



USER GUIDE

Trimble® SPSx80 and SPSx81 Smart GPS Antennas

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Release Notice

This is the July 2007 release (Revision B) of the SPSx80 and SPSx81 Smart GPS Antennas User Guide. It applies to version 3.30 of the SPSx80 and SPSx81 Smart GPS antennas.

Product Limited Warranty Information

For applicable product Limited Warranty information, please refer to the Limited Warranty Card included with this Trimble product, or consult your local Trimble authorized dealer.

Notices

Class B Statement – Notice to Users. This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communication. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Changes and modifications not expressly approved by the manufacturer or registrant of this equipment can void your authority to operate this equipment under Federal Communications Commission rules.

Canada

This digital apparatus does not exceed the Class B limits for radio noise emissions from digital apparatus as set out in the radio interference regulations of the Canadian Department of Communications.

Le présent appareil numérique n'émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de Classe B prescrites dans le règlement sur le brouillage radioélectrique édicté par le Ministère des Communications du Canada.

Europe

This product has been tested and found to comply with the requirements for a Class B device pursuant to European Council Directive 89/336/EEC on EMC, thereby satisfying the requirements for CE Marking and sale within the European Economic Area (EEA). Contains Infineon radio module ROK 104001. These requirements are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential or commercial environment.



Australia and New Zealand

This product conforms with the regulatory requirements of the Australian Communications Authority (ACA) EMC framework, thus satisfying the requirements for C-Tick Marking and sale within Australia and New Zealand.



Taiwan – Battery Recycling Requirements

The product contains a removable Lithium-ion battery. Taiwanese regulations require that waste batteries are recycled.



廢電池請回收

Notice to Our European Union Customers

Restriction of Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS)

This Trimble product complies in all material respects with DIRECTIVE 2002/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) and Amendment 2005/618/EC filed under C(2005) 3143, with exemptions for lead in solder pursuant to Paragraph 7 of the Annex to the RoHS Directive applied.

Waste Electrical and Electronic Equipment (WEEE)

For product recycling instructions and more information, please go to www.trimble.com/ev.shtml.

Recycling in Europe: To recycle Trimble WEEE (Waste Electrical and Electronic Equipment, products that run on electrical power), Call +31 497 53 24 30, and ask for the "WEEE Associate". Or, mail a request for recycling instructions to:

Trimble Europe BV
c/o Menlo Worldwide Logistics
Meerheide 45
5521 DZ Eersel, NL



Safety Information

Before you use your Trimble® SPS GPS receiver, make sure that you have read and understood all safety requirements.

Regulations and safety

The receivers contain an internal radio-modem and can send signals through Bluetooth® wireless technology or through an external data communications radio. Regulations regarding the use of the 450 MHz radio-modems vary greatly from country to country. In some countries, the unit can be used without obtaining an end-user license. Other countries require end-user licensing. For licensing information, consult your local Trimble dealer. Bluetooth, 900 MHz, and 2.4 GHz radio-modems operate in license-free bands.

Before operating an SPSx50 or SPSx51 Modular GPS receiver, or an SPSx80 or SPSx81 Smart GPS antenna, determine if authorization or a license to operate the unit is required in your country. It is the responsibility of the end user to obtain an operator's permit or license for the receiver for the location or country of use.

For FCC regulations, see [Notices, page 2](#).

Type approval

Type approval, or acceptance, covers technical parameters of the equipment related to emissions that can cause interference. Type approval is granted to the manufacturer of the transmission equipment, independent from the operation or licensing of the units. Some countries have unique technical requirements for operation in particular radio-modem frequency bands. To comply with those requirements, Trimble may have modified your equipment to be granted Type approval. Unauthorized modification of the units voids the Type approval, the warranty, and the operational license of the equipment.

Exposure to radio frequency radiation

For 450 MHz radio

Safety. Exposure to RF energy is an important safety consideration. The FCC has adopted a safety standard for human exposure to radio frequency electromagnetic energy emitted by FCC regulated equipment as a result of its actions in General Docket 79-144 on March 13, 1986.

Proper use of this radio modem results in exposure below government limits. The following precautions are recommended:

- **DO NOT** operate the transmitter when someone is 20 cm (7.8 inches) of the antenna.
- **DO NOT** operate the transmitter unless all RF connectors are secure and any open connectors are properly terminated.
- **DO NOT** operate the equipment near electrical blasting caps or in an explosive atmosphere.

- All equipment must be properly grounded according to Trimble installation instructions for safe operation.
- All equipment should be serviced only by a qualified technician.

For license-free 900 MHz radio¹



CAUTION – For your own safety, and in terms of the RF Exposure requirements of the FCC, always observe the precautions listed here.

- Always maintain a minimum separation distance of 20 cm (7.8 inches) between yourself and the radiating antenna on the SPSx50 and SPSx51 radio-modem.
- Do not co-locate the antenna with any other transmitting device.

For 2.4 GHz radio²

Safety. Exposure to RF energy is an important safety consideration. The FCC has adopted a safety standard for human exposure to radio frequency electromagnetic energy emitted by FCC regulated equipment as a result of its actions in General Docket 79-144 on March 13, 1986.

Proper use of this radio modem results in exposure below government limits. The following precautions are recommended:

- **DO NOT** operate the transmitter when someone is within 20 cm (7.8 inches) of the antenna.

The maximum gain of the antenna must not exceed 8 dBi.

For Bluetooth radio

The radiated output power of the internal Bluetooth wireless radio is far below the FCC radio frequency exposure limits. Nevertheless, the wireless radio shall be used in such a manner that the Trimble receiver is 20 cm or further from the human body. The internal wireless radio operates within guidelines found in radio frequency safety standards and recommendations, which reflect the consensus of the scientific community. Trimble therefore believes the internal wireless radio is safe for use by consumers. The level of energy emitted is far less than the electromagnetic energy emitted by wireless devices such as mobile phones. However, the use of wireless radios may be restricted in some situations or environments, such as on aircraft. If you are unsure of restrictions, you are encouraged to ask for authorization before turning on the wireless radio.

Installing antennas



CAUTION – For your own safety, and in terms of the RF Exposure requirements of the FCC, always observe these precautions:

- Always maintain a minimum separation distance of 20 cm (7.8 inches) between yourself and the radiating antenna.
 - Do not co-locate the antenna with any other transmitting device.
-

¹. 900 MHz radios are not used in Europe.

². 2.40 GHz radios are available initially only for Japan.

This device has been designed to operate with the antennas listed below. Antennas not included in this list are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

The antennas that can be used (country dependent) with the **450 MHz radio** are 0 dBi and 5 dBi whip antennas. The antennas that can be used (country dependent) with the **900 MHz radio** are 0 dBi, 3 dBi, and 5 dBi whip antennas. The antennas that can be used (country dependant) with the **2.4 GHz radio** are 2 dBi and 8 dBi whip antennas.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.

Battery safety



WARNING – Do not damage the rechargeable Lithium-ion battery. A damaged battery can cause an explosion or fire, and can result in personal injury and/or property damage. To prevent injury or damage:

- Do not use or charge the battery if it appears to be damaged. Signs of damage include, but are not limited to, discoloration, warping, and leaking battery fluid.
 - Do not expose the battery to fire, high temperature, or direct sunlight.
 - Do not immerse the battery in water.
 - Do not use or store the battery inside a vehicle during hot weather.
 - Do not drop or puncture the battery.
 - Do not open the battery or short-circuit its contacts.
-



WARNING – Avoid contact with the rechargeable Lithium-ion battery if it appears to be leaking. Battery fluid is corrosive, and contact with it can result in personal injury and/or property damage. To prevent injury or damage:

- If the battery leaks, avoid contact with the battery fluid.
 - If battery fluid gets into your eyes, immediately rinse your eyes with clean water and seek medical attention. Do not rub your eyes!
 - If battery fluid gets onto your skin or clothing, immediately use clean water to wash off the battery fluid.
-



WARNING – Charge and use the rechargeable Lithium-ion battery only in strict accordance with the instructions. Charging or using the battery in unauthorized equipment can cause an explosion or fire, and can result in personal injury and/or equipment damage. To prevent injury or damage:

- Do not charge or use the battery if it appears to be damaged or leaking.
 - Charge the Lithium-ion battery only in a Trimble product that is specified to charge it. Be sure to follow all instructions that are provided with the battery charger.
 - Discontinue charging a battery that gives off extreme heat or a burning odor.
 - Use the battery only in Trimble equipment that is specified to use it.
 - Use the battery only for its intended use and according to the instructions in the product documentation.
-

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Introduction

Welcome to the *SPSx80 and SPSx81 Smart GPS Antennas User Guide*. This manual describes how to set up and use the Trimble® SPSx80 and SPSx81 Smart GPS antennas.

The SPS GPS receivers is a family of receivers that comprise the SPSx50 and SPSx51 Modular GPS receivers, and the SPSx80 and SPSx81 Smart GPS antennas. Where necessary, this manual contains references to specific receivers in the product family. When information is specific to a particular model, then the specific model name is used.

Even if you have used other Global Positioning System (GPS) products before, Trimble recommends that you spend some time reading this manual to learn about the special features of this product. If you are not familiar with GPS, visit the Trimble website (www.trimble.com) for an interactive look at Trimble and GPS.

About the SPSx80 Smart GPS antenna

The SPSx80 Smart GPS antenna family comprises the following Smart GPS antennas:

- SPS780 Basic base
- SPS780 Basic rover
- SPS780 Max
- SPS880 Extreme

The Smart GPS antennas are designed for all on-the-rod rover operation and rapid daily base station setup operation.

SPS780 Basic Smart GPS antenna

The SPS780 Basic Smart GPS antenna is the entry level receiver in the SPSx80 Smart GPS antenna family. The SPS780 Basic is available in the following configurations:

- SPS780 Basic base
- SPS780 Basic rover

The receiver is optimized for use on small-to-midsize construction projects.

SPS780 Max Smart GPS antenna

The SPS780 Max Smart GPS antenna is available from new or as an upgrade to the SPS780 Basic Smart GPS antenna. The SPS780 Max configuration provides you with base and rover operation capability plus the ability to work at longer ranges from the base station, and to operate as a rover in a Trimble Virtual Reference Station (VRS™) network.

SPS880 Extreme Smart GPS antenna

The SPS880 Extreme Smart GPS antenna can track the existing GPS L1 and L2 satellite signals plus the future L2C and L5 signals as they become available. The new signals provide the ability to initialize faster, work in harsher GPS environments, and work at longer ranges from the base station. The SPS880 Extreme can also utilize signals from the Russian GLONASS satellites, providing increased satellite availability and fewer/shorter GPS outages.

About the SPSx81 Smart GPS antenna

The SPSx81 Smart GPS antenna family comprises the following Smart GPS antennas:

- SPS781 Basic base
- SPS781 Basic rover
- SPS781 Max
- SPS881 Extreme

The Smart GPS antennas are designed for all on-the-road rover operation and rapid daily base station setup operation.

