All Things Digital

Amateur Radio for the 21st Century

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MONITOR AND TRACK AIRCRAFT USING THE AUTOMATIC DEPENDENT SURVIELLANCE-BROADCAST (ABS-B) SYSTEM

Air and marine radio communications are conducted using internationally standardized AM/FM and MF/HF analog voice and digital data systems. Note: In Canada, any person (for legal purposes) may intercept and make use of ADS-B signals as they are not encrypted and considered broadcasting.

I would like to thank Mr. Elmer Webster of ADS-B Technologies for providing me with detailed information on the ADS-B system, for answering my umpteen questions, proofreading this article, and allowing the use of material from his company's website.

Using an inexpensive USB SDR (software defined radio) receiver dongle, very small quarter-wave antenna and some free software, you can monitor and track commercial aircraft in and around major airports and airways in your area. Even with only Internet access, you can still get started using free access flight tracking websites and/or programs/applications developed for computers and iDevices. I like to photograph commercial and military aircraft that "buzz" around my house, camp or wherever I happen to be and use ADS-B to alert me of what's "out there"; perhaps you will also enjoy this combination of photography and radio.

WHAT IS ADS-B?

Put packet radio transponders (transmitter/responder) and GPS receivers on aircraft, combined with receiving stations and Internet gateways (igates) and you have the ADS-B system which is very similar to our Amateur Radio APRS (automatic packet [radio] reporting system) By 2020, ADS-B will be mandatory worldwide for all aircraft to have at least ADS-B Out (transmit) capability anywhere a standard transponder is now required, but there are no plans to replace the older transponders currently in use so aircraft operators will just have to add another piece of hardware to what they already carry and this gets very costly for commercial airlines with large fleets of aircraft, especially when there are competing aircraft tracking systems, already—with more on the drawing board!

The purpose of the ADS-B system is to further enhance TCAS (aeronautical traffic collision and avoidance system) and ACAS (airborne collision avoidance system) by providing everyone (in the air and/or on the ground) situational awareness of what's happening around them. ADS-B is already in use in Canada (and many other parts of the world) and is rapidly expanding. NAV CANADA, the private corporation which owns/operates Canada's civil air navigation service, has plans for total coverage of Canadian airspace by 2020.

From the ADS-B Technology website (with minor editing):

