

	<b>APPLICATION NOTE FLARM ANTENNA INSTALLATION</b>	Date: 2019-01-22 Version: 1.2 Page: 1 of 19
FLARM Technology Ltd Hinterbergstrasse 15 CH-6330 Cham		Document Number: <b>FTD-041</b>

## Document Status

Published status	Confidentiality status
<input type="checkbox"/> Draft	<input type="checkbox"/> Internal
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## Version Control

Ver.	Date	Summary of changes
<b>1.0</b>	2017-01-10	Initial version
<b>1.1</b>	2018-02-09	Added information that directional antennas are not allowed.
<b>1.2</b>	2019-01-22	Added range analyzer

## Scope and Summary

This Application Note explains technical requirements for installing FLARM antennas. The Application Note is supplemental to the Installation Manual and MCA Installation Instructions. Also refer to the Installation Manual and MCA Installation Instructions for information on GPS and SSR antenna installation.

The Application Note is generic in nature and does not provide detailed instructions for a specific aircraft type. The radiation pattern and range is heavily influenced by material and location of other parts of the aircraft.

Installation of antennas, as well as installation of the complete FLARM system, can be done only under an EASA Minor Change Approval (MCA), as a Standard Change, or the national equivalent. The installation must be released by Part-66 certifying staff. It is not permitted to install FLARM and/or antennas under pilot-owner maintenance.

	<b>APPLICATION NOTE FLARM ANTENNA INSTALLATION</b>	Date: 2019-01-22 Version: 1.2 Page: 2 of 19
FLARM Technology Ltd Hinterbergstrasse 15 CH-6330 Cham		Document Number: <b>FTD-041</b>

## Table of Contents

<b>1</b>	<b>Abbreviations and Definitions.....</b>	<b>3</b>
<b>2</b>	<b>Introduction .....</b>	<b>4</b>
<b>3</b>	<b>Antenna Installation Guidelines .....</b>	<b>4</b>
3.1	Verifying Range .....	4
3.2	PowerFLARM Antenna Types.....	7
3.3	Do's and Don'ts .....	8
<b>4</b>	<b>FAQ.....</b>	<b>15</b>
<b>5</b>	<b>How to Build a Temporary Dipole Antenna Mount.....</b>	<b>18</b>
5.1	Materials Needed .....	18
5.2	Instructions.....	18



FLARM Technology Ltd  
Hinterbergstrasse 15  
CH-6330 Cham

# APPLICATION NOTE FLARM ANTENNA INSTALLATION

Date: 2019-01-22

Version: 1.2

Page: 3 of 19

Document Number:

**FTD-041**

## 1 Abbreviations and Definitions

Term	Meaning/Explanation
<b>external antenna</b>	Antenna installed on top of or below the aircraft fuselage
<b>internal antenna</b>	Antenna installed inside the fuselage or vertical stabilizer, normally only in fiberglass gliders
<b>ESD</b>	Electrostatic discharge
<b>kt</b>	Knots (1kt = 1.852 km/h)
<b>MCA</b>	Minor Change Approval
<b>nm</b>	Nautical mile (1nm = 1.852 km)
<b>RF</b>	Radio Frequency
<b>SSR</b>	Secondary Surveillance Radar
<b>SWR</b>	Standing Wave Ratio
<b>UAV</b>	Unmanned Aerial Vehicle

	<b>APPLICATION NOTE FLARM ANTENNA INSTALLATION</b>	Date: 2019-01-22 Version: 1.2 Page: 4 of 19
FLARM Technology Ltd Hinterbergstrasse 15 CH-6330 Cham		Document Number: <b>FTD-041</b>

## 2 Introduction

FLARM systems are today being installed in a variety of aircraft types: light airplanes, helicopters, gliders, UAVs, etc. The specific requirements for each type of aircraft, as well as individual differences between aircraft, make it difficult to produce comprehensive guidelines. This Application Note nevertheless aims to explain the most common installation types, best practice, and don'ts.

Light airplanes and helicopters will normally be required to use external antennas, of which the placement and installation is normally straightforward. UAVs will require antennas and installation thereof that is very specific to the type of UAV. The most challenging antenna installations are instead for internal antennas, where space is tight. This document therefore focuses on this case.

