WORLD SENSING

LSG7GNS-SXLH

Loadsensing GNSS Meter

User Guide version 1.1

www.worldsensing.com

Document version	Date	Description
Version 1.0	January 2025	First edition of the Loadsensing GNSS meter
version 1.1	March 2025	Added constellation configuration feature, GNSS data troubleshooting guide, tiltmeter axis convention, JSON message changed when there is no fix solution

Table of contents

1. Important instructions prior to use

Please read these instructions carefully and ensure that the required conditions specified in this document are met before using the product. Each of our edge devices includes this information inside the packaging.

1.1. General warnings

Follow these precautions to avoid a battery explosion or leakage of flammable liquid or gas:

- Use the correct battery type. Dispose of the batteries according to instructions. Do not dispose of the batteries by throwing them into a fire or a hot oven, or mechanically crush or cut them.
- Do not leave the batteries in an extremely high-temperature environment.Do not subject the batteries to extremely low air pressure. It may result in an explosion or leakage of flammable liquid or gas.
- Do not short circuit the batteries. This will blow the protection fuse.

Batteries and equipment to be connected via the data port must meet IEC 62368-1 ES1 and PS1 requirements.

Equipment to be installed in restricted access areas.

Table 1 : general warning information

Symbol	Description
	Caution. Do not proceed until the instructions are clearly understood and all required conditions are met.
	Read the instructions for use carefully before using.
	Caution, hot surface.
	According to the European Union WEEE Directive 2012/19/EU, this product and its batteries should not be discarded as unsorted waste. Please send them to separate collection facilities for recovery and recycling. It is your responsibility to dispose of your waste equipment and batteries properly. The correct disposal of your old equipment and batteries will help prevent potential negative consequences for the environment and human health.

2. Technology overview

Global navigation satellite system (GNSS) is a general term describing any satellite constellation that provides positioning, navigation, and timing (PNT) services on a global or regional basis[1]. As of 2024, several global systems are operational: the European Union's Galileo, the United States's Global Positioning System (GPS), Russia's Global Navigation Satellite System (GLONASS), China's BeiDou Navigation Satellite System (BDS), Indian Regional Navigation Satellite System (IRNSS) / Navigation Indian Constellation (NavIC) and Japan Quasi-Zenith Satellite System (QZSS).

Satellites operate in frequencies ranging from 1Ghz to 1.6Ghz (L band) and send signals with 3 components:

- A carrier signal (use as carrier and also to estimate the phase in RTK)
- An identifier (use to measure timing)
- A navigation message containing information where the satellite is (Ephemerides) and where other satellites are (Almanacs).

GNSS receivers estimate the time it took for the satellite's signals to reach it by generating an internal signal that is correlated with the one received.

To resolve a position, each receiver needs to detect at least 4 satellites to compute the pseudorange. The resulting position has some errors due to Ionosphere and Troposphere effects, Multipath noise, Clock and ephemerides errors and nearby objects that could potentially block part of the sky.

In order to reduce the other errors, a differential method could be used and consists of using another GNSS receiver based in a known fixed position (base). Any differences on measuring its position are going to be considered errors, from those errors corrections can be calculated to be shared with other not-fixed receivers (rovers) nearby to lower their errors.

Corrections can be transmitted to the rover through different ways:

- In real time kinematics (RTK) through different technologies (cellular, radio,...)
- Through Post Processing Kinematics (PPK) by gathering all received data from the rover and the corrections of the base in an external site (over cellular or stored in an SD card), and applying the corrections in a post-processing manner.

[1] Source: https://www.gps.gov/systems/gnss/

3. Loadsensing GNSS Meter

The Loadsensing GNSS Meter is a wireless sensor that enables precise automated measurement of surface point movements. It features advanced multi-band Real-Time Kinematic (RTK) technology and innovative edge processing that delivers millimetric precision with great reliability.

Main features

The GNSS sensor comes with a 3-axis integrated tiltmeter to ensure the transmission of measurements even when conditions for precise RTK measurement are not met, and it also allows for the monitoring of changes from vertical in structures and mounting elements.

In terms of radio range capabilities, communication between the nodes and the Gateway is the standard one and up to 15 Km could be achieved in open sight. Radio communication between Base and Rovers is limited to SF7 to ensure proper communication and around 5 Km range could be achieved in open sight.

Worldsensing also provides several accessories for properly mounting the different elements and optimizing the installation on different positions.

The system could be part of any other Loadsensing deployment, enhancing scalability with other geotechnical sensors.

It is not required to have an internet connection to use the GNSS solution, as all the data is being transmitted through LoRa radio, so the deployment could be part of an offline Network.

The GNSS Meter is a low power device that does not require being externally powered and has an autonomy of 2 years by using recommended batteries.

General System operation

A GNSS system is composed of a base station and several rovers, working together to deliver precise, real-time positioning data. To operate the system, a base station must be assigned to a known fixed position, with one or more rovers distributed across the area to be monitored.

Each rover wakes up every hour, receives synchronized corrections from the base via radio, and performs RTK calculations to determine the corrected position. After these calculations, the rovers report the real-time position for that hour, along with two levels of aggregated data: 6-hour and 24-hour averages.

Both the base and the rovers also report tilt data and system performance statistics. This statistical aggregation ensures high accuracy in monitoring.

4. Applications

The GNSS meter provides autonomous three-dimensional geoposition with millimetric precision.

This data is highly appreciated for different purposes, among them to evaluate the stability and behaviour of areas affected by subsidence or heave or slope stability, preventing possible structural, people and environmental damages.

The measurement of subsidence is essential to determine the rate and magnitude of ground movements, as this magnitude informs the urgency and severity of potential impacts.

This data is also ideal for dense point monitoring or as a complement to in-ground sensors like inclinometers and extensometers as it could be used for:

- Correcting Inclinometer and SAAV measurements based on a fixed point.
- Correcting extensometer measurements based on a fixed point.
- Complementing data from geotechnical monitoring

It can be also used in combination with other geospatial techniques like satellite InSAR, ground-based radar, and total stations, enhancing overall data reliability and robustness.

Some of its applications are for:

Subsidence and heave

- Coastal subsidence
- Mining and underground excavations
- Mine closures
- Swelling rocks and expansive soils
- Points of control for satellite InSAR, ground-based radar, total stations, and other geospatial monitoring techniques.

Slope stability

- Areas and assets affected by landslides
- Open pits and slope stability
- Surface points of control for in-place inclinometer strings, extensometers, and settlement systems

Structural movements

- Embankments, soil consolidation, and land reclamation projects
- Bridge abutments settlement
- Foundations settlement

5. Glossary

This glossary provides definitions for key terms and concepts related to the GNSS Meter and its operation. Use it as a reference to better understand the technology, features, and processes described in this guide.

Almanac: Information transmitted by a satellite that contains details regarding the orbits of all the satellites in the network. This information helps receivers determine which satellite to follow.

Augmentation of a global navigation satellite system (GNSS): A method of improving the navigation system's attributes, such as precision, reliability, and availability, through the integration of external information into the calculation process[2].

Baseline: The straight-line distance between the Base and the Rover. This distance is crucial for calculating the propagation delay errors in the RTK process.

Base: A fixed point within the GNSS RTK system that broadcasts its precise location data and status to one or more Rovers. It acts as a reference for the Rover to calculate its position with high precision.

Carrier Phase Measurement: A method used by GNSS receivers to determine position by measuring the phase of the signal carrier wave from the satellites. This measurement, when combined with satellite clock data and orbit data, allows for precise position calculations.

Differential Global Navigation Satellite System (DGNSS): A technique used to improve the accuracy of positioning data by comparing the signal received directly from satellites with corrections sent from a known reference point (Base).

Dilution Of Precision (DOP): Estimation of how reliable the GNSS observation is. Values range from <1 (Ideal) to >20 (Poor).

Ephemerides: The position of the satellites at a specific moment in time.

L Band: The frequency range (from 1 GHz to 1.6 GHz) where satellites operate.

Multipath Noise: A propagation phenomenon where radio signals reach the receiving antenna by two or more paths due to atmospheric effects (reflection, refraction, diffraction, scattering) or other natural or man-made objects.

Post Processing Kinematics (PPK): A technique where data from the Rover and Base are collected and corrections are applied in a post-processing manner.

Propagation Delay: The time it takes for a signal to travel from the satellite to the receiver. Corrections are applied in RTK systems to account for these delays.

Pseudorange: The distance between the GNSS satellite at the time of signal emission and the receiver antenna at the time of signal reception.[3]

[2] https://en.wikipedia.org/wiki/GNSS_augmentation
[3] https://www.sciencedirect.com/topics/engineering/pseudorange

Real-Time Kinematics (RTK): A GNSS-based surveying technique that achieves centimeter-level positioning accuracy by using correction data from a nearby Base station. It mitigates satellite orbit and clock errors, as well as atmospheric delays, providing precise positioning data almost instantaneously.

RTK Fix: A solution where the coordinates calculated by the receiver achieve a certain accuracy with corresponding dilution. A FIX solution indicates that the algorithm has resolved ambiguities effectively.

Rover: A device equipped with a GNSS receiver that receives signals from both satellites and the Base to determine its position.

Synchronization: Ensuring that the clocks of both the Base and the Rover are synchronized, so the time stamps on exchanged data match. This is essential for the RTK correction process.

Loadsensing GNSS System: A fully operational configuration with one Base and multiple Rovers.

Node: A GNSS Meter device, either acting as a Base or a Rover.

6. Device technical Specifications

For detailed technical specifications, please refer to the product datasheet. The datasheet provides comprehensive information about the GNSS Meter's features, performance metrics, and operational parameters.

7. System firmware requirements

The GNSS meter firmware version requirements are the following:

- WSApp version: from app version 2.11 onwards
- CMT Edge version: from firmware version 2.10.1 onwards
- CMT Cloud version: not compatible for this first release

8. Equipment Provided and elements

When ordering a GNSS Meter, the following items will be included:

Table 2 : List of items included on the standard order of a GNSS Meter

Code	Description
LSG7GNS-SXLH + LSG7GNS-SW	Loadsensing Edge Device G7 GNSS Meter
LS-ACC-ANT-03	LoRa Antenna
LS-ACC-GNSS-ANT	GNSS Meter antenna. Calian model: TW3929
LS-ACC-GNSS-CL1	GNSS antenna cable, 20 cm in length, for compact installation

The standard order of the GNSS Meter does not include:

Table 3 : List of items **NOT** included on the standard order of a GNSS Meter

Code	Description
WS-ACC-CELL-1D	Batteries: 4 Saft LSH20 D-size spiral cell (13 Ah) ()
Mounting accessories	Mounting brackets for the node, GNSS and LoRa antennas. See the list

Code	Description
	of compatible supports according to the installation mode in our GNSS accessories user guide (available in our help center)
Additional antenna cables	Longer antenna cables (check the accessories document for more information).

8.1. GNSS Meter device parts

The GNSS Meter is composed by the following elements:

1. Metallic casing
2. External USB-C connector with its cap
3. LoRa radio connector
4. LoRa radio antenna
5. GNSS antenna connector
6. GNSS antenna cable
7. GNSS antenna
8. Pressure stabilizer for protection against condensation (protective vent)

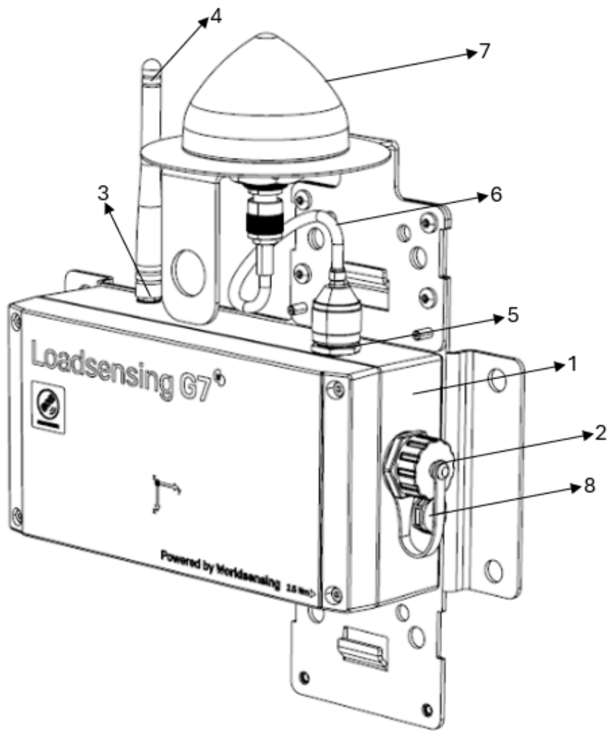

Figure 1: GNSS Meter device parts.

Important note regarding the USB adapter

Please note that the USB adapter from the GNSS meter node is not a mini USB anymore. We strongly recommend purchasing this item through Worldsensing or alternatively use one of WS validated cables, such as the USB 3.2 Generation 2 from Lanberg.

9. Powering up the Device

Loadsensing devices are usually shipped closed and without batteries (if not agreed differently during the ordering process by including for example the pre-configuration service option).

To power up the device:

9.1. Open the device using a 2.5 mm Allen wrench.

9.2. Insert D-type batteries in the battery holder, checking they match the polarity indicated. Please note that the device has reverse battery protection but it is not safe to keep batteries reversed in the device for a long time.

Please consider that the GNSS Meter can be powered autonomously by batteries or alternatively it can also be powered externally, for example with a solar kit, through the USB-C connector. The power supply should be between 3 and 5 VDC, typically requiring converters to 5 VDC.

General warnings

Follow these precautions to avoid a battery explosion or leakage of flammable liquid or gas:

- Use the correct battery type. Dispose of the batteries according to instructions. Do not dispose of the batteries by throwing them into a fire or a hot oven, or mechanically crush or cut them.
- Do not leave the batteries in an extremely high-temperature environment.
- Do not subject the batteries to extremely low air pressure. It may result in an explosion or leakage of flammable liquid or gas.
- Do not short circuit the batteries. This will blow the protection fuse.

Batteries and equipment to be connected via the data port must meet IEC 62368-1 ES1 and PS1 requirements.

Equipment to be installed in restricted access areas.

10. Placement: Open View of the Sky and Line of Sight Between LoRa Antennas

In an RTK system, the GNSS antenna sky visibility requirements are more stringent compared to those needed when obtaining coordinate positions using a smartphone.

This makes it essential to carefully select the locations where the Base and Rovers will be installed.

The Base plays a critical role in the setup, as it is responsible for sending corrections to the Rovers assigned to it. For this reason, special attention must be paid to its placement and installation.

Important note regarding distance between Base and Rover

It is important to note that the greater the distance between the Base and the Rover, the lower the accuracy of the positions measured by the Rover. This is specified in the GNSS Meter datasheet.

10.1 Clear View of the Sky

The GNSS antenna needs an unobstructed view of the sky above the horizon. It is crucial to minimize interference caused by buildings, trees, and other structures that can block satellite signals. These obstructions can lead to signal loss and create multipath issues due to reflected signals.

For optimal performance, the installation location should ensure a clear sky view of at least -30° to +30° above the horizon in all 360° directions. The better the sky visibility, the better the system's performance. Since the Base serves as the system's reference, the sky visibility requirements for the Base should be even stricter. Ideally, the placement of the Base antenna should avoid obstacles above 10° from the horizon.

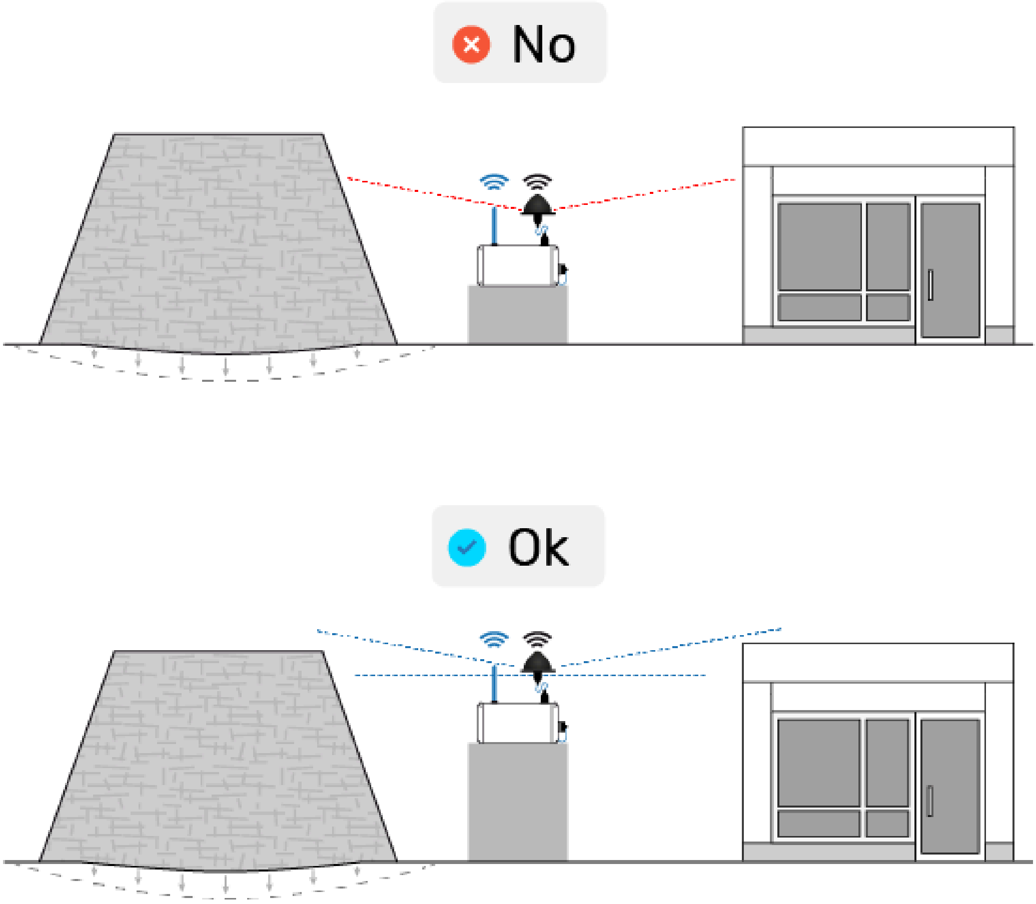

Figure 2: Illustration showing the clear view of the sky conditions required.

