



What's Radarspotting?

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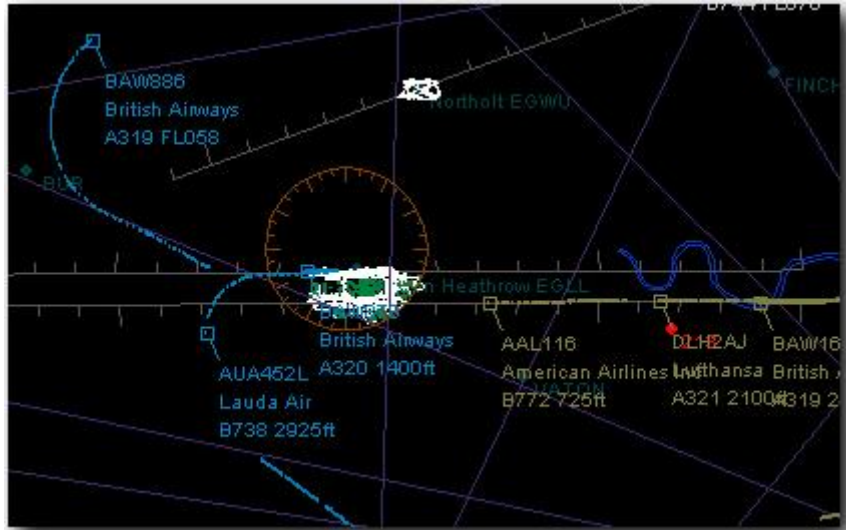
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Radarspotting

Aircraft Spotting in the Digital Age



Welcome to Radarspotting, aircraft spotting in the digital age.

Not so long ago the aircraft spotter would use a radio scanner, binoculars, copy of the Ian Allan Civil Aircraft Markings and maybe a camera.

Today the list could include a laptop or netbook, digital camera and a mode-s receiver. Digital technology now offers an “over the horizon” view, behind walls and clouds and, when the weather’s bad, from the comfort of an armchair instead of a freezing airport fence.

This **Guide** is an introduction to Radarspotting and particularly the Mode-S receiver that’s dramatically changed the aircraft spotting hobby.

Here you’ll find a layman’s introduction to Mode-S, describing the available hobby receivers and software and shows you how you can track aircraft using the Internet or a mobile phone.

But a word of caution. Radarspotting can become addictive and Mode-S software has extensive functionality, much more than can be covered in this guide.

To find out more, please visit the Mode-S manufacturer websites or download the many Guides that are freely available on the Radarspotting.com forum where you can also get free help and advice.

Any feedback on this document would be most welcome.

This isn’t meant to be a recommendation or endorsement of any product and the author cannot accept any responsibility for any consequences resulting from use of this document.

Introduction

Aircraft spotters fall into many categories. Some prefer civil aviation, others military or even both. There are those who collect registrations, the “dot spotters” who look for the dot in the sky and place a dot against the aircraft in books such as Ian Allan’s Civil Air Markings.

Others like to listen to air-to-ground broadcasts using a radio scanner and others who spend a fortune on digital cameras and long lenses, travelling the globe taking pictures of aircraft. Some enthusiasts cover all aspects of the hobby and congregate at air shows such as the UK’s Royal International Air Tattoo and Oshkosh in the USA. I’ve no idea how many aircraft spotters there are but my guess is there could be 100,000 in the UK alone, maybe many more?

The digital camera and photo-editing software have contributed to the enormous success of aircraft image websites such as Airliners.net with over 100,000 registered users and nearly 3 million unique visitors every month. These image web sites, along with those listing aircraft registrations, deliveries, accident reports, spotting locations and other topics all add to the spotters’ online assets.

A fairly recent invention has created a totally new and exciting “must-have” for the aircraft spotter - the Mode-S receiver and Radarspotting.

Using a Mode-S receiver, today’s spotter can sit at home and “spot” aircraft across the world, no matter the weather, day or night. Only ash clouds can interfere with the enjoyment!

For less than the cost of a digital SLR or radio scanner, the Radarspotter can get a Mode-S receiver and share aircraft with fellow spotters. Or if the budget is tight or you want to learn more, there are free aircraft tracking websites displaying aggregated aircraft from several Mode-S receivers. And for a few Euros, one can even track aircraft on Android and iOS mobile phones.

There are now so many options and hopefully this guide will provide a helpful introduction to the new hobby of Radarspotting.

What’s Mode-S?

For the Radarspotting hobby we can describe Mode-S (S for Selective) as a radar technique that makes use of an aircraft’s unique 24-bit data address or identifier.

Individual aircraft are now assigned a unique 24-bit address, as defined by the ICAO (International Civil Aviation Organization), often referred to as a Mode-S or Hex (hexadecimal) code. This unique address can be transmitted by the aircraft’s transponder and/or interrogated by ground based radar. Mode-S operates on the radio frequencies 1030/1090 Mhz.



Figure 1 - Trig Avionics Mode-S TT31 Transponder

Mode-S offers selective aircraft radar interrogation and the inclusion of additional data such as a flight ID and height, heading and, in some instances, geographical location. In other words, the aircraft can be identified and optionally located using data transmitted over a radio frequency.

But not all aircraft are required to use a Mode-S transponder and Mode-S isn't mandated in all parts of the world.

At present, the use of Mode-S transponders in the UK has been mandated in various categories of airspace which could be summarised as all controlled airspace and above FL100 (10,000 feet).

For more information on Mode-S please visit the Eurocontrol website – Google “Eurocontrol Mode-S”.

In this guide, we'll focus on the Mode-S hex code and how it's used to identify an aircraft.

The 24-bit address forms part of the aircraft's Certificate of Registration and is not normally changed, unless the aircraft is re-registered. However, the transponder can be reprogrammed and some military services swap transponders between aircraft.

The 24-bit address can be represented in four formats – Hex, Decimal, Octal or Binary. Hex is the most common.

Here's an example of the various **address** formats for British Airways Airbus A320-232, registration G-EUW:

Registration	Type	Hex	Decimal	Octal	Binary
G-EUW	A320	405457	4215895	20052127	01000000 01010100 01010111

As can be seen from the diagram below, the aircraft has a Mode-S transponder that will respond to a radar request for data, such as the aircraft hex code, altitude and squawk. This data can be received by a Mode-S receiver, decoded and used by the receiver's software to display meaningful information to the Radarspotter. More of this later.