Before making a permanent installation of internal antennas, it is recommended **not to make the first installation permanent**. Read the section "How to build a temporary dipole antenna mount" and follow the guidelines for a first try. This will most probably yield an acceptable range or at least give you a good starting point for further optimization. Keep in mind that for safety purposes, you only need a range of about 2 nm forward (less to the sides). See the FAQ section for explanation. Once you are happy with the achieved range, make the installation permanent.



**Installation of antennas, as well as installation of the complete FLARM system, can be done only under an EASA Minor Change Approval (MCA), as a Standard Change, or the national equivalent. The installation must be released by Part 66 certifying staff. It is not permitted to install FLARM and/or antennas under pilot-owner maintenance.**

The EASA Minor Change Approval (MCA) valid for ELA1 and ELA2 airplanes can be purchased under the following link:

<https://flarm.com/shop/easa-minor-change-approval-mca/>

The documents received as part of the EASA approved MCA are also required for a Standard Change installation.

## 3 Antenna Installation Guidelines

### 3.1 Verifying Range

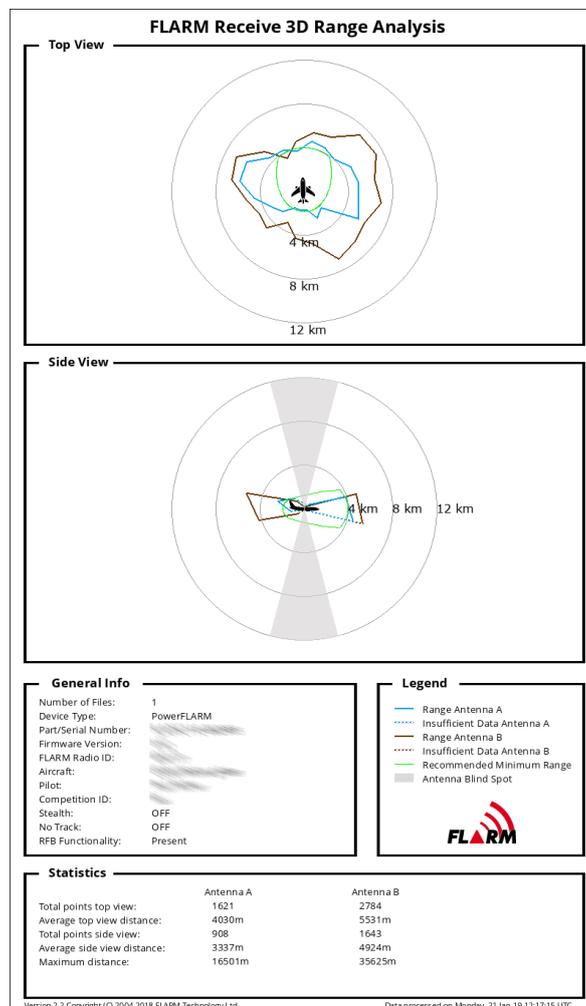
No matter how well and carefully a FLARM installation is planned and executed, the range should be verified after the installation and retested in a yearly interval.

Two simple to execute range analyzer applications exist, focusing either on the receive or transmit aspect of an installation. A radio installation is symmetric, so problems with RF cabling or antennas are visible with either approach. However, if a device is damaged (e.g. due to electrostatic discharge), then this may be asymmetric - the receive path is affected much more often. Such a damage will show poor range in FLARM analyzer, but good range in KTRAX.

