SkyRoof v.1.21 RC

software for Hams and satellite enthusiasts

User's Guide

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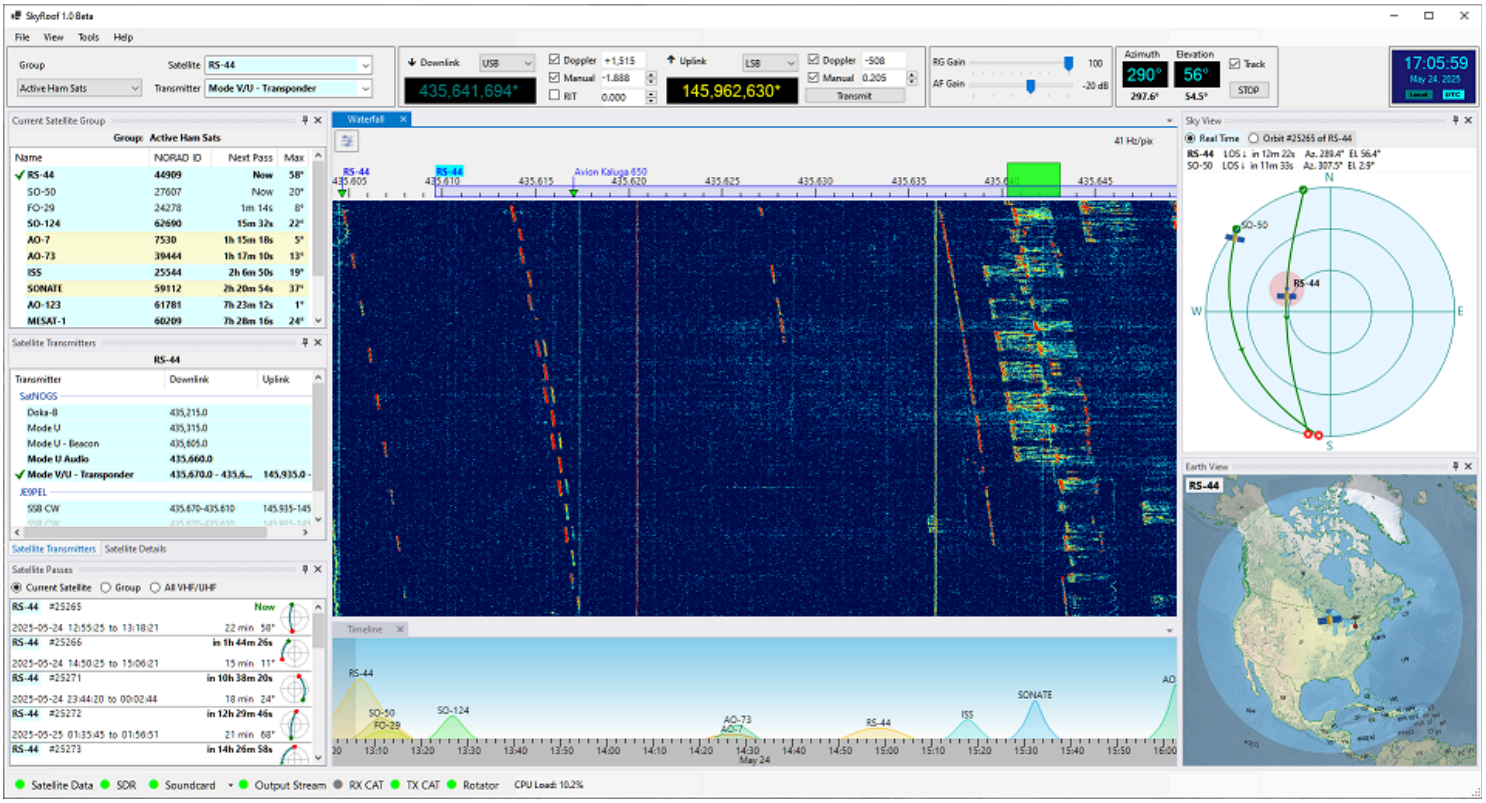
Overview

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 or UDP;
- 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. Currently plugins are available for:
  - Airspy;
  - AirspyHF+;
  - SDRplay;
  - RTL-SDR;
  - HackRF;
  - PlutoSDR;
- **Transceiver**: optional. Currently the command definition files are available for:
  - FT-817;
  - FT-818;
  - FT-847;
  - FT-991a;
  - IC-705;
  - IC-706MKIIG;
  - IC-915;
  - IC-910H;
  - IC-9700;
  - TS-2000;

  Many other radios are supported via HamLib;
- **Antenna rotator** - optional, any rotator supported by HamLib.

Software

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

Quick Start

Installation

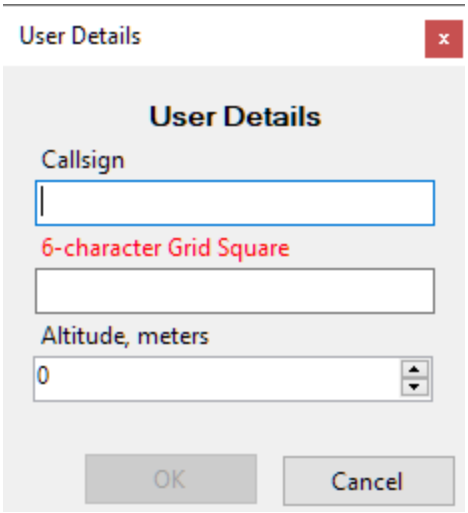
To install SkyRoof, download the installer from the Download page, run it, and follow the on-screen instructions.

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

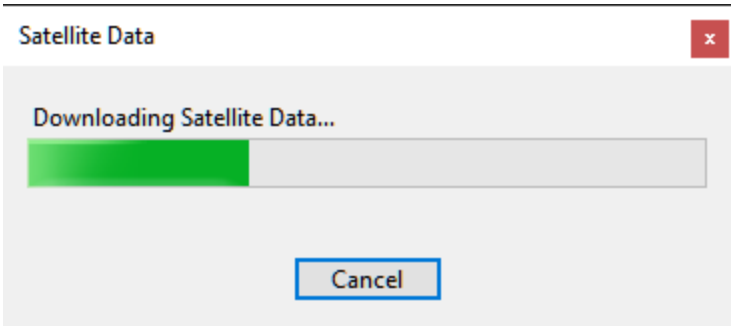
You will be presented with the User Details dialog:



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

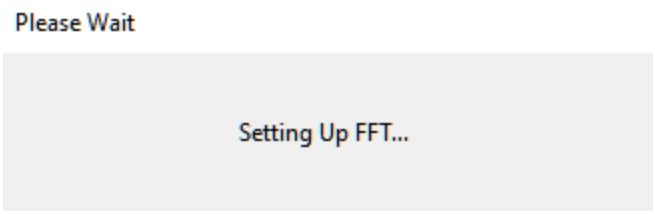
Then SkyRoof downloads the satellite data: make sure that your computer is connected to the Internet.



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!

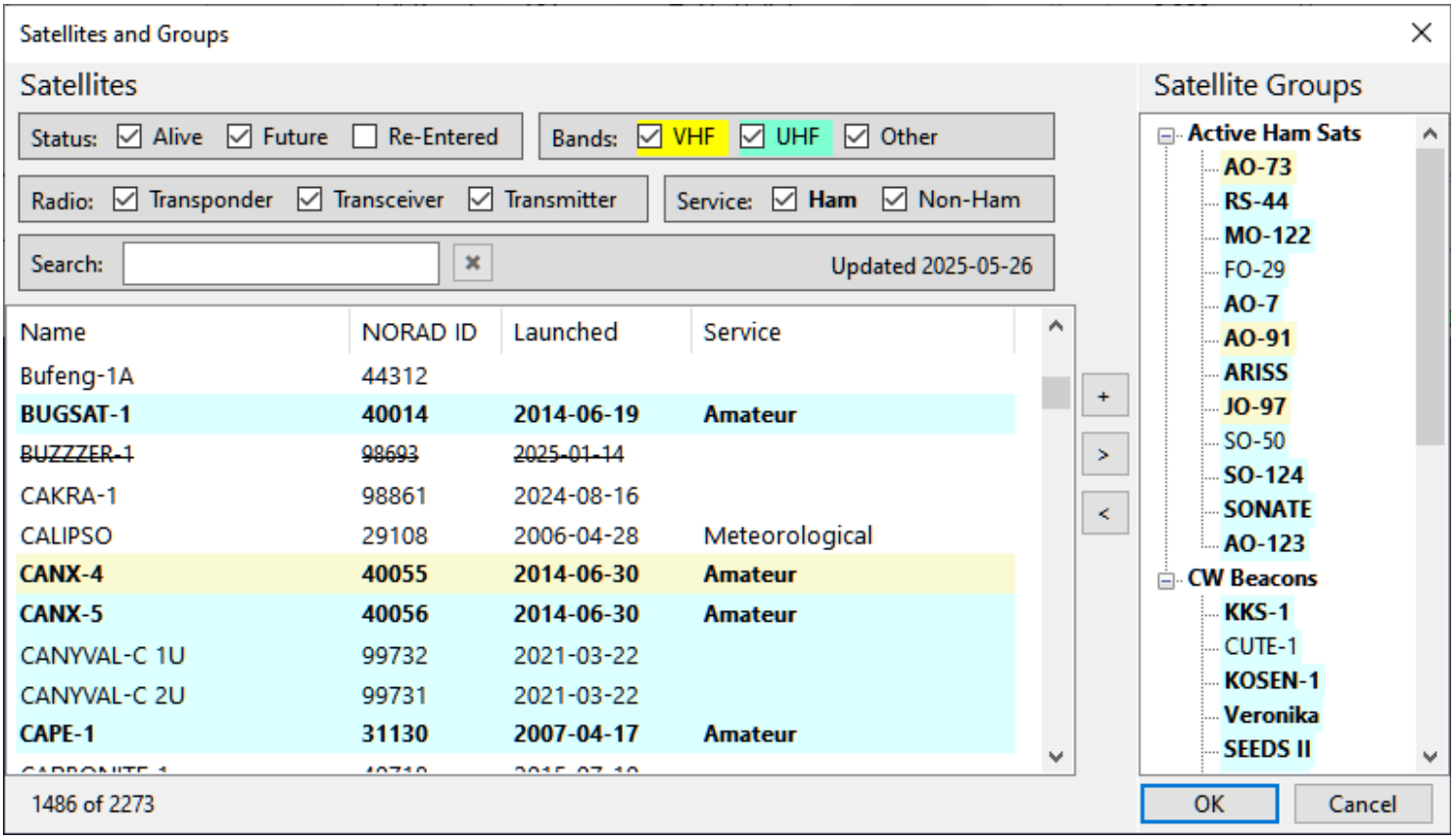


That's all for the quick start! Now you can use the program for tracking the satellites in frequency and space, and for predicting the satellite passes over your location. To do more than that, you have to perform the rest of the setup steps described in the next sections.

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

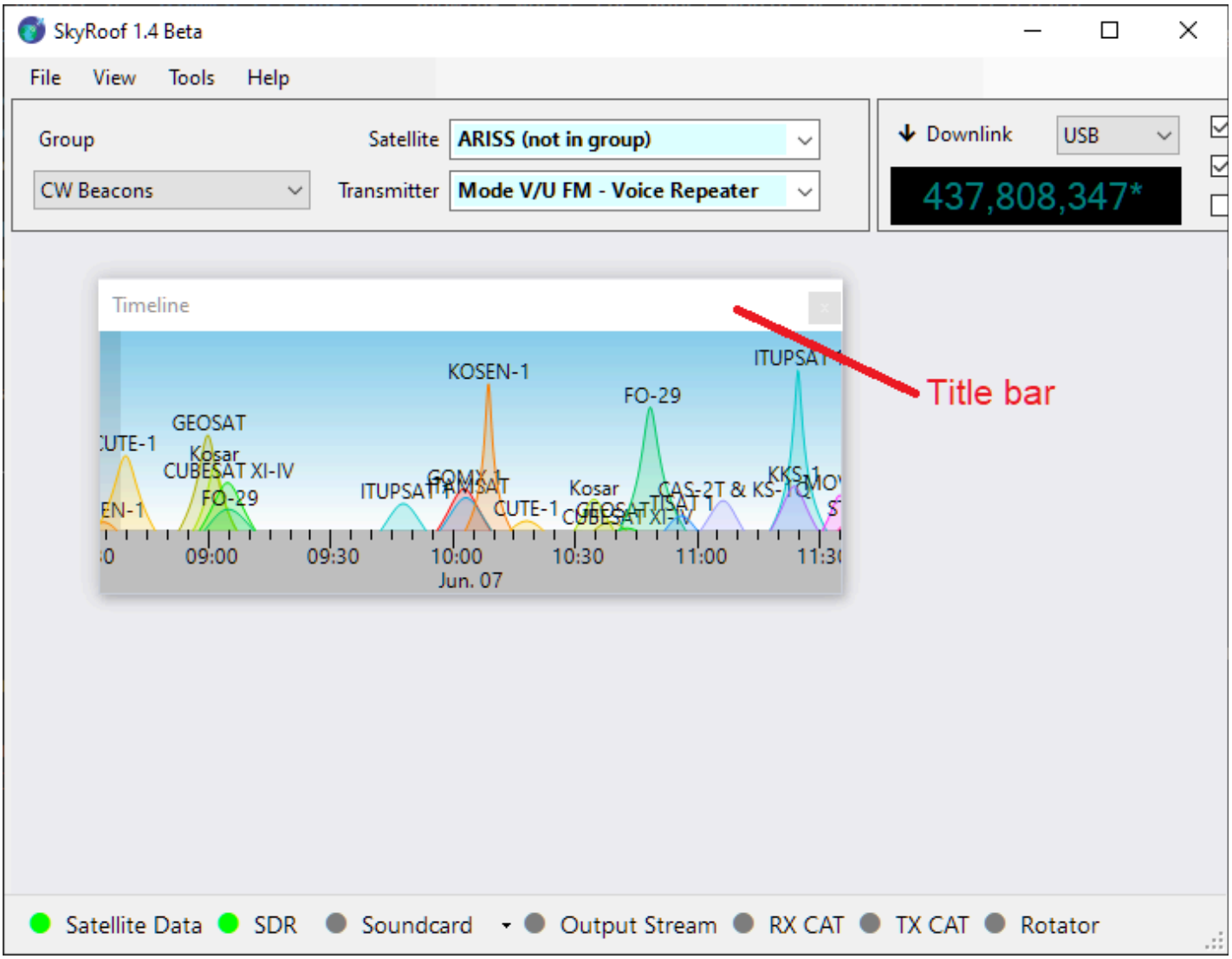
The panels you open are initially in the floating state. This is not very convenient as you cannot move or resize the main window without breaking your panel arrangement. You can dock the panels so that they move and resize when you move/resize the main window.

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**

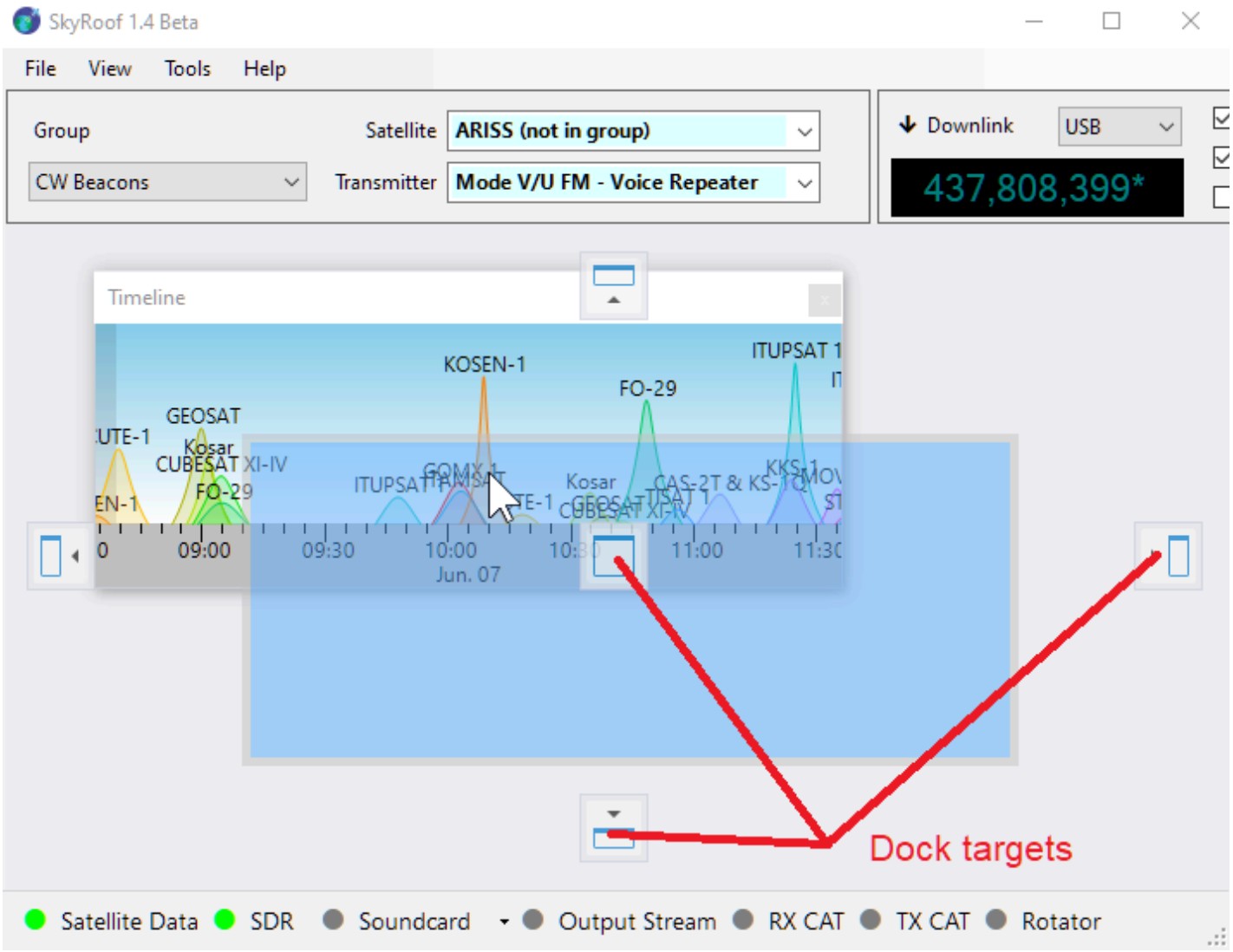
   Locate the top bar of the floating panel labeled "*Timeline*". This is known as the **title bar**.



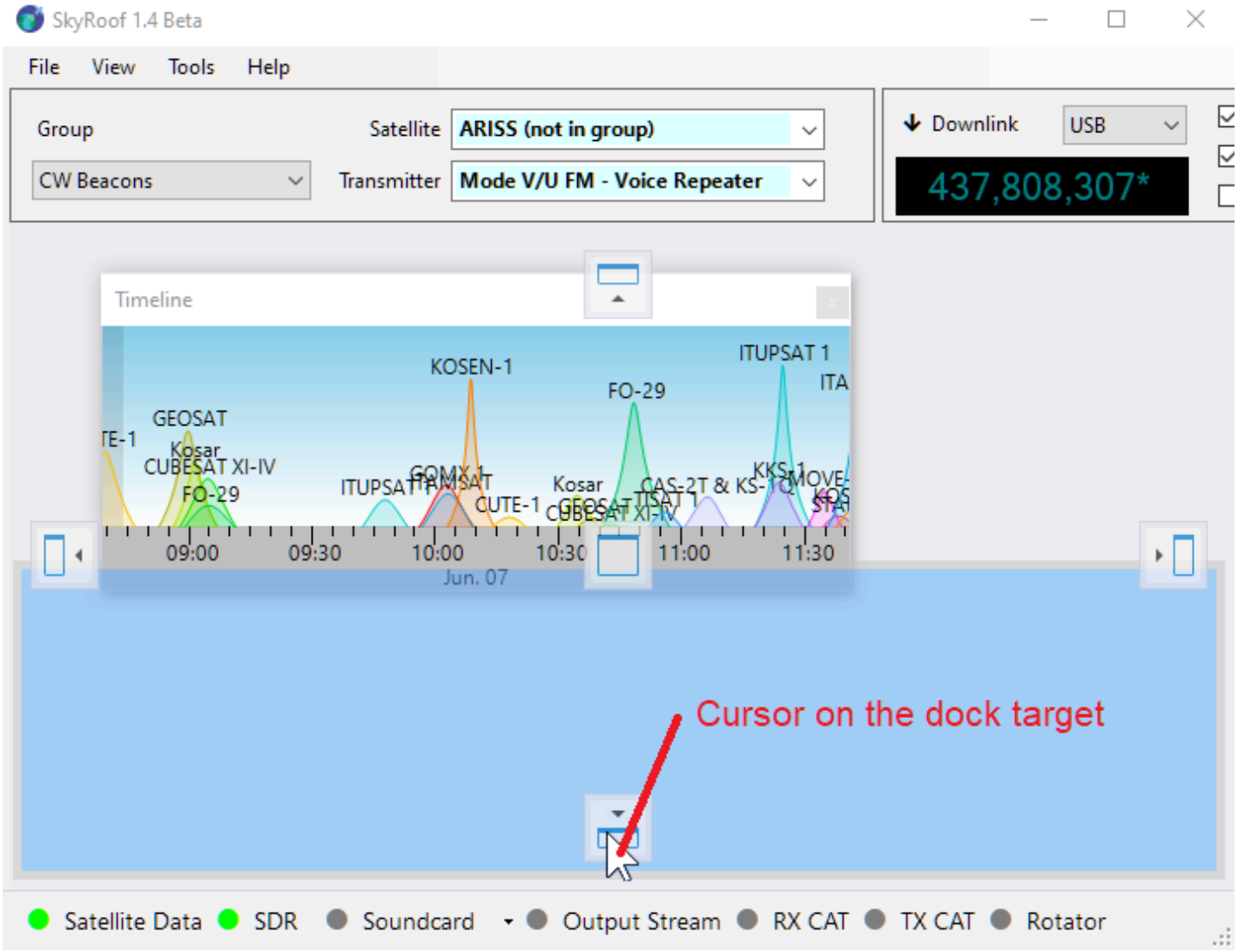
2. **Click and Hold**
   Move your mouse cursor to the title bar and press the **left mouse button**. Keep holding the button down.

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.

