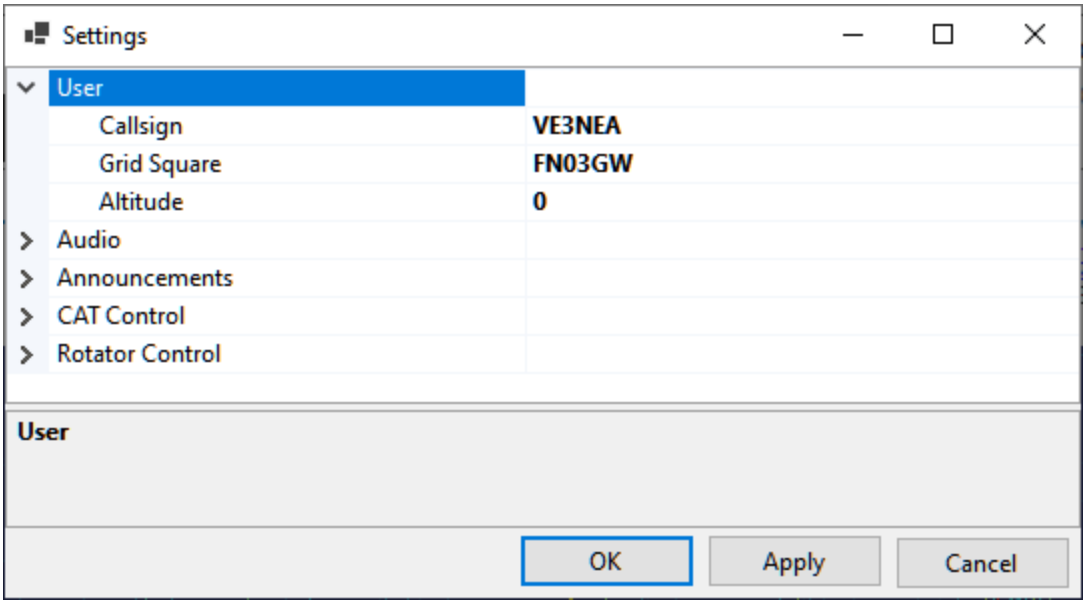
Satellite Highlighting

The satellite entries in various windows and panels, such as Satellites and Groups window, Satellites Details window and Current Group panel, are highlighted according to their properties:

- **Cyan background** - the satellite has at least one transmitter in the UHF band;
- **Yellow background** - the satellite has at least one transmitter in the VHF band;
- **Bold text** - the satellite has the Amateur Service (Ham) flag in the database;
- **Grayed text** - the satellite is not Alive;
- **Striked-out** - the orbit elements (TLE) are not available for this satellite.

Settings window

Click on **Tools** / **Settings** in the main menu to open the Settings window.



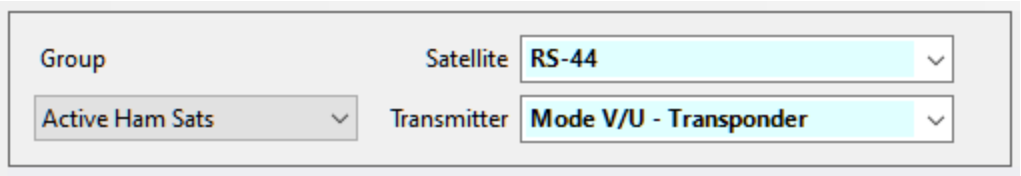
This dialog allows you to edit the settings of SkyRoof. In particular, here you can change the **Callsign**, **Grid Square** and **Altitude** that you entered on the first run of the program.

For the description of other settings see these sections:

- Setting Up Audio
- Setting Up Voice Announcements
- Setting Up CAT Control
- Setting Up Rotator Control

Satellite Selector

Satellite Selector is the panel on the toolbar where you can select the satellite group, the satellite within the group, and the transmitter of the satellite:

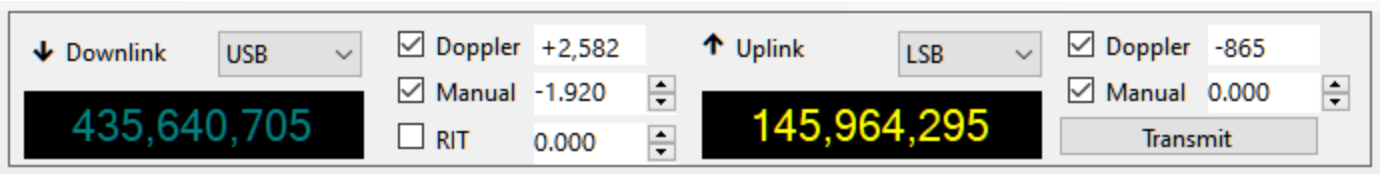


Move the mouse cursor over the **Satellite** or **Transmitter** drop-down box to see detailed information about the selected item on the mouse tooltip.

See the Creating Satellite Groups section for the instructions how to create and edit the groups.

Frequency Control

Frequency Control is the panel on the toolbar that allows you to read and control the frequencies of the SDR receiver, external receiver and external transmitter:

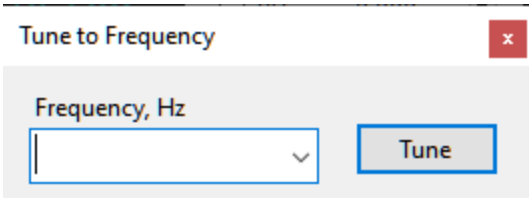


Downlink

The left hand part of the panel represents the receiver settings that apply to both SDR and external radio.

Label

When the receiver is tuned to a downlink transmitter of some satellite, the label "Downlink" appears; when it is tuned to a terrestrial station, the label "Terrestrial" is displayed. To tune to a downlink, select some satellite in the Satellite Selector panel, or select a different transmitter from the drop-down list, or click on the satellite name in any panel. To tune to a terrestrial signal, click on it on the Waterfall Display or on the Frequency Scale, or click on the downlink frequency display and enter the frequency in the **Tune to Frequency** window:



Mode

Select the mode manually for every satellite transmitter that you are using. Your selection is remembered and restored when the transmitter is selected again.

The **Mode** selected in the drop-down box applies to the SDR receiver, if it is enabled, and to the external receiver, if RX CAT is enabled. To enable or disable the SDR or RX CAT, click on the corresponding label on the status bar.

Frequency Display

The frequency display shows either the nominal frequency of the downlink, or the frequency with all corrections applied. Right-click on the display to switch between the two frequencies.

The mouse tooltip of the frequency display shows both frequencies and some other details.

When RX CAT is enabled and working properly, the frequency is shown in a bright color, otherwise the display is dimmed. The color depends on the band: yellow/olive for VHF, cyan/teal for UHF, white/gray for all other bands.

Doppler

The **Doppler** box shows the current Doppler offset of the downlink signal. This value is not editable, but Doppler correction may be enabled or disabled using the checkbox. See the Doppler Tracking section for a detailed discussion of Doppler offset calculation and tracking.

Manual

The manual correction of the downlink frequency. The frequencies of the satellite downlink signals usually differ from the nominal values in the database, for different reasons, by a few hundred Hertz and up to a couple of kilohertz. This difference is pretty stable, so it is enough to enter the correction once to have the receiver accurately tuned. SkyRoof remembers the manual correction for each satellite.

The value of the manual correction may be entered in the **Manual** box by clicking on the up/down buttons, or by spinning the mouse wheel over the box, or by typing the value directly. However, it is more convenient to adjust the correction visually, using the mouse on the Frequency Scale.