### 3.1.1 FLARM Online Range Analyzer

Our online range analysis tool is available online at:

[https://flarm.com/support/tools-software/flarm-range-analyzer/.](https://flarm.com/support/tools-software/flarm-range-analyzer/)



The analyzer requires one or multiple flight logs in the IGC file format, as recorded by the FLARM device. It uses data from received traffic for the analysis, hence only the receive path of the FLARM installation is evaluated. Also, it requires abundant traffic in range during the flight to generate meaningful results. Hence a log from a nice summer day with a lot of activity is better than a log from a night flight. An



FLARM Technology Ltd  
Hinterbergstrasse 15  
CH-6330 Cham

# APPLICATION NOTE FLARM ANTENNA INSTALLATION

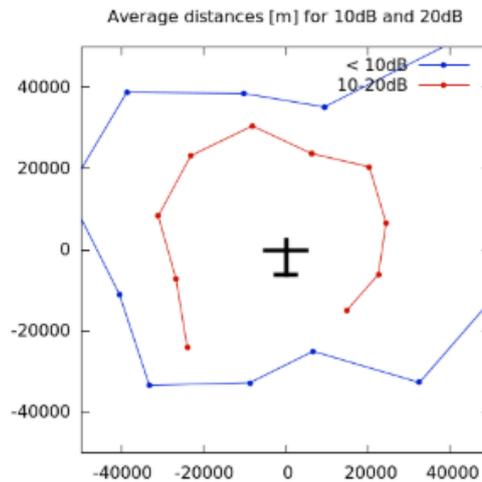
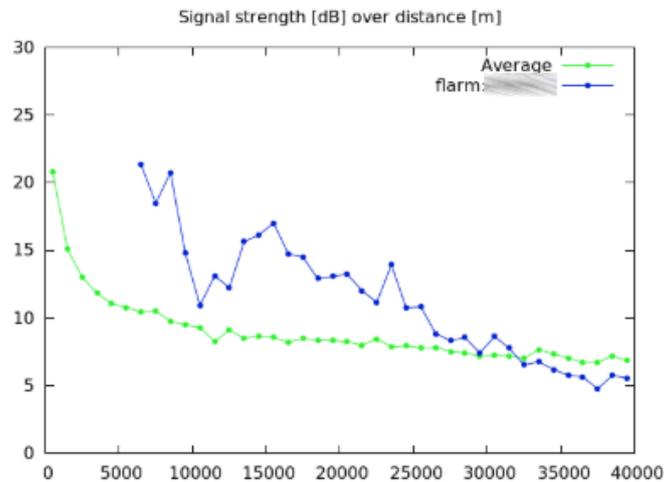
Date: 2019-01-22  
Version: 1.2  
Page: 6 of 19

Document Number:  
**FTD-041**

example result is given above. The green volume indicates the minimum range for good performance.

### 3.1.2 KTRAX Live Range Analyzer

This analyzer processes data received by the OGN network of ground receivers. It thus verifies the transmit function of an installation. The tool is available online: <https://ktrax.kisstech.ch/flarm-liverange/>.



	<b>APPLICATION NOTE FLARM ANTENNA INSTALLATION</b>	Date: 2019-01-22 Version: 1.2 Page: 7 of 19
FLARM Technology Ltd Hinterbergstrasse 15 CH-6330 Cham		Document Number: <b>FTD-041</b>

**Report date:** Mon Jan 21 12:29:21 UTC 2019  
**Last measurement:** 2018-11-17T14:45:47Z  
**Callsign/ID:** -/flarm:   
**Versions:** Hardware: -/Software: -  
**Received by:** 20 OGN station(s)  
**Echos used:** 4427 out of 4427  
**Average frequency deviation:** -9.22 kHz  
**Average GPS accuracy:** 1.6 m  
**Position jumps:** 0  
**SAR:** [Map](#)  
**Database version:** ktrax-ogn v2.2.6

The result compares the performance of the device with the average of processed data. This tool will not work if flying through areas with no OGN coverage, or if privacy options (notrack, random ID, entry in DDB) are active. It does not require the presence of other traffic to provide meaningful results.

It will also not detect damages of the receive path of a device (you are seen by others during flight, but your display does not show traffic).

### 3.2 PowerFLARM Antenna Types

The following omnidirectional antenna types may be used for FLARM.

