SafePilot CAT PRO User Guide

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Introduction

The CAT PRO is a dual antenna solution, providing an RTK position and heading independent from the ship's instrumentation. The built-in rate gyro offers precise and independent Rate of Turn, providing a reliable inertial platform needed for crucial positioning predictions; this being especially important in critical turns.

The CAT PRO units communicate with each other and the pilot's display via Wi-Fi, ensuring a stable and long-range connection. To ensure an even better WiFi coverage at the extreme bridge wings a third unit, the CAT EXTENDER, can be placed in the center of the bridge. This flexible and lightweight solution, can be configured in four different operational modes, making it suitable for all types of operations.

The key features of a CAT PRO PPU set are:

- Independent ship position with up RTK accuracy
- Independent heading
- Reliable real-time ROT 0.1°/min
- AIS targets from ship AIS
- Pocket size (138 x 100 x 25 mm) weighing only 410g
- Long battery life - 30 hours in one charge.
- Fast charging – 3 hours from 0-100%.
- Wireless charging

In the following sections the setup, functionality and technical specification will be presented.

What's in the box

The box is water and shock proof
- 2 x CAT PRO - fully interchangeable HDG / POS receivers
- 1 x CAT EXTENDER – AIS forwarder and network extender
- 2 x Mounting bracket
- 1 x Y-cable – Charging and Pilot Plug
- 2 x Charging cable
- 1 x USB Multicharger
- 1 set of world adapters
- 1 x User guide

Operational modes

As mentioned in the introduction the CAT PRO can be utilized in four different operational modes. This ensures maximum flexibility that will suit all types of vessel maneuvers. In the following the modes and the setup are described.

1. CAT PRO as Pilot Plug Repeater

In the simplest use case of the CAT PRO, it will act as a Pilot Plug Repeater. It will overcome the shortcomings of the AIS pilot plug data format by generating an accurate real time rate of turn and providing the missing decimal readings to the heading data via an integrated rate sensor, intelligent processing and advanced Kalman filter integrated into the unit.

Please note, that a ship's position and speed can be compromised due to the quality of the ship's instruments, and it is therefore advised to use the CAT PRO in mode 2, 3 or 4 for most operations, to get an independent position, speed, and course.

To turn the device in mode 1, follow below procedure:

1. Turn on the CAT PRO by pressing until the button flashes blue
2. Connect the CAT PRO to the pilot plug with the supplied cable
3. Make sure the unit is placed on a horizontal surface, for a reliable Rate of Turn
4. Connect an iPad to the network "CAT PRO (xxxxxxxx)" with password "86912255" and open up SafePilot.

2. CAT PRO as Pilot Plug Repeater with external GNSS Receiver

In Mode 2 the CAT PRO will work as a pair, a CAT PRO AIS and a CAT PRO POS. In addition to the accurate Rate of Turn described in Mode 1, a position, course over ground and speed independent from the ship's instrumentation is received. This enhances the reliability of the positioning data.

To turn a pair in mode 2, follow below procedure:

1. Turn on one CAT PRO by pressing until the button flashes blue (AIS unit)
2. Turn on the other CAT PRO by pressing the button for 4 seconds until it flashes purple (POS unit)
3. Wait a few moments, and observe that they flashes green simultaneously to indicate that they have paired
4. Connect the CAT PRO AIS to the pilot plug with the supplied cable
   a. Make sure the unit is placed on a horizontal surface, for a reliable Rate of Turn
5. Place the CAT PRO POS on the bridge-wing following the guidelines in the next section.

6. Connect an iPad to the network "CAT PRO (xxxxxxxx)" with password "86912255" and open up SafePilot.

3. CAT PRO as stand-alone system

In Mode 3 the CAT PRO acts as a complete independent system, not relying on any of the ship's instrumentation. This setup consists of two units, both placed on the bridgewing. One unit is configured as a CAT PRO HDG, which computes a real-time and very accurate heading, as well as an accurate Rate of Turn via the built-in rate sensor and intelligent filtering. The other unit is configured as a CAT PRO POS, computing a position, speed, and course.

