TRELLEBORG MARINE AND INFRASTRUCTURE

TRELLEBORG

SafePilot CAT PRO

MANUAL

SafePilot

Introduction

To fully utilize the CAT PRO navigation system and all its features safely and easily, please read this manual carefully.

The CAT PRO is a professional dual-antenna navigation solution that offers Real-time Kinematic (RTK) position and heading capabilities. The system can be used two ways: to supplement and improve the ship's instrumentation or as a fully independent stand-alone system.

Using CAT PRO with the ship's instruments will help overcome shortcomings. Due to its built-in rate gyro, the CAT PRO offers precise data for delivering a reliable independent Rate of Turn (ROT), which is needed for positioning predictions and may be crucial for navigation, especially in critical turns. Gathering independent data on position, speed, and course enhances the system's usefulness in port and docking operations.

When used together, the CAT PRO units are connected via Wi-Fi to ensure stable and long-range communication. A third unit, the CAT EXTENDER, can be added to the system to enhance the signal and achieve a more comprehensive Wi-Fi range. The two CAT PRO units are, in this case, fully interchangeable. The device will function as a heading (HDG) or positioning (POS) unit depending on how long the power button is pressed during startup.

Overall, the CAT PRO is a highly flexible system, particularly during extended transit pilotage operations. The unit on the bridge wing can be swapped with the unit charging in the pilot plug, which also means that charging between operations may be unnecessary.

The following sections will review the system setup, functionality, and technical specifications.

The TRELLEBORG MARINE SYSTEMS SafePilot systems are designed as a secondary navigational aid and do not relieve the user (pilot, captain, navigator, etc.) of their professional responsibility and navigational skills. Correct use, knowledge, and understanding of the performance and limitations of the SafePilot systems are the sole and only responsibility of the user.

It is important to note that the SafePilot systems and software do not override or substitute the navigation system (charts, ECDIS) installed on board as required by law.

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What's in the box

2 pcs. CAT PRO . . . . . A

1 pc. CAT EXTENDER . . . . . B

1 pc. USB-C charger with EU, UK, US, Japan and AUS adapters C

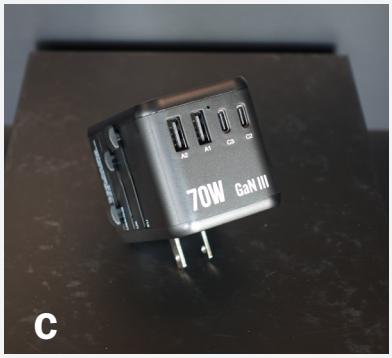
2 pcs. Charging cable(USB-C). . . . . D

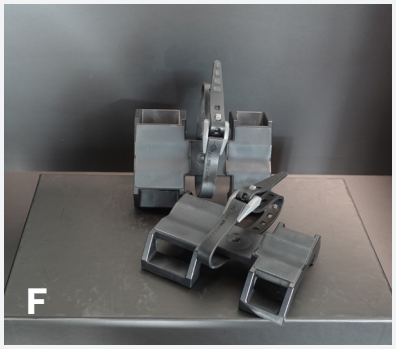
1 pc. AIS & Charging Y-cable (USB-C). . . . . E

2 pc. Mounting Bracket. . . . . F

2 pcs. Safty Lanyard . . . . . G

1 pcs. Quick guide. . . . . E





Technical specifications

CAT PRO:

Wi-Fi

- Client for CAT XT Access point: IEEE 802.11 b/g/n with single band
- Access Point: IEEE 802.11 b/g/n with single band
- Number of clients: 8
- Security: WPA2
- Range: 200m line of Sight

GNSS

- Tracked Systems: GPS / QZSS, Galileo, GLONASS, BeiDou.
- Frequencies: L1C/A, L2C, L1OF, L2OF, E1B/C, E5b, B1I, B2I
- Interference Mitigation: Spoofing and Jamming detection
- Position Accuracy: RTK: 0.01m +/ – 1ppm, SBAS: 0.6m +/ – 1ppm, Stand Alone: 3m +/ – 1ppm
- Speed Accuracy: 1 cm/sec
- Heading accuracy: 0.05°@4m baseline

NETWORK DGNSS CORRECTIONS (NTRIP)

- Protocol: Networked Transport of RTCM via Internet Protocol (NTRIP)

PILOT PLUG INTERFACE

- Automatically polarity correction
- Automatically Rx/Tx correction
- Simultaneous pilot plug Connection/Charge
- Heading Accuracy: 0.1 degrees
- Rate of Turn Accuracy: 0.1°/min.

MECHANICAL

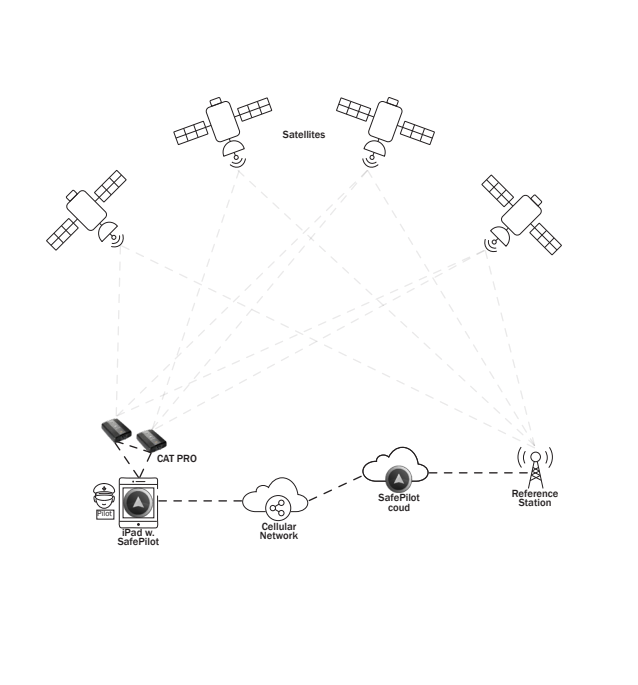
- Weight: 400g
- Dimensions: 138 x 100 x 25mm
- Battery Life: 30 hours
- Charge time: 3 hours
- Battery: 3.6V/7AH
- Humidity: 100%
- Temp. range -20 - 50 °C / -4 - 122 °F