<b>PowerFLARM external antenna AV-75</b> <ul style="list-style-type: none"> <li>■ Monopole antenna, requires a ground plane<sup>1</sup> (the aircraft skin)</li> <li>■ Highest performance</li> <li>■ Normally, antenna diversity is required, just like the SSR antennas (one antenna on top of the aircraft and one below)</li> </ul>	
<b>PowerFLARM Portable device antenna (rubber ducky antenna)</b> <ul style="list-style-type: none"> <li>■ Dipole antenna, does not need a ground plane<sup>1</sup></li> <li>■ Average performance</li> </ul>	

<sup>1</sup> A ground plane is a plane of highly conductive material (e.g. metal) orthogonal to the antenna axis and electrically connected to the antenna ground. If you are unsure about the meaning of the term "ground plane", just use the bundled antennas and keep any conductive material (e.g. aluminum, carbon fiber) away from the antennas.

	<b>APPLICATION NOTE FLARM ANTENNA INSTALLATION</b>	Date: 2019-01-22 Version: 1.2 Page: 8 of 19
FLARM Technology Ltd Hinterbergstrasse 15 CH-6330 Cham		Document Number: <b>FTD-041</b>

<p><b>PowerFLARM Core internal antenna (center-fed dipole antenna)</b></p> <ul style="list-style-type: none"> <li>▪ Dipole antenna, does not need a ground plane</li> <li>▪ High performance</li> <li>▪ Antenna tips should be clear from conductive materials</li> </ul>	
<p><b>Classic FLARM device antenna (1/4 wave whip antenna)</b></p> <ul style="list-style-type: none"> <li>▪ Monopole antenna, requires a ground plane of at least 80 mm (3 inch) radius</li> <li>▪ Average performance</li> <li>▪ Blind spots below the ground plane</li> </ul>	

The use of directional antennas is discouraged: The high range towards a specific direction (e.g. the front) means there will be deficits in other directions. If absolutely needed, it should be combined with an omnidirectional antenna and a FLARM device that supports true RF diversity (PowerFLARM).

### 3.3 Do's and Don'ts

#### 3.3.1 Before connecting, always check type and polarity of antenna connectors carefully

##### Version E devices

FLARM antenna connectors on PowerFLARM Core and PowerFLARM Portable are SMA Female.

##### Version A devices

On PowerFLARM Core, both FLARM antenna connectors are RP-SMA (Reversed Polarity SMA) Female. Of PowerFLARM Portable, the FLARM A antenna connector is RP-SMA Female and the FLARM B antenna connector is SMA Female.



**Note:** The AV-75 external antennas are BNC Female.



FLARM Technology Ltd  
Hinterbergstrasse 15  
CH-6330 Cham

# APPLICATION NOTE FLARM ANTENNA INSTALLATION

Date: 2019-01-22

Version: 1.2

Page: 9 of 19

Document Number:

**FTD-041**

Attaching incompatible antennas to the connectors will cause loss of performance, permanent damage to the device, and void the warranty.

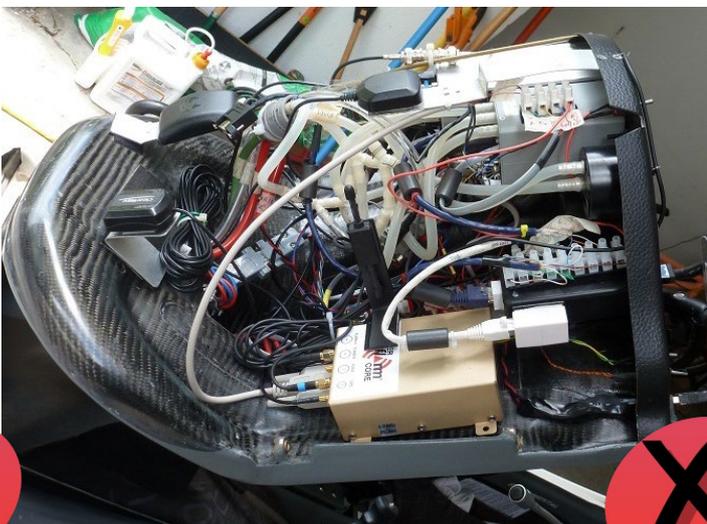
**Note:** Version E and Version A devices are intended for different parts of the world (different frequency bands) and require different antennas.

### 3.3.2 Antenna Clearance

Give the antenna as much clearance as possible, from any material.