AIS data can be distributed to SafePilot via a SafePilot Server.

To turn a pair in mode 3, follow below procedure:

1. Turn on one CAT PRO by pressing until the button flashes blue (HDG unit)
2. Turn on the other CAT PRO by pressing the button for 4 seconds until it flashes purple (POS unit)
3. Wait a few moments, and observe that they flashes green simultaneously to indicate that they have paired
4. Place both CAT PRO POS and CAT PRO HDG on the bridgewing with a clear view of the sky.
    a. It is advised to place the CAT PRO HDG closest to the wheelhouse, for best Wi-Fi coverage.
5. Connect an iPad to the network "CAT PRO (xxxxxxxx)" with password "86912255" and open up SafePilot.
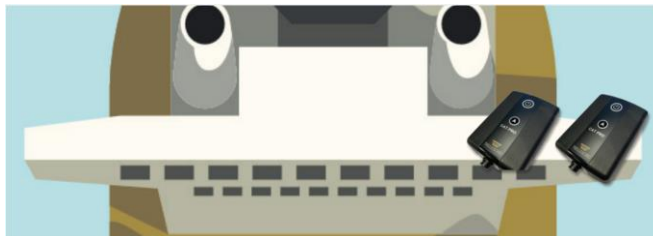
4. CAT PRO as stand-alone system with AIS and extended Wi-Fi Range

In Mode 4 three units are used, the CAT EXTENDER and both CAT PRO's. The CAT EXTENDER will act as the Wi-Fi access point and will forward AIS information from the ship. Having the CAT EXTENDER in the center of the ship, will give a strong and reliable Wi-Fi coverage throughout the entire bridgewing, even on the largest ships such as ULCVs. The CAT PRO HDG will compute the heading and Rate of Turn, and the CAT PRO POS will compute the position, speed, and course.

To turn a pair in mode 4, follow below procedure:

1. Turn on the CAT EXTENDER. Wait until it flashes a solid white (about 5 seconds).
2. Turn on one CAT PRO as HDG by a short press (blue light), and the other as POS by a long press (purple light)
3. Wait a few moments, and observe that all three devices flashes green simultaneously to indicate that they have paired
4. Connect the CAT EXTENDER to the Pilot Plug via the supplied cable.
5. Place the CAT PRO HDG and CAT PRO POS on the bridgewing with a clear view of the sky. This can be one unit on port side and one on starboard side, for a long baseline giving an ultra-accurate heading.
6. Connect an iPad to the network "CAT EXTENDER (xxxxxxxx)" with password "86912255" and open up SafePilot.

Wi-Fi – optimal usage

The Wi-Fi strength is slightly directional in the CAT PRO, and to obtain the best performance it is important to place the units according to the instructions below.

The strength is highest in the directions of the arrow.

