OXTS

WayFinder Prime

USER MANUAL

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OXTS warrants its products to be free of defects in materials and workmanship, subject to the conditions set forth below, for a period of one year from the Date of Sale.

“Date of Sale” shall mean the date of the OXTS invoice issued on delivery of the product. The responsibility of OXTS in respect of this warranty is limited solely to product replacement or product repair at an authorised location only. Determination of replacement or repair will be made by OXTS personnel or by personnel expressly authorised by OXTS for this purpose.

In no event will OXTS be liable for any indirect, incidental, special, or consequential damages whether through tort, contract or otherwise. This warranty is expressly in lieu of all other warranties, expressed or implied, including without limitation the implied warranties of merchantability or fitness for a particular purpose. The foregoing states the entire liability of OXTS with respect to the products herein.

Any use or misuse of the product in a manner not intended may impair the protection provided. Improper installation or usage of the device can lead to malfunction, loss of data, equipment damage, and physical injury. The user is responsible for conducting a proper risk assessment when integrating the product. Please contact OXTS if you believe any service or repair is required on your product.

Product limitations

Products must not be used or sold in the development or utilisation of any weapons or life-threatening applications, as well as any life sustaining or security sensitive applications including but not limited to aviation, medical, or emergency systems where a malfunction could lead to bodily harm or significant property damage.

Limitations of liability

The purchaser shall indemnify OXTS from all third-party claims arising from any product use not covered by the parameters of the product datasheet or not approved by OXTS.

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Introduction

WayFinder Prime is a turnkey multi-sensor solution incorporating GNSS, IMU, LiDAR, and cameras for robust localisation and mapping in all environments. It combines state-of-the-art inertial navigation technology with cutting edge computer vision processing using LiDAR and camera sensors to deliver precise and repeatable vehicle pose and motion information in a wide range of environments including GNSS-denied.

This document covers the technical information, hardware set up and configuration steps to enable you to successfully integrate and operate the device.

Important information is highlighted throughout this manual in these boxes.

Intended use

The WayFinder Prime is designed to precisely measure position, time, orientation, and dynamics data for localisation and mapping applications. It is capable of logging data as a passive measurement device, and/or outputting the data in real-time with low latency for use in active systems. If the outputs are used in any way as part of a control system, appropriate steps should be taken by the System Integrator to ensure that the control system as a whole meets the required functional safety standards, with additional independent and redundant sensors and modules.

The enclosure is rated to IP67 for dust and water protection, and as such the device is suitable for outdoor use in pollution degree 3 environments.

Related documents

This manual covers the technical information for installation and operation of the device, but it is beyond its scope to provide details on service or repair. Contact OXTS support or your local representative for customer service-related inquiries.

Additional manuals provide further information on some of the software and communication types mentioned in this manual. Table 1 lists related manuals and where to find them.

Manual	Description
NAVdisplay Manual	For viewing real-time information from an WayFinder Prime. https://www.oxts.com/software/navsuite/documentation/manuals/NAVdisplay_man.pdf
NAVgraph Manual	For plotting and exporting captured data. https://www.oxts.com/software/navsuite/documentation/manuals/NAVgraph_man.pdf
NAVsolve Manual	Explains how to use our post-processing application. https://www.oxts.com/software/navsuite/documentation/manuals/NAVsolve_man.pdf
NCOM Manual	Description of the OXTS NCOM format. https://www.oxts.com/software/navsuite/documentation/manuals/NCOM_man.pdf
NCOM C Decoder	A collection of C functions that can be used to decode the binary protocols from the WayFinder Prime. https://github.com/OxfordTechnicalSolutions/NCOMdecoder
ROS2 driver	Allows an OXTS INS to interact with a wider ROS network. https://github.com/OxfordTechnicalSolutions/oxts_ros2_driver
NMEA 0183 Description	NMEA description manual for the NMEA outputs. https://www.oxts.com/software/navsuite/documentation/manuals/NMEA_man.pdf

Table 1:
Supplementary manuals

Scope of delivery

The standard kits are supplied complete with user cable, an Ethernet cable and crossover, software, a calibration certificate, a tape measure, and a quick start guide.

Table 2 lists all items that are delivered with each WayFinder Prime.

Component	WayFinder Prime Standard Kit	WayFinder Prime (excl. LiDAR) Standard Kit
Part number	109-01281	109-01289
WayFinder Prime	x1	x1
User cable (14C0238)	x1	x1
Power extension cable M12-M12	x1	x1
Hesai XT32M1X LiDAR	x1	x0
Hesai LiDAR cable (14C0240)	x1	x1
LiDAR adapter plate (14M0279)	x1	x1
LEMO caps (BRE.1K.200.NAS)	x3	x3
USB stick with manuals and software	x1	x1
Tape measure	x1	x1
Declaration of Conformity	x1	x1
Quick start guide	x1	x1

Table 2:
Summary of WayFinder Prime scope of delivery

Conformance notices

The WayFinder Prime complies with all emissions and immunity limits for the standards stated on the Declaration of Conformity. These limits are designed to provide reasonable protection against harmful interference in business, commercial and industrial uses. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following:

- Re-orient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.

The device incorporates a GNSS receiver. No GNSS receiver will be able to track satellites in the presence of strong RF radiations within 70 MHz of either the GPS frequencies L1 (1575 MHz) or L2 (1228 MHz).

The WayFinder Prime conforms to the requirements for CE.

Regulator testing standards

Refer to the included Declaration of Conformance included with the product

Ingress Protection

The device is compliant with IP67 and a pollution degree of 3, only where all of the following conditions are true:

1. All three LEMO sockets (J2, J3, J4) are securely mated to any of the following:
    1.1. LEMO part number BRE.1K.200.NAS,
    1.2. OXTS 14C0238 revision E or later,
    1.3. OXTS 14C0240 revision C or later.
2. Each SMA socket is securely mated to any of the following:
    2.1. Waterproof cap Telegartner H00040A0001 (supplied separately)
    2.2. IP-rated SMA cable Gigatronix JPX1KJPX1KC10L-*M (supplied separately).

If the device is being used with a Hesai XT32M1X, then the following condition also applies:

3. The LiDAR is securely mated to any of the following:
    3.1. LEMO part number BRE.0K.200.NAS,
    3.2. OXTS 14C0240 revision C or later.

In any other configuration, the device MUST NOT be used in wet environments (including but not limited to rain, snow, and conditions liable to cause condensation of water on the device). Doing so risks damaging the device internally, as well as any devices it may be connected to.

Owing to the device's ES1 classification, fuse protection, and metal enclosure, no hazards to health are anticipated as a result of water ingress.

Safety Notices

To avoid violating the warranty and to minimize the chances of getting electrically shocked, please do not disassemble the product. The product must not be tampered with and must not be changed in any way. There are no user-

serviceable parts inside the product. For repairs and maintenance inquiries, please contact an authorized Hesai Technology service provider.

Laser Safety Notice Hesai XT32 - Laser Class 1

This device satisfies the requirements of

- · IEC 60825-1:2014
- · 21 CFR 1040.10 and 1040.11 except for deviations (IEC 60825-1 Ed.3) pursuant to Laser Notice No.56, dated May 8, 2019

NEVER LOOK INTO THE TRANSMITTING LASER THROUGH A MAGNIFYING DEVICE (MICROSCOPE, EYE LOUPE, MAGNIFYING GLASS, ETC.)

LiDAR Safety Precautions

For full details refer to the Hesai XT32 manual here:

https://www.hesaitech.com/downloads/#xt32m2x

Hardware description

Overview

The WayFinder Prime is a multi-sensor localisation system which fuses GNSS, IMU, LiDAR, and camera data to create a precise 3D navigation output in a wide range of environments. Table 3 details the main components that comprise the WayFinder Prime.

Component	Description
GNSS	Two quad-constellation multi-frequency RTK GNSS receivers
IMU	6-axis multi-core IMU10
Stereo cameras	Two built-in calibrated 8 MP cameras
LiDAR	External 360° LiDAR OXTS LiDAR kit option comes with Hesai XT32 pre-installed

Table 3:
Overview of WayFinder Prime components

Rear panel layout

Figure 1 and **Table 4** show the interfaces on the rear panel of the WayFinder Prime.

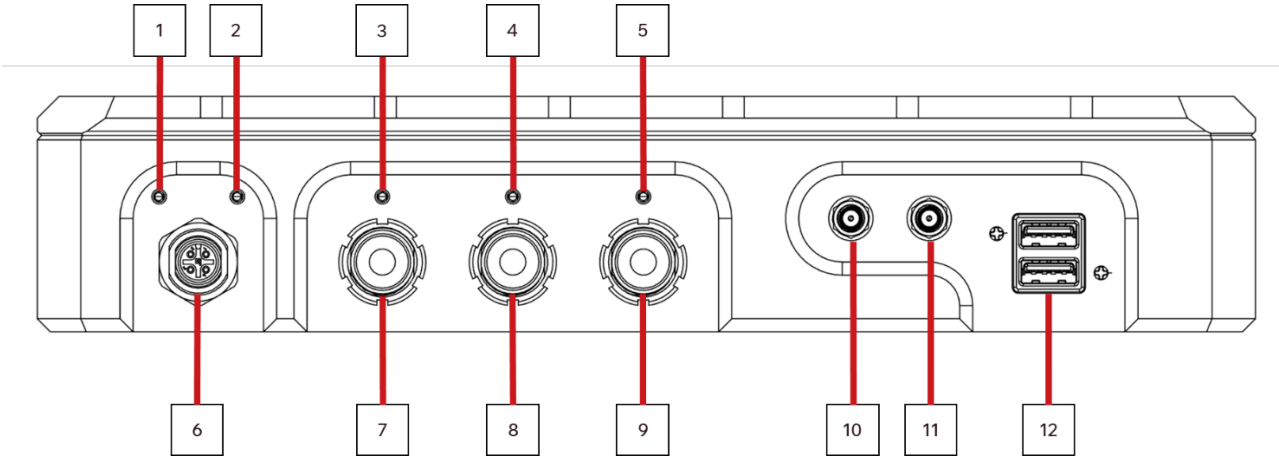


Figure 1:
WayFinder Prime rear panel layout

Label number	Description
1	Power and INS status LED
2	Processor status LED
3	LEMO 1 Ethernet status LED
4	LEMO 2 Ethernet status LED
5	LEMO 3 Ethernet status LED
6	Power Input M12 male (J1)
7	LEMO 1 socket (J2)
8	LEMO 2 socket (J3)
9	LEMO 3 socket (J4)
10	Primary GNSS SMA female
11	Secondary GNSS SMA female
12	USB 3.0 dual port

Table 4:
WayFinder Prime rear panel descriptions

LED definitions

The LEDs on the rear panel indicate the current system status. While they cannot display all the measurements the product is capable of, they provide a useful snapshot for quick, at-a-glance checks without requiring a portable PC. The tables below detail the behaviour of each LED.

