NavStar GMS800 Installation and User Manual

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REVISION HISTORY

Rev.	Revision History	Date	Prepared By	Approved By
A	Draft 1 created	13 September, 2023	S. Malik	J. Saunders
B	Product specifications added	14 September, 2023	S. Malik	J. Saunders

1 OVERVIEW

NavStar's GMS800 is a compact, high-precision GPS/GNSS sensor that provides accurate three-dimensional displacement and tilt measurements for deformation monitoring. It has no moving parts and can provide 24/7 automated monitoring data in extreme climates.

1.1 RTK TECHNOLOGY FOR MONITORING

The GMS800 uses Real Time Kinetic (RTK) GNSS processing to deliver highly accurate three-dimensional displacement and tilt measurements for deformation monitoring.

Real-time kinematic GPS is a type of GPS technology that uses a combination of GPS signals and a local Base Station to provide highly accurate positioning data.

By using a local Base Station in addition to satellite signals, the RTK system cancorrect for any errors that may be present in the GPS data. This is achieved by comparing the GPS data received by the Base Station and the GPS data received by the mobile unit. Any errors that are present in the data are then corrected, resulting in highly accurate positioning data.

A GNSS RTK based monitoring system consists of one main Base Station and one or more GNSS Rover units. The Base Station is always powered and active,receiving data from as many satellites as possible. Rover units make periodic calculations and when active, receive satellite data as well as correction information from the base (via terrestrial radio communication).

During the window of monitoring, the Rover(s) must be able to communicate with the same set of satellites as the Base Station, while intercepting correctionsfrom the Base Station.

It is advised for Rover units to be as near as possible to the Base Station since error is introduced proportional to the distance from the base (approximately +/- 1mm error in displacement per km from the base).