The checkbox allows you to disable the manual correction if necessary.

RIT

The RIT function is useful when listening to a conversation of two stations that are not exactly on the same frequency, or when your CQ is answered off the frequency.

The RIT offset may be entered in the RIT box, but it is more convenient to control it on the Frequency Scale.

Use the checkbox, or the commands on the **Frequency Scale**, to toggle RIT.

Uplink

The Uplink part of the panel is similar to the Downlink part described above. It is enabled only if the selected satellite transmitter has an uplink. The bright color of the frequency display means that TX CAT is enabled and working properly. The **Transmit** button switches the external radio between the RX and TX modes.

The **Manual Correction** setting of the uplink allows you to align your transmit and receive frequencies. See the Frequency Scale section for details.

Dial Knob

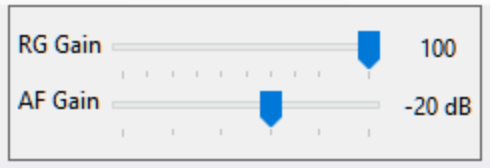
The dial knob of the transceiver can be used to tune the frequency when CAT control is enabled and the **Ignore Dial Knob** option is set to **false**.

When both RX CAT and TX CAT are enabled, the dial knob controls the receiver frequency.

> **NOTE**
>
> When the radio is in the SAT mode, the NOR/REV switch should be in the NOR position for correct tuning with the dial knob.

Gain Control

The Gain Control panel on the toolbar has two sliders to control the RF and AF gain:

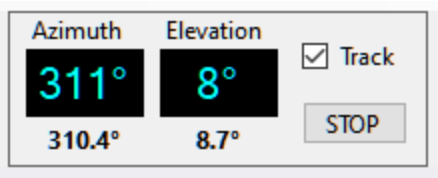


The **RF Gain** slider is enabled only if the **Single Gain** setting is set to **true** in SDR settings.

To adjust the gain, click on the slider, or spin the mouse wheel over it, or drag the thumb control.

Rotator Control

The Rotator Control panel on the status bar shows the current position of the selected satellite and the antenna bearing, if the rotator control function is enabled:

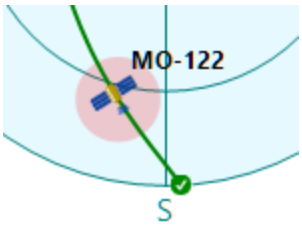


Display

The large Azimuth and Elevation display shows the satellite location, the small numbers below it show the antenna bearing.

The satellite location is dimmed when the rotator control function is disabled. Click on **Rotator** on the status bar to enable or disable this function.

When rotator control is enabled, the current antenna bearing is marked on the Sky View panel with a red spot:



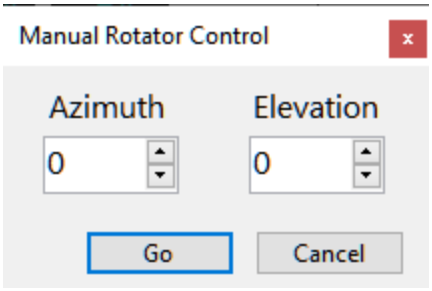
Tracking

When rotator control is enabled but the **Track** checkbox is not ticked, the panel only displays the antenna bearing but does not attempt to change it. Tick the **Track** checkbox to start tracking. Note that the check box is cleared when a different satellite is selected.

In the satellite tracking mode, the antenna bearing turns pink if it differs from the satellite position by more than 1.5 the **Step Size** setting entered in the rotator settings.

Manual Control

Click on the satellite position display to open the **Manual Rotator Control** window:

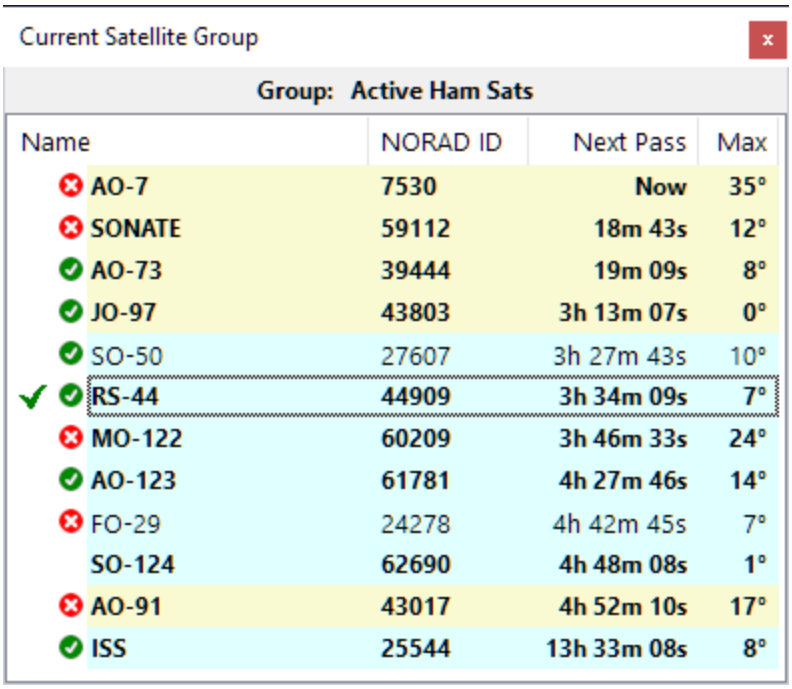


Stopping

To stop antenna rotation, either manual or due to the satellite tracking, click on the **Stop** button.

Current Group

The Current Satellite Group panel shows the list of the satellites in the currently selected group:



The green and red icons indicate real-time satellite status (active or inactive) according to the AMSAT web site. See Satellite Data for details.

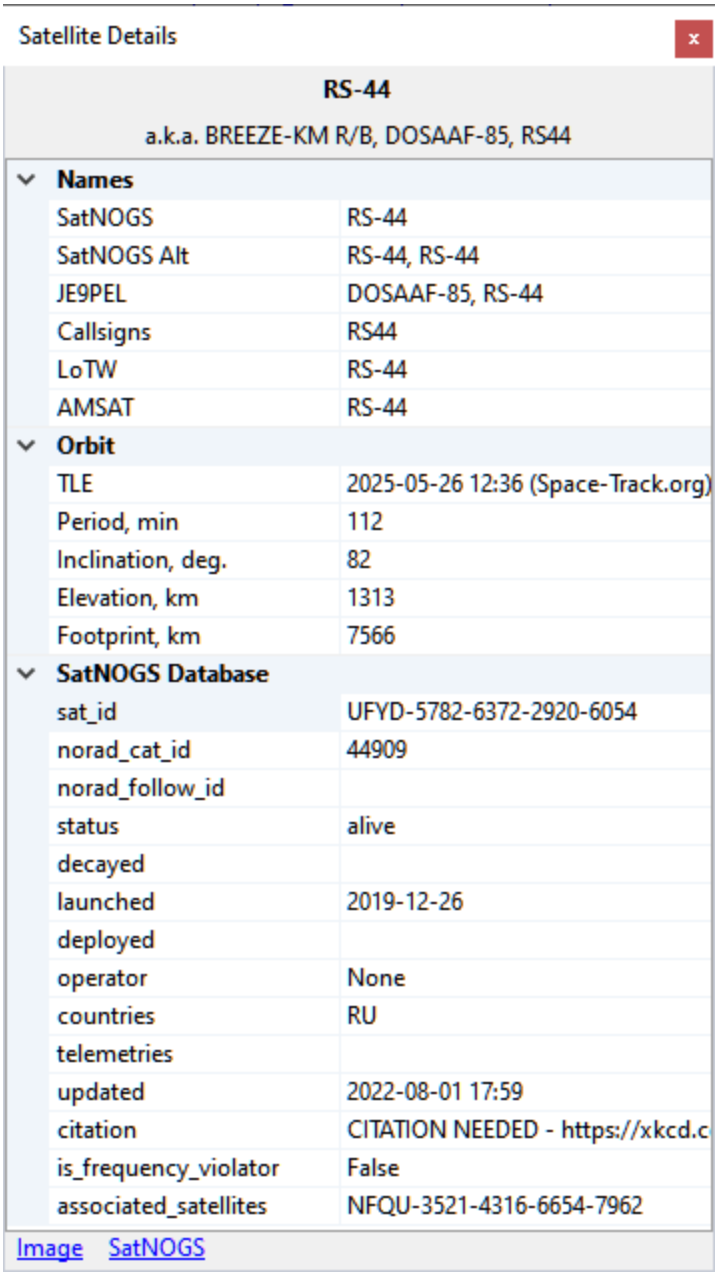
Click on a satellite to select it.