System overview

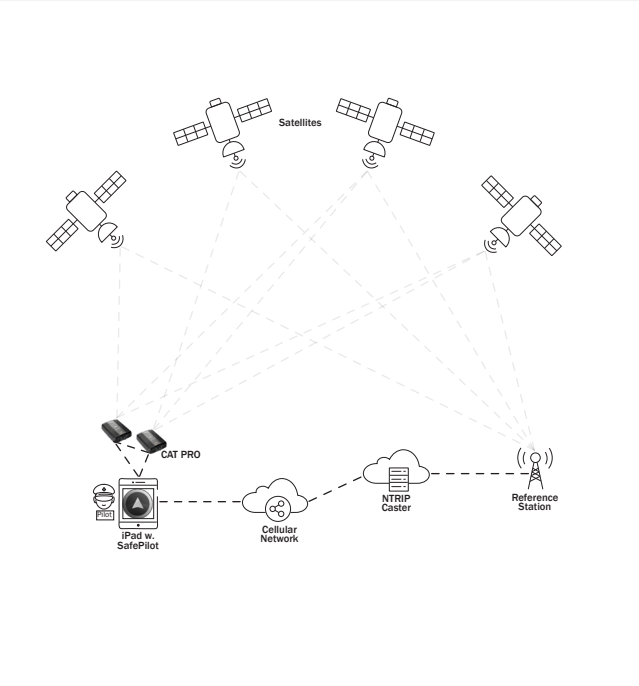
The SafePilot CAT PRO system comprises three units: two CAT PRO units, which can interchangeably be used as either position or heading units, and a CAT EXTENDER for expanding Wi-Fi coverage.

CAT PRO provides position, speed, and course information when used as a position unit. It receives corrections from the Global Navigation Satellite System (GNSS), which are then transmitted to the other CAT PRO unit to calculate the heading.

The system also supports real-time kinematic (RTK) accuracy using internet-based corrections. Typically, these corrections will be provided via a SafePilot server that accesses a local reference station located within the port.



Alternatively, the SafePilot server can be linked to an NTRIP caster to provide corrections. Networked Transport of RTCM via Internet Protocol (NTRIP) is a protocol for transmitting real-time GNSS correction data over the Internet, enhancing position accuracy for autonomous navigation.



When the CAT PRO is used as heading unit, the CAT PRO provides heading and rate of turn. The heading is then computed based on the GNSS corrections transmitted from the CAT MAX POS, while the rate of turn is based on the change in heading and measurements made by the internal gyroscope.

CAT EXTENDER

This unit is used to extend the Wi-Fi range. Although the CAT PRO units can maintain stable and long-range Wi-Fi on their own, placing the units on different vessels without obstructing the signal can be challenging. Obstacles on the vessel can obstruct the signal from the units, causing a blockage. By placing the CAT EXTENDER in the centre of the bridge, better Wi-Fi coverage across the entire bridge will be ensured.

Setup

Whether using one or two CAT PRO units, they should always have a clear sky view when placed outside. Obstructions could cause the CAT PRO system to be less accurate or even wrong because the readings would be based on fewer satellite trackings. To make sure to get the best measurements, the following conditions must be taken into consideration:

- If using the system without connecting any units to the pilot plug, the recommended baseline between the two CAT PROs is 4 meters (13 feet). If it is impossible to get a 4-meter baseline without any obstructions nearby, it would be preferred to place the units closer together and accept a bit less accuracy. Be aware that the baseline should always be a minimum of one meter (3,3 ft).
- If the above is impossible, the two CAT PRO units can also be placed with a longer baseline or on opposite bridge wings. In the latter case, it is important to know that only the signal from shared satellites can be used to compute the heading.
- Ensure the standard deviation does not exceed 0.5 degrees; otherwise, the CAT PRO Heading unit cannot compute a heading. The standard deviation is shown under the quality indicator in the iPad's upper left corner of the SafePilot software - this feature will be described in more detail below.
- Make sure the CAT PRO units have at least a 3m (9,8 ft) clearance from obstructions such as the wheelhouse, rain covers, railings, etc.
- Maintain a distance of at least 0.5 meters (1,6 ft) between the CAT PRO units and obstacles such as antennas. (If the antenna transmits at high power, it may disrupt the CAT PRO from tracking satellites properly)
- For vessels with enclosed bridge wings, it is recommended to place the CAT PRO units on monkey island with the HDG unit at the front center and the POS unit on the port or starboard side from this. Placing the CAT EXTENDER inside and at the centre will provide the best Wi-Fi coverage throughout the bridge.

The following images illustrate suitable and unsuitable locations for the CAT PRO units and provide directions on how one of them can be connected to the pilot plug.

Two very good locations for the CAT PRO units, as the area around the unit is clear and free of obstacles

The location shown in the pictures is not ideal for placing the CAT PRO because a significant portion of the sky is obstructed by the vertical wall and the wheelhouse next to the unit. Additionally, the wall and wheelhouse may cause multipath interference.

Due to the proximity of numerous antennas, this location is not suitable for the CAT PRO.

CAT PRO, connected to the pilot plug and placed on a horizontal surface.

Operation Modes

The CAT PRO has four different operational modes, which can be used depending on the conditions and situations requiring their function. The following section will examine the different ways of usage.

The CAT PRO has slightly directional Wi-Fi strength, which means that the signal is strongest in the direction of the arrow. It is, therefore, important to pay close attention to how the CAT PRO is positioned in order to achieve the best performance.

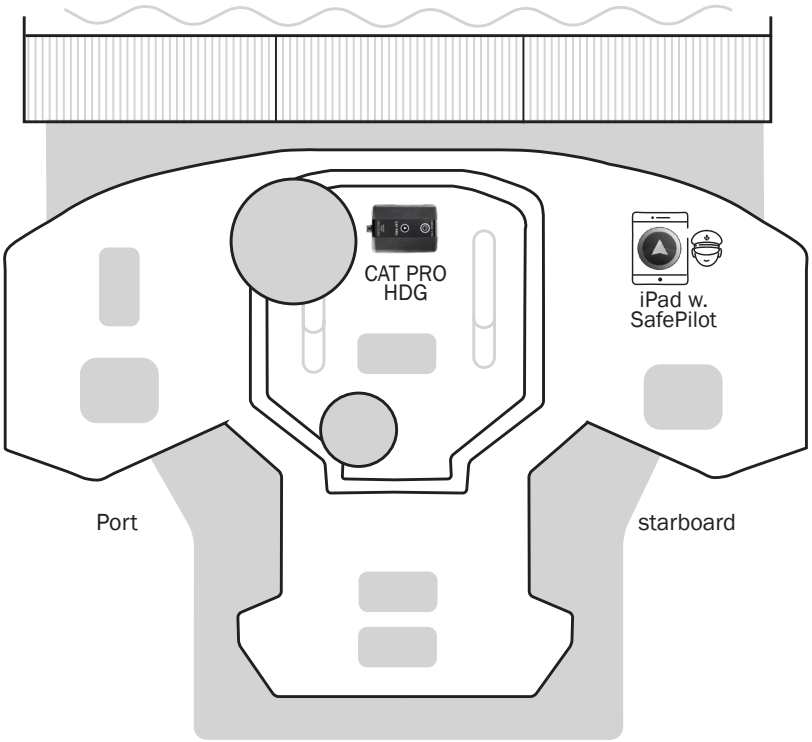
1. Using CAT Pro as Pilot Plug Repeater

In the simplest use case, only one of the CAT PRO units will be used and 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 (ROT) and providing the missing decimal readings to the heading data via an integrated rate sensor, intelligent processing, and an advanced Kalman filter integrated into the unit.