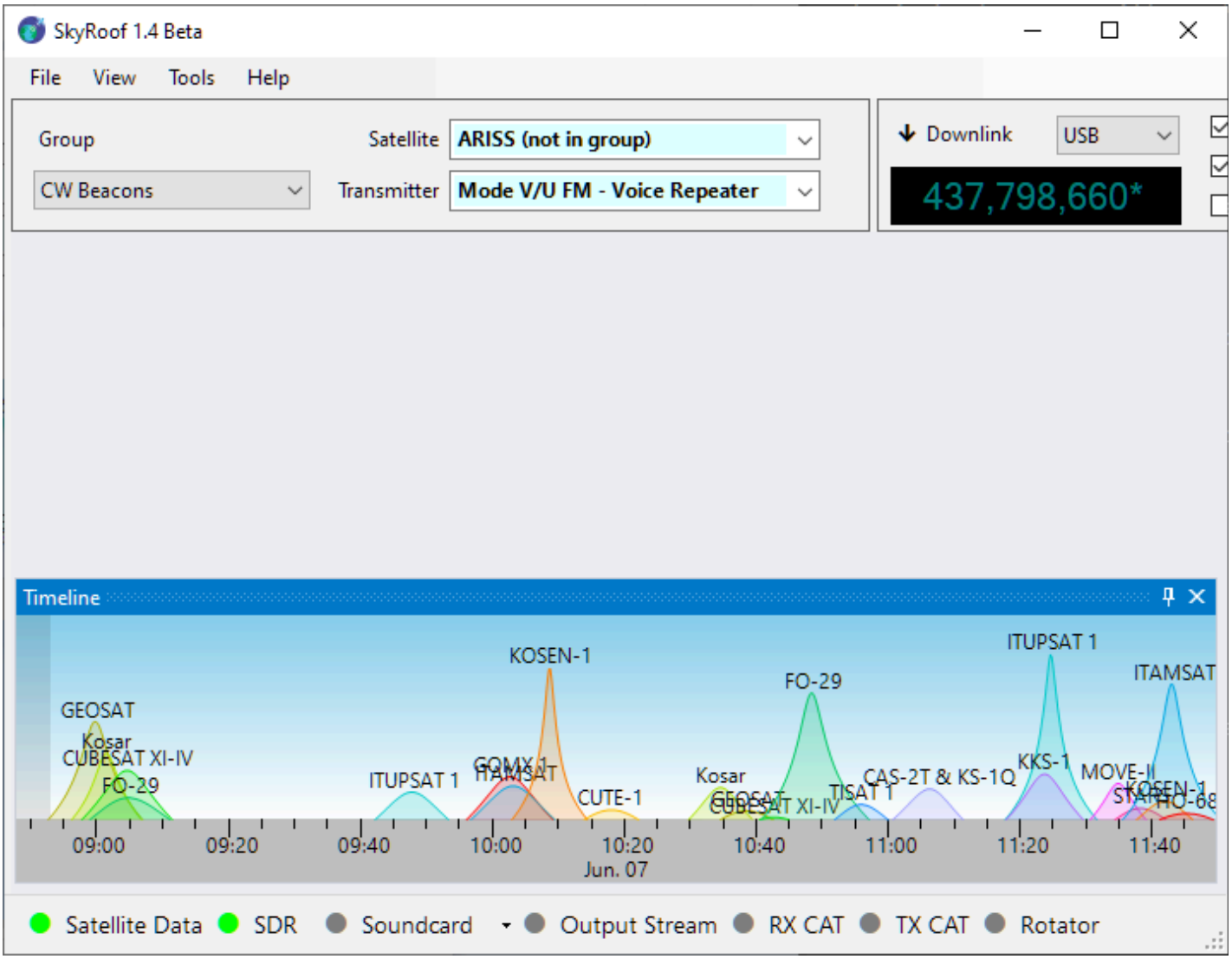
> ⚠️ **Important:** This rectangle is only a visual preview. Do **not** try to align it with the dock target icon. Instead, focus on where your mouse cursor is.



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.

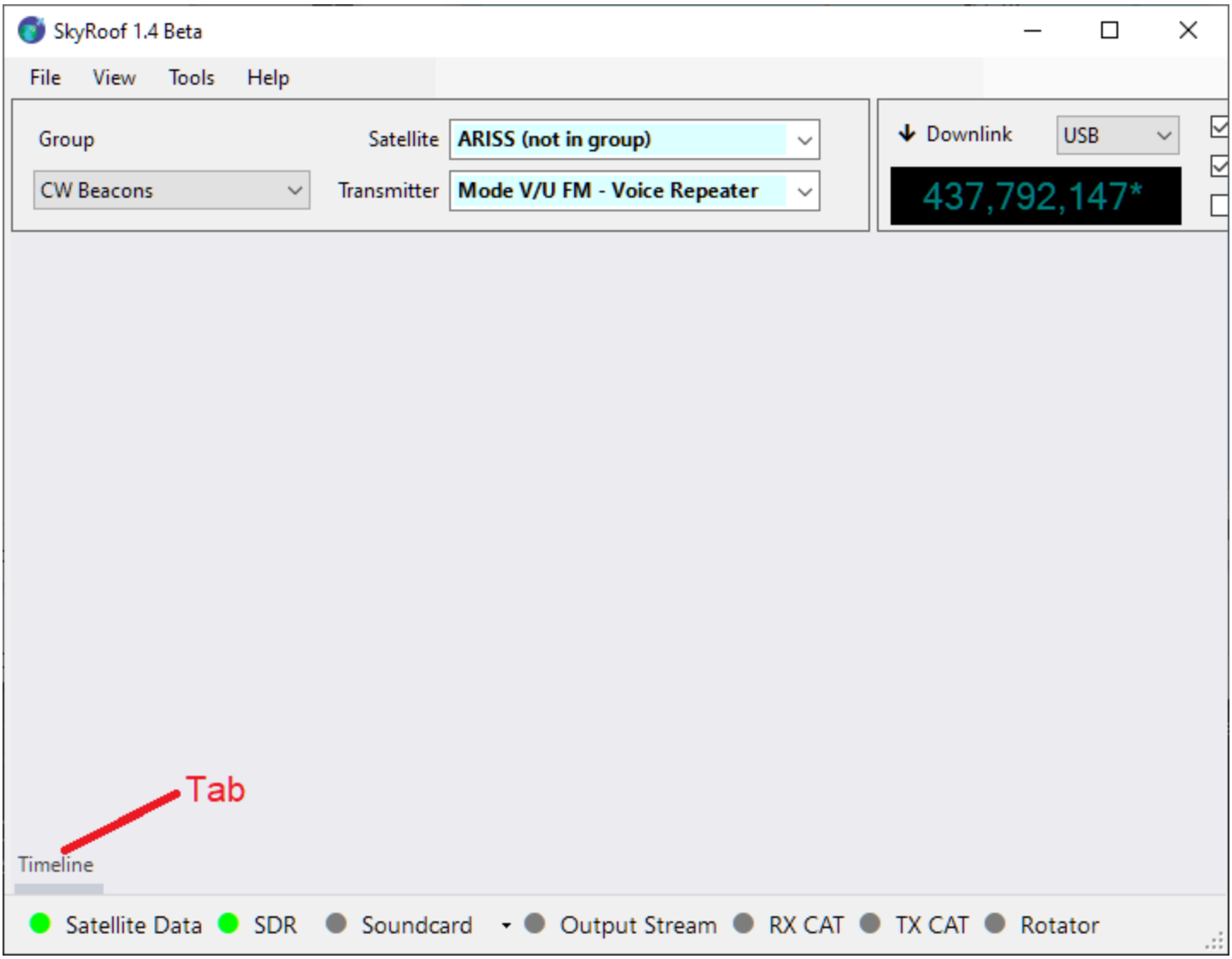


5. **Release to Dock**
   Once the cursor is over your desired dock target icon, **release the mouse button**. The panel will snap into place — either at the side, in the center, or nested inside another panel, depending on the selected icon. Once docked, the panel becomes part of the main window layout,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



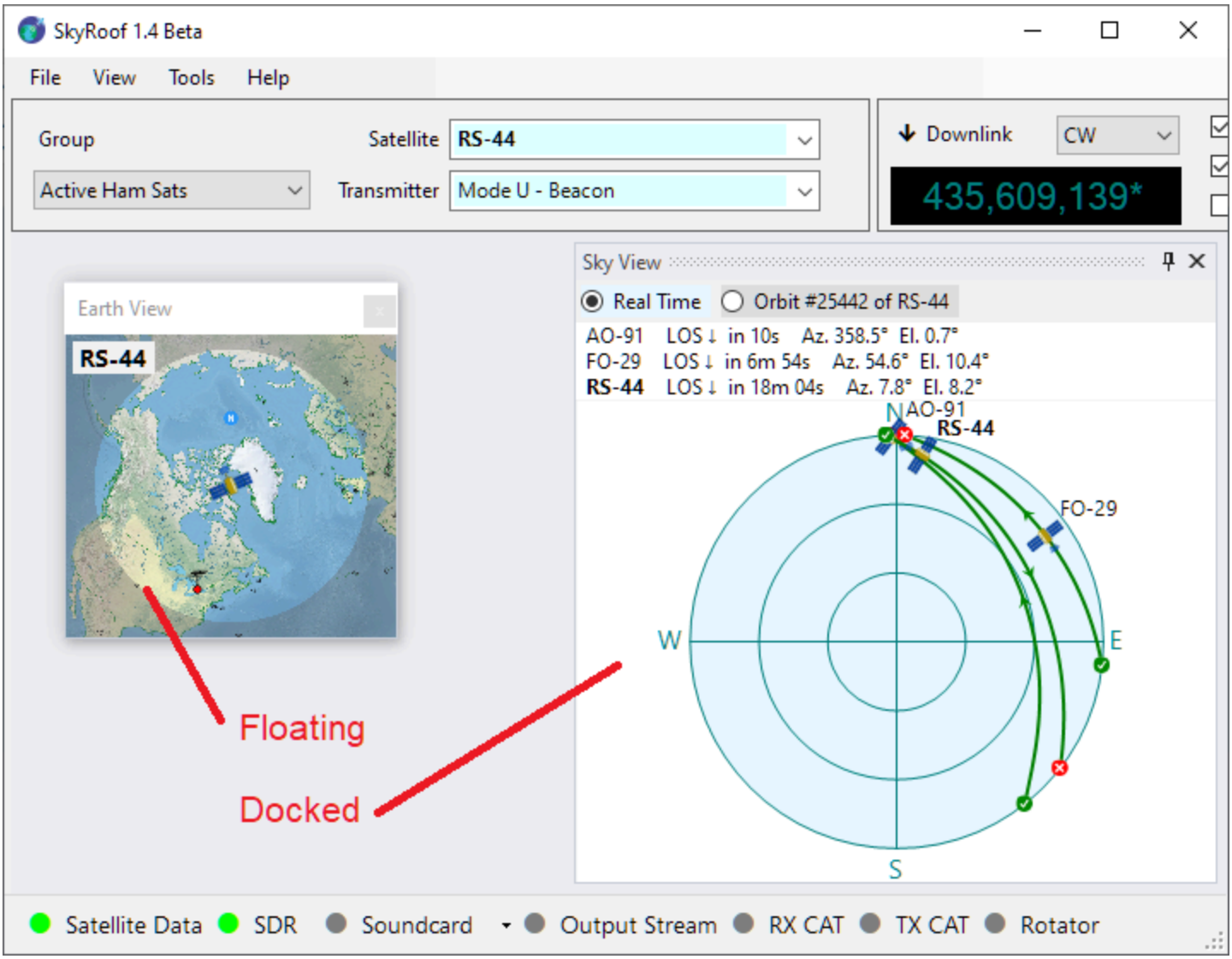
Auto-Hide

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.

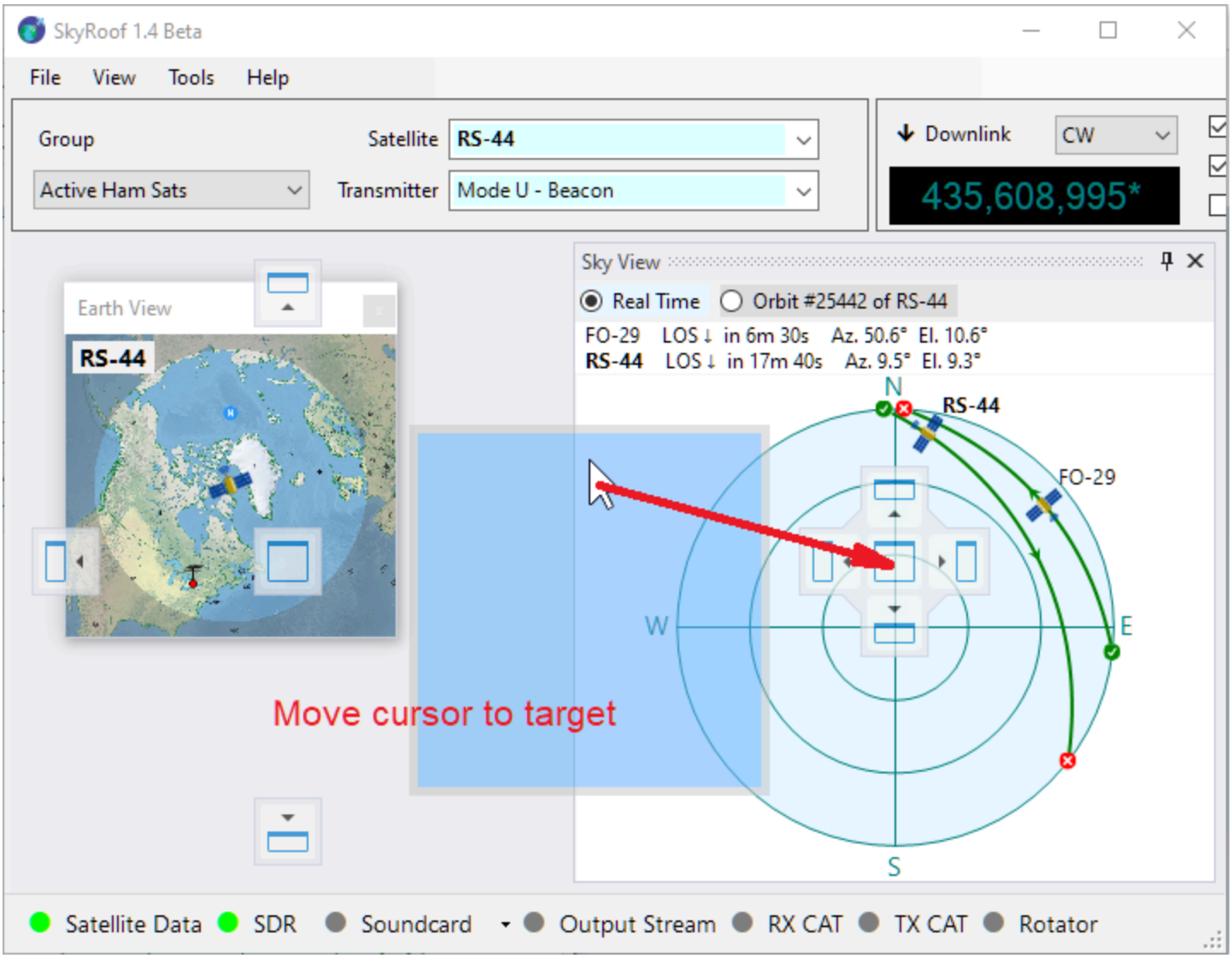


Tabbing

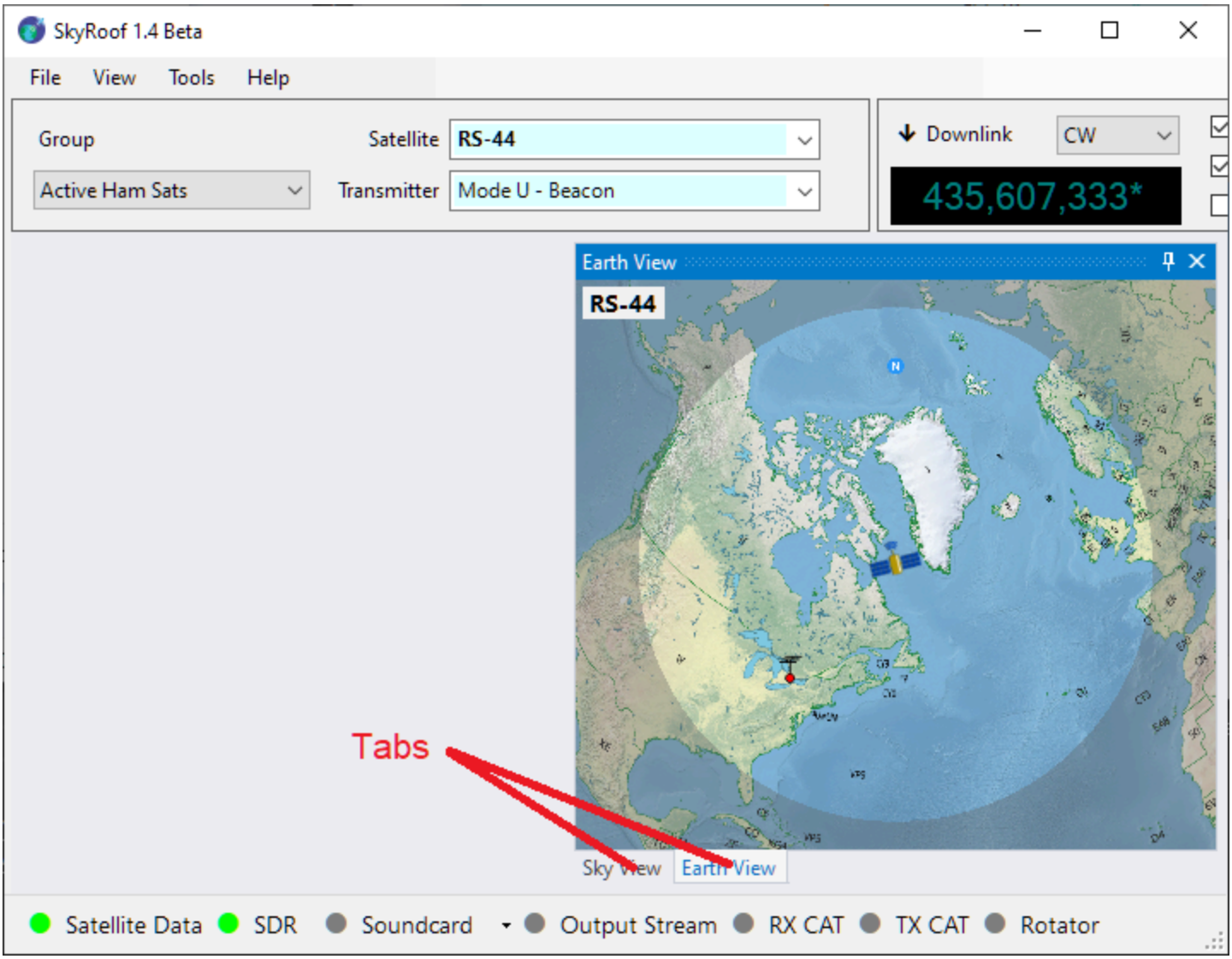
You can also organize panels as **tabs**.



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
Satellite
RS-44
Active Ham Sats
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;
- AirspyHF+;
- SDRplay;
- RTL-SDR;
- HackRF;
- PlutoSDR;

> **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.

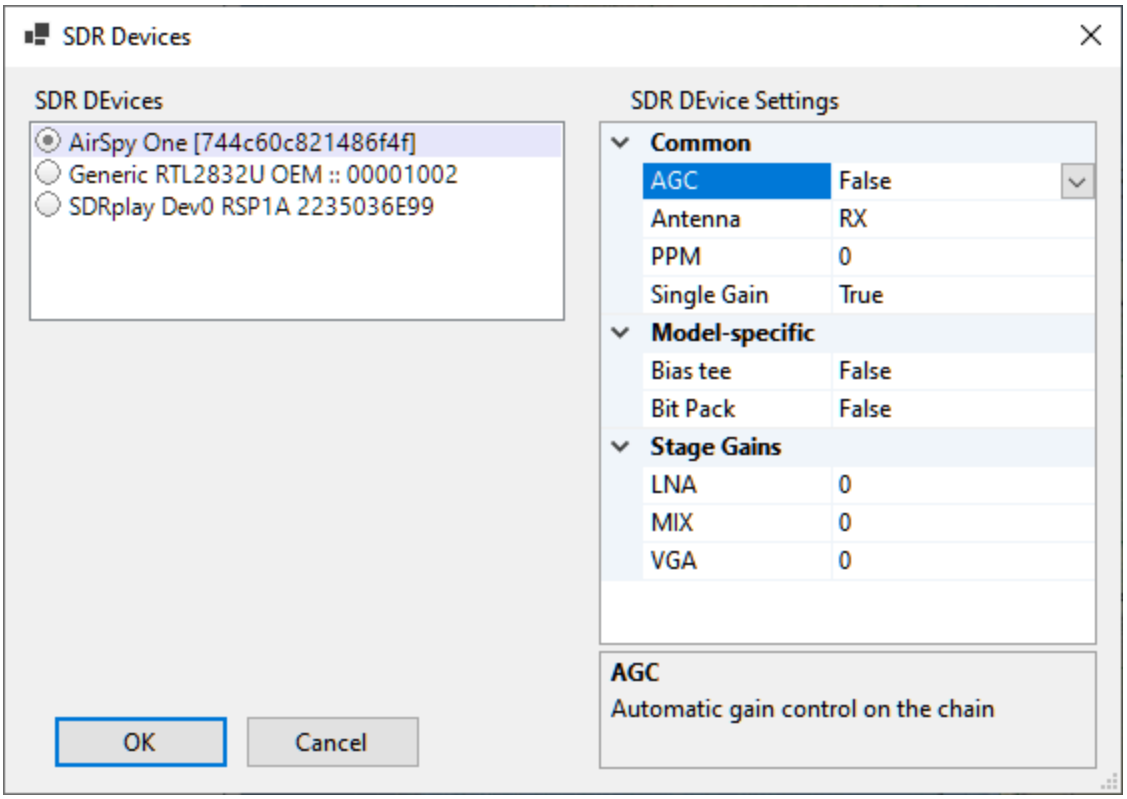
Installing The Drivers

Most of the SDR devices require the driver to be installed before you can start using them. Check the manufacturer's web site, or search on Google, for the driver installation instructions. At the time of this writing, the following instructions were available on the Web: Airspy, RTL-SDR, SDRplay, HackRF, PlutoSDR.

Once you install the drivers and make your radio work with its native software, proceed to the next step.

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

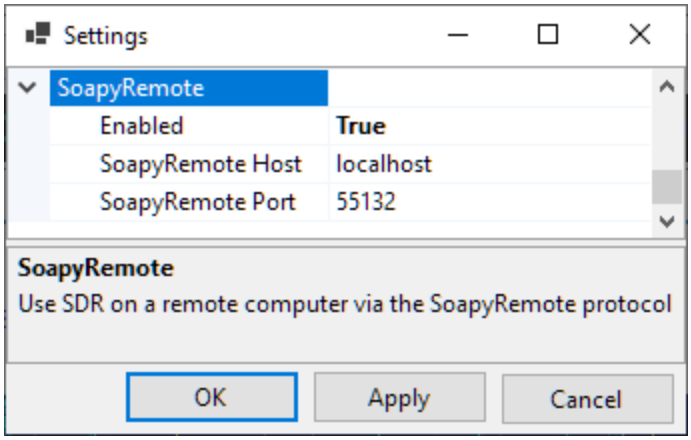
SkyRoof can use SDR devices connected to a remote (or local) computer via the SoapyRemote driver. To enable remote access to SDR:

- **On the remote computer:**

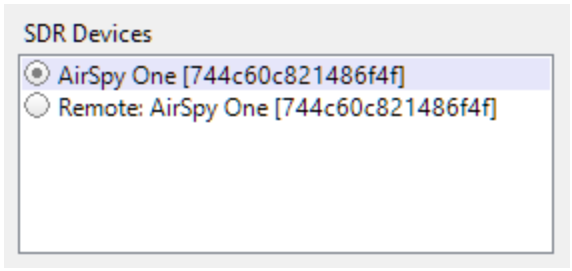
- install SoapySDR which is available as part of PothosSDR;
- run the remote server that comes with SoapySDR:

```
SoapySDRServer.exe --bind
```

- **In SkyRoof:**
  - enable **SoapyRemote** in the **Settings** dialog;
  - enter the **host** name of the remote computer, or leave "localhost" if the radio is on the same computer.