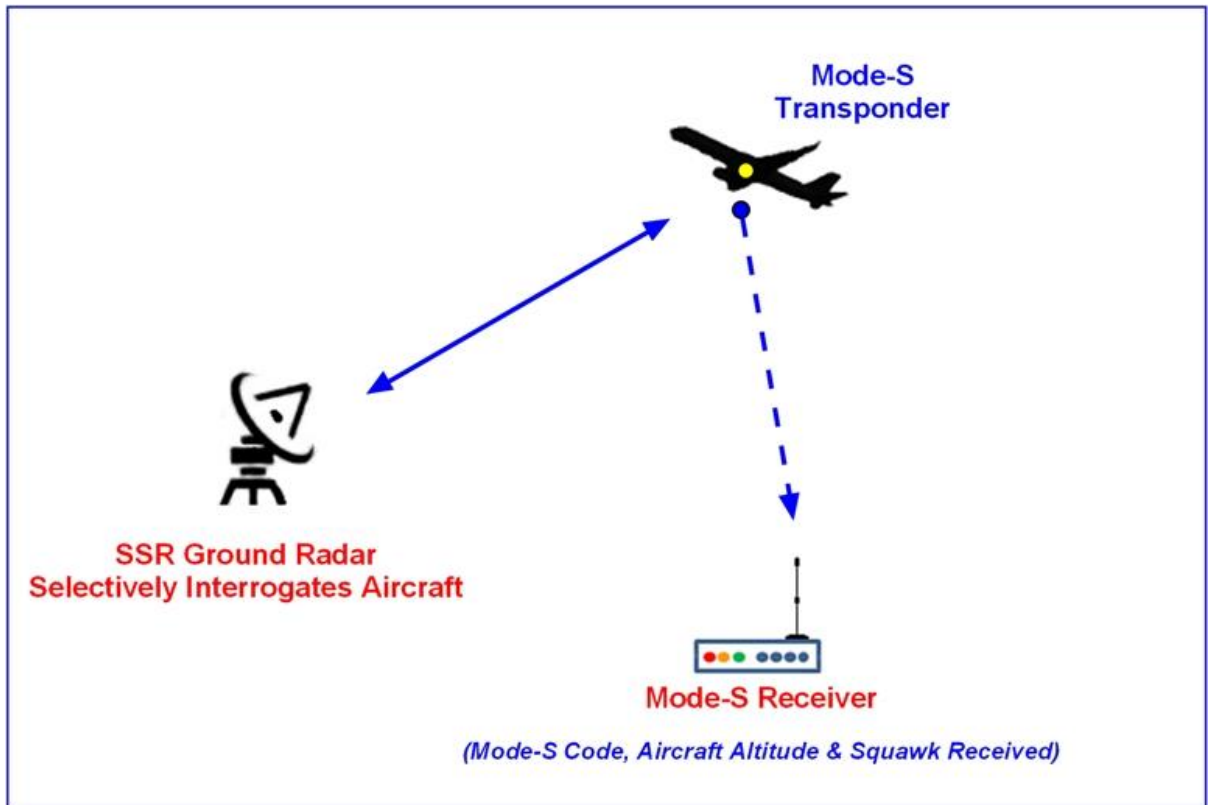


Figure 2 – Mode-S Interrogation

In the next diagram, the aircraft transponders are additionally ADS-B enabled and “broadcast” (independent of radar interrogation) extra data such as position, speed etc. The Mode-S receiver software can now plot the aircraft positions on a map.

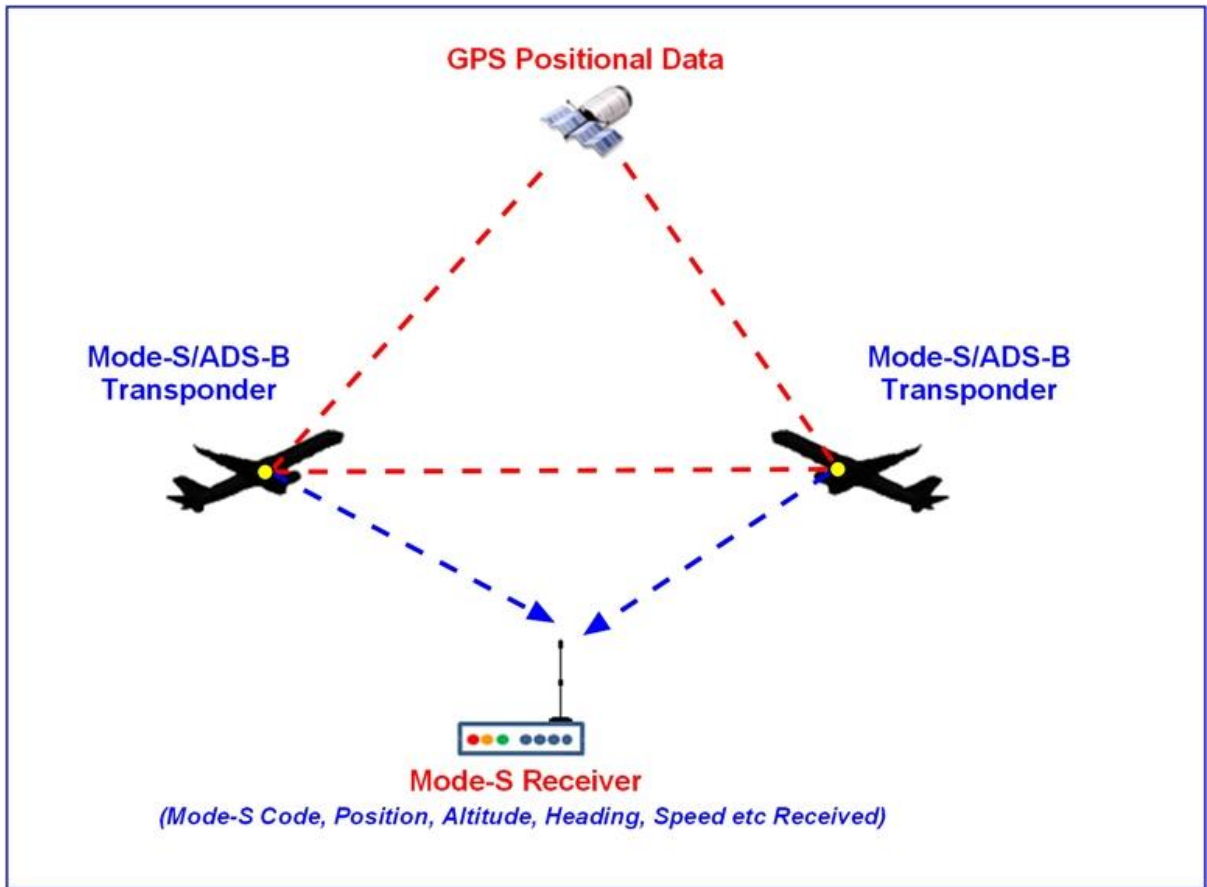


Figure 3 – Mode-S ADS-B

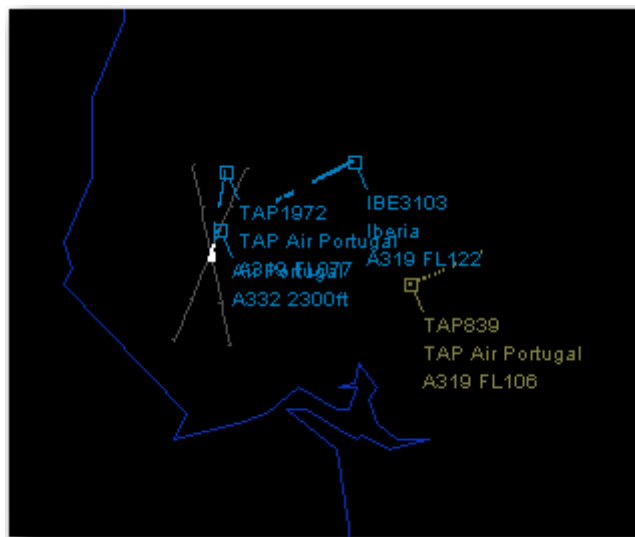


Figure 4 – Lisbon Traffic on a Mode-S Map

Mode-S ADS-B data is broadcast and isn't dependent on radar interrogation. ADS-B stands for **Automatic, Dependent, Surveillance, Broadcast**. In other words, the data is sent **automatically**, is **dependent** on an aircraft's on-board position source, such as GPS or Inertial Navigation Systems (in older aircraft), providing

surveillance information for others to use and is continually **broadcast** to a suitably equipped ground station or other aircraft, without being asked to transmit data.

There's one important thing to mention. Mode-S data is "line of sight". It doesn't usually travel around mountains or large buildings. Nor does it popup above the horizon. So, if you live 20 miles away from a local airport, the transmitted Mode-S data from an aircraft on the ground at that airport won't be available to a receiver in your location. Sometimes weather ducting may prove this wrong.

Typically, Mode-S data can travel up to 250 nautical miles or more if the transmitting aircraft is at a high altitude, say at FL400 (40,000ft). If the weather is favourable, the range can be greater. But if you live in a ground floor flat surrounded by skyscrapers, not much Mode-S data will get to you. Similarly if you live at the bottom of a valley in the Alps you may find the mountains get in the way!

Mode-S Receivers

This guide only covers enthusiast receivers, costing between 200 and 500 GB Pounds.

Commercial grade receivers cost much more and have additional features and are used by airports and aviation authorities.