Using CAT PRO as Pilot Plug Repeater:

- Turn on the CAT PRO with a short press of the button on the top of the device until the LED turns blue
- Connect the CAT PRO to the pilot plug using the provided cable.
- Make sure the unit is placed on a horizontal surface to achieve a reliable rate of turn
- Connect an iPad to the network “CAT PRO (3-xxxxxxxx)” with password “86912255” and open up SafePilot
- To ensure reliability in the Wi-Fi performance, the CAT PRO must be placed, as shown in the layout below, with the arrow pointing towards the bridge wing where the pilot is located during ducking

When using CAT PRO in this mode, be aware that relying solely on the ship’s instrumentation may lead to inaccuracies in reading the ship’s position and speed. This is why it is recommended that two CAT PRO units be utilized for most operations. This way, an independent position, speed, course, heading, and rate of turn is provided.

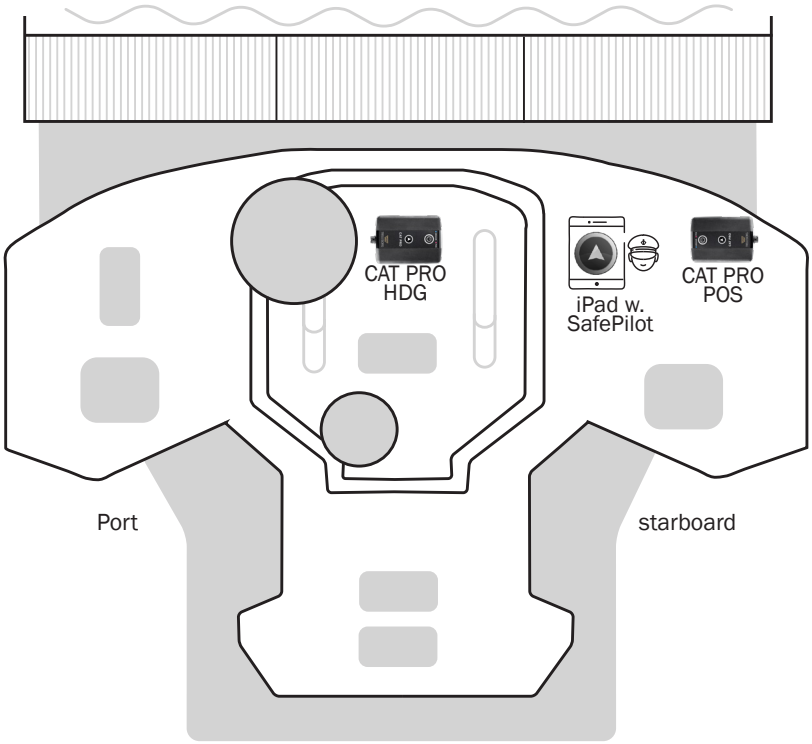


2. Using CAT PRO as Pilot Plug Repeater with external GNSS Receiver

In Mode two, the CAT PRO units will work as a pair. The one connected to the pilot plug will function as a pilot plug repeater, and the other will be an external GNSS unit computing the position. In addition to the improved accuracy in ROT achieved in mode 1, in this mode position, course over ground and speed are also provided independently from the ship's instrumentation, enhancing the position data's reliability.

To use the device in mode 2, please follow the steps below:

- Turn on one of the CAT PRO units by pressing the button on the top until it flashes blue. This will now be the AIS unit.
- Then turn on the other device by pressing its button for approximately four seconds until it starts flashing purple. Now functioning as POS unit
- After a few moments, the units will change to flash green simultaneously, indicating that they have paired
- Connect the CAT PRO AIS unit to the pilot plug with the supplied cable, placing it on a horizontal surface to ensure a reliable ROT
- Place the CAT PRO POS on the bridge wing with regard to the guidelines in the setup section.
- Connect an iPad to the network "CAT PRO (3-xxxxxxxx)" with password "86912255" and open up SafePilot



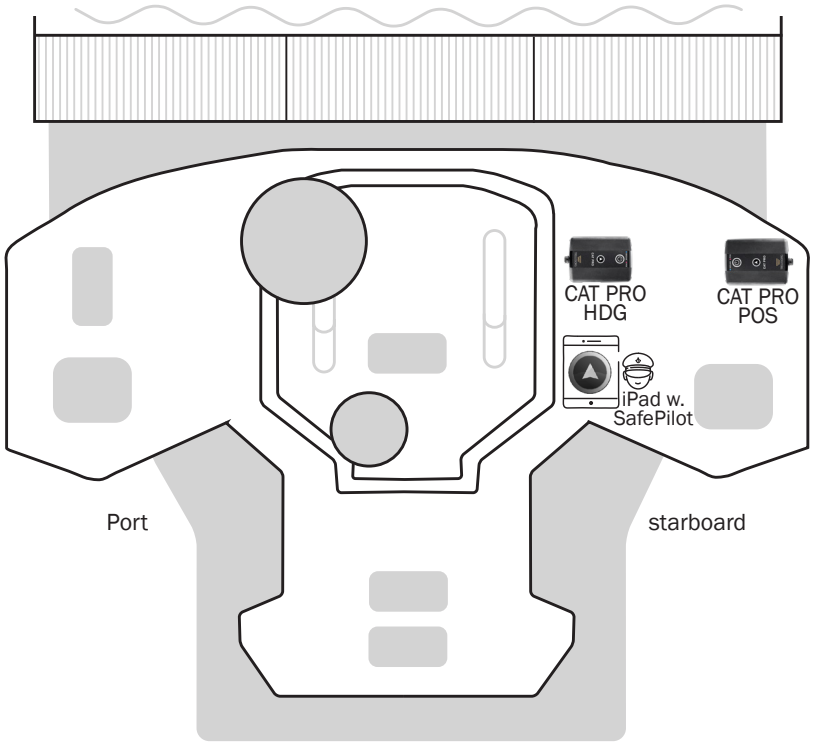
3. Using CAT PRO as a stand-alone system:

In the 3rd mode, the CAT PRO will function as a fully independent system, not relying on the ship's instrumentation.

