Using ADS-B Aircraft Tracking

ADS-B Aircraft Tracking receives and decodes signals from planes overhead

Background

Modern planes carry an Automatic Dependent Surveillance-Broadcast (ADS-B) Mode-S transponder. This transponder periodically broadcasts location and altitude information to air traffic controllers and other aircraft. The system replaced traditional RADAR systems which work by bouncing a radio signal off the plane and listening for the echo. ADS-B uses an accurate on-board GPS receiver and broadcasts the GPS location data to ground controllers and other aircraft via radio, thus providing more accurate and stable data. ADS-B is also used to help aircraft avoid collisions by sending a warning or taking automatic emergency action if the flight computer detects a possible collision from ADS-B data.

Currently, ADS-B data is not encrypted so an SDR can be used to decode these signals. The decoded data can then be used to create a live home aircraft radar system. ADS-B signals can be found at a frequency of 1090 MHz. ADS-B uses "Mode S" which provides the location data for ADS-B. Public websites including flightradar24.com and flightaware.com display ADS-B data through the internet as well. They receive ADS-B data through volunteers who have bought dedicated ADS-B receiver hardware or are using an RTL-SDR and feeder software.

Hardware Considerations

Antenna

With a good antenna an SDR could be capable of receiving aircraft ADS-B signals from over 250 nautical miles away, or about 460 km or 290 miles. Many people have found that in most cases the stock antenna that comes with the dongle can pick up ADS-B signals without modification. Its performance will depend on distance from the aircraft and local RF interference. ADS-B operates at 1090MHz with vertical polarization which just means that a vertically oriented antenna should be used. Frequencies in the gigahertz region are "line of sight" frequencies meaning there should be a clear unobstructed path between the antenna and the transmitter on the aircraft. Since ADS-B signals are generally quite strong and come from aircraft flying up high, reception is quite easy and even untuned antennas can work decently.

The provided telescoping antenna at its shortest length on a suitable ground plane will likely provide adequate reception for most users. However, to increase ADS-B receiving range, place a properly tuned antenna at an elevation.

COAX Feed and Connectors

The coax feed line (the length of coaxial cable between the antenna and dongle) should be high quality, low loss, and as short as possible. At gigahertz frequencies long runs of cheap coax tend to reduce signal strength significantly. Use coax cable intended for satellite TV installations such as RG-6 or RG-8 as these cables are designed to work well at gigahertz frequencies.

Alternatively, use an active USB extension cable and place the dongle as close to the antenna instead of

using coax cable. BNC, N or SMA connectors are recommended. Poor connectors at gigahertz frequencies could net up to 1-3 dB of loss per connector.

Optional: Low Noise Amplifiers (LNAs)

By simply placing an LNA in front of the SDR, ADS-B range can be significantly increased. This is because the noise figure (NF) of the RTL-SDR at 1090 MHz is approximately 5 dB. Using a high-quality LNA can reduce the system noise figure down to 1 dB. Essentially this means that SNR will be about 5-6 dB's higher, resulting in significantly more ADS-B packets received. The additional benefit of using an LNA is that coax and connector losses can be overcome if the LNA is placed right by the antenna. To use ADS-B, the antenna should be placed on a roof or a mast for optimal performance. This means that many meters of coax cable will be needed. Even if high-quality RG-6 coax is used, the loss at 1090 MHz for 10 meters (33ft) would be about 3.5 dB plus about 1 dB in connector losses. The LNA can be placed at the antenna and powered by a bias tee.

Optional: Filters

If there are strong interference broadcast stations nearby (e.g. FM, DAB, DVB-T, GSM) then these signals can cause the dongle to overload and desensitize ADS-B reception. Overloading becomes even more likely if an LNA is used. In these cases a filter should be. The FlightAware 1090 MHz filter can be used. This filter is found at rtl-sdr.com/store. In addition a ADS-B LNA + filter combination unit is available. The filter or the LNA can be placed "first" or closest to the antenna. Place the LNA first, then the filter, if the LNA can handle strong signals (high linearity/OIP3) and there are not too many interfering signals. Most filters usually have an insertion loss of about 3 dB, and so placing the LNA first will nullify that insertion loss. On the other hand, If interfering signals are exceptionally strong, then they could overload the LNA. In this case, place the filter first. The easiest way to check is to view the spectrum in SDR#. If the signal quality decreases with the LNA in front, then put the filter first. If the signal quality looks similar with either the LNA or filter first, then put the LNA first.

Software Installation

1. You must have SDR# installed on your computer. If you do not have that program go back and follow the instructions in the "Setting Up Your RTL-SDR" file. Detecting these signals requires two open-source programs: RTL1090 and Virtual Radar Server.