All the SPSx81 Smart GPS antennas track the GPS L1/L2 and modernized L2C satellite signals.

SPS781 Basic Smart GPS antenna

The SPS781 Basic Smart GPS antenna is the entry level receiver in the SPSx81 Smart GPS antenna family. The SPS781 Basic is available in the following configurations:

- SPS781 Basic base
- SPS781 Basic rover

The receiver is optimized for use on small-to-midsize construction projects.

SPS781 Max Smart GPS antenna

The SPS781 Max Smart GPS antenna is available from new or as an upgrade to the SPS781 Basic Smart GPS antenna. The SPS781 Max configuration provides you with base and rover operation capability plus the ability to work at longer ranges from the base station, and to operate as a rover in a Trimble Virtual Reference Station (VRS™) network.

SPS881 Extreme Smart GPS antenna

The SPS881 Extreme Smart GPS antenna can track the existing GPS L1/L2/L2C satellite signals. This Smart GPS antenna can be upgraded to use signals from the Russian

GLONASS satellites, providing increased satellite availability and fewer/shorter GPS outages. This receiver can also be upgraded to track the GPS modernized L5 signal as it becomes available.

The use of the Smart GPS antenna with the signal upgrades, provides the ability to initialize faster, work in harsher satellite environments, and to work at longer ranges from the base station.

Related Information

Sources of related information include the following:

- Help – The SCS900 Site Controller software has built-in, context-sensitive help that lets you quickly find the information you need. Access it from the *Help* menu. Alternatively, click the **?** button in a dialog, or press **[F1]**. On a Microsoft® Windows® CE device, select *Start / Help*.
- Release notes – The release notes describe new features of the product, information not included in the manuals, and any changes to the manuals. They are provided as a .pdf file on the *Trimble SPS GPS Receiver CD*.
- Trimble training courses – Consider a training course to help you use your GPS system to its fullest potential. For more information, go to the Trimble website at www.trimble.com/training.html.

Technical Support

If you have a problem and cannot find the information you need in the product documentation, contact your local dealer. Alternatively, go to the Support area of the Trimble website (www.trimble.com/support.shtml). Select the product you need information on. Product updates, documentation, and any support issues are available for download.

If you need to contact Trimble technical support, complete the online inquiry form at www.trimble.com/support_form.asp.

Your Comments

Your feedback about the supporting documentation helps us to improve it with each revision. E-mail your comments to ReaderFeedback@trimble.com.

Features and Functions

In this chapter:

- SPS780 Smart GPS antenna features
- SPS781 Smart GPS antenna standard features
- SPS880 Extreme Smart GPS antenna standard features
- SPS881 Extreme Smart GPS antenna standard features
- Use and care
- COCOM limits
- Parts of the receiver
- Button functions
- LED behavior

The Smart GPS antennas are designed to be used for the following infrastructure and site development applications:

- Layout of structure foundations, caissons and piles
- Earthworks, fine grading and finishing stakeout operations
- Initial site measurements to verify design levels and regular subsequent measurements to determine progress volumes
- Measurements and grade/thickness checks on laid materials

The Smart GPS antennas incorporate a GPS antenna, receiver, internal radio, and battery in a rugged light-weight unit that is ideally suited as an all-on-the-pole RTK rover or quick setup/rapid mobilization base station. LEDs enable you to monitor satellite tracking, radio reception, data logging status, and power. Bluetooth® wireless technology provides cable-free communications between the receiver and controller.

You can use the SPSx80 or SPSx81 as part of an RTK GPS system with the Trimble SCS900 Site Controller software.

All the receivers can optionally record GPS data to the receiver's optional internal memory and download to a computer using the serial connection.

Overview

The SPS780/SPS781 and SPS880 Extreme/SPS881 Extreme Smart GPS antennas (see [Figure 2.1](#)) are very similar in setup, operational use, and controls. The SPS880 Extreme/SPS881 Extreme has a taller antenna dome to accommodate the larger GPS antenna and the circuitry required to track additional GPS signals and GLONASS satellites.



Figure 2.1 SPS781 Smart GPS antenna (left), and the SPS881 Extreme Smart GPS antenna (right)

SPS780 Smart GPS antenna features

The SPS780 Smart GPS antenna provides the following standard features. For features specific to each model, see below.

SPS780 standard features

- Small, lightweight design – 1.31 kg (2.89 lb) (integrated radio, GPS receiver, GPS antenna and battery); 3.7 kg (8.16 lb) complete system weight (rover including TSC2 controller and rod)
- The quick setup, high mobility base and rover receiver system is ideal for small to mid-size jobsites and for working on multiple jobsites on a daily or weekly basis
- 24-channel L1/L2 GPS receiver (SPS780 Basic and SPS780 Max)
- Internal, removable, smart Lithium-ion battery provides up to 6.6 hrs GPS rover operation per battery
- Bluetooth® wireless technology for cable free, no hassle base or rover operation
- Simple keypad with on/off key and LED indicators for power, radio, and satellite tracking
- Allows measurement from a moving platform, for example, mounted on a vehicle or marine vessel for increased efficiency on large jobsites

SPS780 Basic features

Base station only, or rover only, operation

SPS780 Basic base

- Base station operational range limited only by normal restrictions common to UHF radio transmissions
- Integrated transmit radio (450 MHz Base configuration only)
- Entry level price point for lower cost of base station
- Can be upgraded to the SPS780 Max

SPS780 Basic rover

- 2 Hz measurement rover receiver update rate
- Rover operational range limited to 1.5 mile (2.4 km) from base station
- Entry level price point for lower cost of rover
- Can be upgraded to the SPS780 Max

SPS780 Max features

- Base/Rover receiver interchangeability for ultimate GPS fleet flexibility
- Rover option offers 10 Hz measurement update rate
- Range limited only by normal restrictions common to UHF radio transmissions
- Operates as a rover within a Virtual Reference Station (VRS) network for operation without a conventional base station
- Integrated transmit/receive radio provides base station and rover operation capability (900 MHz variant contains receive only radio and utilizes the SNB900 radio at the base station for transmit capability)

SPS781 Smart GPS antenna standard features

The SPS781 Smart GPS antenna has the same features as the SPS780 as well as the following additional features:

- RoHS compliant
- Can use GPS L1/L2/L2C signals
- Upgraded hardware for improved satellite tracking and positioning performance
- 72-channel receiver
- 4 SBAS channels

SPS781 Basic features

- Can be upgraded to the SPS781 Max

SPS880 Extreme Smart GPS antenna standard features

- Small, lightweight design – 1.35 kg (2.97 lb) (integrated radio, GPS receiver, GPS antenna and battery); 3.71 kg (8.18 lb) complete system weight (rover including TSC2 controller and rod)
- The quick setup, high mobility base or rover receiver, is ideal for any size jobsite as a rover and for working on multiple jobsites on a daily or weekly basis
- 72-channel L1/L2/L2C/L5 GPS and L1/L2 GLONASS receiver
- Performs all site measurement and stakeout operations within the operating range of the radio
- Internal, removable, smart Lithium-ion battery provides up to 5.5 hrs GPS rover operation per battery
- Bluetooth wireless technology for cable free, no hassle base or rover operation
- Simple keypad with on/off key and LED indicators for power, radio and satellite tracking
- 20 Hz update rate
- Full base/rover interchangeability
- Operates within a VRS network for conventional base station-free rover capability
- Integrated transmit radio (450 MHz version only)
- Tracks GLONASS L1/L2 signals for increased satellite availability and operation in harsh GPS environments
- Receives L2C code and L5 carrier signal for future GPS modernization capability

SPS881 Extreme Smart GPS antenna standard features

The SPS881 Extreme Smart GPS antenna has the same features as the SPS880 Extreme as well as the following additional features:

- RoHS compliant
- The standard SPS881 Extreme (P/N 71489-xx) can receive the GPS L2C signal
- Can be upgraded to use GLONASS signals
- Can be upgraded to use L5 GPS signals
- 4 SBAS channels

Use and care

This product is designed to withstand the rough treatment and tough environment that typically occurs in construction applications. However, the receiver is a high-precision electronic instrument and should be treated with reasonable care.



CAUTION – Operating or storing the receiver outside the specified temperature range can damage it. For more information, see [Chapter 10, Specifications](#).

COCOM limits

The U.S. Department of Commerce requires that all exportable GPS products contain performance limitations so that they cannot be used in a manner that could threaten the security of the United States. The following limitations are implemented on this product:

- Immediate access to satellite measurements and navigation results is disabled when the receiver velocity is computed to be greater than 1,000 knots, or its altitude is computed to be above 18,000 meters. The receiver GPS subsystem resets until the COCOM situation clears. As a result, all logging and stream configurations stop until the GPS subsystem is cleared.

Parts of the receiver

All operating controls are located on the front panel. Serial ports and connectors are located on the bottom of the unit.

Front panel

[Figure 2.2](#) shows a front view of the SPSx81 Smart GPS antenna. The front panel contains the three indicator LEDs, and the power button. The SPSx80 Smart GPS antenna has the same buttons but the surrendering color is yellow rather than black.



Figure 2.2 Front panel

The power button controls the receiver's power on or off functions.

The indicator LEDs show the status of power, satellite tracking, and radio reception.
For more information, see [LED behavior, page 22](#).

Lower housing

Figure 2.3 shows the lower housing of the SPS781 Smart GPS antenna. The lower housing is the same for the SPS780 and SPS880 Extreme, except for the identifying label. The housing contains the two serial ports, one TNC radio antenna connector, the removable battery compartment and the 5/8-11 threaded insert.