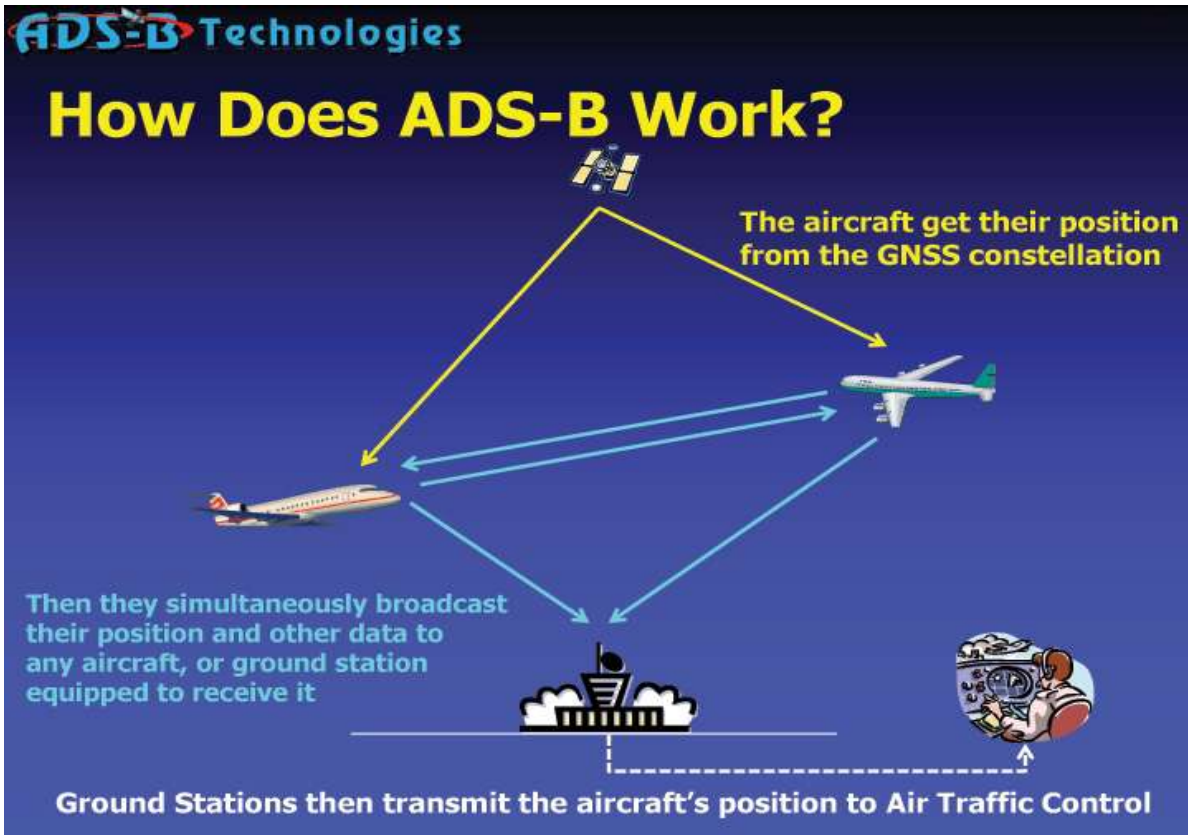
Automatic: it's always on and computer controlled—no human intervention required
Dependent: it depends upon the global navigation satellite system (GNSS) for positional data (GPS)
Surveillance: it provides surveillance services much like radar systems (primary and secondary)
Broadcast: it continuously broadcasts critical flight data (once per second) to other equipped ADS-B aircraft, and ground or satellite receiving stations

"Far different from primary or 'skin-paint' radar which works by bouncing radio waves from fixed terrestrial antennas off of airborne targets and then interpreting the reflected signals, or even SSR (secondary surveillance radar) use with the current aircraft transponders, ADS-B uses conventional GNSS technology and a relatively simple broadcast communications link for its fundamental components.

Also, unlike radar, ADS-B accuracy does not seriously degrade with range, atmospheric conditions, or target altitude, and update intervals do not depend on the rotational speed or reliability of mechanical antennas.

In typical applications, the ADS-B equipped aircraft uses an ordinary GPS receiver to derive its precise position from the GNSS constellation and combines that position with any number of aircraft data, such as speed, heading, altitude and flight number, etc. This information is then simultaneously broadcast to other ADS-B capable aircraft and to ADS-B ground (or satellite) receivers which then relay the aircraft's position and additional information to Air Traffic Control centres in real time." (Figure 1)

FIGURE 1: THE BASIC ADS-B SYSTEM



Aviation transponders (mode A, C or S) transmit on 1090 MHz and receive on 1030 MHz. The mode-S ("selective") transponder is used for ADS-B and there are two types: the short and the "ES" or extended "squitter".

Note: Squitter is the term for a transponder which transmits flight data randomly or intentionally. Mode-S squitters automatically transmit the aircraft's GPS position (latitude/longitude) and other flight information with the extended squitter transmitting the most details. The other transponder types only do so when interrogated by SSR systems.

ATC (air traffic control) uses beacon reinforced radar systems called SSR (secondary surveillance radar) to interrogate (request information) aircraft transponders by transmitting (on 1030 MHz) low-power, rotating radio pulses using DPSK (differential phase shift keying) and listening for any responses between pulses which are plotted on a PPI (plan position indicator) display. Interrogated transponders reply or "squawk" data based on their type/mode and transmitted flight information varies in detail from: "Here I am!" to "Here I am, and here is my flight telemetry". (Figure 2)

