

# Introduction

The GRS-1 receiver is a single-frequency, GPS+GLONASS L1 L2 receiver and hand-held controller built to be the most advanced, compact, and portable receiver for the GIS surveying market. An integrated electronic compass and digital camera make the GRS-1 an all-purpose, GIS field mapping unit.

The GRS-1 receiver is a multi-function, multi-purpose receiver intended for precision markets. Precision markets means markets for equipment, subsystems, components and software for surveying, construction, commercial mapping, civil engineering, precision agriculture and land-based construction and agriculture machine control, photogrammetry mapping, hydrographic and any use reasonably related to the foregoing.

The GRS-1 provides the functionality, accuracy, availability, and integrity needed for fast and easy data collection.

## Principles of Operation

Surveying with the right GPS receiver can provide users accurate and precise positioning, a requirement for any surveying project.

This section gives an overview of existing and proposed Global Navigation Satellite Systems (GNSS) and receiver functions to help you understand and apply basic operating principles, allowing you to get the most out of your receiver.

## GNSS Overview

Currently, the following three global navigation satellite systems (GNSS) offer line-of-site radio navigation and positioning, velocity, and time services on a global, all-weather, 24-hour scale to any user equipped with a GNSS tracking receiver on or near the Earth's surface:

- GPS – the Global Positioning System maintained and operated by the United States Department of Defense. For information on the status of this system, visit the US Naval Observatory website (<http://tycho.usno.navy.mil/>) or the US Coast Guard website (<http://www.navcen.uscg.gov/>).
- GLONASS – the Global Navigation Satellite System maintained and operated by the Russian Federation Ministry of Defense. For information on the status of this system, visit the Ministry of Defense website ([http://www.glonass-center.ru/frame\\_e.html](http://www.glonass-center.ru/frame_e.html)).
- GALILEO – an upcoming global positioning system maintained and operated by Galileo Industries, a joint venture of several European space agencies working closely with the European Space Agency. Unlike GPS and GLONASS, this is a civil endeavor and is currently in the development and validation stage. For information on the status of this system, visit the Galileo Industries website (<http://www.galileo-industries.net>).

Despite numerous technical differences in the implementation of these systems, satellite positioning systems have three essential components:

- Space – GPS, GLONASS, and GALILEO satellites orbit approximately 12,000 nautical miles above Earth and are equipped with a clock and radio. These satellites broadcast digital information (ephemerides, almanacs, time&frequency corrections, etc.).
- Control – Ground stations located around the Earth that monitor the satellites and upload data, including clock corrections and new ephemerides (satellite positions as a function of time), to ensure the satellites transmit data properly.

- User – The community and military that use GNSS receivers and the corresponding satellites to calculate positions.

## Calculating Absolute Positions

When calculating an absolute position, a stationary or moving receiver determines its three-dimensional position with respect to the origin of an Earth-Center Earth-Fixed coordinate system. To calculate this position, the receiver measures the distance (called pseudo-ranges) between it and at least four satellites. The measured pseudo-ranges are corrected for clock differences (receiver and satellites) and signal propagation delays due to atmospheric effects. The positions of the satellites are computed from the ephemeris data transmitted to the receiver in navigation messages. When using a single satellite system, the minimum number of satellites needed to compute a position is four. In a mixed satellite scenario (GPS, GLONASS, GALILEO), the receiver must lock onto at least five satellites to obtain an absolute position.

To provide fault tolerance using only GPS or only GLONASS, the receiver must lock onto a fifth satellite. Six satellites will provide fault tolerance in mixed scenarios.

## Calculating Differential Positions

DGPS, or Differential GPS, typically uses the measurements from two or more remote receivers to calculate the difference (corrections) between measurements, thus providing more accurate position solutions.

With DGPS, one receiver is placed at a known, surveyed location and is referred to as the reference receiver or base station. Another receiver is placed at an unknown location and is referred to as the remote receiver or rover. The reference station collects the range measurements from each GPS satellite in view and forms the differences (corrections) between the calculated distance to the satellites and the measured pseudo-ranges to the satellites.