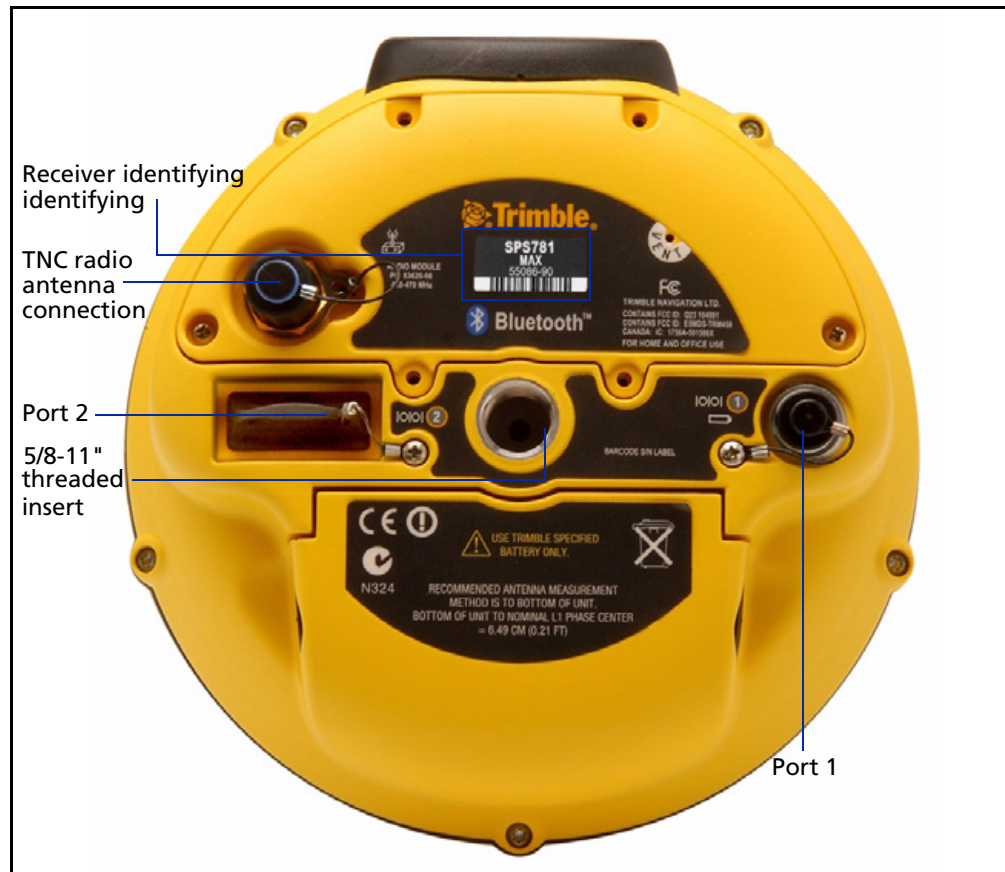





Figure 2.3 Lower housing

Each port or connector on the Smart GPS antenna is marked with an icon to indicate its main function, as shown in Table 2.1.

Table 2.1 Receiver ports



Icon	Name	Connections
	Port 1	Device, computer, external radio, power in
	Port 2	Device, computer, external radio
	RADIO	Radio communications antenna

Port 1 is a 7-pin 0-shell Lemo connector that supports RS-232 communications and external power input. Port 1 has no power outputs.

Port 2 is a DB-9 male connector that allows for full 9-pin RS-232 communications. Port 2 does not support power in or out. For more information on default port settings, see [Default receiver settings, page 68](#).

The TNC port connector is for connecting a radio antenna to the receiver internal radio. A whip “rubber duck” antenna is supplied with the system for units with internal UHF or 900 MHz radios. This connector is not used if you are using an external radio receiver. For longer range operation (to provide higher gain and to raise the antenna higher above the ground), you can use a cable to connect an external radio antenna to the TNC port. For more information on connecting the Smart GPS antenna, see the [Chapter 5, Setting up the Receiver](#).

Button functions

The receiver has only one button, the Power button, represented in this manual by . Press  to switch the receiver on or off, and to perform other functions, as described as follows:

Action	Power button
Turn on the receiver	Press
Turn off the receiver	Hold for 2 seconds
Delete the ephemeris file	Hold for 15 seconds
Reset the receiver to factory defaults	Hold for 15 seconds
Delete application files	Hold for 30 seconds

***Note** – The term “press” means to press the button and release it immediately. The term “hold” means to press the button and hold it down for the given time.*

LED behavior

The three LEDs on the front panel of the receiver indicate various operating conditions. Generally, a lit or slowly flashing LED indicates normal operation, a LED that is flashing quickly indicates a condition that may require attention, and an unlit LED indicates that no operation is occurring. The following table defines each possible LED state:

The term ...	means that the LED ...
Slow flash	alternates on/off for 500 milliseconds.
Fast flash	alternates rapidly on/off for 100 milliseconds
On	is lit steady
Off	is unlit

LED flash patterns

The following table details the possible flash patterns to indicate various states of receiver operation.

Receiver mode	Power LED Green	Radio LED Green	Satellite LED Amber
Receiver OFF	OFF	OFF	OFF
Receiver ON			
Healthy power	ON	N/A	N/A
Low power	Fast flash	N/A	N/A
Tracking <4 SVs	ON	N/A	Fast flash
Tracking >4 SVs	ON	N/A	Slow flash
Logging data internally	Flashes off every 3 seconds	N/A	N/A
Receiving valid data packets	ON	Slow flash	N/A
No data packets	ON	OFF	N/A
Monitor mode	ON	Slow flash	ON

Note – If a column shows “N/A”, that specific LED may or may not be on, but it is not relevant to that particular mode.

Batteries and Power

In this chapter:

- External power
- Battery safety
- Battery performance
- Charging the Lithium-ion batteries
- Storing the Lithium-ion battery
- Disposing of the rechargeable Lithium-ion battery

The GPS receiver is powered by an internal Lithium-ion battery, which can be detached from the receiver for charging. The receiver can also be connected to an external power source through Port 1.

During measurement operations, each internal battery typically provides about 6.6 hours of power if using the internal Rx (receive) radio and about 4.5 hours operating as a base station using the internal 450 MHz Tx (transmit) radio. These times vary according to the type of measurement and the operating conditions.

External power

The GPS receiver uses an external power source in preference to its internal batteries. If the receiver is not connected to an external power source, or if the external power supply fails, the internal batteries are used.

While carrying out static measurements for postprocessed computations using the internal memory, if no external power is supplied and the internal battery is drained, the receiver shuts down. No data is lost and when power is restored, the receiver restarts in the same status as it was when power was lost.

Battery safety

The receiver is powered by one rechargeable Lithium-ion battery. Charge and use the battery only in strict accordance with the instructions in this chapter.



WARNING – Do not damage the rechargeable Lithium-ion battery. A damaged battery can cause an explosion or fire, and can result in personal injury and/or property damage. To prevent injury or damage:

- Do not use or charge the battery if it appears to be damaged. Signs of damage include, but are not limited to, discoloration, warping, and leaking battery fluid.
- Do not expose the battery to fire, high temperature, or direct sunlight.
- Do not immerse the battery in water.
- Do not use or store the battery inside a vehicle during hot weather.
- Do not drop or puncture the battery.
- Do not open the battery or short-circuit its contacts.



WARNING – Avoid contact with the rechargeable Lithium-ion battery if it appears to be leaking. Battery fluid is corrosive, and contact with it can result in personal injury and/or property damage.

To prevent injury or damage:

- If the battery leaks, avoid contact with the battery fluid.
 - If battery fluid gets into your eyes, immediately rinse your eyes with clean water and seek medical attention. Do not rub your eyes!
 - If battery fluid gets onto your skin or clothing, immediately use clean water to wash off the battery fluid.
-

Battery performance

To optimize battery performance and extend battery life:

- Fully charge all new batteries before use.
- Batteries perform best when they are not used at extreme temperatures. The receiver is designed to operate at $-40\text{ }^{\circ}\text{C}$ to $+65\text{ }^{\circ}\text{C}$ ($-40\text{ }^{\circ}\text{F}$ to $+149\text{ }^{\circ}\text{F}$). However, operation at temperatures of less than $0\text{ }^{\circ}\text{C}$ ($32\text{ }^{\circ}\text{F}$) can cause a rapid drop in battery life.
- The Lithium-ion batteries are rated to operate from $-20\text{ }^{\circ}\text{C}$ to $+60\text{ }^{\circ}\text{C}$ ($-4\text{ }^{\circ}\text{F}$ to $+140\text{ }^{\circ}\text{F}$)
- Do not allow a battery that is in storage to discharge to below 5 V.

Charging the Lithium-ion batteries



WARNING – Charge and use the rechargeable Lithium-ion battery only in strict accordance with the instructions. Charging or using the battery in unauthorized equipment can cause an explosion or fire, and can result in personal injury and/or equipment damage.

To prevent injury or damage:

- Do not charge or use the battery if it appears to be damaged or leaking.
- Charge the Lithium-ion battery only in a Trimble product that is specified to charge it.

Be sure to follow all instructions that are provided with the battery charger.

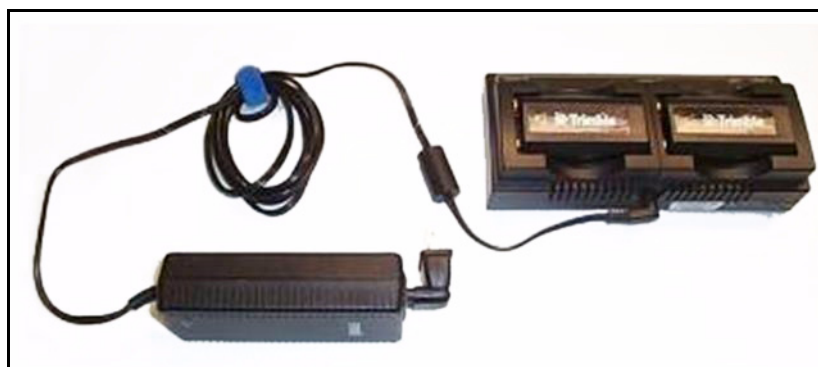
- Discontinue charging a battery that gives off extreme heat or a burning odor.
- Use the battery only in Trimble equipment that is specified to use it.
- Use the battery only for its intended use and according to the instructions in the product documentation.

The rechargeable Lithium-ion batteries are supplied partially charged.

Note – Charge the battery completely before using it for the first time. If the battery has been stored for longer than three months, charge it before use.

To charge the battery, first remove the battery from the receiver, and then place it in the following battery charger, which is connected to mains power:

- The dual-slot GPS battery charger (P/N 61116-00) and power supply (P/N 59221-00):



Storing the Lithium-ion battery

If you must store a Lithium-ion battery for long periods, make sure that it is fully charged before it is stored, and that you charge it at least once every three months while it is stored.

Do not allow a battery that is in storage to discharge to below 5 V. A battery that reaches deep discharge level (5 V or less) cannot be recharged and must be replaced. (To protect a battery that is in use from deep discharge, the receiver switches power sources or stops drawing power when the battery pack discharges to 5.9 V.)

All batteries discharge over time when not in use, and they discharge faster in colder temperatures. Do not store the receiver at temperatures outside the range -40°C to $+70^{\circ}\text{C}$ (-40°F to $+158^{\circ}\text{F}$).

Do not store the batteries in the receiver or in the external charger unless power is applied.

Keep all batteries on continuous charge when not in use. You can keep batteries on charge indefinitely without damage to the batteries.

Disposing of the rechargeable Lithium-ion battery

Discharge a Lithium-ion battery before disposing of it. Dispose of batteries in an environmentally sensitive manner, and adhere to any local and national regulations concerning battery disposal or recycling.

Setup Guidelines

In this chapter:

- [Base station operation guidelines](#)
- [Rover operation guidelines](#)

GPS Real-Time Kinematic (RTK) operation provides centimeter-level accuracy by eliminating errors that are present in the GPS system. For all RTK operations, you require both a base station and a rover receiver.

This chapter introduces the concepts of base station and rover operation, provides information to help you identify good setup locations, describes best practices for setting up the equipment, and outlines the precautions that you need to take to protect the equipment.