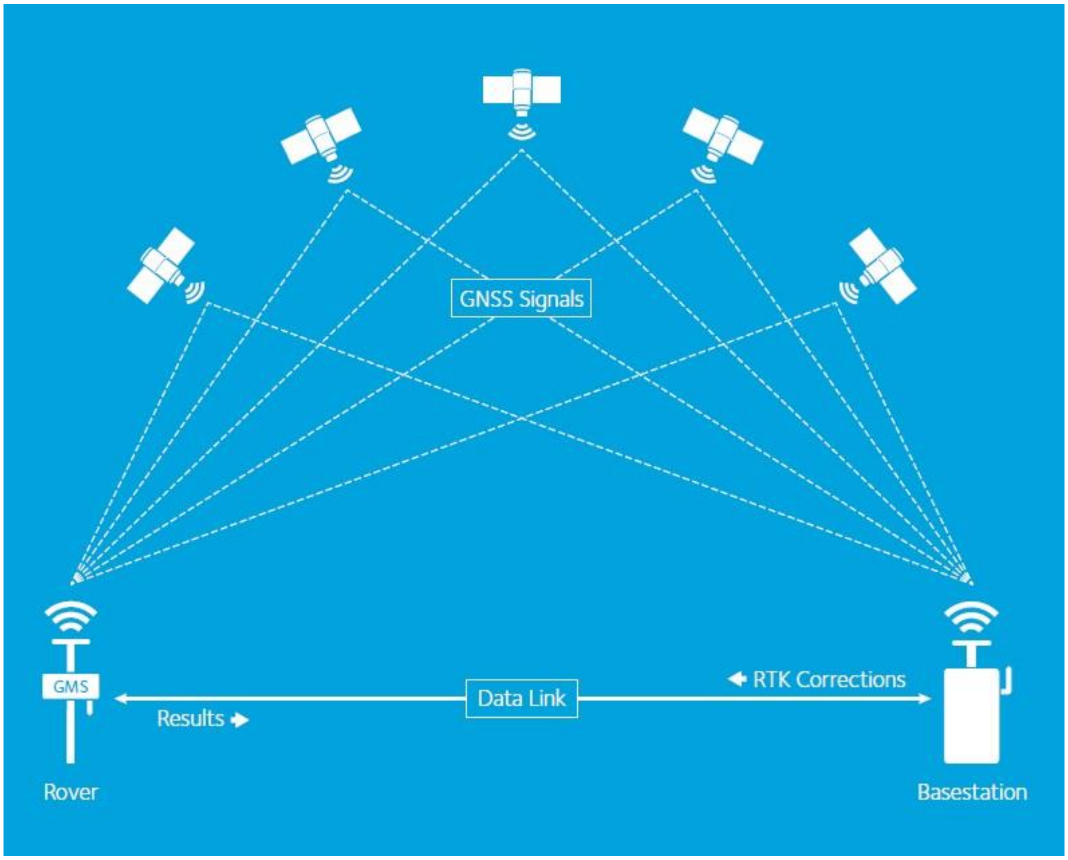


Figure 1: GMS800 System Overview

NavStar's monitoring system is also comprised of a pair of software applications called GeoExplorer and GeoServer (collectively referred to as GeoExplorer). These applications work with a client/server architecture so that many users of the client software can simultaneously access real-time monitoring data by connecting to the database via a corporate network or the internet.

1.2 NavStar Methology and Equipment

Each piece of equipment has 2 antennas. One allows for terrestrial radio communication and the other for satellite reception. Both communication networks are necessary for the technology to function properly.

NavStar generally uses the 900MHz frequency band for terrestrial communication or something similar depending on local governing bodies for RF communication. Corrections from the base to the Rovers are sent via this radio communication as well as the calculations from the Rovers back to the base.

NOTE: For the remainder of the installation and user manual, the communication protocol will be simply referred to as radio communication.

1.2.1 NavStar FLP Logger (FLP100, FLP200) and GPM Module (GPM200)

The FLP is a logger device with a RJ45 port for ethernet connection to a network switch. It is an essential component of the GNSS Base Station andgateway systems.

The FLP is intended for real-time monitoring where the most useful data is that which is available regularly on a set schedule. The FLP can also be used as a Repeater / gateway station. When functioning as a Repeater, it can bounce data further along the radio network or rebroadcast corrections from the base. NavStar uses the term 'gateway' to mean a network connected unit with an alternate path to GeoExplorer.

The GPM is the GNSS module that clips onto the side of an FLP or FLL. The GPS connector (MCX) on the unit is attached to base GNSS antenna.

Figure 2: FLP100 with attached GPM200 module

1.2.2 NavStar FLL Logger (FLL200, FLL300)

The FLL is a ‘lite’ version of the FLP having many of the same features but no ethernet connection. It is used for Base Stations without network access or in Repeater stations. The FLL is also used in other applications but for GNSS based monitoring solutions only the radio connector is important (radio 1, MCX). In the case of Repeaters, a small GPS antenna can be plugged into the GPS connector (MCX) but this is only to record the unit’s location (not for high-precision GNSS monitoring). The serial port (RJ45) is left disconnected when used for only GNSS monitoring.

Figure 3: FLL300 Repeater Box with Solar Controller

1.2.3 NavStar GMS800 Rover

The GMS800 are low power devices that are most often configured as GNSS Rovers. These units function automatically when power is applied. GMS800s have a red power LED which indicates when the unit is active. The green LED blinks when corrections are received from the base. If a GMS800 Rover is installed too far away from the base, the red LED may turn on without any blinking from the green LED.

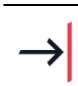
Figure 4: GMS800 GNSS Rover Unit

1.3 INTENDED AUDIENCE

This guide is for the personnel responsible for installing or using NavStar's GMS800. This manual provides steps for installing and operating the GMS800.

1.4 ICONS AND CONVENTIONS USED IN THIS GUIDE

This guide uses the following icons to call attention to important information.

	**WARNING:** This icon appears when an operating procedure or practice, if not correctly followed, could result in personal injury or loss of life.
	**CAUTION**: This icon appears when an operating procedure or practice, if not strictly observed, could result in damage to or destruction of equipment.
	**NOTE**: This icon appears to highlight specific non-safety related information.