The enthusiast market is dominated by **Kinetic Avionic Products' SBS-1**, launched in 2005. Now superseded by the SBS-3, at 130 x 95 x 25mm the SBS-1eR was quarter the size of the original and included an integrated AM/FM radio with software frequency control. The new SBS-3 was launched at the end of 2011 and includes twin Software Defined Radios (SDR) as well as a dedicated 1090MHz receiver for Mode-S data. It ships with a software package called **Basestation** to display Mode-S ADS-B data on a map and store received data in a local database.



Figure 5 - SBS-1eR



Figure 6 - SBS-3

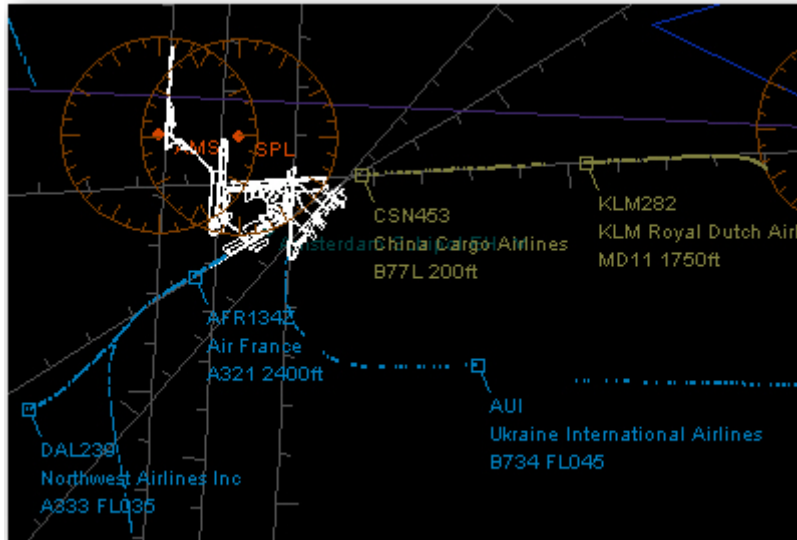


Figure 7 - Basestation, Amsterdam Schiphol

After the SBS-1 came the **RadarBox** from **AirNav Systems**. A similar sized receiver to the SBS-1eR but using different software.



Figure 8 – RadarBox

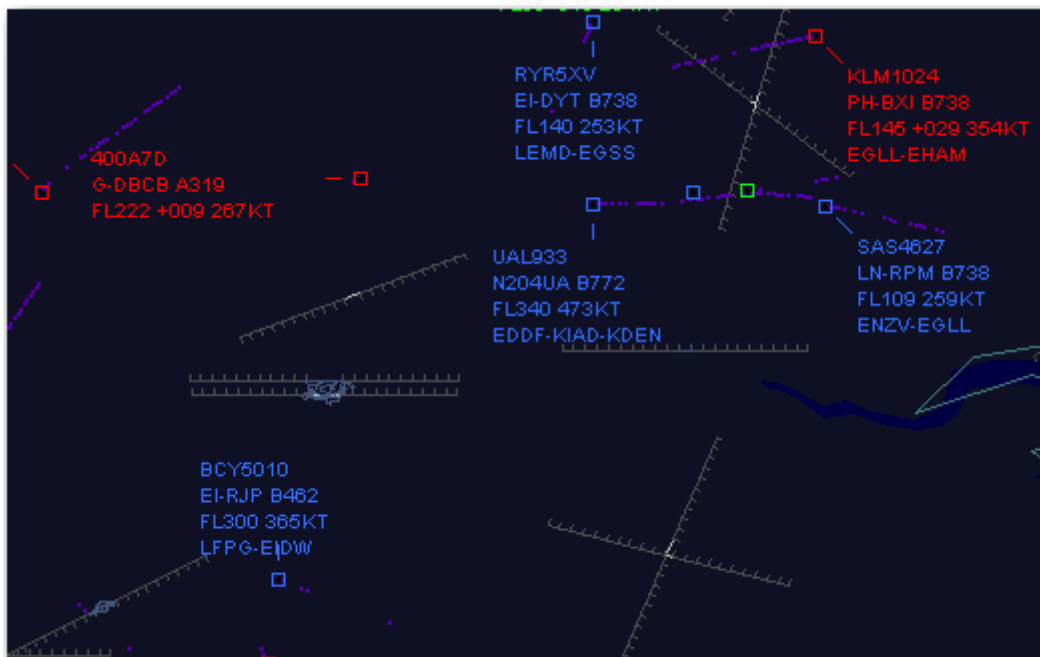


Figure 9 – RadarBox, London

There are two other commercially available enthusiast receivers – **PlaneGadget Radar** and **Aurora Eurotech** which, together with the SBS-1eR and RadarBox are described in the **Mode-S Receivers and Software Check-List** that members can freely download from the Radarspotting Forum:

<http://radarspotting.com/forum/index.php?action=tpmod;dl=item18>

There are also those enthusiasts who've manufactured home-built receivers and some of these may make it to market in due course.

Mode-S Receiver Software

The Radarspotting.com **Check-List** describes the software features, though not all are included with each Mode-S receiver. Common features include:

- Decode Mode-S into meaningful data, such as aircraft hex codes, altitude, position etc.
- Plot positional aircraft on a world map.
- Maintain a database of received aircraft.
- Include or use a third-party to convert the hex code into an aircraft type, registration and owner.
- Display a flight route, aircraft pictures and other helpful information such as the aircraft silhouette and airline logo.
- Share data with others.

Below is an example of how Basestation can display data received in an ADS-B Mode-S message for hex code 4CA2CB. The software has processed the decoded data from the SBS-1 and with the help of free “apps” can present this as an Aer Lingus flight EIN356 from Dublin to Munich operated by an A320 registration EI-DER, heading east off the Norfolk coast at Flight Level 369 (36,900 feet). The red circle/rectangle has been added by the author to highlight the aircraft.

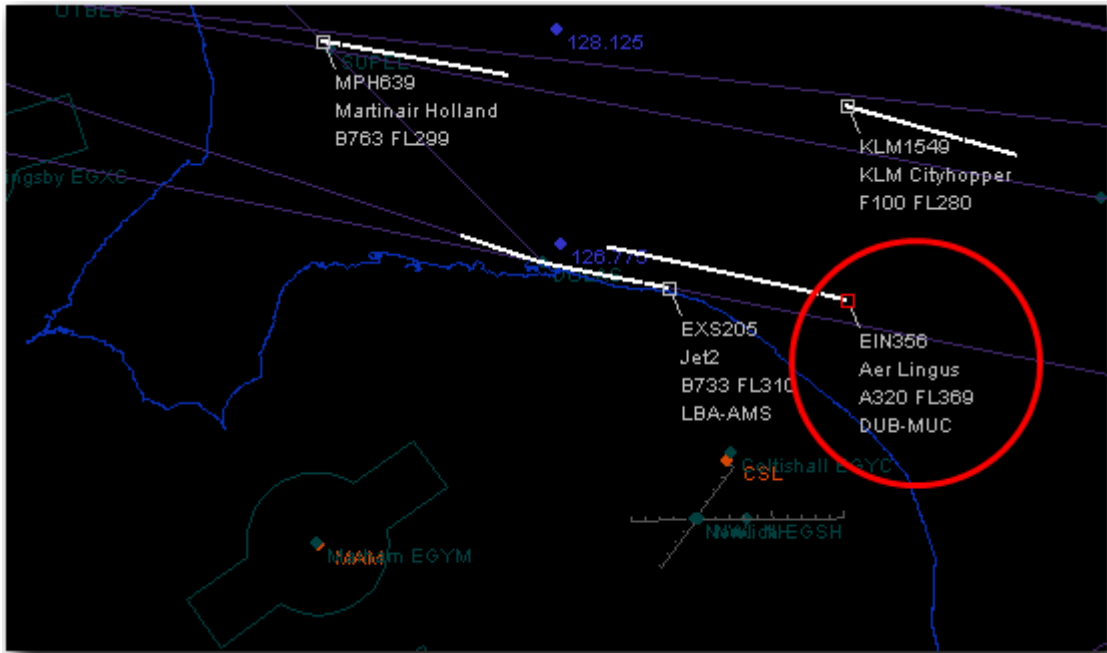



Figure 10- Basestation Map Plot

↘	✈		Aer Lingus	NA	EIN678	EI-DEA		A320	4CA213
→	✈		Aer Lingus	DUB-MUC	EIN356	EI-DER	2072	A320	4CA2CB