These corrections are then built up to the industry standard (RTCM or various proprietary standards) established for transmitting differential corrections and broadcast to the remote receiver(s) using a data communication link. The remote receiver applies the transmitted DGPS corrections to its range measurements of the same satellites.

Using this technique, the spatially correlated errors—such as satellite orbital errors, ionospheric errors, and tropospheric errors—can be significantly reduced, thus improving the position solution accuracy of the GPS.

A number of differential positioning implementations exist, including post-processing surveying, real-time kinematic surveying, maritime radio beacons, geostationary satellites (as with the OmniSTAR service), and the wide area augmentation system (WAAS) service.

The real-time kinematic (RTK) method is the most precise method of real-time surveying. RTK requires at least two receivers collecting navigation data and communication data link between the receivers. One of the receivers is usually at a known location (Base) and the other is at an unknown location (Rover). The Base receiver collects carrier phase measurements, generates RTK corrections, and sends this data to the Rover receiver. The Rover processes this transmitted data with its own carrier phase observations to compute its relative position with high accuracy, achieving an RTK accuracy of up to 1 cm horizontal and 1.5 cm vertical.

## Essential Components for Quality Surveying

Achieving quality position results requires the following elements:

- Accuracy – The accuracy of a position primarily depends upon the satellite geometry (Geometric Dilution of Precision, or GDOP) and the measurement (ranging) errors.
  - Differential positioning (DGPS and RTK) strongly mitigates atmospheric and orbital errors, and counteracts Selective Availability (SA) signals the US Department of Defense transmits with GPS signals.
  - The more satellites in view, the stronger the signal, the lower the DOP number, the higher positioning accuracy.

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- Availability – The availability of satellites affects the calculation of valid positions. The more visible satellites available, the more valid and accurate the position. Natural and man-made objects can block, interrupt, and distort signals, lowering the number of available satellites and adversely affecting signal reception.
  - Integrity – Fault tolerance allows a position to have greater integrity, increasing accuracy. Several factors combine to provide fault tolerance, including:
    - Receiver Autonomous Integrity Monitoring (RAIM) detects faulty GPS and GLONASS satellites and removes them from the position calculation.
    - Five or more visible satellites for only GPS or only GLONASS; six or more satellites for mixed scenarios.
    - Wide Area Augmentation Systems (WAAS, EGNOS, etc.) creates and transmit, along with DGPS corrections, data integrity information (for example, satellite health warnings).
    - Current ephemerides and almanacs.

## Conclusion

This overview simply outlines the basics of satellite positioning. For more detailed information, visit the TPS website.

## GRS-1 Overview

The GRS-1 is a fully integrated hand-held controller and GPS+ receiver. Included in the system is an electronic compass and digital camera.

### **The hand-held controller component of the GRS-1**

includes the Windows® Mobile operating system and color LCD touch screen. Integrated Bluetooth® /Cell phone modem (Option) wireless technology allows this system to be a cable-free controller/receiver for maximum portability. The rugged casing is durable and built for rugged use.

As a field controller, the GRS-1 can run a full suite of field software for working with total stations and RTK GPS systems.

### **The GPS+ receiver component of the GRS-1**

can receive and process GPS+GLONASS L1/L2 signals improving the accuracy of your survey points and positions. The GPS+ features of the receiver combine to provide a positioning system accurate for any survey. Several other features, including multipath mitigation, provide under-canopy and low signal strength reception.

When power is turned on and the receiver self-test completes, the receiver's 50 channels initialize and begin tracking visible satellites. Each of the receiver's channels can be used to track any one of the GPS or GLONASS signals. The number of channels available allows the receiver to track all visible GPS satellites at any time and location.

An internal GPS antenna equipped with a low noise amplifier (LNA) and the receiver's radio frequency (RF) device are connected with a coaxial cable. The wide-band signal received is down-converted, filtered, digitized, and assigned to different channels. The receiver processor controls the process of signal tracking.

Once the signal is locked in the channel, it is demodulated and necessary signal parameters (carrier and code phases) are measured. Also, broadcast navigation data are retrieved from the navigation frame.

After the receiver locks on to four or more satellites, it is possible to solve the so-called "absolute positioning problem" and compute the receiver's coordinates (in WGS-84) and the time offset between the receiver clock and GPS time. All this information can be stored in the the optional SD card and internal flash memory, then processed using a post-processing software package.