While vegetation and trees have a lesser impact compared to buildings and other structures, they can still affect the quality of GNSS signal reception. Large branches or heavy accumulations above the antenna can significantly degrade the signal quality.

Antenna Height

The height at which the GNSS antenna is installed can be important in certain cases. Installing the antenna higher can reduce obstructions to the sky view and help mitigate multipath interference. Elevating the antenna can also prevent issues caused by flooding or snow accumulation.

In flat and open areas, however, height is less critical. In such cases, the antenna already has a clear view of the sky, so the height may have little to no impact on performance.

10.2 GNSS Antenna Mounting and Available Accessories

To ensure the proper functioning of the GNSS antenna, it is important to correctly install the ground plane and secure all connections.

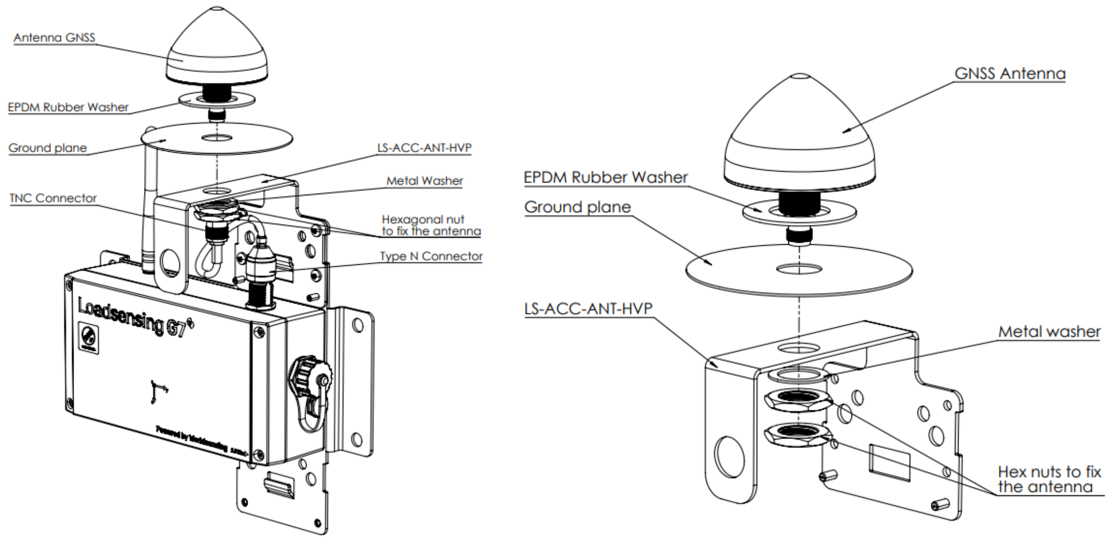

Figure 3: Mounting the GNSS antenna and its components (rubber washer, ground plane, metal washer and nuts) on a bracket.

In our Help Center, you will find specific mounting instructions for installations on poles or rigid surfaces:

- Surface Mounting Instructions for Loadsensing GNSS Meter.
- Survey Pillar and Pole Mounting Instructions for Loadsensing GNSS Meter.

These manuals provide details on the various available accessories as well as guidelines for their correct installation.

10.3 Interference Mitigation: Requirements for Base Installation

In general, we recommend avoiding nearby electronic equipment. Keep the GNSS antenna away from sources of electromagnetic interference, such as power lines, transmitters, or large machinery.

It is also recommended to install the GNSS meter in a dedicated location. The goal is to avoid sharing mounting structures with antennas emitting radio signals, such as cellular or Wi-Fi antennas, to prevent interference.

For the Base, there is a specific requirement to avoid potential interference between the transmission of corrections via LoRa and the reception of GNSS signals, as these operations occur simultaneously.

To install the Base, a minimum distance of 1 meter is required between the LoRa antenna and the GNSS antenna. This distance can be achieved horizontally, vertically, or in another direction.

Worldsensing offers extension cables for both GNSS and LoRa antennas. It is important to use high-quality cables and minimize cable length to reduce signal loss. Both solutions—extending the cable for LoRa or for the GNSS antenna—are equally valid.

We recommend choosing the option that best suits the following requirements:

- **Clear view of the sky** for the GNSS antenna.
- **Line of sight** between LoRa antennas.
- **A minimum distance of 1 meter** between the LoRa antenna and the GNSS antenna.

Depending on the specific installation conditions, one option may be more appropriate than the other.

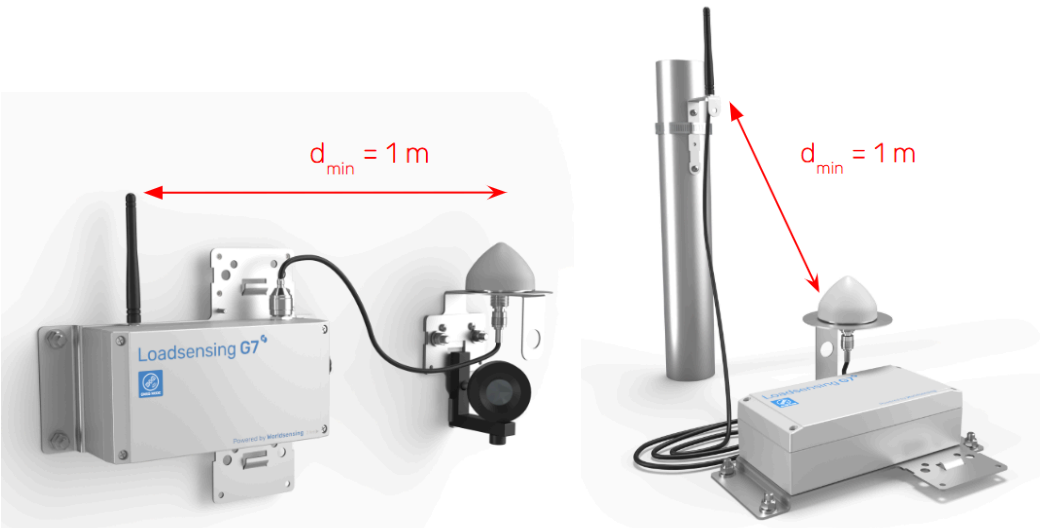

Figure 4: The minimum distance between the LoRa antenna and the GNSS antenna must be 1 meter for the GNSS Meter operating as a Base.

Important note regarding antenna separation for the Base

The minimum 1-meter separation between the LoRa and GNSS antennas for the GNSS Meter operating as a Base is essential to achieve the expected system performance.

10.4 Line of Sight Between LoRa Antennas

Another important requirement when selecting installation locations and auxiliary mounting structures—such as survey pillars, poles, and others—is to ensure **line of sight between LoRa antennas.**

The LoRa antenna of each Rover must have a clear, unobstructed line of sight with the LoRa antenna of the Base. This is crucial to ensure that the Rover correctly receives the corrections and can perform RTK processing to obtain accurate positions.

It is important to note that this **node-to-node communication** (Base to Rover) is more sensitive than the communication between Loadsensing nodes and the Gateway. For this reason, line of sight is required. Additionally, the radio range that can be achieved is slightly shorter—up to 5 km. However, more than the distance, the key factor is ensuring direct line of sight.

To help the user verify whether a Rover will correctly receive the corrections sent by the Base, the **GNSS Corrections Coverage Test** functionality is available in the Worldsensing App. Through this test, the Rover requests the Base to send radio messages similar to the corrections, and the user can view the results directly in the app.

This functionality is explained in detail in section **'12.2 Rover'** of this manual.

11. Considerations on Base Position and the Coordinate System

11.1. Base Position

For the Loadsensing system to operate efficiently, the Base node has to be properly installed. Please follow these recommendations for a reliable operation:

- It is recommended to install the base in a fixed location where ground movements are not expected.
- We strongly advise determining this position using precise techniques, such as traditional surveying or high-accuracy manual GNSS measurements, as it is essential to verify the base's position over time. Accurate measurement of the base position is crucial.
- If any base movement is anticipated, the position must be periodically remeasured using precise surveying techniques and updated in the Loadsensing system to ensure that the corrections sent to the rover remain accurate.
- If the base station experiences a movement and its position is not updated in the system configuration, this can have significant effects on the position calculated by the rover as the RTK correction is based on the precise differences between the GPS signals received by the base and the rover.
- If the base position is determined using an imprecise method, for example with an error of ±1 meter, it will not be possible to verify over time that these coordinates remain valid. This will prevent the management of ground movements that could

shift the base position or any adjustments that may need to be made to it for other reasons.

- Since it is essentially a relative system, it is possible to use the coordinates of a nearby point—such as a surveying prism—as the Base Position coordinates. For instance, if the coordinates of a prism displaced by 30 cm from the center of the GNSS antenna are used, all rover coordinates will also be displaced. However, as the main objective is to measure displacements relative to an initial position of the rovers, rather than their absolute coordinates, using a control point some distance from the GNSS antenna center of the base is acceptable.
- If the base position is set incorrectly (i.e., not adjusted after a move), the corrections sent to the rover will be wrong, and this will be reflected as a systematic error in the calculated rover positions.

Mounting accessories available

Worldsensing offers the accessory 'Vertical Mount Plate for Prism' (LS-ACC-PRS-VP), which allows a prism to be installed vertically aligned (within a tolerance) with the GNSS antenna of the GNSS Meter. There are also suitable prisms designed to align vertically with the antenna when using the '5/8-inch Survey Pole Mount for GNSS Antenna' (LS-ACC-GNSS-RD). These solutions facilitate precise base positioning and its monitoring over time. Other methods may also be valid.

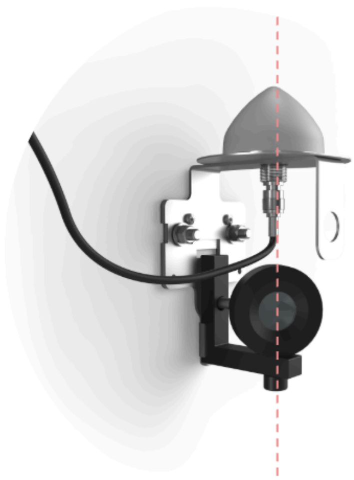

Figure 5: Vertical Mount Plate for Prism' (LS-ACC-PRS-VP), which allows a prism to be installed vertically aligned (within a tolerance) with the GNSS antenna

11.2. Coordinate system

While GNSS systems always operate in WGS84 coordinates, these coordinates are not anchored to any specific tectonic plate. For example, in the case of a base station unaffected by local movements, if the base's initial position is set in WGS84 and then the user checks the reference position in WGS84 after a year, it will have shifted due to tectonic plate movements. Tectonic plates move at varying rates, typically ranging from 1 to 10 centimeters per year. For instance, the position may change by approximately 2.7 cm east-northeast in Barcelona, 4.0 cm northwest in Los Angeles, 1.7 cm southwest in New York, and 2.9 cm west-northwest in Santiago de Chile.

These gradual positional changes can introduce errors in displacement measurements, especially when monitoring focuses on displacements relative to a local origin that doesn't account for tectonic plate shifts. Since typical Loadsensing applications prioritize detecting local movements, it is essential to correct for tectonic motion or adopt a coordinate reference system anchored to the tectonic plate. These systems depend on trusted institutions to apply ongoing adjustments, ensuring tectonic shifts are accurately accounted for and excluded from the measurements.

To address tectonic plate movements in displacement measurements, two strategies can be employed:

Using WGS84 (Dynamic coordinate system)

From a GNSS perspective, this is the most appropriate option. Here, the Base position would be entered in WGS84 coordinates, which must be periodically updated. Since this coordinate system is not fixed to a tectonic plate, the same point—without being affected by ground movements caused by local phenomena—will have changed WGS84 coordinates over time due to tectonic plate motion.

With this approach, the user must later subtract tectonic plate movements from the displacements measured by the Rovers. Each Rover will measure the resultant movements caused by both tectonic plate shifts and deformations of the ground due to local phenomena.

Using a Plate-Fixed Coordinate Systems

A more stable approach for long-term monitoring is to use a coordinate system aligned with WGS84 at a specific epoch and then anchored to the relevant tectonic plate. This eliminates the need for ongoing tectonic corrections and simplifies monitoring, ensuring consistent and reliable displacement measurements over time.

We recommend inputting base reference coordinates in a coordinate system that is a regional realization of the International Terrestrial Reference System (ITRS), a global geocentric reference frame. Examples of regional realizations include:

- ETRS89: Europe's realization of ITRS, aligned with the Eurasian plate.
- NAD83: North America's realization, aligned with the North American plate.
- GDA2020: Australia's realization, aligned with the Australian plate.
- AFREF: Africa's realization, aligned with the African plate.
- SIRGAS: South America's realization, aligned with the South American plate.

For other regions, local adaptations of the ITRF/WGS84 framework may be used, depending on tectonic dynamics and regional geodetic practices. These systems are designed to account for tectonic plate movement by being plate-fixed and using a geodetic ellipsoid to approximate the shape of the Earth.

All these systems are fully compatible with GNSS (Global Navigation Satellite Systems) and ensure accurate, consistent geospatial positioning within their respective regions.

It is important to note that transformations from WGS84 to these systems vary over time due to tectonic motion and periodic updates to reference frames. Therefore, when performing transformations, it is essential to consider the epoch of the transformation to maintain accuracy.

Important note about the general use of WGS84

In the following sections of this document, as well as in the configuration screens of the CMT and Worldsensing App, we refer to the coordinates as WGS84. As explained in this section, this should be understood in a broader sense. When we refer to WGS84, we also mean other regional adaptations of the ITRF/WGS84 framework that may be used (ETRS89, NAD83, GDA2020, etc.), depending on the strategy chosen for the project.

12. Wireless GNSS meter installation and configuration

The device configuration has to be carried out using the Worldsensing App (WS App), which is compatible with USB On-The-Go (OTG) Android devices. For the GNSS meter configuration, the cable is a standard USB-C double edged cable.

Unlike other Loadsensing devices, deploying the GNSS Meter requires on-site configuration. Due to the technology it uses, preliminary tests must be conducted to ensure the GNSS is receiving a proper signal.

Once the node is connected to the Android device, the WS App will prompt for time synchronization. For the GNSS Meter, time and date can be also synchronized through the Android device. However, the node benefits from more precise synchronization (+/-1 s) obtained via satellite, which will be maintained throughout the node's operational life.

12.1. Base

- Before installing the Loadsensing GNSS group, we recommend assessing the monitoring area and locating a fixed point where the Base will be positioned.
- This point should also have line of sight with the other rovers to ensure proper communication. This is important as Base and Rovers must communicate through SF7.

12.1.1. Installing the GNSS Base

Install the Base node using the provided accessories, attaching it securely to a wall or pillar (refer to the accessories document for further details). Ensure the following key points during this step:

- The GNSS antenna must have a wide angle vision to the sky (the widest , the better; see more information in 'Section 10 Placement: Open View of the Sky and Line of Sight Between LoRa Antennas'). Please avoid positioning it next to a wall to avoid shadows.

- The GNSS antenna must be placed separately from the radio antenna to avoid interference (at least 1 meter as the minimum distance requirement; see more information in 'Section 10.3 Interference Mitigation: Requirements for Base Installation'). Please check the accessories that Worldsensing provides for this purpose.
- The GNSS antenna must be placed the more horizontal as possible

Figure 6: Installation of a base in a survey pillar. A prism for survey control has been installed on top of it and its position is being used as the base position for Loadsensing GNSS installation. The GNSS antenna has been installed within a certain distance from the radio antenna by using a 2,5 m cable

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12.1.2. Creating a GNSS Meter Base

Once the base is successfully installed, create a Base by connecting the node to the WS App, accessing the GNSS Base Administrator feature on the WS App main menu.

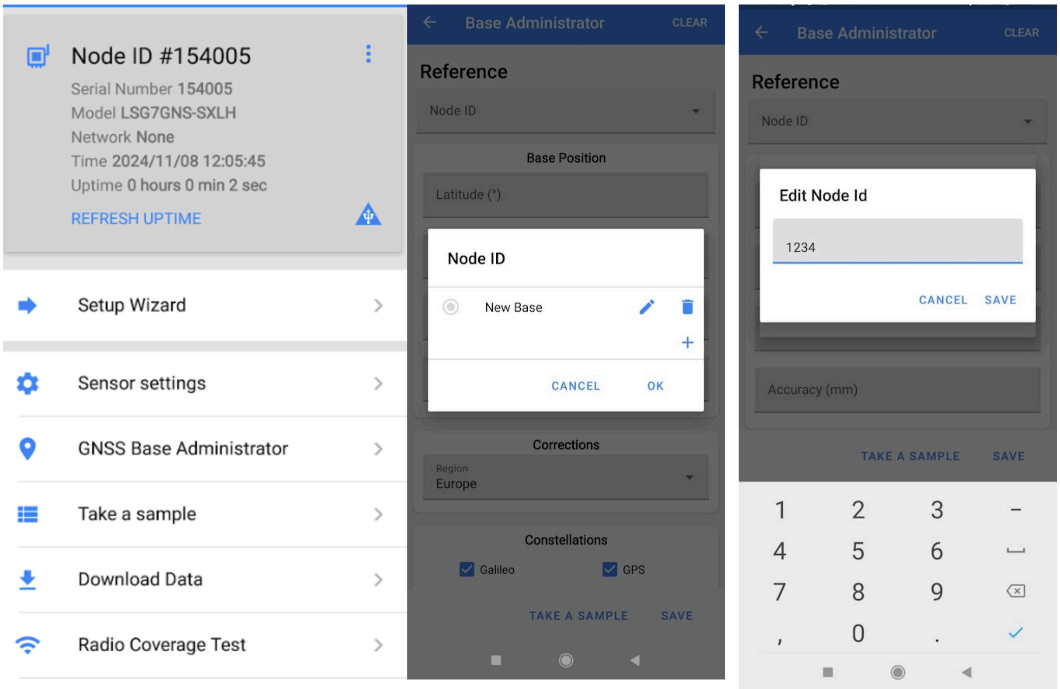


Figure 7: Creating a base using the WS App Base administrator

In this step, the Base element will be created and the information from its position will be used for the RTK fix corrections applied to the Rovers assigned.