When used in this mode, both CAT PRO units should be located on the bridge wing. One unit will be configured as an HDG unit, which will compute an accurate real-time heading and ROT due to the built-in rate sensor and Kalman filter. The other unit is configured as a CAT PRO POS, computing position, speed, and course. AIS data can be distributed to SafePilot via a SafePilot Server.

To use the system in mode 3, please follow the steps below:

- Turn on the CAT PRO units one by one by pressing the button on the top. One should flash blue, which will function as an HDG unit, while the other should flash purple, which is the POS unit.
- After a few moments, the units will shift to simultaneously flashing green, indicating that they have paired
- Place both CAT PRO units outside on the bridge wing on a horizontal surface with a clear sky view (for guidelines see the "Setup" section). The units should be set up as in the illustration below. Note that the HDG unit should be closest to the wheelhouse for the best Wi-Fi coverage.
- Connect an iPad to the network "CAT PRO (3-xxxxxxxx)" with password "86912255" and open up SafePilot



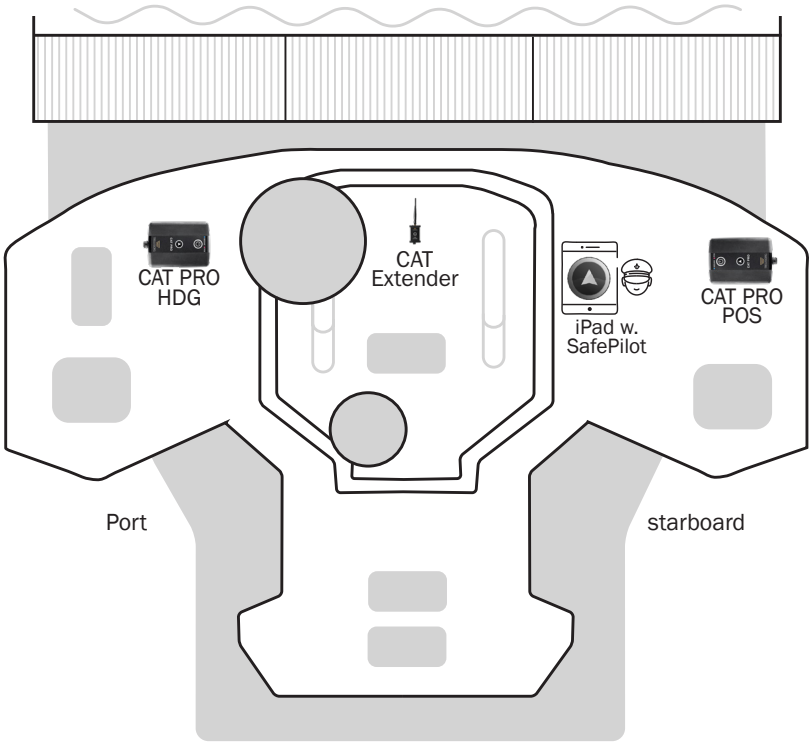
4. Using CAT PRO as a stand-alone system with extended Wi-Fi Range

In this mode, the CAT EXTENDER will be used alongside the two CAT PRO units, making the system comprised of three units. Located in the centre of the ship, the CAT EXTENDER will act as the Wi-Fi access point, providing strong and reliable Wi-Fi coverage throughout the entire bridge wing – even on large vessels.

If necessary, the two CAT PRO units can be placed on the same bridge wing on the same side of the ship, but placing one unit on the port side and one on the starboard side will provide a long baseline, resulting in very accurate heading computations. As in the previous mode, the CAT PRO HDG computes the heading and Rate of Turn, and the CAT PRO POS computes the position, speed, and course.

Using CAT PRO as a stand-alone system with extended Wi-Fi range:

- Turn on the CAT EXTENDER and wait until it lights up in a solid white (about 5 seconds). Always turn on the CAT EXTENDER first before other devices.
- With a short press on the top button, turn on one CAT PRO as the HDG unit (flashing blue) and the other as the POS unit by pressing the top button a bit longer (flashing purple)t
- After a few moments, all three devices should flash green simultaneously, indicating they have paired
- Connect the CAT EXTENDER to the Pilot Plug via the supplied cable. The CAT EXTENDER should be positioned to have a clear view of the bridge wings and the two CAT PRO units, and its antenna must be oriented vertically, pointing upwards
- Place both CAT PRO units outside on the bridge wing on a horizontal surface with a clear sky view (for guidelines, see the “Setup” section)
- Connect an iPad to the network “CAT PRO (3-xxxxxxxx)” with password “86912255” and open up SafePilot



Position and heading quality

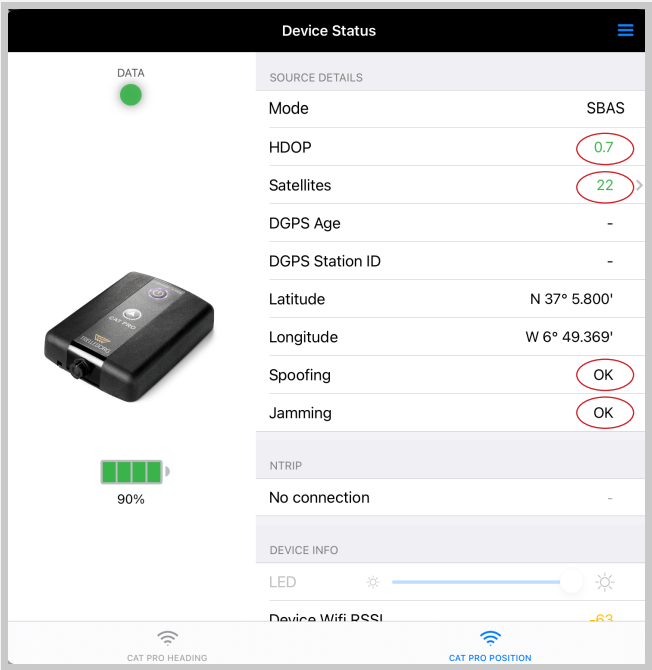
The Device Status window in the SafePilot software provides valuable information about the quality of position, speed, and heading computations. To access it, tap the quality indicator SBAS on the left side of the top bar.

