Summary

The design criteria for PilotAware is a transmit and receive performance, of a well installed carry on device of 30KMs. In practice this has been exceeded. Unfortunately, attenuation and obscuration will reduce or eliminate this. However by using remote internal or external antennas both obscuration and attenuation can improved and an optimum performance for your aircraft can be achieved.

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Introduction

Both PilotAware Classic and PilotAware Rosetta units can be used as carry on equipment, but unlike some other carry on Electronic Conspicuity devices they have also been designed for use with Remote External or Remote internal Antennas. This document describes how remote antennas may be used and why they will improve the performance of any installation.

In addition, when installing remote antennas and a remote GPS mouse, the PilotAware units can be installed behind the dashboard or other places, and therefore be conveniently out of sight but not shielded from working properly.

PilotAware uses 2 antennas. A small one and a larger one. On the PilotAware Classic unit the smaller antenna is a very thin antenna on the end of a thin coaxial cable that can be mounted away from the main unit. On the Rosetta unit the smaller antenna is connected to the Rosetta case for convenience.

The larger antenna is the transmitting and receiving antenna that operates on the PilotAware frequency of 869.525Mhz. This communicates with other PilotAware units and also with the ATOM

GRID network. The ATOM ground station uploads METARs and the location of FLARM and Mode-S equipped aircraft, augmented with a bearing using multilateration, through this larger antenna.

The smaller antenna receives 1090MHz that directly receives ADSB targets and also Mode-S and Mode-C targets without a GPS bearing.

How the Classic and Rosetta units work and what you will and will not see when in range of an ATOM station or not is described in the following YouTube videos.

PilotAware Rosetta Introduction
https://www.youtube.com/watch?v=zyAfh2xhA50&t=0s

PilotAware Atom GRID Introduction
https://youtu.be/A8TtscFCRKo

To understand the difference between Mode-S reception and enhanced Mode-S/3D reception using MLAT available via the ATOM GRID Network please see this YouTube Video.

PilotAware ATOM GRID Mode-S 3D
https://youtu.be/wCjRKH3F_Wo

Why do we need remote antennas?

Carry on devices are fine if they are used correctly. However, carry-on EC devices are not all just fit and forget items. The problem is airframe obscuration and attenuation. This affects all devices but it is more prevalent amongst carry-on devices. The performance reduction is mainly caused by a combination of bad location, incorrect antenna orientation and poor GPS reception.

The UHF radio signals, used by all EC devices, are obscured (completely shielded) by radio opaque objects such as metals or carbon fibre. The engine and airframe are the biggest culprits. The primary effect of airframe obscuration is to prevent the radio waves transmitting in the direction of the obscuring object.

For example, if you put an EC device on the rear shelf of a metal or carbon fibre aircraft such as a RANS, Sportscruiser or Sting, it will be completely obscured to the rear as the signal fails to pass through the metal or carbon fuselage. If the device is positioned low enough, it will also be blocked by the engine and firewall in the forwards direction. Fibreglass airframes such as the Europa or tube and fabric aircraft like the Eurofox will be less affected, but the engine and occupants will still block the signals in the forwards direction. There is a PilotAware YouTube video that describes this further.

PilotAware Atom GRID Features and Obscuration
https://youtu.be/J1imxhjG8ds

The signals are also attenuated by dense objects and liquids such as the fuel in fibreglass or polypropylene fuel tanks and the water in the occupants bodies. The effect of this is to weaken the signals, and hence reduce the effective design range of the device. Received signals are always weaker than transmitted signals.

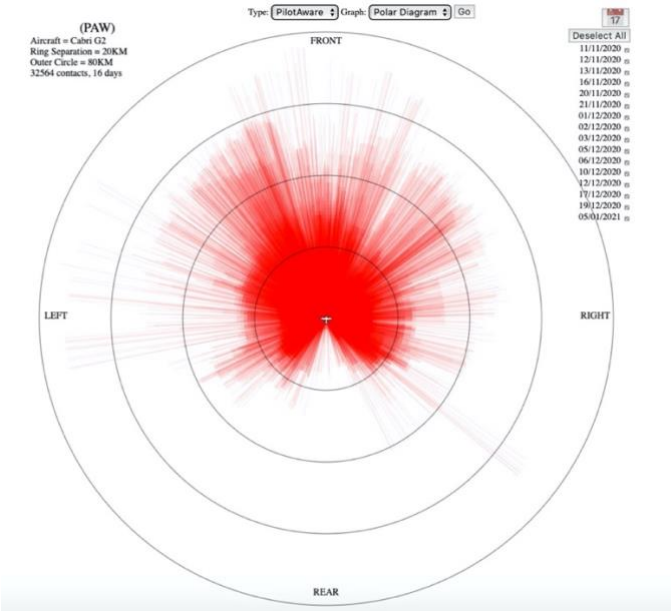
These effects are well understood and performance is improved by placing remote internal antennas inside the aircraft at optimal positions or better still remote antennas outside of the aircraft. This is always done with transponders and VHF radios and therefore, is also the best option for EC performance improvement.