Move the mouse cursor over the satellite name to see the mouse tooltip.

Right-click on the satellite and click on **Satellite Details** in the popup menu to open the Satellite Details Wndow.

Satellite Details

The Satellite Details panel shows information about the currently selected satellite:

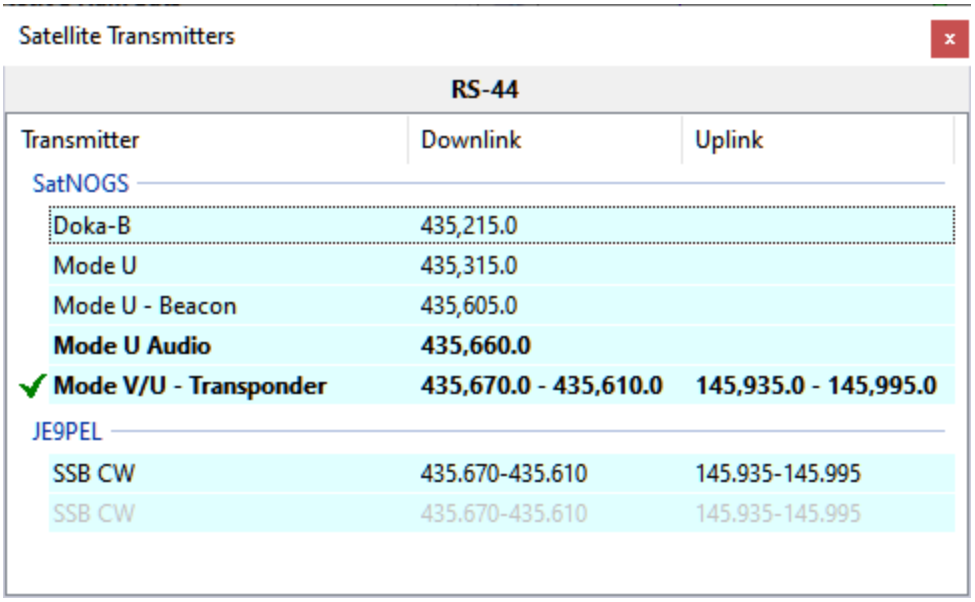


This panel displays the same information as the upper portion of the Satellite Details window. The difference is that, unlike the window, the panel may be docked anywhere in the user interface.

See the Satellite Data section for information about available data.

Satellite Transmitters

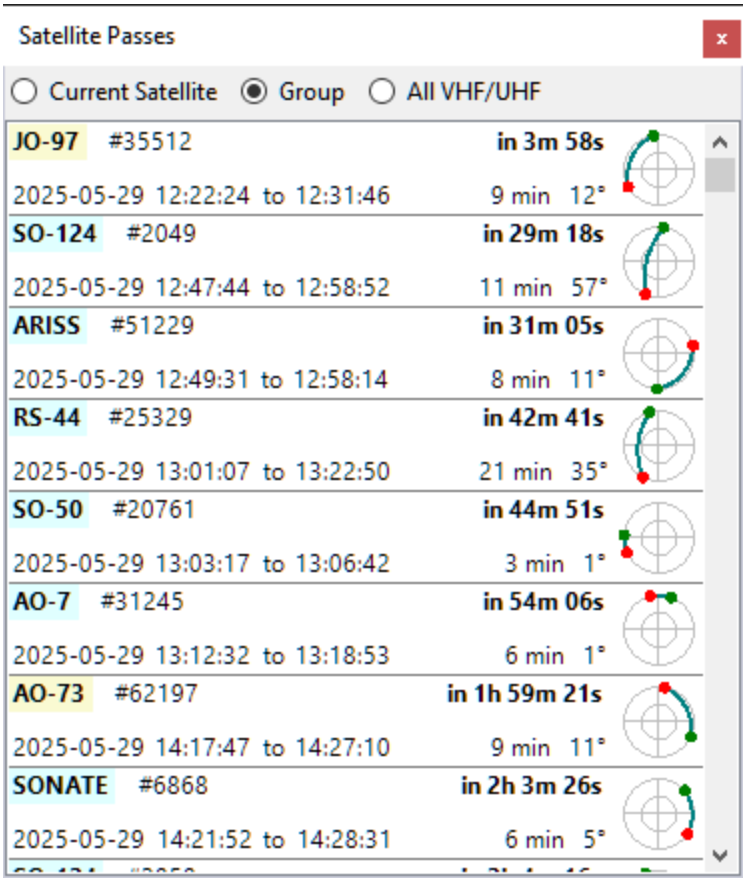
The Satellite Transmitters panel shows the list of transmitters carried by the currently selected satellite. It is similar to the bottom part of the Satellite Details window but is dockable for permanent visibility:



Click on the transmitter in the **SatNOGS** section to select it. Move the mouse cursor over the transmitter name to see the details on the mouse tooltip.

Satellite Passes

The Satellite Passes panel shows the list of predicted satellite passes over your location:



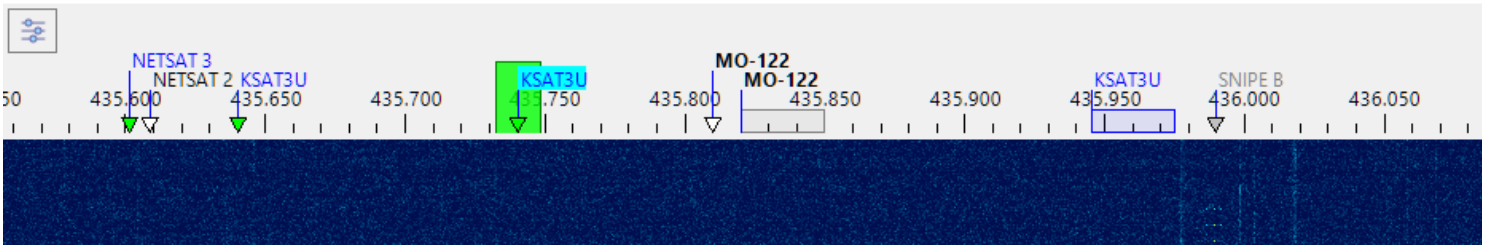
The radio buttons at the top allow you to view either the passes of the selected satellite, of all satellites in the currently selected groups, or all satellites carrying a VHF or UHF downlink transmitter and thus visible on the Frequency Scale.

Click on a pass to make the satellite selected and to view its trajectory on the Sky View panel.

Move the cursor over the satellite name to view extra information on the mouse tooltip, or right-click to open the Satellite Details window.