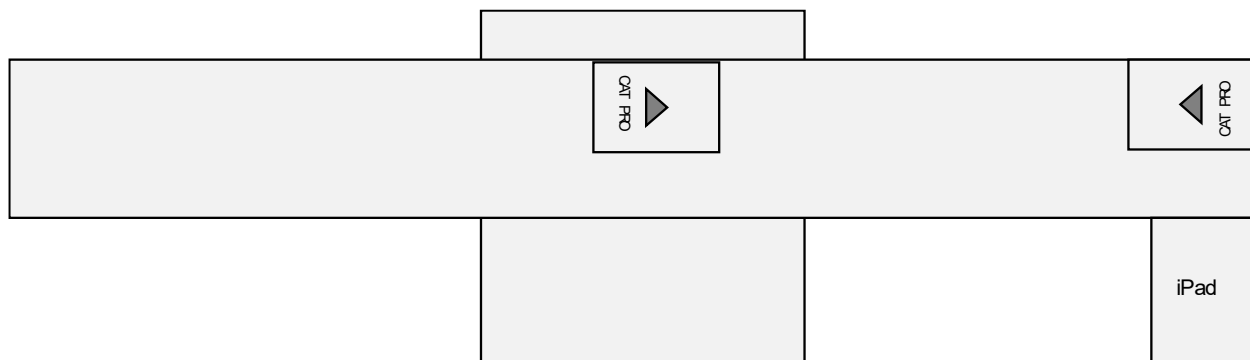## 1. CAT PRO as Pilot Plug Repeater

The CAT PRO is placed with the arrow pointing towards the bridgewing where the pilot is located during docking.
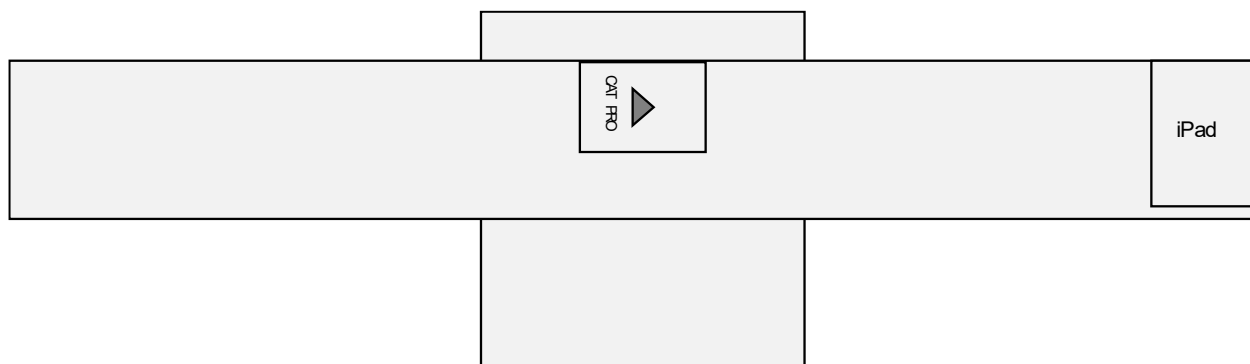
2. CAT PRO as Pilot Plug Repeater with external GNSS Receiver

The CAT PRO's are placed with the arrow pointing towards one another and the Pilot Plug Repeater arrow point towards the bridgewing where the pilot is located during docking.

3. CAT PRO as stand-alone system

The CAT PRO's are placed with the arrow pointing towards the wheel house and on the bridgewing where the pilot is located during docking.
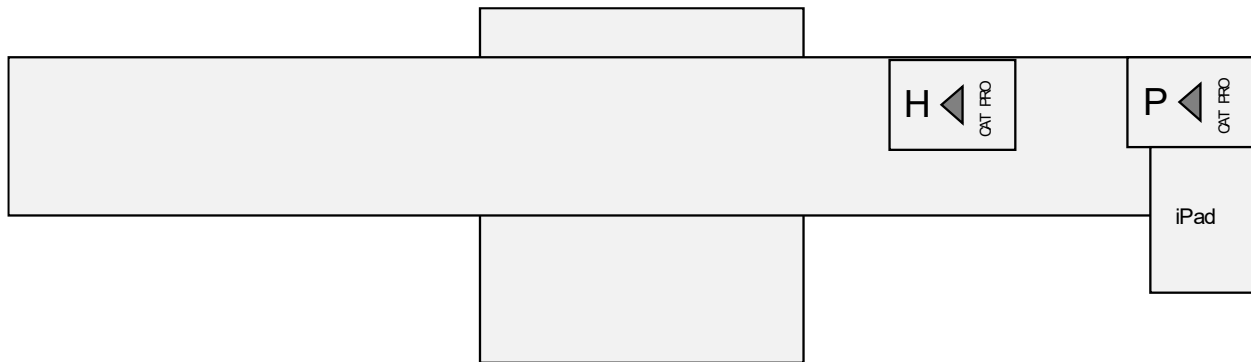
4. CAT PRO with Extender and the units on same bridgewing