`Node ID:` The node ID of the Base must be typed

`Base Position:` Different situations can happen on this step

- The position of the base could be taken from any other survey technique used and could be added to the Base position (Latitude°, Longitude°, Altitude m).
- If no Base position data is available at the time of field configuration of the system, the user can take a sample directly from the node and add the base position taken for other survey techniques later through the CMT. When taking a sample the WS App collect a standard GNSS positioning measurement and a tiltmeter reading. The precision from its position is limited (approximately 1,5 m horizontally and 2 m vertically) because it uses standalone GNSS, as the GNSS meter does not apply correction from any base to obtain this measurement.

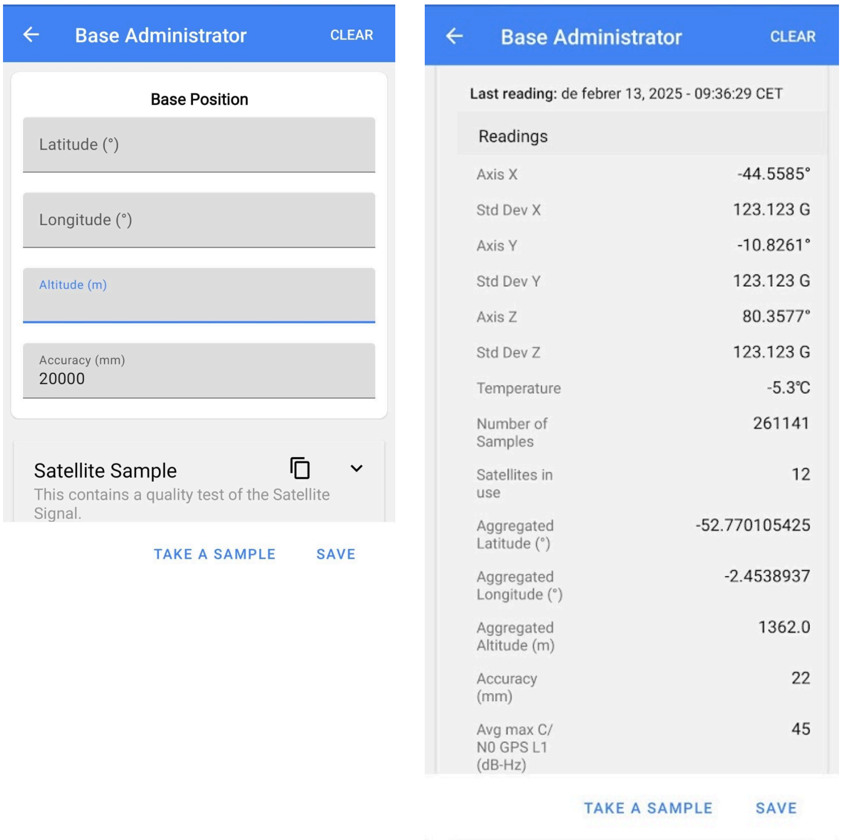


Figure 8: Taking a sample for positioning the base using the WS App Base administrator

By taking a sample and copying it in the portrait Base position fields, Latitude, Longitude and Altitude will be automatically ported.

`Accuracy:` by default the accuracy shown on the screen is 20000 mm. We strongly recommend leaving this parameter as this. The GNSS meter checks the position received with the one that has been registered and if it differs more than the accuracy, readings will be discarded.

`Correction Region:` the region where the project is located must be selected on this menu. The radio region should be the same as the one selected for the standard radio configuration.

Save the configuration to store it on the WS App. It will be now available to be used for Rover configurations. Please consider that as in this step we are not configuring a Base, the user will be able to create different bases and apply their attributes for rover configurations.

`Constellations:`since WS App firmware version 2.12.0 and CMT Edge version 2.10.1 the user is able to configure satellite constellations to be used by the GNSS

Meter. Galileo, GPS and Glonass are enabled by default, but Beidou could be also selected.

It is recommended to use default Constellations configuration. If after installing the GNSS Meter and ensuring the optimal GNSS antenna installation the statistics show that there are not enough satellites in use, the user could enable the Beidou constellation. Enabling this constellation could be useful to increase the number of satellites that the GNSS can see in APAC region.

12.1.3. Configuring a Base

Once the Base has been created on the Base Administrator feature, access the Setup Wizard from the WS App.

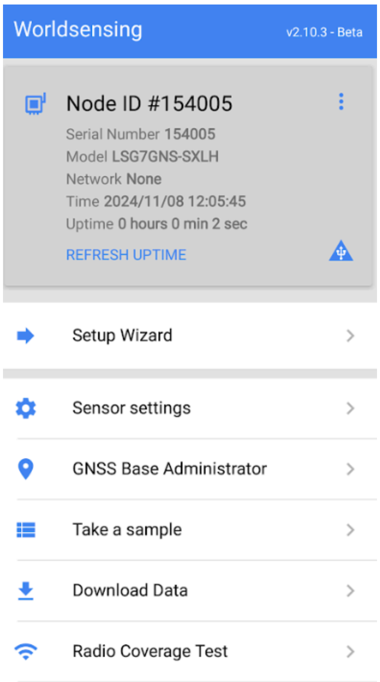


Figure 9: Configuring a base using the WS App Base administrator

The WS App will prompt the user to Add Location from the node. If the GNSS position on the Android device is enabled, the WS App will place the node on this position. Next step will be taking a sample.

Please be aware that the `Add Location` feature will take the location from the Android device for reference purposes. This will not be a precise location. When taking a sample, this will collect a non-RTK fixed position measurement.

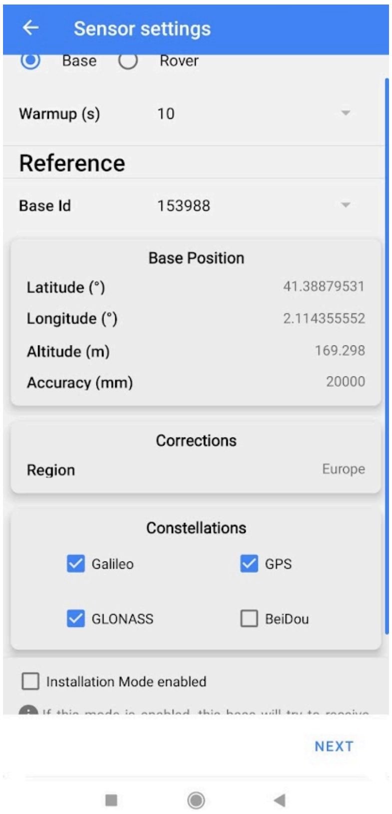


Figure 10: Assigning base settings to a node

`Warm up (s)`: this is the time that the GNSS sensor will awake each hour and search for satellites. Warm up time is set to 10 s by default. 20 s and 30 s warm up time can only be configured through the CMT (please check section 13 from this document)

We recommend using the default warm up time configuration as it has less impact on battery consumption. If after checking that the warm up time is not enough to provide good results, we recommend increasing gradually this parameter.

It is important to use the same warmup time configuration for the base and for all the rovers assigned to a same base

`Base ID:` When selecting a Base ID, the Base position and region configured for that specific ID will be assigned to the Base. The WS App does not allow selecting a Base ID that does not match with the node ID.

Enabling the installation mode means that the Base is constantly able to receive a petition from a coverage test from Rovers. This feature is specific from the Base and has limited impact on the Base battery consumption.

We recommend enabling this mode until checking that the system is correctly operating.

When pressing Next, a Sync with Edge screen will be shown. Fill with the required information and press `SYNC` to execute and send the node configuration to CMT Edge.

This step will be only possible for an Online deployment as internet connection is used for the synchronization. This is not a mandatory step but we highly recommend this synchronization so the system is aware that the configurations and mismatches can be detected easily.

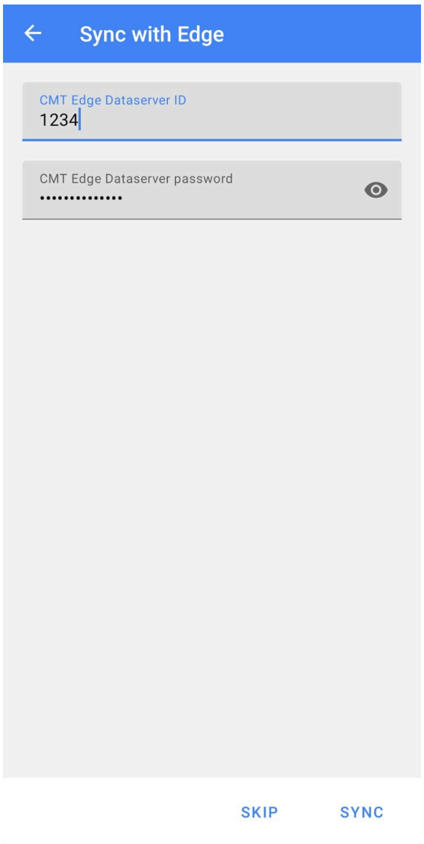


Figure 11: Synchronizing base settings through the Sync with Edge feature

The next step will be the same as the other node configuration. Radio configuration and network size must be defined. Please refer to the Worldsensing app User Guide for more details

For the GNSS Meter, the reporting period is restricted to 1 hour and it is not a configurable parameter.

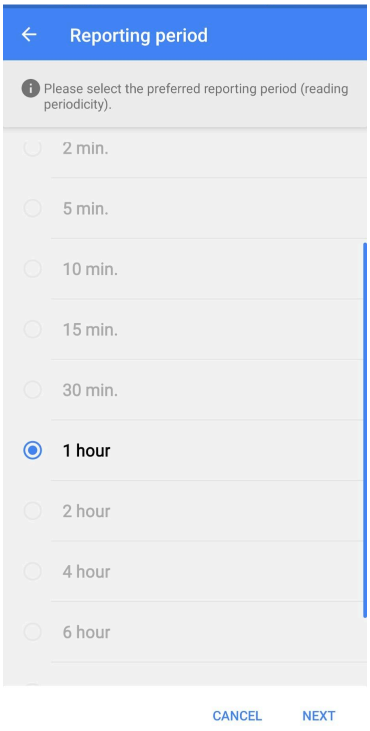


Figure 12: GNSS meter reporting period restricted to 1 h

12.2. Rover

12.2.1. Configuring a GNSS Rover

To configure a GNSS Meter as a rover, access to the Setup Wizard in the WS App.

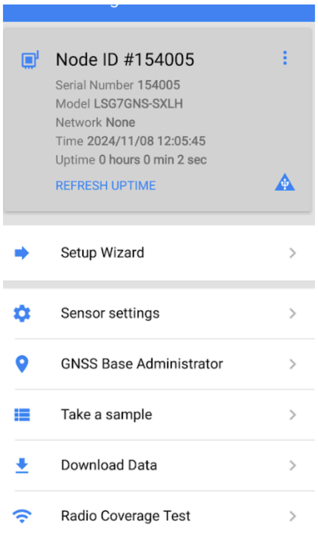


Figure 13: Setup Wizard

The WS App will prompt the user to Add Location from the node. If the GNSS position on the Android device is enabled, the WS App will place the node on this position. The next step will be taking a sample.

Please be aware that the `Add Location` feature will take the location from the Android device for reference purposes. This will not be a precise location. When taking a sample, this will collect a non-RTK fixed position measurement.

After adding the location to the node, select the `Rover` option on the Sensor Settings screen.

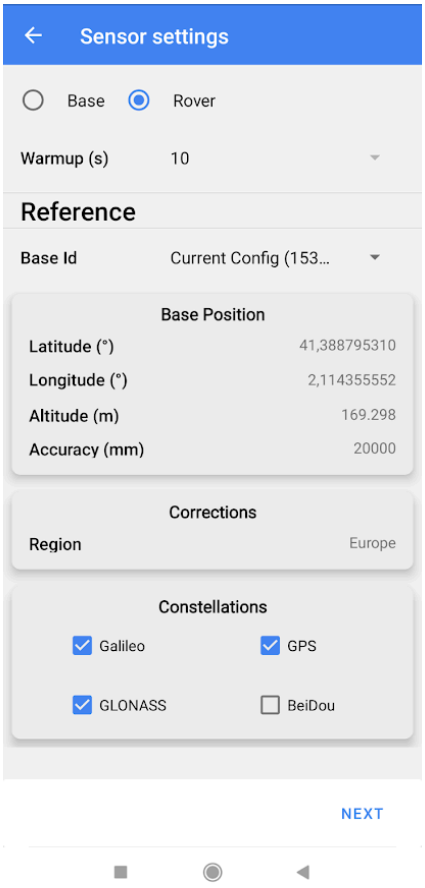


Figure 14: Assigning the Rover settings to the node through the WS App

`Warm up (s):` this is the time that the GNSS sensor will awake each hour and search for satellites. Warm up time is set to 10 s by default. 20 s and 30 s warm up time can only be configured through the CMT (please check section 13 from this document)

We recommend using the default warm up time configuration as it has less impact on battery consumption. If after checking that the warm up time is not enough to provide good results, we recommend increasing gradually this parameter.

It is important to use the same warmup time configuration for the base and for all the rovers assigned to a same base.

`Base ID:` all the Bases that have been created with the Base Administrator will be shown on the drop down menu. A base will need to be selected for each Rover and all their attributes will be assigned to that specific Rover (Base Position and Corrections configurations).

`Constellations:` satellite constellations could be configured to be used by the GNSS Meter. Galileo, GPS and Glonass are enabled by default, but Beidou could be also selected.

Base and Rovers must have the same constellations enabled in order to operate.

When pressing Next, a Sync with Edge screen will be shown. Fill with the required information and press `SYNC` to execute and send the node configuration to CMT Edge.

This is not a mandatory step but we highly recommend this synchronization so the system is aware that the configurations and mismatches can be detected easily. This step will be only possible for an Online deployment as internet connection is used for the synchronization.

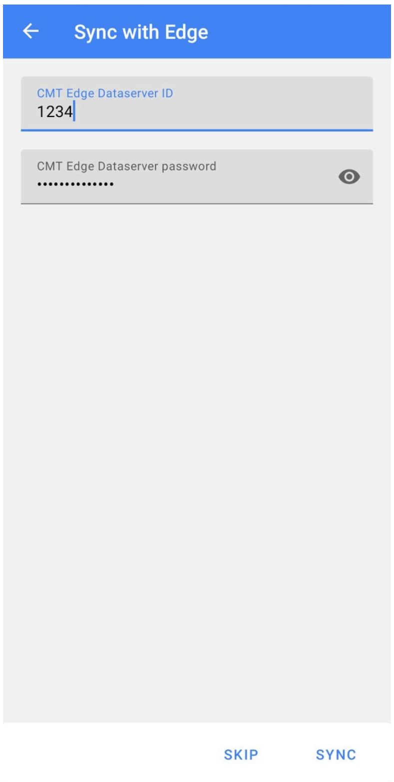


Figure 15: Synchronizing base settings through the Sync with Edge feature

After the synchronization, the user is prompted with the GNSS Corrections Coverage Test screen. This feature is only available on rovers and test will allow to know the radio coverage between a Base and a Rover.

Please note that Corrections Coverage Test result is not available through the CMT.

When deploying this coverage test, 8 radio packages will be sent from the Base to the Rover. The WS App will show the percentage of radio packages received by the rover on the Rover Package reception table and the quality from the signal of communication.

The recommended percentage for communication is 8/8 to achieve the accuracy published in the datasheet, but less ratio could be valid depending on the quality of the data that the user needs to achieve. Less ratio means that less corrections from the base could be achieved, affecting the accuracy of the data.

If the radio signal is not good enough we strongly recommend moving the node's antenna in order to optimize its position. The system could be left running for a couple of days to check if the accuracy of the data obtained is good enough.

If the installation mode is enabled, as the Base is constantly able to receive a petition from a coverage test from Rovers, it will be possible to deploy the coverage test instantaneously.

When disabling the installation mode, the user will not be able to execute this test. The communication between base and rover could be checked on the next sampling cycle (defined as 1 h).

Also the Base package Reception table could be dropped down showing the quality of the signal from the petition from the Rover to the Base.

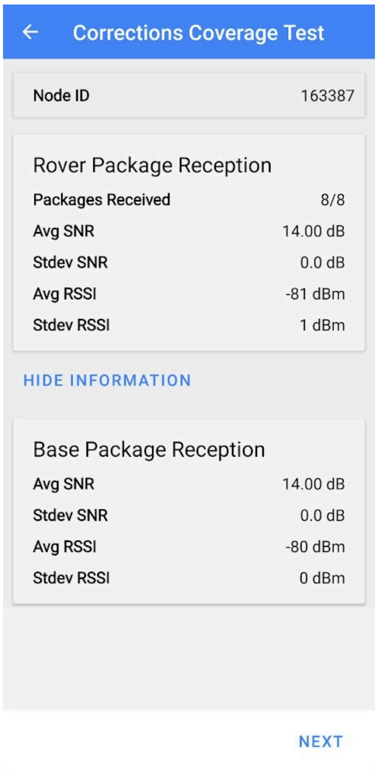


Figure 16: Synchronizing base settings through the Sync with Edge feature

Important

GNSS corrections Coverage test must be done with the GNSS and LoRa antenna connected, if not an error message will appear as follows "No fix. Could not get a GPS fix to synchronize the time".