Frequency Scale

The frequency scale appears on the Waterfall Display panel, above the waterfall:



Satellite Transmitters

The Doppler-corrected frequencies of the satellite transmitters are marked on the frequency scale with small triangles, labeled with the satellite names:

- **green triangles** - the satellites that are currently above the horizon;
- **white triangles** - the satellites that will rise in the next 5 minutes;
- **gray triangles** - the satellites that are already below the horizon, but whose signals are still may be visible on the waterfall;

- **blue rectangles** - the transponder segments of the satellites above the horizon;
- **gray rectangles** - the transponder segments of the satellites below the horizon.

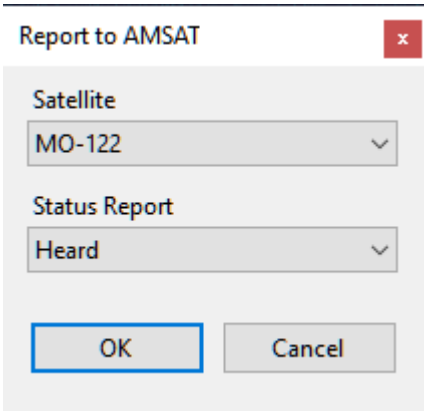
The names of the satellites that belong to the current group are shown in bold;

The current transmitter has its satellite name on the light blue background.

Move the mouse cursor over a satellite name to see the details on the mouse tooltip.

Right-click on a satellite name to open the popup menu with these commands:

- **Select Transmitter** - if the satellite has more than one transmitter on the same frequency, this command is enabled and allows you to set one of the transmitters as selected;
- **Add to Group** - add the satellite to one of the existing groups;
- **Report to AMSAT** - open the dialog to report your observation of this satellite to AMSAT Live OSCAR Satellite Status Page



- **Satellite Details** - opens the Satellite Details window

SDR Receiver

The passband of the SDR receiver is shown on the frequency scale as a green rectangle. To tune the receiver:

- click on one of the satellite labels to start tracking satellite's transmitter;
- click within a blue transponder segment to select the transmitter and set the transponder offset;
- click anywhere on the frequency scale to tune to a terrestrial signal;
- drag the green rectangle to another frequency with a mouse;
- spin the mouse wheel on or near the green rectangle.

The effect of tuning depends on the transmitter selection:

- when tuned to a terrestrial signal, tuning the SDR receiver just changes the receiver frequency;
- when a satellite transmitter is tracked, tuning adjusts the **Manual Offset** of the satellite (see below);
- if a satellite transponder is selected, tuning changes the receiver offset within the transponder segment.

Another way to tune the SDR receiver is to use the Frequency Control on the toolbar.

If RX CAT is enabled, tuning the SDR receiver also tunes the external radio to the same frequency.

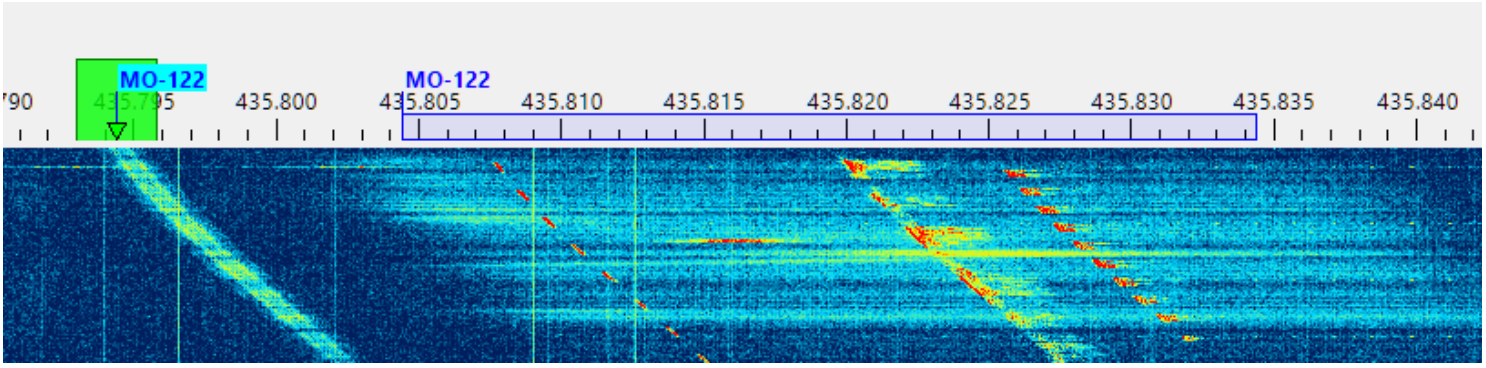
NOTE

Get a mouse with a free-spinning wheel, such as Logitech MX Master 3S, this makes tuning much easier.

Manual Offset

The Manual Offset setting compensates for the transmitter frequency error, see Frequency Control and Doppler Tracking for details.

The offset value is usually the same for all transmitters of a satellite, adjust it for some non-transponder transmitter before using the transponder. Most satellites with a transponder also carry a telemetry or beacon transmitter that you can use to set the manual offset:

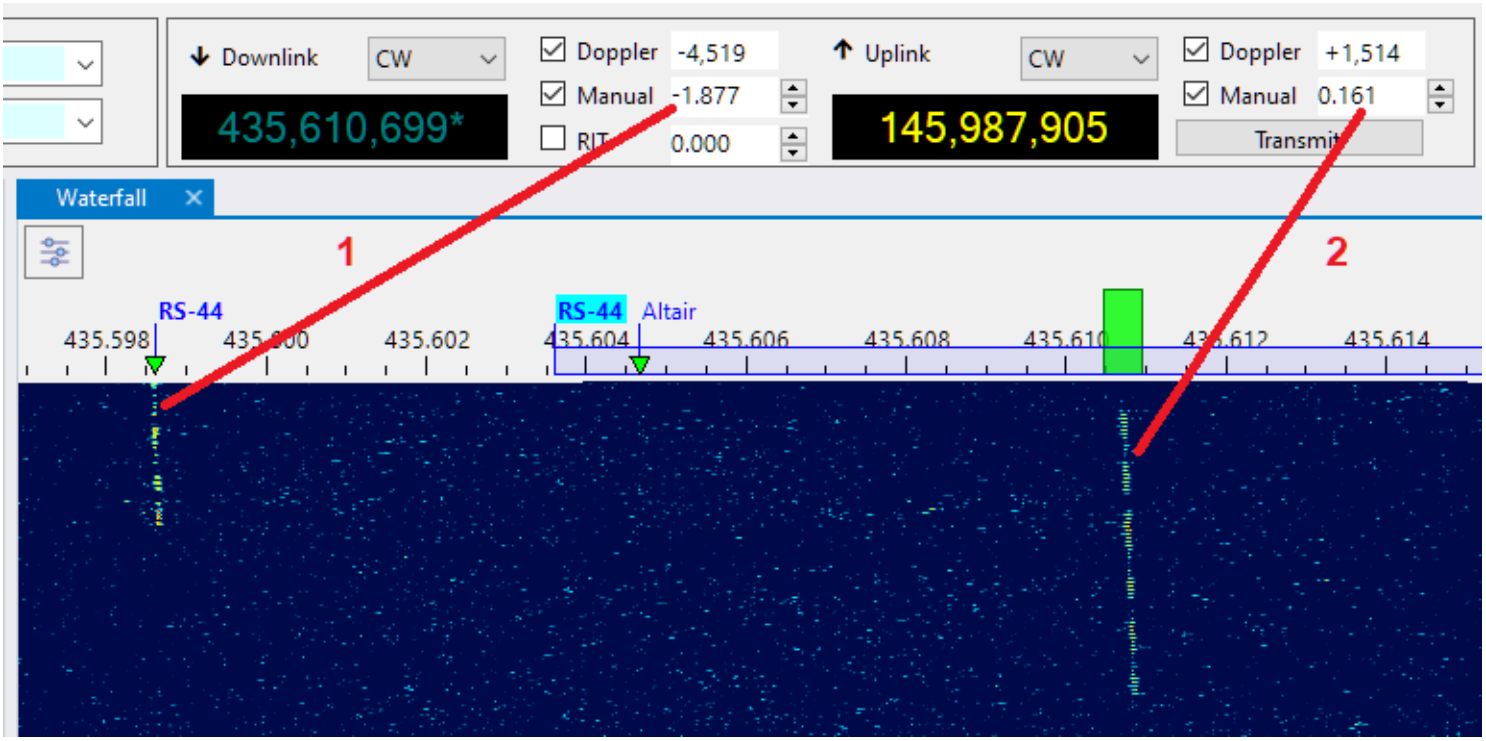


Aligning The Uplink and Downlink Frequencies

The screenshot below shows how to set Manual Correction for the uplink and downlink for a linear transponder, such as RS-44.

1. Select the beacon transmitter of the satellite and adjust the Downlink Manual Correction setting to align the transmitter label and its signal trace on the waterfall. For RS-44 the required correction is about -1900 Hz. If your offset is different, then yor SDR requires PPM calibration.

2. Select the transponder transmitter and find a clear frequency within the transponder segment. Send a sequence of dots and adjust the Uplink Manual Correction to align the center of the green rectangle with the trace of your signals coming from the satellite.

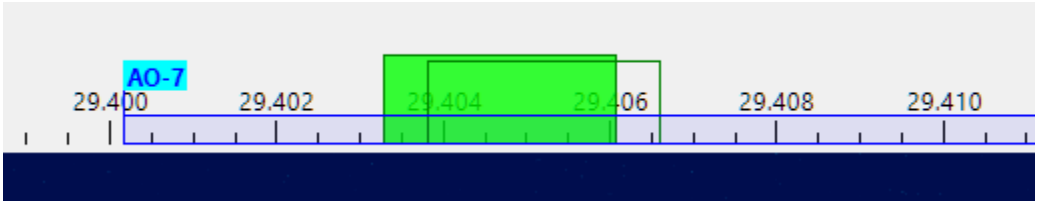


These adjustments need to be done only once. They stay the same, within a few tens of Hertz, between the satellite passes.

When TX CAT is enabled, RX CAT is disabled and the Ignore Dial Knob is set to false in the Settings, it is possible to adjust the Uplink Manual Offset using the dial knob on the radio.

RIT

While the RIT function could be controlled using the Frequency Control panel, it is more convenient to do this on the frequency scale:

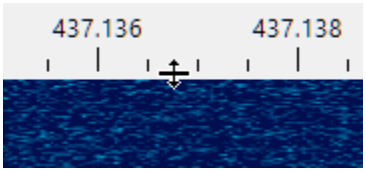


When RIT is enabled, the clear rectangle shows the current receiver passband, while the green rectangle stays on the main frequency.

- spin the mouse wheel on or near the green rectangle while holding the **Ctrl** key down: this enables RIT and tunes its offset;
- spin the mouse wheel on or near the green rectangle WITHOUT holding the **Ctrl** key down: this disables RIT and tunes the main frequency;
- right-click on or near the green rectangle to turn RIT on and off.

Resizing

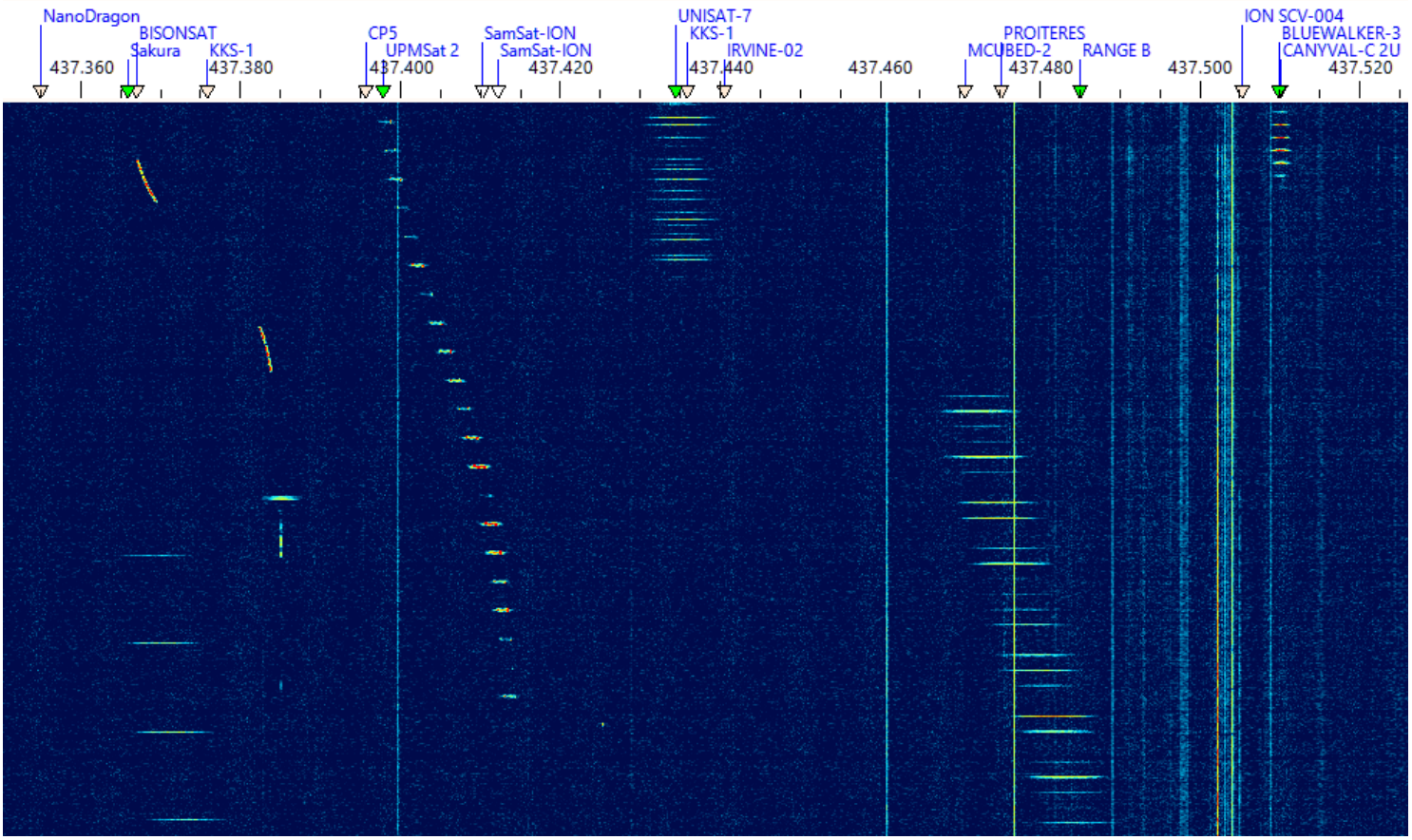
Adjust the height of the frequency scale by dragging the splitter between the scale and the waterfall:



Waterfall Display

Using Waterfall Display

The waterfall display and associated Frequency Scale is the central piece of SkyRoof that integrates most of the functions available in the application:



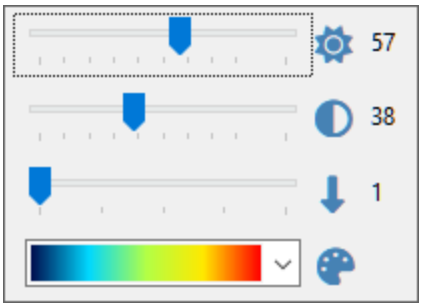
The waterfall spans over 3 MHz of spectrum (depending on the SDR model) so that it covers the whole satellite segment, 435-438 MHz, on the 70 cm band. On the 2 m band the satellite segment is only 200 kHz wide, 145.8-146 MHz, so it also fits completely in the waterfall.