Colour	Description
Off	There is no power to the INS or the system power supply has failed.
Red	Power is applied to the INS.

Table 5:
INS Power LED states

Colour	Description
Off	The operating system has not yet booted. This occurs at start-up.
Red	The operating system as booted and is active

Table 6:
Processor status LED states
In the current versions of the software the strapdown navigator will not leave green and return to any other state. This may change in future releases.

Colour	Description
Off	No connection
Red	100 Mbps link, no Ethernet traffic
Red flash	100 Mbps link, live Ethernet traffic
Orange	10 Mbps link, no Ethernet traffic
Orange flash	10 Mbps link, live Ethernet traffic

Table 7:
LEMO Ethernet status LED states

Connectors

Power

The WayFinder Prime has a 4-way M12 Male plug. Figure 2 shows the pin layout. Please note that all 4 power pins must be used to provide accurate amp rating coverage.

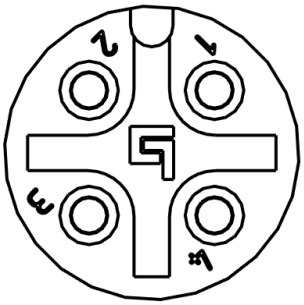


Figure 2:
WayFinder Prime M12 power input pin layout

Pin #	Colour	Function	Description
1	Brown	Supply+	Power supply
2	White	Supply+	
3	Blue	Supply	
4	Black	Supply	

Table 8:
WayFinder Prime M12 power input pin description

I/O

The WayFinder Prime has three LEMO connectors with the main data I/O pins. The pin layout is the same for all three and is shown in Figure 3.

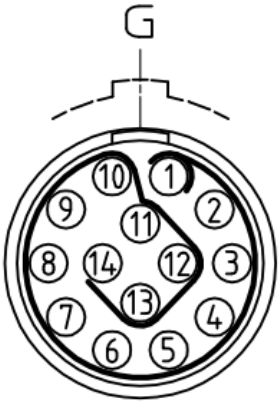


Figure 3:
WayFinder Prime LEMO I/O connector pin layout

Table 9, Table 10, and Table 11 show the pin descriptions for LEMO connectors 1, 2, and 3 respectively.

Pin #	Function	Description	Notes
1	Reserved	Reserved	
2	RS232 TX Radio	RS232 transmit – DGNSS corrections	
3	Trigger 2	Trigger 2 (input/output/camera)	
4	Supply+	Power supply output +	10-28 V DC pass through
5	Supply-	Power supply output -	10-28 V DC pass through
6	Reserved	Reserved	
7	DGND	Digital ground	
8	ERX-	Ethernet receive -	Twisted pair with Pin 11
9	ETX-	Ethernet transmit -	Twisted pair with Pin 14
10	1PPS	1 pulse per second	
11	ERX+	Ethernet receive +	Twisted pair with Pin 8
12	Reserved	Reserved	
13	RS232 RX Radio	RS232 receive – DGNSS corrections	
14	ETX+	Ethernet transmit +	Twisted pair with Pin 9

Table 9:
LEMO 1, General IO (J2) pin description

Pin #	Function	Description	Notes
1	WSS1	Wheel speed sensor 1	
2	Reserved	Reserved	
3	Reserved	Reserved	
4	Supply+	Power supply output +	10-28 V DC pass through
5	Supply-	Power supply output -	10-28 V DC pass through
6	WSS2	Wheel speed sensor 2	
7	DGND	Digital ground	
8	ERX-	Ethernet receive -	Twisted pair with Pin 11
9	ETX-	Ethernet transmit -	Twisted pair with Pin 14
10	1PPS	1 pulse per second	
11	ERX+	Ethernet receive +	Twisted pair with Pin 8
12	Reserved	Reserved	
13	Reserved	Reserved	
14	ETX+	Ethernet transmit +	Twisted pair with Pin 9

Table 10:
LEMO 2 LiDAR (J3) pin description

Pin #	Function	Description	Notes
1	Reserved	Reserved	
2	UART TTL TX	UART Transmit – INS output	
3	Trigger 1	Trigger 1 (input/output/camera)	
4	Supply+	Power supply output +	10-28 V DC pass through
5	Supply-	Power supply output -	10-28 V DC pass through
6	Reserved	Reserved	
7	DGND	Digital ground	
8	ERX-	Ethernet receive -	Twisted pair with Pin 11
9	ETX-	Ethernet transmit -	Twisted pair with Pin 14
10	1PPS	1 pulse per second	
11	ERX+	Ethernet receive +	Twisted pair with Pin 8
12	Reserved	Reserved	
13	UART TTL RX	UART Receive – INS input	
14	ETX+	Ethernet transmit +	Twisted pair with Pin 9

Table 11:
LEMO 3, External sensor sync (J4) pin description

USB

USB can be used to connect external devices to the onboard compute. Operating on USB3.0 interface, devices such as external stereo cameras or other aiding devices can be connected and have their processing run on WayFinder Prime's onboard compute hardware.

Dimensions

Figure 4 shows the outer dimensions of the WayFinder Prime and location of the IMU measurement origin point.

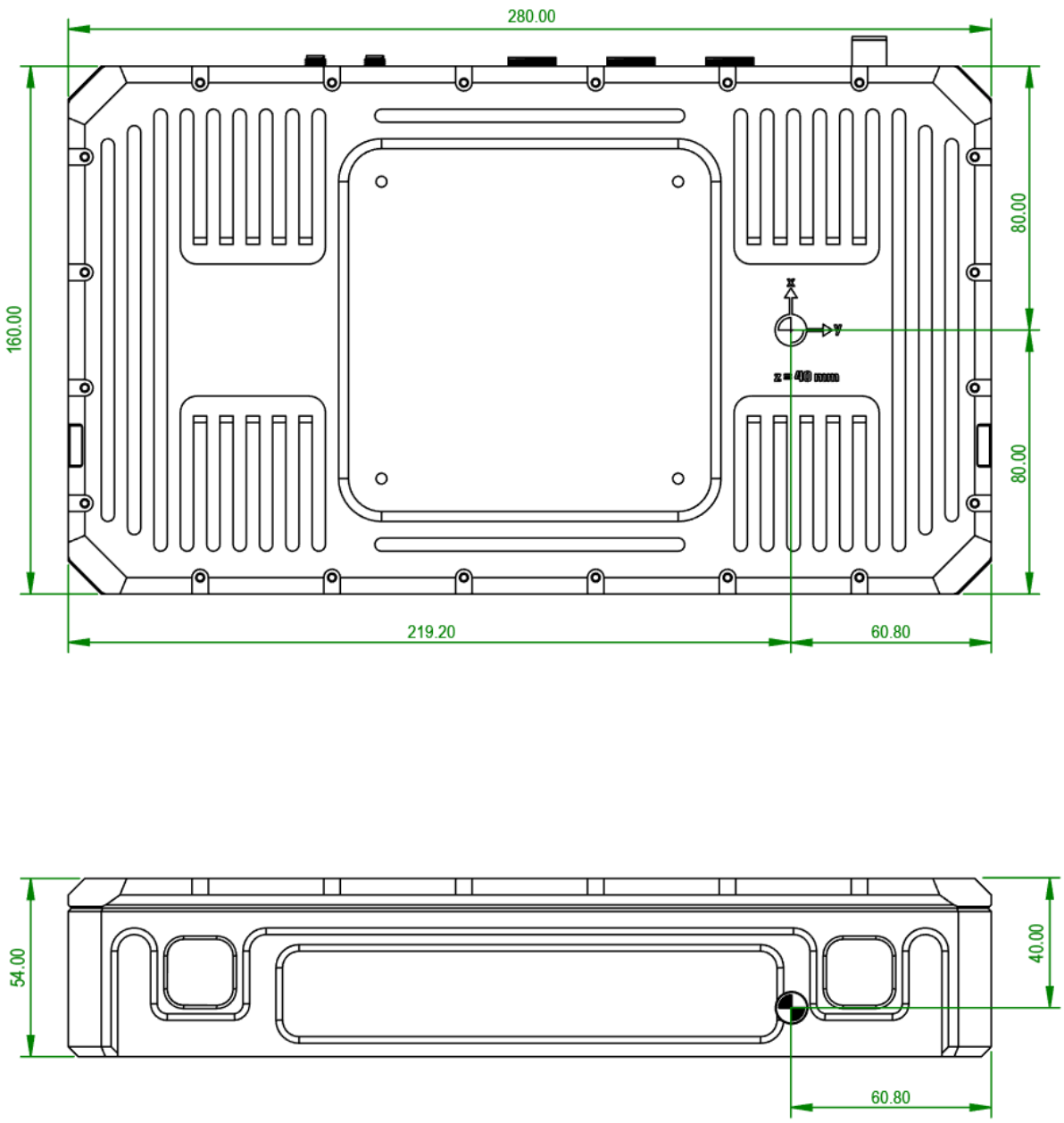


Figure 4:
WayFinder Prime dimensions and measurement origin

Coordinate frame

The WayFinder Prime supports multiple coordinate frames for data output, with all measurements and transformations referenced to the IMU frame. Figure 5 shows the IMU frame axis directions.