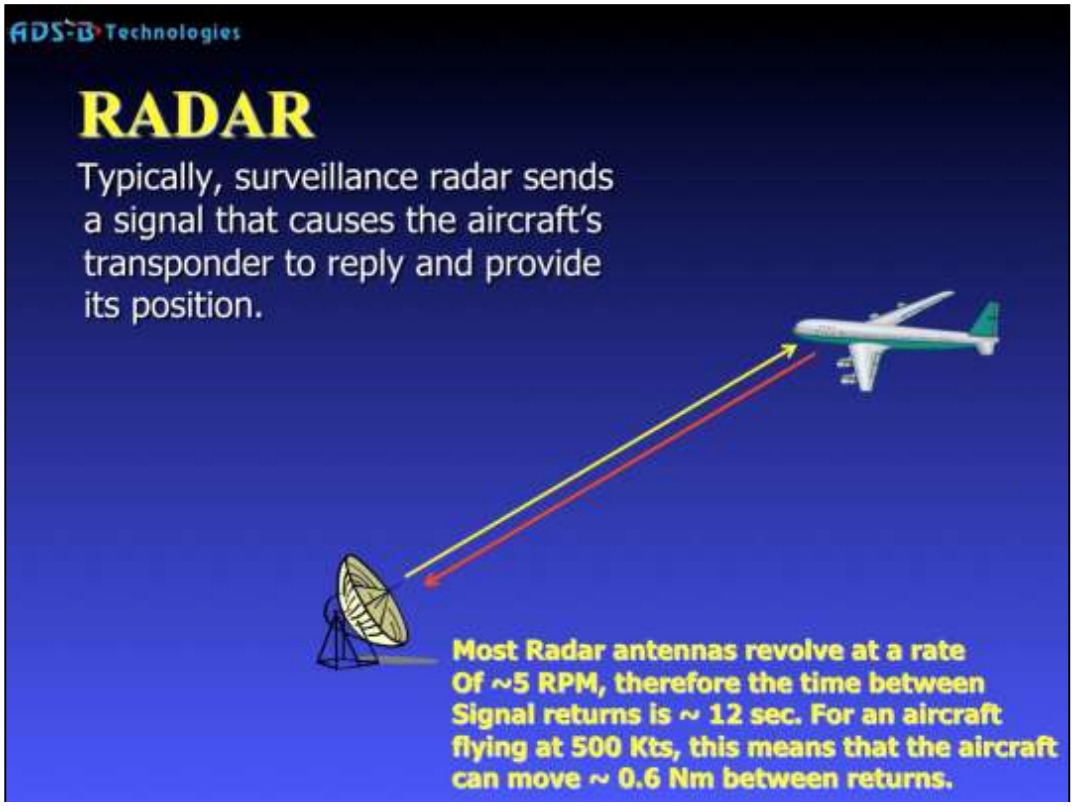