RTL1090

2. Download RTL1090 from this webpage, https://rtl1090.com/.

3. Scroll down the page to find the IMU (Installer and Maintenance Utility). Selecting that option will automatically download all the required files (Figure 1).

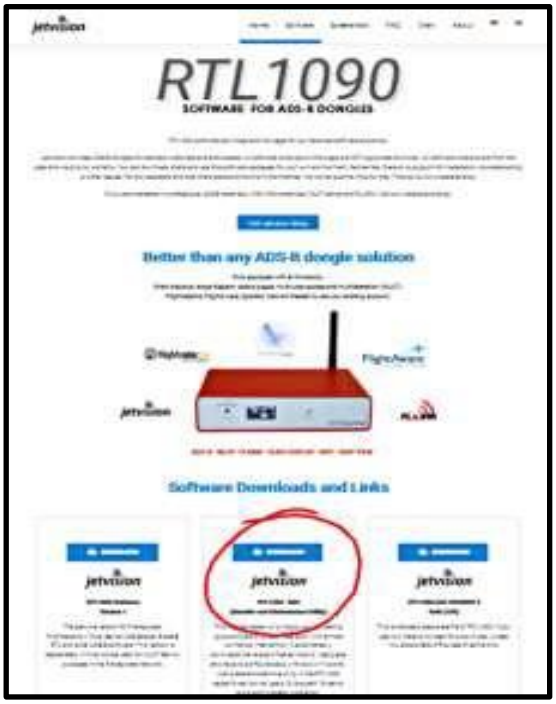

Figure 1: The IMU that you should install is circled in red.

4. Unzip the downloaded file into the same folder that contains SDR#.

5. Double-click on the file rtl1090imu. Windows security and/or antivirus software may suggest that the application not be run. Click "more info" and "run anyway". Follow the instructions in the Popup window to install the program.

6. On the second screen it will ask you to confirm your Windows version please select Windows Vista, 7, 8. It is important that you install 1090 into the same folder with SDR#. The program needs to access some of the files from SDR# and will not run if it is in a separate folder.

7. You will be asked to install Zadig but that was completed during an early stage. So click NO. The 1090 program will walk you through the installation process of Zadig anyway. Just keep clicking the buttons as if you are following those instructions while not actually installing the driver.

8. As soon as the program is installed you should see a small square screen appear. To start decoding press the start button (Figure 2).

Figure 2: The 1090 start window.

9. Leave 1090 running in the background as you install the Virtual Radar Server.

Virtual Radar Server

To visualize the decoded data on a map, the Virtual Radar Server is needed. VRS is Windows (and Linux compatible via Mono) based free software program which displays plane positions in a web browser using Google maps. The map can then be shared with other people over the internet if desired.

10. Virtual Radar Server can be downloaded from http://www.virtualradarserver.co.uk/Download.aspx.

11. To install the software navigate to your downloads folder and double-click on the VirtualRadarSetup. This will take you through the process of installing the program.

12. The first step to installation is accepting the software license agreement.

13. Next, the installer will ask where you want the software installed. This program can be but doesn't have to be installed in the same folder as the other programs.

14. The installer will then ask you to identify a server port. Make sure that the chosen port does not conflict with the port that is being used by another web server. If you don't know what ports are in use just accept the default value provided by the installer. Later, if the Virtual Radar Server won't run try reinstalling the program with a different port number.

15. The installer asks you to select additional tasks. The only option is to change the settings on your firewall so other computers on your network can access Virtual Radar Server. You are encouraged to NOT check this box.

16. Before your installation is complete you may be required to install an older version of .NET. If so please follow the prompts and install the software.

17. The installer should have placed an icon for the Virtual Radar Server in the Start menu. Click that icon to open the virtual radar server (Figure 3).

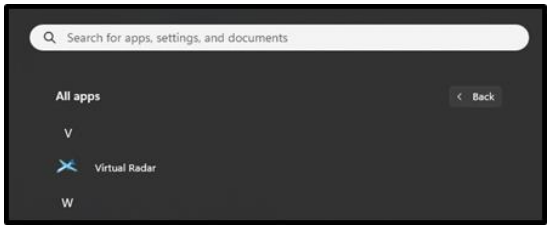

Figure 3: The icon to look for in your start menu.