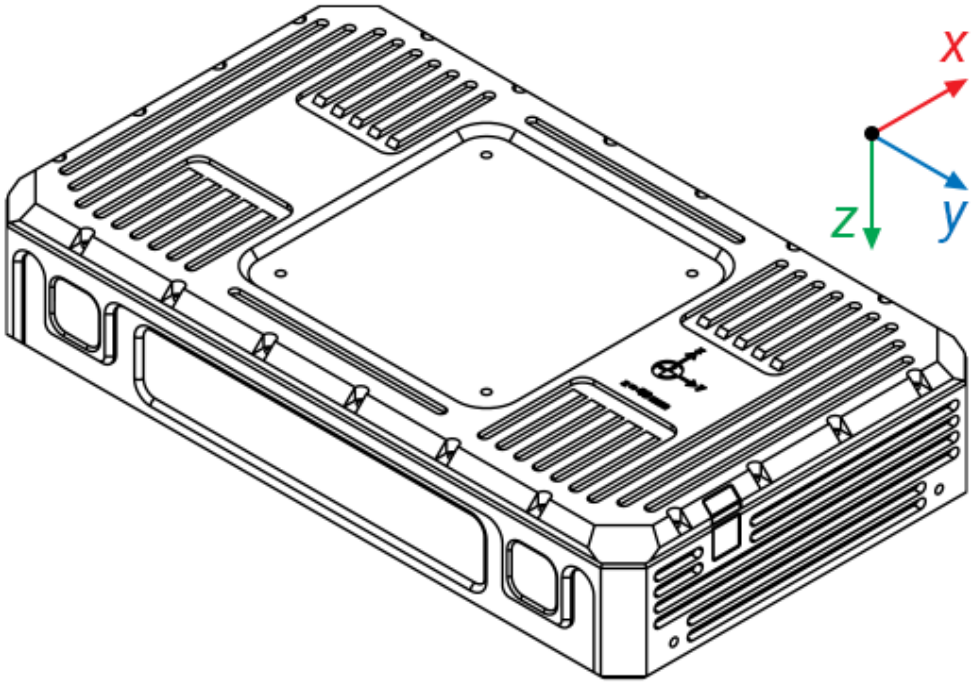


Figure 5:
WayFinder Prime IMU coordinate frame axes

The device can be mounted in any orientation; its axes do not need to match those of the platform. The configuration file defines the transformation from the IMU frame to the vehicle frame.

Design in

Usage guidelines

The WayFinder Prime is suitable for use in harsh environments including outdoors and in wet locations. To ensure safe operation in these conditions, the following considerations should be made.

- Ensure that all cable connections and ports are properly sealed and waterproof to prevent water ingress and damage to internal components.
- Maintain adequate creepage and clearance distances between high-voltage and low-voltage components.
- Properly ground the equipment to prevent static buildup.
- Regularly inspect the device and its enclosure for signs of wear, corrosion, or damage caused by exposure to wet conditions.

Mounting

It is essential to mount the device securely to the vehicle, taking appropriate safety precautions when attaching it to the vehicle exterior. The device must remain fixed relative to the GNSS antenna; any movement or rotation will degrade performance. For vehicles subject to high shocks, vibration mounts may be necessary.

Ensure the correct bolts are used during installation—all mounting holes have metric threads. Using imperial-threaded bolts may cause damage and must be avoided. Figure 6 shows the mounting points for the WayFinder Prime.

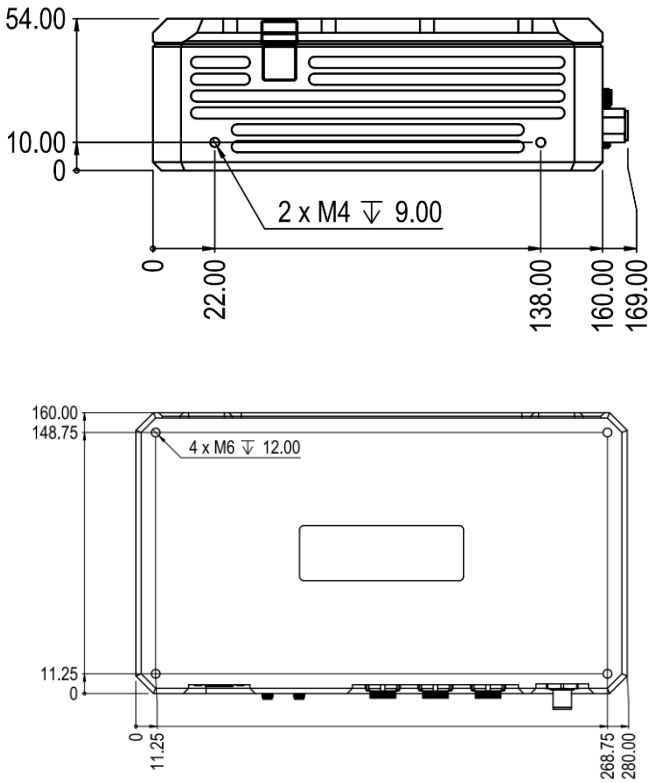


Figure 6:
WayFinder Prime mounting points (mm)

Installing the device in direct sunlight may cause the enclosure's internal temperature to rise significantly. In hot environments, this can cause the case to exceed its maximum temperature rating. To prevent this, avoid prolonged exposure to direct sunlight or ensure constant airflow across the enclosure.

Ensure the device is installed away from significant heat or cooling sources, as sudden ambient temperature changes can adversely affect satellite signal tracking and IMU biases.

Orientation and alignment

The WayFinder Prime's orientation on the platform is specified using three consecutive rotations that align it to the vehicle's coordinate frame. The order of rotation is:

1. Heading (about the z-axis)
2. Pitch (about the y-axis)
3. Roll (about the x-axis)

You can mount the device at any angle, as long as you accurately describe its orientation to the platform in the configuration. This lets the system rotate the outputs to match the vehicle frame based on your settings.

Specifications

Table 12 details the specifications of WayFinder Prime when used with GNSS or a LiDAR Map.

Parameter	With GNSS	With LiDAR Map[3 4]
Horizontal position accuracy[1]	1.5 m CEP SPS 0.4 m CEP DGPS 0.01 m 1σ RTK	0.03 m CEP
Vertical position accuracy[1]	0.02 m 1σ RTK	0.03 m CEP
Velocity accuracy	0.05 km/h RMS	0.05 km/h RMS
Roll/pitch accuracy	0.02° 1σ	0.02° 1σ
Heading accuracy[2]	0.05° 1σ	0.05° 1σ
Update rate	100 Hz (250 Hz optional)	100 Hz (250 Hz optional)

Table 12:
WayFinder Prime performance specifications with GNSS or LiDAR Map

[1]Typical values, subject to ionospheric/tropospheric conditions, satellite geometry, baseline length, multipath. Requires clear view of the sky and appropriate differential corrections to achieve full specification.
[2]Using dual antenna with 1 m separation baseline. Higher accuracy can be achieved with wider antenna separation.
[3] With Hesai XT32M1X LiDAR.
[4]Accuracy relates to the localisation solution with respect to the LiDAR map. If during LiDAR map creation the localisation data quality degraded, the global accuracy will not be 0.03 m but the relative accuracy with respect to the map will be 0.03 m in real-time or post-process. For 0.03 m global accuracy, LiDAR map should be generated in RTK conditions.

Table 13 details the specifications of WayFinder Prime when used without GNSS or a LiDAR Map.

Parameter	Real-time[1]	Post-process[1]
Position error as % of distance travelled	0.14%	0.07%
Velocity (RMS)	0.13 km/h	0.06 km/h
Roll/pitch (1σ)	0.03°	0.02°
Heading (1σ)	0.08°	0.05°

Table 13:
WayFinder Prime performance specifications without GNSS or LiDAR Map.

[1]With Hesai XT32M1X LiDAR

Table 14 details the GNSS specifications of WayFinder Prime.

Parameter	Value
GNSS tracking	GPS/QZSS L1C/A, L2C GLONASS L1OF, L2OF GALILEO E1B/C, E5b BEIDOU B1I, B2I
Acquisition	25 s (cold start)
Dual antenna	Y

Table 14:
WayFinder Prime GNSS specifications

Table 15 details the inertial sensor specifications of WayFinder Prime.

Accelerometers	Value
Full range	±8 *g*
Bias	0.02 m/s^2
In-run bias stability	5 µg
VRW	0.012 m/s/√hr
Scale factor	0.02%
Linearity	0.1%
Axis alignment	<0.01°
Gyros	**Value**
Full range	±490°/s
Bias	0.03°/s
In-run bias stability	0.8°/h
ARW	0.12°/√hr
Scale factor	0.08%
Axis alignment	<0.05°

Table 15:
WayFinder Prime inertial sensor specifications

Table 16 details the camera specifications of WayFinder Prime.

Parameter	Value
Sensor resolution	3280 × 2464 pixels
Shutter type	Rolling
Horizontal field of view	62.2°
Vertical field of view	48.8°
Depth of field	Approx 10 cm to ∞

Table 16:
WayFinder Prime camera specifications

Table 17 details the LiDAR specifications of the Hesai XT32M1X LiDAR supplied with WayFinder Prime.

Parameter	Value
Number of channels	32
Horizontal field of view	360°
Vertical field of view	31° (-16° to 15°)
Range	0.05 - 120 m

Table 17:
WayFinder Prime (OXTS supplied) LiDAR specifications

Table 18 details the physical specifications of WayFinder Prime.

Parameter	Base kit	Inc. Hesai XT32M1X
Input voltage[1]	10-28 V dc	10-28 V dc
Power consumption	20 W	28 W
Dimensions	280 × 160 × 54 mm	280 × 160 × 130 mm
Mass	2.55 kg	3.5 kg
Internal storage[2]	32 GB (INS) + 250 GB	32 GB (INS) + 250 GB

Table 18:
WayFinder Prime physical specifications

[1] Voltage range of connected devices such as radio modems must be considered.
[2] OS takes a portion of the 250 GB storage on the system.

Table 19 details the environmental specifications of WayFinder Prime.