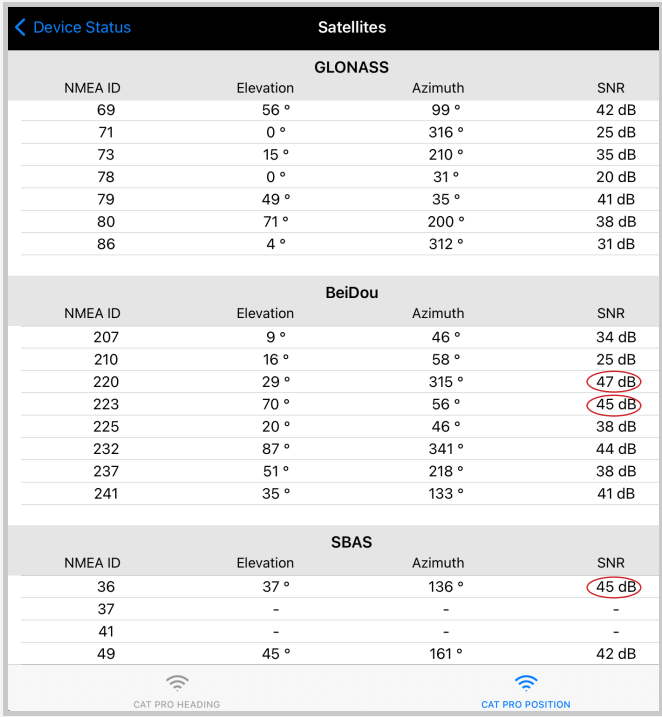
The information from the different units is shown in separate windows. To switch between these, tap either CAT PRO HEADING or CAT PRO POSITION in the bottom bar of the Device Status window. The values displayed in these windows indicate whether the CAT PRO POS unit is placed appropriately or should be moved to a better location and whether it is in contact with the CAT PRO HDG.

When evaluating the placement of each unit, it's important to consider the general guidelines listed in the "Setup" section above.

General quality guidelines for the CAT PRO POS unit:

- The unit should be able to connect to more than 20 satellites
- HDOP (horizontal dilution of precision) value must not exceed 1.5
- Both the spoofing and jamming status should be OK
- At least three satellites should have an SNR (signal-to-noise ratio) beyond 45 dB





GLONASS

NMEA ID	Elevation	Azimuth	SNR
69	56 °	99 °	42 dB
71	0 °	316 °	25 dB
73	15 °	210 °	35 dB
78	0 °	31 °	20 dB
79	49 °	35 °	41 dB
80	71 °	200 °	38 dB
86	4 °	312 °	31 dB

BeiDou

NMEA ID	Elevation	Azimuth	SNR
207	9 °	46 °	34 dB
210	16 °	58 °	25 dB
220	29 °	315 °	47 dB
223	70 °	56 °	45 dB
225	20 °	46 °	38 dB
232	87 °	341 °	44 dB
237	51 °	218 °	38 dB
241	35 °	133 °	41 dB

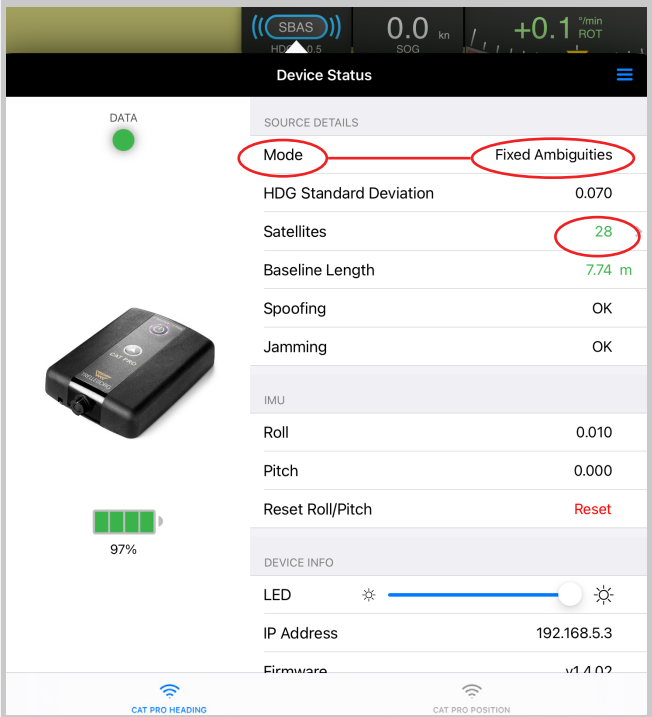
SBAS

NMEA ID	Elevation	Azimuth	SNR
36	37 °	136 °	45 dB
37	-	-	-
41	-	-	-
49	45 °	161 °	42 dB

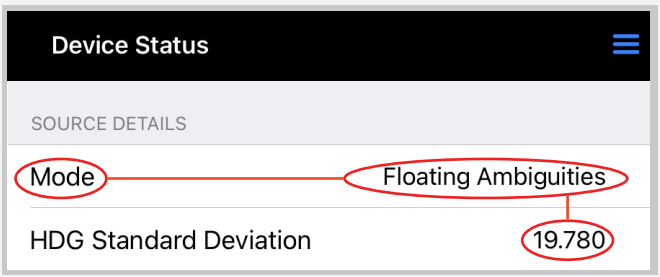
General Guidelines for the CAT PRO HEADING Unit

- For the HDG unit to function optimally, it should have access to more than 15 satellites. The number indicates how many satellites the two CAT PRO units commonly connect to. If there are not enough shared satellites, the HDG unit should be placed in a location with a clear view of the sky and/or covering the same part of the sky as the Pos unit.
- The Mode indicator can show one of the following three statuses:

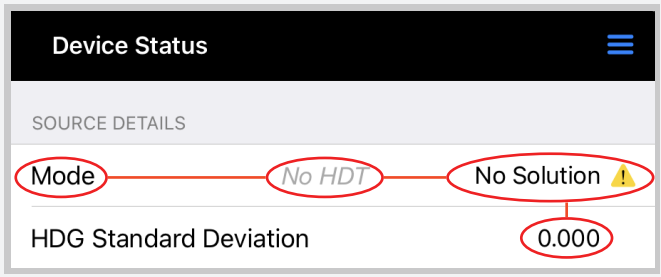
Fixed Ambiguities: The heading is displayed and is of high precision.



