

### PilotAware Antennas, Installation and Operation.

Thank You for Purchasing PilotAware. This document has been produced to provide information on antennas their differences and how you can get the optimum performance from your PilotAware Classic.

#### Standard PilotAware Antennas

There are two antennas used on the PilotAware Classic.

1. The first antenna looks like the one to the left in the photograph below and is used to receive signals at 1090MHz which include the Mode C/S and ADSB transmissions.



This ADSB-In antenna is connected via the RTL USB dongle shown to a USB port on the Raspberry Pi computer and is used to receive ADSB-In and Mode C/S signals at 1090 Mhz. The USB dongle can go into any of the four ports of the Raspberry Pi but by convention it is usually located in the bottom left USB port.

This antenna is not optimized for 1090Mhz, but the signals from ADS-B equipment are very strong and can be picked up very easily by this antenna. You will receive aircraft transmitting ADS-B from as far away as 150Km with this antenna in its standard form. If necessary, this simple antenna can be reduced to 68mm in length to improve reception or if space is required to fit on the coaming. The antenna on the right has been cut to the optimum length of 68mm which is roughly half the original size.

2. The second antenna is called an 'end feed dipole' antenna and screws into the 50ohm male SMA connector on the PilotAware Classic Unit. It looks like this.



The PilotAware radio transceiver which we call P3I (Pilot Third Eye), operates at 869.525MHz and has been designed to meet The European Telecommunications Standard Institute (ETSI) requirements. This is defined in the ETSI specification EN 330-220 (Short range radio devices).

### **Temporary or Permanent Installation?**

PilotAware is sold as portable carry on equipment. However, it is also capable of being used in a more permanent installation but this will be subject to meeting the local regulations and gaining the relevant approval(s) from the agency that certifies your particular aircraft. It is your responsibility to ensure that this is done correctly for your particular application, particularly if modifications are done to the airframe. Advice on specific requirements in the UK can be gained from your CAA, LAA or BMAA inspector.

### **Positioning the Antenna(s) for Optimum Performance**

Whether a temporary or permanent installation is used, a rudimentary understanding of the relevant laws of physics will help you decide what antenna to use and, more importantly for this article, specifically where the antenna(s) are located.

This is a simple explanation, written for the majority of users to understand and help them position their PilotAware Classic units and antennae for maximum effect. More technical

users with even better understanding will hopefully post their advice on the PilotAware Forum [forum.pilotaware.com](http://forum.pilotaware.com) to help optimize the advice given here. Radio engineering solutions, as the Buddha would say, have many paths to perfection.

PilotAware, uses the open unregulated 869.525 MHz Band to transmit and receive signals between participating aircraft. This is how we can See and be Seen. Where we position the antenna has a considerable effect on the performance of PilotAware both in its transmission and reception. In tests we have shown that with a correct type and a correctly positioned antenna, PilotAware has a range of 20+Km, more than enough for a secondary conspicuity aid. So what stops PilotAware achieving this from any location in the aircraft? The following paragraphs are provided to help you understand why.

### **Attenuation**

Radio waves prefer what we call 'free space line of sight'. For our purpose we can assume that they work best in cold dry air with nothing in the way. Unfortunately, this is the best case and is virtually never achievable. Things do get in the way and even the air can have variable density (due to temperature and humidity), all of which have a detrimental effect on performance. In the same way that a frosted glass window will disrupt light waves and a brick wall will completely stop them, some things will totally block, partially block or distort radio waves. This is particularly so in the case of metal. If you want to prove this put a radio in a sealed biscuit tin and you will see that it doesn't work. Likewise, if PilotAware is put into a sealed metal aircraft it will not work properly.

Fortunately, all metal aircraft are not completely sealed as they have doors and windows which let in radio waves. This is one of the reasons, why your mobile phone sometimes works in the air, but it's not ideal. Also in most aircraft there is a huge mass of metal engine usually up front, or in the case of a micro-light weight shift or pusher aircraft, behind the pilot which will absorb a lot of the radio energy emanating from PilotAware reducing the range. Get the idea? When radio waves go through metal they are significantly reduced, or attenuated as the radio engineers say.

Attenuation also happens when radio waves go through water. To prove this put your radio in a bucket of water and again it will not work. Oh no! sorry, that's for a completely different reason, so don't try that at home.

So where is the water in a light aircraft, particularly with an air cooled engine? Well I'm sorry to have to say this but as far as physics is concerned, radio waves regard you, the pilot, and your passengers as a big bag(s) of water. That's how microwave ovens work by heating up the water in the stuff you put into them. Makes sense?

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Therefore, you need to position your antenna such that it avoids the metal and water in your aircraft.