18. Go to the Tools menu and choose options (Figure 4).

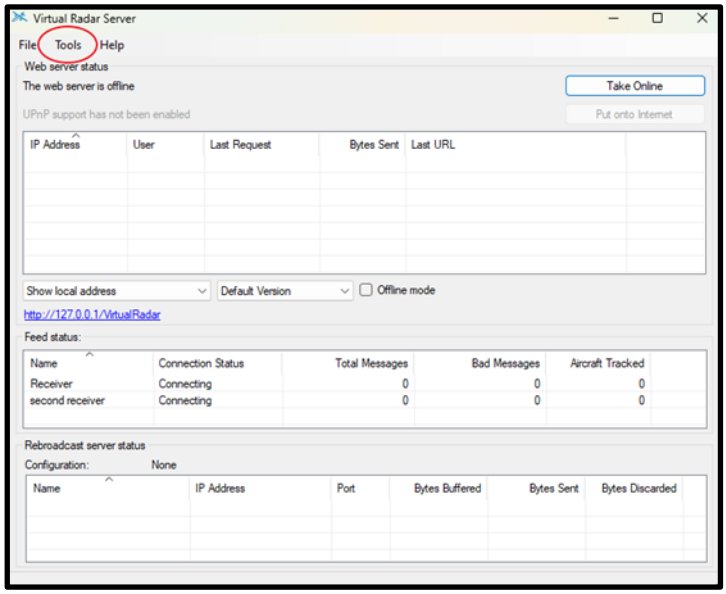

Figure 4: The Tools menu of the Virtual Radar Server window is circled in Red

19. Click on Receiver Locations then click the green + (Figure 5). Add the name of the location and coordinates of the receiver. Latitude and longitude can be determined by clicking on that location in a Google map.

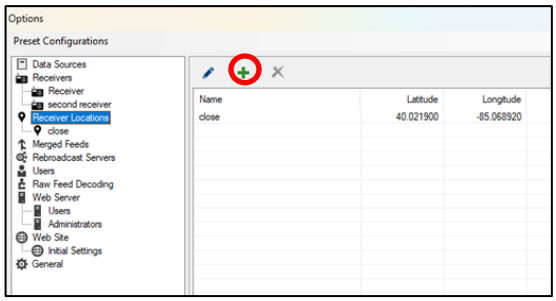

Figure 5: The plus button is circled in red.

20. Remaining in the Options menu click on receivers. Then click on the green plus icon to add a receiver.

Please set the parameters as follows (Figure 6):

- Name the receiver RLT-SDR
- Change format to AVR or Beast Raw Feed. Without this the software will decode messages but will not track planes.
- Choose the appropriate location in the dropdown menu
- Keep the IP address at 127.0.0.1
- Set the port as 31001 which is the output port for RTL1090