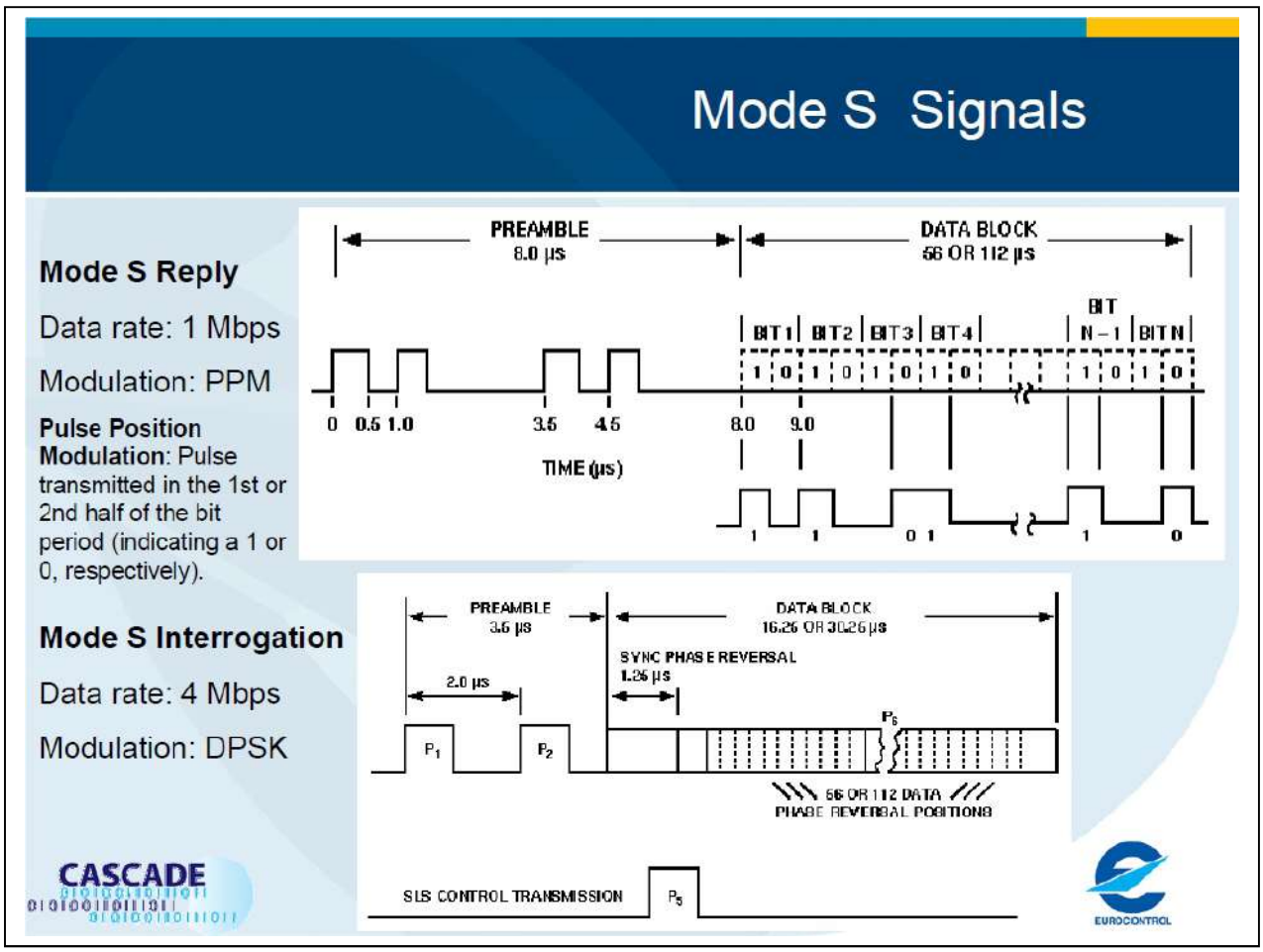