  - Open the **SDR Devices** dialog and select the remote SDR device from the list. If the device and remote server are on the localhost, you will have a choice between a direct connection to the radio and a connection via the server.



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 is 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.

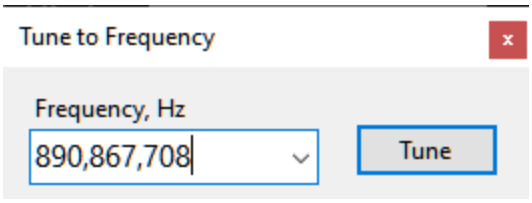
3-rd Party Software

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.

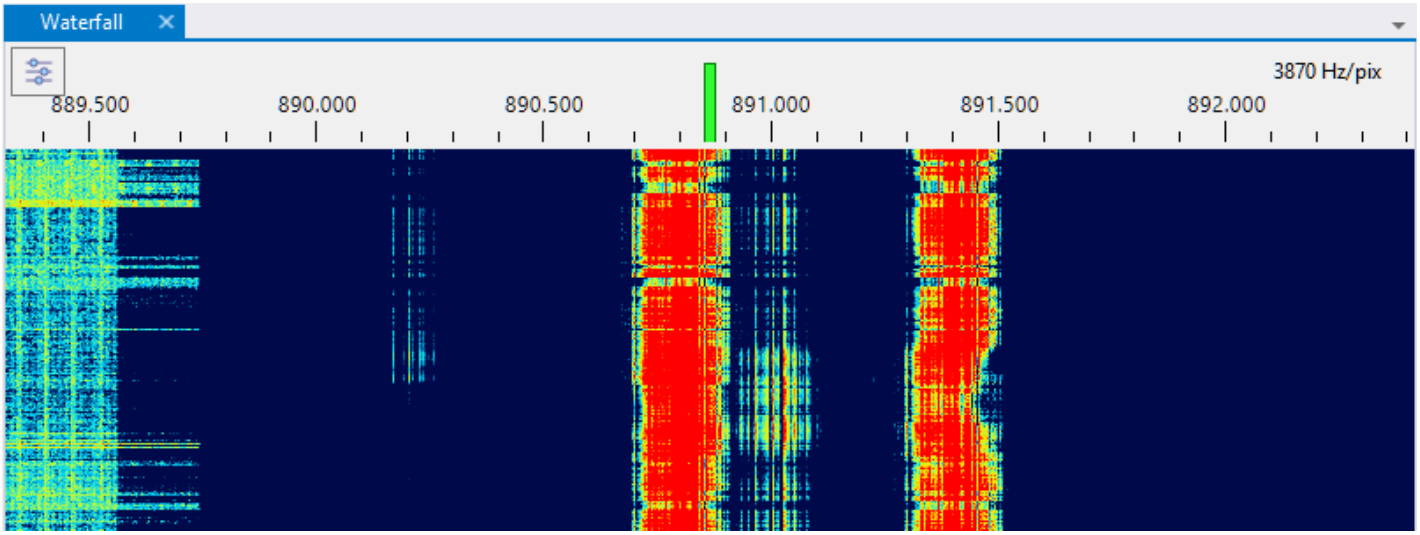
2. Click on the Downlink frequency display in the Frequency Control panel on the toolbar to open the frequency entry dialog:



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

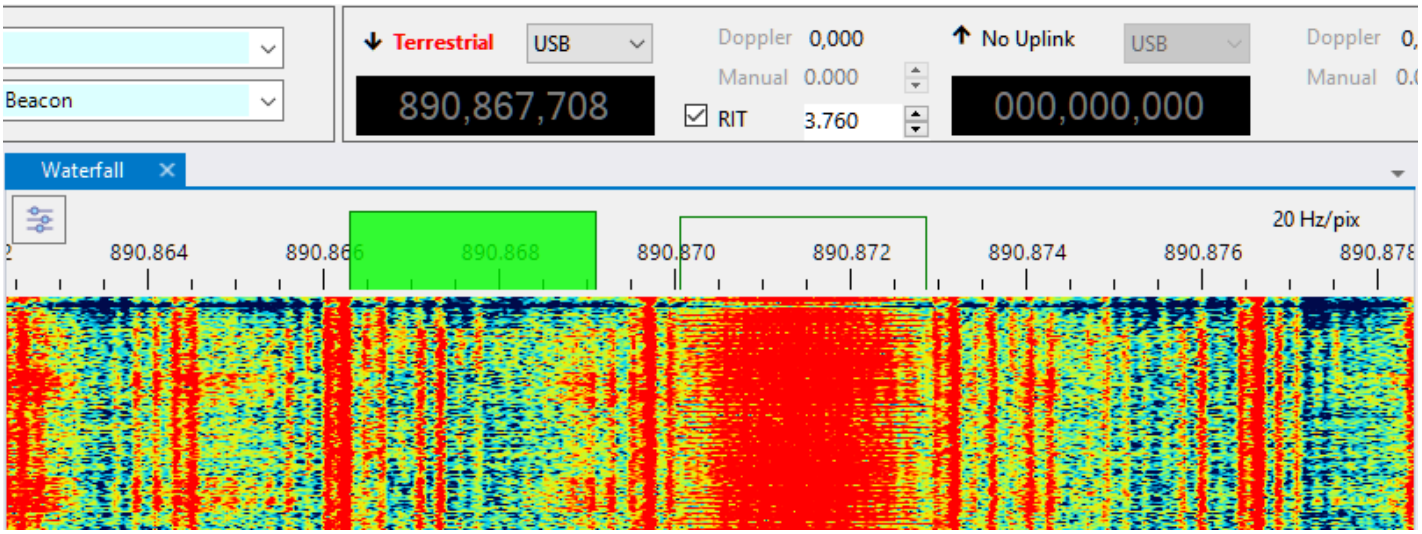
```
890,800,000 + 67,708 = 890,867,708 Hz
```

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. In 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.

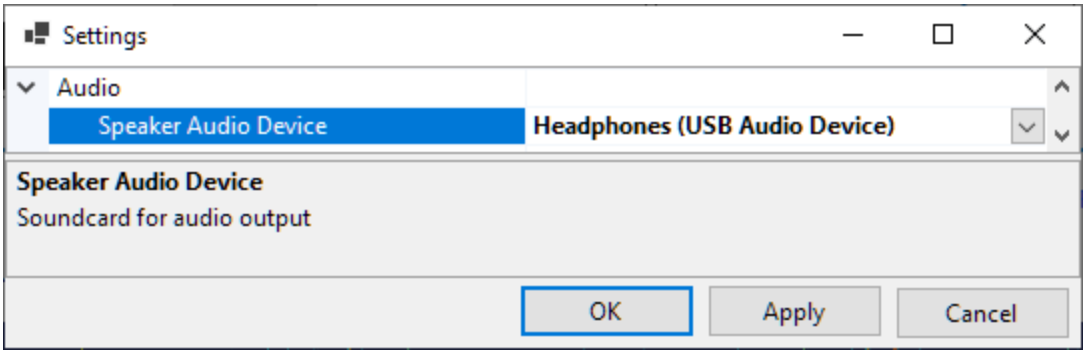
8. Compute the PPM correction. The frequency error measured in the previous step is 3,760 Hz, so the PPM is:

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

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

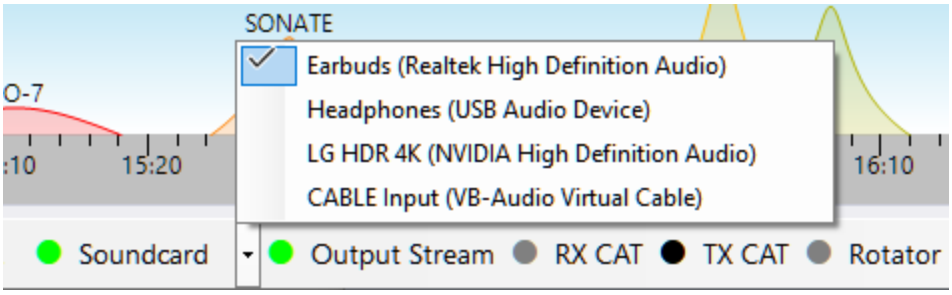
Setting Up Audio

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.

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

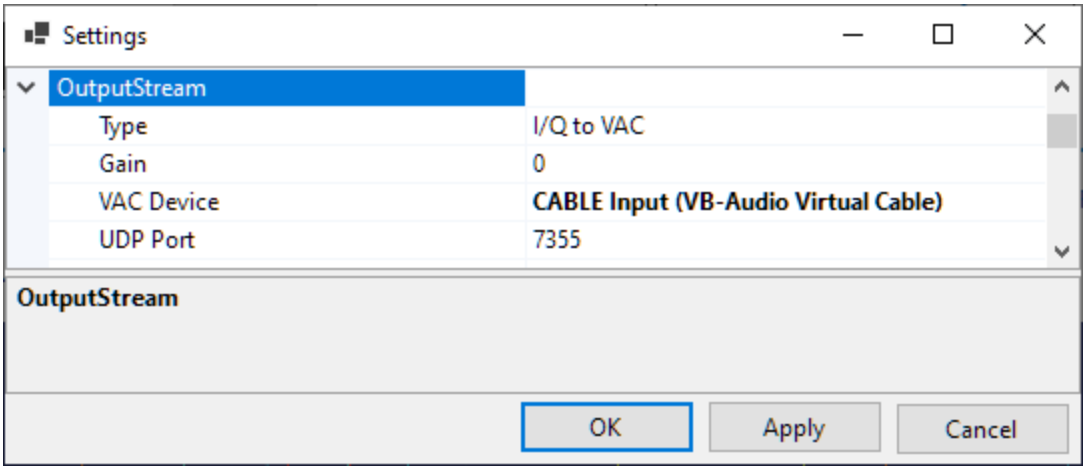


Setting Up Output Stream

SkyRoof can optionally send the raw I/Q data or demodulated audio, either to a Virtual Audio Cable (VAC) or as a stream of UDP packets. The data are sent as 32-bit floating point values in the IEEE 754 format. The sampling rate is 48 kHz in all streaming modes.

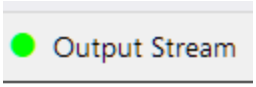
Configuring

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



- **Type** - select the stream type:
  - I/Q to VAC;
  - Audio to VAC;
  - I/Q to UDP;
  - Audio to UDP.
- **Gain** - gain or attenuation, in dB, that will be applied to the streamed data;
- **VAC Device** - the Virtual Audio Cable device to use;
- **UDP Port** - the UDP port number to use.

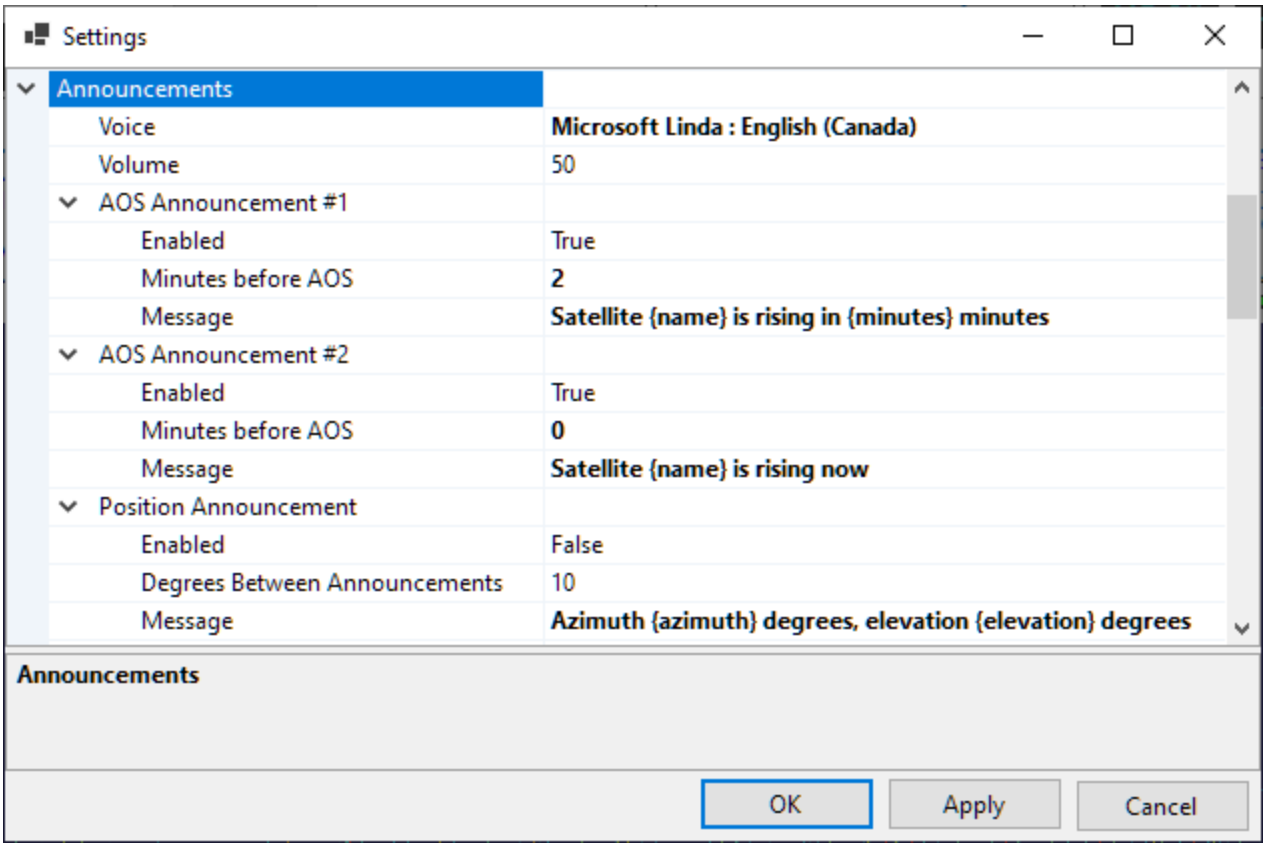
Output streaming can be turned on and off by clicking on the **Output Stream** label on the status bar:



Setting Up Voice Announcements

SkyRoof can make voice announcements of the the satellite AOS events and position changes. Up to two AOS 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;
- **Degrees Between Announcements**: 1° to 30°. Satellite position is announced when the angular distance between the previous and current positions exceeds this value;
- **Message** - enter the announcement message. For the satellite name enter `{name}`, for the number of minutes before AOS enter `{minutes}`, for the azimuth and elevation enter `{azimuth}` and `{elevation}` respectively.

Setting Up CAT Control

SkyRoof uses an external program, either skyctld.exe from SkyCAT or rigctld.exe from HamLib, to control the transceiver. In both cases the CAT control commands are sent using the TCP protocol, so the radio may be moved to a remote computer and controlled via the network if desired.

SkyCAT

SkyCAT is specifically designed for the best satellite tracking experience. It has an open architecture where support of the new radio models is added by creating the command definition files with the corresponding commands. Check the SkyCAT web site for the list of currently supported radios. If your radio model is not yet supported, either create a command definition file for it using the instructions on the SkyCAT web site, or use rigctld.exe instead (see below).

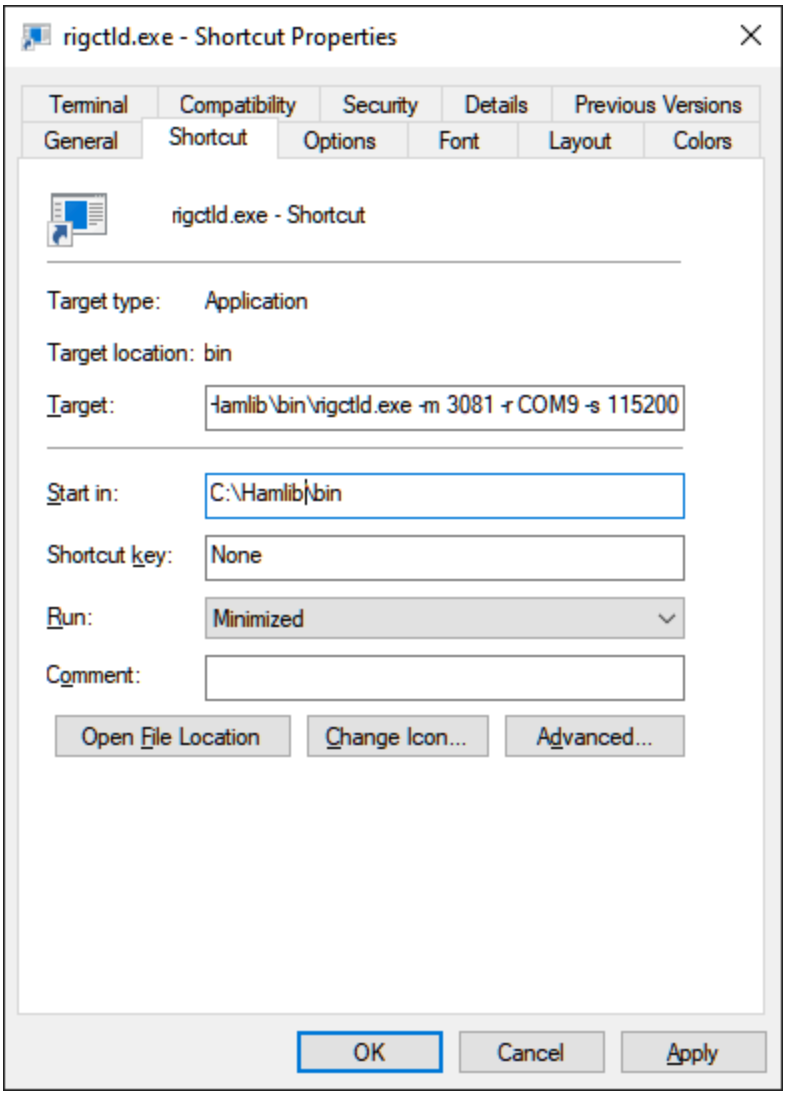
Using skycat.exe

If your radio is supported by SkyCAT, use skycatd.exe, a command line program that comes as part of the SkyCAT package. To start using it, follow the setup instructions on the SkyCAT web site.

Using rigctld.exe

If a SkyCAT command definition file for your transceiver is not yet available, use **rigctld.exe**, a HamLib-based CAT control daemon. Note, however, that some commands may not work properly with rigctld.exe.

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; 3081 is the Id of IC-9700 (see the list of id's);
- **-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;

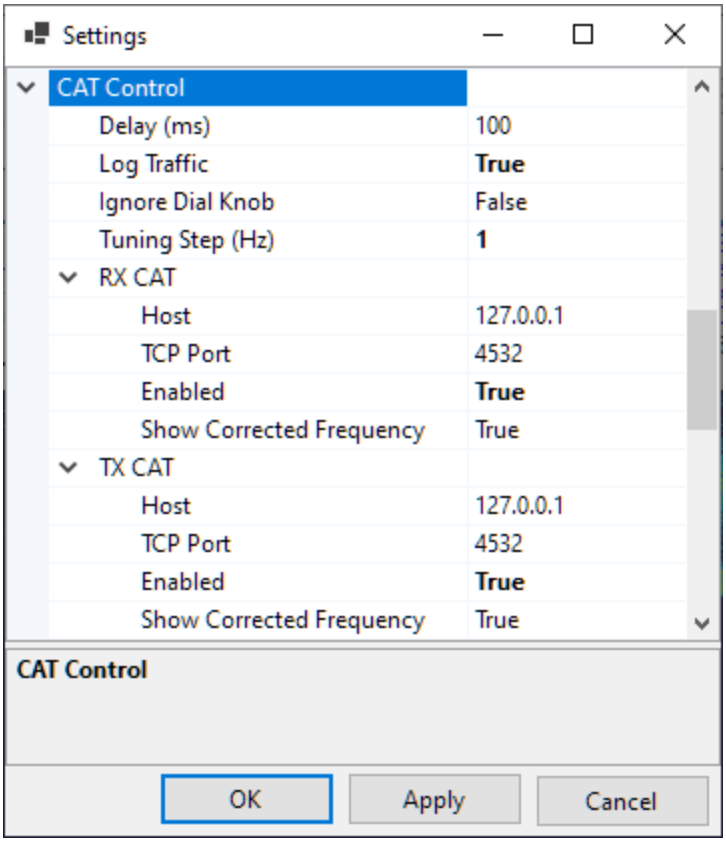
- **-vvvvv** - optional, writes detailed information to the console window. Useful for troubleshooting.

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

Settings

The CAT Control settings in the Settings dialog are the same for skycatd.exe and rigctld.exe.

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's CAT interface 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, so that the dial knob rotation is ignored.

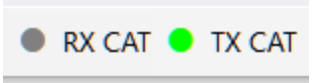
The two sections in the Settings, **RX CAT** and **TX CAT**, allow you to use either the same radio for RX and TX, or two different radios. You can also enable only one of those, or disable both. The recommended configuration is to use an SDR for reception and a transceiver for transmission, in this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

To use the same radio for RX and TX, set **Host** and **TCP Port** 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 skycatd or 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 skycatd and 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:

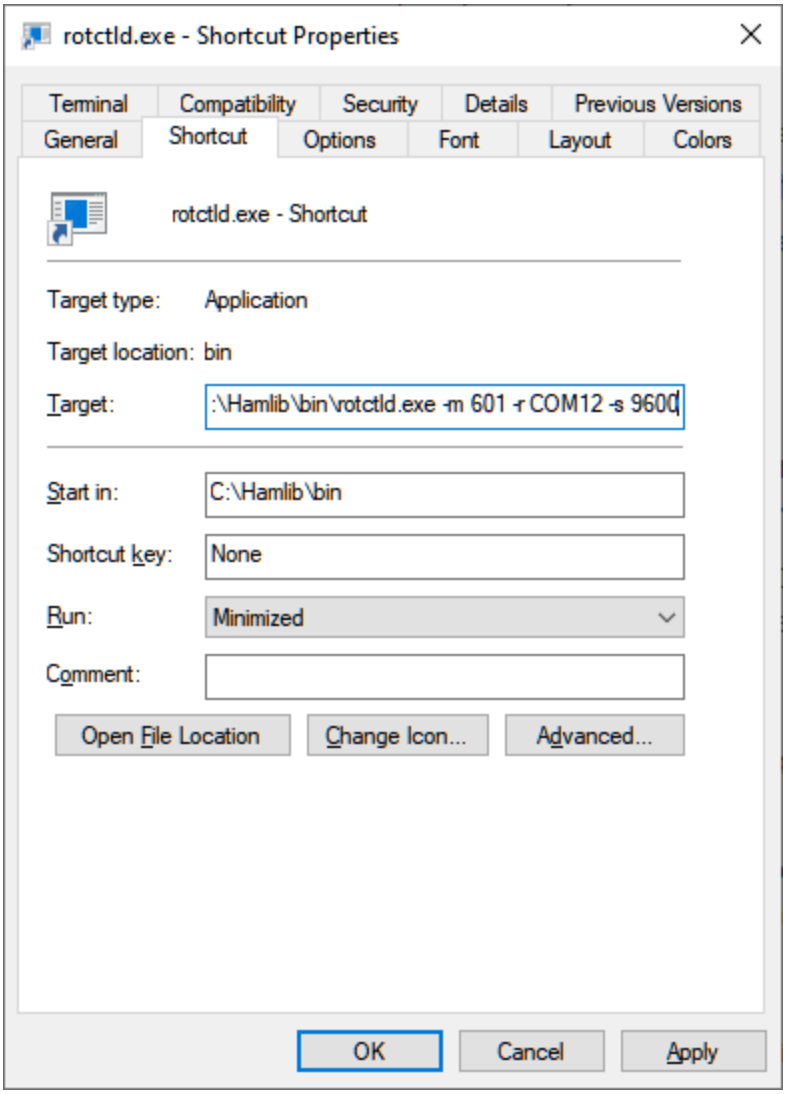
- **Show Corrected Frequency** - The SkyRoof can display either the nominal frequency of the satellite transmitter, or the frequency with all corrections applied. Another way to toggle this setting is via the right-click menu on the frequency display widget on the toolbar.