Capabilities of the GRS-1 receiver include:

- Multipath reduction
- Wide area augmentation system (WAAS)
- Single-frequency static, kinematic, and differential GPS (DGPS) survey modes
- Setting different mask angles
- Setting different survey parameters

### The integrated 1.3 megapixel camera

is used taking pictures of surveyed objects or survey sites.

## Getting Acquainted with the GRS-1

The GRS-1 is an integrated field controller and 50-channel GPS receiver with an internal electronic compass and digital camera. USB and serial ports, along with Bluetooth®/cell phone modem (Option) wireless technology provide communication paths with other devices. An external GPS antenna connector allows an optional PG-A5 antenna to be connected for centimeter-level surveys.

The standard GRS-1 package contains the following items:

- GRS-1 integrated receiver/controller activated for GPS L1/L2 signals
- Handstrap and soft case
- USB cable and power converter/adaptor cable

For more details on accessories and options available for the GRS-1, contact your local Topcon dealer.

### Rechargeable and Backup Batteries

The GRS-1 comes equipped with a rechargeable battery (GRS-1 Battery) for powering the unit. The battery can be charged in the unit or in an optional battery charger. A backup battery is also located in the battery pocket and the unit's serial number is located under the battery.

The battery provides seven hours of operation, depending on the mode of the receiver. Under normal conditions, the backup battery provides eight to ten years of power backup for data and system integrity.

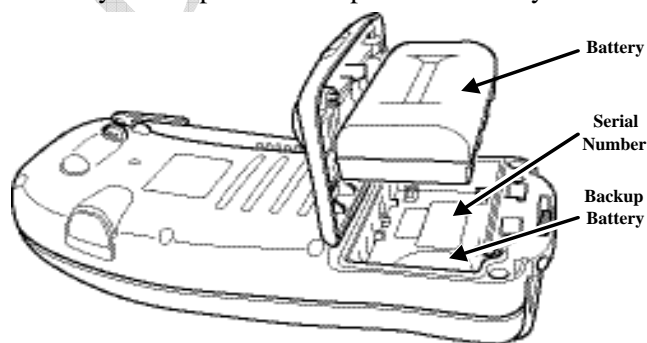


Figure 1-2. GRS-1 Battery

### GRS-1 Front

The front of the GRS-1 is the primary interface with its components and installed software.

- The **internal GPS antenna** detects signals from GPS+ satellites and sends them to the GPS receiver board for processing.

- The **display screen and touch panel** provides a graphical and tactile user interface for the unit.
- The **power button** turns the receiver on and off.
- The **ESC (escape) button** exits from the current screen or function.
- The **ENT (enter) button** applies settings, numerical values, and records points (depending on the settings of internal software). Pressing this button for one second activates the controller's Windows Start menu.
- The **Bluetooth LED** indicates the level of activity at the Bluetooth wireless technology module:
  - Solid blue light: the module is on and a connection has been established.
  - No light: the module is off.
- The **charging LED** indicates the level of charge in the battery:
  - Green: battery has a full charge.
  - Red: battery is charging.
  - Red blink: charging error.



Figure 1-3. GRS-1 Front

## GRS-1 Ports

The GRS-1 has the following three ports:

- USB – used for high-speed connection to a computer via ActiveSync.

- Serial – used for communication between the internal GPS module (port A of the module) and an external device. Power – used to connect the GRS-1 to an external power source. This port can also be used to charge the batteries.

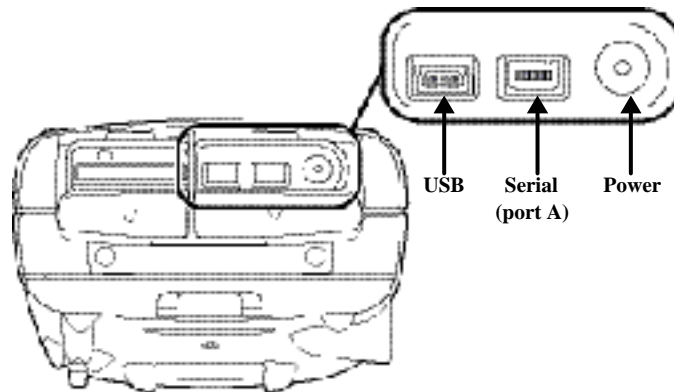


Figure 1-5. GRS-1 Ports

## SD Card Slot

The SD (secure digital) slot provides extended memory for the controller (SD Card Slot). The data that resides on the SD card can be accessed via the USB or serial port, or Bluetooth wireless technology. A secure digital card can be purchased at your local computer supply store. Located above the card slot is the software reset button for restarting the operating system if software is not responding.