***Note** – This chapter provides setup information for all the receivers in the SPS GPS receiver family.*

Base station operation guidelines

A base station consists of a receiver that is placed at a known (and fixed) position. The receiver tracks the same satellites that are being tracked by the rover receiver, at the same time that the rover is tracking them. Errors in the GPS system are monitored at the fixed (and known) base station, and a series of position corrections are computed. The messages are sent through a radio link to the rover receiver, where they are used to correct the real time positions of the rover.

Base station components

The base station has the following components:

- GPS receiver
- GPS antenna
- Base station radio
- Power supply

GPS receiver and GPS antenna

The base station GPS receiver can be one of following types:

- A Smart GPS antenna, such as the SPSx80 or SPSx81, which incorporates a GPS receiver, GPS antenna, power supply, and radio into a single compact unit. A Smart GPS antenna can be rapidly set up on a tripod, fixed height tripod, or T-Bar anywhere that is convenient on the jobsite.
- A Modular GPS receiver, such as the SPSx50 or SPSx51, which incorporates a GPS receiver, power supply, and radio in a single unit. The GPS antenna (and, optionally, the base station radio antenna) is separate from the receiver. Because the GPS antenna is separate, you can use the following optimized components:
 - a geodetic antenna with large ground plane, to eliminate multipath (the major source of GPS errors) at the base station
 - a high-gain or directional radio antenna, to increase broadcast range and to provide maximum coverage

You can also place a modular GPS receiver in an easily accessible and secure location, safe from theft and the weather, while the antennas are placed high on a tower or building, clear of obstructions and able to deliver maximum performance.

You can use either type of receiver in a permanent, semi-permanent, or daily quick setup configuration. If semi-permanent or permanent operation is required, however, the modular receiver delivers significant advantages.

Base station setup guidelines

For good performance, observe the following base station setup guidelines:

- Place the GPS receiver in a location on the jobsite where equal range in all directions provides full coverage of the site. This is more important on larger jobsites, where the broadcast range of the base station radio may limit the operations of the GPS system.
- Place the GPS antenna in a location that has a clear line of sight to the sky in all directions. Do not place the GPS antenna near vertical obstructions such as buildings, deep cuttings, site vehicles, towers, or tree canopy.
- Place the GPS and radio antennas as high as practical. This minimizes multipath from the surrounding area, and enables the radio to broadcast to the maximum distance.

Note – *The GPS antenna must have a clear line of sight to the sky at all times during operation.*

- Choose the most appropriate radio antenna for the size and footprint of the site. The higher the gain on the antenna, the longer the range. If there is more focus on the transmission signal, there is a reduced coverage area. A 3 db or 5 db gain antenna provides a mix of good range and reasonable directional coverage.
- Make sure that the GPS receiver does not lose power. The GPS receiver has an integrated battery, which has to be charged. To operate continuously for more than a day without loss of power at the base station, provide external power. Sources of external power include:
 - AC power
 - 12 V car or truck battery
 - Trimble custom external battery pack
 - Generator power
 - Solar panel

When you use an external power supply, the integrated battery provides a backup power supply, enabling you to maintain continuous operation through a mains power failure.

When the GPS receiver is connected to a power source greater than 15 V, the integrated battery is continuously charged from the connected power source. This helps to ensure that the battery stays charged (SPSx50 and SPSx51 only).

- Do not locate a GPS receiver, GPS antenna, or radio antenna within 400 meters (about 1,300 feet) of:
 - a powerful radar, television, or cellular communications tower
 - another transmitter
 - another GPS antenna

Cell phone towers can interfere with the base station radio broadcast and can stop corrections from reaching the rover receiver. High-power signals from a nearby radio or radar transmitter can overwhelm the receiver circuits. This does not harm the receiver, but can prevent the receiver electronics from functioning correctly.

Low-power transmitters, such as those in cell phones and two-way radios, do not interfere with receiver operations.

- Do not set up the base station directly beneath or close to overhead power lines or electrical generation facilities. The electromagnetic fields associated with these utilities can interfere with GPS receiver operation. Other sources of electromagnetic interference include:
 - Gasoline engines (spark plugs)
 - Televisions and computer monitors
 - Alternators and generators
 - Electric motors
 - Equipment with DC-to-AC converters
 - Fluorescent lights
 - Switching power supplies
- Place the GPS receivers in a protected and secure location. If the base station is in the center of a jobsite where heavy machinery is operating, place flags around the base station to warn operators of its existence.
- If you place the SPSx50 or SPSx51 Modular GPS receiver in a lock box on the jobsite to protect the receiver from theft or from the weather, shield the lock box from direct sunlight and provide ventilation for the receiver through an inlet and extractor fan. A receiver that has a broadcast radio generates significant heat. Do not allow the temperature in the box to exceed 50 °C (122 °F).

If working in a cold climate, you may need to provide heat to the receiver. Do not operate the receiver below –40 °C (–40 °F).

- Trimble recommends that, wherever possible, you keep GPS receiver equipment dry. The receivers are designed to withstand wet weather, but keeping them dry prolongs their life and reduces the effects of corrosion on ports and connectors. If the equipment gets wet, use a clean dry cloth to dry the equipment and then leave the equipment open to the air to dry. Do not lock wet equipment in a transport case for prolonged periods. Avoid exposing the GPS receiver to corrosive liquids and salt water wherever possible.

- Trimble recommends that you install lightning protection equipment at permanent base station locations. Equipment should include a gas capsule lightning protector in the GPS and radio antenna feed line and appropriate safety grounding. A static dissipater near the antennas can reduce the likelihood of a direct lightning strike. Also protect any communications and power lines at building entry points. For more information, contact your local Trimble dealer, or go to the Huber and Suhner website (www.hubersuhnerinc.com).
- Trimble recommends that you use surge protection equipment on all permanently installed equipment.

Rover operation guidelines

The second part of the RTK GPS system is the rover receiver.

The rover receiver is mounted on a pole, vehicle, marine vessel, or in a backpack, and is moved between the points that require measurement or stakeout. The rover receiver is connected to a base station or to a source of RTK corrections such as a Virtual Reference Station (VRS) system. The connection is provided by an integrated radio, a cellular modem in the controller, or through an external cellular phone that is connected to the receiver either by Bluetooth wireless technology or by means of a cable.

The correction stream for some other positioning solutions, such as SBAS (WAAS/EGNOS/MSAS) and the OmniSTAR service¹, is broadcast through geostationary satellites, and detected by the GPS antenna itself. No integrated radio or base station is required.

Rover receiver components

The rover receiver has the following components:

- GPS receiver
- GPS antenna
- Optional integrated radio receiver and antenna for RTK operations
- Optional items for the different mounting options (see below)

In most rover applications, the receiver operates entirely from its own integrated battery unit. On a vehicle or on a marine vessel, however, an external power supply can be used. Use an external power supply if one is provided. The internal battery then acts as a uninterruptible power supply, covering any external power failures.

¹: OmniSTAR is available only with the SPSx50 and SPSx51 Modular GPS receivers.

Choose a rover receiver according to the needs of the job:

- A Smart GPS antenna, such as the SPSx80 or SPSx81, incorporates the GPS receiver, GPS antenna, power supply, and receive radio into a single compact unit. A Smart GPS antenna can be rapidly set up on a pole, vehicle, or backpack. This makes it easy to carry when you are measuring around the jobsite.
- A Modular GPS receiver, such as the SPSx50 or SPSx81, incorporates the GPS receiver, receive radio, and power supply into a single unit. The GPS antenna and, optionally, the receive radio antenna, is separate from the receiver. When you use a modular GPS receiver as a rover, you can use optimized components placed in the best locations for your application. For example:
 - A small, lightweight rover antenna can be mounted on a pole or backpack; placed in a high, inaccessible location on a marine vessel mast or cabin; or placed on a site vehicle roof or truck bed.
 - A rubber duck radio antenna, or an external radio antenna, can be mounted on a vehicle or vessel roof to provide maximum coverage.

A Modular GPS receiver can be placed in a location that is both easily accessible and safe from theft and the weather. The antennas can be placed high on a vehicle or vessel roof, clear of obstructions and able to deliver maximum performance.

Rover receiver setup guidelines

For good rover operation, observe the following setup guidelines:

- Place the GPS antenna in a location that has a clear line of sight to the sky in all directions. Do not place the antenna near vertical obstructions such as buildings, deep cuttings, site vehicles, towers, or tree canopy. GPS rovers and the base station receive the same satellite signals from the same satellites. The system needs five common satellites to provide RTK positioning.
- Place the GPS and radio antennas as high as possible to minimize multipath from the surrounding area. The receiver must have a clear line of sight to the sky at all times during operation.
- GPS satellites are constantly moving. Because you cannot measure at a specific location now does not mean that you will not be able to measure there later, when satellite coverage at the location improves. Use GPS planning software to identify the daily best and worst satellite coverage times for your location and then choose measurement times that coincide with optimal GPS performance. This is especially important when operating in the worst GPS locations. The Trimble Planning software is on the *Trimble SPS GPS Receiver CD* included with the receiver. You can also download the Trimble Planning software from the Trimble website (www.trimble.com/planningsoftware_ts.asp).

- The SPS850 Extreme/SPS851 Extreme and the SPS880 Extreme/SPS881 Extreme can track the GPS L2C modernization signal. Additionally, these receivers can track the GPS L5 modernization signal and some receivers can also track the GLONASS satellite constellation (for more information, see [GPS satellite signal tracking, page 75](#)). These signals help you to get positions at the worst times of the day and in the worst GPS locations, but do not guarantee that you will.
- To get a fixed position solution with centimeter accuracy, initialize the rover receiver. For initialization to take place, the receiver must track at least five satellites that the base station is also tracking. In a dual-satellite constellation operation, for example, GPS and GLONASS, the receiver must track at least six satellites.
- To maintain a fixed position solution, the rover must continuously track at least four satellites that the base station is also tracking. In a dual-satellite constellation operation, for example, GPS and GLONASS, the receiver must track at least five satellites. The radio link between the base and rover receivers must also be maintained.
- Loss of the satellite signals or loss of the radio link results in a loss of centimeter position accuracy. From Fixed, the receiver changes to Float or Autonomous mode:
 - In Float mode, the rover has connection to the base station through a radio, but has not yet initialized.
 - In Autonomous mode, the rover has lost radio contact with the base station receiver, and is working by itself with the available GPS signals.
- On a vehicle or marine vessel, place the GPS antenna in a location as free from shock and vibration as possible. For the modular GPS receivers, a single magnetic mount is normally sufficient to hold the antenna in a suitable location, whereas for the larger smart antenna, a triple magnetic mount is normally recommended. Good alternatives include a 5/8" thread bolt in a suitable location on the roof bars, or a door-mounted pole bracket.



CAUTION – The SPS880 Extreme and SPS881 Extreme are not suited to on-vehicle operation where it will be subject to heavy vibration, that is, operation in rough ungraded terrain. Use in these conditions can damage the receiver.