FIGURE 2: SECONDARY SURVEILLANCE RADAR EXAMPLE

Both mode-S ADS-B transponders transmit wide-band packet radio signals at 1 Mbps (megabits per second) automatically (once per second) on 1090 MHz using PPM (pulse position modulation) with a 56-bit message for the short squitter and 112-bit message for the ES or “1090ES” transponder (Figure 3).

FIGURE 3: MODE-S TRANSPONDER/SSR SIGNAL DATA FORMATS



Note: Mode-S (Selective) transponders are interrogated by SSR via their unique 24-bit ICAO (international civil aviation organization) address and only the selected transponder with reply back instead of every mode-S transponder in the area; this is also used by airborne TCAS.

ADS-B QUICK START

Note: My "All Things Digital" webpage has the [free] ADS-B decoding software along with detailed user instructions and additional articles.

1. **Internet Method:**

   Point your browser to any free flight tracking website—that's it! Many Hams and radio hobbyists feed ADS-B received data to such websites. If you prefer, download and try the free iDevice programs (Android or Apple) for handheld ADS-B on the go! (Figure 4)

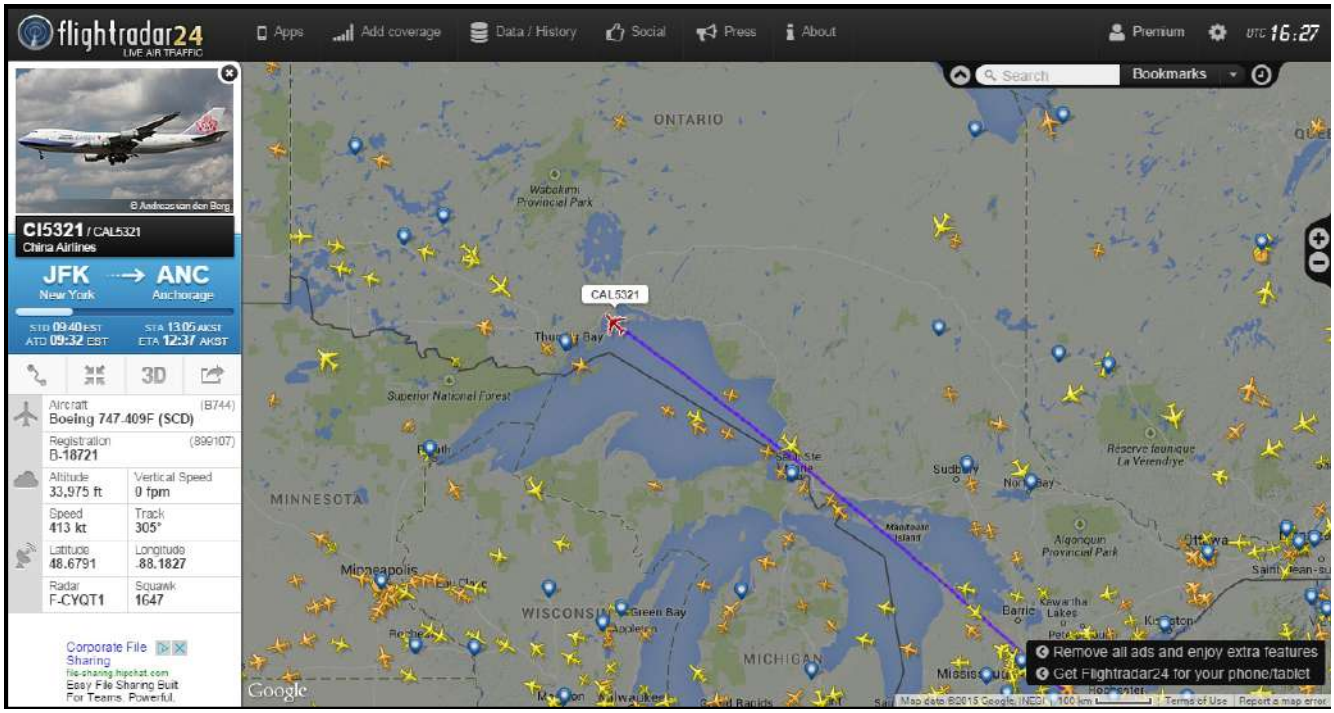


FIGURE 4: FIGHTRADAR 24 LIVE FLIGHT DATA INTERNET STREAMING

2. **Radio Method:**

   You'll need a suitable receiver and it's a USB direct conversion receiver (DCR) built around the Realtek RTL2832U chip and R820T (Rafael Micro) or E4000 (Elonics) digital tuners (Figure 5, next page). Designed to receive European format digital broadcast TV (DVB-T) and digital FM audio broadcast (DAB) signals, it was discovered (in early 2012) that these could be easily reprogrammed into wide-band, multi-mode SDRs.

FIGURE 5: E4000/RTL2832U SDR DONGLES AND ANTENNAS CONNECTORS

For ADS-B reception, the R820T is highly recommended because it has an extra 7 dB of gain with no breaks in reception (24 MHz to 1766 MHz) while the E4000 covers 52 MHz to 2200 MHz with a gap from 1100 MHz to 1250 MHz. The MDS (minimum discernible signal) averages around -116 dBm or 0.35 uV which isn't too shabby for a $20 (or less) receiver!