- Zoom in and out using the mouse wheel
- Pan by dragging the waterfall horizontally with your mouse

A mouse-click on the waterfall display:

- tunes the SDR and external radio to a terrestrial signal
- or, if the frequency is within the transponder segment of a passing satellite, selects that satellite and sets the transponder offset to the clicked signal.

A click on the **Sliders** button in the top left corner of the panel opens the sliders that adjust brightness, contrast and scrolling speed of the waterfall, and select a color palette:



See Also

- Frequency Scale
- Doppler Tracking

Waterfall Display Characteristics

Finding and tracking satellite signals on the VHF and UHF bands is a difficult task. These signals are weak because the output power of most satellite transmitters is in the milliwatt range. The fact that an omnidirectional antenna needs to be used to receive all in-range satellites at the same time makes this task even more difficult. On top of that, we need to see the whole 3-MHz frequency segment where the satellite signals may appear, and at the same time we want a very high resolution to examine the structure of the signals, and to tune precisely to CW, SSB and digital transmissions.

The waterfall display in SkyRoof solves these problems by computing power spectra oversampled by a factor of about 100. This has three important consequences:

1. You can zoom in the waterfall display without changing its resolution in Settings, just by spinning the mouse wheel. When zoomed in to the maximum, you can see the signals with a **100x** magnification (20 Hz resolution).

2. When zoomed out to the maximum to see the whole 3-MHz segment, the sensitivity of the waterfall display to narrowband signals improves by about **15 dB** due to oversampling.

3. Spectrum oversampling, however, increases the requirements to the hardware:

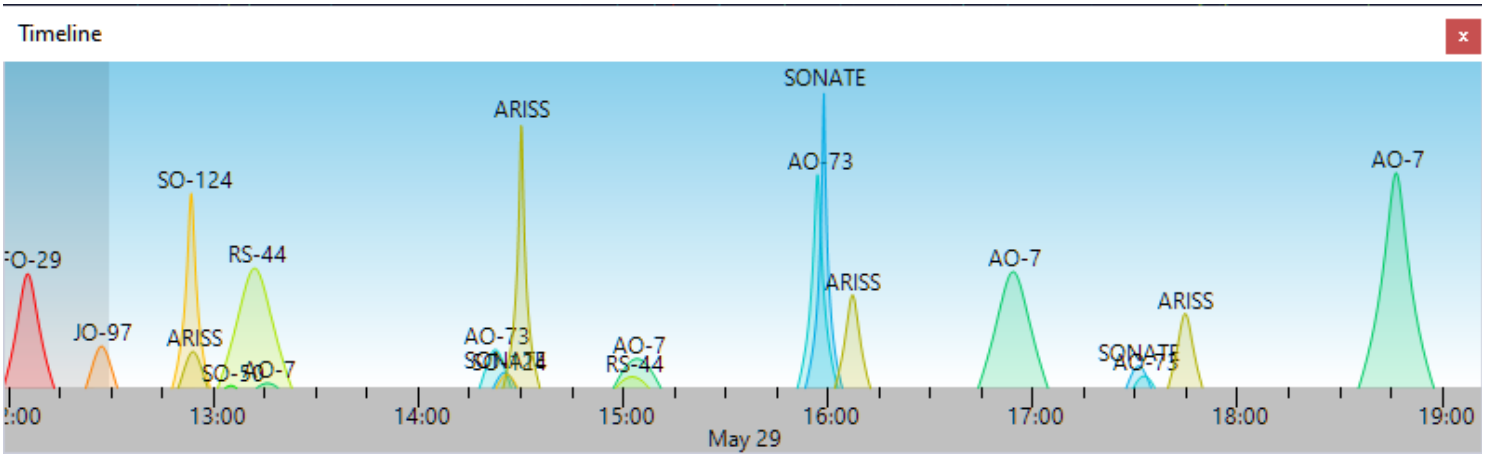
    - more CPU power is needed to compute very large spectra;
    - more texture memory is needed in the video card to store the spectra;
    - support of OpenGL 3.3 or higher is required for the zoom function.

    Please see the System Requirements section for the exact requirements.

If your computer does not meet these requirements, you can still use the pass prediction, Doppler correction, radio control and rotator control functions in SkyRoof, just disable the SDR function and close the Waterfall Display panel.

Time Line

The TimeLine panel shows the satellite elevation chart as a function of time for all satellites in the selected group:



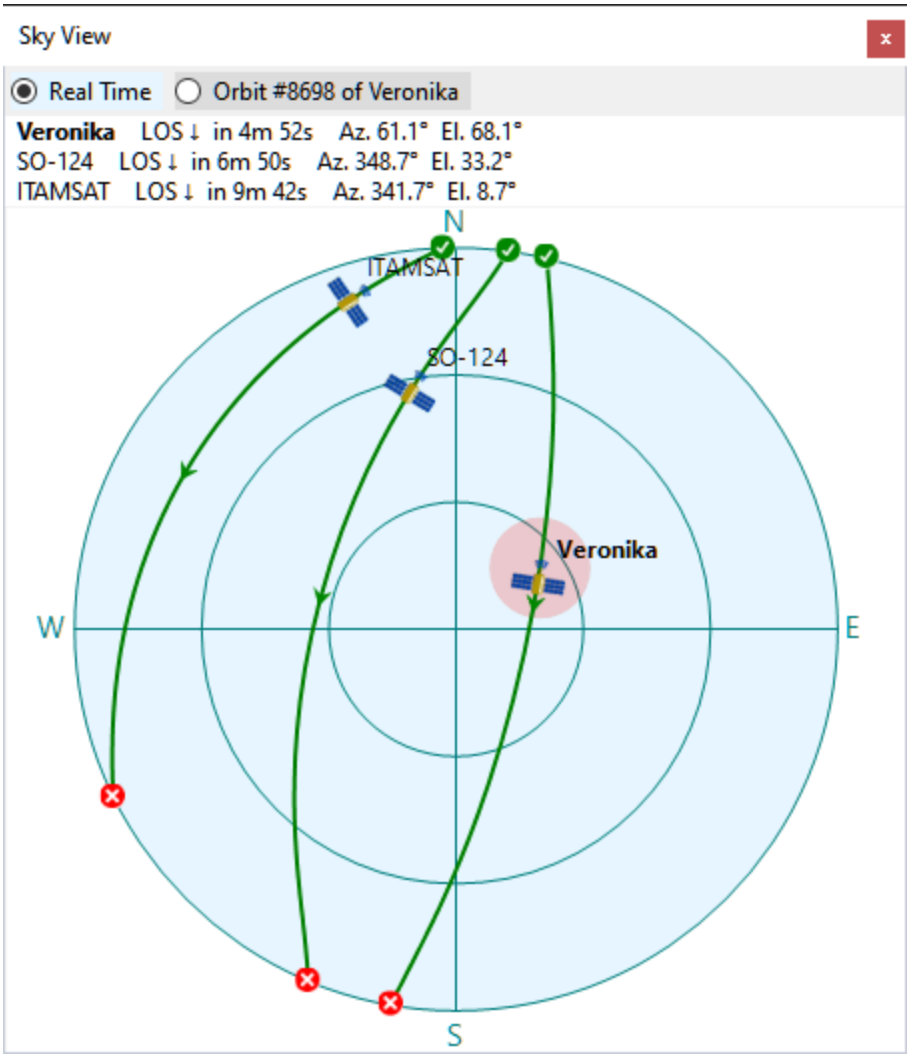
- Zoom in and out using the mouse wheel
- Pan by dragging the chart with your mouse
- Click on the satellite name to make it current, and to view the pass on the Sky View panel.

