Virtual Radar from a Digital TV Dongle

Track aircraft by reprogramming an inexpensive digital TV USB stick to receive Automatic Dependent Surveillance-Broadcast signals.

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It is now possible to track aircraft within a 100 mile radius and plot their positions on a real-time display — for about $25! There is a caveat, however — the tracked aircraft must employ a special ADS-B transmitter that continually transmits the aircraft’s flight parameters. The majority of all aircraft flying in US airspace will not be required to use this system until 2020. So, while you probably can’t track that Piper Cub buzzing your neighborhood on a Sunday afternoon, there is still plenty of fun to be had, and you won’t even need to heat up your soldering iron. All you need to do is obtain an inexpensive DVB-T stick that plugs into a computer’s USB connector (this type of device is often referred to as a dongle), download some free software, and build a simple antenna.

**ADS-B**

Automatic Dependent Surveillance-Broadcast, or ADS-B, is a replacement for (or supplement to) traditional aircraft position detection by ground-based radar that has been used for more than 50 years for air traffic control.¹ This represents a major change in surveillance philosophy — instead of using radar to interrogate an aircraft and determine its position, each aircraft will find its own position using GPS and then automatically transmit this and other information to a network of ground stations. This change is a key part of the FAA’s NextGen — the Next Generation Air Transportation System, which is scheduled to be in full operation by 2020.

More than 27 countries are in the process of building ADS-B ground stations and equipping aircraft with the technology, so the number of aircraft that will show up on virtual radar screens will continue to grow in the coming years. ADS-B has the benefit of being less costly to build and operate than ground radar. It also provides better positional accuracy, which will improve safety, particularly at busy airports.

**Virtual Radar System**

My ADS-B receiving system consists of the three major elements shown in Figure 1: a homebrew collinear antenna, a DVB-T TV tuner dongle, and a Windows-based PC running ADSB# and Virtual Radar Server software. While the FAA is putting millions of dollars into its ground station network, you can make yours for about $25.

**Antenna**

ADS-B signals are transmitted at 1090 MHz. My antenna is a collinear vertical comprised of eight half-wave coaxial offset sections with a half-wave whip at the top.² The antenna is omnidirectional and has a gain of 6 dBi. It is designed to be assembled without the need for soldering.

¹Notes appear on page 42.
Receiver

In the US and most of North America, television broadcast stations have switched to digital using the ASTC standard, but in Europe, Australia, and parts of Africa, a different standard called DVB-T (Digital Video Broadcast-Terrestrial) is used. In these areas a small DVB-T stick or dongle is used to receive terrestrial TV broadcasts on laptops and computers.

While the DVB-T stick was intended as a TV receiver, some clever software developers working on mobile communications in a group called Osmocom discovered that this inexpensive hardware could be repurposed for use as a VHF-UHF software defined radio (SDR) receiver. SDR applications soon added support for this new RF front end, which typically tunes as low as 24 MHz, to well over 1700 MHz. It is important to use a DVB-T TV tuner dongle that uses the sensitive Rafael Micro R820T tuner chip. Sensitivity is as good as most communications gear and continuously variable filter selectivity is made possible through DSP. Integrating these elements creates a low-cost ADS-B ground station that rivals the performance of units costing $500 and up.

Software

Conversion from RF to digital is done with an open source application called ADSB# (read as “ADSB sharp”) created by Youssef Touill and the SDR# development team. This Windows application automatically sets the receiver for optimal performance and processes data transmissions from aircraft within range and sends the raw ADS-B data to the real-time display program. Real-time display (see Figure 2) and data sharing is accomplished with the Virtual Radar Server (VRS) application. VRS decodes the ADS-B information and presents it along with other useful data on a real-time Google Maps display. Data from ADSB# is sent using Ethernet protocols so it is not necessary for VRS to be running on the same computer as ADSB#.

Coaxial Collinear Antenna

This antenna provides enough gain to hear plane transmissions from 100 miles or more away, yet costs only a few dollars and takes less than an hour to make using the following procedure:

Cut seven pieces of RG-6/U coax 7 inches long, and one piece 10 inches long. Then, expose 1 inch of the center conductor from one end of all eight coax pieces by rolling the coax against the blade of a sharp utility knife to cut through the vinyl outer jacket, foil shield, and foam insulation. Take care not to press hard enough to cut or nick the center conductor. Make sure the end is clear of stray shield wires or foil.

Figure 2 — Real time aircraft tracking using Virtual Radar Server software with aircraft positions plotted on Google Maps.

Tools — tape measure, electrical tape, utility knife, and a hacksaw.

Figure 3 — Collinear antenna sections cut from RG-6/U coax. The different lengths of exposed center conductor at each end aid assembly.
The collinear elements are mounted inside a length of PVC pipe for additional weather protection and to provide for mounting. Feel free to incorporate your own ideas, but the simplest method I’ve found is use a right-angle Type F adapter (available at most home improvement stores) and a few PVC pipe fittings as shown in Figure 9.