2 SAFETY

WARNING: Always follow safety precautions and use proper personal protective equipment (PPE) including safety glasses and high-visibility clothing when working in the field with this equipment.

3 INSTALLATION

3.1 PREREQUISITES

3.1.1 Sky View

To compute a three-dimensional position both the Base Station and Rover need to have a clear view of at least 5 GPS/GNSS satellites in common. In practice, this means that both the Base Station and Rover need to have clear views of thesky free of obstructions of any kind above 15 degrees from the horizon. This includes power poles, trees, buildings, rock faces, and other similar obstructions.

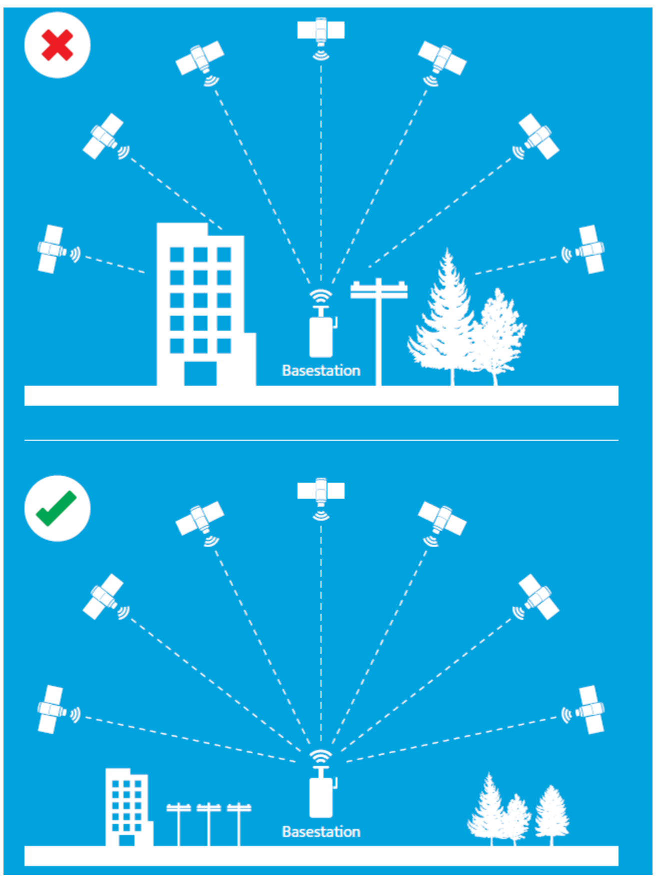
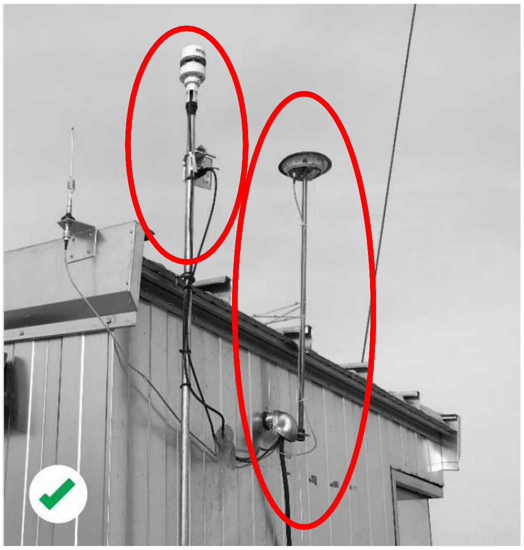


Figure 5: Non-Ideal and Ideal Base Station Sky View

Example Installations



Ideal Installation

- radio and GNSS antennas free from obstruction and clear view of sky.

NOTE:
Raising the radio antenna up on a mast would allow the system to function even more effectively.

Non-Ideal Installation

- Power lines / obstructions overhead

Figure 6: Example Installations

3.1.2 Base Station Installation Requirements

The RTK Base Station is the fixed point to which the computed coordinates for Rovers are referenced. If the Base Station is moving this will cause apparent movement of all Rovers that have an RTK Data Link from the Base Station. It is critical to ensure there is reliable power and communications for the Base Station. If the Base Station goes offline, all Rovers will be unable to compute positions.