#### Don't let it touch anything!

Keep in mind that not just conductive material but also humans attenuate signals. Glass fiber and Kevlar barely attenuate signals or deteriorate the antenna balance.



	<b>APPLICATION NOTE FLARM ANTENNA INSTALLATION</b>	Date: 2019-01-22 Version: 1.2 Page: 10 of 19
FLARM Technology Ltd Hinterbergstrasse 15 CH-6330 Cham		Document Number: <b>FTD-041</b>

### 3.3.3 Antenna Separation

Antennas should be separated from each other:

- Min. distance between antenna on FLARM A and FLARM B port: 30 cm (1 ft)
- Min. distance between antenna on FLARM A port and GPS antenna: 30 cm (1 ft)
- Min. distance between antenna on FLARM B port and GPS antenna: 30 cm (1 ft)
- Min. distance between ADS-B/SSR antenna and GPS antenna: 10 cm (4")

### 3.3.4 Use of RF Diversity

Port A is the default and is always active. You should always connect an antenna to it.

If you feel that your airplane attenuates signals strongly in some directions (blind spots), you can connect a second antenna to the FLARM B port (true RF diversity). On some devices, this requires an additional feature license. With the license, both ports are functionally equal.



**Connecting more than one antenna to one RF Port (e.g. via a passive splitter) is a bad idea in general. Unlike true RF diversity, it can lead to very poor, unpredictable ranges.**

### 3.3.5 Maintain Aircraft Safety

Ensure that the installation does not conflict with any operation of the aircraft, e.g. canopy emergency release: The coaxial antenna cable is strong and will not break if you have to leave the aircraft in an emergency!

### 3.3.6 Antenna Orientation

FLARM uses a vertically-polarized radio signal. Thus, do not tilt the antennas more than max +/- 15° from the vertical.



FLARM Technology Ltd  
Hinterbergstrasse 15  
CH-6330 Cham

# APPLICATION NOTE FLARM ANTENNA INSTALLATION

Date: 2019-01-22

Version: 1.2

Page: 11 of 19

Document Number:

**FTD-041**



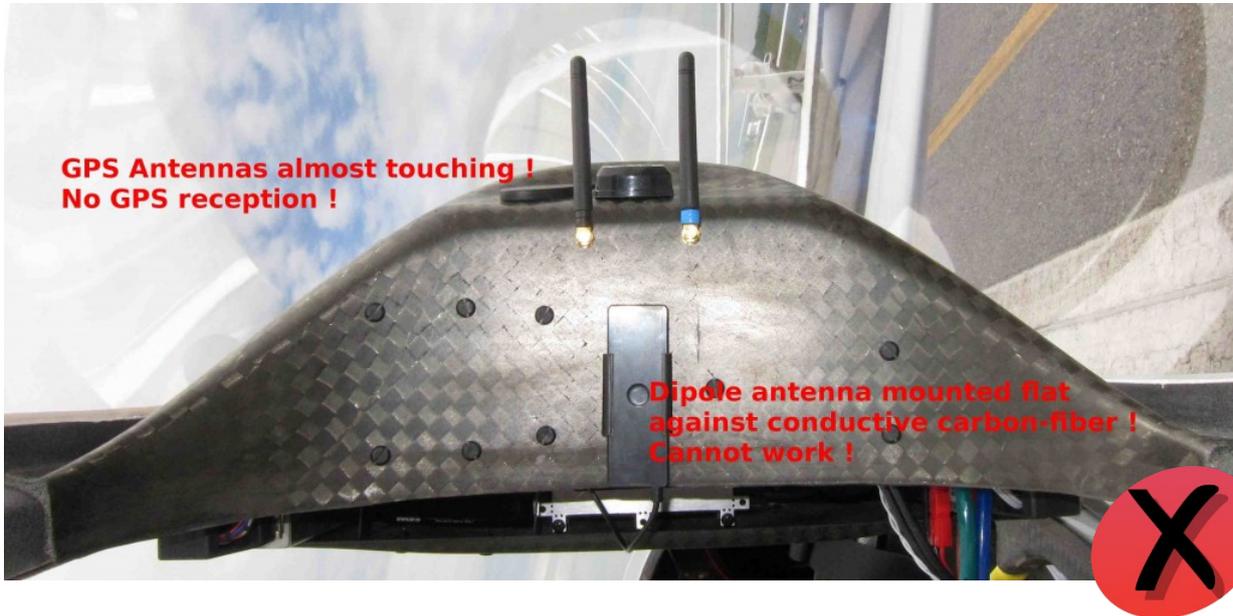
### 3.3.7 PowerFLARM Portable

Mount PowerFLARM Portable device horizontally on a level surface. Tilting will cause the antennas to get too close together