Figure 11 – Basestation Aircraft List



Aircraft Details

Flag: 
Status: Okay
Squawk: 2072




Lat: 52.942°
 Altitude: 36,975 ft
 Speed: 514.6 kts




Long: 1.529°
 Vert. Rate: 0
 Track: 102.7°

ModeS: 4CA2CB
 Operator: Aer Lingus
 Type: A320
 

Reg: EI-DER
 Country: Ireland
 
Route:
Flight No : EIN356
 

Squawk:

[Planepictures.net: EI-DER](#)
[Airliners.net: EI-DER](#)
[Jetphotos.net: EI-DER](#)

Type : Airbus A320-214 Current Flight No : EIN356	Serial No : 2583 Last Seen :	Notes :
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Links

[Airframes: EI-DER](#)
[G-INFO: EI-DER](#)
[G-INFO: 4CA2CB](#)
[FAA Registry: EI-DER](#)
[Planespotters: EI-DER](#)

Figure 12 – Basestation Aircraft & Flight Details

Basestation includes a database viewer called **Reporter** which records all the received data by hex code together with its associated flights. In the Reporter extract below, we can see that this same aircraft also operated EIN35Y and EIN35H on the same day, 06/12/2010.

4CA2CA	EI-DES	Ireland	A320		Airbus A320-214	No
4CA2CB	EI-DER	Ireland	A320		Airbus A320-214	No

Records 1 to 50000 31735 of 50000 No filter

Flights For Selected Aircraft

Start Time	End Time	Callsign	FirstIsOnGr...	LastIsOnGr...	FirstLat	LastLat
06/12/2010 16:30:27		EIN356	No	No		
06/12/2010 12:19:57	06/12/2010 13:47:53	EIN35Y	No	No	50.93587	53.65634
06/12/2010 11:50:25	06/12/2010 11:54:20	EIN35Y	No	No	48.452	48.5977
06/12/2010 10:33:54	06/12/2010 10:41:42	EIN35H	No	No	48.54785	48.33212
06/12/2010 09:03:25	06/12/2010 10:09:47	EIN35H	No	No	53.47465	51.05548
05/12/2010 22:06:42	05/12/2010 23:25:52	EIN6N7	No	No	50.50992	53.63502
05/12/2010 19:14:07	05/12/2010 20:21:00	EIN65A	No	No	53.42973	51.10323
05/12/2010 13:39:12	05/12/2010 15:02:04	EIN33W	No	No	52.54514	53.58495
05/12/2010 10:30:30	05/12/2010 11:33:52	EIN33E	No	No	53.55203	53.03893

Figure 13 - Basestation Reporter

Other products offer similar functionality.

As well as spotting aircraft from your own Mode-S receiver, there are options to “share” data from other receivers. Some of these incur monthly charges, such as the AirNav network, or the one-off €25 PlanePlotter registration or better still free community networks. Alternatively you can use the free aircraft tracking websites, such as FlightRadar24.com.

Here’s my Basestation map with shared data.

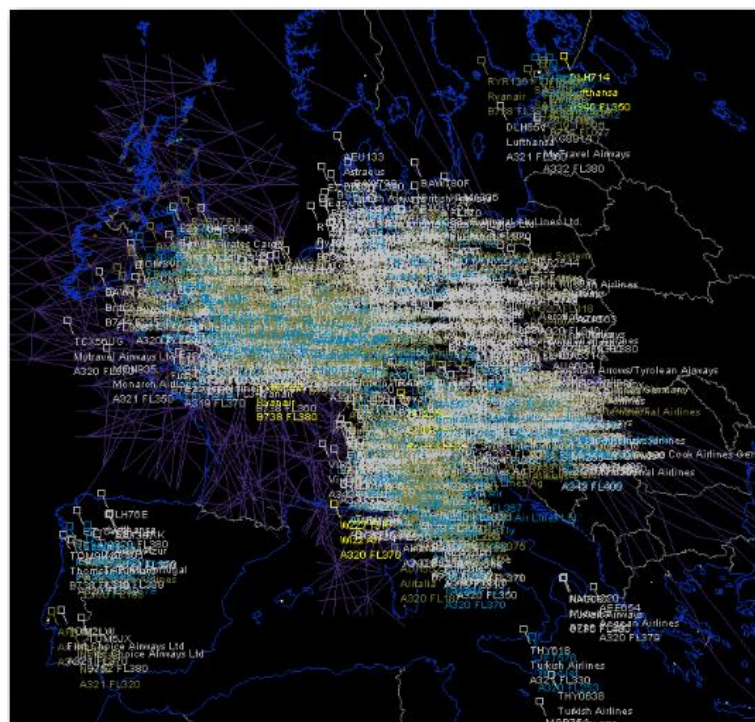


Figure 14 - Shared Data on Basestation Map

Aircraft Tracking without a Mode-S Receiver

I'm often asked what's the difference between buying a Mode-S receiver, using PlanePlotter without a receiver or using aircraft tracking websites. Here's how they typically compare:

Options?	Typical Cost?	Internet Required?	Customised Setup?	Local Database?	Local Software?	Any Dependency?
Mode-S Receiver	€250 to €550	No	Yes	Yes	Yes	None
PlanePlotter	€25	Yes	Yes	Yes	Yes	Data Sharers
Websites	Free	Yes	No	No	No	Data Sharers
Phone Apps	€3 to €5	No	No	No	No	Data Sharers

If you buy your own receiver, you can choose where to use it and can receive data from aircraft in your local vicinity. You'll be able to customise the software setup and maintain a local aircraft and flights' database. Buy you could end up spending a lot of money on the receiver and optional items such as an external antenna (for greater range) and subscribing for shared data.

A lower cost option is to buy a one-off PlanePlotter licence for just €25 and view aircraft from other people's Mode-S receivers. Unlike your own receiver which updates positions every few seconds, PlanePlotter data is refreshed once every minute and you have no control over what you'll see. The PlanePlotter software offers some customisation and "borrows" the Basestation database layout which can be maintained locally. PlanePlotter can also be used in conjunction with a Mode-S receiver and is the software that's shipped with the PlaneGadget Radar.

The cheapest options, and a great introduction to radarspotting, are the free aircraft tracking websites. These are fed data from Mode-S receivers and you get what's available. If there's no feed from a receiver in your location, you may not see local aircraft or only those at very high levels. And experience shows that feeds to these websites come and go. The feeders take holidays, go to bed and sometimes sell their receivers!

Similarly, the mobile phone apps rely on the same network of feeders and you get what's available. And at present, there are whole swathes of the globe that aren't covered.

Let's look at these options in more detail.

PlanePlotter

PlanePlotter (PP) is a very good product. Many Mode-S receiver users have added it to their Radarspotting tool kit, mainly to share data with others, see beyond their

local area and take advantage of PP's unique Multilateration (Mlat). Mlat is a complex topic so I'll keep my explanation fairly simple.

As mentioned earlier, not all Mode-S transmissions include positional data. Typically private and military aircraft don't transmit positions nor do some larger aircraft operated by airlines such as Flybe.

Mlat uses data from three or more Mode-S receivers to calculate the aircraft's location by means of geometry. The PP Mlat tutorial explains:

If you know the precise distance between an unknown location and three known locations, then it is simply a matter of geometry to determine the position of the unknown. In the case of multilateration using radio signals, the distance is measured in terms of the travel time of the signal, at the speed of light (300 metres per microsecond).