Parameter	Value
Operating temperature	-15° to 40°C
Ingress protection	IP67[1]
Pollution degree	3
Vibration	0.1g/Hz 5-500 Hz
Shock	100 g, 11 ms

Table 19
WayFinder Prime environmental specifications

[1]Requires all LEMO connections to be occupied either with user cable or provided caps. SMA connections should be occupied or capped also.

Notes on specifications

The performance specifications are listed for operation of the system under the following conditions:

- A short warm-up period (~3 minutes) during which motion inputs will be used by the navigation system to estimate IMU sensor error characteristics and GNSS lever arm errors.
- Open-sky environment, free from cover by trees, bridges, buildings, or other obstructions. The vehicle must have remained in open sky for at least five minutes for full accuracy.
- The vehicle must exhibit some motion behaviour. Acceleration of the unit in different directions is required so the Kalman filter can estimate any errors in the sensors. Without this estimation, some of the specifications degrade due to a lack of valuable motion information.
- The system will estimate and improve GNSS antenna lever arm accuracies. For optimal performance the optimised lever arm accuracy should be 5 mm.
- The distance from the INS measurement point to the primary GNSS antenna must be known by the system to a precision of 5 mm or better. The vibration of the system relative to the vehicle cannot allow this to change by more than 5 mm. The system will estimate this value itself in dynamic conditions following a coarse measurement by the user.
- For single antenna systems, the heading accuracy is only achieved under dynamic conditions. Under benign conditions such as low speeds, the performance will degrade. The performance is undefined when stationary for prolonged periods of time.

To achieve full accuracy in real time, the device will require appropriate differential corrections where applicable. Alternatively, a RINEX file can be downloaded post-mission and used to post-process the data to full accuracy.

The “1σ” specification has been used for parameters where offset cannot be measured by the device, for example position (the offset of the base station cannot be found by the device alone). The “RMS” specification was used where the offset is known, for example velocity. For angles and measurements derived from the angles, the “1σ” specification is used because the mounting of the device compared to the vehicle gives an offset the device cannot measure.

Power requirements

Use the WayFinder Prime with a DC power supply rated to at least 25 W.

Environmental protection

The device is compliant with IP67 and a pollution degree of 3 when proper fittings are connected. Refer to the information in the Ingress Protection section on page 3 for more details.

Export control classification

Export control regulations are subject to change, and so the classification of the device may also change. The information presented here was correct when the manual was published.

The accelerometer and gyro sensors used in the WayFinder Prime, as well as the un-aided navigation system as a whole, do not fall under the requirements for controlled items on the Export Administration Regulations Commerce Control List (CCL). As such the WayFinder Prime is designated ECCN 7A994 meaning no license is required for export or reexport.

The onboard compute is designated ECCN 5A992.C meaning no license is required for export or reexport.

Using WayFinder Prime

Default IP addresses

By default, WayFinder Prime uses the following IP address configuration:

Device	Default IP address
INS	192.168.1.200
LiDAR	192.168.1.201
WayFinder Prime PC	192.168.1.202

Table 20:
Default IP addresses

When connecting to all 3 devices, any local device should have an IP address in the 192.168.1.1-192.168.1.255 range. The subnet mask of any connecting device should be set to 255.255.255.0 (or 192.168.1.0/24) to allow communication across the 192.168.1.1-192.168.1.255 range.

Contact OXTS Support for help with changing IP addresses of WayFinder Prime sensors.

The supplied LiDAR is configured to unicast to the WayFinder Prime's onboard compute in order to reduce network traffic but it can always be accessed via web UI on its IP address listed above.

Configuring WayFinder Prime

WayFinder Prime devices are configured using the NAVconfig application in NAVsuite.

The WayFinder Prime comes preloaded with a configuration that sets the common parameters such as the LiDAR lever arms. However, there are some parameters that will be unique to each installation that must still be configured for first time use. In subsequent uses, if the installation has not changed then the configuration step can be skipped.

Click 'Modify configuration', select 'Read settings from a device', and select the INS device IP address from the drop-down list to download and edit the preloaded configuration.

Hardware setup

This section considers how the device is orientated on the vehicle and where the antennas are located.

IMU orientation

Set the WayFinder Prime's Y and Z axes relative to the platform on which it is mounted. Specify this mounting orientation accurately to ensure course over ground aligns with heading during initialisation.

Primary/Secondary Antenna

Set the X, Y and Z positional offset from the WayFinder Prime's IMU measurement origin point to the primary and secondary antennas.

GNSS Differential corrections/NTRIP

For RTK GNSS, enable the NTRIP client, enter your login details, and set the default gateway to your 4G modem or the device sharing its internet connection. Leave *Forward received corrections through network DGPS* unticked and do not select *netdgps* as a corrections source. Set the corrections datum correctly to avoid hidden global bias, which can cause position jumps when switching between GNSS and the LiDAR map.

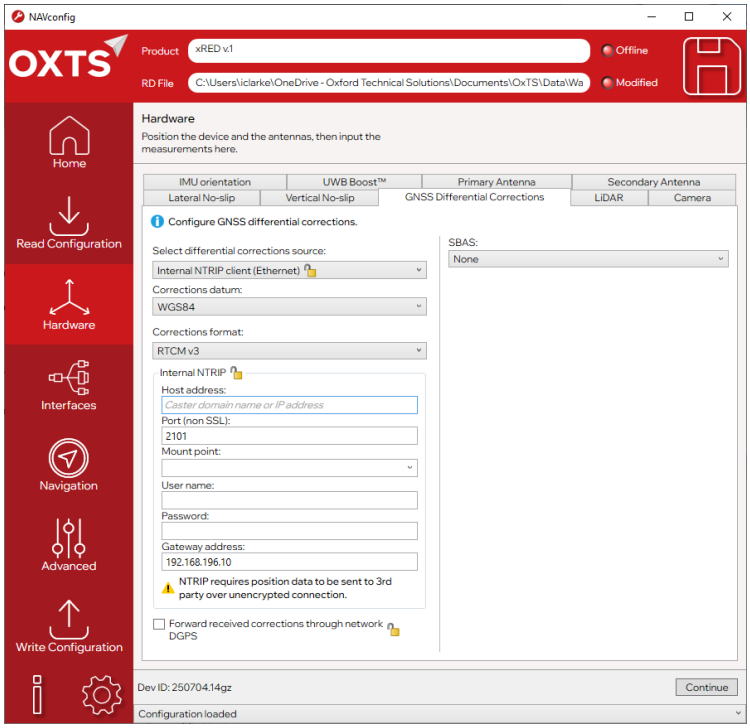


Figure 7:
NAVconfig differential correction configuration

LiDAR

The LiDAR odometry checkbox and lever arms are pre-set in the factory configuration for the installed LiDAR. For reference, the LiDAR's position and rotation lever arms are outlined in :

LIP		LIR	
X	0	Roll	180
Y	-0.08	Pitch	0
Z	-0.09	Yaw	90

Table 21:
Pre-set factory configuration for LiDAR LIP and LIR values

Camera

The visual odometry checkbox and lever arms will be pre-set from the factory configuration. For reference, the position and rotation lever arms for the cameras are as follows:

CIP		CIR	
X	0.076	Roll	90
Y	0.021	Pitch	0
Z	-0.012	Yaw	-90

Table 22:
Pre-set factory configuration for camera CIP and CIR values

Interfaces

This section outlines the real-time data outputs available from the device. By default, NCOM data is broadcast over Ethernet at 100 Hz.

PTP

The pre-set configuration will use the following PTP settings to synchronise time with the Hesai XT32M1X:

Parameter	Value
PTP mode	PTP
System mode	Master
Time epoch	GPS
Custom offset	315964782

Table 23:
Pre-set factory configuration for PTP

Select “UTC” in the Time Epoch drop-down to run in UTC mode. When using UTC, configure a -18 s offset for LIO and other aiding applications slaved to the INS PTP Master later in the setup.

For WayFinder Prime to use an external PTP Master, choose PTP Mode “Slave” in the dropdown but ensure you know what time epoch your master is using.

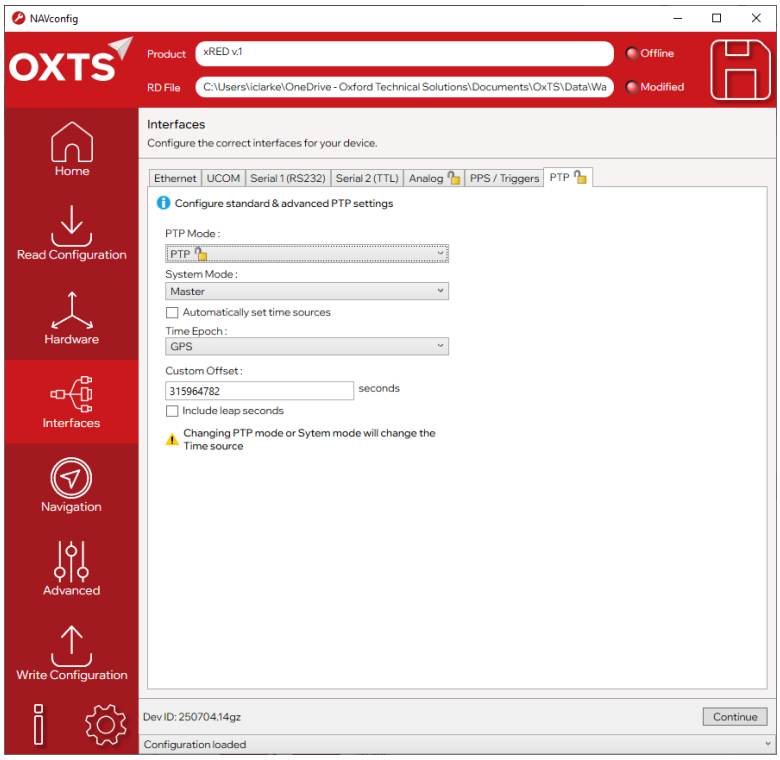


Figure 8:
NAVconfig PTP configuration

Web apps

The WayFinder Prime hosts a number of web apps that can be accessed through a browser to monitor and control various aspects of the device.