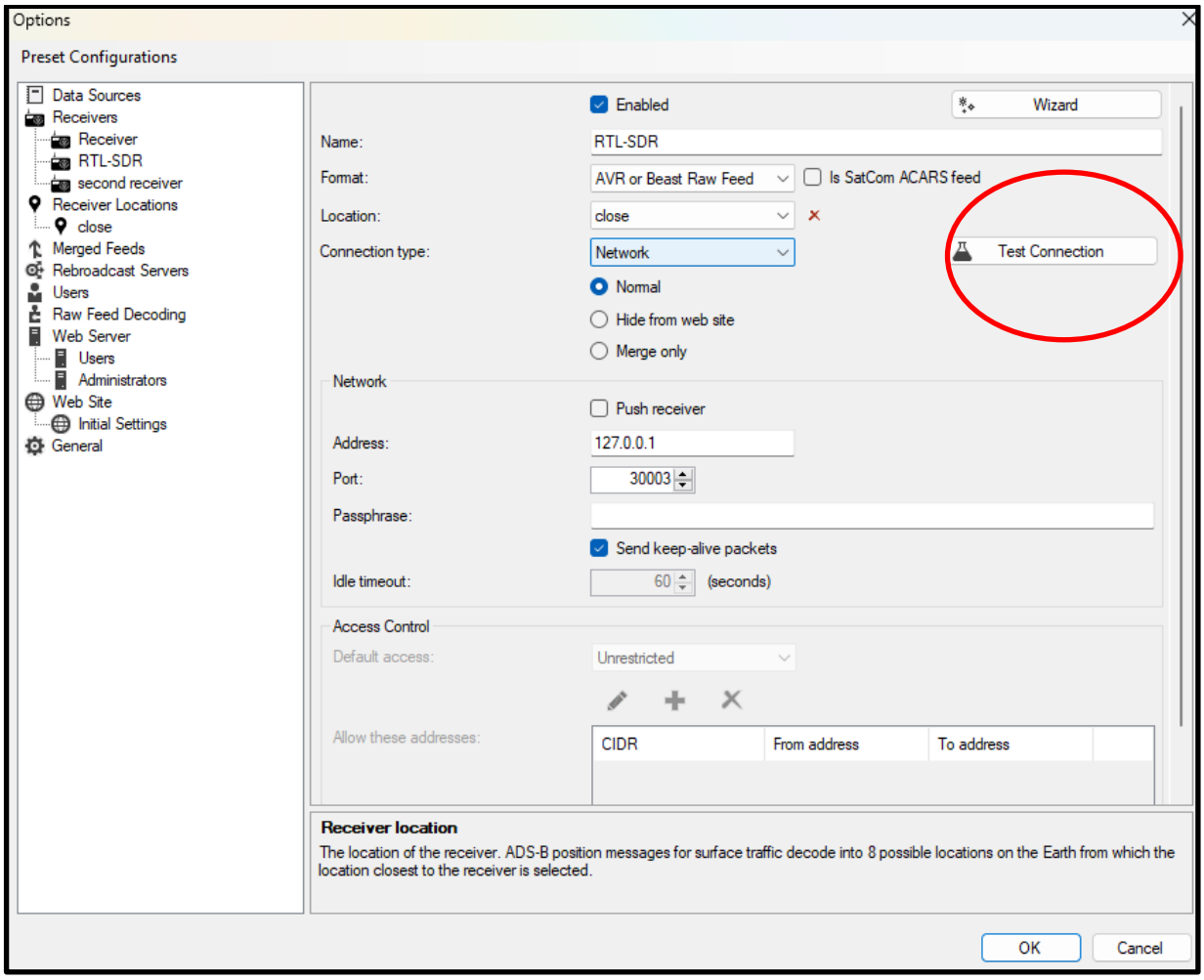

Figure 6: The parameters for the receiver. The test connection button which is needed for step #21 is circled in red.

21 With RTL1090 running, click on Test Connection (See Figure 6). A message showing that a connection can be made should appear (Figure 7).

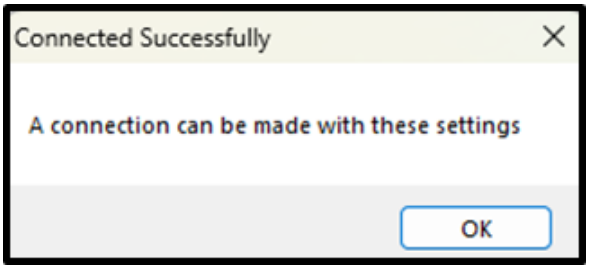

Figure 7: The message you receive if the parameters are entered correctly.

22. Click on Receivers again, and set the "Web site receiver", "Closest aircraft receiver" and "Flight Simulator X receiver" to the RTL-SDR receiver just created (Figure 8). Press OK.

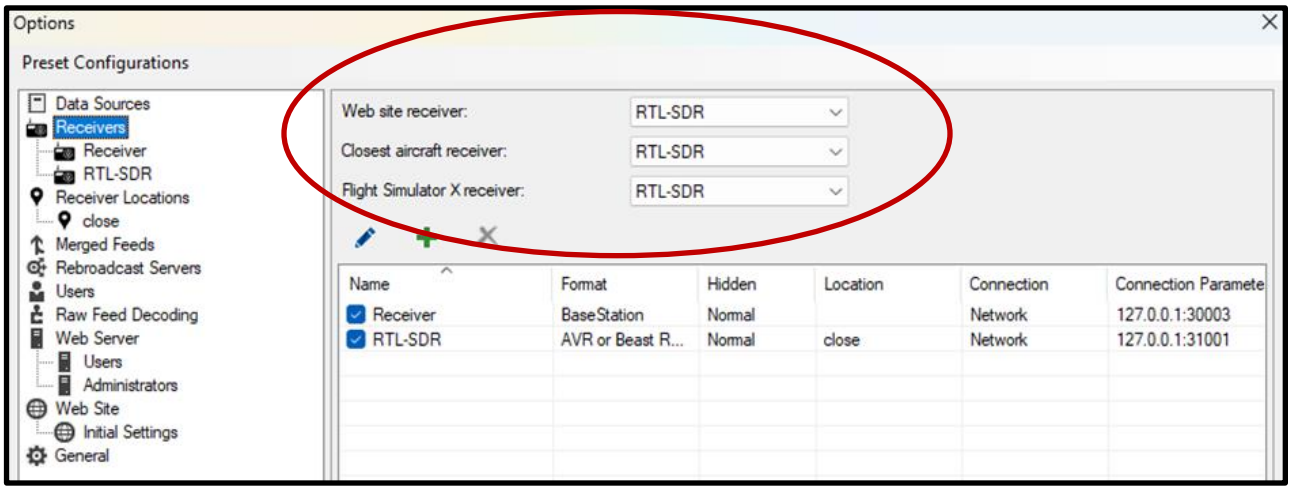

Figure 8: The current settings for the receiver are circled in red.