The dark part of the chart represents the past time.

Sky View

The Sky View panel shows the trajectory of the satellites in the sky, as visible at your location:

The radio buttons at the top switch the chart between the real-time display showing all satellites in the selected group that are currently above the horizon, and a specific pass of a specific satellite.



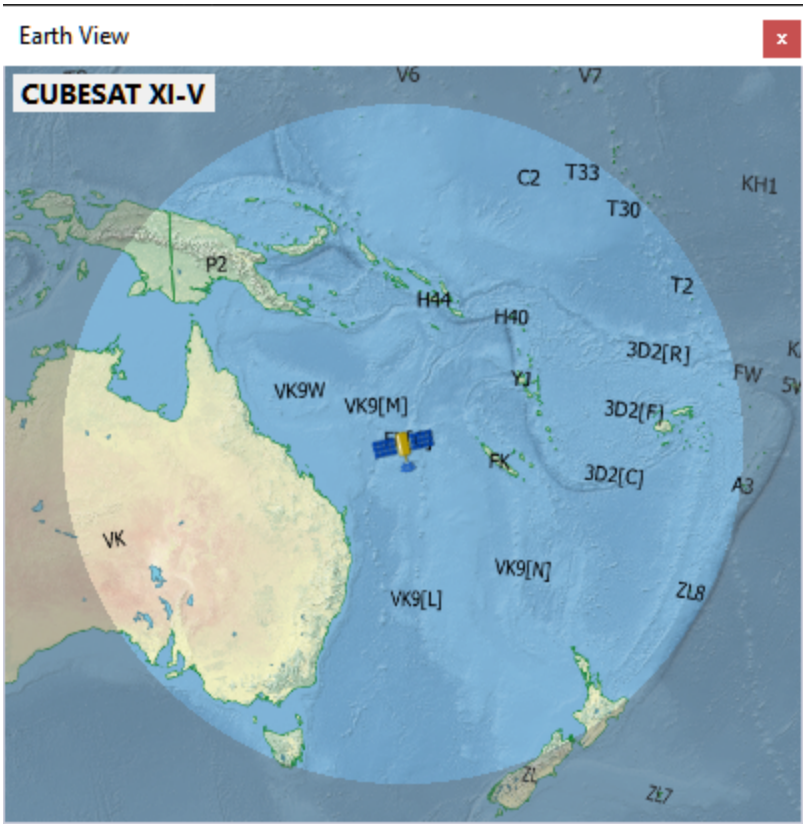
The pink spot indicates the current antenna bearing if Rotator Control is enabled.

To select the pass to be displayed, click on it in the Current Group panel, Satellite Passes panel or Time Line panel.

Click on the satellite name next to the satellite icon to make it selected.

Earth View

The Earth View panel shows the view of the Earth from the satellite:



The highlighted area is what the satellite can see from its current position. The satellite is above the horizon for the observers in this area.

Use the mouse wheel to zoom the view in and out.

Satellite Data

Data Sources

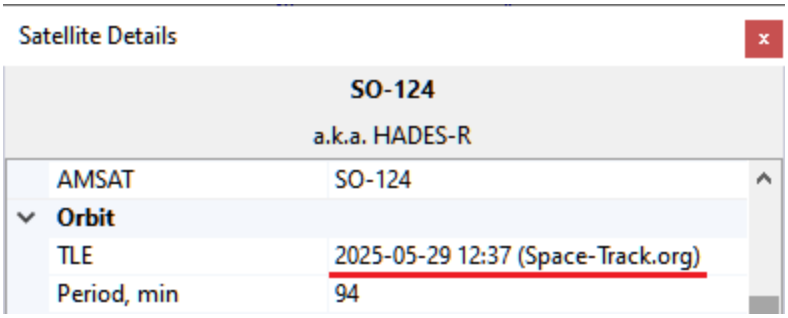
SkyRoof obtains satellite date from several sources:

- SatNOGS DB is the main source of satellite data. It is a frequently updated, crowd-sourced dataset that contains detailed information about all satellites transmitting in the Ham bands;
- JE9PEL Satellite List is another dataset with information about the satellites, maintained by Mineo Wakita JE9PEL, that, in particular, includes the callsigns of the satellites. This dataset presents the frequencies in an undocumented format, so its data are included in the SkyRoof database only FYI.
- LoTW - The ARRL LoTW service accepts satellite QSO only if the satellite abbreviation is one of those published on their web site. These abbreviations are stored in a file in the Data folder, you can view them in the Satellite Details window.
- AMSAT Live OSCAR Satellite Status Page accepts satellite observations with their own satellite abbreviations, these abbreviations are stored in a file in the Data folder.

TLE

The satellite orbit elements (TLE data) are downloaded from **SatNOGS DB**.

SatNOGS obtains these data from different sources and makes the latest and most reliable data available on their web site. The source of TLE and its creation time are shown in the Satellite Details window or panel:

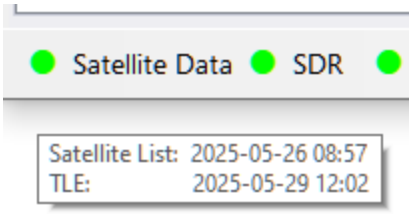


and in the mouse tooltip of the satellite:

Automatic Updates

SkyRoof automatically downloads the satellite list every 7 days, and TLE data every 24 hours.

The mouse tooltip of the Satellite Data label on the status bar shows the last download time:



The light next to the label turns yellow if the satellite data are not up to date.

Manual Updates

In addition to automatic downloads, the data may be manually downloaded at any time using the **Tools / Download All Satellite Data** and **Tools / Download Only TLE** menu commands.

Loading TLE from File

If your system is not connected to the Internet, you can load TLE data from a local file using the **Tools / Load TLE from File** menu command. Two TLE formats are supported:

- **.json** - TLE data from the SatNOGS web site, recommended (download);
- **.txt** - 3-line TLE data in a text file, available from many sources, e.g. CelesTrak (download).

Note that TLE import cannot add new satellites, it only loads orbital elements for the satellites already in the database.

AMSAT Satellite Status

AMSAT Live OSCAR Satellite Status Page is a crowd-sourced, real-time Ham satellite status page.

Posting Status Data

You can post your satellite status observations the the AMSAT web site either by filling the submission form on their site, or using the right-click menu of the satellite labels on the Frequency Scale. A valid Ham callsign must be entered in the Settings window for this function to work.

Downloading Status Data

Set the **Amsat Satellite Status / Enable** option in the Settings window to `true` to enable automatic downloads of the satellite status information from the AMSAT web site. The statuses are shown on the Current Group panel, the green and red icons represent the active and inactive status respectively.