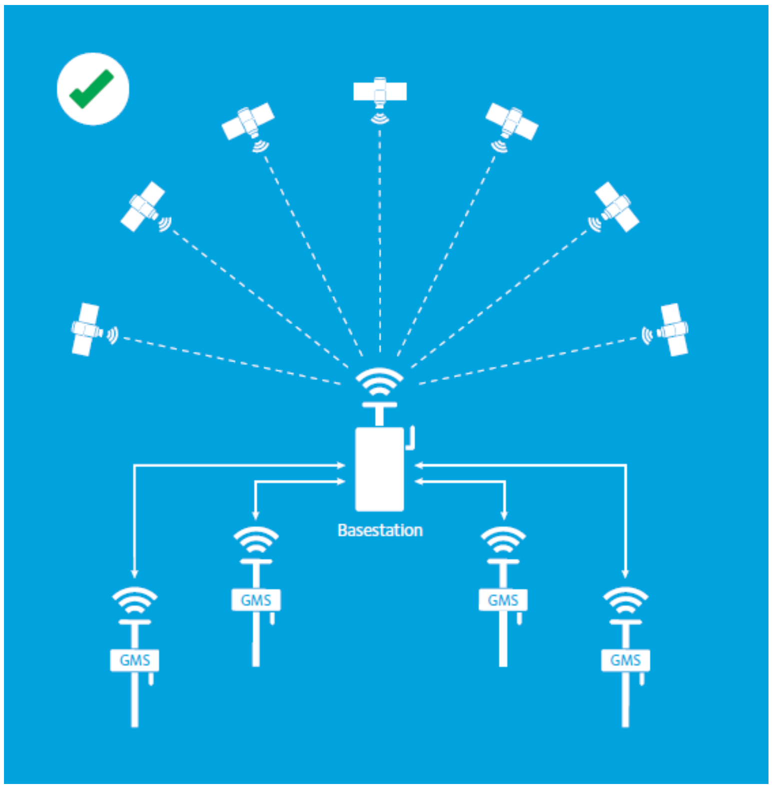


Figure 7: Base Station Installation

EXAMPLE INSTALLATION

Ideal Installation

- Excellent installation with strong mount for the GNSS antenna, no obstructions, and Data Link antenna which is elevated but not interfering with the GNSS antenna.

Figure 8: Example Installation

3.1.3 Reliable RTK Data Link

The RTK Data Link is critical to compute three-dimensional positions. As such, ensuring that every GMS800 has a clear radio link to the appropriate Gateway is essential.

The ideal location would be near the main AC power and close to a network switch. It is possible to have network access via point-to-point wireless link, but it is more reliable to have a wired connection if possible. If the base loses power OR network access, then the entire system is offline and not collecting data.

NOTE: If the base loses power OR network access, then the entire system is offline and not collecting data.