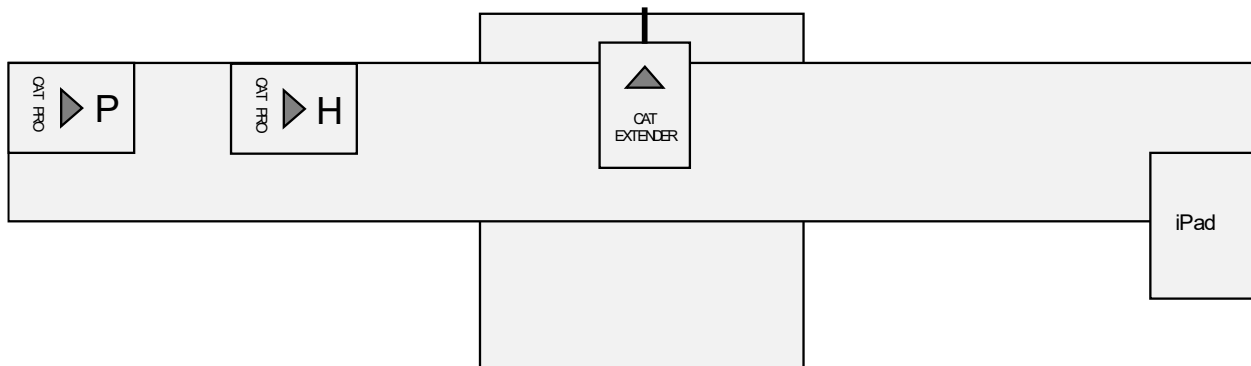The Extender is placed with a clear view towards the bridgewing where the two CAT PRO's are located and the CAT PRO's are placed with the arrow pointing towards the wheel house and on the opposite bridgewing where the pilot is located during docking. The antenna on the extender should be vertically orientated pointing up.
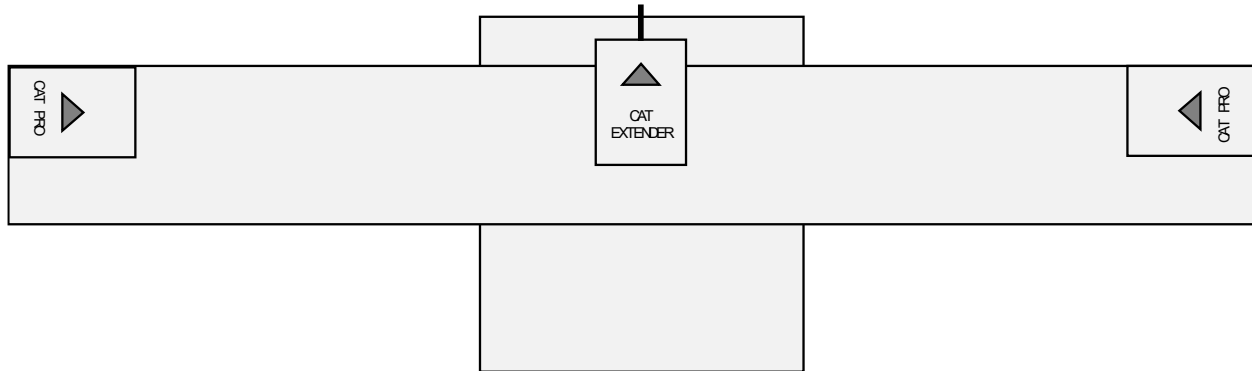
5. CAT PRO with Extender and a unit on each bridgewing

The Extender is placed with a clear view towards both bridgewings where the two CAT PRO's are located and the CAT PRO's are placed with the arrow pointing towards the wheel house. Wi-Fi strength is equally strong on each bridgewing. The antenna on the extender should be vertically orientated pointing up.

Position and Heading

The CAT PRO position unit provides position, speed, and course. It communicates GNSS corrections to the CAT PRO heading unit for it to compute a heading. The accuracy of the heading depends on the distance between the CAT PRO position and CAT PRO heading. At 4m baseline the accuracy is 0.05°, by extending the baseline further the accuracy will become better.