- Homepage – For an overview of system health and tool for accessing all other web apps
- Visualiser – For WayFinder Prime data monitoring
- LiDAR Navigation – For operating LiDAR aiding
- PCAP logger – for logging LiDAR data
- Rendezvuos – for operating Camera ZVU

Homepage

Access the WayFinder Prime homepage by entering its IP address (default: 192.168.1.202) in a browser. The homepage displays sensor status on the left and installed applications on the right. Applications show their version details and can be opened by clicking their tiles. Device IP settings are in the bottom left, and onboard apps can be updated via the "Manage Applications" section in the bottom right. Contact OXTS Support for software update information.

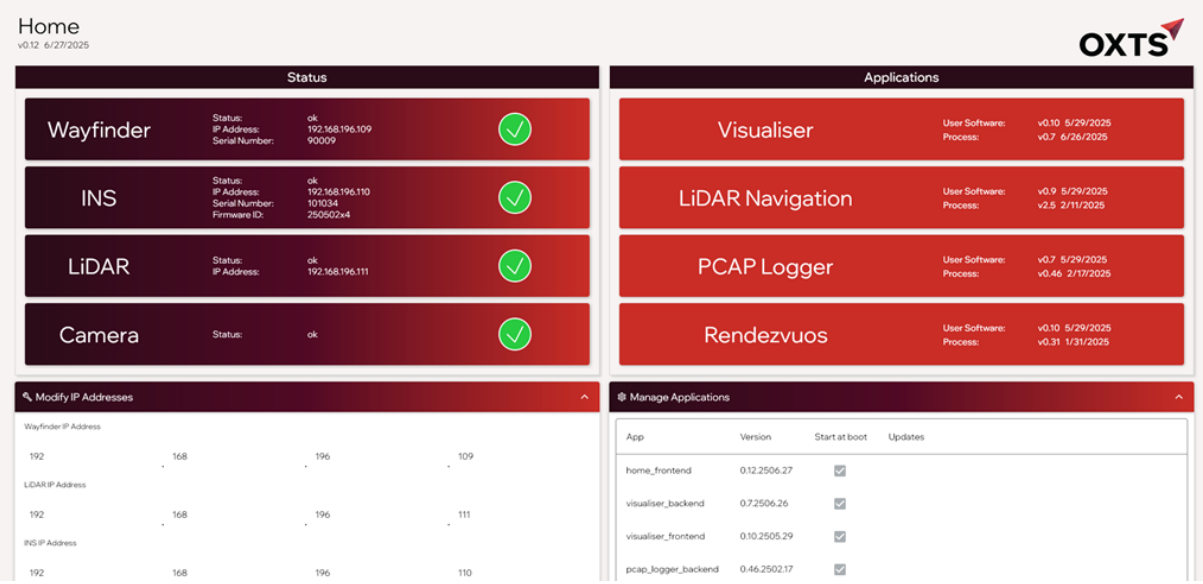


Figure 9:
WayFinder Prime Homepage app

Visualiser (INS data)

The Visualiser app provides a lightweight, real-time way to monitor INS data from WayFinder Prime, ensuring you stay informed about data quality and system health. You can send commands via the command bar (contact OXTS Support for details). Measurement groups can be expanded or collapsed for a streamlined view. Clear status icons help you quickly verify system performance, with green indicating optimal operation and amber providing helpful alerts for fine-tuning. The Map plugin displays the vehicle's position on a basic map, enhancing situational awareness once the INS is initialized and with internet access.

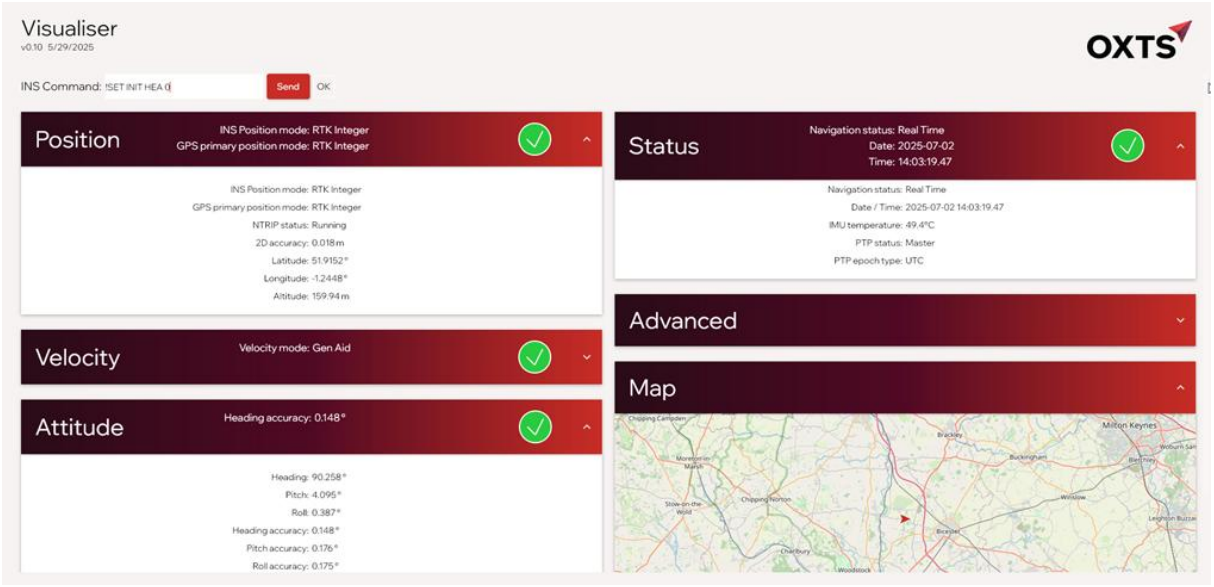


Figure 10:
WayFinder Prime Visualiser app

LiDAR Navigation

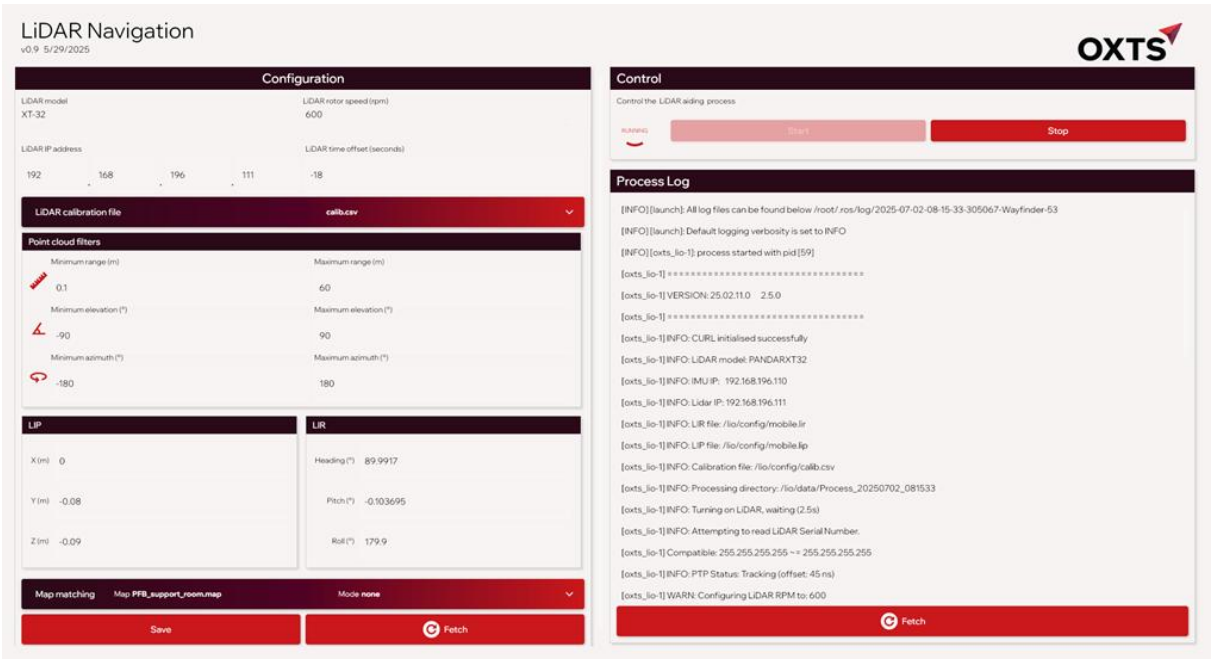


Figure 11:
WayFinder Prime LiDAR Boost app

LiDAR boost includes an odometry and map matching module for velocity and position updates to the INS.

Configuration

- Default parameters are optimised for general use but can be adjusted for specific vehicles.
- Hesai XT32 LiDAR calibration files are auto-retrieved by LiDAR Boost if not already on WayFinder Prime; users can also provide their own.
- Set LiDAR RPM to 600 (verify RPM if using a different LiDAR).
- Match the time offset to the WayFinder Prime PTP setting: -18 s for UTC epoch, 0 s for GPS epoch.
- Limit LiDAR range to exclude the vehicle and avoid data beyond 50–60 m for best navigation.
- Default LiDAR-to-IMU lever arms (LIP) for Hesai XT32 (m): X=0, Y=–0.08, Z=–0.09
- Default LiDAR-to-IMU rotation (LIR) for Hesai XT32 (°): Yaw=90, Pitch=0 Roll=180

- Create LiDAR maps offline using the LIO GUI and upload via the LiDAR Navigation web app for map matching

Control

- LiDAR Navigation starts automatically at boot and begins aiding after INS initialisation.
- Users can control, stop, or reconfigure LiDAR Navigation within the web app, including loading maps and switching to navigation mode.
- With correct time sync, LiDAR Boost - Odometry shows “Gen Aid” velocity mode in the Visualiser app.
- When map matching is active, “Gen Aid” position mode appears in the Visualiser app.