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:

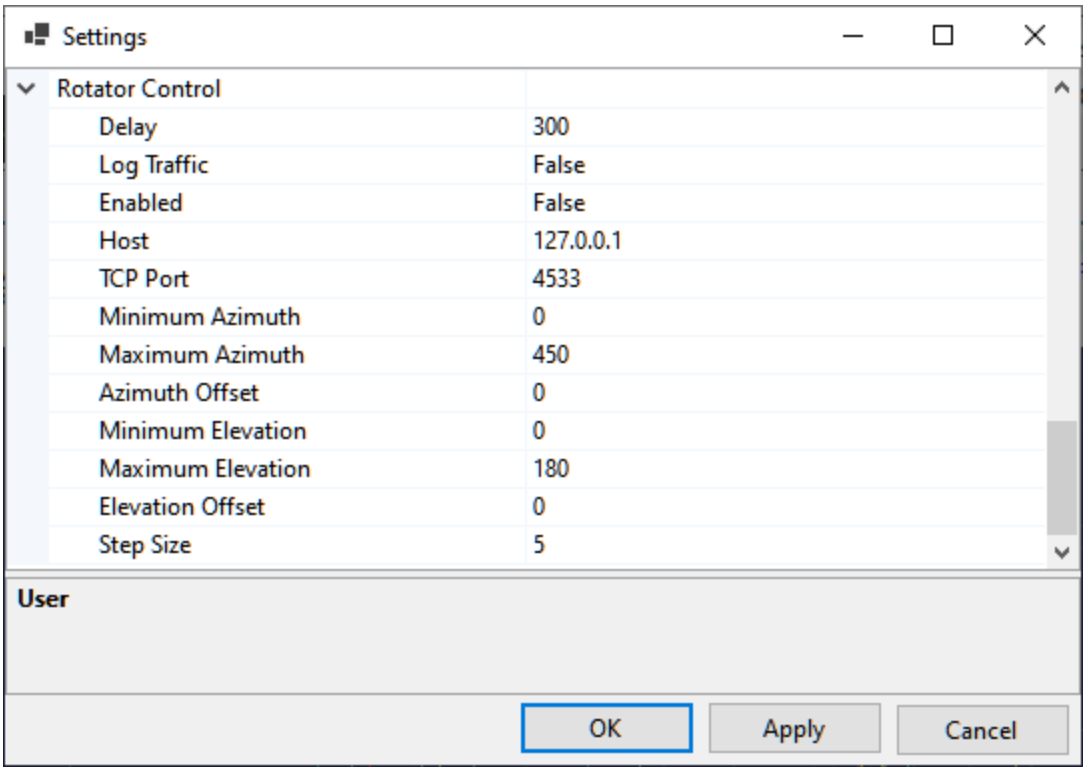
- **-m 601** - the rotator model is Yaesu GS-232A;
- **-r COM12** - the COM port used by the rotator;
- **-s 9600** - the COM port speed.

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

The list of rotator models supported by rotctld.exe is available on the HamLib web site. Note that one of the models is **PSTRotator**. When this model is selected, rotctld.exe just passes the rotation commands to the PST Rotator software.

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, but you can set it to a lower value, such as 100 ms, without adverse effects;
- **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 azimuth and elevation 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.

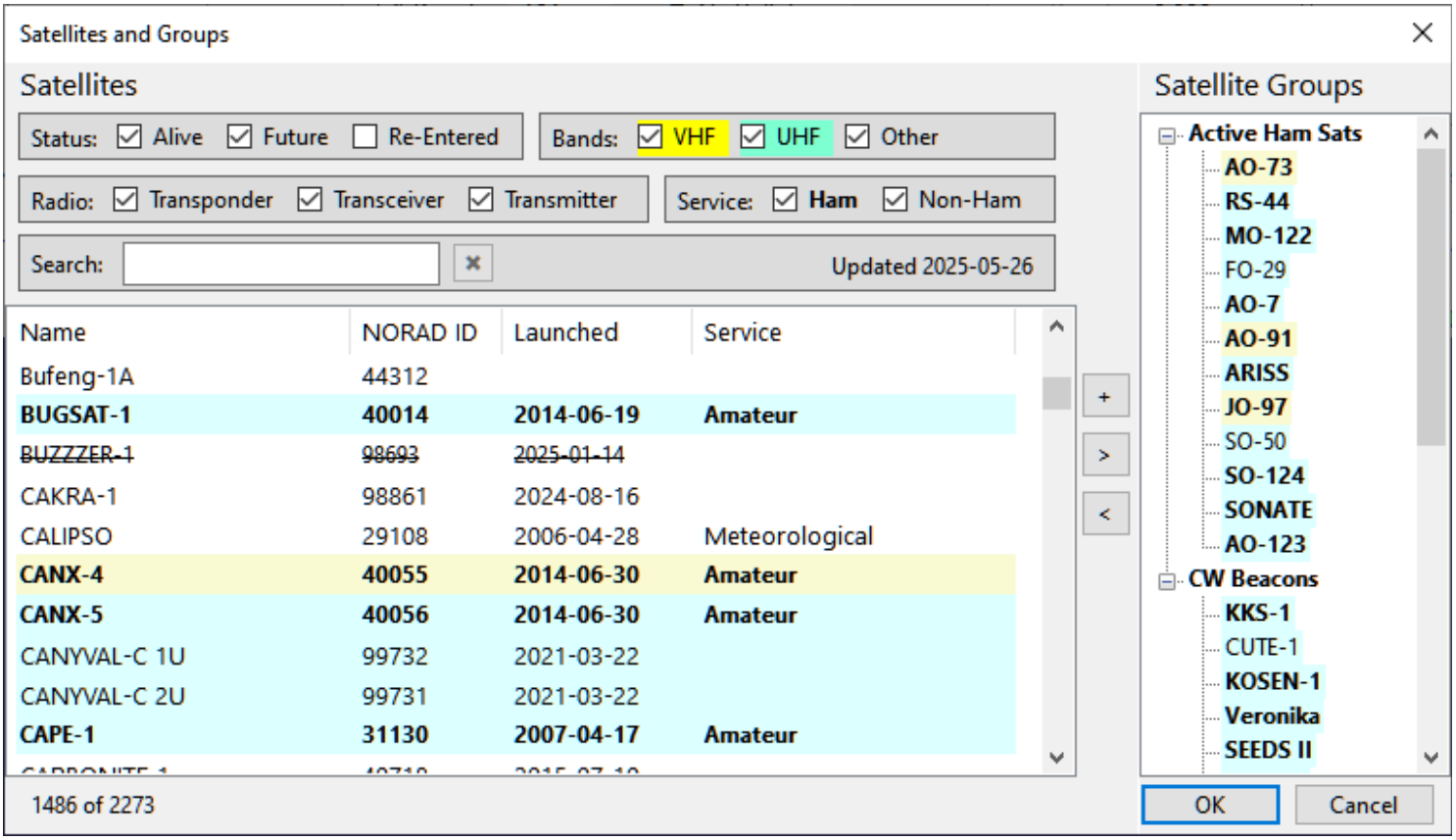
If your rotator does not control elevation, set the MinimumElevation and MaximumElevation to the same value. With such settings, wrong elevation will not be considered a bearing error. Note that the bearing error is indicated with a pink color on the Rotator Control panel.

See Also

- Smart Antenna Rotation

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.

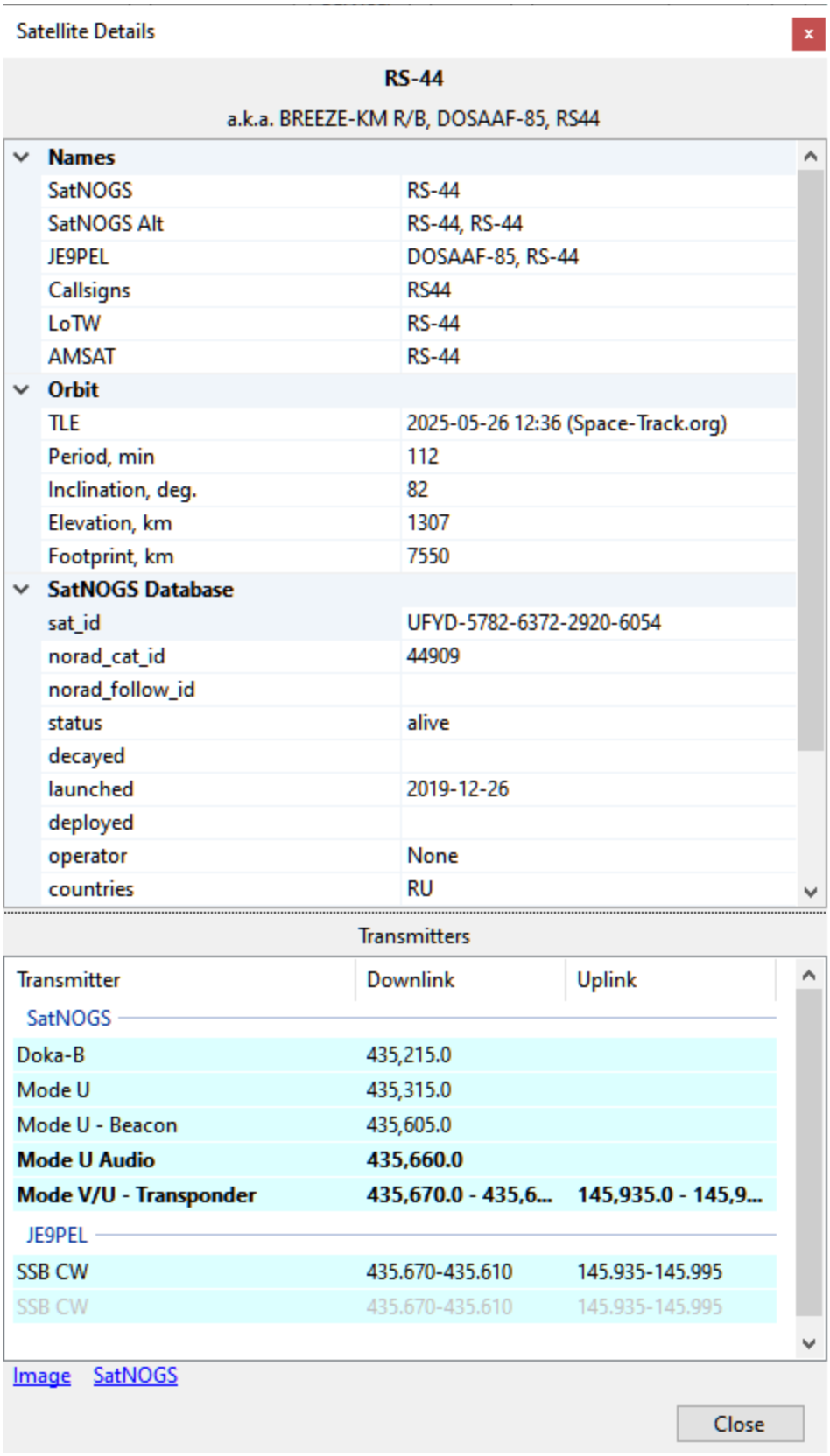
Editing Satellite Groups

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.

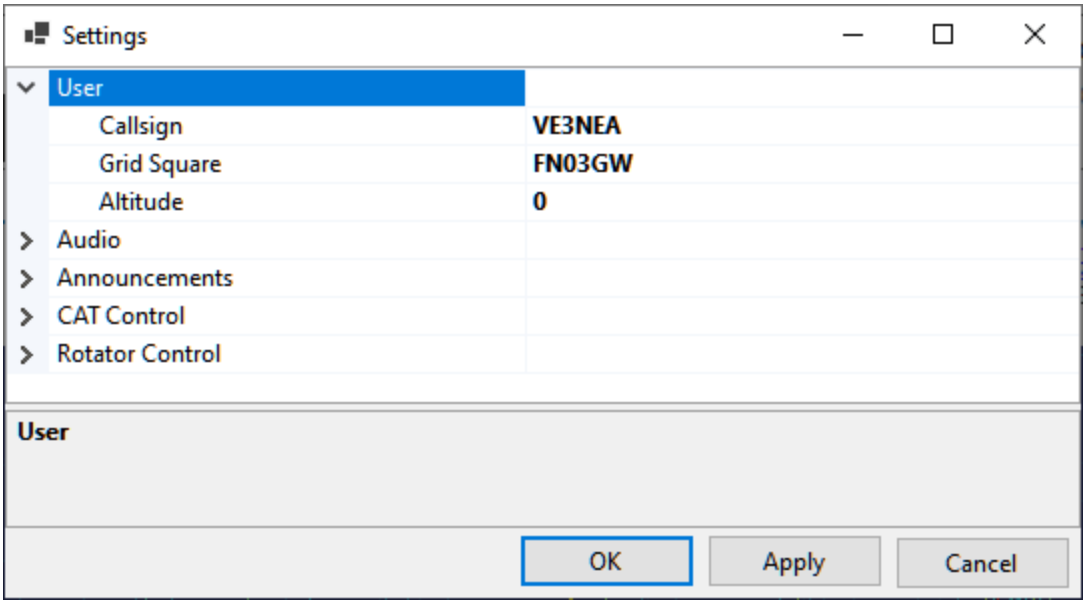
Satellite Highlighting

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.



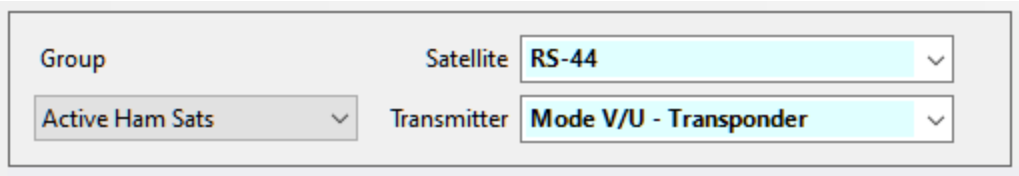
This dialog allows you to edit the settings of SkyRoof. In particular, here you can change the **Callsign**, **Grid Square** and **Altitude** that you entered on the first run of the program.

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:

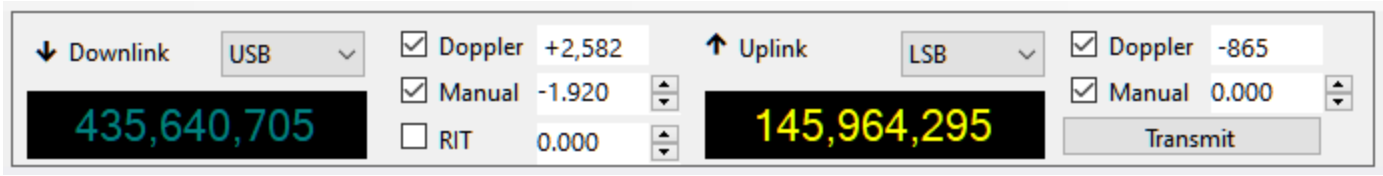


Move the mouse cursor over the **Satellite** or **Transmitter** drop-down box to see detailed information about the selected item on the mouse tooltip.

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:

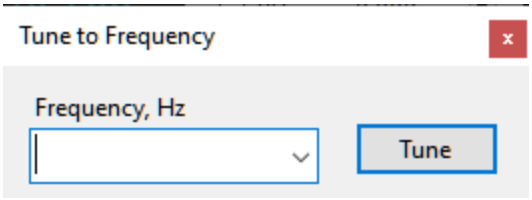


Downlink

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

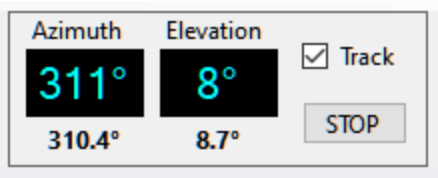
The Gain Control panel on the toolbar has two sliders to control the RF and AF gain:

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:

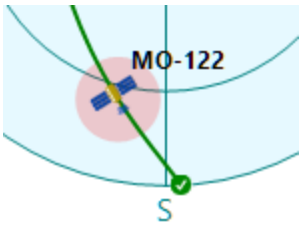


Display

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:



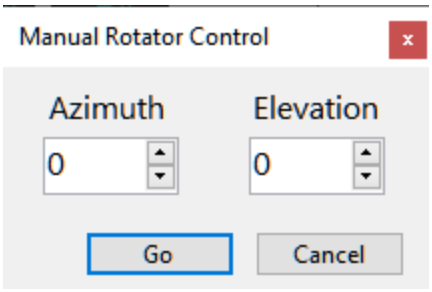
Tracking

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 you switch to another satellite.

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

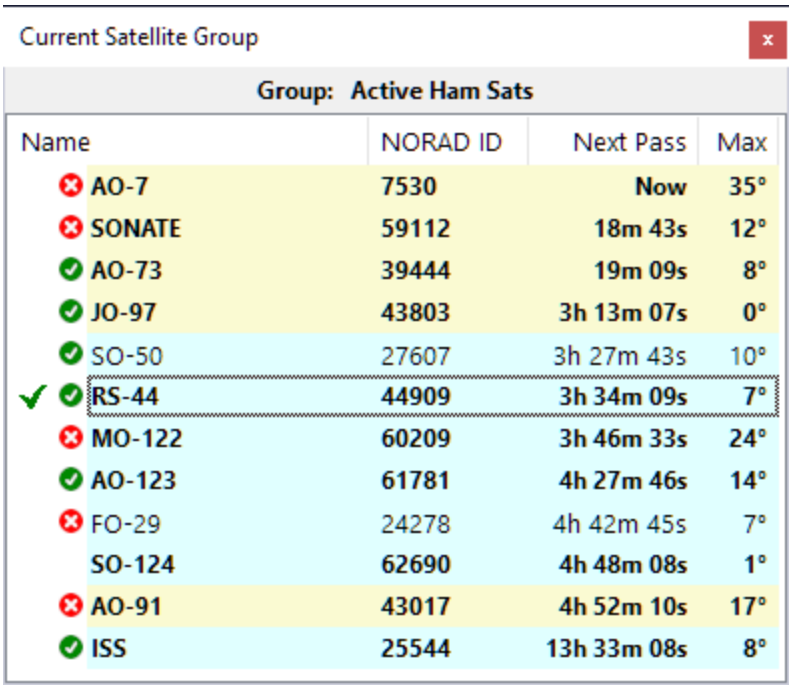
To stop antenna rotation, either manual or due to the satellite tracking, click on the **Stop** button.

See Also

- Smart Antenna Rotation

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.

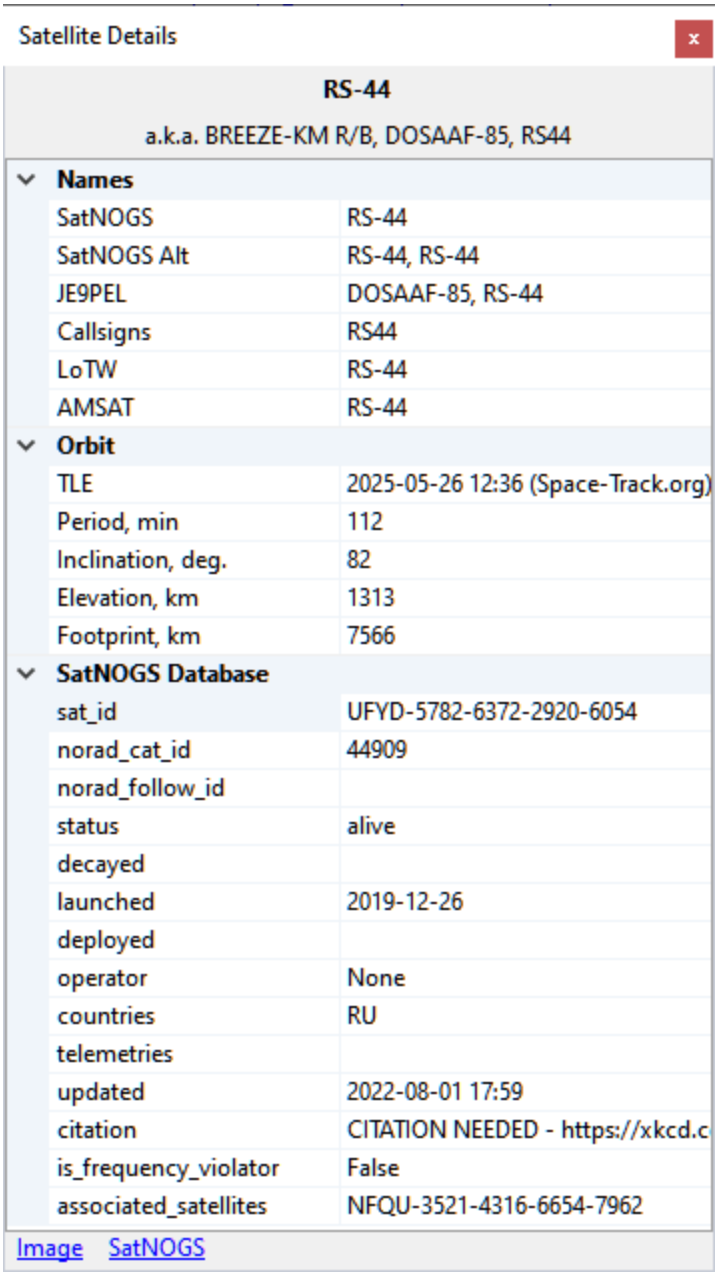
Click on a satellite to select it.