As I said, it's a complex subject. Let's just say that PP Mlat is sometimes able to plot the whereabouts of non-positional Mode-S aircraft. Commercial grade Mode-S receivers, such as Kinetic's SBS-2 offer Mlat but at a much higher price than the enthusiast can justify.

The three PP images below show:

- Aircraft from my Mode-S receiver located near Peterborough, UK, white plots.
- Shared data from other PP users (cyan plots) together with my locally received data.
- The third only shows Mlat plots.

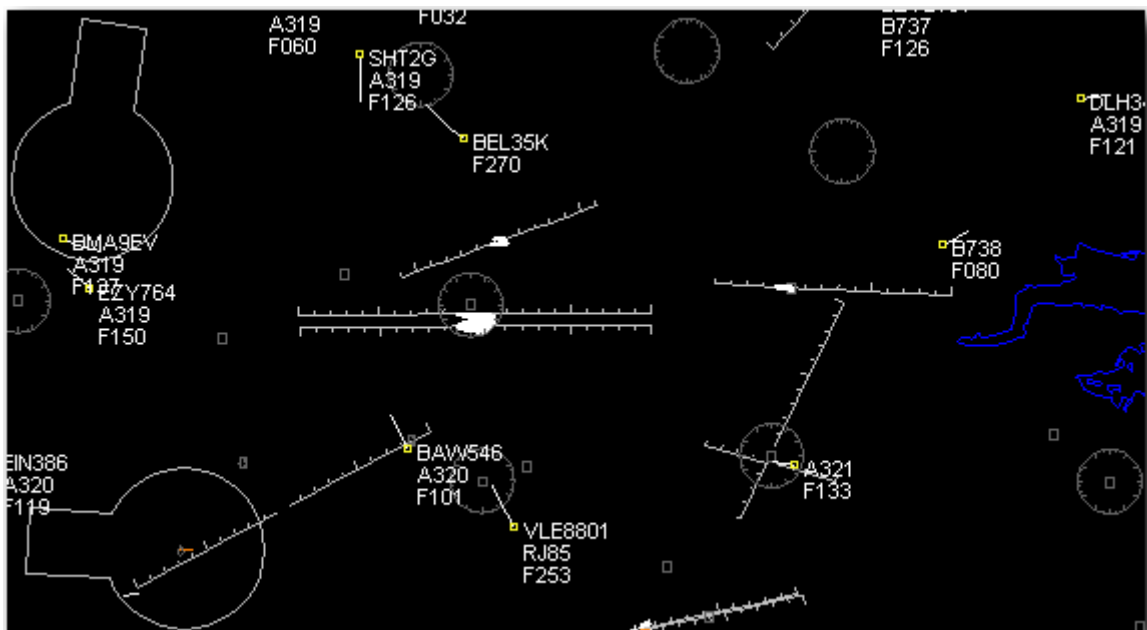


Figure 15 - Local Data

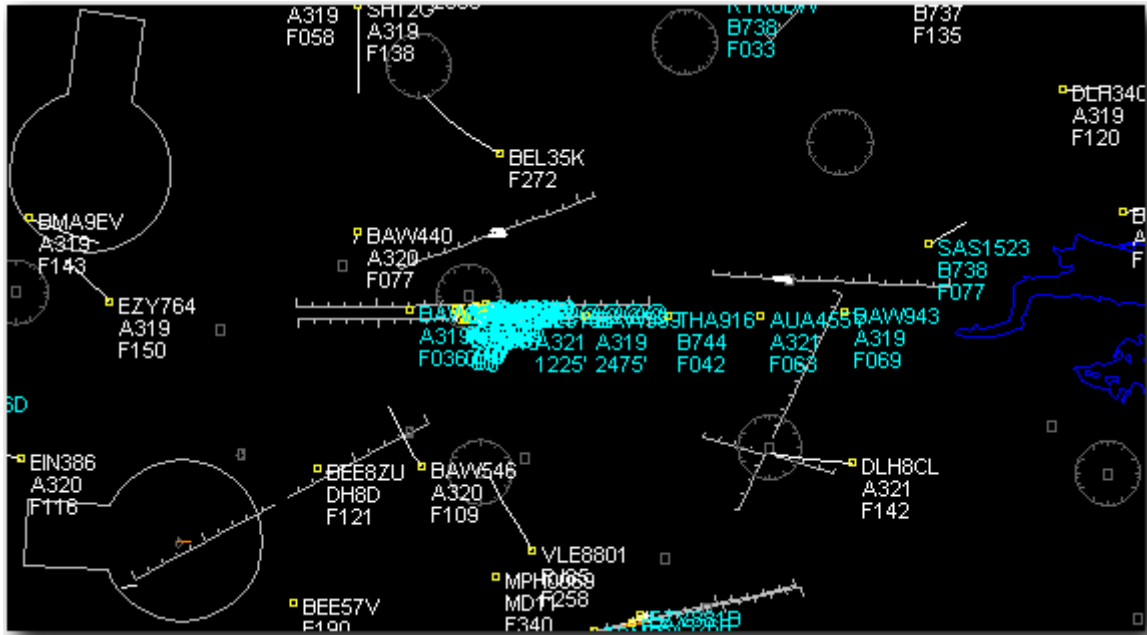


Figure 16 - Local (white) and Shared (cyan) Data

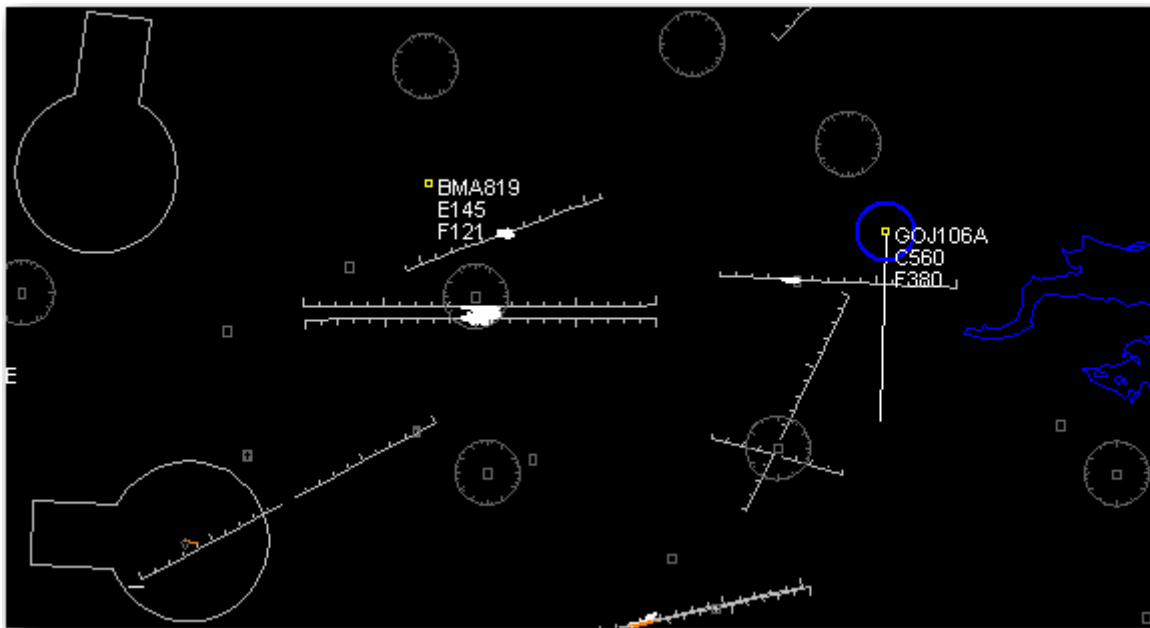


Figure 17 - Mlat Plots

There's much more to PP and I recommend visiting the COAA website – www.coaa.co.uk.

Aircraft Tracking Websites

Over the last year, websites have appeared offering real time aircraft tracking. Most are free to use though some may charge.