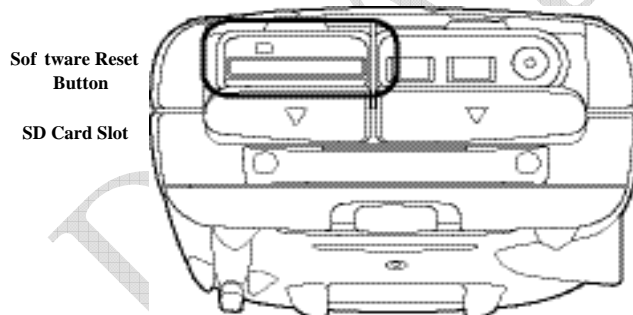


Figure 1-6. SD Card Slot

## Integrated Camera

The integrated 1.3 megapixel camera can be used for taking pictures.

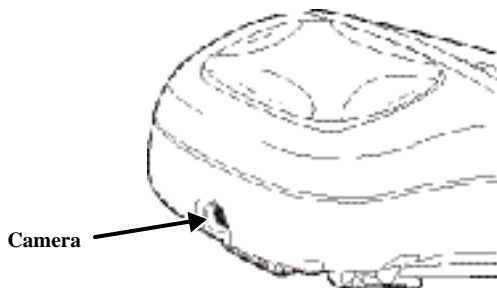
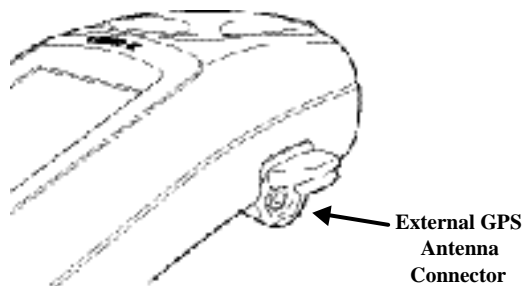


Figure 1-7. GRS-1 Camera

## External GPS Antenna Connector

The external GPS antenna connector allows an optional external antenna to be connected to the controller for



post-process survey applications.

Figure 1-8. GRS-1 External GPS Antenna Connector

## System Cables

The GRS-1 package includes standard communication and power cables for communicating with the GRS-1 and providing a power source. GRS-1 Package Cables lists the cables included in the standard GRS-1 package.

Table 1-1. GRS-1 Package Cables

Cable Description	Cable Illustration
<p><b>AC Power cable and adapter</b> Connects the GRS-1 to a grounded outlet.</p>	
<p><b>USB cable</b> Connects the GRS-1 to an external device (controller or computer) for high-speed data transfer and receiver configuration.</p>	

## Optional Accessories

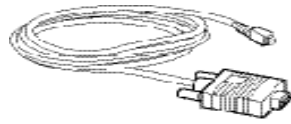
Table 1-2. GRS-1 Op gives a brief list of optional accessories that can be used with the GRS-1. Contact your dealer to purchase optional accessories. GRS-1 Optional Accessories

Accessory	Illustration
<p><b>External GPS Antenna and Cable</b> Connecting an external PG-A1 GPS antenna increases the range of the GRS-1.</p>	

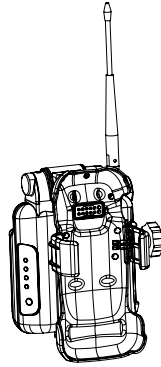
**Serial cable**

Connects the GRS-1 to an external device (controller or computer) for data transfer and receiver configuration.

Note: A ferrite core is attached to this cable.



**Radio Modem Holder**



DRAFT