- To mount the modular GPS receiver on a pole, use two pole mounting brackets and a second tripod clip (P/N 571 204 300). See [Figure 4.1](#).



Figure 4.1 Rod mount for a modular GPS receiver

To mount the modular GPS receiver on a marine vessel, use the receiver bracket (P/N 56830-00). For marine moving base and heading applications, use the receiver bracket to mount two receivers together.

- Make sure that the rover receiver does not lose power. An SPSx50 or SPSx51 is typically powered by its internal battery. You cannot change the battery, but the charge typically lasts for longer than a working day. The batteries in the SPSx80 or SPSx81 can be changed when flat. (See [Chapter 3, Batteries and Power](#)). If you do not use the rover receiver very often, ensure that it is charged at least every three months. For vehicle operation or marine vessel operation, Trimble recommends that you use an external power source so that the internal battery can be saved for times when the receiver is being used off the vehicle or vessel.
- Do not locate the receiver or antenna within 400 meters (about 1,300 ft) of powerful radar, television, cellular communications tower, or other transmitters or GPS antennas. Low-power transmitters, such as those in cellular phones and two-way radios, normally do not interfere with receiver operations. Cellular towers can interfere with the radio and can interfere with GPS signals entering the receiver. This does not harm the receiver, but it can prevent the receiver electronics from functioning correctly.
- Do not use the rover receiver directly beneath or close to overhead power lines or electrical generation facilities. The electromagnetic fields associated with these utilities can interfere with GPS receiver operation. Other sources of electromagnetic interference include:

- gasoline engines (spark plugs)
 - televisions and computer monitors
 - alternators and generators
 - electric motors
 - equipment with DC-to-AC converters
 - fluorescent lights
 - switching power supplies
- Trimble recommends that, wherever possible, all GPS receiver equipment is protected from rain or water. Although, the receivers are designed to withstand all wet weather conditions, keeping the receivers dry prolongs the life of the equipment and reduces the effects of corrosion on ports and connectors. If the equipment gets wet, use a clean dry cloth to dry the equipment and then leave the equipment open to the air to dry. Do not lock wet equipment in a transport case for prolonged periods. Wherever possible, avoid exposing the GPS receiver to corrosive liquids and salt water.
 - If you are using the rover receiver in open spaces, Trimble recommends that you stop work during electrical storms where the risk of lightning strike is high.
 - Where cables are involved, Trimble recommends that you use cable ties to secure the cables to the rod or other equipment to avoid inadvertent snagging while moving about the jobsite. Be careful not to kink, twist, or unnecessarily extend cables, and avoid trapping them in vehicle doors or windows. Damage to cables can reduce the performance of GPS equipment.

Internal radio setup for rover operations

The internal radio of the SPS GPS receiver is delivered with the transmit (Tx) radio frequencies preprogrammed into the receiver. To add receive (Rx) radio frequencies to 450 MHz radios, use the WinFlash utility (see [Appendix C, Adding Internal Radio Frequencies](#)). Radio frequencies cannot be added to the 900 MHz radios.

Once the radio frequencies are configured, use the controller or receiver to select channel frequencies during base station or rover setup operations.

Cellular modem and external radio

Instead of the internal radio, you can use a cellular modem or an external radio as your data communications link.

To connect a cellular modem to a Smart GPS antenna, you need the following:

- Smart GPS antenna
- One of the following:
 - TSC2 controller with CompactFlash card cellular modem, for example, a Audiovox modem card

- Cellular modem or a cellular phone that can transmit data
- Serial (cell phone to DB9) cable (supplied with the cellular modem or phone).
- Port 2 of the Smart GPS antenna supports full RS-232 protocol, and should function properly with most cell phone cables. Some cellular units may require custom cabling.

Alternatively, the receiver also supports a cable-free Bluetooth connection with Bluetooth-enabled cell phones.

For more information on using a cellular modem as a data link, refer to the *SCS900 Site Controller Software Getting Started Guide* and *SCS900 Site Controller Software Office Guide*.

Setting up the Receiver

In this chapter:

- Connecting the receiver to external devices
- Common ways to set up a base station
- Common ways to set up a rover receiver

In this chapter, recommendations for setting up the receiver as a base station or for rover operations are provided. The recommendations cover a variety of common use scenarios.

Note – This chapter provides setup information for all the receivers in the SPS GPS receiver family.

Connecting the receiver to external devices

You can connect a Smart GPS antenna to the following devices:

- a Trimble controller running the Trimble SCS900 Site Controller software
- an external radio-modem

Trimble controller with SCS900 Site Controller software

You can operate an SPS GPS receiver with any Trimble controller, for example, a TSC2 or TCU controller, that is running the SCS900 software. Typically, the receiver and the controller operate from their own individual power sources. The receiver and controller can communicate through Bluetooth wireless technology and can be connected without a cable. However, if a cable is required, [Table 5.1](#) shows how to connect the cables for each combination of SPS GPS receiver and Trimble controller.

Table 5.1 Connecting to a Trimble controller running the SCS900 Site Controller software

To connect a ...	Use cable part number ...	Use this cable connector ...	and connect the cable to ...
SPSx50 or SPSx51 Modular GPS receiver to a ...			
TSC2	59046	DB9	TSC2
		Lemo	SPSx50 or SPSx51
	59043	DB9	TSC2
		DB9	SPSx50 or SPSx51
TCU	53004007	6-pin Hirose	TCU
		Lemo	SPSx50 or SPSx51
	53002007	6-pin Hirose	TCU
		DB9	SPSx50 or SPSx51
TSCe™	31288-xx ¹	Lemo	TSCe
		Lemo	SPSx50 or SPSx51
ACU	44147	4-pin Hirose	ACU
		Lemo	SPSx50 or SPSx51
SPSx80 or SPSx81 Smart GPS antenna to a ...			
TSC2	59046	DB9	TSC2
		Lemo (Port 1)	SPSx80 or SPSx81
	59043	DB9	TSC2
		DB9	SPSx80 or SPSx81
TCU	53004007	6-pin Hirose	TCU
		Lemo (Port 1)	SPSx80 or SPSx81
	53002007	6-pin Hirose	TCU
		DB-9	SPSx80 or SPSx81
TSCe	31288-xx ¹	Lemo	TSCe
		Lemo (Port 1)	SPSx80 or SPSx81
ACU	44147	4-pin Hirose	ACU
		Lemo	SPSx80 or SPSx81

¹This cable is available in different lengths. The -xx indicates the length of the cable, in meters.

External radio-modems

The most common data link for Real-Time Kinematic (RTK) operation is a radio. The Smart GPS antenna is available with the following internal radios:

- 410 – 430 MHz (Tx/Rx, Rx only, or Tx only)
- 430 – 450 MHz (Tx/Rx, Rx only, or Tx only)
- 450 – 470 MHz (Tx/Rx, Rx only, or Tx only)
- 900 MHz (Rx only)

Note – “Tx” indicates that the radio transmits corrections. “Rx” indicates that the receiver receives corrections. “Tx/Rx” indicates that the radio both transmits and receives corrections.

If the Smart GPS antenna does not have an internal transmit radio, or you want to connect to a higher powered external transmit radio or cellular modem, use the DB9 port, the Lemo port, or Bluetooth wireless technology.

The SPSx80 and SPSx81 Smart GPS antennas support the following Trimble base radios:

- SiteNet™ 450
- TRIMMARK 3
- TRIMTALK™ 450
- Trimble SNB900
- Trimble PDL450
- Trimble HPB450

The Smart GPS antenna also supports third-party transparent radios and third-party cellular modems.

To use an external radio with the Smart GPS antenna, you need an external power source for the radio—except for the SNB900 radio, which contains an internal battery. To configure the radio modem separately, use the external radio’s configuration program, or display and keypad.

Common ways to set up a base station

You can set up a base station in different ways depending on the application, coverage area, degree of permanence versus mobility, and available infrastructure. Before you set up a base station, please read [Chapter 4, Setup Guidelines](#).

Setting up a base station for permanent or semi-permanent installation

For construction applications, where machine and site positioning operations using GPS will be carried out over a long time (weeks, months, or years), ensure that you choose the base station location carefully.

A semi-permanent or permanent base station helps to eliminate the types of error that can result from repeated daily setups, and ensures that you always use the GPS antenna at the exact original location. The requirement for a permanent base station setup increases as more receivers that use the base station as a source of corrections, increases the cost of any base station downtime.

On the largest jobsites, and on those that remain operational for the longest time, a permanent or semi-permanent installation is a popular solution. A modular GPS receiver is typically used as the base station, located in a site office or trailer where it is easy to access (to check or configure), and where it is secure from theft and the weather. The GPS and radio antennas are normally mounted on a permanent structure on the roof of the building, where they are high and clear from obstructions and where the radio antenna can provide the maximum range of operation.

Trimble recommends that you use the Trimble Zephyr Geodetic™ Model 2 GPS antenna. This antenna has a large ground plane that reduces multipath, providing the best GPS performance at the base location. The antennas are connected to the receiver by high quality RF cables.

The receiver is connected to a permanent power supply (mains or generator power). The internal battery of the receiver is always being charged, and acts as an uninterruptible power supply if there is a power failure. In some cases, the receiver may also be connected by an Ethernet cable to the Internet, so that it can be monitored and configured from a remote location, and can warn an administrator by e-mail or text message if there is a change to the configuration or status. In these situations, the receiver can transmit GPS RTK corrections to a remote radio or receiver over the Internet, for rebroadcast requirements, without using repeaters.



Figure 5.1 SPSx50 receiver permanent installation

Setting up a base station for daily site use: T-Bar

For construction applications where a daily setup and takedown of equipment is required for security reasons, Trimble recommends that you use a T-Bar setup.

The T-Bar consists of a post mounted in concrete (so it cannot move), which has a solid metal T-Bar mounted to it to provide lateral and vertical separation between the GPS antenna and radio antenna. The T piece of the T-Bar has a vertical rod at each end. Each end terminates in a 5/8"×11 thread to which the antennas can be mounted. Trimble recommends that one end is clearly marked **GPS** and the other end is clearly marked **Radio** so that at each daily setup, the GPS and radio antennas are mounted at the same location. Switching antennas by mistake introduces a position error in all resulting measurements. You can buy the parts you need to make a T-Bar from any reputable hardware store. Make certain that the T-Bar cannot rotate after construction. Rotation of the T-Bar can introduce a position error into all subsequent measurements.

On the upright post, mount either a bracket (to which the GPS receiver can be mounted), or a well-ventilated lockbox (in which the GPS receiver itself can be secured).

Each day, mount the GPS antenna on the **GPS** end of the T-Bar and the radio antenna on the **Radio** end of the T-Bar. Connect the antennas to the receiver using the appropriate cables. The receiver uses its own integrated battery, or an external 12 V battery through the 12 V crocodile clips cable that are provided with the receiver. If you choose to use AC power, remember that the heat generated by the charging process and the radio transmitter increases the need for good ventilation around the receiver.