The CAT PRO position unit can provide RTK accuracy, by sending RTK corrections from SafePilot. This can be obtained in two ways. A SafePilot Server gathering data from a local reference station installed in port can be used. Alternatively, the SafePilot app on the iPad can be linked to a NTRIP server providing the corrections. In the near future a free RTK service called HAS will be available worldwide. When this becomes available SafePilot will support it and automatically deliver the RTK corrections to the CAT PRO.

Location of units for optimal GNSS performance

A proper location of the two units is crucial for a good GNSS fix. It must be installed outside with a clear view of the sky. This means that there must not be any obstructions above or in the vicinity of the CAT PRO. Obstructions close by can cause multipath reflections, that degrades the accuracy drastically. Therefore, pay a lot of attention to the location of the antennas.

We recommend a baseline between the two units of 4m which will give a heading accuracy better than 0.05°. But it is better to place them closer and have less accurate heading than to have a 4m baseline with obstructions nearby. Just make sure that the baseline is more than 1m which is the minimum. The CAT PRO HDG will not compute a heading if the standard deviation is larger than 0.5deg.

Often the vessel layout makes it hard to place the CAT PRO at a perfect location, and a compromise must be made. Therefore, try to obey the following rule of thumbs:

- Keep the CAT PRO at least 3m away from vertical obstructions like the wheelhouse.
- Keep the CAT PRO at least 0.5m away from obstacles like antennas. (If the antenna is transmitting high power, it might cause the CAT PRO not to track satellites!)
- Make sure that nothing is above the CAT PRO such as railings and rain covers made of metal and wood. Most plastic is transparent to GNSS signals.
- Try not to place the CAT PRO directly on the metal floor, as it will introduce multipath reflections and worsen Wi-Fi performance. Raise it by at least 30cm from the floor.
- Use the Brackets also on flat surfaces. The bracket has got stronger magnets which will ensure that the CAT PRO does not move out of position.

On enclosed bridge wings we recommend operational mode 4, with the CAT PRO POS and CAT PRO HDG placed on monkey island, at the front center.

Figure 1 Optimal location - no obstructions nearby

Figure 2 Bad because of the vertical wall next to the unit. A very large part of the sky is blocked and the wall close by will cause multipath

Figure 3 Bad because the wheelhouse is too close and blocking 40% of the sky

Figure 4 Compromise because antennas block large part of the sky and they might transmit high power

Figure 5 Compromise because pipes are next to and above the CAT PRO

Position Quality

In the sensor view in SafePilot information about the quality of the position, speed and heading is shown. If the quality indications described below is not satisfied, the location of the unit should be revised.

Guideline for a good position:

- More than 20 satellites in view.
- HDOP should be less than 1.5.
- Spoofing and Jamming status OK.
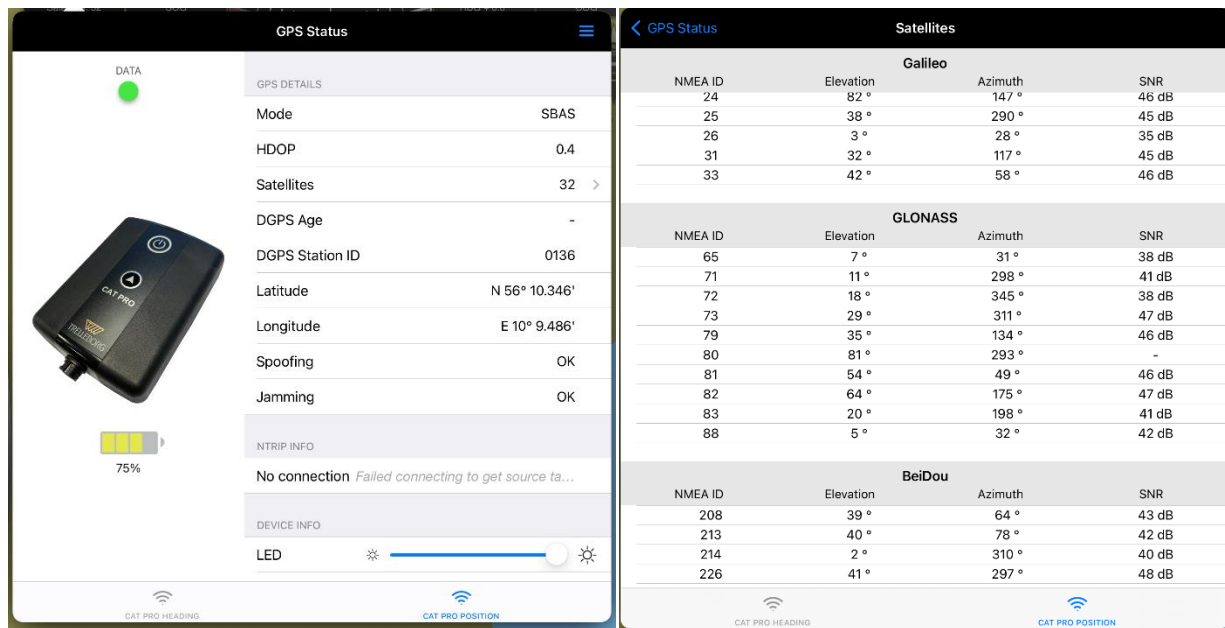- At least 3 satellites should have SNR greater than 45dB.

Figure 2 GNSS Quality indications in SafePilot

Heading Quality

Under the CAT PRO HEADING tab in the sensor view, information about the heading quality is shown. The heading is only shown if it is better than 0.5 degrees. Please note, that for a HDG to be computed, it is crucial that both the POS and HDG units have a clear view of the sky. Therefore, if a HDG is not obtained, make sure that both the HDG and POS unit are located as optimal as possible.

Guideline for a good heading:

- More than 15 satellites should be in view.
  This number is the satellites which are common for the POS and HDG unit. If this number is low, it can be due to no clear view of the sky or a placement where it does not see the same part of the sky as the POS unit.
- The mode can be either "No Solution", "Floating Ambiguities" or "Fixed Ambiguities".
  In "No Solution" it will not compute a heading. This is most likely since it doesn't receive corrections from the POS unit.

In "Floating Ambiguities" it will compute a heading, but the quality is not good enough (above 0.5 degree).

In "Fixed Ambiguities" the quality of the heading is good and is shown.

- The HDG standard deviation is the minimum accuracy of the heading. This must be lower than 0.5 for a heading to be showed.
- Spoofing and Jamming status OK.

Pilot Plug Mode

The CAT PRO or the CAT EXTENDER can be fitted in the Pilot Plug of the ship to receive AIS targets from the ship's AIS.

Using the CAT EXTENDER in Pilot Plug

If using the CAT EXTENDER, connect this to the pilot plug to receive AIS targets. Adding to this it has the advantage that, the CAT EXTENDER will be in the center of the bridge, ensuring a good Wi-Fi coverage over the entire bridge.

Using the CAT PRO in Pilot Plug

If not using the CAT EXTENDER and AIS targets from the PPU is needed, the CAT PRO HDG must be connected to the pilot plug. Note that this means that the CAT PRO HDG cannot compute the heading itself but will forward the heading from the pilot plug.

It is very important that the CAT PRO HDG is installed horizontally to get accurate Rate of Turn.

Charging interface

The CAT PRO features two charging options, either by cable or via a wireless charge pad. The CAT EXTENDER can only be charged through a cable.

Cable Charging

When connecting the cable charger cable, the CAT PRO will start to flash red, to indicate it is charging. When fully charged it will flash a solid red. The CAT PRO supports being charged while in use. The current charge capacity and if it is charging, is shown in SafePilot.