PCAP logger

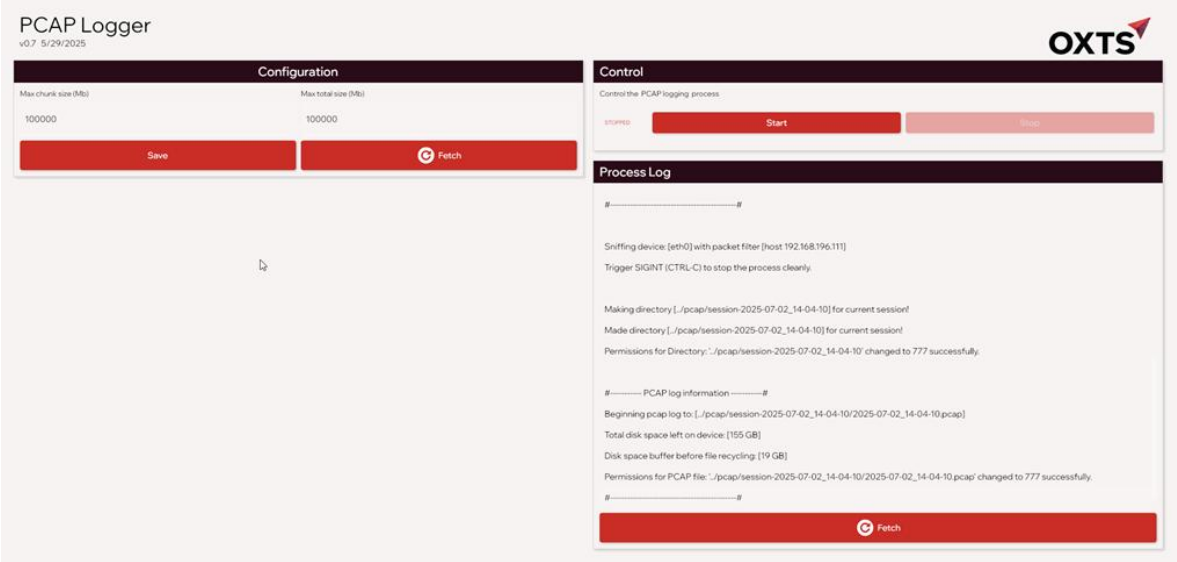


Figure 12:
WayFinder Prime PCAP logger app

The PCAP logger records LiDAR data to the onboard SSD for map creation, post-process LiDAR Boost trajectory enhancement and pointcloud georeferencing.

Configuration

- Users can set a max chunk size (file size before a new PCAP file is created) and a maximum disk space limit (before old data is overwritten).

Control

- PCAP logging is off by default and requires the user to start logging manually.
- Starting logging will create a new session folder where the PCAP data will be stored.
- Data can be accessed via FTP, under `pcap_logger_backend/data/` folder.
- Stopping logging will end the current PCAP log and save to file.
- When disk space is full, the logger deletes the oldest PCAP files to free space.

Rendezvuos (visual zero velocity update)

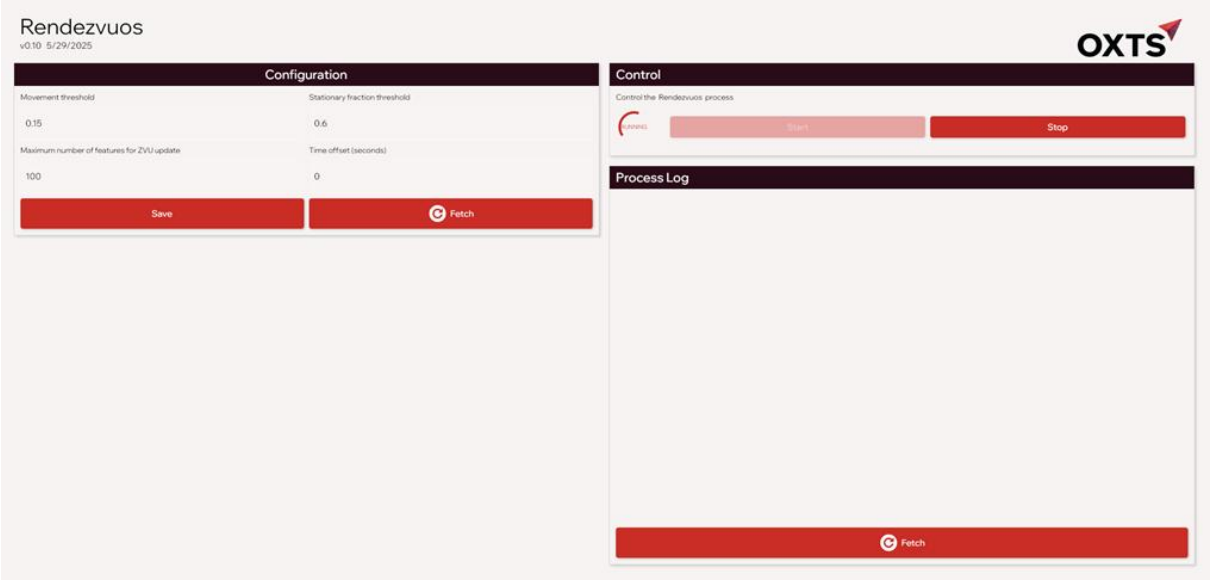


Figure 13:
WayFinder Prime Rendezvuos app

Control and configure the camera based Zero Velocity Update (ZVU). The camera aiding process will start automatically but can be manually controlled here. The configuration settings should not need to be changed.

Configuration

- Apply and save the correct time offset if not using UTC PTP (e.g., GPS); no offset is needed for UTC PTP.
- When running, the Visualiser app will report “Gen Aid” velocity mode in the Visualiser app, only when the WayFinder Prime is static.

Control

- Start and stop the aiding process and monitor its live status within the Rendezvuos app.
- Restart Rendezvous by stopping, waiting, and starting again if issues arise, or contact OXTS for support.
- If “Gen Aid” doesn’t appear in the Visualiser app while static, check that visual aiding is enabled in NAVconfig > Hardware > Camera settings.

NOTE: The onboard camera images are not stored. All raw data is discarded after zero velocity data has been generated.

Initialisation process

Before the WayFinder Prime can output navigation measurements, it must first initialise using all the measurements listed in **Table 24**.

Quantity	Description
Time	Measured by internal GNSS
Position	Measured by internal GNSS
Velocity	Measured by internal GNSS
Heading	Approximated to course over ground (with large error) when the vehicle moves. Dual antenna models have the option for static initialisation which does not require any movement. Single antenna setups will calculate heading via forward motion.
Roll, pitch	"Vehicle Level" option: assumed zero with a large error tolerance. Otherwise: estimated over first 40 s of motion with large error

Table 24:
Quantities required for initialisation

The WayFinder Prime starts once it estimates all required quantities. It uses course over ground as the initial heading when speed exceeds the initialisation threshold (default 5 m/s), unless static initialisation is selected. If mounted level, enabling Vehicle Level allows immediate start; otherwise, it takes about 40 seconds to estimate roll and pitch.

Real-time outputs

During the initialisation process the system runs 1 s behind, allowing GNSS information to be compared to information from the inertial sensors. After initialisation the system has to catch-up from this 1 s lag. It takes 10 s to do this. During the first 10 s the system cannot output full data in real time, the delay decays to the specified latency linearly over this 10 s period.

The NCOM navigation status turns from "Ready to initialise" to "Locking on" during initialisation. When the system is running in real time this status message will report "Real-time".

Warm-up period

During the first few minutes of operation the system will not conform to specification. During this period the Kalman Filter runs a more relaxed model for the sensors. This lets the system:

- Make better estimates of the errors in the long term (if it does not get these correct then they become more difficult to correct as time goes on).
- Track the errors in the inertial sensor during their warm-up period (when their errors change more quickly than normal).

During this period it is necessary to provide the IMU some motion input or the errors will not be estimated and the specification will not be reached. A few minutes of representative dynamics such as normal driving manoeuvres is sufficient. The NCOM output message includes status information that can be used to identify when the required specification has been met.

Retrieving data via FTP

An FTP server is running on the WayFinder Prime which allows anonymous access to a user space for raw data logging and configuration files.

The user can access this via any FTP client at the IP address of the device, by default 192.168.1.202.

Folder structure

Folder structure is sorted by WayFinder Prime application, with access laid out as below:

Raw data logs

/applications/<WayFinderappbackend>/data

Configuration files

/applications/<WayFinderappbackend>/config

Example of the PCAP logger app's FTP space shown below.

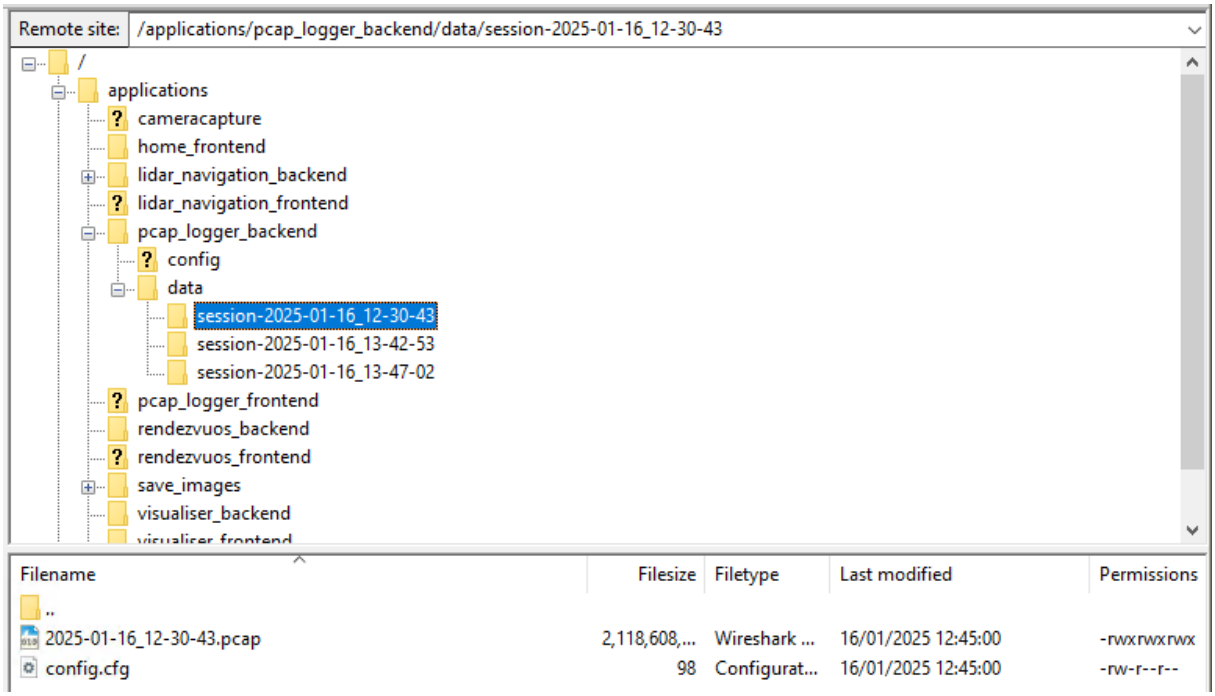


Figure 14:
FTP location for logged PCAP data

Appendix A – Ensuring optimal operation

In order to maximise performance and ensure optimal operation, there are a number of areas to consider during installation and operation of the INS. Table 25 lists the topics to pay attention to.