In such scenarios, an SPSx80 Smart GPS antenna is also often used. Simply mount the SPSx80 on the T-Bar, and optionally connect to an external battery or radio unit.

Advantages

Use of a T-Bar setup ensures that the base station is set up with exactly the same position and height every day. This helps eliminate the errors typically associated with daily tripod setup. For example, wrong antenna height, base not set up over the point, base set up in the wrong location.

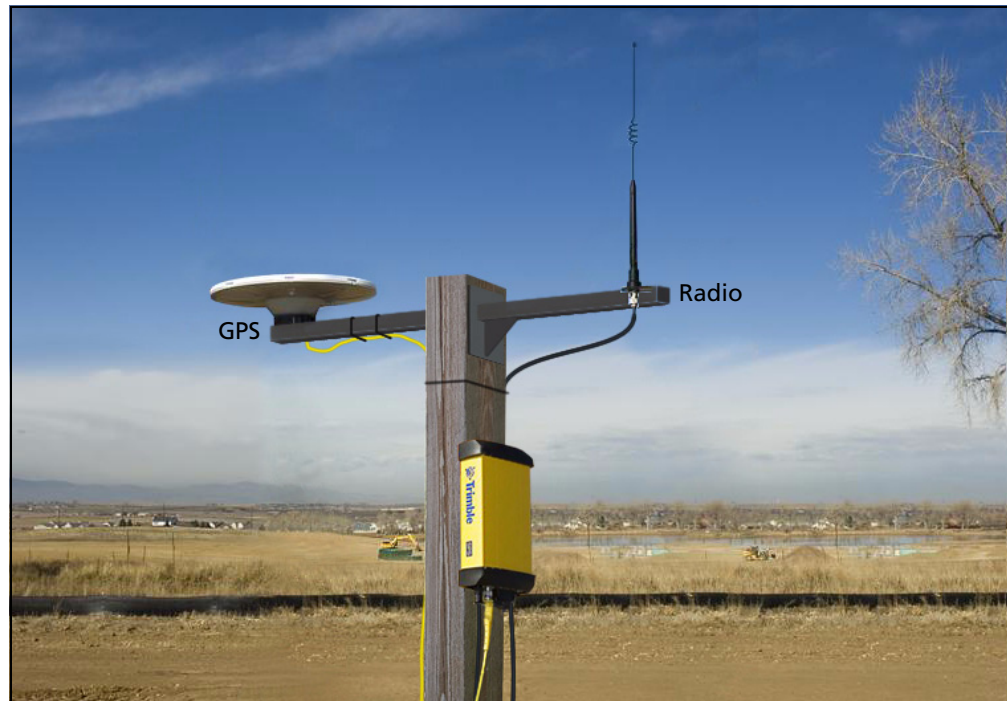


Figure 5.2 System set up on a T-bar showing an external radio antenna to gain longer range

Setting up a mobile base station: Tripod and fixed height tripod

If you are repeatedly moving between jobsites, or if you are visiting a jobsite for the first time before a T-Bar or similar setup can be established, Trimble recommends that you use either a tripod and tribrach setup, or a fixed height tripod.

The fixed height tripod is quicker and easier to set up over a control point. It allows you to re-establish the antenna height exactly so the receiver can be set up faster without using the SCS900 software or without needing to enter a revised antenna height in the

receiver front panel. Take great care to ensure that the GPS antenna is set up accurately over the control point, and that the GPS antenna height is measured accurately, in the right way (vertical or slope height) to the right location on the antenna (base of antenna or to a specified location on the antenna). When you start the rover receiver, it is extremely important to check in, at one or more known locations, to check for possible position or height errors. Checking in at a known location is good practice and can avoid costly errors caused by a bad setup.

Typically, the tripod and fixed height tripod methods do not give significant height clearance above the ground, and can reduce the range of operation caused by radio limitations.

Tripod and tribrach setup

In the tripod setup, the tripod is located over the control point, and the tribrach and tribrach adaptor is mounted on the tripod and centered over the point.

1. Mount the GPS antenna on the tribrach adaptor.
 - If you are using a Smart GPS antenna, use the 25 cm spacer rod provided with the Base Station Accessory kit. This allows the radio antenna in the receiver to clear the head of the tripod.
2. Clip the GPS receiver to the tripod (Modular GPS receiver only).
3. Connect the GPS antenna to the receiver using the appropriate cable (Modular GPS receiver only).
4. If necessary, connect the GPS receiver to an external 12 V power supply. Use the crocodile clip cable or the Trimble custom power pack.



Figure 5.3 Tripod and tribrach setup

Fixed height tripod setup

A fixed height tripod setup is similar to a tripod setup, but is simplified by the central leg of the tripod, that is placed directly on the control point. If the central leg is leveled accurately, the fixed height tripod is quick and easy to set up, and provides an accurate way to measure the true antenna height.

1. Set up the tripod over the control point.
2. Attach the GPS antenna to the head of the tripod.
3. If using an external high-gain radio antenna, mount the radio antenna to the radio antenna bracket that is attached to the head of the tripod (beneath the GPS antenna). See [Figure 5.4](#).
4. If using the SPSx50 or SPSx51 Modular GPS receiver, hook the receiver to the center leg of the tripod, using the tripod clip.
5. If using the SPSx80 or SPSx81 Smart GPS antenna, you can mount the antenna using the 25 cm spacer rod (supplied with the SPSx80 or SPSx81 Base Station Accessory kit) so that the radio antenna clears the head of the tripod.

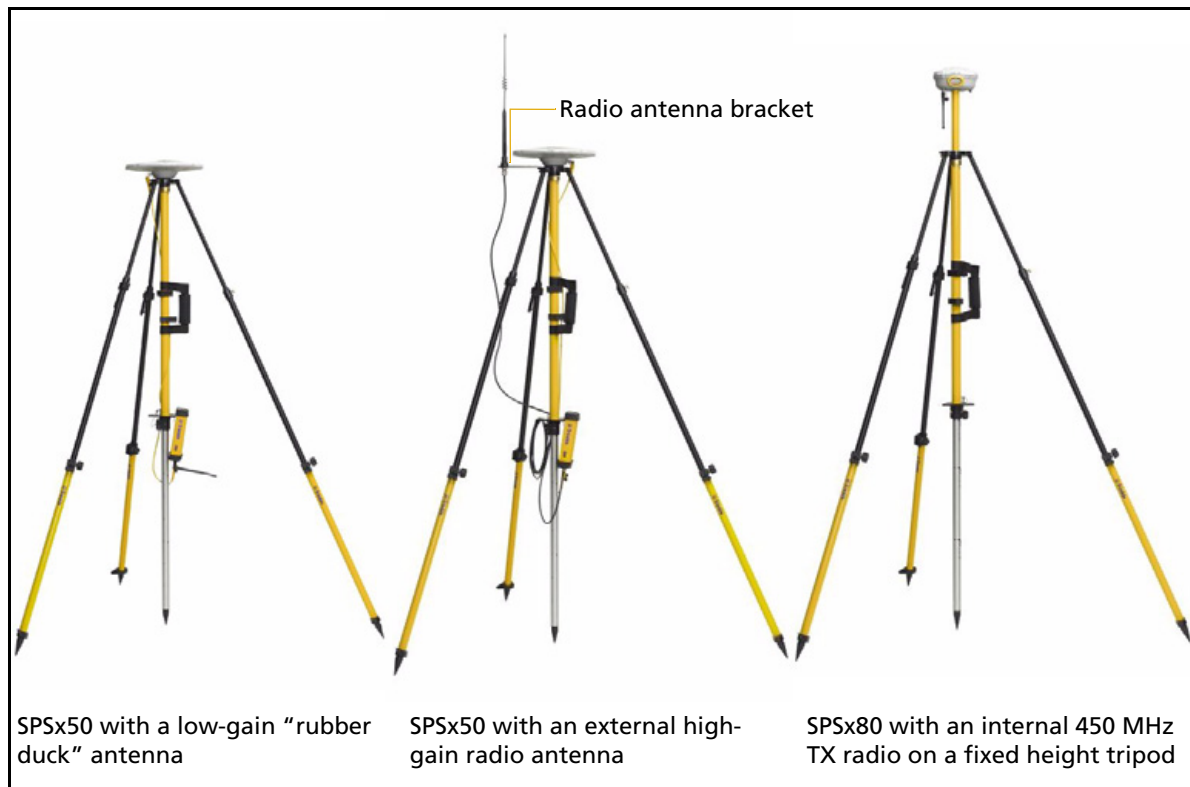


Figure 5.4 Fixed height tripod setup

Common ways to set up a rover receiver

You can set up a rover receiver in different ways depending on the application. The components that make up a rover receiver are:

- GPS receiver
- GPS antenna
- controller/computer
- rod mounting equipment, including a rod, receiver bracket, and controller bracket
- vehicle mounting equipment, including a suction cup and ball joint, extension arm, controller bracket, magnetic antenna mount, and necessary cables.
- backpack equipment, including backpack and antenna-mounting rod
- marine vessel mounting equipment, including receiver bracket, cables, antenna, and radio antenna brackets.

Setting up the rover receiver on a jobsite vehicle



CAUTION – This following rover setup is suited only to offroad (jobsite) vehicle use. Do not use this method on a vehicle that is driven at speed or in traffic.

1. Do one of the following, depending on your receiver:
 - SPSx50 or SPSx51: Mount the GPS antenna for the receiver on the roof of the vehicle. Use a single magnetic mount or a 5/8"×11 thread bolt attached to the roof bars. Run the GPS antenna cable for the receiver into the vehicle either through a rubber grommet in the roof, or through the passenger door window, which needs to be left slightly open during operation.
 - SPSx80 or SPSx81: Mount the Smart GPS antenna on the roof of the vehicle. Use a triple magnetic mount or a 5/8"×11 thread bolt attached to the roof bars.

2. Place and secure the GPS receiver in a convenient location in the vehicle.

The GPS receiver can be controlled through the controller connected using Bluetooth wireless technology.

If the receiver is not connected to vehicle power, then the receiver needs to be accessed only to turn it on at the start of each measurement session. It may be more convenient if the SPSx50 or SPSx51 is placed in a location where the vehicle operator can see the keypad and display, to monitor receiver status and to configure settings as required. Most receiver capability can be controlled using the SCS900 Site Controller software.

3. Attach the suction cup to the front windscreen, dashboard, or other convenient location in the vehicle, making sure that it does not obstruct the driver's view.
4. Attach the RAM extension arm to the suction cup, and the controller bracket to the RAM extension arm.
5. Lock the controller into the controller bracket and then adjust the bracket until the controller is in the most convenient location. Make sure that the controller does not restrict visibility through the front windscreen during vehicle use.
6. Lock the brackets so that the controller is held securely. If required, connect either the GPS receiver or the controller to an in-vehicle power supply as needed.



Figure 5.5 Configuring an SPSx50 from the cab. A Zephyr Model 2 antenna is mounted on the roof.