The next step will be the same as the other node configuration. Radio configuration and network size must be defined. Please refer to the Worldsensing app User Guide for more details

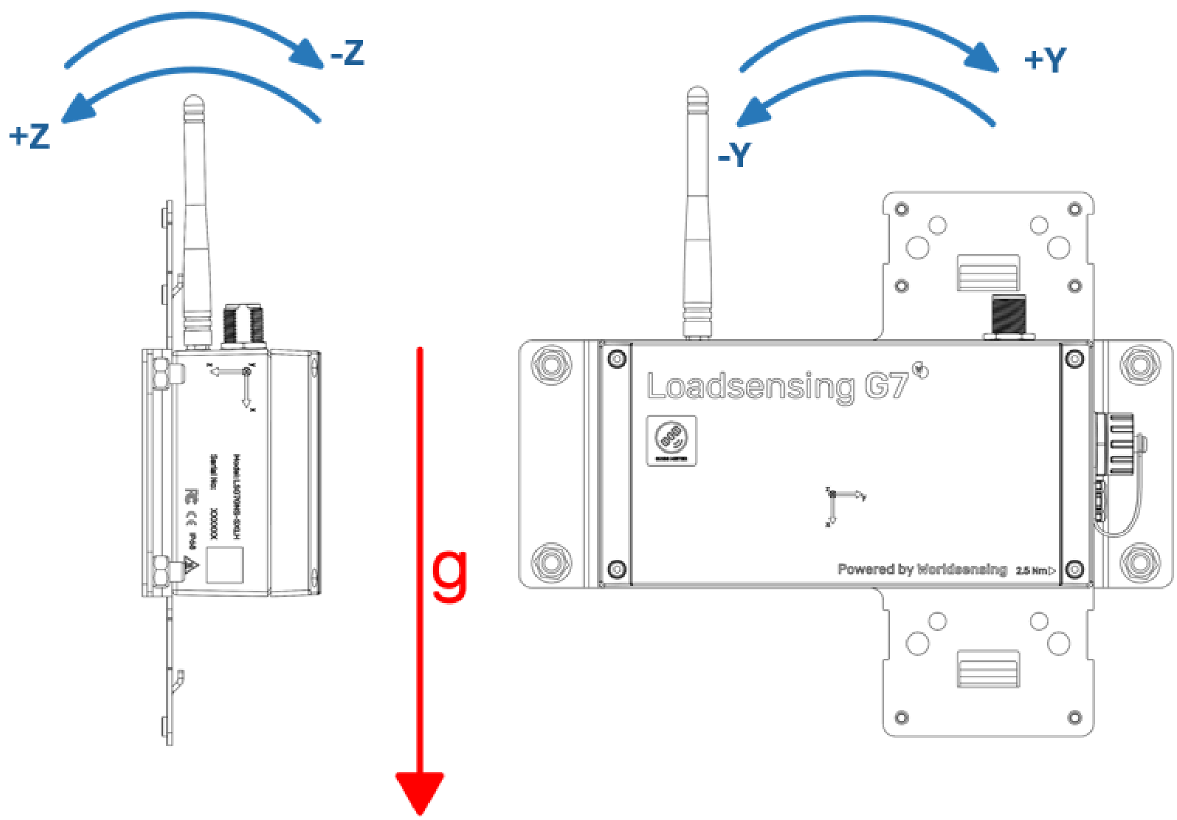
For the GNSS Meter, the reporting period is restricted to 1 hour and it is not a configurable parameter.

13. Tiltmeter axis and sign convention

The GNSS Meter also uses a triaxial accelerometer that measures the 3 axis inclination with respect to the gravity's direction every hour. The device could be installed on any orientation among the 360° and it has a 90 ° range. Check the specs on the datasheet.

Find attached a schematic of the different angle installation with respect to the 3 axis.

Below is a drawing positioning from the GNSS attached vertically and horizontally to a plane showing the different axes of interest and their sign convention (gravity is also indicated).



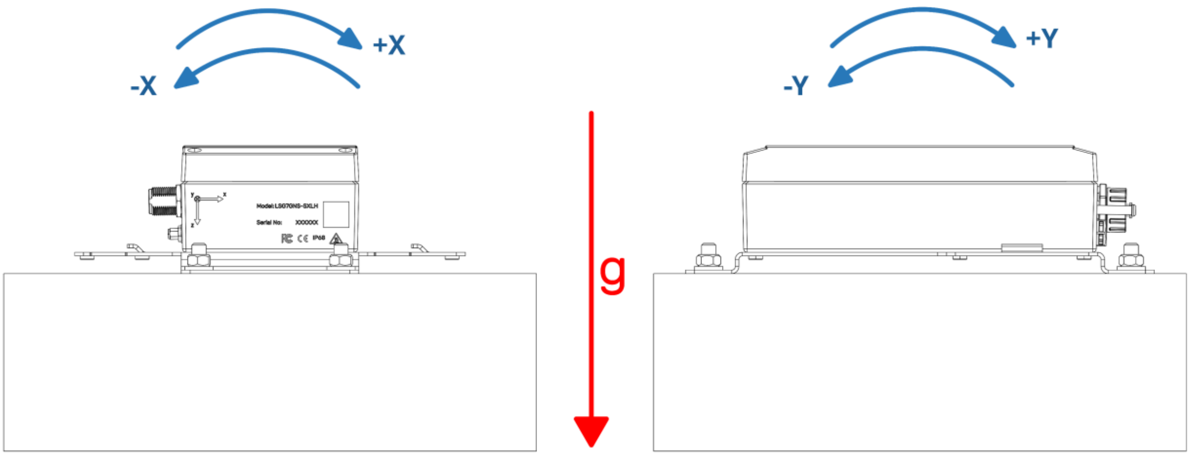


Figure 17: Tiltmeter axes of interest in vertical and horizontal position.

14. Safely closing the device

The GNSS Meter has undergone water tightness testing by an external laboratory and has been rated IP68 at 2 m for 2 hours.

14.1. To guarantee water tightness some actions are required:

- Lock the box by tightening screws crosswise on the lid. Adjust the screws using a torque wrench. If this is not done properly, the base faces and cover may not be parallel, screwing may become more difficult and the screw threads or the Helicoil inserts may be damaged. Moreover, the O-ring (seal) may not be properly sealed and the degree of protection against water intrusion could be compromised.
- Screw the box at 2,5 Nm (the force that needs to be applied is marked on the outside of the device) using a torque screwdriver (e.g. Ref. 1227107 from WERA).
- Make sure the sealing ring has not been physically or chemically manipulated.

Regarding IP68 compliance

There is no need to seal the GORE valve to comply with IP68.

Worldsensing cannot guarantee the IP68 rating if any of the above conditions are not met or if one or several components (e.g. the GORE valve) are damaged.

Risk of damage

Avoid torquing box screws beyond 2.5 Nm to prevent damage to the Helicoil insert. Use manual tools only; electric drills or screwdrivers are not recommended.

15. Device and data management through CMT Edge

15.1. Remote configuration and Data management

This section highlights the specific features of the GNSS Meter on CMT Edge. For a general user guide of this platform, please refer to the dedicated guide. Below, we detail the specific remote configuration and data management processes for the GNSS Meter.

Once the GNSS node has been configured successfully, the node's unique ID will become visible on the CMT Edge main page, enabling streamlined identification and management.

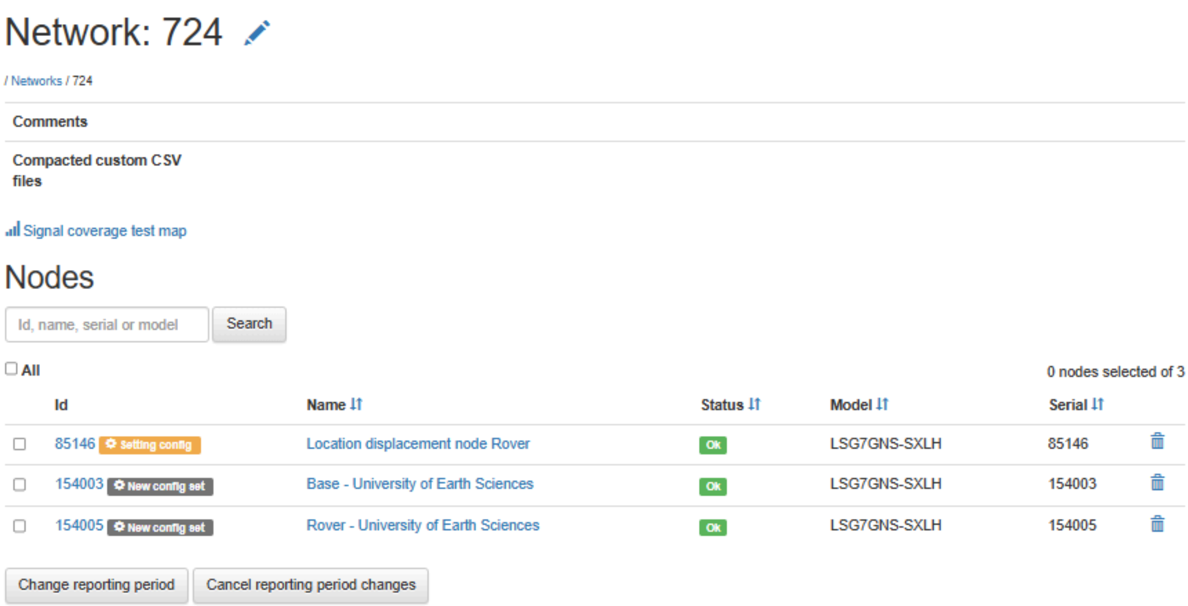


Figure 18. CMT Edge Network view

There will be no label differentiation between base and rover, so we strongly recommend adding the name on the configuration panel from the node.

As mentioned on chapter 10, the reporting period of the GNSS meter is restricted to 1 h and can not be modified. The feature to change the reporting period is also available while only offers to set the reporting period to 1 hour. We strongly recommend reapplying the 1 h reporting period once the GNSS meters have been configured.

Data files

Base and Rover have different files:

- For **Base**, Health, tiltmeter and statistics file (see Appendix A for more information) will be automatically generated
- For **Rover**, Health, tiltmeter, GNSS reading and statistics file (see Appendix A for more information) will be automatically generated

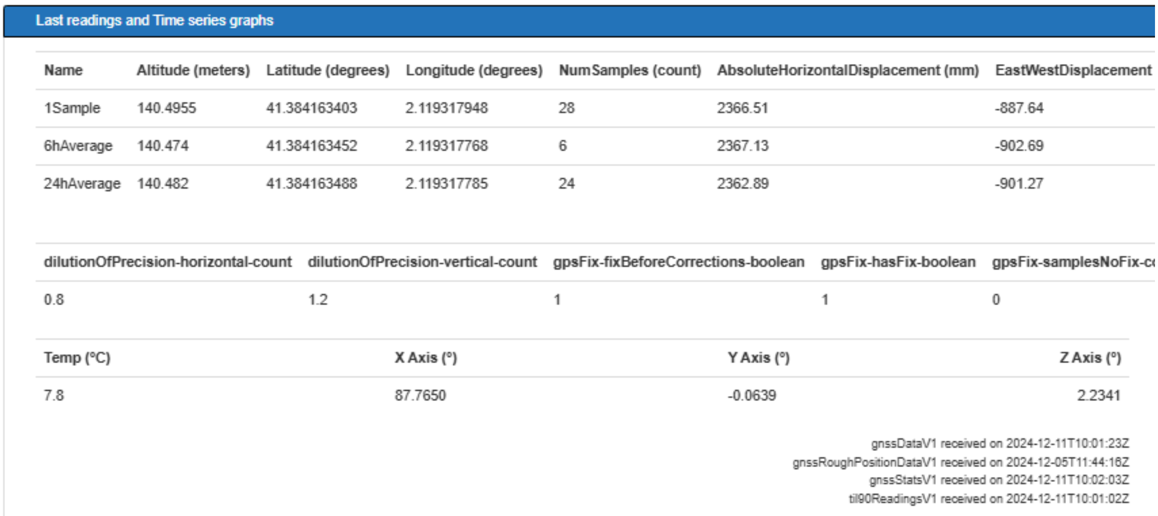
In the same panel, below the CSV files, there are four tabs informing about the: Last readings and Time series graphs (1), Status (2), Metadata (will always remain blank) and Last Messages (3).

Last readings and Time series graphs:

Altitude (m), Latitude (m) and Longitude (m) will be shown in WGS84 format for its 1 hour sampling and the 6h and 24 h aggregate, among the number of samples.

Also, statistical parameters from the last readings and tiltmeter data (Temperature (°C), X Axis (°), Y Axis (°) and Z Axis (°) will be displayed).

On the right bottom from the panel, last messages type and time reception (in UTC) will also be displayed


Last readings and Time series graphs

Name	Altitude (meters)	Latitude (degrees)	Longitude (degrees)	NumSamples (count)	AbsoluteHorizontalDisplacement (mm)	EastWestDisplacement
1Sample	140.4955	41.384163403	2.119317948	28	2366.51	-887.64
6hAverage	140.474	41.384163452	2.119317768	6	2367.13	-902.69
24hAverage	140.482	41.384163488	2.119317785	24	2362.89	-901.27

dilutionOfPrecision-horizontal-count	dilutionOfPrecision-vertical-count	gpsFix-fixBeforeCorrections-boolean	gpsFix-hasFix-boolean	gpsFix-samplesNoFix-c
0.8	1.2	1	1	0

Temp (°C)	X Axis (°)	Y Axis (°)	Z Axis (°)
7.8	87.7650	-0.0639	2.2341

gnssDataV1 received on 2024-12-11T10:01:23Z
gnssRoughPositionDataV1 received on 2024-12-05T11:44:16Z
gnssStatsV1 received on 2024-12-11T10:02:03Z
til90ReadingsV1 received on 2024-12-11T10:01:02Z

Figure 19. Example of Last Readings and Time series graphs tab.

Status

It displays the same information about the radio transmissions as in other Loadsensing devices (see the CMT Edge guide).

Last messages

This tab includes the last received JSON formatted messages for each available kind. See Annex for data JSON formatted messages information.

Configuration

Some parameters from node's configuration can be changed remotely, as the Warm up Time (bear in mind that this parameter must be coincident on Base and Rover configurations) and enabling the installation Mode (only for base).

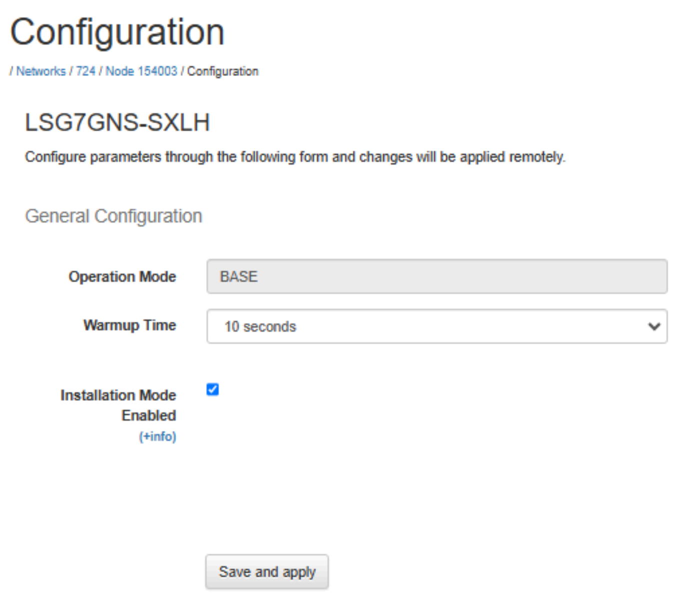


Figure 20: General configuration. Warm up time configuration

After the selection of the new configuration, an orange label stating the new configuration will be shown on the main network page. The label will turn gray when the configuration is effectively applied on the node.

The operational mode cannot be changed from the configuration menu and needs to be done through the GNSS meters configuration menu.

15.2. GNSS Meters configuration menu

This menu will allow the user organizing the different GNSS Groups (Base and Rovers) managed by a CMT Edge. Different actions could be done through it such as assign Rovers to a Base, or removing them, add the element's Name, modify position, define accuracy or swiching operational mode from nodes (Base/Rover) .

This menu is a complementary tool for easier GNSS groups administration but the system can be configured locally through the mobile application.

Although that, we strongly recommend reapplying again the configuration from the GNSS Meter configuration menu to the GNSS Meter system to avoid any parameters mismatch.

Some of the terms that will be used on this chapter include:

- `GNSS Group:` A Base with one or more rovers that share the same common parameters
- `Common parameters` (Reference) in GNSS Group
- `Base position`: refers to latitude, longitude, altitude and accuracy. The accuracy is set by default to 20 meters.
- `Radio plan:` radio used for communication between devices (only configurable through App)

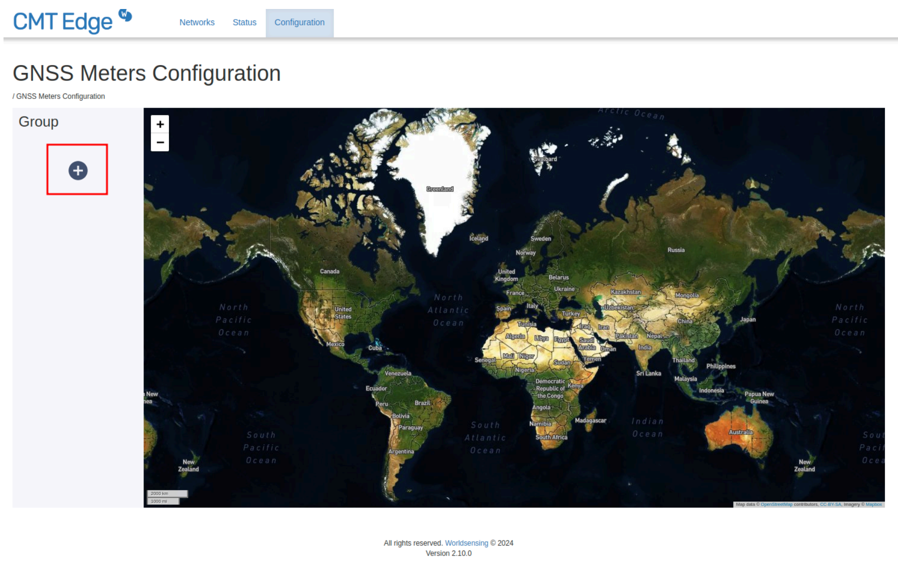
15.3. Creating a GNSS Group

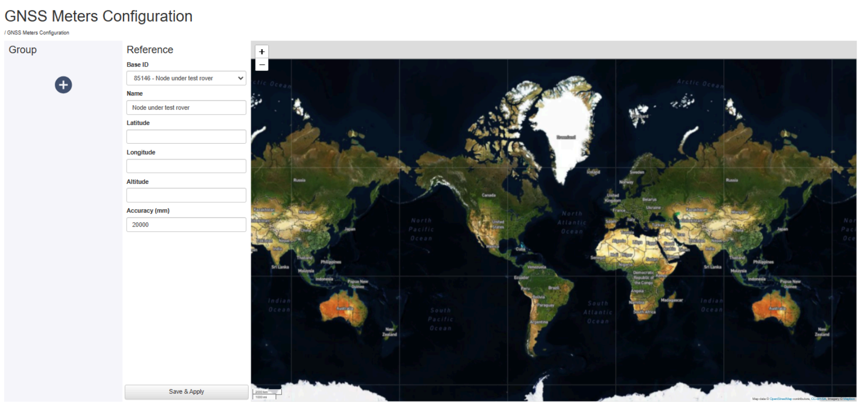
After deploying an Online configuration and having synchronized data with Edge through the Sync Edge WS App feature, groups created (base + rovers) will be shown on the GNSS Meters configuration panel.