PilotAware and Obscuration
https://www.youtube.com/watch?v=Xu8a0f0PkzY&t=0s

What Should be Expected of a Well Installed Carry on Device?

As mentioned earlier, there is nothing inherently wrong with a well-designed carry on device that has been installed properly. As shown this should have a clear line of sight for both antennas, which will be vertically oriented and also a clear line of sight for the GPS. There will however, be obscuration and attenuation in some direction. This is inevitable because the carry on device is inside the aircraft that is possibly occupied with up to 4 people.

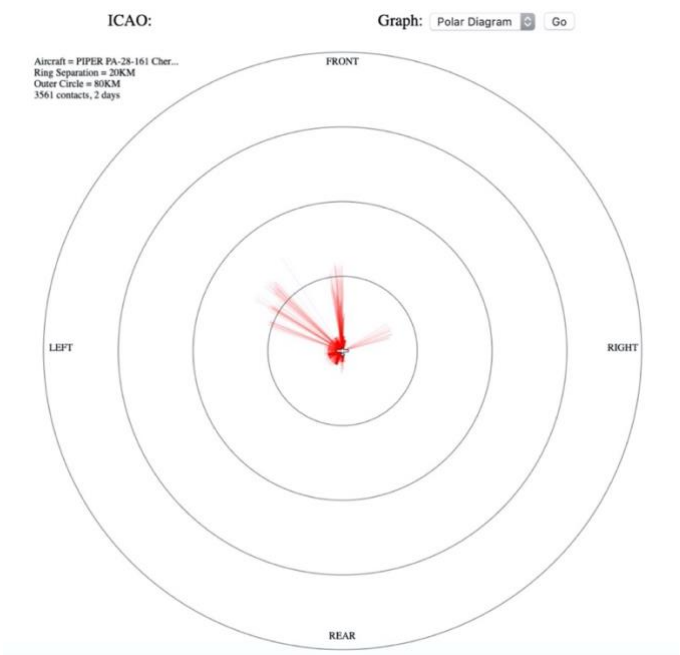
The following polar diagram shows what a real world, well-positioned EC device can achieve,



This polar diagram, collected from several ATOM GRID stations, is from a CabriG2 helicopter with a carry-on PilotAware Rosetta mounted in front of the dashboard. The polar diagram is analysed as follows. The air to ground range of the PilotAware unit is 50Kms + in all directions, except to the rear where there is significant obscuration. The obscuration is caused by the passengers, fuel and the engine to the rear of the aircraft. This obscuration could be reduced by the use of remote internal antennas or better still by using remote external antennas.

What Should be Expected from a Poorly Installed Carry on Device?

Here you can see a much different picture. The signal is attenuated and so only travels 10 or 15KMS or so air to ground and it is severely obscured to the majority of the port side.

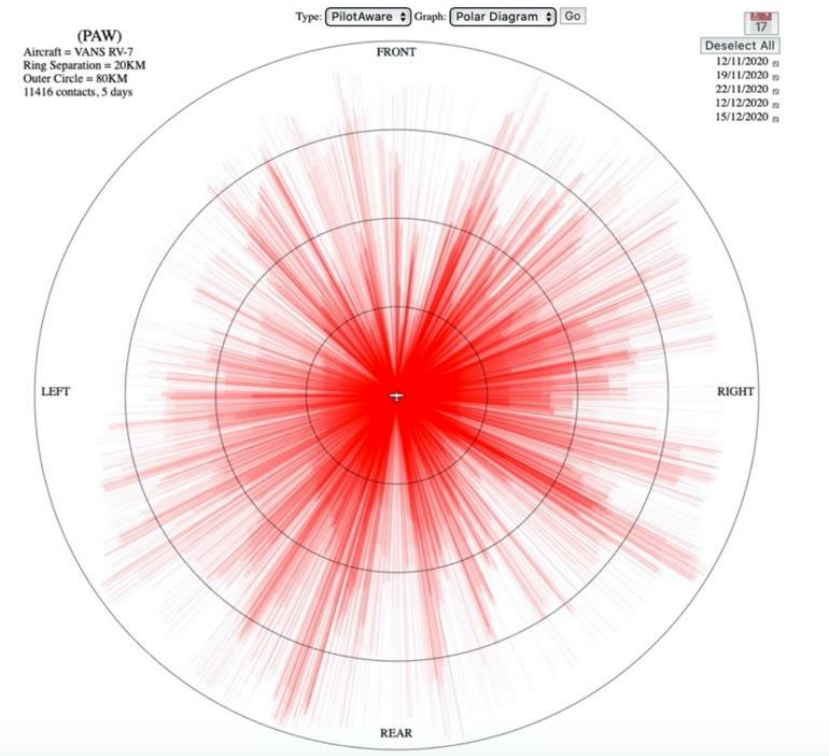


This polar diagram is taken from a carry on device installed in a PA28, probably fixed to a port window. It can be seen that the EC device has been occasionally detected at 25KMs to the left but the main detections are much weaker with significant obscuration to the starboard side. This is most probably caused by airframe obscuration and occupant attenuation. This is not a PilotAware device. Again this poor performance could be improved by the use of remote internal antennas or better still by using remote external antennas if this option is available from the chosen device manufacturer.