Setting up the rover receiver on a rod

For rod-based operation, mount the SPSx50 or SPSx51 Modular GPS receiver as follows:

1. Mount the two rod brackets on the rod.
2. Tighten the top bracket, making sure that it is at a convenient height for the receiver.
3. Place the receiver in the slot in the rod bracket, and secure with the tripod clip.
4. Move the lower rod bracket down until it is over the second tripod clip on the receiver and then tighten the rod bracket onto the rod. The receiver is held in place between the two brackets.
5. Insert the controller into the controller bracket as shown opposite.
6. Use the 5/8" thread to attach the GPS antenna to the top of the rod.
7. Use the GPS antenna cable to connect GPS antenna to the receiver.



For rod-based operation, mount the SPSx80 or SPSx81 Smart GPS antenna as follows:

1. Mount the receiver on the top of the rod using the 5/8"×11 thread in the base of the SPSx80 or SPSx81.
2. Insert the controller into the controller bracket.
3. The SPSx80 or SPSx81 and controller communicates through Bluetooth wireless technology. However, if a cable is required, connect the cable between the controller and receiver (see [Figure 5.6](#) through [Figure 5.7](#)).



Figure 5.6 Connections for a rover SPSx81 setup, a TSC2 or TCU controller, and a 450 MHz base station



Figure 5.7 Cabled connections for an SPSx81 setup, a TSC2 or TCU controller, and a 900 MHz base station (with external power)

Setting up a rover receiver on a belt or in a backpack

If you prefer to work free of the weight of the receiver on a pole, you can mount the rover receiver on a belt (SPSx50 or SPSx51 only) or carry it in/on a backpack (all receivers). When you wear the receiver on a belt, ensure that the display is always visible so that you can easily check the status of the receiver. If you carry the receiver in a backpack, use an external radio antenna mount to allow for optimal radio signal reception. If you use a low gain antenna mounted directly on the receiver in a backpack, it may affect the radio signal reception and reduce the likelihood of obtaining an RTK Fixed solution.

Configuring the Receiver Settings

In this chapter:

- Using the SCS900 Site Controller software to configure the base station, the rover, and the radios
- Configuring the receiver to log data for postprocessing
- Configuring the receiver in real time
- Configuring the receiver using application files
- Creating and editing the configuration files that control the receiver

You can configure the Smart GPS antennas in a variety of ways. This chapter describes the different configuration methods, and explains when and why each method is used.

The Smart GPS antenna has no controls for changing settings. To configure these receivers:

- In real time, use external software such as the *HYDROpro*[™] software, or the GPS Configurator or WinFlash utility.
- In an application file, use the Configuration Toolbox utility.

The SCS900 Site Controller software is likely to be your main tool to set up and operate the receiver on a daily basis. All necessary field configurations are handled through the SCS900 software running on a TSC2 or TCU controller. For more information, refer to the *Trimble SCS900 Site Controller Software Getting Started Guide* or the *Trimble SCS900 Site Controller Software Office Guide*.

The external software detailed in this chapter is primarily used to update the receiver firmware and to configure upgrades or radio channels.

Using the SCS900 Site Controller software to configure the base station, the rover, and the radios

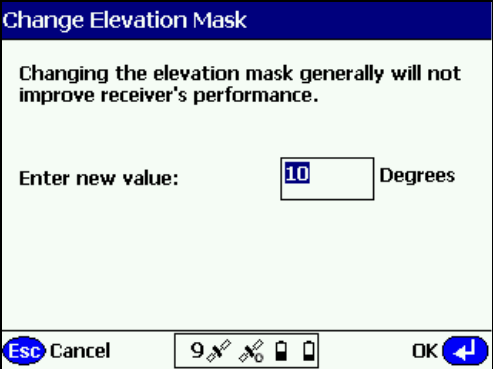
As part of a total system solution for construction applications, the SPS GPS receivers are operated by a TSCe, ACU, TCU, or TSC2 controller running the SCS900 Site Controller software. The SCS900 Site Controller software provides the tools to configure and start the GPS receiver in the modes used by the SCS900 system: RTK Base Station, RTK Rover, DGPS Rover, OmniSTAR rover, SBAS Rover (using WAAS/EGNOS/MSAS). Wizards help you through the process and, where possible, assign suitable default operational parameters to the system. This eliminates the need for an operator to know how to configure the receiver with the right settings.

The SCS900 Site Controller software manages:

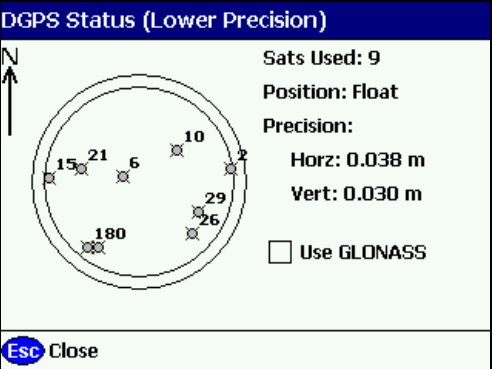
- the radio, whether internal or external
- all cellular communications components, such as modems and cell phones
- the use of the Bluetooth wireless technology

The software also scans communication ports on the receiver to identify connected devices. If the software cannot automatically identify the connected component, for example, a GPS antenna, it offers options (often with graphics) to help you manually select the correct component.

The SCS900 Site Controller software allows you to set operational tolerances and settings (such as those shown below), which must be achieved before measurements can be accepted. When outside of these tolerances, the SCS900 Site Controller software warns you through on-screen messages or indications, and the non-automatic acceptance of recorded positions. To set operational tolerances, go to the *Settings* menu in the SCS900 Site Controller software.



Example 1: From the Sky Plot screen, press Ctrl+M to open this screen and change the angle below which the receiver will not track satellites



Example 2: Use the Sky Plot screen to set if the receiver will track GLONASS satellites

Configuring the receiver to log data for postprocessing

The receivers do not come equipped with the Data Logging option. The receivers can have this added either at the time of purchase, or at a later date as an option. With the Data Logging option enabled, the receiver has available memory that facilitates the collection of GPS observations over a period of time, and that can be used with GPS postprocessing software such as the Trimble Geomatics Office™ for the computation of control networks and baselines.

***Note** – The SCS900 system does not support postprocessed applications. Trimble recommends that you use the front panel keypad and display, or the Web User Interface (SPSx50 and SPSx51 only), or the GPS Configurator software (SPSx80 and SPSx81 only) to configure the receiver for postprocessed measurement sessions.*

Configuring the receiver in real time

The SPSx80 and SPSx81 Smart GPS antennas can be configured in real time by the GPS Configurator software.

When you configure the receiver in real time, you use the software to specify which settings you want to change. When you apply the changes, the receiver settings change immediately.

Any changes that you apply to the receiver are reflected in the current application file, which is always present in the receiver. The current application file always records the most recent configuration, so if you apply further changes (either in real time or using an application file) the current file is updated and there is no record of the changes that you applied originally.

Configuring the receiver using application files

An application file contains information for configuring a receiver. To configure a receiver using an application file, you need to create the application file, transfer it to the receiver and then apply the file's settings. The GPS Configurator software does this automatically when you work with configuration files.

Overview

An application file is organized into records. Each record stores configuration information for a particular area of receiver operation. Application files can include the following records:

- File Storage
- General Controls
- Serial Port Baud Rate/Format
- Reference Position

- Logging Rate
- SV Enable/Disable
- Output Message
- Antenna
- Device Control
- Static/Kinematic
- Input Message


An application file does not have to contain all of these records. When you apply an application file, any option that is not included in the records in the file remains at its current setting. For example, if you apply an application file that only specifies the elevation mask to use, all other settings remain as they were before the application file was applied.

You can store up to twenty different application files in the receiver. You can apply an application file's settings at the time it is transferred to the receiver, or at any time afterwards.

Special application files

The receiver has three special application files, which control important aspects of the receiver's configuration.

Default application file

The default application file (Default.cfg) contains the original receiver configuration, and cannot be changed. This file configures the receiver after it is reset. You can reset the receiver by pressing  for at least 15 seconds, or by using the reset option in the GPS Configurator software.

For more information, see [Chapter 8, Default Settings](#).

Although you cannot change or delete the default application file, you can use a power up application file to override any or all of the default settings.

Current application file

The current application file (Current.cfg) reflects the current receiver configuration. Whenever you change the receiver's configuration, either in real time or by applying an application file, the current file changes to match the new configuration.

You cannot delete the current file or change it directly, but every change to the receiver's current configuration is applied to the current file as well.

When you switch off the receiver then turn it on again, all the settings from the current application file are applied, so you do not lose any changes that you have made. The only exceptions are the following logging parameters:

- Logging rate

- Position rate
- Elevation mask

These parameters are always reset to the factory default values whenever the receiver is switched off.

Power Up application file

The power up application file (Power_up.cfg) is used to set the receiver to a specific configuration any time the unit is powered up.

In this file, you can specify that the receiver is reset to defaults before the power up settings are applied. This ensures that restarting the receiver always resets it to factory defaults prior to applying the power up application file.

Alternatively, you can specify that the power up settings are applied immediately after the current application file's settings have been applied. Restarting the receiver results in a configuration that uses your default settings for the options you define in the power up file, but the current settings for all other options.

By default, there is no power_up application file on the receiver. To use a power up application file, you must create and save a power_up application file in the GPS Configurator software. If you save this file to disk, the file is called power_up.cfg. The extension .cfg is used, by convention, to identify application files on the office computer. When you transfer this file to the receiver, the file is saved on the receiver as power_up, and becomes the new power up file.

Applying application files

An application file's settings do not affect the receiver's configuration until you *apply* the application file. You can do this at the same time that you save the file.

Alternatively, you can save the file on the computer or in the receiver, then open it later and apply its settings.

Storing application files

You can store application files that you create in the GPS Configurator software on the receiver and on the computer. For example, each file can represent a different user sharing the same receiver, or a particular mode of operation. Saving application files on your computer as well as in your receiver is optional, but it is useful because:

- it gives you a permanent copy of the settings you have sent to a receiver, for audit or your own reference.
- you can use the same file to configure multiple receivers identically.
- you can use an existing application file as a template to create other application files with similar settings.

Naming application files

The application filename in the office computer and in the receiver are always the same. This makes it easier to recognize and keep track of your application files.

When you change the name of the application file in the receiver, this changes the application filename on your computer. When you transfer an application file from the receiver and save it to the computer, the system renames the file to match the internal receiver file. However, if you use Windows Explorer, for example, to change the .cfg filename on the computer, this **does not** change the internal receiver filename. This means that the GPS receiver does not recognize the change to the filename on the computer.

Creating and editing the configuration files that control the receiver

The Configuration Toolbox software enables you to create and edit GPS receiver configuration files. The settings in these files control the operation of the GPS receiver. The GPS receiver configuration file can then be copied and sent to the receiver.