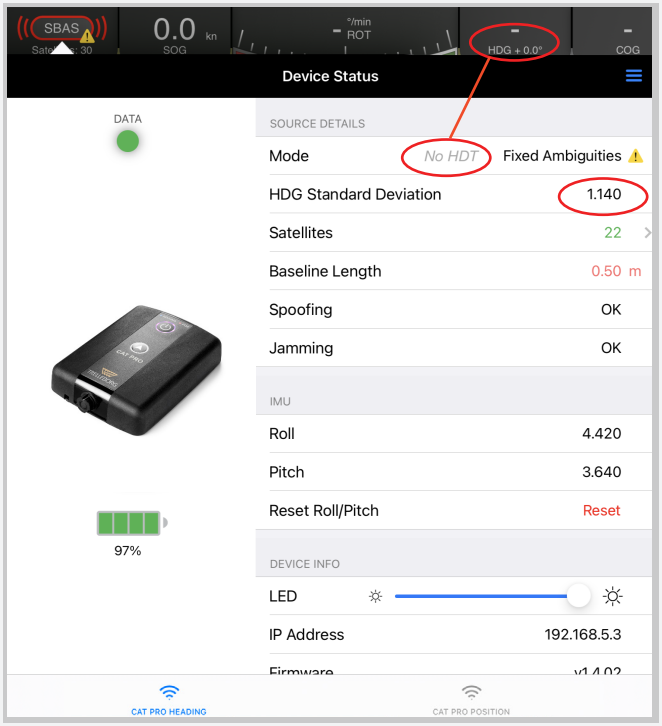
Floating Ambiguities: A heading is computed, but the quality is not very good (The HDG standard deviation is above 0.5° – see the bullet below)



No Solution: No heading is computed. Most likely because the HDG unit does not receive any corrections from the position unit



- The HDG standard deviation indicates the minimum heading accuracy. The indication must be lower than 0.5° for a heading to be displayed
- In case the HDG standard deviation value exceeds 0.5 for 5 minutes or more, the IMU will stop computing the heading. This means no heading will be provided, as seen below.



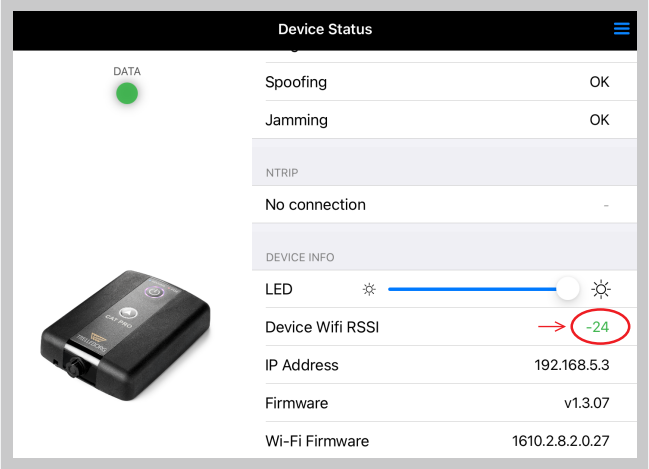
Monitoring WiFi and RSSI

Maintaining a stable WiFi connection between the different units is essential for ensuring high-quality data reception and reliable connectivity. The strength of the signal can be monitored in the Device Status window under the "Device WiFi RSSI" point. This reference point will indicate whether the connection is strong or if there are any issues.

The signal quality is categorized into three levels:

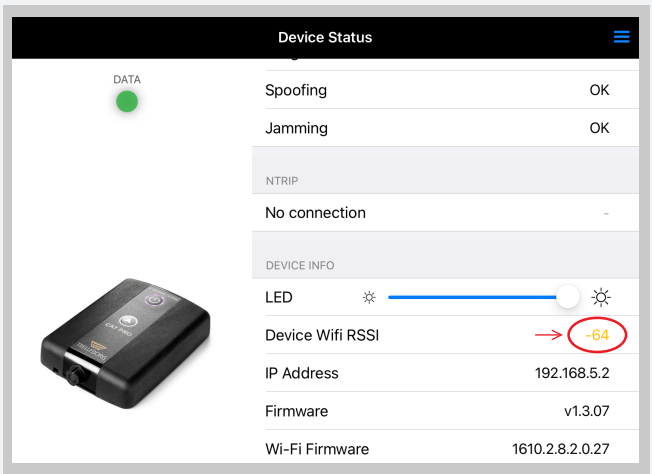
- **Green** (Signal Strength: -60 or better):

  A green indicator signifies a stable connection; no further action is needed



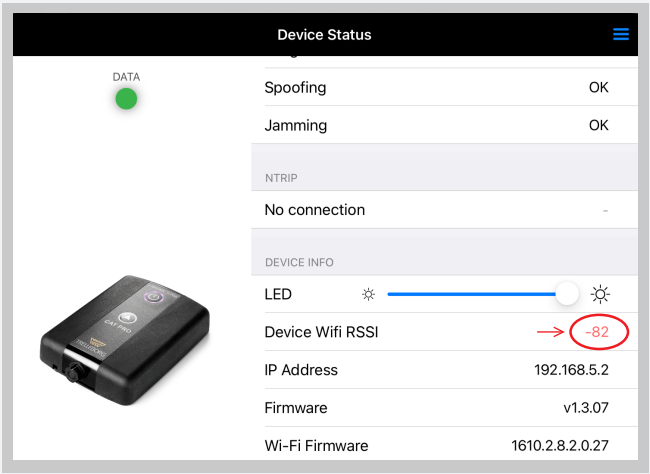
- **Yellow** (Signal Strength: Between -60 and -75):

  A yellow indicator means the connection is weaker than preferred. In such cases, relocating the CAT PRO units to a better position for improved WiFi signal is advisable.



- **Red** (Signal Strength: Below -75):

  A red indicator means the WiFi connection is too weak. For reliable connectivity, the units must be relocated to an area with a stronger signal (preferably above -60).

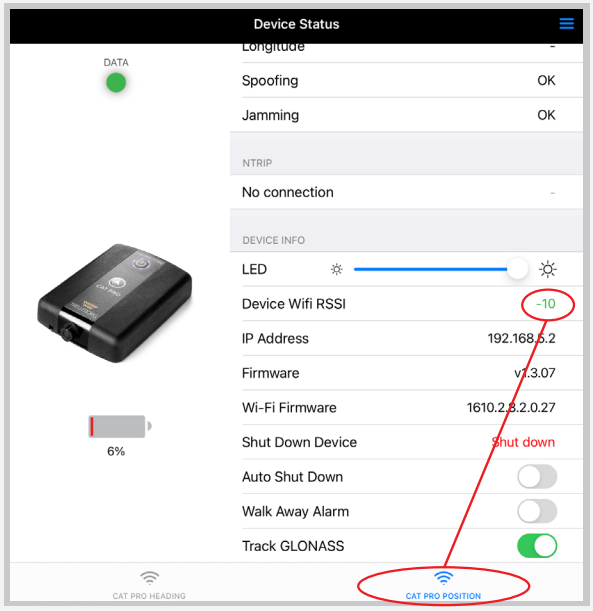


The location of the information to check the signal strength may vary depending on the mode in which the system is being used. However, the key takeaway is that it is essential to monitor the client unit or units closely.