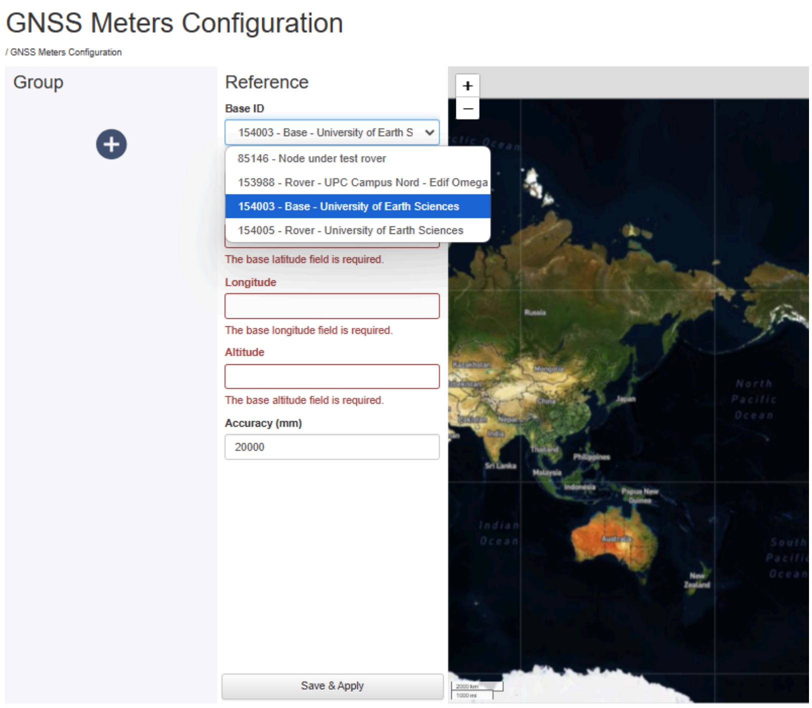
For an Offline configuration or for those Online configuration where synchronization through the Sync Edge WS App has not been done, no group will be created on the GNSS Meter configuration panel.

For these last cases, after connecting the nodes on the CMT, we recommend creating groups on the GNSS Meters configuration following the hierarchy from the onsite configuration. In any case, the system will work without the need of configuring it through the CMT.

By clicking the (+) add button under the "Group" the user will create a group, selecting a GNSS node to be the Base. The ID of the group will be the same as the GNSS Node Id that acts as the Base.


CMT Edge
Networks
Status
Configuration
GNSS Meters Configuration
/ GNSS Meters Configuration
Group
All rights reserved. Worldsensing © 2024
Version 2.10.0


GNSS Meters Configuration
Group
Reference
Base ID
85146 - Node under test rover
Name
Node under test rover
Latitude
Longitude
Altitude
Accuracy (mm)
20000
Save & Apply


GNSS Meters Configuration
/ GNSS Meters Configuration
Group
Reference
Base ID
154003 - Base - University of Earth S
85146 - Node under test rover
153988 - Rover - UPC Campus Nord - Edif Omega
154003 - Base - University of Earth Sciences
154005 - Rover - University of Earth Sciences
The base latitude field is required.
Longitude
The base longitude field is required.
Altitude
The base altitude field is required.
Accuracy (mm)
20000
Save & Apply

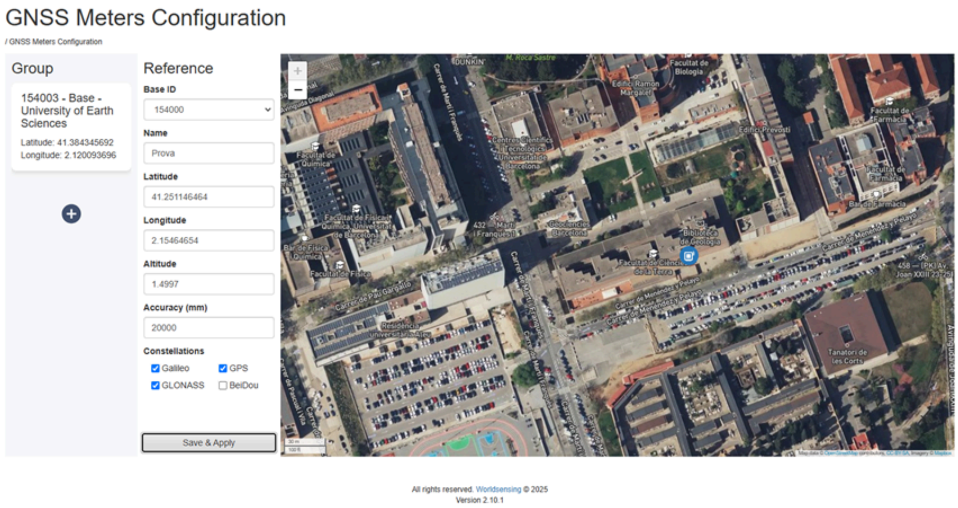
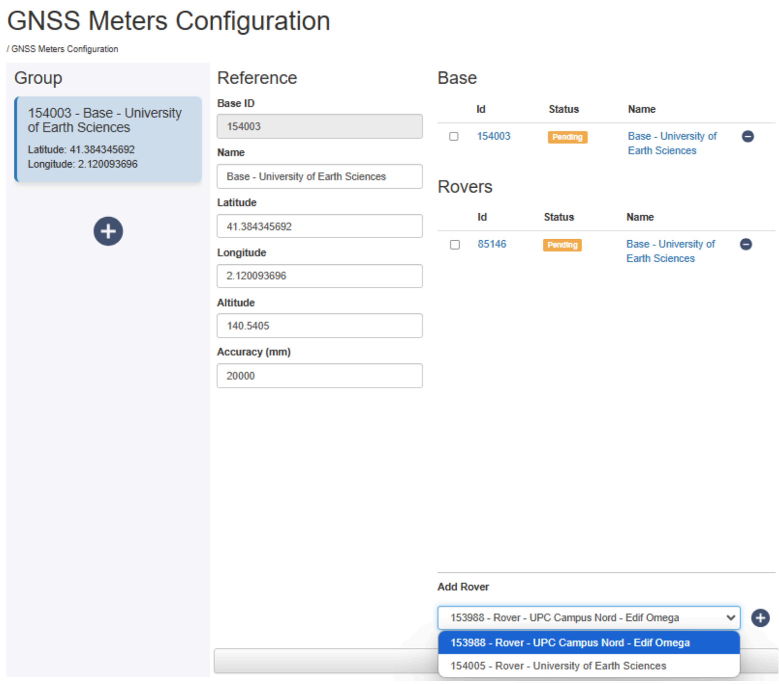


Figure 21: Creating a group on the GNSS Meters Configuration.

Reference must be selected and coordinates from the base must be typed. After that, the reference will be created and positioned on the map. The status of the Base will appear as pending until it has been applied on the next radio cycle.

The user can add all the rovers from the group through the menu. A list showing all the nodes available on the Network will be displayed.



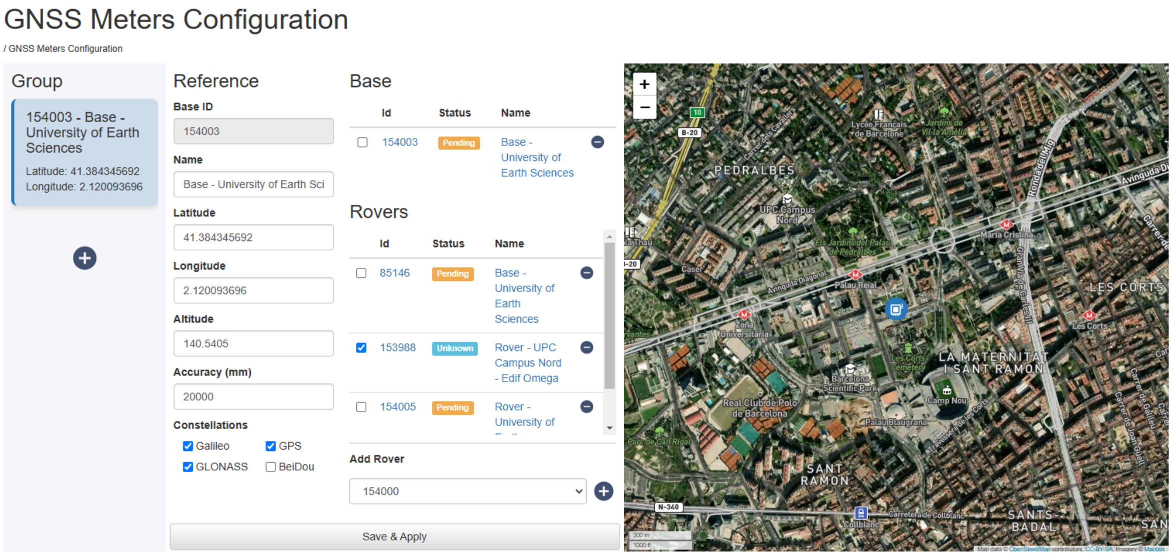


Figure 22: Adding a rover on a group on the GNSS Meters Configuration.

Node status label

The Status from the node will provide important information regarding the actions that have been taken on it. There are different Status that the GNSS node can have:

Table 4: GNSS Status Colours and meaning on GNSS Meters Configuration.

Status	Description
Unknown	Node connected with unknown configuration. Basically an intermediate status before actually saving and applying the configuration.
Mismatch	A node which has a different configuration from other GNSS nodes in its group.
Pending	Configuration from node is pending to be applied and matches with the base configuration. The configuration will be scheduled to be sent to the node in the next opportunity window.
Applied	Configuration from node has been applied and matches with the base configuration

Causes for mismatch status

Mismach Status could be due to different causes:

- If a node is re-configured via mobile app and, for some reason, any of the common parameters differs from the other GNSS nodes in that group (i.e if base base position has been resigned, different warm up time configuration). When syncing this node with the GW, the CMT Edge will show that there is a difference among the nodes in the group.
- If, after changing any parameter in the GNSS Meters configuration in the CMT Edge, the user does not apply it to all the nodes in the GNSS Group.

For offline deployments, as synchronization with Edge will not be possible, the Status from the nodes will be Unknown until the next radio cycle.

Please note that nodes removed from GNSS Meter configuration groups but connected to the CMT will keep reporting data even though they do not belong to any group, as they are only removed virtually from the tool.

15.4. Switching operational mode from a node (Rover/Base) and relocating a base

There could be the case that a node that has been assigned as a Rover needs to be switched into a Base due to the fact that communication between it and the other nodes is better. After checking that the node is in a stable position through other precise techniques, the user could reassign it through the GNSS Meters configuration Menu.

In this case the base should be erased through the (-) button. When this action is done, all the Group will be deleted.

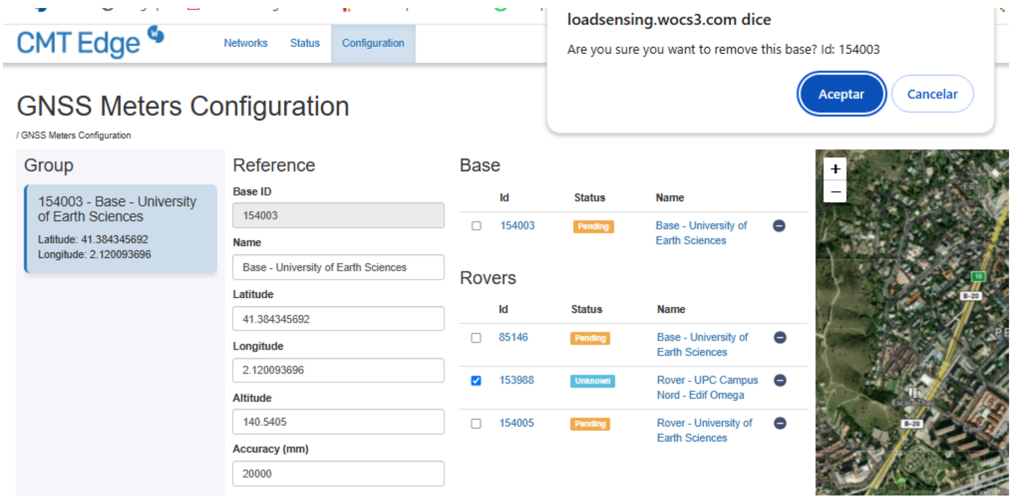


Figure 23: Erasing a GNSS meter rover from the GNSS Meters Configuration.

And the user will need to add all the Rovers again. Configuration from nodes will be pending to be applied and will be scheduled to be sent to the node in the next opportunity window.

If a Rover is converted to a Base or the other way around, the statistics CSV file will rotate and a new csv file will be created.

As mentioned in the previous chapter, we strongly recommend checking the position from the base with any other precise technique periodically to ensure its position. If the base station experiences a movement, the user must access the Reference coordinates and modify them accordingly.

This can have significant effects on the position calculated by the rover.

Please note that there are no specific logs for this Menu. Additional logs can be found on the Logs Menu.

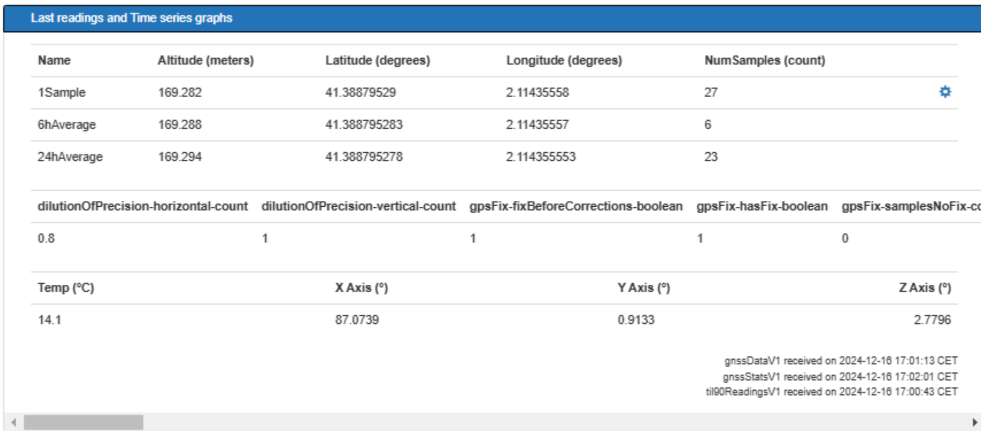
15.5. Logs

Logs now allows tracking down whether a node has been configured with a specific configuration.

This information will also appear when the configuration has been done through the WS App if the Sync with Edge feature has been selected.

15.6. Engineering units

It is possible to obtain engineering units through the Last reading and Time series graphs menu, by clicking on the right wheel.


Last readings and Time series graphs

Name	Altitude (meters)	Latitude (degrees)	Longitude (degrees)	NumSamples (count)
1Sample	169.282	41.38879529	2.11435558	27
6hAverage	169.288	41.388795283	2.11435557	6
24hAverage	169.294	41.388795278	2.114355553	23

dilutionOfPrecision-horizontal-count	dilutionOfPrecision-vertical-count	gpsFix-fixBeforeCorrections-boolean	gpsFix-hasFix-boolean	gpsFix-samplesNoFix-cc
0.8	1	1	1	0

Temp (°C)	X Axis (°)	Y Axis (°)	Z Axis (°)
14.1	87.0739	0.9133	2.7796

gnssDataV1 received on 2024-12-16 17:01:13 CET
gnssStatsV1 received on 2024-12-16 17:02:01 CET
til90ReadingsV1 received on 2024-12-16 17:00:43 CET

Figure 24: Engineering units configuration is accessible through the right wheel.

15.6.1. Haversine formula

For the GNSS node, the Haversine formula has been implemented to calculate the great-circle distance (absolute horizontal displacement) from the initial position, based on the longitude and latitude of the two points on a sphere.

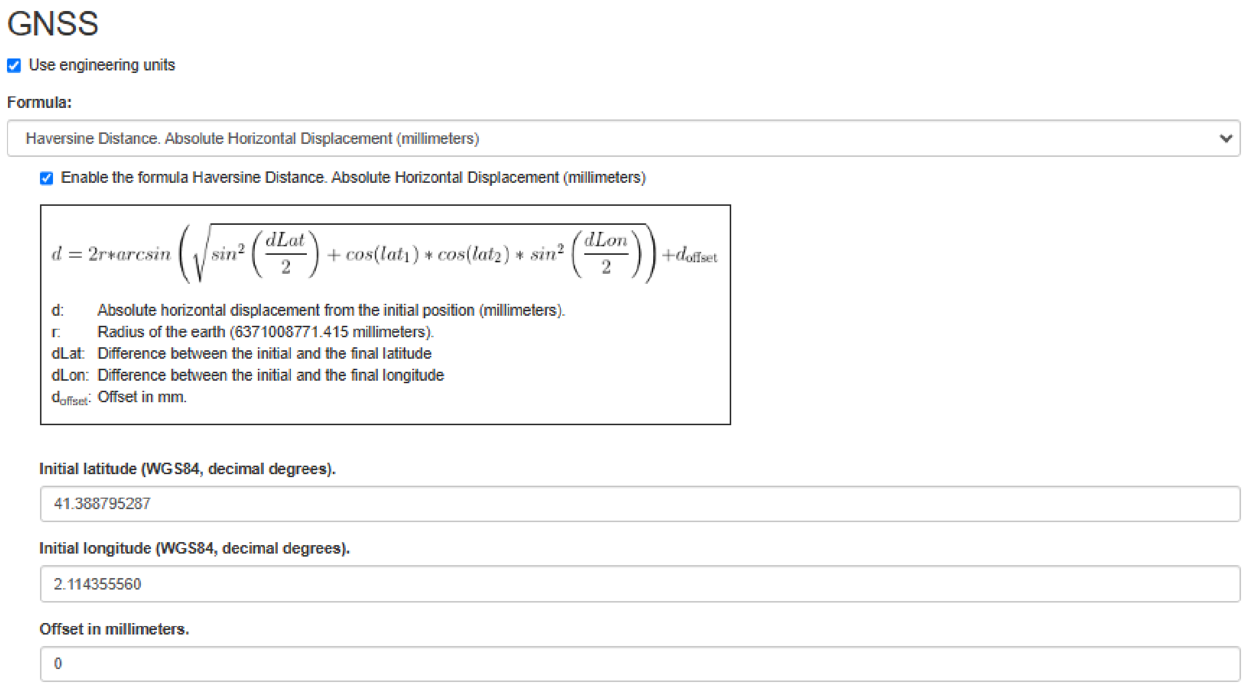


Figure 25: Haversine Formula from Engineering units configuration is accessible through the right wheel.