What Should be Expected of a Well Installed Device using External Antennas.

Every installation will be different, but by using external antennas with a good ground plane 360^0 transmission and reception is eminently possible with PilotAware units. The following Polar Diagram shows a PilotAware unit fitted with external antennas on a metal aircraft.

Here is the **VECTOR** Polar diagram from a VANS RV7 aircraft using a PilotAware Rosetta EC device fitted with remote external antennas. Gathered from 5 flights and 11,416 detections the **VECTOR** software is building an excellent polar pattern with 360 degrees of transmission at an air to ground range of over 60Kms to available distant ATOM stations. Each radial ring represents 20Kms. This is a good example of the benchmark for a well-designed EC installation using external antennas.



What options are there for fitting remote antennas to PilotAware units?

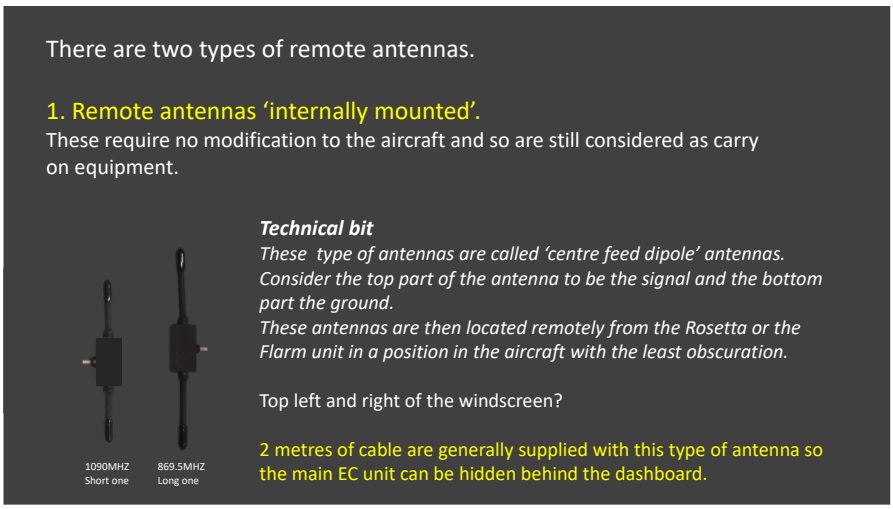
There are two remote antenna options. Remote Internal Antennas and Remote External Antennas.

Remote internal antennas

Remote internal antennas are used by folks who do not want, or who cannot modify their aircraft for any reason. PilotAware remote internal antennas come with 2 metres of high grade RG316 coaxial cable so that they can be optimally positioned within the aircraft. For example in certified aircraft, such as a PA28 or a Cessna 152, a popular place to install the antennas is either side of the windscreen. Each antenna is provided with rubber suction mounts to do this. More permanent Scotch Tabs are also provided. The thin coaxial cable can also be routed behind the trim around the window and thus out of sight. The GPS mouse is then mounted on the centre of the dashboard giving a clear view of the required satellites.

For tube and fabric aircraft, remote internal antennas can be positioned high up and to the rear of the pilot and passengers or any other suitable place. The fabric of the aircraft is transparent to radio waves so a good radiation pattern should be achieved.

Remote internal antennas look like this.