THE ANTENNAS

These USB SDR antenna inputs are 75-ohm impedance (they are designed for European VHF/UHF digital FM/TV use, after all) but most are supplied with 50-ohm impedance magnetic mount antennas (Figure 6, next page) which you can put on a small metal disc ground plane (pizza pie pans or ring cake pans work great) but the ADS-B reception range is only about 50 km (indoors) because the supplied antennas aren't tuned for 1090 MHz and tuned antennas are preferred at this frequency; you can use the quarter-wave magnetic mount antenna (range limited to about 75 km) or make an elevated quarter-wave version using tuned radials (all elements 65 mm) and this extends the reception range (150 km) indoors depending on terrain and line of sight propagation.

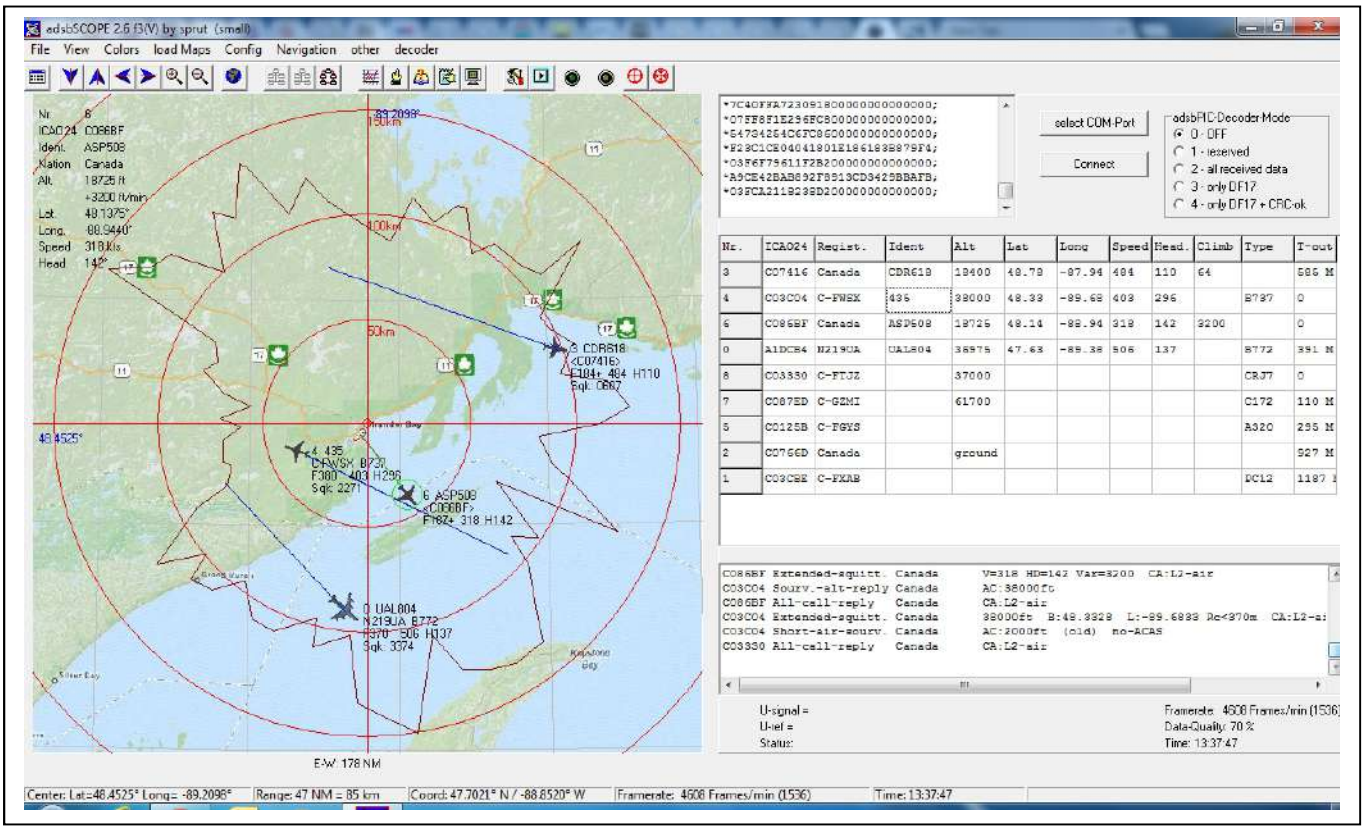
FIGURE 6: VARIOUS ANTENNAS: FAR LEFT/RIGHT TUNED ADS-B QUARTER-WAVES AND CENTRE THREE THE SUPPLIED, UNTUNED (VHF/UHF) VERSIONS