The CAT PRO supports up to USB PD 3.0, up to USB HVDCP and up to QuickCharge 3.0. When in fast-charging mode, the CAT PRO charges from 0-100% in 3 hours, and 1.5 hours for the CAT EXTENDER.

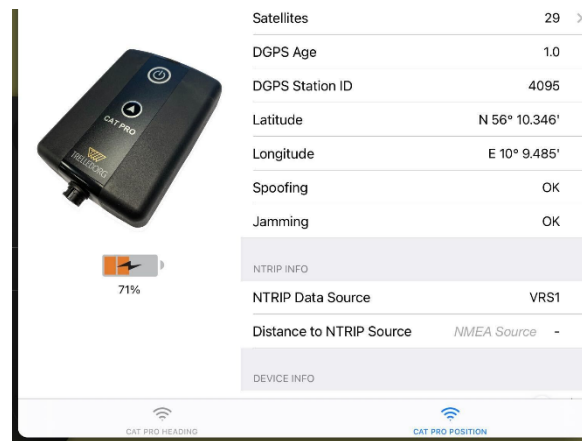*Figure 3 Charge and battery status*

Wireless charging

Place the CAT PRO centered on a wireless charge pad that supports Qi charging. The CAT PRO will start flashing red, indicating it is charging. When fully charged it will flash a solid red.

Technical Specification

Specifications (RMS)	CAT PRO
Weight	410g per unit
Dimensions	138 x 100 x 25 mm
Protection rating	IP65
Humidity	100%
Battery capacity	30 hours
Charge time	3 hours for fully charged, in fast-charge mode.
GNSS Dual Frequency	GPS/GLONASS/BeiDou and GALILEO
Speed	1 cm/s (=0.02kn)
Altitude Accuracy	3 cm (RTK)
ROT	<0.5°/min
Heading accuracy (RMS)	0.05° (@4m)

Position Accuracy (RMS)	CAT PRO
RTK	1cm + 1ppm
DGPS	0.40m
SBAS	0.60m
Stand-alone	2.0m

Specification	CAT EXTENDER
Weight	150g
Dimensions	80 x 54 x 23 mm
Protection rating	IP54
Charge time	3 hours for fully charged, in fast-charge mode.
Battery capacity	30 hours
AIS targets	From ship AIS

Common Errors and Troubleshooting

No Wi-Fi connection to iPad:
- Do not lay the iPad on a metal surface, it will decrease the Wi-Fi connectivity.
- If using the CAT EXTENDER, make sure it is placed in a central place on the bridge. Make sure no obstacles is in the very near proximity of the antenna.
- Try to fulfill the guidelines from the Wi-Fi section above.

Units not pairing:
- Turn off all units and gather them in proximity of each other.

Three-unit setup (with CAT EXTENDER):

1. Turn on the CAT EXTENDER. Wait until it flashes a steady white.
2. Turn on the CAT PRO HDG by pressing the power button until it flashes blue. The unit should start flashing green synchronously with the CAT EXTENDER within 5 seconds.
3. Turn on the CAT PRO POS by long pressing the power button until it flashes purple. The unit should start flashing green synchronously with the CAT EXTENDER and CAT PRO HDG within 5 seconds

Two-unit setup (without CAT EXTENDER):

1. Turn on the CAT PRO HDG by pressing the power button until it flashes blue. Wait 5 seconds until it flashes blue slowly.
2. Turn on the CAT PRO POS by long pressing the power button until it flashes purple. The unit should start flashing green synchronously with the CAT PRO HDG within 5 seconds.

No heading:
- Make sure the CAT PRO POS is connected to the CAT PRO HDG (not flashing quickly)
- Make sure the baseline between the CAT PRO POS and the CAT PRO heading is larger than 1m.

No RTK position:
- Make sure the NTRIP file is filled in correctly and that the iPad has got a solid connection to the cellular network.

Firmware Update

If a newer firmware is available, it is recommended to upgrade to the latest version. To update the units, it is done Over the Air (OTA) via SafePilot.

Feature not implemented yet.