For many years we've had "flight tracking" sites which can "track" a single airline flight. These have typically used Federal Aviation Authority radar feeds, mostly covering the USA, with tracks delayed by 5 minutes. Such sites include:

- <http://flightaware.com/>
- www.flightstats.com
- www.flytecomm.com

We now have aircraft tracking sites which will show Mode-S positional flights across the world. Data is typically uploaded by Mode-S receiver users to a central server where it's aggregated and displayed on a Google map. Free to use, these sites are generating advertising revenue or promoting related products. The data is usually live with refresh rates of between 20 – 60 seconds.

As mentioned earlier, these sites are totally dependent on the sharing of data from a community of Mode-S receivers. Global coverage is incomplete but expanding all the time.

Here are some examples from the www.flightradar24.com website:

www.flightradar24.com

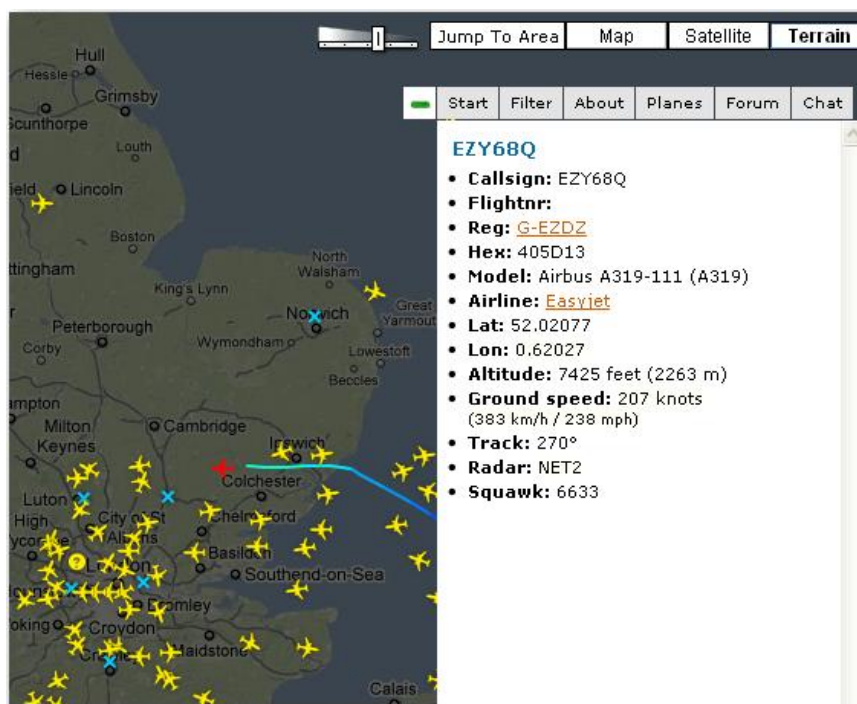


Figure 18 - Flightradar24.com

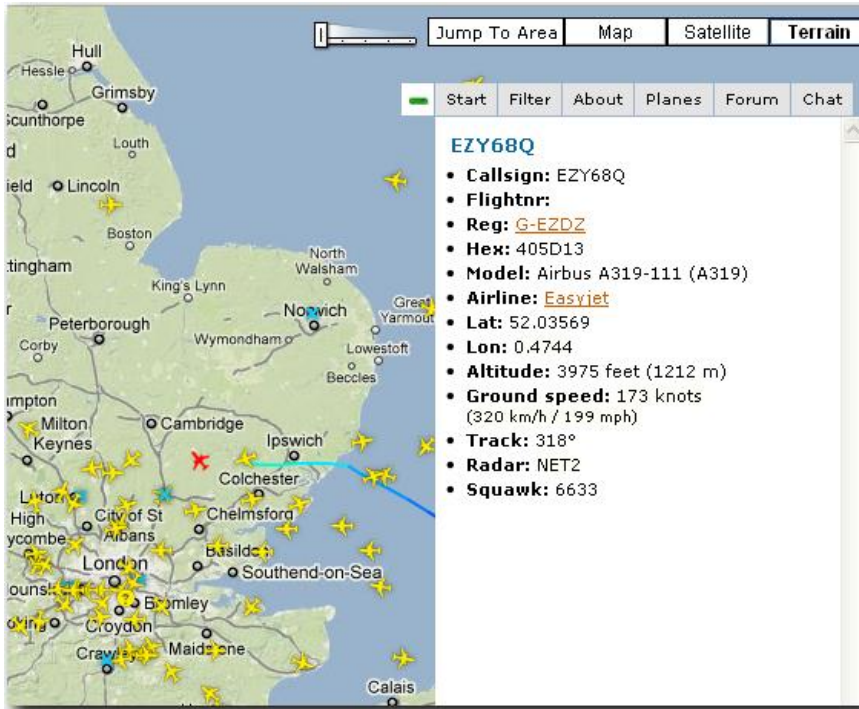


Figure 19 - Max Brightness Slider



Figure 20 - Road Map View



Figure 21 - Satellite View

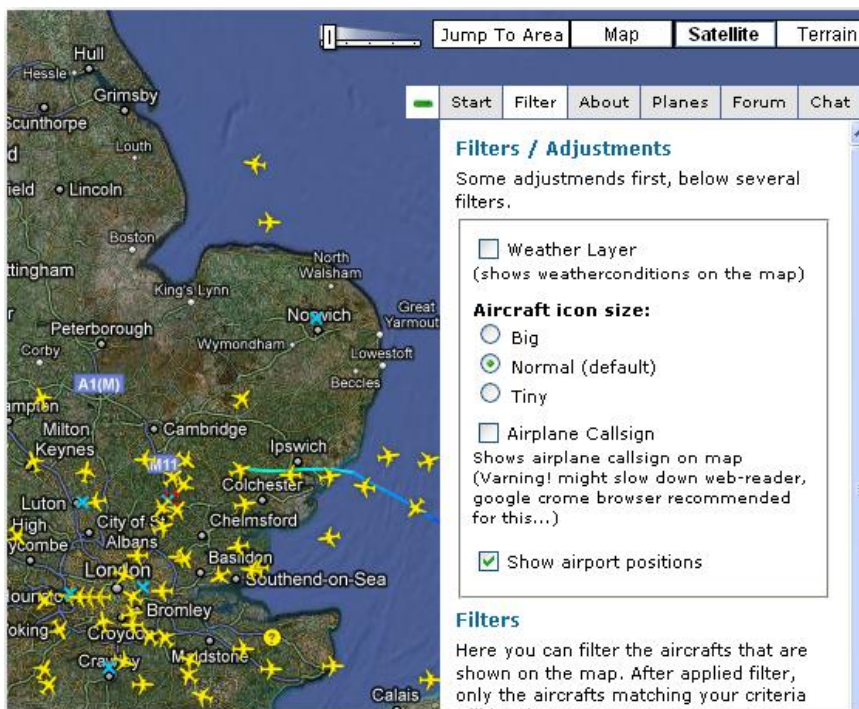


Figure 22 - Filter Options

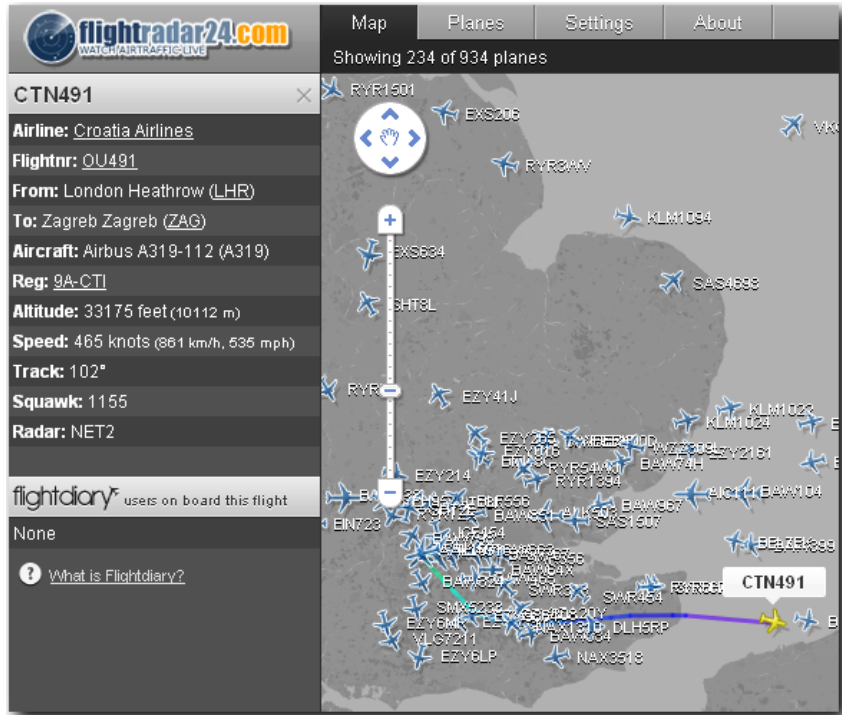


Figure 23 - New Flightradar24 Beta Site

As can be seen the website offers a high degree of visitor configuration and a useful set of filters. To fully understand what's available you must visit the website and compare with others such as:

www.radarvirtuel.com

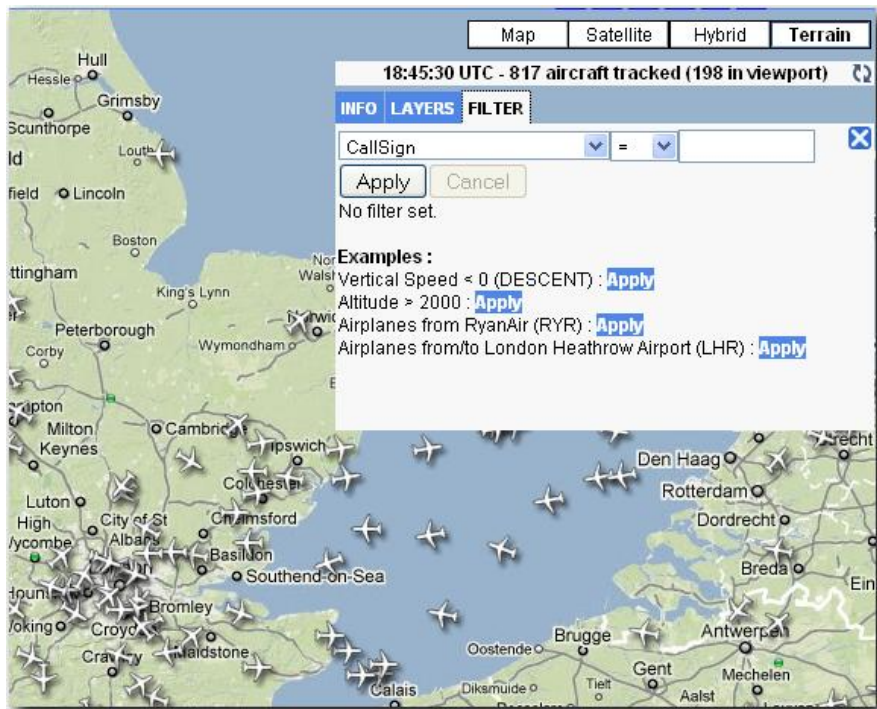


Figure 24 - RadarVirtuel

www.planefinder.net



Figure 25 – PlaneFinder

<http://casper.frontier.nl>

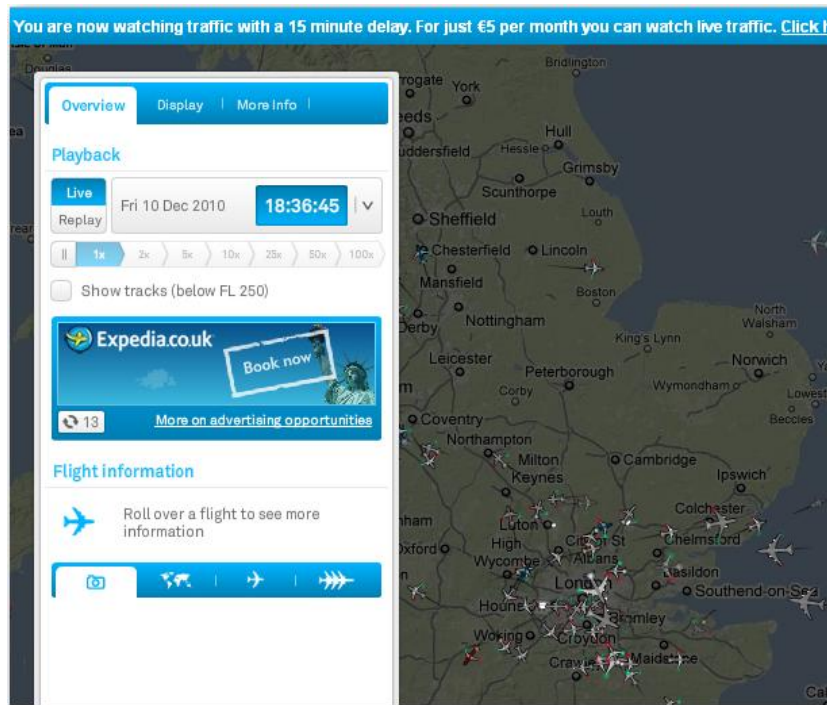


Figure 26 – Casper

Casper offers a free display by selected locations with 15 minute delayed data. Live data is available by subscription for €5 per month.



Figure 27 - Atlas by Flightglobal

The Mobile Phone Apps

If you have an iPhone, iPad, iTouch or an Android mobile phone you can use them to track aircraft using one of the available apps, either free or paid versions.

As with the websites, the apps rely on data being uploaded from a community of Mode-S receivers.

The first app for the iOS (iPhone) was launched by a UK based company called **pinkfoot** which later launched apps for the Android operating system.

www.pinkfoot.com.

At the time of writing pinkfoot has a number of phone apps:

Plane Finder Version 3.0 priced GBP £2.99.

The original plane tracking app.

Plane Finder Free.

A free version of the Plane Finder app that includes live data.

Plane Finder HD Version 3.00 priced GBP £4.99

Plane Finder for the iPad! All the features of Plane Finder engineered for the iPad display.

Plane Finder HD Free

A free version of the Plane Finder HD App that includes live data.

Plane Finder AR Version 2.01 priced GBP £1.99

Point the camera of a compatible iPhone at an aircraft and find out the flight number, registration etc. Shows you what's flying overhead, through clouds and walls!

Plane Finder AR Free Version 2.0

A free version of the Augmented Reality Plane Tracking app.

Plane Finder Android

Free and Paid GBP £2.50. Live flight tracking for the Android platform.

Plane Finder for Windows Phone priced GBP £2.29

Live flight tracking for the Windows Phone platform.