15.6.2. East-West and North-South Displacements

Displacement calculations in the North-South (N/S) and East-West (E/W) directions can also be performed. For these displacement calculations, we have implemented the formula described in Section "4.1.3 Geographic/Topocentric Conversions" from the 'IOGP Report 373-07-02 (EPSG Guidance Note 7-2)– Coordinate conversions and transformation including formulas'. Specifically, we use version: Guidance Note 7-2 (ver 70, December 2024).

In our case, the ellipsoidal coordinates of the topocentric origin correspond to the ellipsoidal coordinates (WGS84 coordinates, see Section 10 of this User Guide for more information about coordinate systems) of the GNSS Meter Rover's initial position.

We create a topocentric coordinate system with its origin at the Rover's initial position and mutually perpendicular axes U, V, and W. The U-axis is oriented locally east, the V-axis is oriented locally north, and the W-axis is up, forming a right-handed coordinate system.

Thus, we obtain the U (East-West) and V (North-South) coordinates of the successive positions measured by the Rover relative to its initial position. These U and V coordinates correspond to the displacements measured in the E-W and N-S directions, respectively.

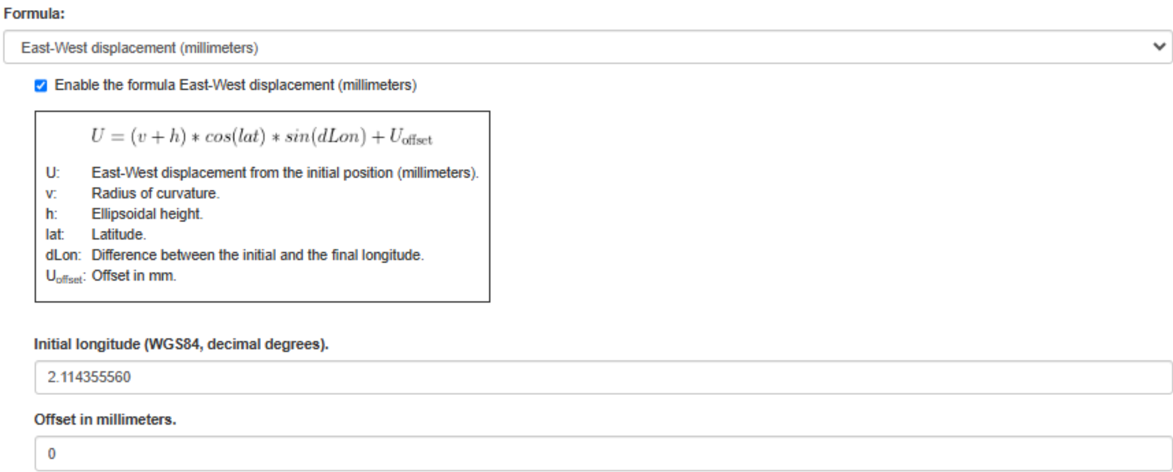


Figure 26. East-West displacement formula from Engineering units configuration.

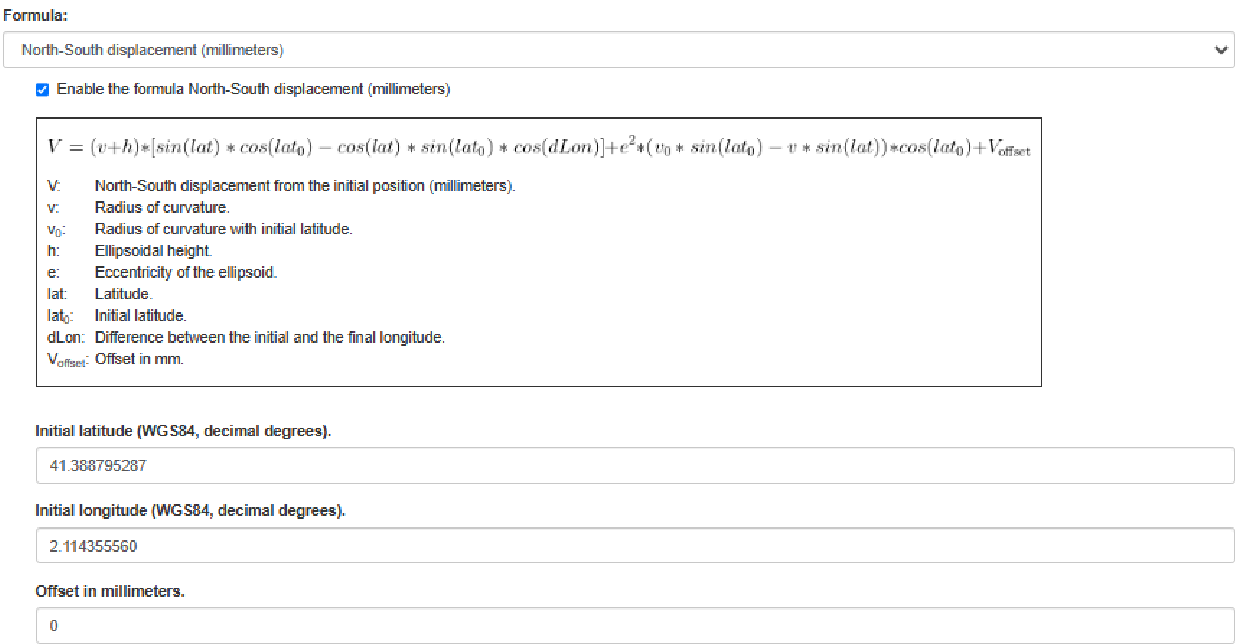


Figure 27. North-South displacement formula from Engineering units configuration.

Where

v is the radius of curvature in the prime vertical at latitude ‘lat’, where $v = a/(1 - e^2\sin^2(lat))^{0.5}$

v_0 is the radius of curvature in the prime vertical at latitude ‘lat_0’, where $v_0 = a/(1 - e^2\sin^2(lat_0))^{0.5}$

e is the eccentricity of the ellipsoid where $e^2 = (a^2 - b^2)/a^2 = 2f - f^2$

The WGS 84 ellipsoid parameters are:

a = 6378 137.0 m

1/f = 298.257223563

15.6.3. Sign Criteria

The following sign criteria has taken into account:

East	+
North	+
Harversine distance	Always +
Heave	+

Table 5. Sign criteria for GNSS data

15.6.4. Ellipsoidal Height

Please note that on the above formulae we are referring to h as the Ellipsoidal height. Do not mix this parameter with the Geoid Height (N) which is the difference of the vertical distance between the reference geoid and the ellipsoid, which may sometimes be referred to as the elevation at Mean Sea Level (MSL). Orthometric height is referred to the elevation above/below sea level.

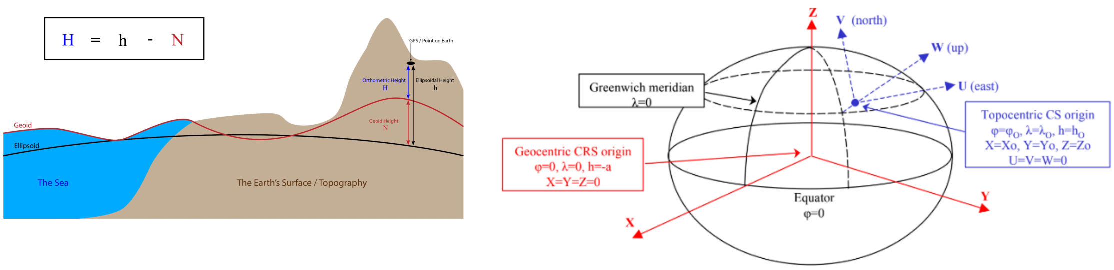


Figure 28. Ellipsoidal height and geocentric and topocentric representations[4] [3]

If the user wants to use data from the Loadsensing GNSS system to fill in the formulae, altitude can be considered as Ellipsoidal height.

[4] Source: The Difference Between Ellipsoidal, Geoid, and Orthometric Elevations? by Virtual Surveyor

The ellipsoidal coordinates of the topocentric origin correspond to the ellipsoidal coordinates (WGS84 coordinates) of the GNSS Meter's initial position.

See section 10 for considerations on Base position and the Coordinate System

15.6.5. Vertical Displacement

For the calculation of vertical displacement, a simple formula that subtracts the initial ellipsoidal height from the ellipsoidal height of the current measurement is used.

Figure 29. Vertical displacement formula from Engineering units configuration.

The CSV file is prepared for all formulas to be configured simultaneously, so all columns are always present.

When configuring the engineering units, the 1h sample and the 6 h and the 24 h aggregates will be shown.

Last readings and Time series graphs

Name	Altitude (meters)	Latitude (degrees)	Longitude (degrees)	NumSamples (count)	AbsoluteHorizontalDisplacement (mm)	EastWestDisplacement (
1Sample	169.288	41.388795293	2.114355605	24	3.81	3.76
6hAverage	169.289	41.388795245	2.114355582	6	5.02	1.84
24hAverage	169.291	41.388795268	2.114355575	24	2.46	1.25

dilutionOfPrecision-horizontal-count	dilutionOfPrecision-vertical-count	gpsFix-fixBeforeCorrections-boolean	gpsFix-hasFix-boolean	gpsFix-samplesNoFix-co
0.7	1	1	1	0

Temp (°C)	X Axis (°)	Y Axis (°)	Z Axis (°)
15.0	87.0714	0.9297	2.7768

gnssDataV1 received on 2024-12-17 10:01:10 CET
gnssStatsV1 received on 2024-12-17 10:01:51 CET
til90ReadingsV1 received on 2024-12-17 10:00:43 CET

Figure 30. Last readings and Time series graphs.

15.7. Data integration

Data integration can be configured in CMT for FTP protocol and/or API Calls or MQTT protocol. Please note that integration through Modbus TCP is not available for the GNSS except for the Tiltmeter data, which is supported given that the memory map is the same as the TIL90X.

For more information, please refer to the specific CMT guides.

New specific paths for the GNSS have been added at the bottom of the FTP configuration menu: LSG7GNS-SXLH data, LSG7GNS-SXLH statistics and LSG7GNS-SXLH tiltmeter data (Figure 25).

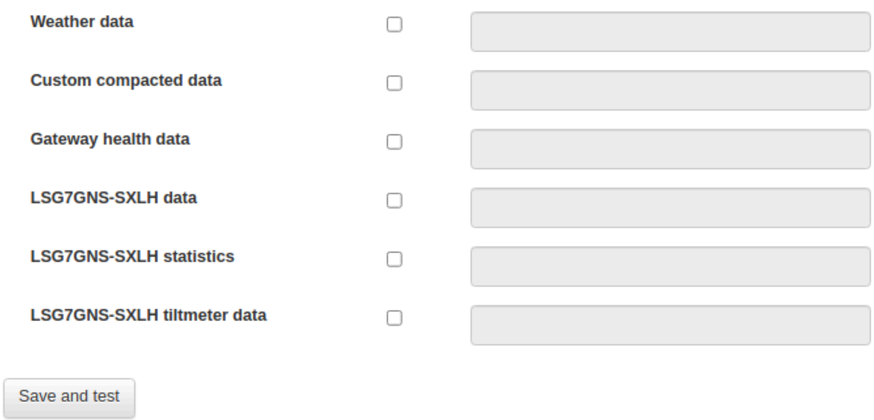


Figure 31: Specific paths on the FTP integration for the VM.

Custom Compacted files are only available for data reading messages.

Please take into consideration that MQTT option is a service that needs to be enabled by support@wordsensing.com.

16. Maintenance

The node LSG7GNS-SXLH is packaged in a rugged aluminum alloy, and should provide many years of trouble-free operation.

Wireless sensors like the GNSS meter require no maintenance other than normal cleaning, battery replacement and inspection of the seals. Apart from this maintenance, the devices are not field serviceable.

The wireless GNSS Meter LSG7GNS-SXLH is a precision instrument. Minor external actions or misactions during the installation, can cause bad readings. Visual inspections can help to understand the cause of some registered movements.

It is important to avoid any impact to protect the internal sensors and to avoid distorting the mechanics of the device, as the reliability of the wireless GNSS Meter can be affected by impacts, high vibration levels or Water ingress. The wireless node should never be submerged in water. WATER DAMAGE TO INTERNAL COMPONENTS VOIDS THE WARRANTY.

In case of doubt regarding the reliability of the readings, first inspect the wireless node mounting and the structure where it is attached. Any compromise to or mechanical deformation of the mounting hardware can cause unstable readings.

After ruling out issues related to the structure or the mounting hardware, we recommend installing the device on a known stable place and compare data with a known reference unit. If the results of the wireless GNSS Meter lead you to think that the unit is not working as expected, please open a ticket to support@worldsensing.com in our Help Center to request a Return Material Authorization (RMA).

After receiving the device, Worldsensing will inspect the mechanical parts, reassemble and check the device. If this occurs after expiration of the warranty, Worldsensing will repair the equipment at its factory and may require additional charges for parts and labor charges. Worldsensing will provide a quote for repairs, if feasible, for products returned after warranty expiration.

Worldsensing is not liable for damages or erroneous decisions caused by defective units, since it is only responsible for the warranty of the equipment.

17. Battery Life Estimatations

Battery consumption varies depending on the type of operation mode (Base/Rover) and environmental and wireless network conditions. For the GNSS, also the warm up time will impact on consumption.

SF9@14dBm			
Warm up time	**10 s**	**20 s**	**30 s**
Base	2,1 years	1,8 years	1,6 years
Rover	2,6 years	2.2 years	1,9 years

Table 6. Battery life estimations using recommended Saft batteries LSH20. Calculations assuming GNSS clear sky visibility default base configuration with a maximum time of 2 minutes to test the radio link between base and rover and 1 hour reporting period. Base and Rover communicate through SF7. Receiver offset enabled

According to WS simulations, radio communication conditions between nodes and GW have a very low impact on battery lifespan, so the above table could be also valid for FCC radio intermediate conditions (SF8@20dBm).

The table below shows average consumptions by using same radio conditions (SF9@14dBm) for a 10 seconds warm up time according to different temperature profiles.

SF9@14dBm			
Warm up time=10s	**Singapore**	**Barcelona**	**Moscow**
Base	2	2,2	2,2
Rover	2,4	2,6	2,7

Table 7. Battery life estimations using recommended Saft batteries LSH20 according to different temperature profiles.

18. Data storage

The node stores the event information in the local memory. In the unlikely case where the connectivity is lost or if the GW is down, the data will be always stored and can be locally retrieved. For downloading data through the WS App, please refer to the WSApp user manual.

19. Environmental best practices

19.1. Installation and operation

Please install Worldsensing products in an energy-efficient manner by minimizing power usage for computers, mobile phones or other devices needed for setup and configuration. Minimize the use of small components needed for installation, like mounting brackets and other connection materials. Avoid using toxic materials and/or hazardous substances.

- Remove the batteries if you are not using the node.
- For nodes with switch, use the usb mode when not in operation.

19.2. Return Material Authorization (RMA)

In the event of requesting a Return Material Authorization (RMA) please make sure to use the most environmentally friendly mode of transportation possible.

19.3. Product End of Life and disposal

Please take the necessary measures to extend the life of the product and reuse it when possible.

Once the product reaches its end of life (EoL) recycling is crucial to divert material from waste streams into new applications.

Electrical and electronic devices, and batteries must be recycled according to the European Union WEEE Directive 2012/19/EU.

Please separate batteries from equipment.

This product and the batteries it may contain should not be discarded as unsorted waste. Please send them to separate collection facilities for recovery and recycling.

19.4. Product packaging

Worldsensing's product packaging is recyclable. Separate the different materials for a correct waste management.

19.5. Safety and emergency procedures

Please read the safety sheet that comes with our products before installing them. For safety information on batteries and other materials, as well as instructions in case of emergency please read the safety information available at: https://info.worldsensing.com/safety-information/

In the case of an emergency and after it has been managed, please evaluate the waste generated in order to dispose of it in accordance with current legislation and local regulation.

It is your responsibility to dispose of your waste equipment, batteries and packaging properly to help prevent potential negative consequences for the environment and human health.

The cost of environmental waste management is included in the battery's selling price.

By following these best practices you can help protect the environment. Thank you for your cooperation.

20. FAQ'S

Which is the configurable reporting period on the GNSS node?

The GNSS Meter configured as a Rover turns on once per hour (as the reporting period is hard-coded to 1 h and not configurable through the App), receives the corrections sent by the base, performs the RTK calculations, and obtains a set of RTK fix positions.The coordinates of the position measured each hour will be sent along with the coordinates of the position resulting from aggregating the measurements of the previous 6 hours, and along with the coordinates of the position resulting from aggregating the measurements of the previous 24 hours.

How is this high precision achieved ?

The precision achieved will depend on the distance from the base and the rover and also on the aggregation. The precision is presented by using the 50 th and the 95 th percentile in the datasheet.

As measurements are being aggregated with those taken previously to send the 6-hour and 24-hour aggregates, if for a certain hour corrections are not "good enough " the results are attenuated with the aggregates of the different hours.

What is GNSS warmup time? is this parameter affecting to the precision and power consumption?

The warmup is the time during which the GNSS Meter is active before starting to receive/send corrections.