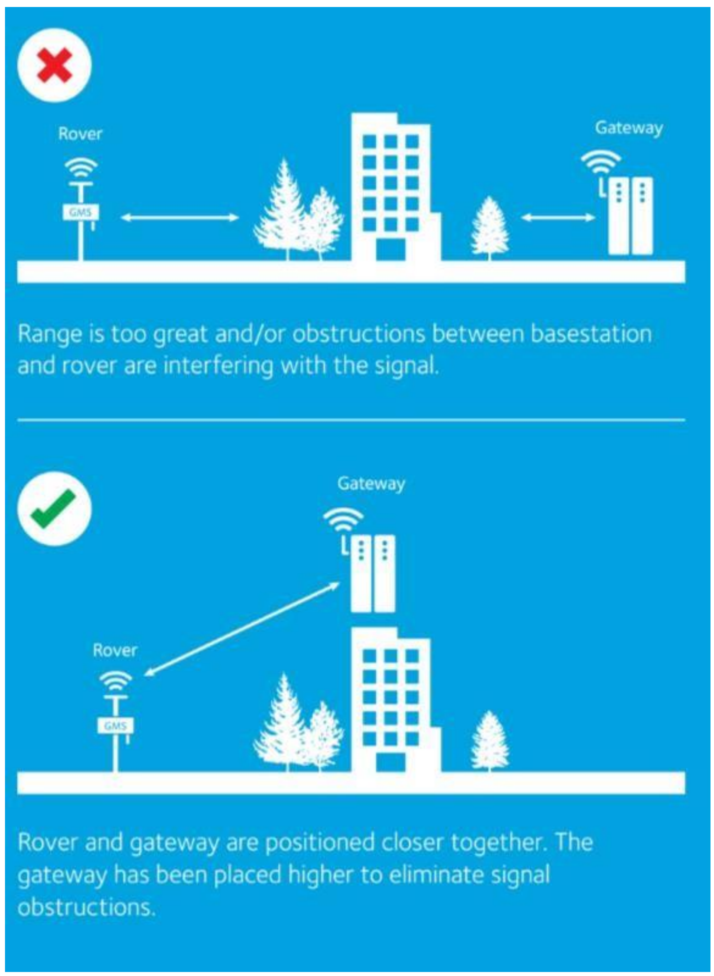


Figure 9: Non-Ideal and Ideal Rover and Base Stationorientation

3.1.4 GNSS Rover Installation Requirements

The GNSS antenna should be the highest point of the installation and secured permanently (concrete pillar is the best). The GNSS antenna should have a clear view of the sky, 15 degrees and higher from the horizon.

See next page for example installations.

EXAMPLE INSTALLATIONS

Excellent Installation

- Strong metal pole with concrete foundation
- Antenna has clear 360˚ viewof the sky

Acceptable Installations

- Susceptible to minor vibrations
- This type of installation is much easier to work with if no concrete work is necessary

Unacceptable Installation

- Rover installation next to a steep embankment
- Due to antenna obstructed from sky view in one direction, there is a chance the system may not work at all or may provide intermittent data

Figure 10: Example Installations

3.1.5 Other Installation Notes

The 900 MHz radio antenna with the Base Station should be as high as possible and free from obstructions. If possible, there would be a 'line of sight' view to each of the Rover units. The GNSS antenna should be secure without possibility of vibration or movement. A concrete pillar is the best solution. NavStar uses an FLP based system for Base Stations with network access and an FLL when thereis no network access. When using an FLL based Base Station it is necessary to have an FLP gateway as part of the system. Every Base Station (FLP or FLL) has an attached GPM module which functions as the GNSS base.

3.1.6 Power

GMS800 Rover units are solar powered.

3.1.7 Tiltmeters

Some Rover units, such as the GMS800 have built in bi-axial Tiltmeters. It is important to choose a reference orientation for the A and B axis so that changes in tilt can be quantified in the future. For example, the A axis could be positioned north/south or in a hillside situation, one of the axes could be positioned up/down slope.

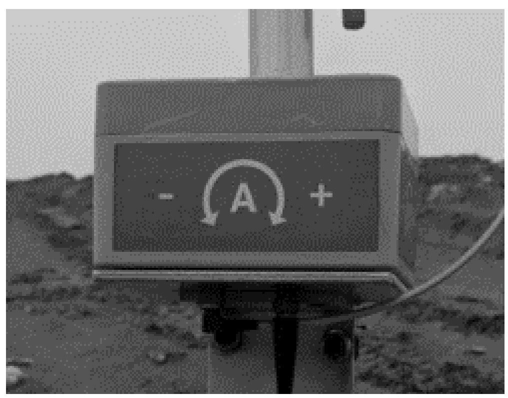


Figure 11: Example of GMS800 showing direction for Tiltmeter orientation

3.1.8 Additional Gateways

It is possible and encouraged to have additional gateways, especially for larger installations. This adds an important level of redundancy to the system. Additional gateways can function as Repeaters for Rovers that are away from the base. The 'gateway' aspect of these stations is that they have another path to the network. These stations can also rebroadcast corrections from the base. NavStar uses the FLP line of products for gateways.