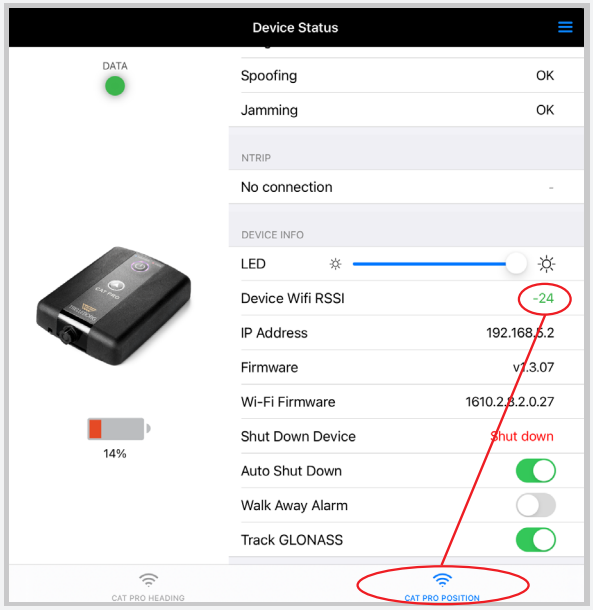
The following provides a brief overview of which unit or units to monitor when used in different modes:

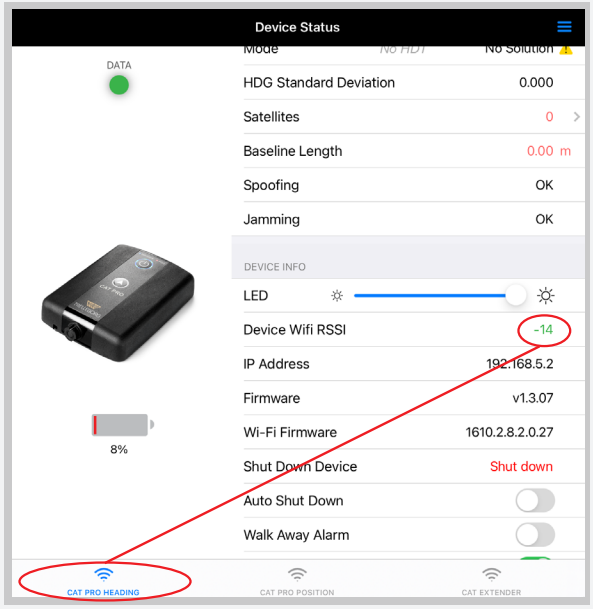
- **Mode 1:** The CAT PRO HDG unit is, in this mode, connected directly to the pilot plug. This eliminates the need for WiFi and monitoring the connection

Mode 2: In the second mode, the CAT PRO POS unit is the client to the HDG unit which is connected to the pilot plug and provides the signal. In this case, the signal strength can be monitored in the Device Status window when it displays the status for the POS unit, as shown in the screen capture below:



Mode 3 and 4: When used in this mode, both units will be clients of the ship's WiFi (in mode four through the EXTENDER). It is, therefore, important to monitor the signal for both devices.





If the signal gets lost, it may be necessary to turn the unit with the lost signal off and on again to regain the connection.

Lights Guide

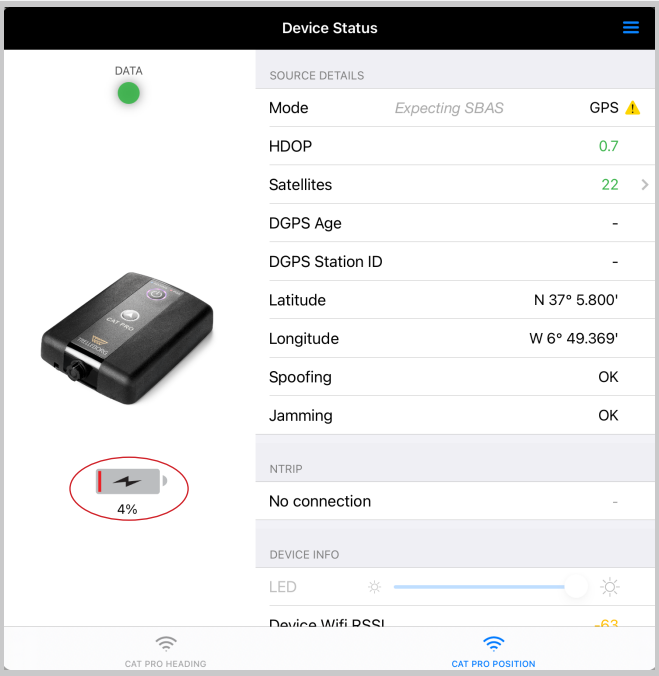
CAT PRO:		
	Steady Purple	Position OK
	Fast Flashing Purple	Not Connected to PRO access point
	Slow Flashing Purple	No GPS position
	Steady Red	Fully Charged
	Fast Flashing Red	Low Battery
	Slow Flashing Red	Charging
	Simultaneous Flashing Green	Units Paired
	Steady Blue	AIS/HDG data OK
	Slow Flashing Blue	No AIS data

Charging and Auto Power off

The CAT PRO offers high flexibility with two charging options: via cable or with a wireless charge pad. Additionally, the two units are fully interchangeable, allowing for easy switching if one needs to be charged.

Cable Charging

The CAT PRO flashes red when the charging cable is connected, indicating that charging is in progress. When the unit is fully charged, the light switches from flashing to lighting up in solid red. The SafePilot software displays the current battery level and whether the unit is charging.



The CAT PRO is fully functional while charging. It supports up to USB PD 3.0, USB HVDCP, and QuickCharge 3.0. When fast charging is used, the CAT PRO battery charges from zero to 100% in approximately 3 hours.

Wireless Charging

Place the CAT PRO centred 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.

The units are fully functional while charging, and the progress can be tracked in the SafePilot software. The battery load percentage is shown along with a lightning symbol indicating that the charging is ongoing.

Auto Power off

It is possible to enable/disable the feature, as required, through SafePilot software.

Either of the two CAT PRO Units will turn off automatically under certain conditions.

If the following conditions are met, the unit will turn off. This will also occur when the devices are connected to a Pilot Plug or charger.