Configurations of 10 seconds, 20 and 30 seconds are available through the WS App and the CMT. The last two options are appropiate for scenarios where it is more difficult to achieve fix conditions, such as installations with more limited sky visibility, fewer satellites, etc. In favorable conditions, 10 seconds is sufficient, and we haven't seen improvements by increasing the warmup time.

The higher is the warm up time, the highest will be the node consumption. Estimations of battery life using different warm up time are included in the datasheet.

Is there any communication limitation between the base and the rovers?

Rover and base require SF 7 for radio communication in order to grant that corrections are arriving. In order to achieve this we recommend to have line of sight between both (this can also be achieved/improved by using any of our LoRa antenna extensions). Communication between base/rovers and the Gateway works according to the configured radio.

For correct base operation it is important to separate the GNSS from the LoRa radio antenna at least 1 meter. This action is possible by using the antenna cable extension that WS offers.

Which is the reporting format used for coordinates?

The coordinates output is based on WGS84 system and there is no option to covert them to local/project.

Several formulae are available on the CMT that allow the calculation of distance between two points (by using the Haversine formula), East/West, North/South, and vertical displacements from an initial position.

21. Troubleshooting guide

In this chapter we are providing some guidance for the users to identify data patterns that may help understanding why RTK fix solution is not achieved or even how to improve precision on the results.

If there is **no RTK fix solution**, data from Altitude, Latitude and Longitude will be blank.

Name	Altitude (meters)	Latitude (degrees)	Longitude (degrees)	NumSamples (count)
1Sample				0
6hAverage				0
24hAverage	118.634	48.711482018	2.254563733	4

Causes of this lack of RTK Fix could be the following:

- There is no enough sky visibility
- There is no good radio communication between Base and Rover
- There is a mismatch between GNSS Base and Rovers parameters configuration.

The **main parameters** to identify it and the expected value to obtain a fix are the following:

Parameter	Expected value	Actions for improvements
Satellites in use *"satellites-inUse-count-a:00:00:03"*	>= 18	Check chapter 10
Number of corrections applied "corrections-numCorrectionsApplied-count -a:00:00:04"	Should be close to the duration of the sample (30 by default)	1. Check chapter 10 2. Compare results between base and rover. If base results are higher, deploy a GNSS corrections coverage test and improve radio communication
Corrections per sample *"corrections-numPerSample-count-a:00:00:04"*	Up to 120 packets are being sent (During 30 seconds corrections are applied, sending 4 packages/sec).	3. Check chapter 10 4. Compare results between base and rover. If base results are higher, deploy a GNSS corrections coverage test and improve radio communication
Average corrections length *"corrections-avgCorrectionLength-count-a:00:00:04"*	> 400 bytes	1. Check chapter 10 2. Compare results between base and rover and deploy a GNSS corrections coverage test 3. This parameter saturates at 600 bytes. If it happens, disable some constellation
Corrections unexpected packets *"corrections-unexpectedPackets-count-a:00:00:04"*	Should be close to 0 (maximum value would be 63 and means that is saturated).	Reconfigure the Base and Rovers using the WS App and check that: • Rover has the correct base asigned • There are no mismatches

Parameter	Expected value	Actions for improvements
		• Base assignation is correct
corrections-timeToFirst *"corrections-timeToFirst-seconds-a:00:00:04"*	around 10 seconds. Could be higher if the gps fix takes more time.	1. Check chapter 10 2. Check time to fix 3. Increase gradually the warm up time from the CMT
RTK time to fix "RTK-timeToFix-seconds-a:00:00:06"	In ideal conditions could be around 14, but it could vary. If the value is 0 means that there is no fix	1. Check chapter 10 2. Increase gradually the warm up time from the CMT
GNSS signal quality (CN/0) of the different bands	Excellent > 45 35<Fine <45 Not good < 35 Referred to the average of the maximum for each second.	Check chapter 10

Appendix A. Definition of fields for the data files.

There are two different formats outputting the system: CSV and JSON.

CSV formatted files

The GNSS node incorporates a new structure called Universal format which will be adopted for the G7 generation of nodes. This structure aims to standardize file names, messages, file structure and parameters read for both architectures (Edge and Cloud).

21.1.1. CSV Filename

Will follow the following format:
$nodeid-$model-$version-[readings|health|stats]-$readingtype[GNS|TIL|VIB]-[current|$date].csv

a. $version refers to format version and is a numeric starting from 1

b. $date with format yyyy_MM_dd_HH_mm_ss, where:

  i. yyyy: year with 4 numbers

  ii. MM: month, 01 to 12 (2-digit)

  iii. dd: day of the month, 01 to 31

  iv. HH: hour of the day, 24h format, 00 to 23

  v. mm: minute, 00 to 59 (2-digit)

vi. ss: second, 00 to 59 (2-digit)

c. $model refers to the model (Without dashes) LSG7ACLBILHVIB

d. $readingtype type of reading. For the GNSS would be as follow (current will be replaced by the date when the month has been closed):

153965-LSG7GNSSXLH-1-readings-GNS-current.csv

153965-LSG7GNSSXLH-1-stats-GNS-current.csv

153965-LSG7GNSSXLH-1-readings-TIL-current.csv

153965-LSG7GNSSXLH-1-health-current.csv

21.1.2. CSV structure

- It will no longer have metadata (Model ID, GW ID, firmware, etc…….). There will be no initial rows apart from the actual header, which will be the name of each datapoint).
- Timezone information has been added as a column after the datetime (matches with the one configured on the CMT Edge).
- All datapoint names are now a concatenation of the [source]-[datapoint name]-[unit]-[address] from the JSON.
- The ordering will be according to the source's address and then alphabetically by the datapoint name. For example, in the GNSS the order is

1. 1Sample-altitude,
2. 1Sample-latitude,
3. 1Sample-longitude,
4. 1Sample-numSamples,
5. 6h-altitude,…

While specific GNSS files (readings and Statistics) have the G7 structure, tiltmeter csv file still has the G6 famlily structure and will be readapted once the G7 tiltmeter family has been launched.

Health files do incorporate humidity parameters for the G7 nodes, but still have the G6 structure for the CMT Edge 2.10.0

21.1.3. Readings fields

Example for ID: 154005

Download a file template here.

Source Address	Datapoint	Description	Units	Range	Precision
	Date-and-time	Time Stamp of Reading collection.	YYYY-MM-DD hh:mm:ss"	N/A	N/A
	Timezone	Time zone expressed in UTC	UTC+XX	N/A	N/A
1Sample-a:00:00:00	altitude	Altitude referred to the ellipsoidal height	meters	-1000.0000 to 5710.8863	4 decimal places
	latitude	Latitude in WGS84	Decimal degrees	±90°	9 decimal places
	longitude	Longitude in WGS84	Decimal degrees	±180°	9 decimal places
	numSamples	Number of values used to compute the 1h sample.	counts	0-63	N/A
6hAverage-a:00:01:00	altitude	Average altitude referred to the ellipsoidal height computing 6 h data,	meters	-1000.0000 to 5710.8863	4 decimal places
	latitude	Average latitude in WGS84 referred to the ellipsoidal height computing 6 h data,	Decimal degrees	±90°	decimal places
	longitude	Average longitude in WGS84 referred to the ellipsoidal height computing 6 h data,	Decimal degrees	±180°	decimal places

Source Address	Datapoint	Description	Units	Range	Precision
	numSamples	Number of samples (1h samples) with data used to calculate the average	counts	0-6	I/A
24hAverage-a:00:02:00	altitude	Altitude referred to the ellipsoidal height computing 24 h data	meters	-1000.0000 to 5710.8863	decimal places
	latitude	Average latitude in WGS84 referred to the ellipsoidal height computing 24 h data,	Decimal degrees	±90°	decimal places
	longitude	Average longitude in WGS84 referred to the ellipsoidal height computing 24 h data,	Decimal degrees	±180°	decimal places
	numSamples	Number of samples (1h samples) with data used to calculate the average	counts	0-24	I/A
Engineering Units					
1SampleAbsoluteHorizontalDisplacement--millimeters-c:00:00:00		Absolute horizontal displacement from the initial position by using Haversine formula	millimeters	-	2 decimal places
1SampleEastWestDisplacement--millimeters-c:00:00:01		East-West displacement from the initial position	millimeters	-	2 decimal places
1SampleNorthSouthDisplacement--millimeters-c:00:00:02		North-South displacement from the initial position	millimeters	-	2 decimal places
1SampleVerticalDisplacement--millimeters-c:00:00:03		Vertical displacement from the initial position	millimeters		2 decimal places

Source Address	Datapoint	Description	Units	Range	Precision
6hAverageAbsoluteHorizontalDisplacement--millimeters-c:00:00:04		Absolute horizontal displacement from the initial position by using Haversine formula	millimeters		2 decimal places
6hAverageEastWestDisplacement--millimeters-c:00:00:05		East-West displacement from the initial position	millimeters		2 decimal places
6hAverageNorthSouthDisplacement--millimeters-c:00:00:06		North-South displacement from the initial position	millimeters		2 decimal places
6hAverageVerticalDisplacement--millimeters-c:00:00:07		Vertical displacement from the initial position	millimeters		2 decimal places
24hAverageAbsoluteHorizontalDisplacement--millimeters-c:00:00:08		Absolute horizontal displacement from the initial position by using Haversine formula	millimeters		2 decimal places
24hAverageEastWestDisplacement--millimeters-c:00:00:09		East-West displacement from the initial position	millimeters		2 decimal places
24hAverageNorthSouthDisplacement--millimeters-c:00:00:10		North-South displacement from the initial position	millimeters		2 decimal places
24hAverageVerticalDisplacement--millimeters-c:00:00:11		Vertical displacement from the initial position	millimeters		2 decimal places

21.1.4. Statistics file fields

Example for ID: 154005

Download a file template here

Source Address	Datapoint	Description	Units	Range	Precision
Date-and-time		Time Stamp of Reading collection. "YYYY-MM-DD hh:mm:ss"	"YYYY-MM-DD hh:mm:ss"	N/A	N/A
Timezone		Time zone expressed in UTC	UTC+XX	N/A	N/A
dilutionOfPrecision-a:00:00:00	horizontal	Average Horizontal Dilution of Precision (while in corrections state)	count	0.0 to 25.5	1 decimal place
	vertical	Vertical Dilution of Precision	count	0.0 to 25.5	1 decimal place
gpsFix-a:00:00:01	fixBeforeCorrections	False if It couldn't get fix before corrections	boolean	1 or 0	No decimal
	hasFix	True (1) If has fix	boolean	1 or 0	No decimal
	samplesNoFix	Number of times it didn't have fix during sending/receiving corrections (counted 1 per second)	count	TBD	TBD
	timeToFix	Average time to get GPS fix. Max value if you cannot get it (there is an error flag) or if it overflows.	seconds	TBD	TBD

Source Address	Datapoint	Description	Units	Range	Precision
time-a:00:00:02	deviation	Deviation found when got GPS pulse per second	seconds	0..4095 Sent with offset +2.047 to -2.048 (it can be saturated)	3 decimal places
	updated	Error (1) if it couldn't update the date and time	boolean	1 or 0	No decimal
satellites-a:00:00:03	inUse	Average of Number of satellites in use (while in corrections state)	count	0..63 Probably the max is 32	TBD
	inView	Average of Number of satellites in view (while the GNSS is on)	count	TBD	TBD
corrections-a:00:00:04	avgCorrectionLength	Average length of the corrections sent/received.	count	TBD	TBD
	numCorrectionsApplied	Number of seconds where corrections have been applied.	count	TBD	TBD
	numPerSample	correction messages sent or received per sample.	count	TBD	TBD
	timeToFirst	Time the node takes for sending/receiving 1st correction	seconds	TBD	TBD
	unexpectedPackets	Radio corrections received that where rejected due to either signature or format issues.	count	TBD	TBD

Source Address	Datapoint	Description	Units	Range	Precision
correctionsRadioInfo-a:00:00:05	rssiAvg	Avgerage RSSI of received corrections	decibelMilliwatt	-30.0 to -120.0 dBm	
	rssiStdDev	Standard deviation RSSI of received corrections	count	TBD	No decimal
	snrAvg	Average SNR of received corrections	decibels	-20.0 to +20.0	1 decimal place
	snrStdDev	Standard deviation SNR of received corrections	count	0.0 to 25.5	1 decimal place
RTK-a:00:00:06	timeToFix	time that it took to get a RTK fix	seconds	TBD	TBD
PositionMAD1Sample-a:00:01:00	altitude	Altitude Median Absolute Deviation (MAD) from 1 sample	milimeters	TBD	TBD
	latLong	Latitude/Longitude Median Absolute Deviation (MAD) from 1 sample	milimeters	TBD	TBD
PositionMAD6hAverage-a:00:02:00	altitude	Altitude Median Absolute Deviation (MAD) from 6 samples	milimeters	TBD	TBD
	latLong	Latitude/Longitude Median Absolute Deviation (MAD) from 6 samples	milimeters	TBD	TBD
PositionMAD24hAverage-a:00:03:00	altitude	Altitude Median Absolute Deviation (MAD) from 24 samples	milimeters	TBD	TBD
	latLong	Latitude/Longitude Median Absolute	milimeters	TBD	TBD

Source Address	Datapoint	Description	Units	Range	Precision
		Deviation (MAD) from 24 samples			
a:00:04:00	L1	Carrier to Noise Density Ratio average of the maximum value from each second for the band	decibelHertz	TBD	TBD
a:00:04:01	L2	Carrier to Noise Density Ratio average of the maximum value from each second for the band.	decibelHertz	TBD	TBD
a:00:05:00	E1	Carrier to Noise Density Ratio average of the maximum value from each second for the band	decibelHertz	TBD	TBD
a:00:05:01	E5b	Carrier to Noise Density Ratio average of the maximum value from each second for the band	decibelHertz	TBD	TBD
a:00:06:00	G1	Carrier to Noise Density Ratio average of the maximum value from each second for the band	decibelHertz	TBD	TBD
a:00:06:01	G2	Carrier to Noise Density Ratio average of the maximum value from each second for the band	decibelHertz	TBD	TBD

Source Address	Datapoint	Description	Units	Range	Precision
a:00:07:00	B1	Carrier to Noise Density Ratio average of the maximum value from each second for the band	decibelHertz	TBD	TBD
a:00:07:01	B2	Carrier to Noise Density Ratio average of the maximum value from each second for the band	decibelHertz	TBD	TBD

21.1.5. Data files - JSON (MQTT ex-change format)

JSON files are text messages named gnssDataV1 and gnssStatsV1 that can be transferred through MQTT or API Calls with the following structure.

Following the same structure as the other MQTT integrations the JSON files are transferred via MQTT. An example with the filled fields can be found below:

gnssDataV1


```
{
  "measurements": [
    {
      "values": [
        {
          "name": "numSamples",
          "value": "26"
        }
      ],
      "unit": "count",
      "address": "a:00:00:00"
    },
    {
      "values": [
        {
          "name": "latitude",
          "value": "41.384163453"
        },
        {
          "name": "longitude",
          "value": "2.119317687"
        }
      ],
      "unit": "degrees",
      "address": "a:00:00:00"
    },
    {
      "values": [
        {
          "name": "altitude",
          "value": "140.4935"
        }
      ],
      "unit": "meters",
      "address": "a:00:00:00"
    },
    {
      "values": [
        {
          "name": "numSamples",
          "value": "5"
        }
      ],
      "unit": "count",
      "address": "a:00:01:00"
    },
    {
      "values": [
        {
          "name": "latitude",
```

gnssDataV1


```
                "value": "41.384163457"
            },
            {
                "name": "longitude",
                "value": "2.119317823"
            }
        ],
        "unit": "degrees",
        "address": "a:00:01:00"
    },
    {
        "values": [
            {
                "name": "altitude",
                "value": "140.494"
            }
        ],
        "unit": "meters",
        "address": "a:00:01:00"
    },
    {
        "values": [
            {
                "name": "numSamples",
                "value": "23"
            }
        ],
        "unit": "count",
        "address": "a:00:02:00"
    },
    {
        "values": [
            {
                "name": "latitude",
                "value": "41.384163467"
            },
            {
                "name": "longitude",
                "value": "2.119317767"
            }
        ],
        "unit": "degrees",
        "address": "a:00:02:00"
    },
    {
        "values": [
            {
                "name": "altitude",
                "value": "140.485"
            }
        ],
        "unit": "meters",
        "address": "a:00:02:00"
    },
    {
        "address": "c:00:00:00",
        "values": [
            {
                "value": "7.63"
            }
```

gnssDataV1


```
            ],
            "unit": "millimeters"
        },
        {
            "address": "c:00:00:01",
            "values": [
                {
                    "value": "-6.44"
                }
            ],
            "unit": "millimeters"
        },
        {
            "address": "c:00:00:02",
            "values": [
                {
                    "value": "-4.11"
                }
            ],
            "unit": "millimeters"
        },
        {
            "address": "c:00:00:03",
            "values": [
                {
                    "value": "10"
                }
            ],
            "unit": "millimeters"
        },
        {
            "address": "c:00:00:04",
            "values": [
                {
                    "value": "6.14"
                }
            ],
            "unit": "millimeters"
        },
        {
            "address": "c:00:00:05",
            "values": [
                {
                    "value": "4.94"
                }
            ],
            "unit": "millimeters"
        },
        {
            "address": "c:00:00:06",
            "values": [
                {
                    "value": "-3.67"
                }
            ],
            "unit": "millimeters"
        },
        {
            "address": "c:00:00:07",
            "values": [
```

gnssDataV1


```
            {
              "value": "10.5"
            }
          ],
          "unit": "millimeters"
        },
        {
          "address": "c:00:00:08",
          "values": [
            {
              "value": "2.57"
            }
          ],
          "unit": "millimeters"
        },
        {
          "address": "c:00:00:09",
          "values": [
            {
              "value": "0.25"
            }
          ],
          "unit": "millimeters"
        },
        {
          "address": "c:00:00:10",
          "values": [
            {
              "value": "-2.55"
            }
          ],
          "unit": "millimeters"
        },
        {
          "address": "c:00:00:11",
          "values": [
            {
              "value": "1.5"
            }
          ],
          "unit": "millimeters"
        }
      ],
      "datetime": "2024-12-20T14:00:00Z",
      "sources": [
        {
          "status": 0,
          "model": "GNSS",
          "manufacturer": "Worldsensing",
          "type": "1Sample",
          "address": "a:00:00:00"
        },
        {
          "status": 0,
          "model": "GNSS",
          "manufacturer": "Worldsensing",
          "type": "6hAverage",
          "address": "a:00:01:00"
        },
        {
```