Topic	Consideration
Installation	Antennas installed with same orientation
	Antennas installed clear of obstructions
	Antennas able to see same constellation of satellites
	Antennas and cables routed clear of sources of EMI
	Unit mounted rigidly in vehicle
	Unit and antennas unable to move independently
	Unit mounted away from direct sunlight or sources of high or very low air flow
	Appropriate antivibration mounts used if necessary
	Unit has a stable, uninterrupted power supply
Configuration	Dual antenna set up as per OXTS guidelines
	Differential corrections enabled and configured
	Secondary antenna separation distance measured as accurately as possible
	Ethernet output enabled and monitored during vehicle operation
	Vibration levels are set to normal (higher levels will reduce confidence in IMU error models)
	GNSS environment set to Open skies (lower settings will reduce confidence in GNSS error models)
	A good warm up as been performed in RTK and an improved configuration committed to the unit
Pre-drive checks	Ensure all equipment is mounted securely
	Differential corrections are being received and the unit is in RTK position mode
	Position accuracy is being received over ethernet
	All cable connections are secure
Initialisation	Good GNSS conditions for dual antenna static initialisation (open skies, no multipath)
	Able to drive in a straight line and exceed speed threshold for kinematic initialisation
	Care not to exceed initialisation speed while reversing or turning
Vehicle operation	Device status is monitored
	Avoid extended periods in blocked or obstructed GNSS environments without additional aiding sources such as a wheel speed

Table 25:
Optimal operation checks

Appendix B – Using the orientation measurements

This section has been provided to clarify the definitions of heading, pitch and roll that are output by the WayFinder Prime.

The WayFinder Prime uses quaternions internally to avoid the problems of singularities and to minimise numerical drift on the attitude integration. Euler angles are used to output the heading, pitch and roll, and these have singularities at two orientations. The WAYFINDER PRIME has rules to avoid problems when operating close to the singularities; if you regenerate the rotation matrices given below then they will be correct.

The Euler angles output are three consecutive rotations (first heading, then pitch and finally roll) that transform a vector measured in the navigation co-ordinate frame to the body co-ordinate frame. The navigation co-ordinate frame is the orientation on the earth at your current location with axes of north, east and down.

If $\boldsymbol{V_n}$ is vector $\boldsymbol{V}$ measured in the navigation co-ordinate frame and $\boldsymbol{V_b}$ is the same vector measured in the body co-ordinate frame the two vectors are related by:

$$V_n = C_{bn} \cdot V_b$$

$$V_n = \begin{bmatrix} \cos\psi & \sin\psi & 0 \\ \sin\psi & \cos\psi & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\phi & -\sin\phi \\ 0 & \sin\phi & \cos\phi \end{bmatrix} \cdot V_b$$

where:

ψ is the heading angle;

θ is the pitch angle; and

ϕ is the roll angle.

Remember: heading, pitch and roll are usually output in degrees, but the functions *sin* and *cos* require these values in radians.

Appendix C – Drawing list

Table 26 lists the available drawings that describe components of the WayFinder Prime system. Many of these drawings are attached to the back of this manual.

Drawing number	Drawing Name
14C0238	WayFinder Prime user cable
14C0240	Hesai XT32 adapter cable
14M0279	LiDAR adapter plate

Table 26:
List of available drawings

Cable BOM

	OPTION 1	OPTION 2
J1	LEMO FGG.1K.314.CLAK75	
J2	Katlax CBF12-S44S0-02BPUR	RS 250-0634
J3	FS Cables C6GPH00003	
J4	Unstripped wire ends	
J1 Cable	LEMO 116 094	
J4 Cable	28 AWG, Shielded, Twisted Pairs, Black Jacket	
Y Transition	TE 462A011-25/225-0	
ID Labels	Yellow heatshrink tubing	
-	-	-

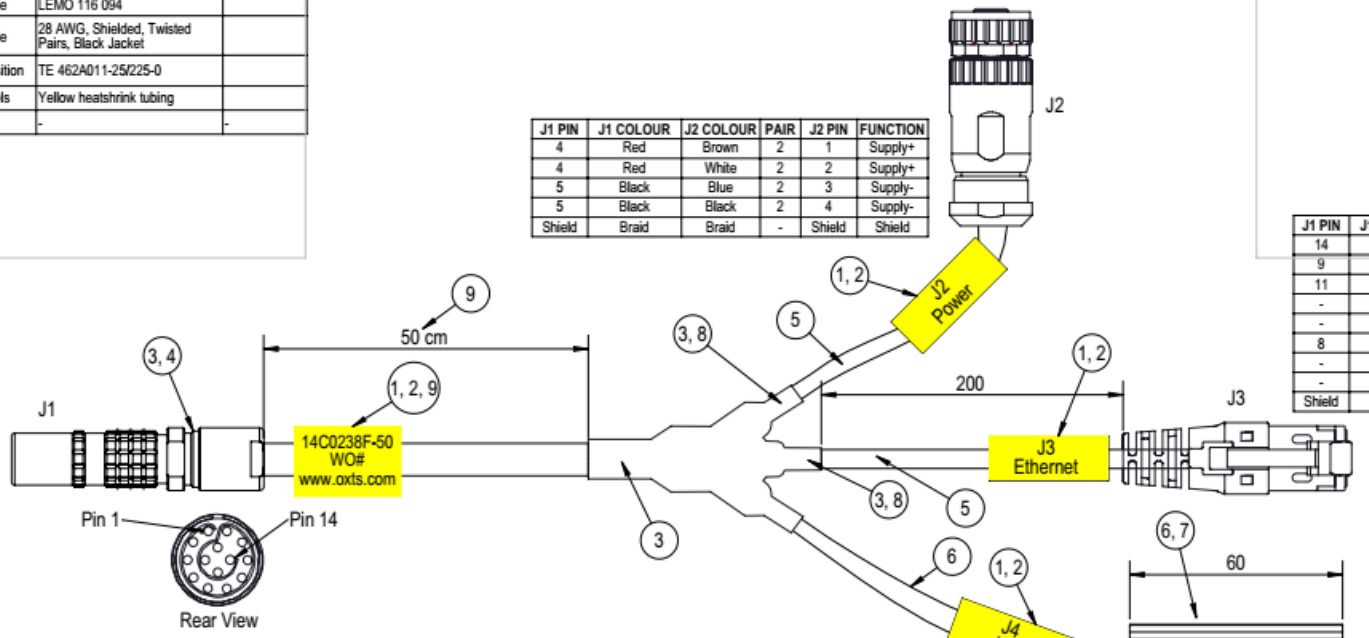
	CABLE LENGTH
J1	500 mm
J2	200 mm
J3	200 mm
J4	200 mm

Notes

See "14C0238 Cable Assembly Notes.pdf".

J1 PIN	J1 COLOUR	J2 COLOUR	PAIR	J2 PIN	FUNCTION
4	Red	Brown	2	1	Supply+
4	Red	White	2	2	Supply+
5	Black	Blue	2	3	Supply-
5	Black	Black	2	4	Supply-
Shield	Braid	Braid	-	Shield	Shield

J1 PIN	J1 COLOUR	J3 COLOUR	PAIR	J3 PIN
14	Black	White/Orange	3	1
9	Orange	Orange	3	2
11	Black	White/Green	5	3
-	-	Blue	-	4
-	-	White/Blue	-	5
8	Green	Green	5	6
-	-	White/Brown	-	7
-	-	Brown	-	8
Shield	Braid	Shield	-	Shield



J1 PIN	Colour	Pair	Destination	Fn. WF 2	Fn. WF 3	Fn. WF 4
1	Yellow	4	J4	CAN+ Compute	WS1	CAN+ INS
2	Brown	1	J4	RS-232 Tx INS	Eth2_3-	UART TTL Tx INS
3	Black	6	J4	Trigger 2	Eth2_4+	Trigger1
4	Red	2	J2	Supply+	Supply+	Supply+
5	Black	2	J2	Supply-	Supply-	Supply-
6	Black	4	J4	CAN- Compute	WS2	CAN- INS
7	Black	7	J4	Digital Ground	Digital Ground	Digital Ground
8	Green	5	J3	Eth1_1-	Eth2_1-	Eth3_1-
9	Orange	3	J3	Eth1_2-	Eth2_2-	Eth3_2-
10	Violet	7	J4	PPS	PPS	PPS
11	Black	5	J3	Eth1_1+	Eth2_1+	Eth3_1+
12	Black	1	J4	-	Eth2_3+	-
13	Blue	6	J4	RS-232 Rx INS	Eth2_4-	UART TTL Rx INS
14	Black	3	J3	Eth1_2+	Eth2_2+	Eth3_2+
Shield	Braid	7	Shield	Shield	Shield	Shield

J1 PIN	J1 COLOUR	J4 COLOUR	PAIR	J4 PIN	Fn. WF 2	Fn. WF 3	Fn. WF 4
1	Yellow	Yellow	4	Loose	CAN+ Compute	WS1	CAN+ INS
6	Black	White	4	Loose	CAN- Compute	WS2	CAN- INS
10	Violet	Violet	7	Loose	PPS	PPS	PPS
7	Black	Black	7	Loose	Digital Ground	Digital Ground	Digital Ground
3	Black	Green	6	Loose	Trigger 2	Eth2_4+	Trigger1
13	Blue	Blue	6	Loose	RS-232 Rx INS	Eth2_4-	UART TTL Rx INS
12	Black	Grey	1	Loose	-	Eth2_3+	-
2	Brown	Brown	1	Loose	RS-232 Tx INS	Eth2_3-	UART TTL Tx INS
Shield	Braid	Braid	-	Shield	Shield	Shield	Shield

Cable and Wire Tolerances

≤0.3m	+25mm	-0mm
0.3m to 1.5m	+50mm	-0mm
1.5m to 3.0m	+100mm	-0mm
3.0m to 7.5m	+150mm	-0mm
>7.5m	+5%	-0%

REVISION HISTORY

F: Changed J3 to an SFTP cable. Added wurks order and website to cable ID. Corrected J2 pinout (red changed to brown, using all pins - 1 and 3 only were incorrect).