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:

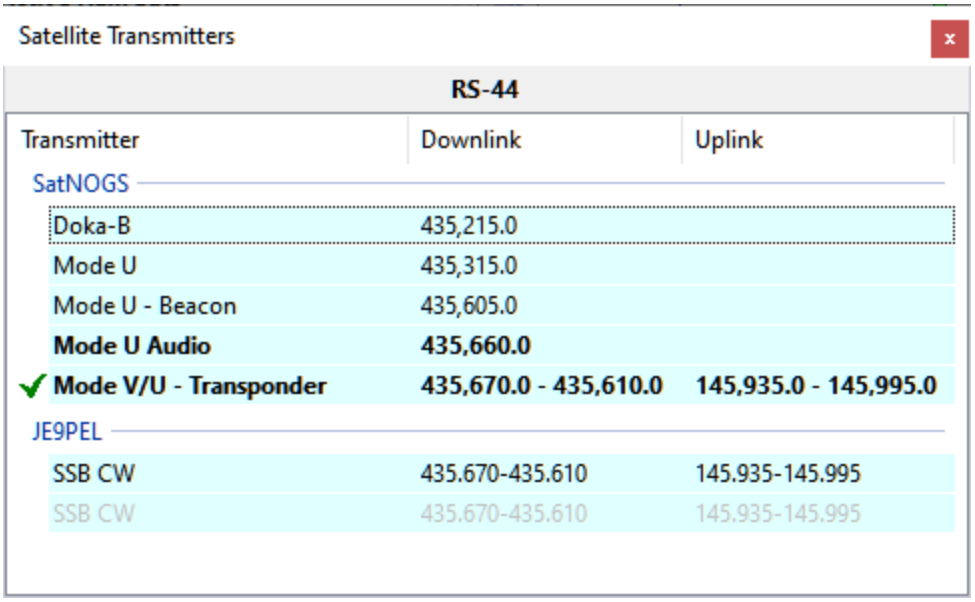


This panel displays the same information as the upper portion of the Satellite Details window. The difference is that, unlike the window, the panel may be docked anywhere in the user interface.

See the Satellite Data section for information about available data.

Satellite Transmitters

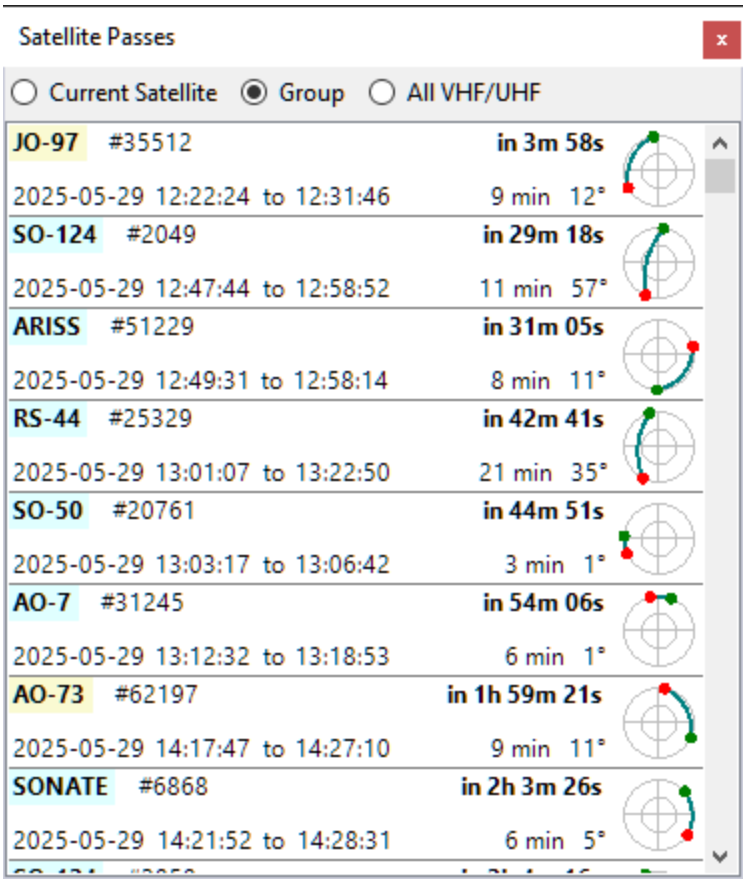
The Satellite Transmitters panel shows the list of transmitters carried by the currently selected satellite. It is similar to the bottom part of the Satellite Details window but is dockable for permanent visibility:



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:



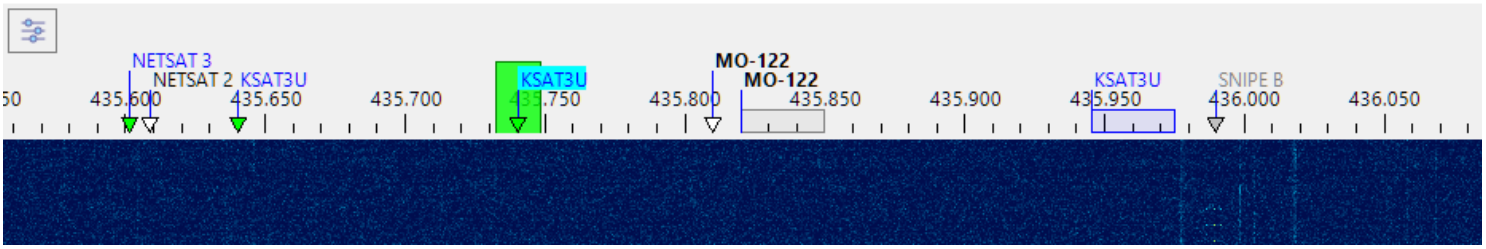
The radio buttons at the top allow you to view either the passes of the selected satellite, of all satellites in the currently selected group, or all satellites carrying a VHF or UHF downlink transmitter and thus visible on the Frequency Scale.

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.

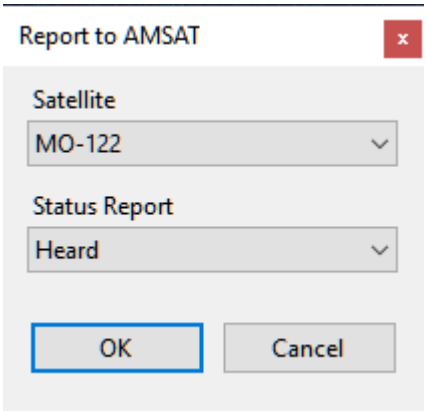
The names of the satellites that belong to the current group are shown in bold;

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

The frequency scale does not show all satellites at all times, only those that are currently available at your location. The satellite labels appear about 5 minutes before the AOS, and stay for a while after LOS, so that the existing signal traces could be identified, but then they disappear. This also applies to the linear satellites and their transponder segments. When the segment is not visible, you cannot tune within it using the mouse controls. The operator tunes in the transponder segment to tune to some station, or to find a clear space to send CQ. If the satellite is below the horizon, this, of course, cannot be done, and if you are still using the tuning commands, the program assumes that you are trying to do something else, e.g., tune to a terrestrial signal.

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. Hold the **Alt** key down to increase the tuning speed.

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.

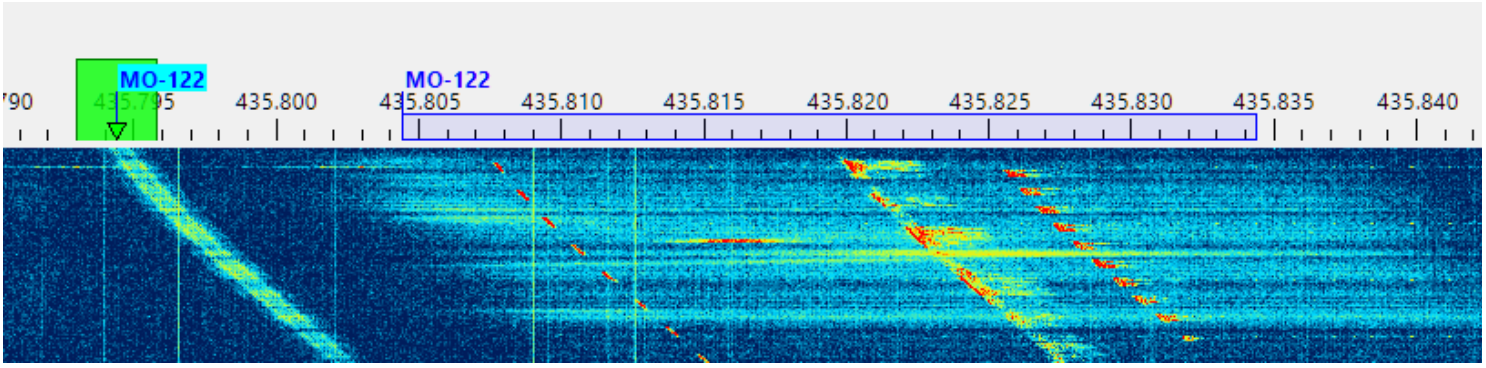
If RX CAT is enabled, tuning the SDR receiver also tunes the external radio to the same frequency.

> **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, so you can 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. The screenshot below shows the telemetry signal of the MO-122 satellite, and the green rectangle perfectly aligned with its frequency by adjusting the Downlink Manual Offset:



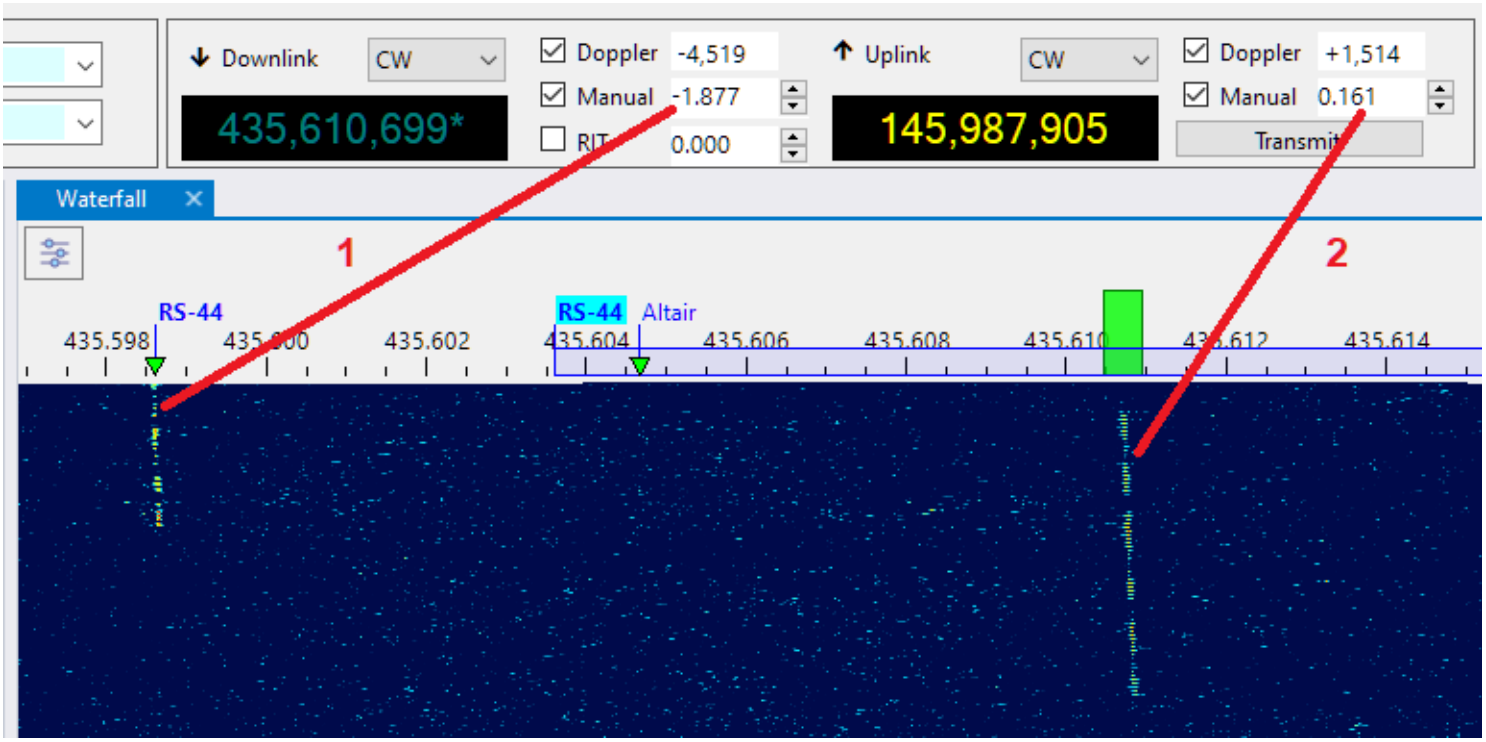
Aligning The Uplink and Downlink Frequencies

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 significantly different from this value, this means that your 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.

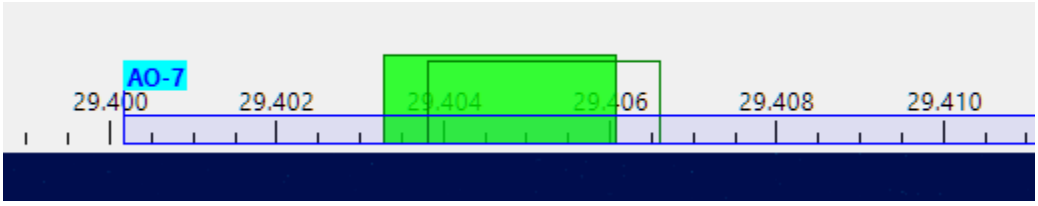


These adjustments need to be done only once. They stay the same, within a few tens of Hertz, between the satellite passes.

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:



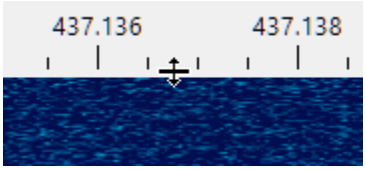
When RIT is enabled, the clear rectangle shows the current receiver passband, while the green rectangle stays on the main frequency.

- 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

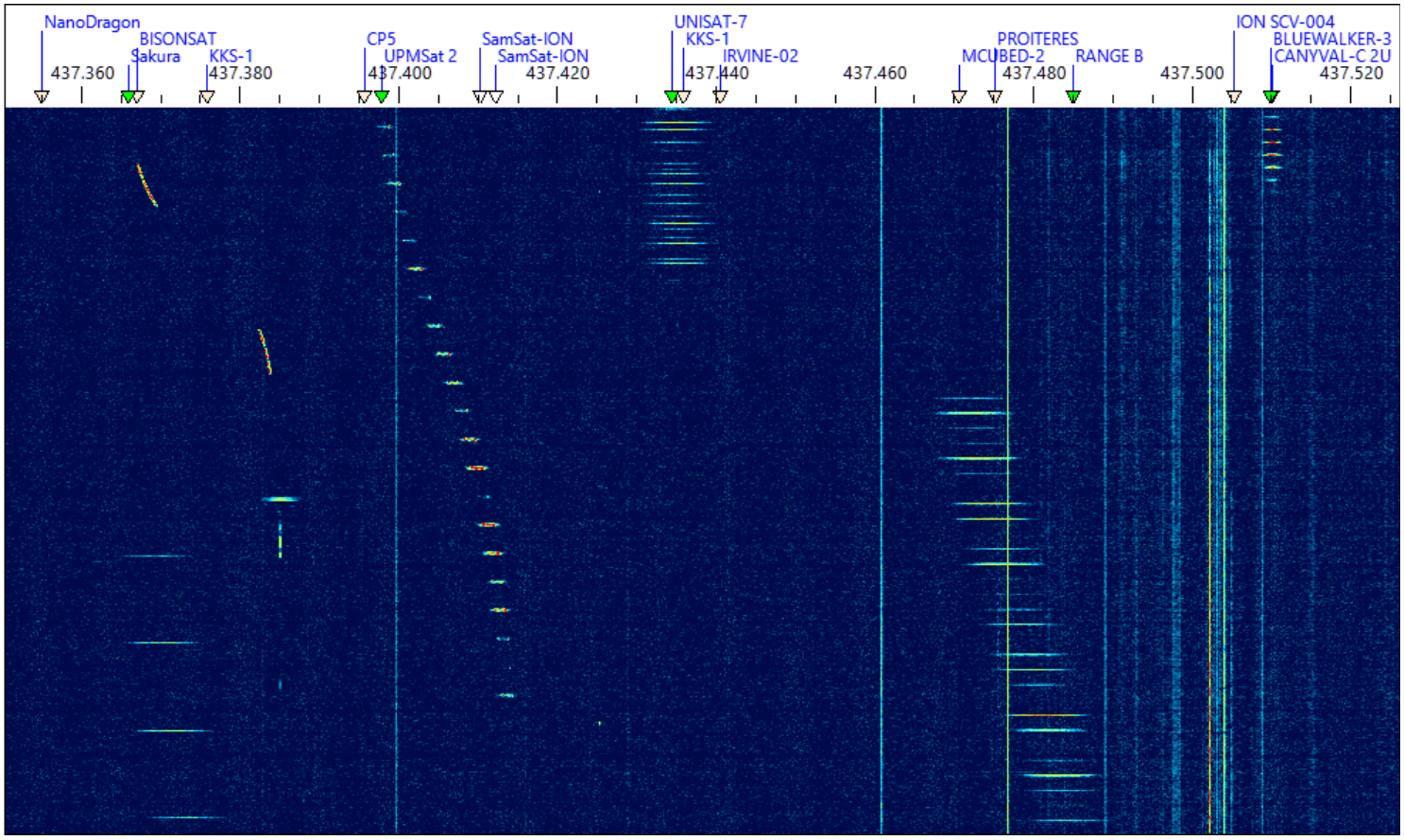
Adjust the height of the frequency scale by dragging the splitter between the scale and the waterfall:



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:



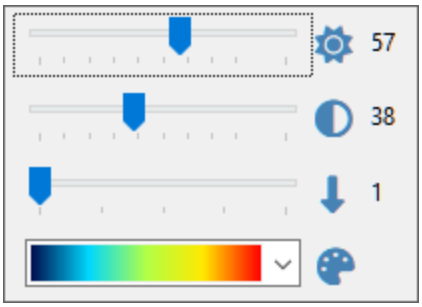
The waterfall spans over 3 MHz of spectrum (depending on the SDR model) and covers the whole satellite segment, 435-438 MHz, on the 70 cm band. On the 2 m band the satellite segment is only 200 kHz wide, 145.8-146 MHz, so it also fits completely in the waterfall.

- 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:

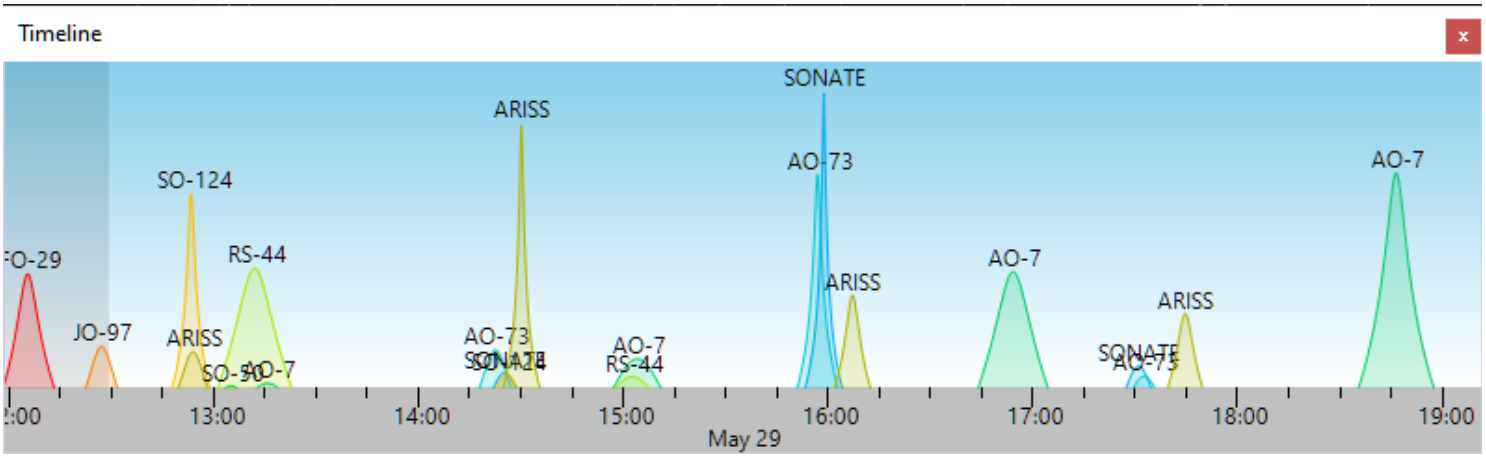
    - more CPU power is needed to compute very large spectra;
    - more texture memory is needed in the video card to store the spectra;
    - support of OpenGL 3.3 or higher is required for the zoom function.

    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:



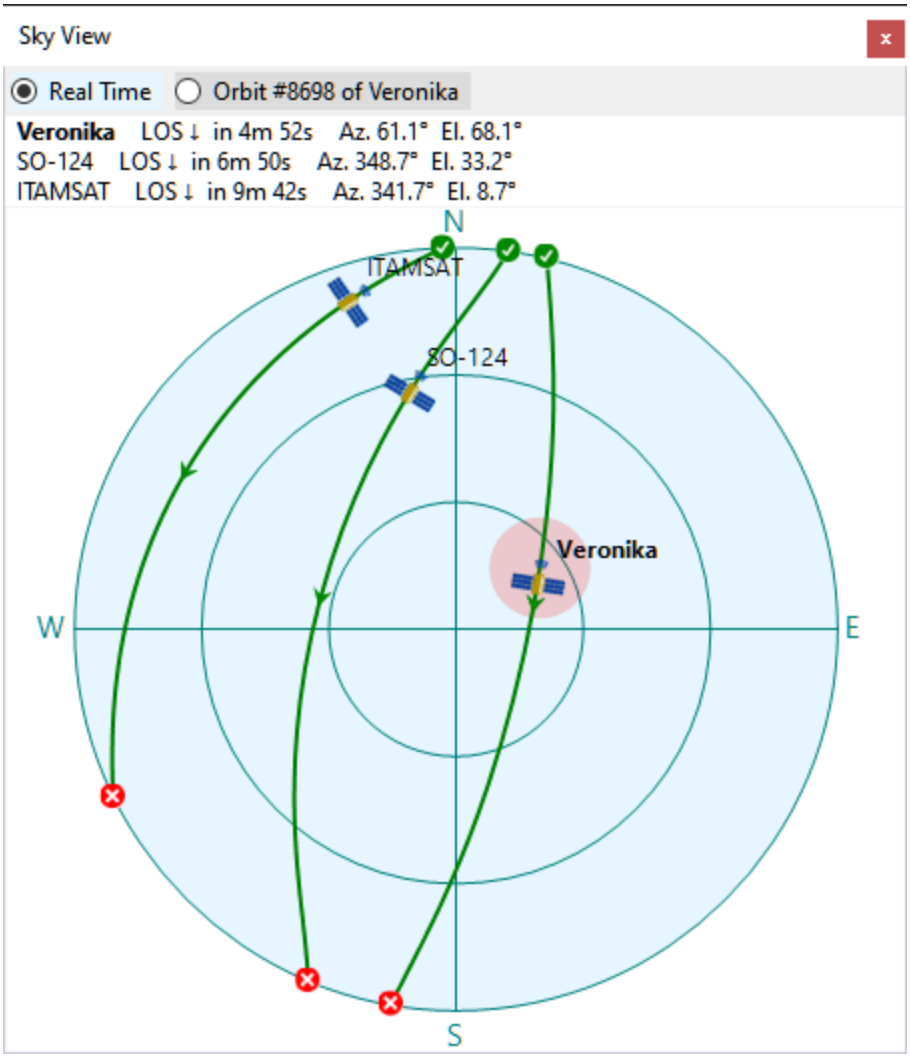
- Zoom in and out using the mouse wheel
- Pan by dragging the chart with your mouse
- Click on the satellite name to make it current, and to view the pass on the Sky View panel.