### 3.3.8 Dipole Antennas

Rubber ducky or center-fed dipole antennas are especially sensitive to their surroundings. Unlike monopole antennas, they do not need a ground plane. Do not mount them on any kind of conductive material (e.g. any type of metal or carbon fiber).



### 3.3.9 RF Cabling

Guide cable horizontally away from the PowerFLARM remote antenna. Do not tie the cable to one arm of the dipole (vertical to the antenna), since it will distort the signal.



### 3.3.10 Electrostatic Discharge

Radio circuits are sensitive to electrostatic discharges, and FLARM is no exception. The antenna should be protected appropriately, e.g. by a rubber coating. Even so,

	<b>APPLICATION NOTE</b> <b>FLARM ANTENNA</b> <b>INSTALLATION</b>	Date: 2019-01-22 Version: 1.2 Page: 13 of 19
FLARM Technology Ltd Hinterbergstrasse 15 CH-6330 Cham		Document Number: <b>FTD-041</b>

the human body is capable of amassing and releasing high voltages, so care must be taken in daily use. Also, the plastic canopy used in e.g. gliders, together with canopy covers made of fabric, can lead to high voltages. Make sure all parts of the antenna have sufficient clearance to the canopy (2cm).

### 3.3.11 Alternative Antenna Types

PowerFLARM is delivered with universal antennas that work well for most glider installations.

However, some alternative omnidirectional antenna types or placement locations may be beneficial. Contact your local PowerFLARM dealer for alternative antennas.

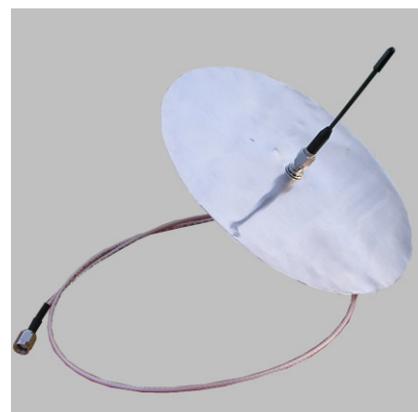
### 3.3.12 Directional Antennas

The use of directional antennas is discouraged in general. These antennas will make the range much worse in most directions. If absolutely required, RF diversity should be used with a very good, omnidirectional primary antenna.

### 3.3.13 On Top of the Glare Shield

A simple  $\frac{1}{4}$  wave monopole whip antenna with ground plane of at least 80 mm (3 inch) radius works very well, if installed properly.

Some gliders can be ordered with this type of FLARM antenna pre-installed; talk to your supplier.



**Figure 1** Example of factory installed glare shield antennas; required ground plane is hidden under the cover. ADS-B/SSR antenna on the left, FLARM antenna on the right.

Possible supplier: Mobile Mark PSTG0-925SE

<https://www.tessco.com/product/384213>

**Note:** The length and picture on the Tessco site are incorrect. Actual length is 2  $\frac{7}{8}$ .

	<b>APPLICATION NOTE FLARM ANTENNA INSTALLATION</b>	Date: 2019-01-22 Version: 1.2 Page: 14 of 19
FLARM Technology Ltd Hinterbergstrasse 15 CH-6330 Cham		Document Number: <b>FTD-041</b>

You will also need an extension cable with suitable connectors (RP-SMA to SMA) and a ground plane.

**Note:** This is not a product that FLARM has tested, supplies, or officially endorses. It will require the installation of a suitable ground plane and cables to work properly. We do not supply support for this type of installation.