THE SOFTWARE

A free program called “Zadig” is used to install a custom device driver and reprogram the USB dongle receivers into wide-frequency, multi-mode SDRs. A “middle-ware” program (ADSB# or RTL1090) tunes the dongle to 1090 MHz and streams ADS-B transponder packets to a decoder program which displays received data visually and textually (RTL1090 also has a very simple PPI display). I can highly recommend two stand-alone (Windows based) ADS-B programs (I have no access to Linux or Apple computers); a commercial program called “PlanePlotter” (PP) by COAA (*Centro de Observação Astronómica no Algarve)* and a free one called “adsbSCOPE” by “sprut”.

Once registered (user license purchased), PP provides Internet data sharing with other PP users via the COAA server. The program supports various ADS-B receivers and connection methods such serial port (RS232/USB) and networking (TCP/IP, UDP, etc.); it has an application programming interface (API) for computer programmers to use, along with other advanced features for the serious hobbyist. PP has a 21-day free trial (try before you buy) but there's no file sharing until it's registered; it has detailed instructions and an excellent Yahoo user group to help you get started.

FIGURE 7: ADSBSCOPE SCREEN DISPLAY OF ADS-B SIGNALS



adsbSCOPE (Figure 7) is free and the Delphi 5/6 (Visual Pascal) compatible source code is provided so I was able to make changes to its German language error messages and European number format usage, and also fix a few minor errors and learned a bit about how the digital ADS-B signal is decoded (as much as my limited German and mathematics background allows!). If you are a hobbyist programmer, you'll like being able to tinker with the source code.

adsbSCOPE displays all flight information on one PPI “radar-like” map display and can automatically look up additional flight data from its internal database or an Internet aircraft database and add that information to its knowledge base. You can also create ADS-B “radar profiles” of your reception area (the jagged red lines) on the display. This is a great stand-alone, portable program for use in the field and/or when you don’t have Internet access (like at my camp).

Any Windows based (XP and greater) fast single-core or duo/dual-core computer is more than adequate (I use a Windows 8.1 tablet at my camp). There are other free ADS-B webserver (Internet) programs and I’ve supplied links to them in the References and Resources section.

ALTERNATIVE WEBSERVER SHARING (2015 ADDENDUM)

The SDR# (SDR Sharp) group created a VirtualRadar based webserver which uses your reprogrammed USB SDR dongle in combination with ADSB# to share data via their “ADSBHub” (Figure 8). It’s very popular in Europe, extremely easy to setup over PP/adsbSCOPE, plus there’re no advertisements, requirements or commitments on your part like more popular [commercial] sharing websites, but North American hobbyists don’t seem to know about this [great] free alternative.