The dark part of the chart represents the past time.

Sky View

The Sky View panel shows the trajectories 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.



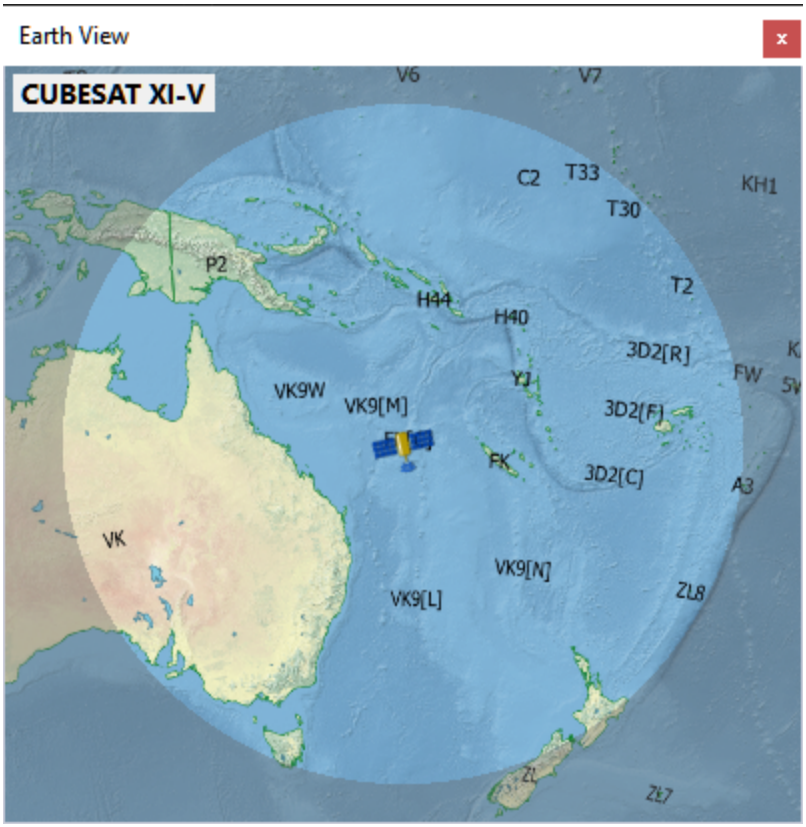
The pink spot indicates the current antenna bearing if Rotator Control is enabled.

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 located in this area.

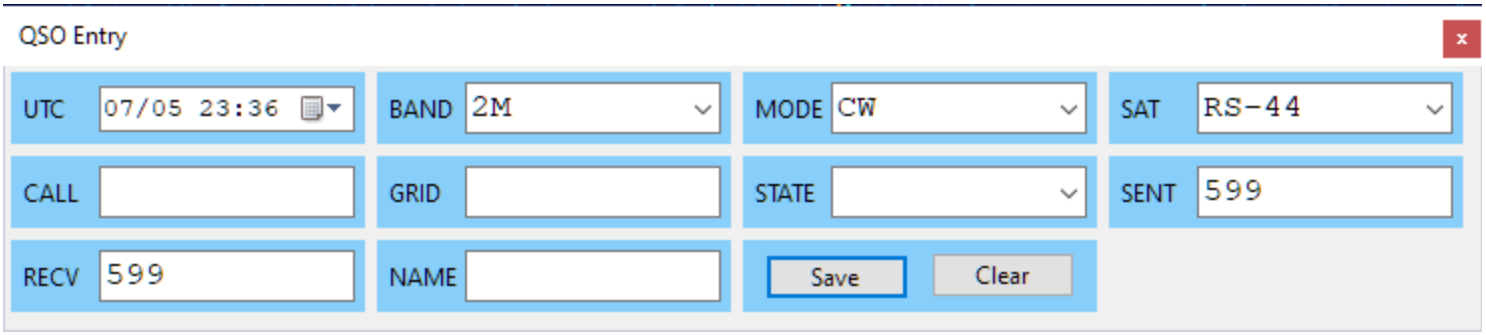
Use the mouse wheel to zoom the view in and out.

QSO Entry Panel

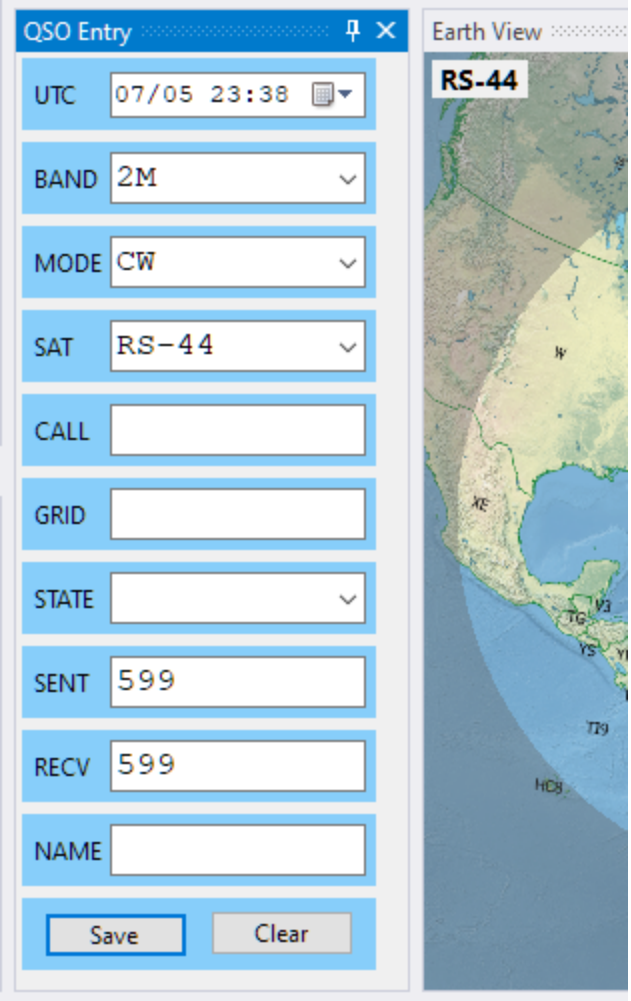
The QSO Entry panel allows the operator to enter the QSO details with minimum effort and save them to an ADIF file. This file may be later imported to the logging software for award tracking, QSL management, etc.

Configuring The Panel

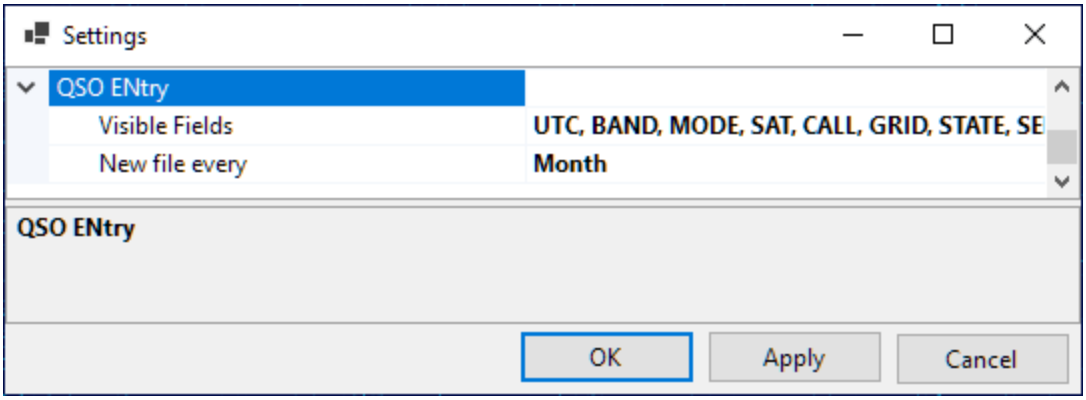
Click on **View / QSO Entry** to open the panel:



You can either dock the panel somewhere in the main window as described in Configuring Window Layout, or keep it floating. By resizing the panel you can arrange the input fields in a row, a column, or a matrix:



If you do not need some input fields, disable them in the Settings dialog:



Specify if a new ADIF file should be created every day, month or year, using the **New file every...** setting.

Entering The QSO Data

- **UTC** - this field shows the current UTC time. Click on it to freeze the clock or to make it run again, or enter the date and time manually if saving an old QSO;
- **Band, Mode, Sat** - These fields are populated automatically, based on the currently selected satellite transmitter. You can select different values from the drop-down lists,

or type them in, if needed;

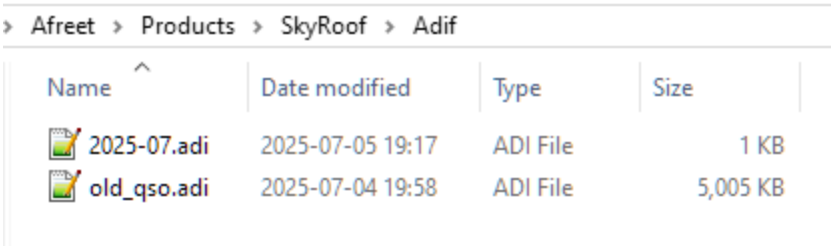
- **Call** - as you enter the callsign, the program tries to guess its grid square, US state and operator's name (see below).
- **Grid, State** - if the program fails to guess these values, or guesses them incorrectly, enter them manually;
- **Sent, Recv** - sent and received reports. Auto-populated with default values when the mode is set, change them manually as needed;
- **Name** - auto-populated if known to the program, otherwise enter manually.

The fields with manually entered values have a blue frame around them, these fields are not auto-populated.

The minimum QSO record consists of **UTC, Band, Mode** and **Call**, all other fields are optional.

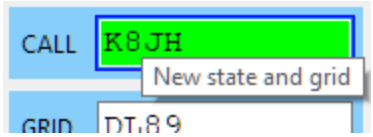
Information Lookup

When the QSO Entry panel opens, it loads all ***.adi** files in the **Adif** sub-folder of the **Data Folder** and builds the lookup lists of the grid squares, states and operator names associated with the callsigns. These lists are used to auto-populate the corresponding input fields. You can put an adif file with all your previous QSO in that folder to help the program build good lookup lists:



Callsign Status

When the program loads the adif files, it also builds the lists of worked callsigns, grid squares and states. Only the QSO with the `PROP_MODE` field set to `SAT` are counted. As you enter the callsign, the color of the input box changes to indicate the status:



Interfacing with Logging Software

The QSO Entry panel can interface with logging software, using a simple plugin system, to enter the QSO directly to the log and to get the callsign status and lookup values. The plugin DLL has to export 4 functions:

- Init();
- SaveQso(qso_data);
- GetStatus(qso_data);
- Augment(qso_data).

If you are the author of a logger, please contact me directly for details.

How to Decode Telemetry from PEARL-1C

I/Q or Audio data, streamed via VAC or UDP, may be used to decode telemetry transmitted by the satellites. There is a number of telemetry decoders to choose from. One such decoder is gr_satellites.exe command line tool, its installation instructions are here.

This command runs gr_satellites.exe to decode telemetry of the PEARL-1C satellite using the I/Q UDP stream from SkyRoof:

```
(base) C:\Ham>gr_satellites 58342 --udp --udp_port 7355 --udp_raw --iq --samp_rate
48e3 --hexdump
```

This command decodes the same satellite via I/Q output to VAC :

```
(base) C:\Ham>gr_satellites 58342 --audio "CABLE Output (VB-Audio Virtual Cable)" --
samp_rate 48000 --iq
```

To use the second command, you will need a virtual audio cable, such as VB-Audio.

Run one of these commands, then in SkyRoof settings:

- select either I/Q to VAC or I/Q to UDP, depending on the command you use;
- set Gain, dB to 0;
- select the VAC in the list of audio devices;
- click on the Output Stream label on the status bar to enable the output.

Example output from gr_satellites.exe v.5.7.0:

```
pagesize :debug: Setting pagesize to 4096 B
top_block_impl :debug: Using default scheduler "TPB"
udp_source :info: Listening for data on UDP port 7355.
***** VERBOSE PDU DEBUG PRINT ******
((transmitter . 9k6 FSK downlink))
pdu length =         64 bytes
pdu vector contents =
0000: 9c 86 aa 8e a6 62 e0 a0 8a 82 a4 98 86 e1 03 f0
0010: f9 11 01 83 43 33 a9 e7 a4 10 00 00 11 00 00 00
0020: 00 00 00 00 7a 0f 01 00 00 00 00 00 00 00 00 00
0030: 05 00 00 00 77 fb 01 00 67 aa 00 00 00 00 00 00
**********************************
***** VERBOSE PDU DEBUG PRINT ******
((transmitter . 9k6 FSK downlink))
```

```
pdu length =         88 bytes
pdu vector contents =
0000: 9c 86 aa 8e a6 62 e0 a0 8a 82 a4 98 86 e1 03 f0
0010: fb 11 01 81 43 33 00 00 00 00 00 00 00 00 00 00
0020: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0030: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0040: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0050: 00 00 00 00 00 00 00 00
**********************************
***** VERBOSE PDU DEBUG PRINT ******
((transmitter . 9k6 FSK downlink))
pdu length =         56 bytes
pdu vector contents =
0000: 9c 86 aa 8e a6 62 e0 a0 8a 82 a4 98 86 e1 03 f0
0010: 06 11 01 82 43 33 83 8a 01 00 9e 00 00 00 04 00
0020: 00 00 88 ff f8 ae 00 00 80 01 00 00 0f 02 00 00
0030: 00 00 00 00 00 00 00 00
```

How to Receive Images from NOAA-15 and NOAA-19

An external program is needed to decode and display the weather images transmitted by the NOAA-15 and NOAA-19 satellites. In this tutorial we will use WXtoIMG.

Installing VAC

A virtual audio cable, VAC, is required to pass the satellite signals demodulated in SkyRoof to the image decoding program. Download and install VB-Audio if you do not have it yet, and reboot your system. Be sure to get the latest version (2024) of VB-Audio, the old version may not work correctly.

Setting Up WXtoIMG

- download wxinst21102-beta.exe and run the installer, then start WXtoIMG;
- enter your latitude and longitude when prompted;
- the program tries to download the TLE data from a URL that no longer works. Download the weather.txt file manually and save it to the WXtoIMG data folder. Type this in File Explorer to find the data folder:

```
%appdata%\WXtoImg
```

- tick **Satellite / Autodetect APT** in the menu;
- click on **Options / Recording Options** and select the **Record only when active...** radio button. Select the VAC cable in the **soundcard** drop-down list;
- click on **File / Record** in the menu, then
  - select **Record and auto process**;
  - tick **Create images**;
  - click on the **Auto Record** button.

Configuring SkyRoof

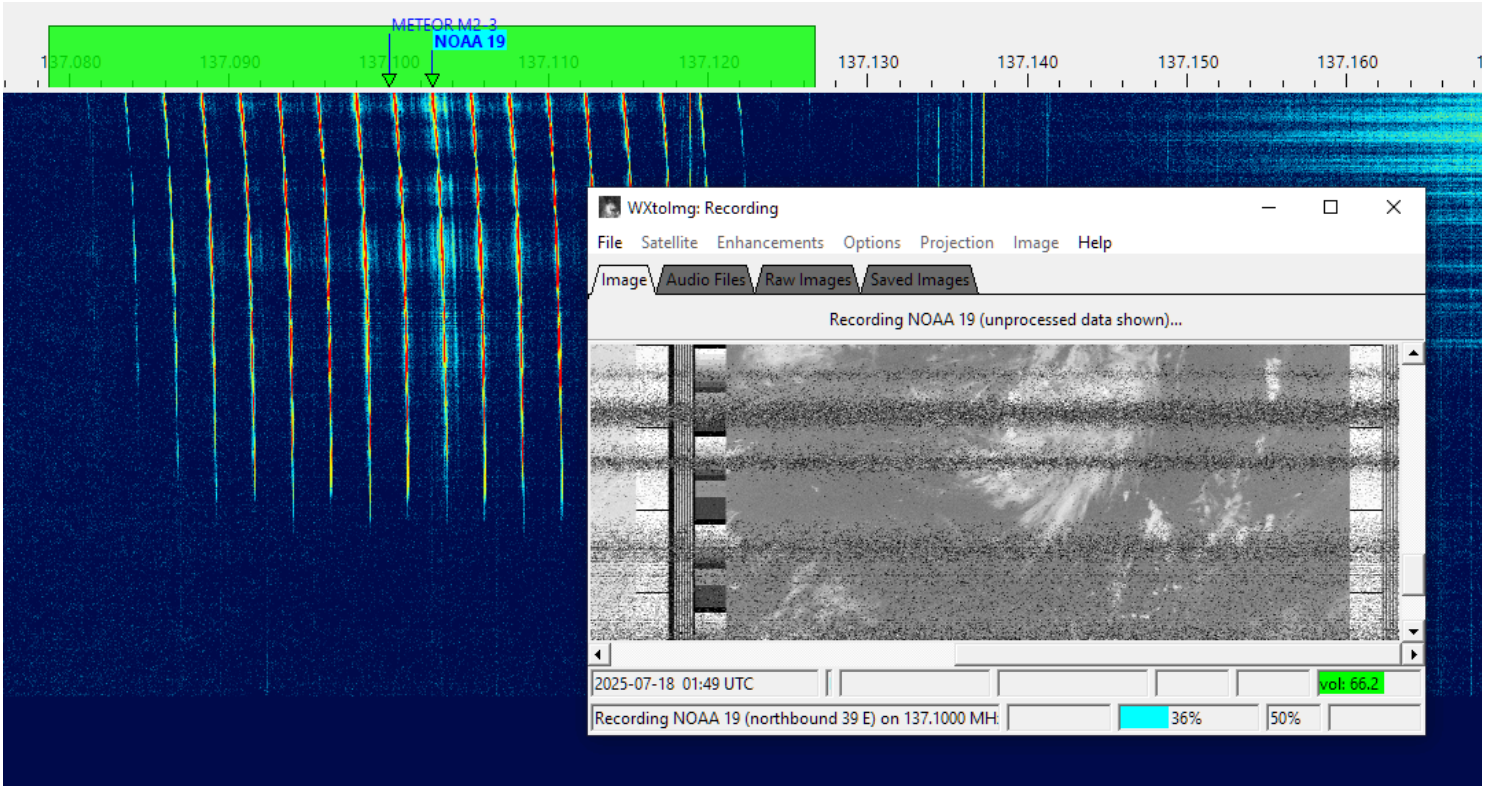
In SkyRoof:

- select the NOAA-15 or NOAA-19 satellite. If it is not in the current group, add it using the Satellites and Groups dialog;
- Select **APT** transmitter on the 137 MHz band from the list of transmitters;

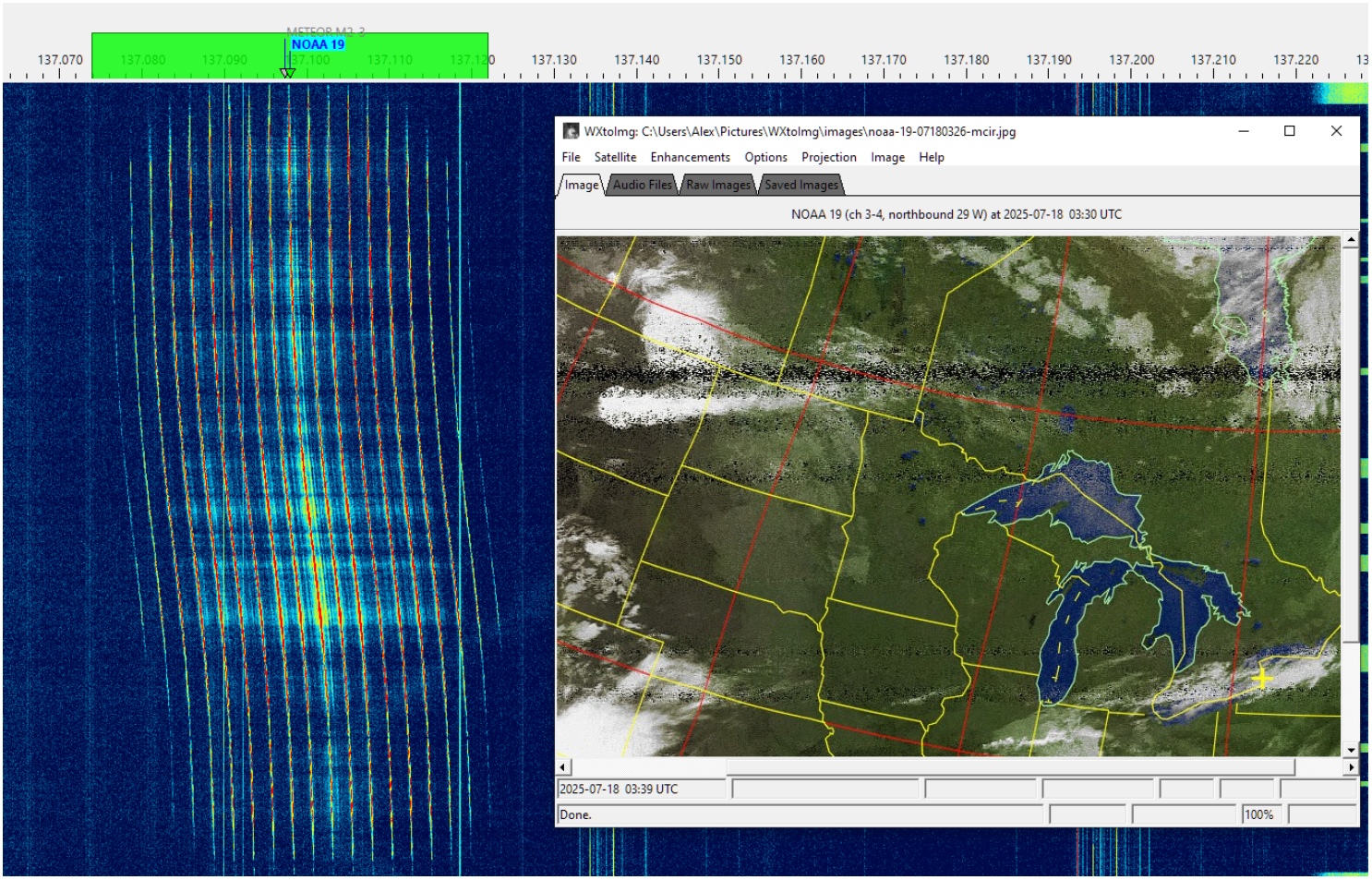
- Select **FM_D** downlink mode in the drop-down list on the toolbar;
- in the **Output Stream** section of the Settings window:
  - select **Audio to VAC**;
  - set Gain, dB to 0;
  - select the VAC in the list of audio devices;
  - click on the Output Stream label on the status bar to enable the output.