3.1.9 Repeaters

Repeater stations are essentially gateways without network access. They can 'repeat' the radio data but have no direct access to the network. NavStar uses FLL series equipment as Repeaters. FLPs can also act as Repeaters if required.

3.2 Optional Configurations

3.2.1 Base with no network accessibility

The gateway and base aspects of the Base Station can be separated. If there is a good location for sky visibility without network connection it is possible to set up an FLL-based station. Corrections are broadcast across the 900Mhz network but require an FLP based gateway to receive the Rover responses and pass the data onto the network (GeoExplorer).

3.2.2 Base with no access to radio network

It is also possible to have the base in a location with network access but no good line of sight to the Rover units for radio communication. In this case, it is possible for the base to pass correction information across the network to a separate gateway station. This other gateway can broadcast the base's corrections to the Rover units. In this situation the base would not need a radio antenna (only GNSS antenna).

3.2.3 Distant Rover units

By default, NavStar provides a small BNC 900MHz omnidirectional antenna. For units that do not have line of sight or are further than a kilometer away, it is possible to install a directional or different type of antenna that can improve the quality of communication. It is also possible to install cable extensions so the small BNC antenna can be raised up on a mast.

3.3 GMS800 INSTALLATION

3.3.1 Step 1: Mount GNSS Antenna

Mount the GNSS antenna with a clear view of the sky and connect to the GMS800 using the supplied TNC – TNC antenna cable.

3.3.2 Step 2: Attach Data Link

Attach the Data Link antenna to the BNC port on the GMS800.

NOTE: If necessary, an external antenna with extension cable maybe used.

3.3.3 Step 3: Connecting Solar

Attach the solar panel to the barrel plug connector on the bottom of the GMS800.

3.3.4 Step 4: Powering ON

Remove the lid from the GMS800 and turn the power switch to the ON position (ON is to the right).

The red PWR LED will illuminate within 5 seconds of enabling the power.

3.4 GMS800 OPERATION

The GMS800 functions simply by applying power. All units have been programmed (firmware/application) prior to shipping and are plug and play ready for installation/operation immediately with no additional configuration required for default operation.

3.4.1 Default Operation

The GMS800 is by default on a measurement cycle of one hour. In between measurements it is in a ‘deep sleep’ (low battery usage) state. Removing and applying power can force a measurement (and the cycle to restart).

When the GMS800 is first powered, the PWR (red) LED will turn on and remain solid for the duration of the cycle. The TX (yellow) LED blinks during a transmission and the RX (green) LED blinks during reception. The CORR (green) LED blinks every time a correction is received from the Base Station.

When power is first applied or the GMS800 ‘wakes up’ for a new cycle, it sends a message via the Base Station to the server (GeoExplorer software) to request any new configuration that may have been sent since the last measurement. An example of this is the measurement cycle interval. If a new configuration is received, then that will be applied before measurement.