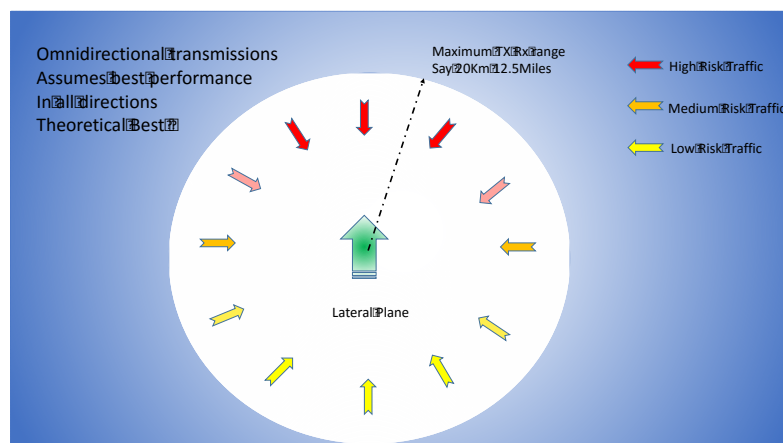
### Positioning the antenna

If you position the antenna directly behind a front mounted engine the signal will be attenuated (lowered) going forwards. If you position the antenna in front of the pilot and passenger the signal will be attenuated (lowered) going backwards.

Therefore, for an internally mounted antenna, depending on your aircraft configuration you need to position the PilotAware where it transmits and receives with a clear view of the surrounding sky and avoiding as much metal or water as possible. Either to the front the back or side to side. If you don't it will still work but not as well! So if you have PilotAware installed temporarily in your aircraft make sure that it has a good view of the sky and avoids the water and the metal.

For pragmatic reasons the transmission of PilotAware Classic should be considered as omnidirectional. That is radiating out in all directions.

The diagram below (fig1) shows that the probable risk of collision is greatest in an 180° arc in front of the aircraft. The risk gets less as we move to the rear of this until a collision from directly behind is very low.



Therefore, when positioning your antenna, you should (i) account for the position of other aircraft into account and the probability of them being a real risk, (ii) the position of the metal and water content of your aircraft that will be in the way of your omnidirectional transmissions.

For example, an antenna mounted on the coaming, in front of the pilot and passenger, will have a good range looking forwards and sideward but will be attenuated in a forwards and slightly downwards direction because of the engine and rearward direction because of the passengers.

There is no need to look at all configurations here as these will be different for each aircraft and as time progresses the good folk on the PilotAware forum [forum.pilotaware.com](http://forum.pilotaware.com) will, no doubt, give advice on all aircraft types.

Antennas mounted outside the aircraft are usually best as they put distance between the transceiver, the metal and the water but this may not always be possible.

### Monopole or Dipole?

You may have heard of monopole and dipole antennas. What's this all about? Well without getting into detail all you need to know is that with a monopole antenna you need an earth plane with a dipole you don't. Monopoles with a good earth plane are usually more efficient than dipoles.

The PilotAware Classic comes complete with an end-fed dipole antenna as standard for P3I and so no earth plane is required. Centre fed dipoles which are also called horn antennas, are also available from [pilotawarehardware.com](http://pilotawarehardware.com). These are connected to an extension lead so can be fitted remotely to the PilotAware unit if this fits your installation better.

An earth plane is a metal base usually aluminium, that the antenna sits on and to which the outside metal part of the antenna is connected. The bigger the better but a piece of aluminium about 1/16" to 1/4" thick, by about 6 inches square or a similar area that fits the space you have will do. The picture below shows an earth plane for a monopole antenna.



This is what the antennas look like from the outside



More information on a permanent installation for PilotAware including antenna installation can be found at <http://www.pilotaware.com/wp-content/uploads/2016/09/160915-Permanent-Installation.pdf>

Obviously to fit an antenna(s) so that it is outside the aircraft will require drilling a hole(s) in a metal, wooden or composite aircraft, including the pod on a trike, or fixing the antenna to an aluminium brace and cutting the fabric, on a tube and fabric aircraft such as a Cub, Eurofox or SkyRanger.

Usually 2-3 metres of extension cable is sufficient to facilitate the antenna extension and this has been shown to work well. Both the PilotAware P3I Tx/Rx antenna and the ADSB Rx antenna will benefit from external mounting however as the ADSB-in is receive only and the 1090MHz transmissions from ADSB are much stronger this is usually less of a problem for up to a 20Km range. Extension cables and antennas, both monopole and dipole, are available at [pilotawarehardware.com](http://pilotawarehardware.com).

### **Approval**

If you do wish to install an external antenna, the manufacturer of your aircraft or importer, should be consulted as to the best practice to fit an external antenna for your type of aircraft. Also your licensing authority such as the CAA, LAA, BGA, BHGA or BMAA in the UK, will need to be consulted for the relevant approval.

This may require the granting of permission so to do, a fee and an inspection by an authorized inspector following the installation. As owner of the aircraft it is your responsibility to ensure that this is done correctly and in order. In other European countries the regulation process may differ and it is your responsibility to ensure that you adhere to these local regulations.

### **In summary**

It testing PilotAware Classic, the positioning of the antenna has been shown to be very important to get the best out of your PilotAware installation. With a good installation more than 30Kms transmission distance has been achieved on several aircraft types. No doubt, as more and more different types of aircraft are fitted with PilotAware units, advice will be forthcoming on the best place to fit the antenna in each aircraft type. Keep an eye on the PilotAware Forum. [forum.pilotaware.com](http://forum.pilotaware.com)

So, remember the basic physics when locating your antenna so that you have the best chance of **Seeing and being Seen**.

**The PilotAware Team**