Receiving Images

When the selected satellite raises above the horizon, WXtoIMG will start decoding and produce an image like this:



At the end of the pass WXtoIMG will post-process received data and display an enhanced image:


NOAA 19
137.070
137.080
137.090
137.100
137.110
137.120
137.130
137.140
137.150
137.160
137.170
137.180
137.190
137.200
137.210
137.220
WXtoImg: C:\Users\Alex\Pictures\WXtoImg\images\noaa-19-07180326-mcir.jpg
File Satellite Enhancements Options Projection Image Help
Image Audio Files Raw Images Saved Images
NOAA 19 (ch 3-4, northbound 29 W) at 2025-07-18 03:30 UTC
2025-07-18 03:39 UTC
Done.
100%

How to Receive SSTV from ISS

There are two popular programs that demodulate SSTV: **MMSSTV** and **RX-SSTV**, either one may be used with SkyRoof to receive SSTV transmissions form ISS.

Installing VAC

A virtual audio cable, VAC, is required to pass the satellite signals demodulated in SkyRoof to the SSTV decoding program. Download and install VB-Audio if you do not have it yet, and reboot your system. Be sure to get the latest version (2024) of VB-Audio, the old version may not work correctly.

Setting Up MMSSTV

- download MMSSTV, install it and run the program;
- click on **Option / Setup MMSSTV** in the menu to open the settings dialog, and:
  - click on the **Misc** tab;
  - select your VAC in the **Sound Card / In** drop-down list;
  - enter "48000" in the **Clock / Hz** box.
- in the main window:
  - click on the **RX** tab;
  - in the **RX Mode** panel right-click on the second and third button, and select "PD120" and "PD180" respectively;
  - click on **RX Mode / Auto**.

Setting Up RX-SSTV

- download RX-SSTV, install it and run the program;
- in the **Sound Card Selection** window that pops up on start-up select your VAC as **Sound Input**;
- click on **Setup / SSTV Engine** in the menu, click on the **Misc** tab, and set **Clock / Hz** to "12000";
- click on **Setup / RX-SSTV** in the menu, under **User-defined buttons** set the first two buttons to "PD120" and" PD-180";
- in the main window:
  - click on the **RX** tab;
  - click on the **PD120** or **PD180** button, depending on the mode used at ISS (see below).

Setting Up SkyRoof

In SkyRoof:

- select the **ARISS** satellite. If it is not in the current group, add it using the Satellites and Groups dialog;
- Select ISS transmitter that is used to send SSTV (see below);
- Select **FM** downlink mode in the drop-down list on the toolbar;
- in the **Output Stream** section of the Settings window:
  - select **Audio to VAC**;
  - set Gain, dB to 0;
  - select the VAC in the list of audio devices;
  - click on the Output Stream label on the status bar to enable the output stream.

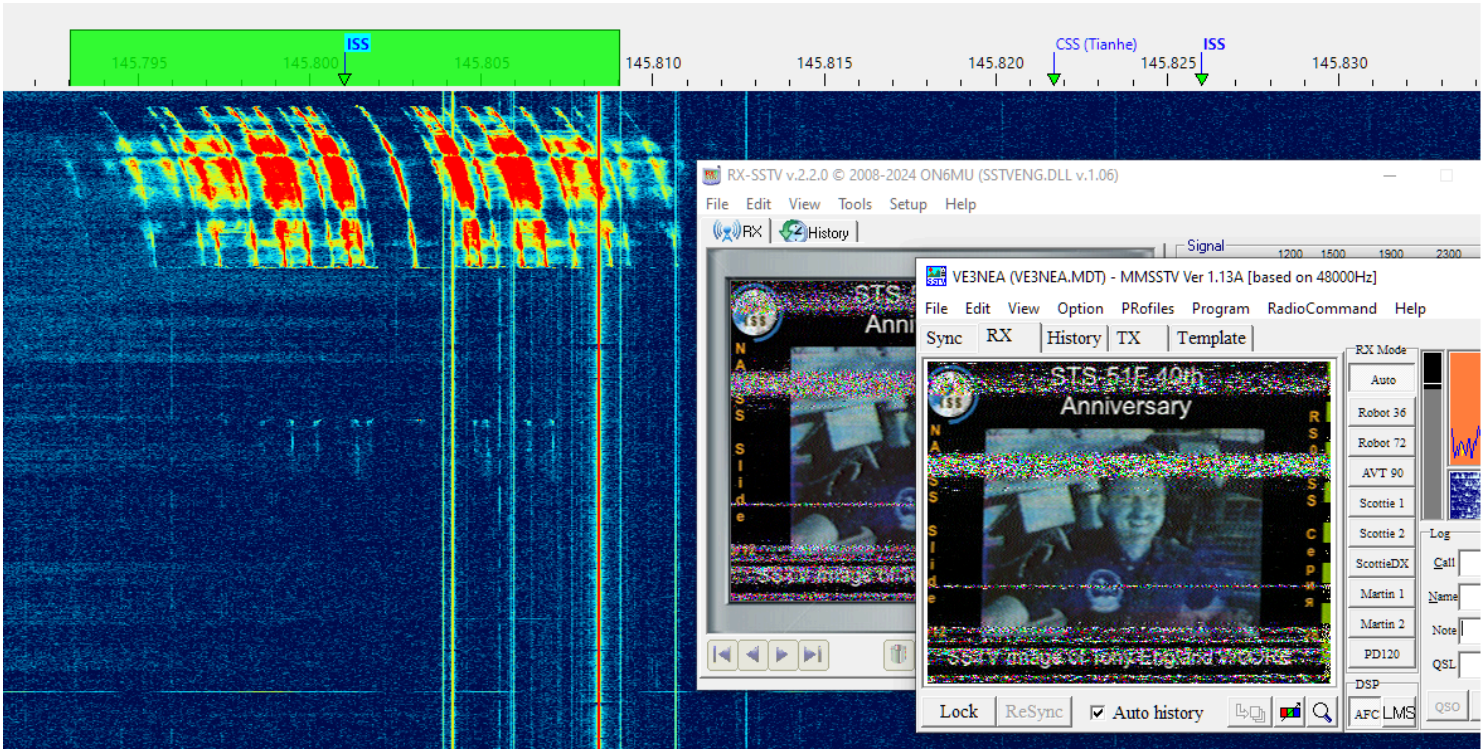
Receiving SSTV

Find out when the next SSTV activity on ISS will take place, usually it happens every few months and lasts for up to a week. One good source of information about such activities is the ARISS web site. You will need to know:

- when SSTV signals will be transmitted;
- which transmitter on ISS will be used, usually it is one of these:
  - **Mode U - SSTV** on 437.800 MHz;
  - **Mode V Imaging** on 145.800 MHz;
- which SSTV mode will be used, usually it is either **PD120** or **PD180**. In these modes the image transmission takes 120 s and 180 s respectively.

In SkyRoof, select ARISS in the list of satellites, and the transmitter that is used in the current SSTV activity. When ISS rises above the horizon and its signals start to appear on the waterfall, the RX-SSTV or MMSSTV program automatically starts decoding the image. If for some reason it doesn't, click on the SSTV mode button (PD120 or PD180) to start it manually.

Here is an example of an image received from ISS in July 2025. Both SSTV decoders seem to have the same image quality, which is mainly determined by the signal strength variations:


145.795
ISS
145.800
145.805
145.810
145.815
145.820
CSS (Tianhe)
145.825
ISS
145.830
RX-SSTV v.2.2.0 © 2008-2024 ON6MU (SSTVENG.DLL v.1.06)
File Edit View Tools Setup Help
RX
History
Signal
VE3NEA (VE3NEA.MDT) - MMSSTV Ver 1.13A [based on 48000Hz]
File Edit View Option PRofiles Program RadioCommand Help
Sync RX History TX Template
STS-51F 10th
Anniversary
RX Mode
Auto
Robot 36
Robot 72
AVT 90
Scottie 1
Scottie 2
ScottieDX
Martin 1
Martin 2
PD120
Log
Call
Name
Note
QSL
DSP
AFC
LMS
QSO
Lock
ReSync
Auto history

How to Receive FSK & AFSK Telemetry and other info using UZ7HO packet radio TNCs

by Marcus PY2PLL

An external program is needed to decode and display common information usually disseminated using FSK or AFSK. In this tutorial the UZ7HO sound modems will be used. More information about these modems can be found at the UZ7HO Personal page under **Packet-Radio** - English version.

Installing VAC

A virtual audio cable, VAC, is required to pass the satellite signals demodulated in SkyRoof to the decoding program. Download and install VB-Audio if you do not have it yet, and reboot your system. Be sure to get the latest version (2024) of VB-Audio, the old version may not work correctly.

Setting Up The Sound Modems

- Download and extract zipped files content to new folders -- one folder for each executable -- somewhere on your PC storage. For AFSK, e.g. the common modes for APRS, AX-25, 1200bps packet and other similar modes, use this low speed modem; for the higher speeds and formats such as 9600/19200 G3RUH FSK, etc., use this high speed modem Sometimes there is false virus detection or unsafe download alert from some web browsers. As already recommended in the SkyRoof FAQ, scan both links using one of the several online virus scanning services that you can use to check the link.

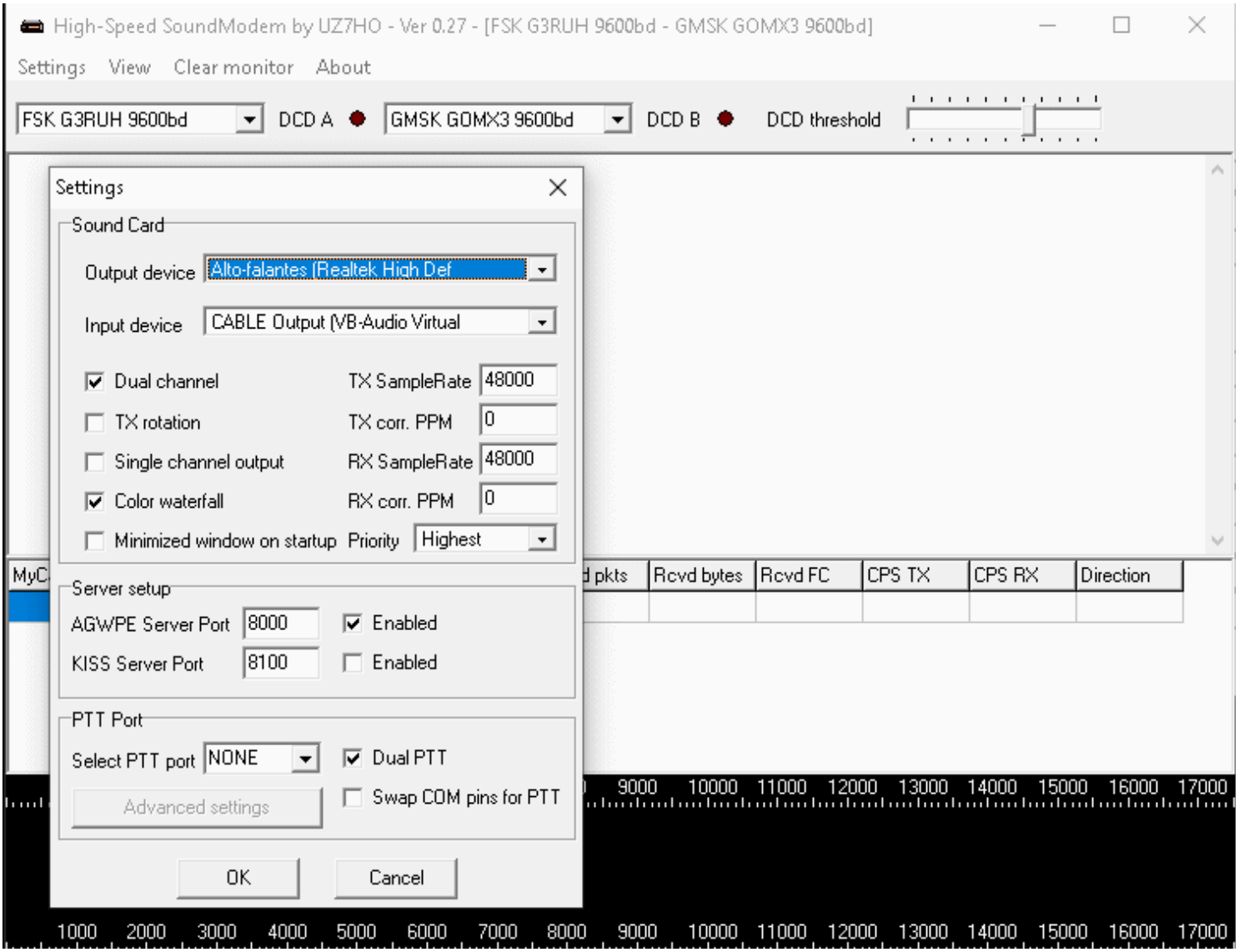
  P.S.: there are a few extra modems that can be tested for other modulation formats such as BPSK, GMSK. etc. in this archieve. But this How-To only covers AFSK and FSK associated to **FM_D** SkyRoof mode. For the UZ7HO itself, there is a more detailed user guide at Soundmodem User Guide v114

- Once downloaded and extracted, create corresponding desktop shortcuts to easy programs launch;

- The following examples will cover **Veronika** or **Tigrisat** satellites FSK data;

- Configure the sound modems audio setup using the already installed VACs. This setup is under Settings => Devices tab. Despite the fact that those modems can be used to TX and RX, the sample picture below assumes that the use is RX only;

- Select **FSK G3RUH 9600bd** in one of the drop down menus and adjust **DCD slider** up to the point that the "led" blinks a little bit.



Configuring SkyRoof

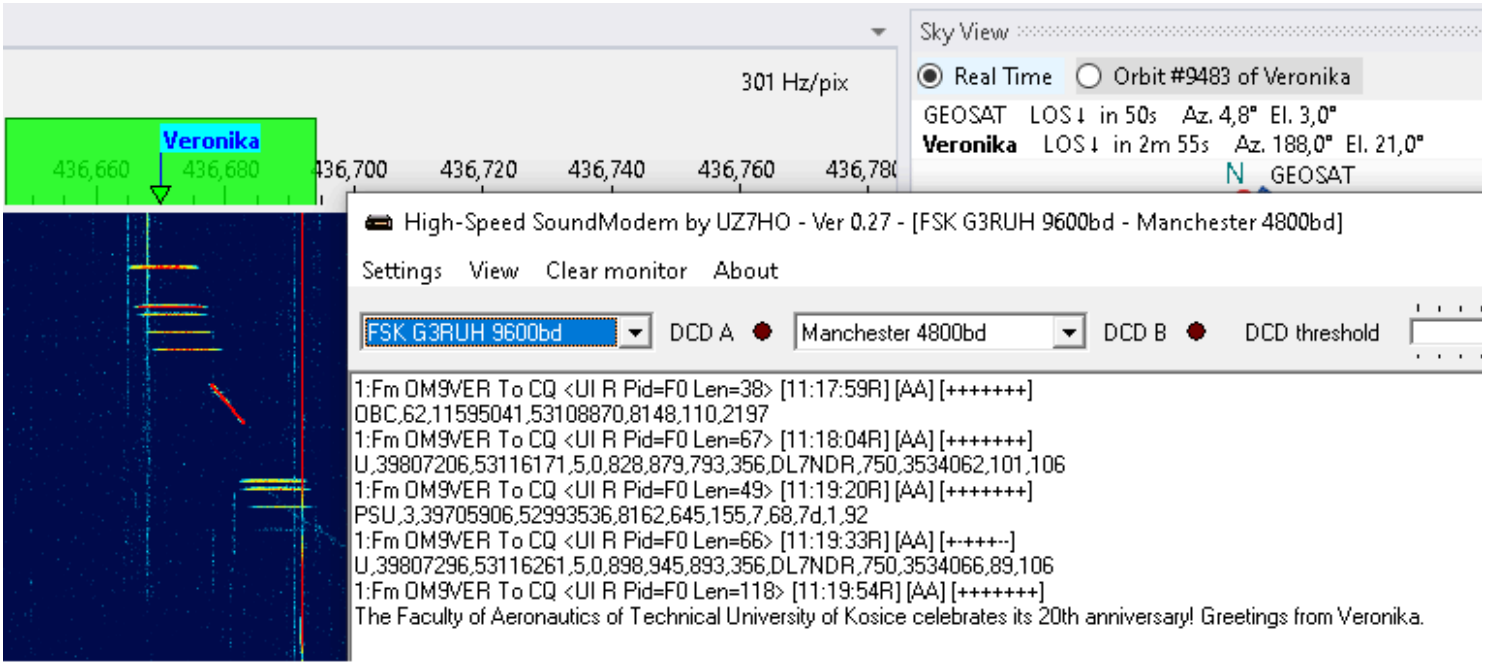
In SkyRoof:

- select the Veronika satellite. If it is not in the current group, add it using the Satellites and Groups dialog;
- Select **GFSK9K6 AX25** transmitter on the UHF band from the list of transmitters;
- Select **FM_D** downlink mode in the drop-down list on the toolbar;
- in the **Output Stream** section of the Settings window:
- select **Audio to VAC**;
- set Gain, dB to 0;

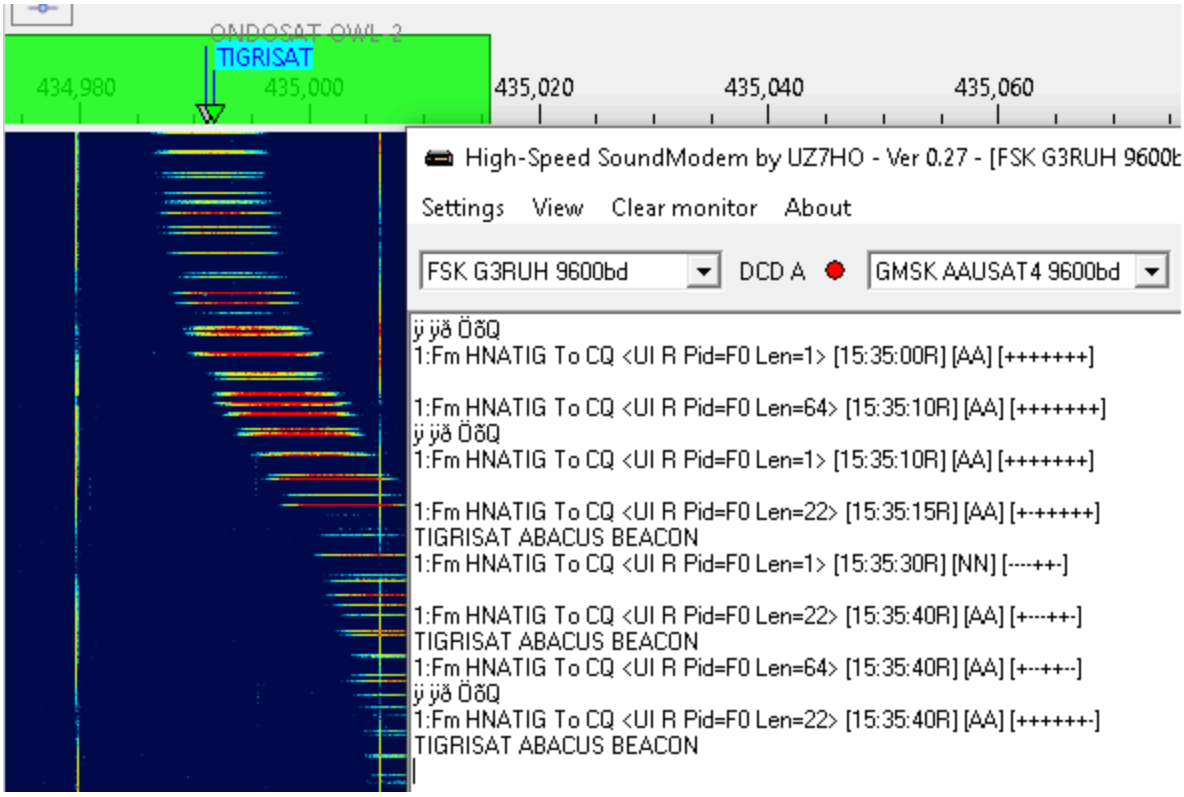
- select the VAC in the list of audio devices;
- click on the Output Stream label on the status bar to enable the output.