Satellite status data are downloaded once an hour. You can manually download it at any time using the **Tools / Download AMSAT Statuses** menu command.

Doppler Tracking

The SGP4 algorithm used in SkyRoof to compute the Doppler offset produces very accurate results for the LEO satellites, typically within tens of Hertz, if it receives accurate input data. For best results, ensure that the following conditions are met.

Home Location

Make sure that your grid square is accurate. Correct it in the Settings window if necessary.

System Time

Your system clock should be accurate to a second. Get one of those little programs that run in the system tray and periodically synchronize your clock with the time servers on the Internet. NetTime is one such program.

PPM correction

Find the PPM correction factor of your SDR radio as described in the Calibrating PPM Correction section and enter it in SDR settings.

TLE Data

SkyRoof downloads the TLE data automatically every 24 hours. Some sources claim that TLE may be updated once a week, but that would not be enough for accurate Doppler tracking, especially for the satellites that perform frequent orbit corrections. When in doubt, download TLE manually as described in the Satellite Data section.

Transmitter Frequency Correction

Most satellite transmitters transmit on the frequencies that differ from the nominal values by up to a few kHz. A one-time correction described in the Frequency Control and Frequency Scale sections eliminates this error.

Data Folder

SkyRoof keeps all of its data in the **data folder**.

- Click on **Help / Data Folder** in the main menu to open this folder in File Explorer.
- To open the folder when the program is not running, type this in File Explorer: `%appdata%\Afreet\Products\SkyRoof`

Data Files

- **Settings.json** - this is the file where all user-defined settings are stored;
- **amsat_sat_names.json** - satellite names used on AMSAT Live OSCAR Satellite Status Page. The Frequency Scale section explains how to post your observations to this page;
- **lotw_sat_names.json** - the list of satellite abbreviations accepted by LoTW;
- **Satellites.json** - the satellite database compiled from the downloaded data;
- **cat_info.json** - information about the CAT capabilities of different radios;
- **wsjtx_wisdom.dat** - optimal FFT transform settings found by automatic testing.

Folders

- **Logs** - contains the log files with error messages and other information;
- **Downloads** - a copy of the satellite data downloaded from various sources, kept for troubleshooting;
- **Palettes** - definition of the color palettes used by the waterfall display. Add your own palette as a text file with "html" color codes. Pick the color codes at htmlcolorcodes.com.

Frequently Asked Questions

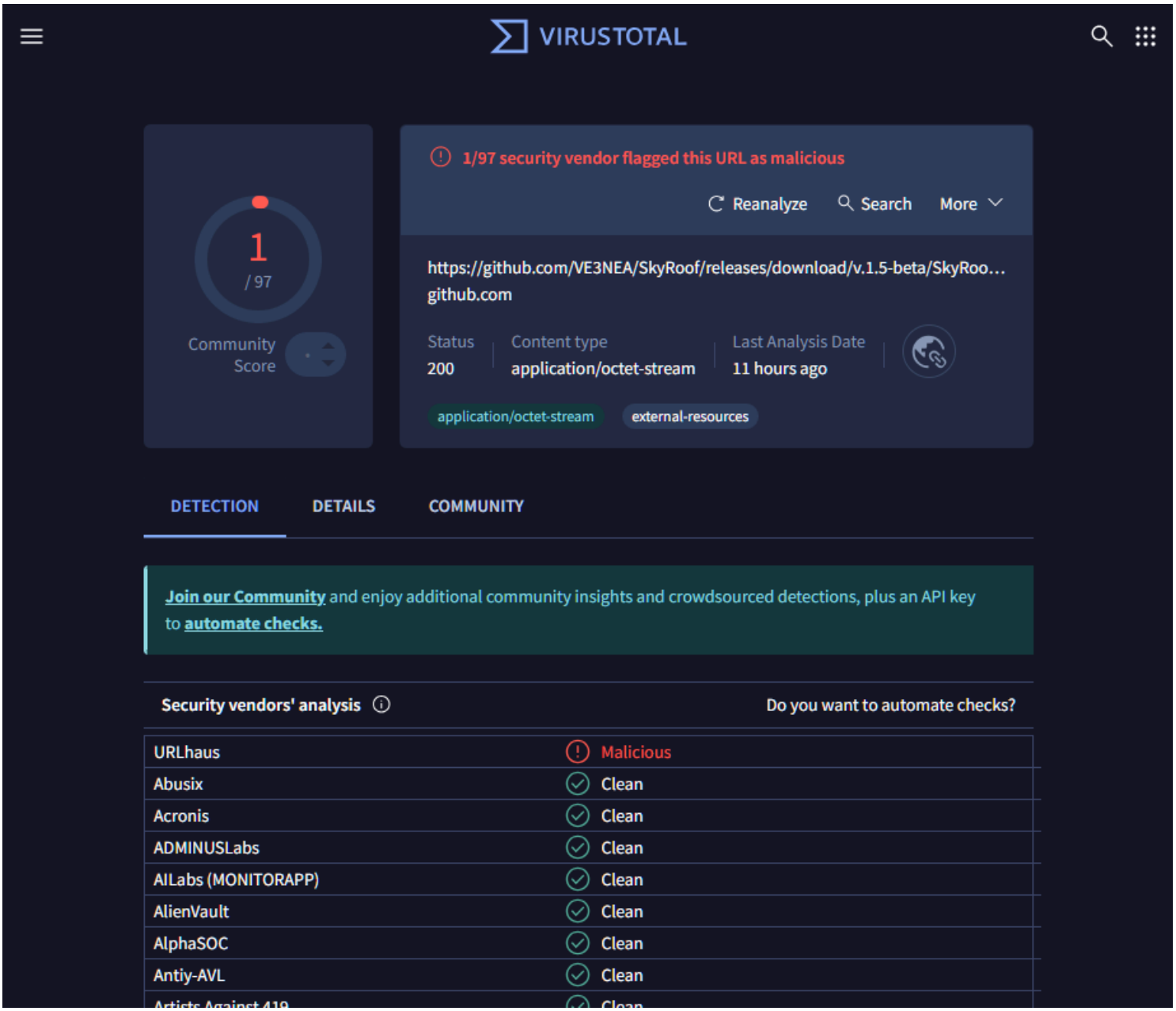
Q: I downloaded SkyRoof, and my virus scanner shows an infection. Is it real?

A: Most likely, it is a false detection. However, it is always a good idea to test the download links **before downloading** any software. There are several online virus scanning services that you can use to check the link. VirusTotal and Hybrid Analysis are just two examples.

Copy the download link and paste it in the virus scanner page. The scanner will download the file, test it with multiple antivirus programs, and show you the results.

In the screenshot below the download link of SkyRoof 1.5 beta was tested with VirtusTotal, and all virus scanners, except one, agreed that the file was clean. When you see something like this, you know that it was a false alarm.

If the file is clean, you can add it to the exception list of your virus scanner and safely install it. For Windows Defender follow these instructions, for other anti-virus products follow the instructions in their documentation.



Q: The right part of the SkyRoof toolbar does not fit in the screen, even though the screen resolution is 1980x1280.

A: This happens because your **text size** setting in Windows is too high. For example, if it is set to 200%, the effective screen width is only `1900 / 2 = 950 pixels`. To fix this, right-click on the Desktop, click on **Display Settings** and set the text size to a lower value.

Q: How can I run two instances of SkyRoof?

A: By default, only one instance of SkyRoof can run at any time, but there is a work around. Make a copy of the SkyRoof.exe file in the same folder, but with a different name, e.g., SkyRoof_2.exe. Each exe will have its own settings, its own data folder, and will run independently of the other instance.