E: Changed J4 cable to not have multiple different signals with black wires.

D: J1 connector and cable. J2 now a pre-terminated cable. J3 PN specified. Added Y transition. Insulation should no longer be stripped from individual wires at J4.

DRAWN BY	M. Romański	DATE 2025-06-06
CHECKED BY	D. Robinson	DATE 2025-06-10
APPROVED BY	T. Bailey	DATE 2025-06-10

THIRD ANGLE PROJECTION

A3 SHEET 1 OF

DIMENSIONS: mm DRAWING NOT TO SCALE

DRAWING No.: 14C0238-50

DRAWING REVISION: F

OXTS

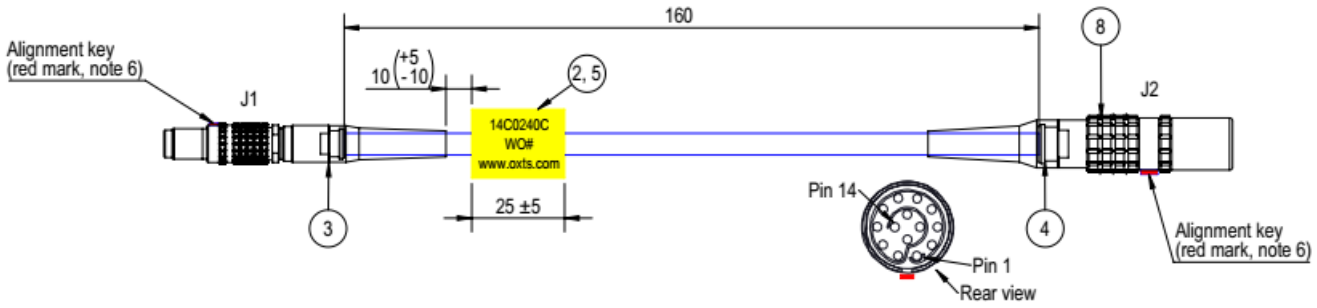
TITLE

xVINS Lemo connector cable

Cable BOM	
J1 + Cable	Hesai XT Connection Box
J2	LEMO FGG.1K.314.CLAC50Z
J2 Bend Relief	LEMO GMA.1B.045.DN

Notes

See "14C0240 Cable Assembly Notes.pdf".



LiDAR WayFinder

J1 PIN	FUNCTION	COLOUR	J2 PIN
1	GPS PPS signal	Black	10
2	Note 7	Silver	NC
3	Ground/Supply negative	Brown	5, 7
4	Supply positive	White	4
5	Ethernet Tx+	Yellow	14
6	Ethernet Tx-	Green	9
7	Ethernet Rx+	Pink	11
8	Ethernet Rx-	Grey	8
9	Note 7	Red	NC
Shield	Shield	Shield	Shield

Cable and Wire Tolerances

≤0.3m	+25mm	-0mm
0.3m to 1.5m	+50mm	-0mm
1.5m to 3.0m	+100mm	-0mm
3.0m to 7.5m	+150mm	-0mm
>7.5m	+5%	-0%

REVISION HISTORY

C: Changed J1 and cable to those from the Hesai XT Connection Box. Added bend relief to J2.

DRAWN BY	M. Romański	DATE 2025-06-02
CHECKED BY	D. Robinson	DATE 2025-06-11
APPROVED BY	T. Bailey	DATE 2025-06-10

THIRD ANGLE PROJECTION

A3 SHEET 1 OF

DIMENSIONS: mm DRAWING NOT TO SCALE

DRAWING No.: 14C0240

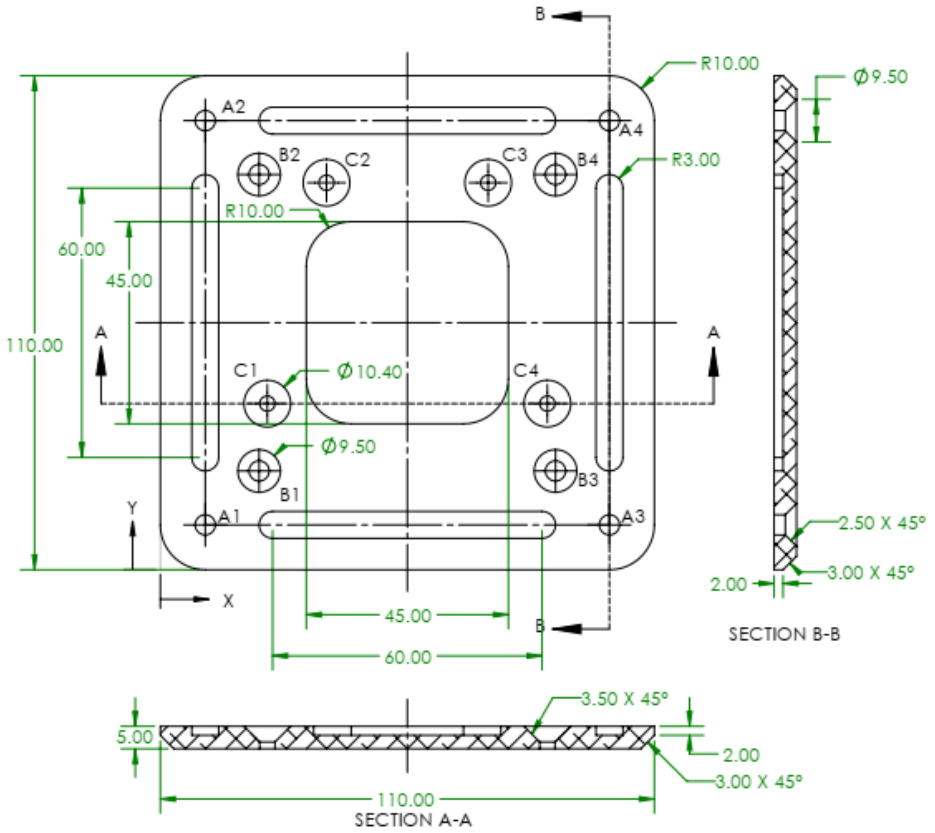
DRAWING REVISION: C

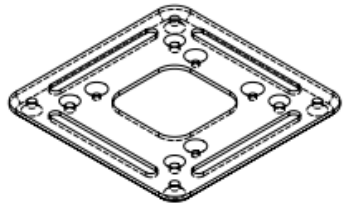
OXTS

TITLE

xVINS Hesai XT32 LiDAR cable

REVISIONS				
ZONE	REV.	DESCRIPTION	DATE	APPROVED
	A	First Release	21/02/2024	Caroline Oakes
E6-7, D6-7	B	Added mouting holes for the Ouster	04/11/2024	Tom Bailey





TAG	X LOC	Y LOC	SIZE
A1	10	10	Ø4.50 THRU
A2	10	100	Ø4.50 THRU
A3	100	10	Ø4.50 THRU
A4	100	100	Ø4.50 THRU
B1	22	22	Ø4.50 THRU
B2	22	88	Ø4.50 THRU
B3	88	22	Ø4.50 THRU
B4	88	88	Ø4.50 THRU
C1	23.82	37	Ø3.40 THRU
C2	37	86.18	Ø3.40 THRU
C3	73	86.18	Ø3.40 THRU
C4	86.18	37	Ø3.40 THRU

Notes:
- 2.50 X 45° Chamfer on A & B
- 3.50 X 45° Chamfer on C

ALL CHAMFERS/ROUNDS TO HAVE TOL OF ±0.5 UNLESS STATED OTHERWISE
BASIC SIZES ACC. TO ISO 2768-m

LINEAR DIMENSIONS							
UP TO 6	OVER 6 TO 30	OVER 30 TO 120	OVER 120 TO 400	OVER 400 TO 1000	OVER 1000 TO 2000	OVER 2000 TO 4000	
±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2.0	
ANGULAR DIMENSIONS							
L	UP TO 10	OVER 10 TO 50	OVER 50 TO 120	OVER 120 TO 400	OVER 400		
!	±1°	±0.5°	±0.3°	±0.2°	±0.1°		

SURFACES TO ISO 1302	
Ra	CLASS
0.4	N5
0.8	N6
1.6	N7
3.2	N8
6.3	N9

DRAWN BY: William Pavey 01/11/24
CHECKED BY: Maciej Romanski 14/11/24
APPROVED BY: Tom Bailey 14/11/24

MASS: 131.6g
MATERIAL: C259 ELOX PLUS
MATL SPEC: C259 ELOX PLUS
HEAT TREATMENT: -
PROCESS FINISH: -
FINISH: Bead Blasted

THIRD ANGLE PROJECTION
A3 SHEET 1 OF 1
SCALE:1:1
DIMENSIONS: mm DO NOT SCALE DRAWING
DRAWING No.: 14M0279
DRAWING REVISION: B

OXTS
TITLE: Wayfinder Lidar Adapter
PROJECT: Wayfinder

Revision history

Revision	Comments
250908	First release
251013	Fixed broken link to Hesai LiDAR manual. Amended LED descriptions.

Table 27:
Revision history

Blank for user notes

Connect with us today

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Beijing, 100020,
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x.com/oxts_official

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oxts.com

OXTS