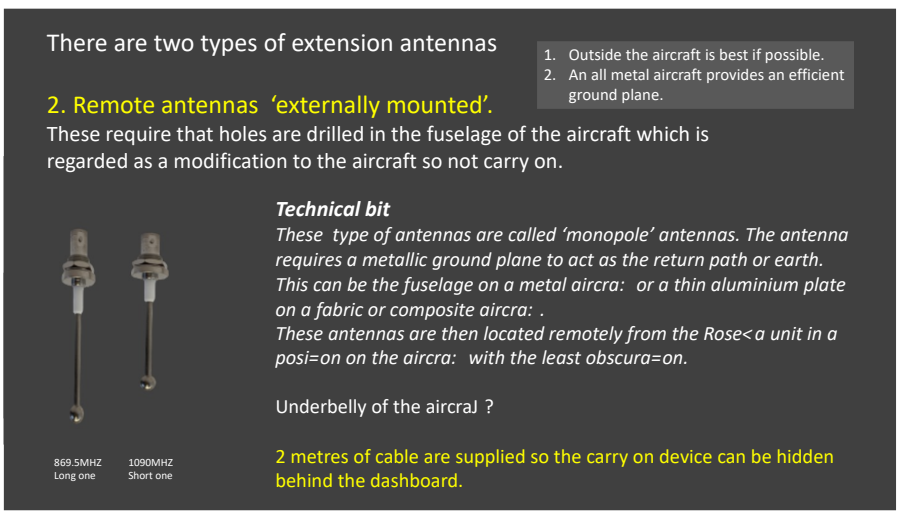


Remote External Antennas

Remote external antennas, mounted outside of the aircraft, will always give the best performance when correctly fitted. Remote external antennas differ from remote internal antennas in that they are monopole antennas and therefore require a ground plane to operate correctly. On metal aircraft the fuselage acts as a good ground plane and will give the results shown in the previous polar diagram. If the external antennas are mounted on a wooden, tube and fabric, fibreglass aircraft or the pod on a gyrocopter, or weight-shift microlight, then a metal ground-plane will be required. This will take the form of a thin sheet of aluminium about 20cm square. Antennas should be mounted a minimum of 15cm apart and as far away from the transponder antenna if a transponder is fitted.

There are no hard and fast rules about where the external antennas are fitted. Underneath the aircraft, behind the front seats is a popular position as this site is far enough away from the engine to reduce the obscuration. Also, PilotAware ATOM GRID Ground Stations are now providing information and will provide more in the future. An underbelly installation will also improve the air to ground capability. Post a question on the PilotAware forum, forum.pilotaware.com to see how others have installed antennas in similar aircraft to the one that you fly.

Remote external antennas look like this.



To What Type of Aircraft Are You Fitting Remote Antennas?

You can install either internal or external antennas to LAA and BMAA permit to fly aircraft without a major modification. Just ask your inspector.

However, for aircraft on the CAA or EASA registers it has not been so easy. It is possible to install antennas on EASA aircraft using the standard change CS-SC004a in CS STAN issue 3, or the minor change route could be used instead. However, I am told by those very helpful people in Cologne that help is at hand.

Over the last 9 months EASA, has been working to extend the light touch regulation, currently available for the installation of remote external antennas for Flarm devices. This is soon to be changed to include other EC devices operating on a non-aviation frequency.

The intention is that, *"This template could be drastically simplified for the installation of an electronic conspicuity device. No flight test (no flight conditions, no permit to fly) is needed. A flight check is sufficient."* This will of course include PilotAware and other EC devices. EC devices operating on 1090MHz or 978MHz will not be included as they operate on an aviation frequency and will be subject to the full modification requirements for the filling of antennas. With the UK leaving the EU and EASA, the adoption of this light touch for aircraft on the CAA register, will depend on whether this is harmonised by the UK authorities. The next issue of CS STAN is due in early 2021.

PilotAware VECTOR

If you want to check the performance of your PilotAware installation then you can do this by using PilotAware **VECTOR.**

VECTOR is another free service from PilotAware that will report on the fidelity of any EC device, **not just PilotAware.** This will show you how good your installation is. Please see the following video on how **VECTOR** works.

PilotAware VECTOR
https://www.youtube.com/watch?v=VOoZPhzFNDY&t=0s

To use PilotAware **VECTOR** you need to have made a flight or flights of about an hour in the last 30 days or so. You also need to have the correct ICAO code installed in all EC devices on board.

https://www.pilotaware.com/analysis/vector

PilotAware Remote Internal and External Installation Kits

To make life easy PilotAware has produced installation kits that use either internal or external antennas. These are available for sale on the PilotAware website.

External Antenna Installation Kits

These are available from,
https://www.pilotaware.com/product/external-antenna-installation-kit

If you just want the external antennas they are found at,
https://www.pilotaware.com/product/aviation-grade-external-antennas

The installation instructions for Remote External antennas are found at,
https://global-uploads.webflow.com/5d56c24810fbfdbe08b488cd/5f82e4305451d79058ef8a74_Installation%20Instructions%20Kit%201%20Rohan%20Antennas..pdf

Internal Antenna Installation Kits

These are available from,
https://www.pilotaware.com/product/internal-antenna-installation-kit

If you just want the internal antennas or GPS Mouse they can be found at,
https://www.pilotaware.com/product/internal-1090mhz-aerial
https://www.pilotaware.com/product/internal-869-5mhz-antenna
https://www.pilotaware.com/product/gps-mouse

The installation instructions for Remote Internal Antennas are found at,
https://global-uploads.webflow.com/5d56c24810fbfdbe08b488cd/5f82e456591348f4124c85ea_Installation%20Instructions%20Kit%203%20Internal%20Antennas%20.pdf

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