### **3.3.14 External AV-75 antenna**

The external AV-75 antennas are normally required for light aircraft (other than fiberglass gliders) and helicopters. Typically, one antenna is mounted on top of the aircraft and one antenna on the bottom of the aircraft, similar to the SSR antennas.

The following antenna cables are approved: 50  $\Omega$  RG58, RG142B, RG142B/U, RG400, or equivalent.

### **3.3.15 Antenna in Vertical Stabilizer**

Some carbon fiber gliders have dedicated glass only areas in their tails for VHF and other antennas.

It may be possible to place the FLARM antenna there.

The following antenna cables are approved: 50  $\Omega$  RG58, RG142B, RG142B/U, RG400, or equivalent.

### **3.3.16 Antenna in Gear Well**

This location is NOT recommended for the Port A antenna.

In carbon fiber gliders, the Port B antenna may be placed in or near the gear well to improve range below, if the gear doors are not made of carbon.

	<b>APPLICATION NOTE FLARM ANTENNA INSTALLATION</b>	Date: 2019-01-22 Version: 1.2 Page: 15 of 19
FLARM Technology Ltd Hinterbergstrasse 15 CH-6330 Cham		Document Number: <b>FTD-041</b>

## 4 FAQ

**Q:** What is the minimum required range for a timely warning?

**A:** When flying at or below 250 kt, a range of 2 nm (3 704 m) forward and 1 nm to the side and behind will give the pilots a warning at least 15 seconds before closest convergence.

Any range beyond that may be useful for tactical purposes but it adds very little to safety.

Calculation:

Worst case below 10 000 ft is normally two aircraft converging at 250 kt each  
-> 500 kt closing speed -> 257 m/s

For a 15 second warning -> 3 858 m -> 2.08 nm

The profile of a glider when seen from straight ahead at 2 nm distance is about as thick as a human hair held at arm's length; almost impossible to see...

The FLARM Range Analyzer (see Section 3.1.1) indicates the recommended range for a typical GA aircraft.

**Q:** Can you tell me if my antenna installation will perform well?

**A:** No, we will not be able to predict how your particular installation will perform. You have better knowledge of the material used in your airplane than we do. Stick to the guidelines in this document and your installation should be OK for collision avoidance. If you want to get extended range, you will have to do some testing.

**Q:** I found this antenna datasheet on the Internet, can I use it for PowerFLARM?

**A:** Maybe. It is often difficult to determine real world antenna performance from datasheets. Some antennas tested by FLARM Technology do not meet their published specifications. If you like experimenting, make sure the connectors, operating frequency, and impedance (50 Ohm) match! A generic rule: The larger the antenna, the better it works. Some antennas (monopoles) require ground planes: a metallic horizontal flat surface onto which the antenna is placed perpendicularly. Some other antennas (dipoles) do not work well with ground planes. Do your research.

	<b>APPLICATION NOTE FLARM ANTENNA INSTALLATION</b>	Date: 2019-01-22 Version: 1.2 Page: 16 of 19
FLARM Technology Ltd Hinterbergstrasse 15 CH-6330 Cham		Document Number: <b>FTD-041</b>

**Q:** May I use an extension cable for the antennas?

**A:** Yes, but total attenuation should remain < 1.5 dB. Do not use RG-174 or similar poor coaxial cables. Also, keep in mind that every connector introduces signal losses. The following antenna cables are approved: 50 Ω RG58, RG142B, RG142B/U, RG400, or equivalent

**Q:** Does the human body attenuate the FLARM signal?

**A:** Yes

**Q:** Does the FLARM signal harm the human body?

**A:** PowerFLARM devices meet or exceed all relevant CE and FCC requirements. The signal is up to 100 times weaker than a cell phone signal, while using similar frequencies, and the device transmits only very sparingly. Any harm is thus completely unlikely.

**Q:** May I use an antenna splitter to attach two FLARM antennas to one antenna port?

**A:** No, this will most likely result in signals cancelling themselves out.

RF splitters work by diverting half the power each to two ports while transmitting, and by combining incoming RF energy in the receive case. In principle, splitters can be used to increase the coverage, e.g. when you have a metallic fuselage that makes it impossible to put a single antenna with good reception. However, destructive interference can just as well achieve the opposite. The results will be unpredictable. We thus recommend using a device with true radio diversity (e.g. PowerFLARM).