CAT PRO HDG:

- If no heading has been achieved for 30 minutes
- If no clients are registered, on the Wi-Fi Network for 30 minutes

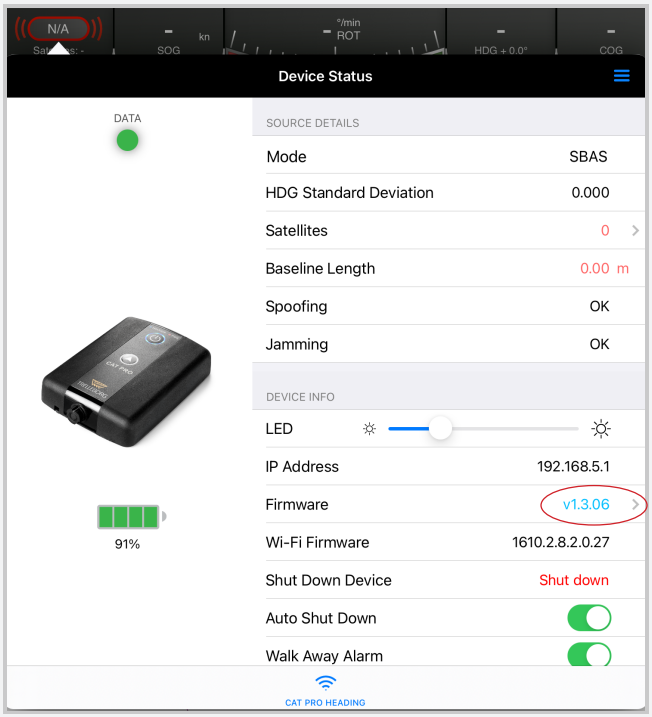
CAT PRO POS:

- If not connected to the CAT PRO POS Unit for 30 minutes
- If no valid position is achieved for 30 minutes

Firmware Update

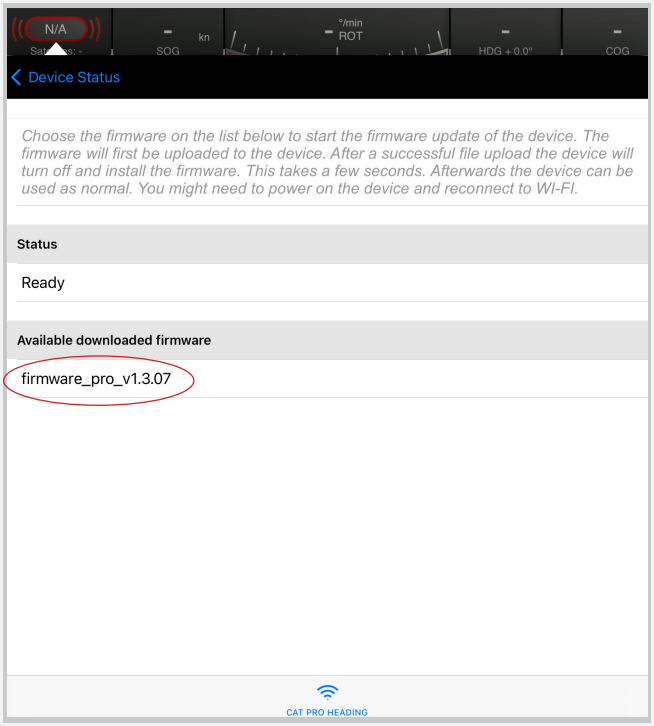
It is recommended that CAT PRO devices always be updated to the latest firmware version

When an update is available, it will be displayed in the GPS Status view window, and the version currently installed will be marked blue.

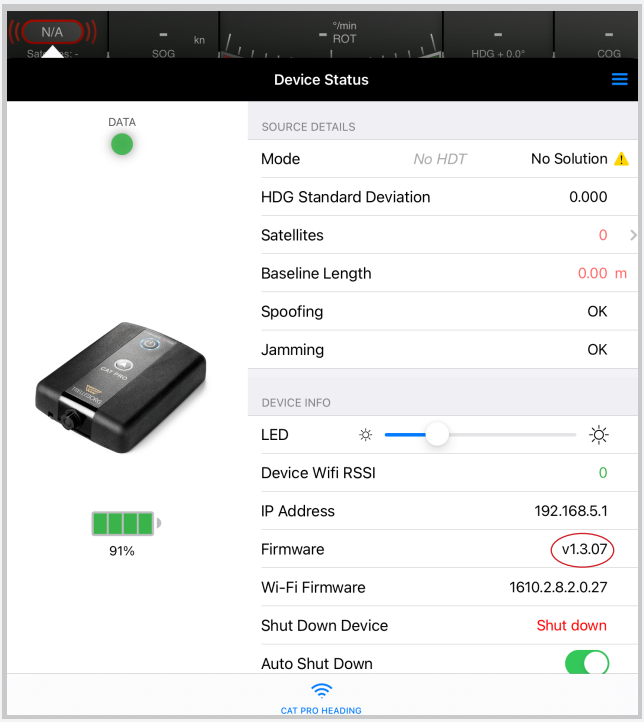


The update can be done Over the Air (OTA) by following the steps below:

- Turn on the two CAT PRO units
- Connect to its Wi-Fi and open SafePilot.
- To update the firmware, tap on the firmware field in the GPS Status view window. A new window will appear showing the available firmware.
- Tap on the new firmware version, and the device will start updating



- After completing the update, the unit will restart, and the new firmware version will be displayed in black in the Status view window



Maintenance

To ensure the CAT PRO units remains in great condition, please keep the following in mind:

- Keep the CAT PRO units clean and dry while stored.
- The battery level should be maintained at 50-60% if the device is not used for an extended period of time
- All cables need regular inspection, and the connectors must be checked to ensure they are clean
- Inspect the straps on the mounting bracket and make sure they are in good condition. Replace if any of the straps show signs of wear and tear
- Always remember to remove the CAT PRO from the bracket before taking it off the railing

COMMON ERRORS & TROUBLESHOOTING

No Wi-Fi connection to iPad:

- Do not place the iPad on a metal surface, as this may affect its ability to connect to WiFi.
- Make sure the iPad is placed centrally on the bridge and that there are no obstacles within close proximity of the antenna
- Ensure compliance with the Wi-Fi signal guidelines in the “Operation Mode” section

Units not pairing:

- Turn off all units and place them in close proximity to each other
- Turn on the CAT PRO HDG by pressing the power button. It will start flashing blue. Wait 5 seconds until it begins to flash blue more slowly
- Turn on the CAT PRO POS by pressing the power button until it flashes purple. The unit should start flashing green synchronously with the CAT PRO HDG within 5 seconds

No position is shown:

- Confirm that the CAT PRO POS is connected to the CAT PRO HDG. The CAT PRO POS will be fast flashing purple if not connected
- Make sure the arrows on the two units point towards each other

No RTK position:

- Make sure the NTRIP file is filled in correctly, and ensure that the iPad has a stable connection to the cellular network

SafePilot Software

The SafePilot is a user-friendly software available as an app for iPad and Apple Watch. It handles key tasks such as navigation data, planning functions, route and arrival times, recording, chart handling, predictions, and history. Additionally, it offers specialized functions for docking and alignment, lock operations and weather data among other things.
To learn more about our products and SafePilot, or to purchase the software, please feel free to contact Trelleborg Marine & Infrastructure or visit our website for additional information.

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LEARN MORE
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Trelleborg is a world leader in engineered polymer solutions that seal, damp and protect critical applications in demanding environments. Its innovative solutions accelerate performance for customers in a sustainable way.

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