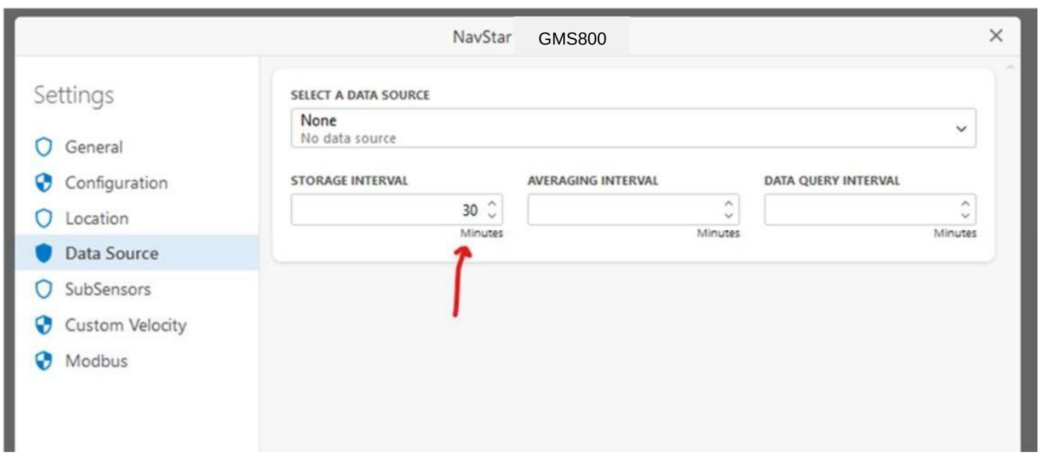


Figure 12: Measurement interval of GMS800 set to 30 mins in GeoExplorer

The GMS800 begins its measurement cycle by tracking and receiving data from satellites. At the same time, it receives correction information from the Base Station (CORR LED blinks). When sufficient data is received from both these sources, a calculation is made, and the result is sent to the server.

NOTE:

Operation with insufficient data

When the GMS800 is unable to properly track satellites (example: full view of sky is restricted because of nearby obstacles) or it is unable to receive enough quality corrections from the base, it will fail to make a calculation. A timeout of 120 seconds indicates that there was an inability to make a calculation (resolve a position). The GMS800 will enter its sleep cycle and wake after an hour (default) to try again.

Operation without a Base Station

At the beginning of a cycle, the GMS800 requests a configuration change from the server. If there is no response, this is interpreted as no Base Station found. In this case, the GMS800 times out after 14 seconds and enters deep sleep (and will try again next measurement cycle). Without a Base Station, the red PWR LED will turnon and there will be activity on the TX transmission LED but no activity on the RX (reception) or CORR LED (corrections from base).

3.5 GMS800 TESTING

A GMS800 is essentially tested and functions correctly if it can make a calculation and send it to the server (GeoExplorer software).

It is not possible to test a GMS800 for complete functionality without several other components of the system including:

1. Server with GeoServer (server portion of GeoExplorer) and SQL database installed.
2. Base Station (FLP200 + GPM200) with functioning radio and GNSS antennaand clear view of the sky.
3. GMS800 with GNSS and radio antennas attached and clear view of sky.

To perform a test, this setup must be complete (refer to Installation prerequisites) and the only required step is to apply power to the GMS800.

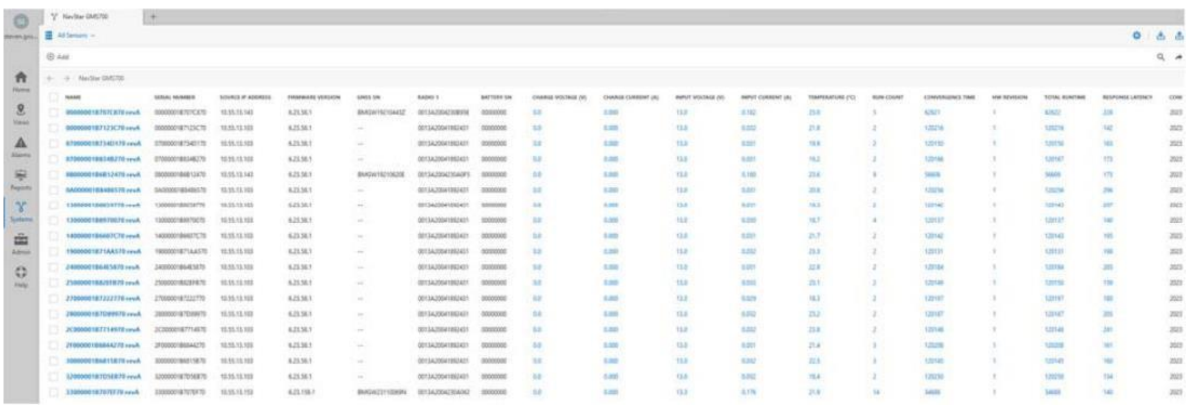


Figure 13: Screenshot of GMS800 tests in GeoExplorer

NOTE:

A successful test in GeoExplorer provides an incredible amount of detail regarding the GMS800 operation and functionality.