gnssDataV1


```
        "status": 0,
        "model": "GNSS",
        "manufacturer": "Worldsensing",
        "type": "24hAverage",
        "address": "a:00:02:00"
    },
    {
        "status": 0,
        "address": "c:00:00:00",
        "name": "1SampleAbsoluteHorizontalDisplacement",
        "type": "Formula"
    },
    {
        "status": 0,
        "address": "c:00:00:01",
        "name": "1SampleEastWestDisplacement",
        "type": "Formula"
    },
    {
        "status": 0,
        "address": "c:00:00:02",
        "name": "1SampleNorthSouthDisplacement",
        "type": "Formula"
    },
    {
        "status": 0,
        "address": "c:00:00:03",
        "name": "1SampleVerticalDisplacement",
        "type": "Formula"
    },
    {
        "status": 0,
        "address": "c:00:00:04",
        "name": "6hAverageAbsoluteHorizontalDisplacement",
        "type": "Formula"
    },
    {
        "status": 0,
        "address": "c:00:00:05",
        "name": "6hAverageEastWestDisplacement",
        "type": "Formula"
    },
    {
        "status": 0,
        "address": "c:00:00:06",
        "name": "6hAverageNorthSouthDisplacement",
        "type": "Formula"
    },
    {
        "status": 0,
        "address": "c:00:00:07",
        "name": "6hAverageVerticalDisplacement",
        "type": "Formula"
    },
    {
        "status": 0,
        "address": "c:00:00:08",
        "name": "24hAverageAbsoluteHorizontalDisplacement",
        "type": "Formula"
    },
```

gnssDataV1


```
            {
                "status": 0,
                "address": "c:00:00:09",
                "name": "24hAverageEastWestDisplacement",
                "type": "Formula"
            },
            {
                "status": 0,
                "address": "c:00:00:10",
                "name": "24hAverageNorthSouthDisplacement",
                "type": "Formula"
            },
            {
                "status": 0,
                "address": "c:00:00:11",
                "name": "24hAverageVerticalDisplacement",
                "type": "Formula"
            }
        ],
        "device": {
            "model": "LSG7GNS-SXLH",
            "_id": "154005",
            "publicId": "154005",
            "details": {
                "type": "ROVER"
            }
        },
        "message": {
            "trigger": "SCHEDULED",
            "type": "MEASUREMENTS",
            "version": "1.0.0",
            "metadata": {
                "frameNumber": 1,
                "AMType": 85,
                "endOfData": true,
                "totalFrames": 1,
                "multipart": false,
                "AMTypeSubversion": 0
            }
        },
        "networkInformation": {
            "gatewayIds": [
                {
                    "id": "759"
                }
            ],
            "firstReceptionTimestamp": "2024-12-20T14:01:08Z",
            "radio": {
                "linkQuality": -94,
                "frequency": 868.1,
                "snr": 13,
                "sf": 9
            },
            "sequenceCounter": [
                5
            ],
            "device": {
                "loraAddress": "154005",
                "macType": "ETSIV1"
            },
```

gnssDataV1

"message": {
"type": "radio",
"technology": "LoRa"
},
"id": "724"
}
}

Table 15.

When it is not possible to obtain a RTK fix, a "No readings in RTK fix" error will be present on the JSON message and Latitude, Longitude and Altitude on the gnss DataV1 will appear as 0.

Given that the measurements are not valid, engineering units will not be calculated and a "No value calculated because there is no corresponding reading in RTK fix" will also appear.

gnssDataV1


```
{
  "errors": [
    {
      "subCode": 0,
      "code": 2,
      "description": "No readings in RTK fix",
      "address": "a:00:00:00"
    },
    {
      "subCode": 0,
      "code": 2,
      "description": "No readings in RTK fix",
      "address": "a:00:01:00"
    },
    {
      "subCode": 0,
      "code": 2,
      "description": "No readings in RTK fix",
      "address": "a:00:02:00"
    },
    {
      "address": "c:00:00:00",
      "code": 0,
      "subcode": 0,
      "description": "No value calculated because there is no corresponding reading in RTK fix"
    },
    {
      "address": "c:00:00:03",
      "code": 0,
      "subcode": 0,
      "description": "No value calculated because there is no corresponding reading in RTK fix"
    },
    {
      "address": "c:00:00:04",
      "code": 0,
      "subcode": 0,
      "description": "No value calculated because there is no corresponding reading in RTK fix"
    },
    {
      "address": "c:00:00:07",
      "code": 0,
      "subcode": 0,
      "description": "No value calculated because there is no corresponding reading in RTK fix"
    },
    {
      "address": "c:00:00:08",
      "code": 0,
      "subcode": 0,
```

gnssDataV1


```
            "description": "No value calculated because there is no corresponding reading in RTK fix"
        },
        {
            "address": "c:00:00:11",
            "code": 0,
            "subcode": 0,
            "description": "No value calculated because there is no corresponding reading in RTK fix"
        }
    ],
    "measurements": [
        {
            "values": [
                {
                    "name": "numSamples",
                    "value": "0"
                }
            ],
            "unit": "count",
            "address": "a:00:00:00"
        },
        {
            "values": [
                {
                    "name": "latitude",
                    "value": "0"
                },
                {
                    "name": "longitude",
                    "value": "0"
                }
            ],
            "unit": "degrees",
            "address": "a:00:00:00"
        },
        {
            "values": [
                {
                    "name": "altitude",
                    "value": "0"
                }
            ],
            "unit": "meters",
            "address": "a:00:00:00"
        },
        {
            "values": [
                {
                    "name": "numSamples",
                    "value": "0"
                }
            ],
            "unit": "count",
            "address": "a:00:01:00"
        },
        {
            "values": [
                {
                    "name": "latitude",
                    "value": "0"
```

gnssDataV1


```
                },
                {
                    "name": "longitude",
            "value": "0"


                }
            ],
            "unit": "degrees",
            "address": "a:00:01:00"
        },
        {
            "values": [
                {
                    "name": "altitude",
                    "value": "0"
                }
            ],
            "unit": "meters",
            "address": "a:00:01:00"
        },
        {
            "values": [
                {
                    "name": "numSamples",
                    "value": "0"
                }
            ],
            "unit": "count",
            "address": "a:00:02:00"
        },
        {
            "values": [
                {
                    "name": "latitude",
                    "value": "0"
                },
                {
                    "name": "longitude",
                    "value": "0"
                }
            ],
            "unit": "degrees",
            "address": "a:00:02:00"
        },
        {
            "values": [
                {
                    "name": "altitude",
                    "value": "0"
                }
            ],
            "unit": "meters",
            "address": "a:00:02:00"
        }
    ],
    "datetime": "2025-02-25T11:00:00Z",
    "sources": [
        {
```

gnssDataV1

" "status": 0,
 	
"model": "GNSS",
"manufacturer": "Worldsensing",
"type": "1Sample",
"address": "a:00:00:00"
},
{
"status": 0,
model": "GNSS",
"manufacturer": "Worldsensing",
"type": "6hAverage",
"address": "a:00:01:00"
},
{
"status": 0,
"model": "GNSS",
"manufacturer": "Worldsensing",
"type": "24hAverage",
"address": "a:00:02:00"
},
{
"status": 0,
"address": "c:00:00:00",
"name": "1SampleAbsoluteHorizontalDisplacement",
"type": "Formula"
},
{
"status": 0,
"address": "c:00:00:03",
"name": "1SampleVerticalDisplacement",
"type": "Formula"
},
{
"status": 0,
"address": "c:00:00:04",
"name": "6hAverageAbsoluteHorizontalDisplacement",
"type": "Formula"
},
{
"status": 0,
"address": "c:00:00:07",
"name": "6hAverageVerticalDisplacement",
"type": "Formula"
},
{
"status": 0,
"address": "c:00:00:08",
"name": "24hAverageAbsoluteHorizontalDisplacement",
"type": "Formula"
},
{
"status": 0,
"address": "c:00:00:11",
"name": "24hAverageVerticalDisplacement",
"type": "Formula"
}
],

gnssDataV1


```
        "device": {
            "model": "LSG7GNS-SXLH",
            "_id": "163022",
            "publicId": "163022",
            "details": {
                "type": "ROVER"
            }
        },
        "message": {
    "trigger": "SCHEDULED",


            "type": "MEASUREMENTS",
            "version": "1.0.0",
            "metadata": {
                "frameNumber": 1,
                "AMType": 85,
                "endOfData": true,
                "totalFrames": 1,
                "multipart": false,
                "AMTypeSubversion": 0
            }
        },
        "networkInformation": {
            "gatewayIds": [
                {
                    "id": "30499"
                }
            ],
            "firstReceptionTimestamp": "2025-02-25T11:08:29Z",
            "radio": {
                "linkQuality": -39,
                "frequency": 920.2,
                "snr": 8,
                "sf": 7
            },
            "sequenceCounter": [
                181
            ],
            "device": {
                "loraAddress": "93486286",
                "macType": "ETSIV1"
            },
            "message": {
                "type": "radio",
                "technology": "LoRa"
            },
            "id": "30499"
        }
    }
```

gnssStatsV1


```
{
  "measurements": [
    {
      "values": [
        {
          "name": "horizontal",
          "value": "0.7"
        },
        {
          "name": "vertical",
          "value": "1"
        }
      ],
      "unit": "count",
      "address": "a:00:00:00"
    },
    {
      "values": [
        {
          "name": "fixBeforeCorrections",
          "value": "1"
        },
        {
          "name": "hasFix",
          "value": "1"
        }
      ],
      "unit": "boolean",
      "address": "a:00:00:01"
    },
    {
      "values": [
        {
          "name": "samplesNoFix",
          "value": "0"
        }
      ],
      "unit": "count",
      "address": "a:00:00:01"
    },
    {
      "values": [
        {
          "name": "timeToFix",
          "value": "2"
        }
      ],
      "unit": "seconds",
      "address": "a:00:00:01"
    },
    {
      "values": [
        {
          "name": "updated",
          "value": "1"
        }
      ],
```

gnssStatsV1


```
            "unit": "boolean",
            "address": "a:00:00:02"
        },
        {
            "values": [
                {
                    "name": "deviation",
                    "value": "0.039"
                }
            ],
            "unit": "seconds",
            "address": "a:00:00:02"
        },
        {
            "values": [
                {
                    "name": "inUse",
                    "value": "18"
                },
                {
                    "name": "inView",
                    "value": "30"
                }
            ],
            "unit": "count",
            "address": "a:00:00:03"
        },
        {
            "values": [
                {
                    "name": "avgCorrectionLength",
                    "value": "473"
                },
                {
                    "name": "numCorrectionsApplied",
                    "value": "29"
                },
                {
                    "name": "numPerSample",
                    "value": "115"
                },
                {
                    "name": "unexpectedPackets",
                    "value": "1"
                }
            ],
            "unit": "count",
            "address": "a:00:00:04"
        },
        {
            "values": [
                {
                    "name": "timeToFirst",
                    "value": "11"
                }
            ],
            "unit": "seconds",
            "address": "a:00:00:04"
```

gnssStatsV1

},
{
"values": [
{
"name": "rssiStdDev",
"value": "4"
},
{
"name": "snrStdDev",
"value": "2.9"
}
],
"unit": "count",
"address": "a:00:00:05"
},
{
"values": [
{
"name": "rssiAvg",
"value": "-77"
}
],
"unit": "decibelMilliwatts",
"address": "a:00:00:05"
},
{
"values": [
{
"name": "snrAvg",
"value": "10.4"
}
],
"unit": "decibels",
"address": "a:00:00:05"
},
{
"values": [
{
"name": "timeToFix",
"value": "15"
}
],
"unit": "seconds",
"address": "a:00:00:06"
},
{
"values": [
{
"name": "altitude",
"value": "4"
},
{
"name": "latLong",
"value": "1"
}
],
"unit": "millimeters",
"address": "a:00:01:00"

gnssStatsV1

},
{
"values": [
{
"name": "altitude",
"value": "7"
},
{
"name": "latLong",
"value": "2"
}
],
"unit": "millimeters",
"address": "a:00:02:00"
},
{
"values": [
{
"name": "altitude",
"value": "9"
},
{
"name": "latLong",
"value": "3"
}
],
"unit": "millimeters",
"address": "a:00:03:00"
},
{
"values": [
{
"name": "avgMax",
"value": "50"
}
],
"unit": "decibelHertz",
"address": "a:00:04:00"
},
{
"values": [
{
"name": "avgMax",
"value": "47"
}
],
"unit": "decibelHertz",
"address": "a:00:04:01"
},
{
"values": [
{
"name": "avgMax",
"value": "47"
}
],
"unit": "decibelHertz",
"address": "a:00:05:00"

gnssStatsV1


```
            },
            {
               "values": [
                  {
                     "name": "avgMax",
                     "value": "49"
                  }
               ],
               "unit": "decibelHertz",
               "address": "a:00:05:01"
            },
            {
               "values": [
                  {
                     "name": "avgMax",
                     "value": "49"
                  }
               ],
               "unit": "decibelHertz",
               "address": "a:00:06:00"
            },
            {
               "values": [
                  {
                     "name": "avgMax",
                     "value": "48"
                  }
               ],
               "unit": "decibelHertz",
               "address": "a:00:06:01"
            },
            {
               "values": [
                  {
                     "name": "avgMax",
                     "value": "0"
                  }
               ],
               "unit": "decibelHertz",
               "address": "a:00:07:00"
            },
            {
               "values": [
                  {
                     "name": "avgMax",
                     "value": "0"
                  }
               ],
               "unit": "decibelHertz",
               "address": "a:00:07:01"
            }
         ],
         "datetime": "2024-12-20T14:00:00Z",
         "sources": [
            {
               "status": 0,
               "model": "GNSS",
               "manufacturer": "Worldsensing",
```

gnssStatsV1
"type": "dilutionOfPrecision", "address": "a:00:00:00" }, { "status": 0, "model": "GNSS", "manufacturer": "Worldsensing", "type": "gpsFix", "address": "a:00:00:01" }, { "status": 0, "model": "GNSS", "manufacturer": "Worldsensing", "type": "time", "address": "a:00:00:02" }, { "status": 0, "model": "GNSS", "manufacturer": "Worldsensing", "type": "satellites", "address": "a:00:00:03" }, { "status": 0, "model": "GNSS", "manufacturer": "Worldsensing", "type": "corrections", "address": "a:00:00:04" }, { "status": 0, "model": "GNSS", "manufacturer": "Worldsensing", "type": "correctionsRadioInfo", "address": "a:00:00:05" }, { "status": 0, "model": "GNSS", "manufacturer": "Worldsensing", "type": "RTK", "address": "a:00:00:06" }, { "status": 0, "model": "GNSS", "manufacturer": "Worldsensing", "type": "PositionMAD1Sample", "address": "a:00:01:00" }, { "status": 0, "model": "GNSS", "manufacturer": "Worldsensing", "type": "PositionMAD6hAverage", "address": "a:00:02:00"

gnssStatsV1


```
            },
            {
              "status": 0,
              "model": "GNSS",
              "manufacturer": "Worldsensing",
              "type": "PositionMAD24hAverage",
              "address": "a:00:03:00"
            },
            {
              "status": 0,
              "model": "GNSS",
              "manufacturer": "Worldsensing",
              "type": "C\/N0 GPS L1 Band",
              "address": "a:00:04:00"
            },
            {
              "status": 0,
              "model": "GNSS",
              "manufacturer": "Worldsensing",
              "type": "C\/N0 GPS L2 Band",
              "address": "a:00:04:01"
            },
            {
              "status": 0,
              "model": "GNSS",
              "manufacturer": "Worldsensing",
              "type": "C\/N0 Galileo E1 Band",
              "address": "a:00:05:00"
            },
            {
              "status": 0,
              "model": "GNSS",
              "manufacturer": "Worldsensing",
              "type": "C\/N0 Galileo E5b Band",
              "address": "a:00:05:01"
            },
            {
              "status": 0,
              "model": "GNSS",
              "manufacturer": "Worldsensing",
              "type": "C\/N0 Glonass G1 Band",
              "address": "a:00:06:00"
            },
            {
              "status": 0,
              "model": "GNSS",
              "manufacturer": "Worldsensing",
              "type": "C\/N0 Glonass G2 Band",
              "address": "a:00:06:01"
            },
            {
              "status": 0,
              "model": "GNSS",
              "manufacturer": "Worldsensing",
              "type": "C\/N0 Beidou B1 Band",
              "address": "a:00:07:00"
            },
            {
```

gnssStatsV1


```
            "status": 0,
            "model": "GNSS",
            "manufacturer": "Worldsensing",
            "type": "C\/N0 Beidou B2 Band",
            "address": "a:00:07:01"
        }
    ],
    "device": {
        "model": "LSG7GNS-SXLH",
        "_id": "154005",
        "publicId": "154005",
        "details": {
            "type": "ROVER"
        }
    },
    "message": {
        "trigger": "SCHEDULED",
        "type": "MEASUREMENTS",
        "version": "1.0.0",
        "metadata": {
            "frameNumber": 1,
            "AMType": 84,
            "endOfData": true,
            "totalFrames": 1,
            "multipart": false,
            "AMTypeSubversion": 0
        }
    },
    "networkInformation": {
        "gatewayIds": [
            {
                "id": "759"
            }
        ],
        "firstReceptionTimestamp": "2024-12-20T14:01:49Z",
        "radio": {
            "linkQuality": -87,
            "frequency": 869.525,
            "snr": 10,
            "sf": 7
        },
        "sequenceCounter": [
            6
        ],
        "device": {
            "loraAddress": "154005",
            "macType": "ETSIV1"
        },
        "message": {
            "type": "radio",
            "technology": "LoRa"
        },
        "id": "724"
    }
}
```

CONTACT WORLDSENSING

Need more support?
Get in touch with our Customer Success team:
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Phone: +34 93 418 05 85 (08.30h - 16.30h UTC)

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