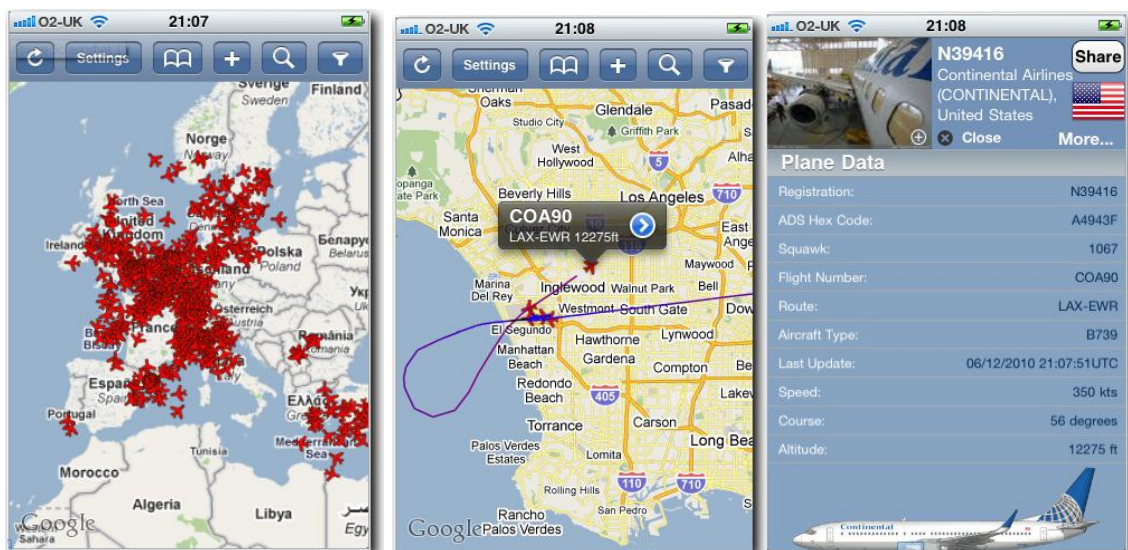


Figure 28 - iPhone



Figure 29 - AR (Augmented Reality)

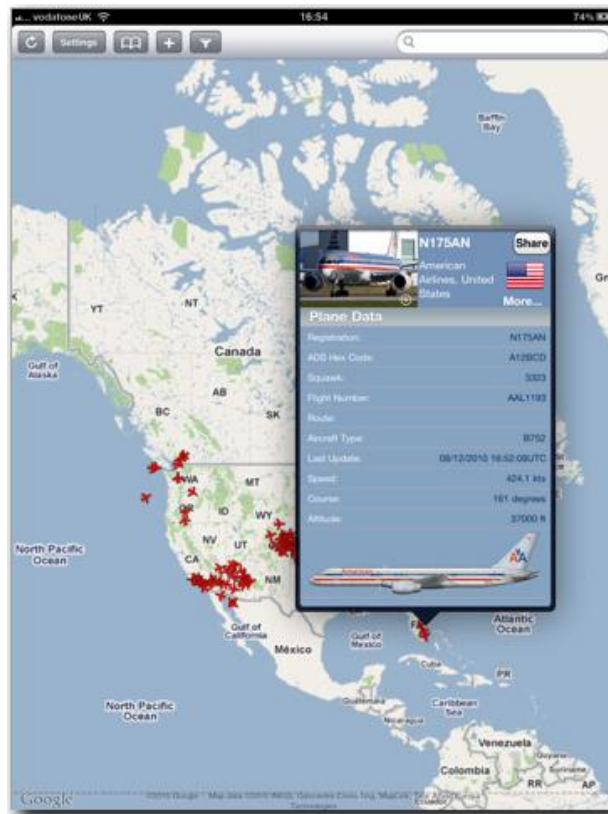


Figure 30 - iPad



Figure 30 – Android Free and Paid

www.flightradar24.com

Next came apps from Flightradar24.

Flightradar24 Free Version 1.3.1 for iPhone – Free

Flightradar24 Pro Version 3.4 GBP £1.99

For iPhone, iPad and iPodTouch. Includes HD and AR (Augmented Reality)

Flightradar24 Free for Android – Free

Flightradar24 Pro for Android – GBP £2.50

For Android phones. Includes AR (Augmented Reality)



Figure 31 – FlightRadar24 iOS with AR



Figure 32 – FlightRadar24 Android Free

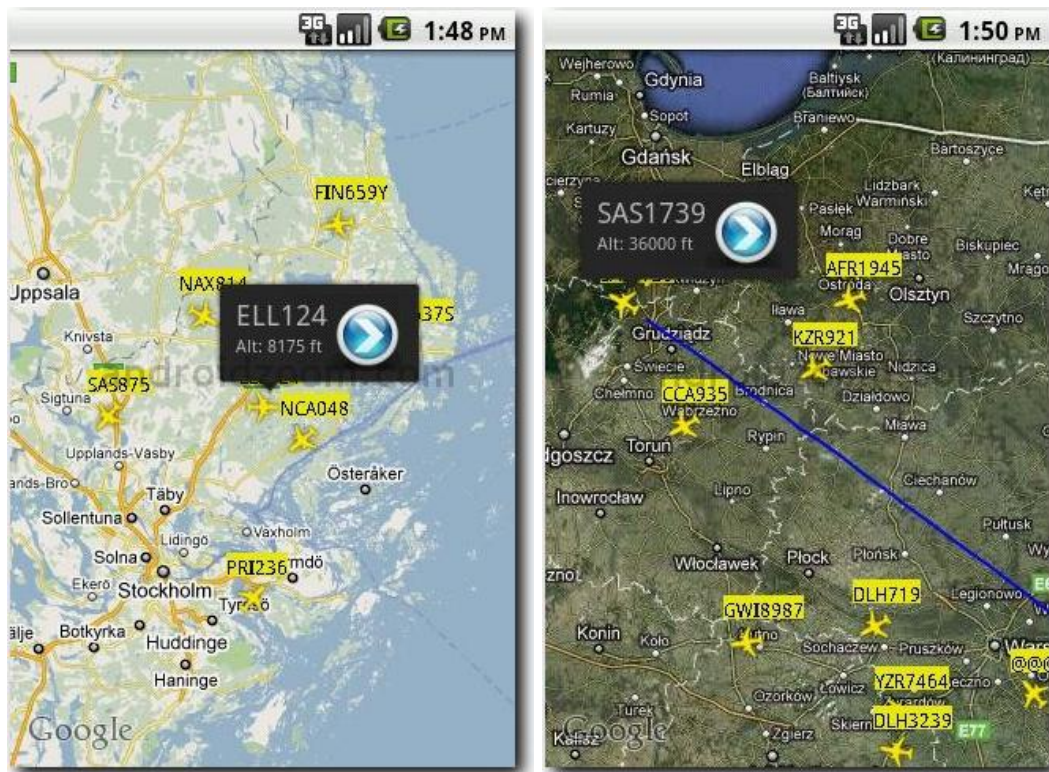


Figure 33 – FlightRadar24 Android Paid

Summary

Radarspotting is here to stay and, hopefully, develop even further. No self-respecting spotter should ignore the possibilities, from running one's own Mode-S receiver, using the free aircraft tracking websites or the fun of Augmented Reality on a mobile phone to spot through walls and clouds.

If you're into aircraft spotting, explore further and discover for yourself the exciting possibilities. It doesn't cost you anything. But if you get bitten you may soon be adding a Mode-S receiver to your inventory and be warned, Radarspotting can become quite addictive.

Links

Aircraft Tracking Websites and Mobile Phone Apps

Atlas	www.flightglobal.com/atlas
Casper	http://casper.frontier.nl
FlightRadar24	www.flightradar24.com
PlaneFinder	www.planefinder.net
RadarVirtuel	www.radarvirtuel.com

Flight Tracking Websites

Aeroseek	www.aeroseek.com
Flightaware	http://flightaware.com
FlightExplorer	www.flightexplorer.com
Flightstats	www.flightstats.com
Flightview	www.flightview.com
Flightwise	www.flightwise.com
FlyteComm	www.flytecomm.com

Mode-S Receivers and Software

AirNav Systems	www.airnavsystems.com
Aurora Eurotech	www.auroraeurotech.com
Kinetic Avionic Products Ltd	www.kinetic-avionics.com
PlaneGadget Radar	www.radargadgets.com
PlanePlotter	www.coaa.co.uk

Radarspotting Forums

AirNav Forum	www.airnavsystems.com/forum
Kinetic Forum	www.kinetic-avionics.co.uk/forums
PlanePlotter	http://groups.yahoo.com/group/planeplotter/
Radarspotting Forum	http://radarspotting.com/forum

Aviation Resources

Airliners.net	www.airliners.net
Aviation Herald	www.avherald.com
Eurocontrol	www.eurocontrol.int
Gatwick Aviation Society	www.gatwickaviationsociety.org.uk
Libhomeradar	www.libhomeradar.org
Skyliner	www.skyliner-avation.de