23. Click on the link in the middle right of the VRS main window (Figure 9). 16. A web page with a special VRS Google map will load. Zoom out and scroll to your location on the map. Graphics of planes should appear as the ADS-B frame decodes from ADS-B decoder program.

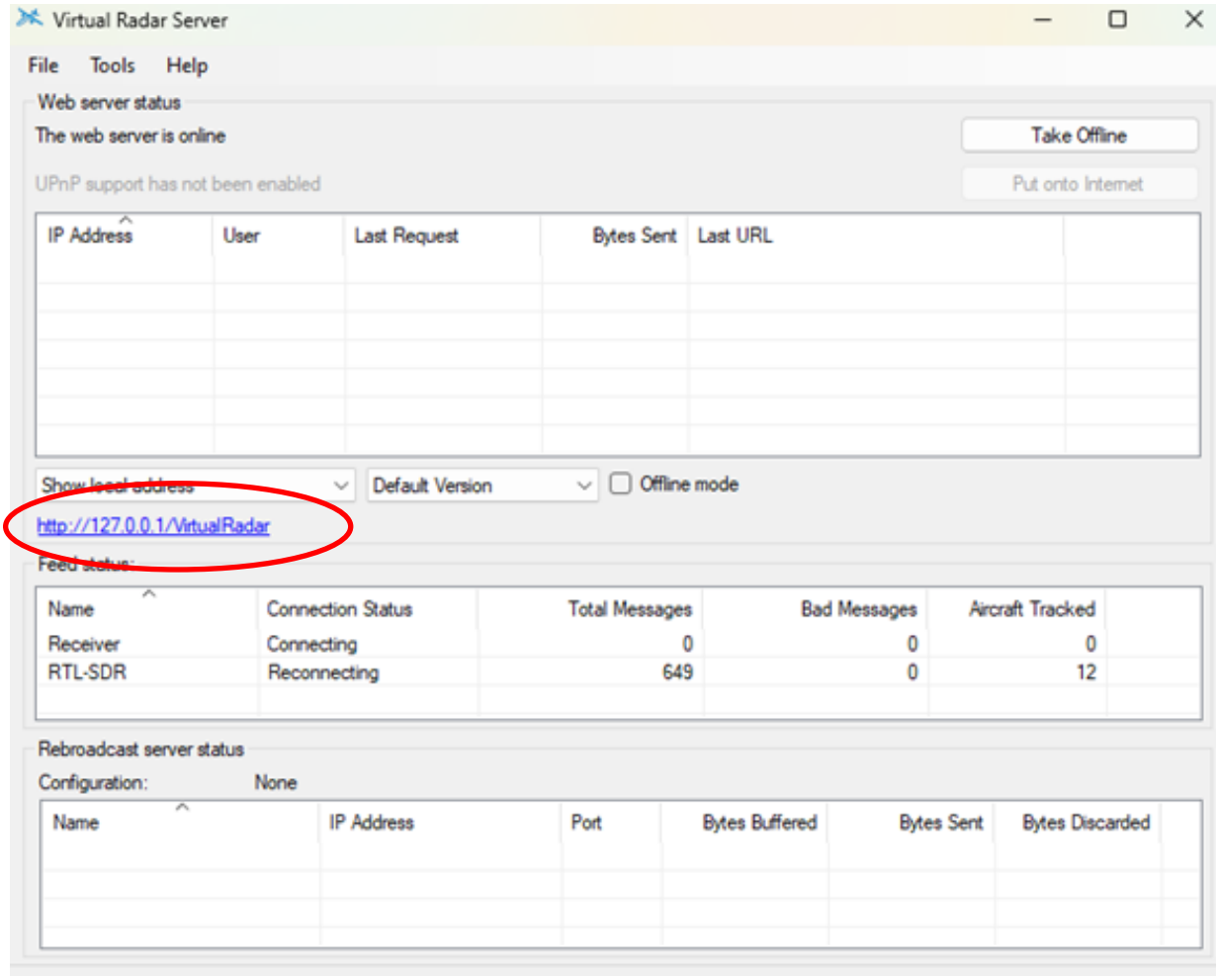

Figure 9: The link you need to click is circled in red.

To use Virtual Radar Server in the future simply start RTL1090 and then Virtual Radar Server.