Cut a piece of ¼ inch PVC 42 inches and slide the antenna inside with the right-angle adapter attached to the Type F connector at the base. Drill a hole large enough to pass the feed line coax in a ¼ inch plug and feed the coax through the plug and middle of the T as shown. Add a Type F connector to the end of the feed line, and fit the pieces together as shown. Finish weatherproofing the housing by placing a ¼ inch PVC cap on top. The PVC pipe can be pressed together very tightly, so gluing should not be necessary. This makes it easy to disassemble the antenna if needed in the future. Add a dab of silicone to seal the hole where the feed line goes through the plug.

**Just Add Software**

All that’s left is to install two free software programs: **ADSB#** and **Virtual Radar Server. ****ADSB#** is a server that manages the dongle, extracts raw data frames and then transfers them via Ethernet protocol to **Virtual Radar Server** for further processing, and the visual tracking map and user interface.

**ADSB#**

Download **ADSB#** by running the auto-
Figure 9 — The antenna is housed in a 42 inch PVC pipe for weather protection and mounting support. The connection at the bottom is made through a 90° Type F adapter exiting through a PVC T and PVC plug.

Figure 10 — The ADSB# (pronounced “ADSB sharp”) control panel.

Figure 11 — The Virtual Radar Server control panel.


Run the script and open the ADSB folder that it creates. A program called Zadig must be run one time to install the WinUSB driver before the dongle can be used.²

Launch Zadig, then click OPTIONS and LIST ALL DEVICES. The DVB-T dongle will show up as BULK IN 0 — select it, make sure WINUSB is the selected choice, and click INSTALL DRIVER. That’s all there is to it!

Note: Zadig must be run with administrator privileges, and some anti-malware programs may try to prevent it from installing the needed driver. For more help with Zadig issues see https://github.com/pbatard/libwdi/wiki/zadig.

To launch ADSB#, leave all settings at their default values and click the START button. The FRAMES/SEC indicator will give an indication of how many ADS-B signals are being received (see Figure 10).

Virtual Radar Server

Virtual Radar Server is an open source .NET application that runs a local web server. You can connect to the web server with any modern browser and see the positions of aircraft via Google Maps, generate reports, and integrate other useful information. Your PC must be running Windows XP SP2 (or newer), either 32-bit or 64-bit, along with Microsoft .NET Framework 3.5.5, which can be obtained from the Microsoft Download Center if necessary.

Download VRS from the following URL and follow the installation guidelines: www.virtualradarserver.com/download.aspx.

The first time Virtual Radar Server runs it will prompt you for some user configuration information (see Figure 11). The configuration can also be changed at will by using TOOLS-OPTIONS. Configure the following fields as shown:

1. DATA FEED
   1.1 DATA SOURCE: AVR OR BEAST RAW FEED
   1.2 CONNECTION TYPE: NETWORK

2. NETWORK
   2.1 ADDRESS 127.0.0.1
   2.2 PORT 47806

VRS communicates by way of a built-in web server and the above settings tell it to look to port 47806 of your computer (127.0.0.1 is the “local host” or the local Ethernet interface) for the raw ADS-B data stream that is being generated by ADSB#. Click TEST CONNECTION and confirm that a connection can be made.

Return to the main screen and note the URL adjacent to SHOW LOCAL ADDRESS — click this link and your browser will
display a map generated by Google Maps and information about ADS-B-equipped aircraft that are within range. Most aircraft are not transmitting position information at this time, so don’t be surprised to see real-time tracking of only a fraction of the total ICAO identifiers that are displayed. Congratulations, you are now viewing your own virtual radar!

Virtual Radar Server offers many features and options that are too detailed to attempt to describe here. With a bit more configuration you can put your map page live on the internet for others to view, and better yet, send your raw data to ADS-B “hub” sites that aggregate data from many locations to provide up to a global view. One such hub is operated by the developer of ADSB#, and can be enabled by simply clicking the box on the ADSB# control panel. Change the NETWORK ADDRESS in VRS to SDRSHARP.COM and you will see your data along with that from other ADSB# users around the world. Clearly, with this low-cost solution, it won’t be long until a global network of ADS-B monitoring stations will emerge.

The author of VRS, Andrew Whewell, has created an online forum for help and assistance. Most common questions can be found by via the forum http://forum.virtualradarserver.co.uk/.

Notes
1 FAA ADS-B frequently asked questions: www.faa.gov/nextgen/implementation/programs/adsb/faq/
2 Analysis of the coaxial collinear antenna by L.B. Cebik, W4RNL: w4rnl.net/g4.net/download/coco.pdf
5 ADSB# Quick Start Guide: www.atouk.com/wordpress/?page_id=237
6 Virtual Radar Server home page: www.virtualradarserver.co.uk
7 Windows Driver (WinUSB) installation using Zadig: www.rtlsdr.org/softwarewindows.

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