A list of some details that can be seen in GeoExplorer:

1. Serial number of GMS800 (also a sticker on the PCB + enclosure)
2. IP address of gateway/Base Station
3. Firmware version
4. GNSS daughter board serial number
5. Radio module serial number
6. Battery board serial number
7. Solar power details (charge voltage, current)
8. Input voltage to GMS800 (can use to determine voltage/life of battery pack)
9. Input current to GMS800
10. Internal temperature of GMS800
11. Total number of measurement cycles ever performed.
12. Convergence time of calculation
13. Response latency (measurement of comms quality to gateway)
14. Tilt measurement (X, Y, Z axis)
15. Correction packets (received from the base for previous calculation)
16. Positioning info (lat/long/elevation etc.)
17. Number of satellites used in calculation.
18. 3D displacement referenced to chosen baseline.
19. Seconds since last measurement

4 PRODUCT SPECIFICATIONS

Table 1: Product and Technical Specifications

Item	Specification
Physical and Electrical	
Enclosure Dimensions	160 mm x 160 mm x 100 mm
Enclosure Material	Fiberglass Reinforced Polyester
Weight* **Without battery*	1.35 kg
Connectors	TNC(F) for GNSS Antenna BNC(F) for Radio Antenna
Mounting	2” Pole Clamps included. Flexible hole pattern also works for alternate mounting
Temperature	Operating: -40°C to +85°C Storage: -55°C to +85°C
Power Consumption	42 mWH per measurement ~8000 measurements with 6 X Lithium D Batteries at room temperature with ‘In RTK mode’
Sensors	
GNSS Channels	555
GNSS Signals Received	GPS L1 C/A, L1C, L2C, L2P, L5 GLONASS* L1 C/A, L2 C/A, L2P, L3, L5 Galileo* E1, E5 AltBOC, E5a, E5b, E6 BeiDou* B1I, B1C, B2I, B2a, B3I QZSS* L1 C/A, L1C, L2C, L5, L6 **Optional, requires extra license*
Biaxial Tilt Accuracy	< 0.01°
Environmental Sensors	Temperature, Input Voltage, Input Current, Charge Voltage, Charge Current, Runtime Metrics

Typical GNSS Measurement Performance		
	Post-processing mode	RTK mode
Horizontal Repeatability (24 hr. average)	3 mm	8 mm
Vertical Repeatability (24 hr. average)	5 mm	15 mm
Included GNSS Antenna* **Additional antenna options available*		
Signals Received	GPS L1/L2 GLONASS L1/L2 Galileo E1 BeiDou B1	
Dimensions	176 mm D x 55 mm H	
Connector	TNC (F)	
Mounting	5/8” Coarse Thread Mount	
Phase Center Ability	< 2.0 mm	
Noise Figure	< 2.0 dB (typical)	
Power Supply Options		
Solar / Lead Acid	2.6AH 12V Integrated Lead Acid power supply system including internal solar controller 10 W solar panel typical	
Solar / Supercapacitor	Maintenance free supercapacitor system with advanced charge efficiency 10 W solar panel typical	
Telemetry		
Mesh Radio	868 MHz, 900 MHz, 2.4 GHz	
Wi-Fi	802.11 B/G/N	
LTE	Bands 1, 2, 3, 4, 5, 8, 12, 13, 18, 19, 20, 25, 26, 28 and 39	
LTE Carrier Approvals	AT&T (LTE-M), Verizon (LTE-M), Bell (LTE-M), Telus (LTE-M)	

The repeatability and precision of GNSS measurements at a particular location and time are affected by the number and geometric distribution of satellites in the visible sky, the effect of multipathing, unit distance from Base Station, and other factors. The measurement performancestated above assumes a typical installation with favourable topography.

5 SERVICE, REPAIR AND CONTACT INFORMATION

This product does not contain any user-serviceable parts. Contact Terra Insights forproduct services or repairs.

- For sales information: sales@terrainsights.com
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