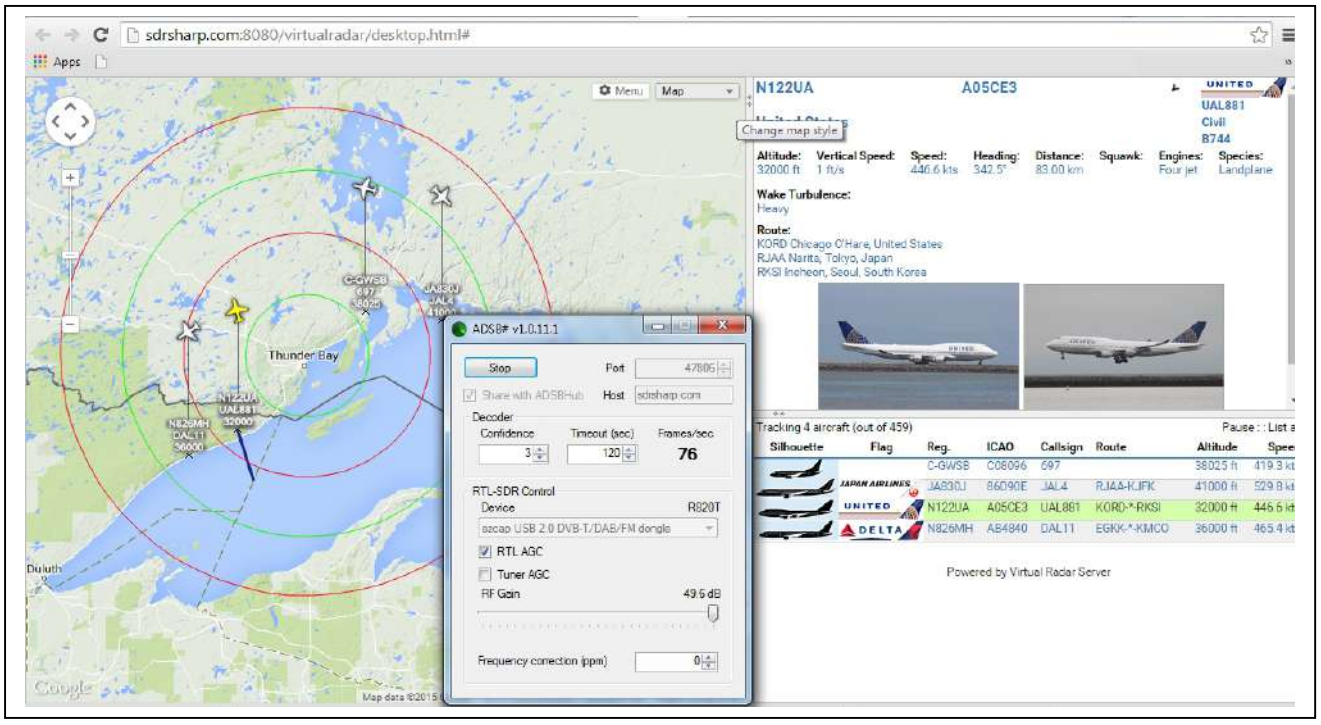


FIGURE 8: SDR# VIRTUALRADAR/ADSBHUB WEBSERVER

Both adsbSCOPE and PP can download simple satellite maps or use Google Maps and the Open Source Maps (OSM) for their pseudo-PPI displays, and you can also create your own for PP use from scanned map/chart images.

MY FINAL

Okay, a lot of material but hopefully it's not too overwhelming for digitally enable radio hobbyists and/or Hams! In the next column, we'll look at an interesting Amateur Radio digital data mode called "WSPR" which is not designed for making two-way contacts but intended for testing propagation conditions, antennas, receivers or transmitters, and collecting and analyzing various data.—73

REFERENCES AND RESOURCES

ADS-B
http://ads-b.com
http://en.wikipedia.org/wiki/Automatic_dependent_surveillance-broadcast

Cheap and Easy SDR (Robert Nickel, W9RAN)
https://docs.google.com/folderview?id=0B98akUlPIomlRGxjVElDNDJqaW8

Software (Android and Apple)
FlightAware, Plane Finder, Flightradar24, FlightView, FlightTrack, Flight Tracker

Software (Windows)
http://www.coaa.co.uk/planeplotter.htm
http://rtl1090.web99.de/homepage
http://www.sprut.de/electronic/pic/projekte/adsb/adsb_en.html
http://www.sdrsharp.com/#download
http://www.virtualradarserver.co.uk/Default.aspx
http://zadig.akeo.ie

SSR
http://en.wikipedia.org/wiki/Secondary_surveillance_radar

TCAS
http://en.wikipedia.org/wiki/Traffic_collision_avoidance_system

Tracking Websites
http://www.flightradar24.com
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http://sdrsharp.com:8080/virtualradar/desktop.html