**Q:** May I use an antenna splitter to share the GPS antenna with another device?

**A:** Yes, but it requires careful planning. An active GPS antenna should be used to avoid loss of sensitivity, and it must be clear which port is used to power the antenna.

**Q:** Do the FLARM antennas really have to be within 15 degrees of vertical?

	<b>APPLICATION NOTE</b> <b>FLARM ANTENNA</b> <b>INSTALLATION</b>	Date: 2019-01-22 Version: 1.2 Page: 17 of 19
FLARM Technology Ltd Hinterbergstrasse 15 CH-6330 Cham		Document Number: <b>FTD-041</b>

**A:** Yes, really. A 90 degrees tilted antenna will have near zero range. The effect at work is called polarization. FLARM radio signals are polarized vertically. A horizontal antenna thus receives next to nothing.

**Q:** Why does PowerFLARM Version A have Reversed Polarity SMA connectors for the FLARM antenna?

**A:** This applies to devices shipped e.g. in the US. The requirements come from the local regulation body for RF devices, the FCC. Please don't ask us why this makes sense.

**Q:** What about the SSR/ADS-B antennas?

**A:** Placement of the SSR/ADS-B antenna is not as crucial as the signals it receives are many times stronger than the FLARM signals. Observe the same fundamental rules as for the FLARM antennas but don't lose sleep over its placement.

**Q:** Can I fully test an antenna with a Standing Wave Ratio (SWR) meter?

**A:** No, even 50-ohm resistors look **great** on SWR meters... (Don't worry if you don't know what an SWR meter is). That said, SWR meters are a reasonable starting point to evaluate antennas and they reliably detect issues with cabling.

**Q:** May I use directional antennas with FLARM?

**A:** In general no. Directional antennas will make the range much worse in most directions. They do not solve range issues. In an RF diversity setup however, they may complement a very good primary antenna. Also see Section 3.3.12.

## 5 How to Build a Temporary Dipole Antenna Mount

We highly recommend starting with a temporary antenna installation to verify proper operation and range of PowerFLARM. In particular, we do not recommend making the installation permanent before it has been checked with the online range analyzer tool.

### 5.1 Materials Needed

- Black, fat sharpie
- Thin cardboard 2 x 6 inch
- Double sided tape
- Scissors
- 5 minutes



### 5.2 Instructions

1. Paint one side of the cardboard completely black to avoid reflections on the canopy.



2. Fold cardboard in the middle.





FLARM Technology Ltd  
Hinterbergstrasse 15  
CH-6330 Cham

## APPLICATION NOTE FLARM ANTENNA INSTALLATION

Date: 2019-01-22

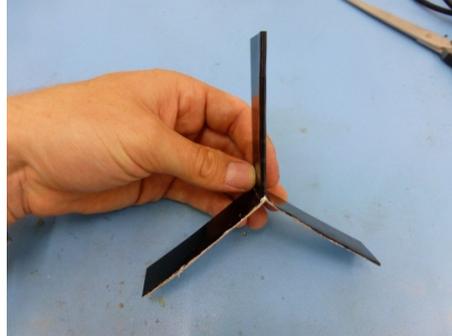
Version: 1.2

Page: 19 of 19

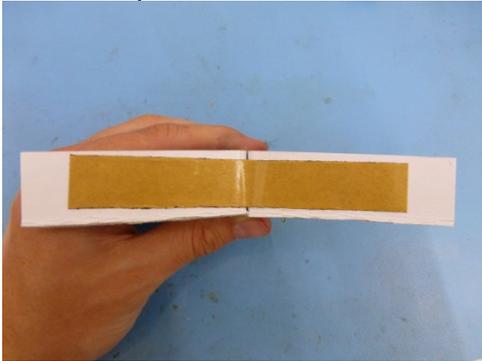
Document Number:

**FTD-041**

3. Cut bottom halves and fold out bottoms.



4. Apply double sided tape to the folded-out bottoms for subsequent installation in the airplane.



5. Attach antenna and cable with its double-sided sticker.