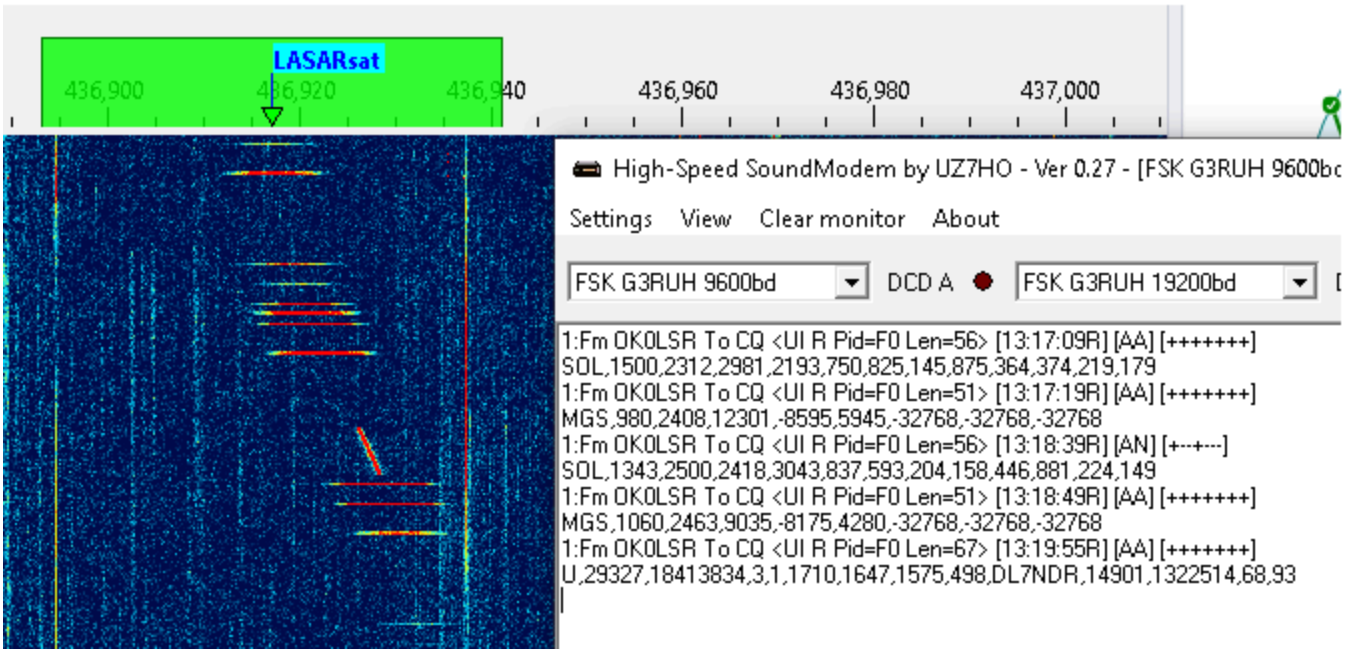
Receiving Data

When the selected satellite raises above the horizon, the UZ7HO FSK Modem will start decoding and produce output like this:



For Tigrisat, the decoded telemetry should be like the picture below:




LASARsat
436,900
436,920
436,940
436,960
436,980
437,000
High-Speed SoundModem by UZ7HO - Ver 0.27 - [FSK G3RUH 9600bc
Settings
View
Clear monitor
About
FSK G3RUH 9600bd
DCD A
FSK G3RUH 19200bd
1:Fm OK0LSR To CQ <UI R Pid=F0 Len=56> [13:17:09R] [AA] [+++++++]
SOL,1500,2312,2981,2193,750,825,145,875,364,374,219,179
1:Fm OK0LSR To CQ <UI R Pid=F0 Len=51> [13:17:19R] [AA] [+++++++]
MGS,980,2408,12301,-8595,5945,-32768,-32768,-32768
1:Fm OK0LSR To CQ <UI R Pid=F0 Len=56> [13:18:39R] [AN] [+--+---]
SOL,1343,2500,2418,3043,837,593,204,158,446,881,224,149
1:Fm OK0LSR To CQ <UI R Pid=F0 Len=51> [13:18:49R] [AA] [+++++++]
MGS,1060,2463,9035,-8175,4280,-32768,-32768,-32768
1:Fm OK0LSR To CQ <UI R Pid=F0 Len=67> [13:19:55R] [AA] [+++++++]
U,29327,18413834,3,1,1710,1647,1575,498,DL7NDR,14901,1322514,68,93

Satellite Data

Data Sources

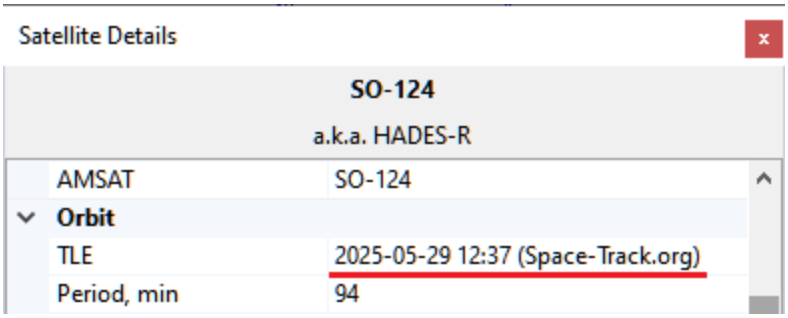
SkyRoof obtains satellite date from several sources:

- 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:

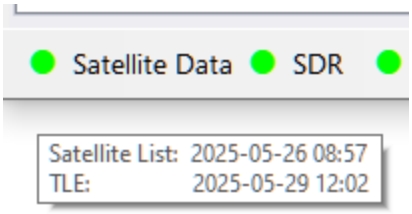


and in the mouse tooltip of the satellite:

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** - lists the CAT capabilities of a generic simplex radio;
- **wsjtx_wisdom.dat** - optimal FFT transform settings found by automatic testing.

Folders

- **Logs** - contains the log files with error messages and other information;
- **Adif** - QSO records stored in the ADIF format;
- **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.

Smart Antenna Rotation

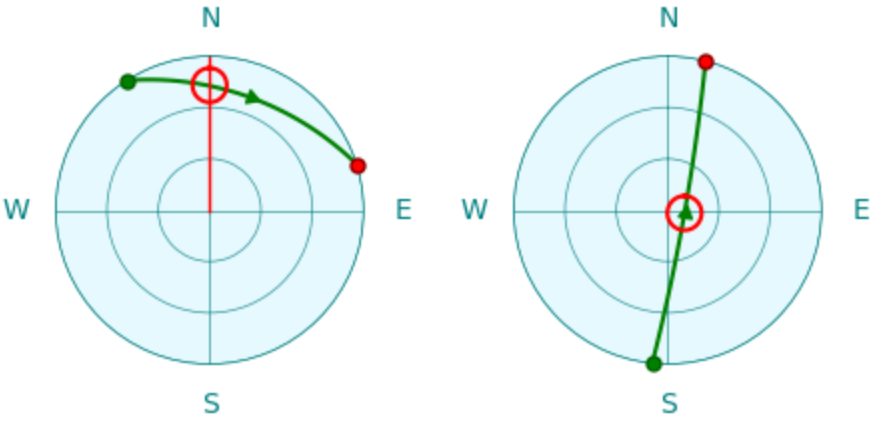
SkyRoof uses a unique antenna rotation algorithm, based on dynamic programming, that globally optimizes the tracking of the satellite pass and ensures the minimum possible communication downtime. The algorithm makes full use of the extended range of azimuth and elevation available in the modern rotators.

Limitations of the Simple Approach

The satellite path prediction algorithm computes the satellite azimuth in the range of **0° to 360°** and elevation in the range of **0° to 90°**. A simple antenna rotator just sends these azimuth and elevation values to the controller. This works most of the time, but there are cases when this requires the antenna to rotate by 180° or 360°. While the antenna is making this full circle, or half-circle, it does not point at the satellite, causing a significant downtime in the communication. The charts below show two such cases.

In the first chart the path crosses the 360° azimuth line, and the antenna needs to make a full circle counter clockwise to get to 0°.

In the second chart, when the satellite is at its highest elevation point, its azimuth quickly changes from South to North, by about 180°. This rotation may take up to a minute, causing a significant downtime.



Rotator Capabilities

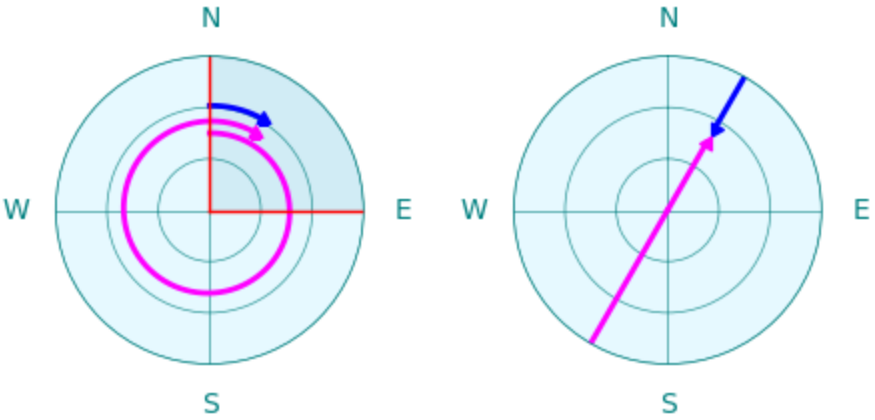
Many antenna rotators have an extended range of azimuth and elevation that goes beyond the **0° to 360°** for the azimuth and **0° to 90°** for the elevation. This allows the controller to point the antenna in the same direction in more than one way. We will use Yaesu G-5500DC, one of the most popular satellite antenna rotators, as an example. This rotator has the following rotation range:

- **0° to 450°** for the azimuth;

- **0° to 180°** for the elevation.

With this azimuth range, there is a 90° segment where every point may be reached in two ways. The first chart below shows that Azimuth=30° and Azimuth=390° point in the same direction.

With this elevation range, every point may be reached in two ways, with elevation < 90° and > 90°, as shown in the second chart.



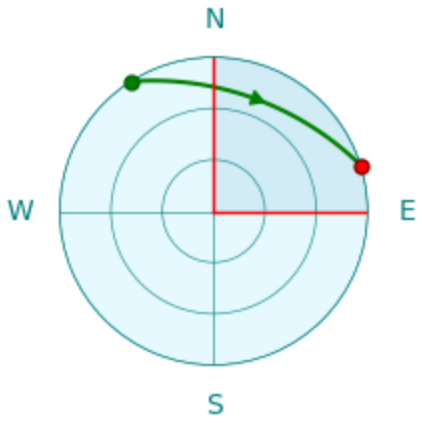
Note also that the rotation speed of G-5500DC is different in the horizontal and vertical planes. Here is what appears in its specifications:

```
Rotation time (approx.):
  Elevation (180°): 65 sec.
  Azimuth+(360°): 60 sec.
```

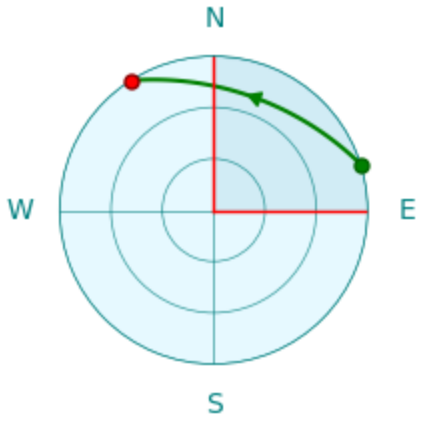
The SkyRoof algorithm assumes that vertical rotation is two times slower than horizontal.

Algorithm

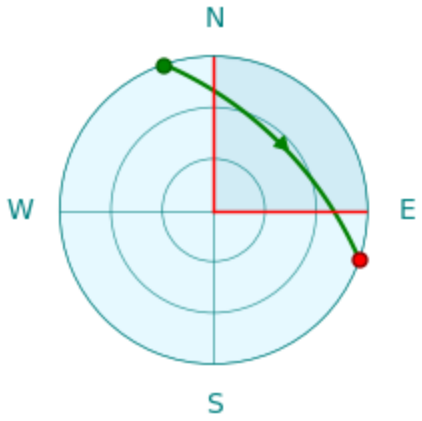
The SkyRoof algorithm that finds the optimum tracking strategy for the given satellite path is not rule-based, it uses the global optimizaton approach to find the optimal solution. The examples below show how it handles certain special cases.



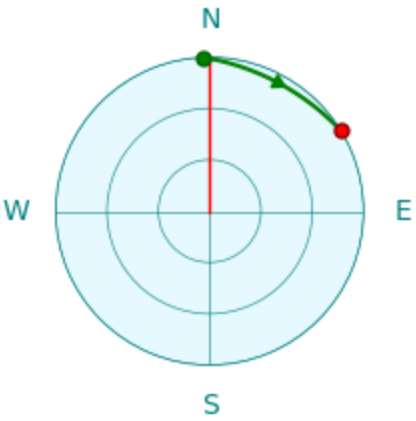
This is an easy case. The azimuth changes from 330° to 80°, so the rotation starts at 330° and, when the azimuth crosses 360°, continues in the same direction, up to 440°, which is the same direction as 80°.



The same path, but in the opposite direction. The simple approach described above, that is used in many simple antenna rotation programs, no longer works. If we start at Azimuth=80°, we hit the 0° limit and cannot continue. The algorithm in SkyRoof looks at the whole pass and chooses to start at 440° instead of 80° so that the pass is tracked without interruption.

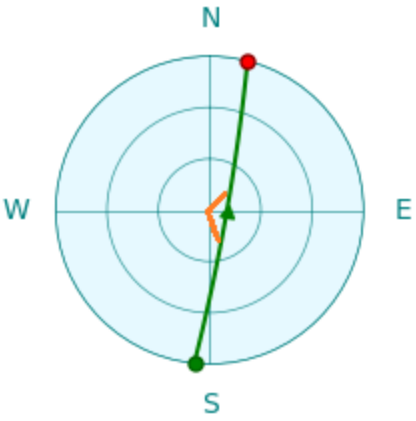


Now the path crosses both 0° and 450° lines. In this case the 90° overlap is not enough to ensure uninterrupted tracking. The dynamic algorithm still finds a solution: it uses the elevations > 90°. Tracking starts at (Az=170°, El=180°) and ends at (Az=280°, El=180°). Again, all azimuths are in the 0° - 360° range, ensuring uninterrupted tracking.



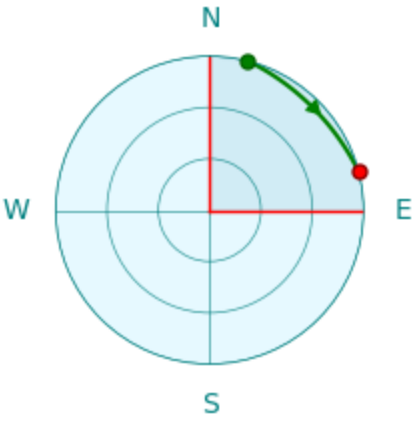
SkyRoof has a parameter in the rotator control settings that determines the steps in which the antenna is rotated, to prevent frequent starts and stops of the motors. Indeed, if the antenna beam width is, say, 60°, there is no point in rotating it in 1° steps. The default step size is 5°.

The path in the chart above crosses 360°, but it extends beyond the red line only by a couple of degrees. If the overshoot does not exceed the rotation step, the algorithm is smart enough to start the path at 0° so that 360° rotation is not required. This works even if the rotator does not have an extended azimuth range.



This path comes close to the zenith and, as we have seen before, requires the antenna to make a fast rotation by about 180° in azimuth. The rotators that support elevations of 0° to 180° can use elevation > 90° for the second half of the path, thus eliminating the 180° azimuth change. However, to switch from the elevation < 90° to > 90°, the antenna must deviate from the path a little bit and pass through the zenith (90°), as shown with the

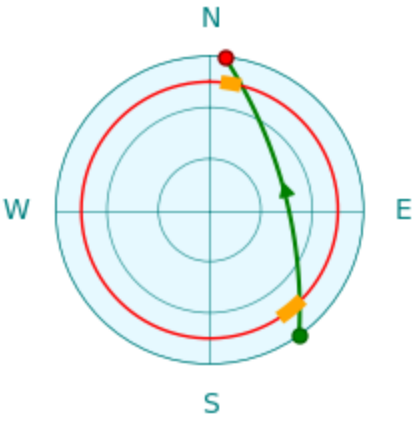
orange lines in the chart above. Dynamic programming plans this deviation in an optimal way.



In many cases there is more than one way of tracking the same path. For example, the path above may be tracked in three different ways:

- (Az=20°, El=0°) -> (Az=70°, El=0°)
- (Az=380°, El=0°) -> (Az=430°, El=0°)
- (Az=200°, El=180°) -> (Az=250°, El=180°)

When the algorithm finds multiple optimum paths, it chooses the one which has the starting point closest to the current antenna direction.



Some antenna rotators have a turning range that does not cover the whole upper hemisphere. The chart above shows the case where the rotator has an elevation range of 15° to 90°. This could be a limitation of the hardware or just an obstructed horizon that makes lower elevation angles useless. The algorithm obeys these restrictions, it does not go beyond the red line. It follows the path shown in the chart with orange lines.

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.

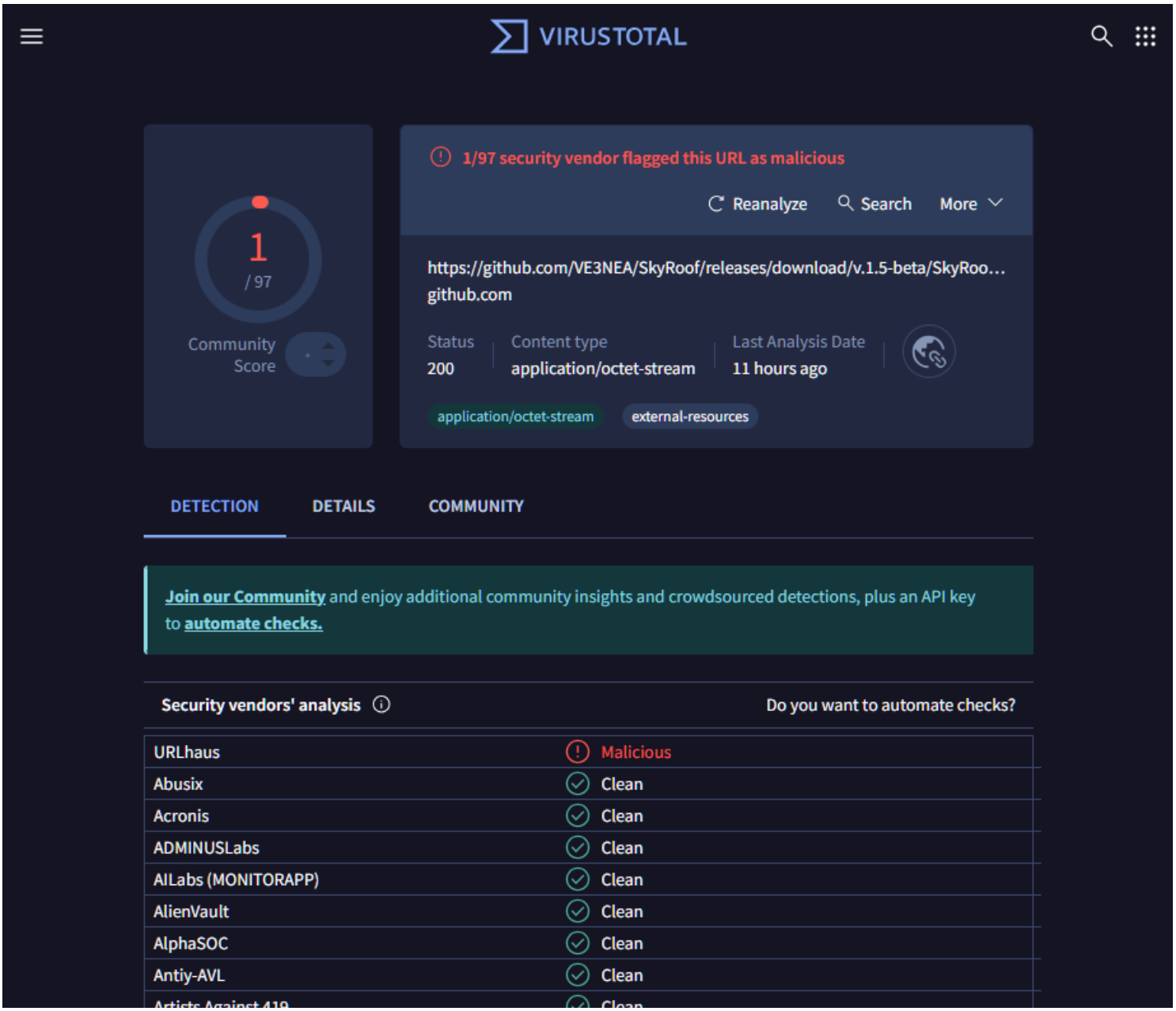
Copy the download link and paste it in the virus scanner page. The scanner will download the file, test it with multiple antivirus programs, and show you the results.

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.

To prevent such problems in the future, please submit the file to Microsoft for analysis using this link:

https://www.microsoft.com/en-us/wdsi/filesubmission



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.

Q: I found an error in the satellite database: one of the satellite transmitters is marked as active, while it has been inactive for years. How can I correct the error?

A: SkyRoof uses satellite data from the SatNOGS database. This database is crowd-sourced, so anyone can suggest changes. If you find an error in a satellite record (shown in the Satellite Details and Satellite Transmitters panels), click on the "SatNOGS" link in the Satellite Details panel to open the SatNOGS web site, then click on Transmitters, and select Edit from the drop-down menu. You may need to create an account with them (free) in order to submit changes.

Q: How can I add a satellite that is currently not listed in SkyRoof?

A: The only way to add a satellite to SkyRoof is to add it to the SatNOGS database. Here is how you can do this:

- navigate to the SatNOGS DB web site;
- click on **Sign Up / Log In** in the top right corner of the page;
- create a free account, or log in to an existing one;
- click on **All Satellites**;
- in the **Actions** drop-down list select **Suggest New Satellite*.

See this Wiki page for details.

Q: My video card does not have an OpenGL 3.3 driver. Is there a way to use a software-only implementation of OpenGL?

A: Some users have had success with the OpenGL 3.3 functionality implemented in the software, though this approach is very CPU-intensive. You can try this or this solution. Download the 64-bit version of the library and extract all DLL's from the archive to the SkyRoof folder.

Q: How do I prevent CTCSS from turning off when using SkyRoof with FM satellites and an Icom radio?

A: If you're experiencing an issue where the CTCSS tone turns off when transmitting or changing frequencies with SkyRoof and an Icom radio, the solution is to disable the "Auto Repeater" setting in the radio. This setting causes the radio to automatically disable repeater-related features like CTCSS when the frequency is changed, assuming you're no longer on a repeater. Disabling "Auto Repeater" prevents this behavior and keeps CTCSS

enabled during frequency changes. This workaround was highlighted in a helpful YouTube video.

Q: What are all those offset settings for?

A:

- **Downlink Manual Correction:** the frequencies of most satellite transmitters slightly differ from their published values. The purpose of this setting is to compensate for the difference, you set it once for each satellite and never change it again;
- **RIT:** just as in any HF radio, it is used to quickly switch the receiver between two frequencies close to each other. A typical use case is when someone answers your CQ slightly off the frequency and you want to tune to it without changing your main operating frequency;
- **Uplink Manual Correction:** this setting allows you to precisely align your own signal received back from the satellite with your receiver frequency. It needs to be set only once per satellite, and the offset is usually very small;
- **Transponder Offset:** the position of your operating frequency within the transponder passband. This offset is included in the Corrected Downlink Frequency shown on the toolbar, the actual value of the offset is shown only on the mouse tooltip of the frequency display. There are many ways to tune within the transponder passband, such as click on the desired frequency, drag the green passband rectangle, spin the mouse wheel over the rectangle, etc. These methods work only when the transponder is selected in the Transmitter drop-down box.
- **Doppler correction:** this correction is computed and applied automatically, it keeps your RX and TX signals in sync when you tune through the transponder segment.

Q: How to troubleshoot the rotator control?

A:

1. Set up and enable rotator control as described in Setting Up Rotator Control.
    - if the Rotator light on the status bar is red, the problem is with the SkyRoof to rotctld.exe connection;
    - if the light is green, then the SkyRoof to rotcltd.exe connection is fine, the problem is with the rotctld.exe to rotor connection.
2. Add the `-vvvvv` option to the command line that starts rotctld.exe, and restart it. This option tells rotctld.exe to print detailed information to the console window (the black

window that opens when rotctld.exe is started).
3. Read the rotctld.exe documentation that will help you to understand information in the console window.

4. Possible causes of SkyRoof to rotctld.exe connection problems:

    - rotctld.exe failed to start;
    - SkyRoof is configured to use a port number different from the rotctld.exe listening port.
5. Possible causes of the rotctld.exe to rotator connection error problems:

    - the rotator is not connected to the computer or not powered on;
    - the COM port number or Baud rate specified on the command line is wrong - then the COM port fails to open;
    - the rotator model specified on the command line is wrong - then the commands sent to the rotor are rejected or have no effect.
6. Make rotator control work without SkyRoof first: use **rotctl.exe**, an interactive version of rotctld.exe, and send commands to the rotator manually, by typing them in the console window. Rotator control uses three commands, "P", "p" and "S" (set position, read position, stop rotation). Once you make rotctl.exe work with the rotator, run rotctld.exe with the same command line parameters.