You can also create a file, called an application file or *appfile*, (*.cfg), which contains all the receiver settings necessary for a particular job or application. Application files can be stored on both the receiver and computer. Multiple files can be maintained to represent multiple users sharing a device and/or multiple modes of operation. You can also save files to audit the operating settings of a receiver.

For applications requiring real-time positions in any coordinate system other than WGS-84, you need the Configuration Toolbox software to define and transfer the necessary coordinate system and transformation parameters.

A maximum of ten files can be stored in the receiver. This includes the files *default.cfg* and *current.cfg*, which always reside in the receiver.

Note – *If you use the SCS900 Site Controller software in the field, you do not need to use the Configuration Toolbox software to set up the transformation parameters. This is done through the Site Calibration process in the SCS900 software.*

Installing the Configuration Toolbox software

You can install the Configuration Toolbox software from the *Trimble SPS GPS Receiver CD* that is shipped with your receiver, or download it from the Trimble website.

The Configuration Toolbox software requires one serial port dedicated to receiver communications.

Installing new versions of the Configuration Toolbox software updates the Coordinate System Library. If you have calibrated sites stored on your computer, save them as receiver configuration files. This ensures that the coordinate system information for particular sites are not overwritten.

Installing new versions of the Configuration Toolbox software into a directory containing a previous version overwrites the older program and data files. By default, application files located in the root installation folder, C:\TOOLBOX, are moved to the APPFILE\ subfolder.

The installation program creates the subfolders shown in [Table 6.1](#) within the installation folder.

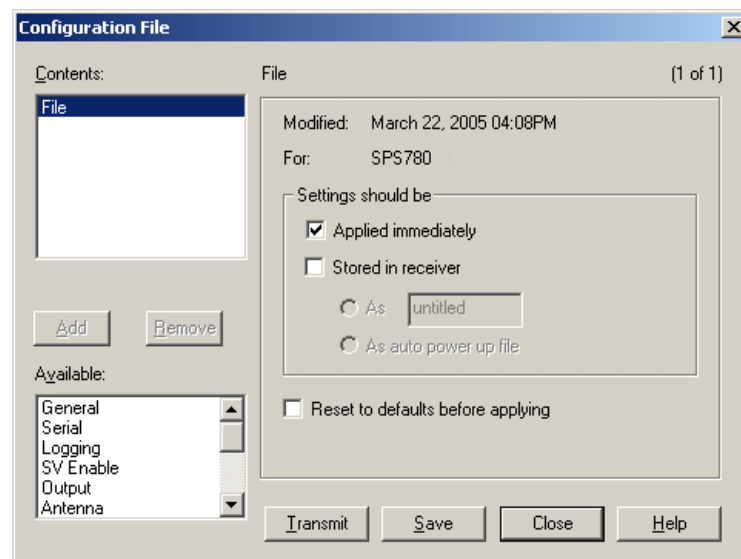
Table 6.1 Subfolders within the installation folder

Subfolder	Description
bin\	Contains the Configuration Toolbox executable file (ctoolbox.exe) and dynamic link libraries (*.dll).
appfiles\	This is the preferred directory for storing application files. Existing application files from earlier versions of Configuration Toolbox are moved here during the installation.
cseditor\	Contains the Coordinate System Editor executable file (cseditor.exe), dynamic link libraries (*.dll), and help files.
geolib\	Contains the geodetic database files used by the Configuration Toolbox software and the Coordinate System Editor software.

Configuring the receiver using the Configuration Toolbox software

1. Select *Start / Programs / Trimble / Configuration Toolbox*.
2. Select *File / New / Construction / SPS78x or SPS88x*.
3. Make the appropriate selections for your receiver settings. For more information, see the Help and the *Configuration Toolbox User Guide*.
4. To save the application file, select *File / Save As*.

Make sure that you specify the same 8-character file name when you save the file both in the computer and on the receiver, as shown in the *Configuration File* dialog:



Transmitting the application file to the receiver

1. Connect the data/power cable (P/N 32345 or 59044 (RoHS compliant)) to the receiver and the computer.
2. Connect the O-shell Lemo connector to the receiver port.
3. Connect the female DB9 connector to the computer.
4. Connect the power leads of the data/power cable to the power supply.
5. To open the application file you require, select *File / Open*.
6. With the file open and the *Configuration File* dialog open, select *Communications / Transmit File*.

A message appears when the application file is successfully transmitted. If an error occurs, select *Communications / Transmit File* again. This overrides any incompatibility in baud rates and enables successful communication.

To check the successful transmission, close the *Configuration File* dialog and then select *Communications / Get File*. A list of all application files in the receiver appears.

If you clicked **Apply Immediately** in the application file, the new file will be the current file.

To change files, select the required file from the list and then select *Communications / Activate File*.

AutoBase Feature

In this chapter:

- Setting Up a Base Station
 - Best practice
 - Antenna type
- Scenarios
 - Scenario One: Base station setup on first visit to a site
 - Scenario Two: Base station setup on a repeat visit to that site
 - Scenario Three: The stored base station position seems to be missing
- AutoBase process

The Trimble SPS781, SPS880 Extreme, and SPS881 Extreme Smart GPS antennas feature AutoBase™ technology, which provides the following advantages:

- Reduced risk of a setup that uses incorrect base station coordinates.
- Reduced daily setup times for a mobile base station. When you use an SPS781, SPS880 Extreme, or SPS881 Extreme Smart GPS antenna as a base station receiver, you do not need to reconfigure the receiver at the start of each day.

The AutoBase feature is a function of the version 3.x receiver firmware, which supports both GPS modernization (L2C and L5 signals) and GLONASS signals. You cannot turn off the AutoBase warning feature.

Note – With the SPS781, SPS880 Extreme, or SPS881 Extreme Smart GPS antenna, always start a base station setup by using the SCS900 Site Controller software to initialize the SPS880 Extreme Smart GPS antenna on a new point. See [page 62](#).

Please read this chapter even if you have used the AutoBase feature in other Trimble receivers. New functions now provide even greater benefits.

Setting Up a Base Station

The AutoBase feature influences how you set up an SPS781, SPS880 Extreme, or SPS881 Extreme Smart GPS antenna as a base station. Before the receiver can transmit RTK corrections (that is, operate as an RTK base station), the current position of the receiver must correspond to a previous base station position. The base station position—latitude, longitude, and height—must be part of the GPS site calibration.

Note – There is no need to configure the base station receiver settings manually.

1. To perform the **first** base station setup at a new location, always use the SCS900 Site Controller software to initialize the SPS781, SPS880 Extreme, or SPS881 Extreme Smart GPS antenna on a new point. You generally do this only once, the first time that you occupy the point, but see the Caution below.

When the base station setup is complete, the receiver generates and stores an application file that contains the parameters for that location.



CAUTION – When you perform a future base station setup at the same location, the receiver assumes that there has been no change to either the antenna height or the antenna height measurement method used previously. It is therefore essential that you keep the antenna height constant between setups.

If there is any risk that the antenna height might have changed, you must use the SCS900 Site Controller software to start (and so reset) the SPS781, SPS880 Extreme, or SPS881 Extreme Smart GPS antenna. From the SCS900 Site Controller software, select *Start Base Station*.

2. To perform a **future** base station setup at the same location, simply press the **Power** key on the receiver. The receiver turns on, determines its location, finds the appropriate application file, initializes the settings, and starts to broadcast RTK CMR+ corrections through the internal radio or through the external radio (whichever radio was used the previous time).

If the receiver uses an external radio, such as an SNB900 radio, the AutoBase feature raises the Bluetooth® wireless connection to the radio. If a Bluetooth connection is not used, the AutoBase feature searches the receiver communications ports for the external radio. When the receiver finds the external radio, the receiver transmits RTK CMR+ corrections to the radio.

Best practice

After each new base station setup, and at the start of every measurement session, Trimble recommends that you measure one known point to verify that the position and height errors are within tolerance. The measurement takes only a few seconds, but can eliminate the gross errors typically associated with daily base station setup.

Antenna type

The selected antenna type determines which options are available for determining the antenna height. The AutoBase feature uses an antenna type of “R8 Model 2/SPS880 Internal.”

Scenarios

These scenarios describe what you may experience when using AutoBase technology.

Note – The AutoBase Warning feature is always turned on in an SPS781, SPS880 Extreme, or SPS881 Extreme Smart GPS antenna.

Scenario One: Base station setup on first visit to a site

- You set up the base station receiver on a point that you **have not** previously used as a base station with that receiver.
 1. The receiver is powered on.
 2. The receiver begins tracking satellites.
 3. The receiver determines the current position.
 4. The receiver reviews the base positions stored in the receiver.
 5. The receiver does not find any base station that corresponds to the current position.
 6. The receiver will not begin transmitting RTK corrections and the radio LED will not flash.

No RTK corrections will be streamed until the base station is set up using the SCS900 Site Controller software.

Scenario Two: Base station setup on a repeat visit to that site

- You set up the base station receiver on a point that you **have** previously used as a base station with that receiver.
 1. The receiver is powered on.
 2. The receiver begins tracking satellites.
 3. The receiver determines the current position.
 4. The receiver reviews the base station positions stored in the receiver.
 5. The receiver finds a base station position that corresponds to the current position. A base station position is found, so the AutoBase warning is not displayed.
 6. The receiver loads the previous base information.



CAUTION – If there are two or more base positions within a 50 meter radius of your current position, the receiver will make the most recently created base position file active.

7. The antenna type, antenna height, and measurement method used in the previous setup of this base station are applied.



CAUTION – When you perform a future setup at the same location, the receiver assumes that there has been no change to either the antenna height or the antenna height measurement method used previously. It is therefore essential that you keep the antenna height constant between setups.

If there is any risk that the antenna height might have changed, you must use the SCS900 Site Controller software to start (and so reset) the SPS781, SPS880 Extreme, or SPS881 Extreme Smart GPS antenna. From the SCS900 Site Controller software, select *Start Base Station*.

8. The receiver begins generating RTK CMR+ corrections.
9. The RTK corrections begin streaming on the radio or port defined in the previous setup of this base station.

Scenario Three: The stored base station position seems to be missing

- You set up the base station receiver on a point that you *have* previously used as a base station, as in Scenario Two. But for some reason, the stored base station position is not found in the receiver. Someone has inadvertently deleted the data, or perhaps a different receiver (for example, the other receiver in a pair) was used on the previous occasion.
1. The base station receiver is set up on a point that you have previously used as a base station.
 2. The receiver is powered on.
 3. The receiver begins tracking satellites.
 4. The receiver determines the current position.
 5. The receiver reviews the base station positions stored in the receiver.
 6. The receiver does not find any base station that corresponds to the current position.
 7. The receiver will not begin transmitting RTK corrections and the radio LED will not flash.

No RTK corrections will be streamed until you do one of the following things:

- Use the SCS900 Site Controller software to set up the base station.
- Change to the receiver that was previously used as the base station at this location.

AutoBase process

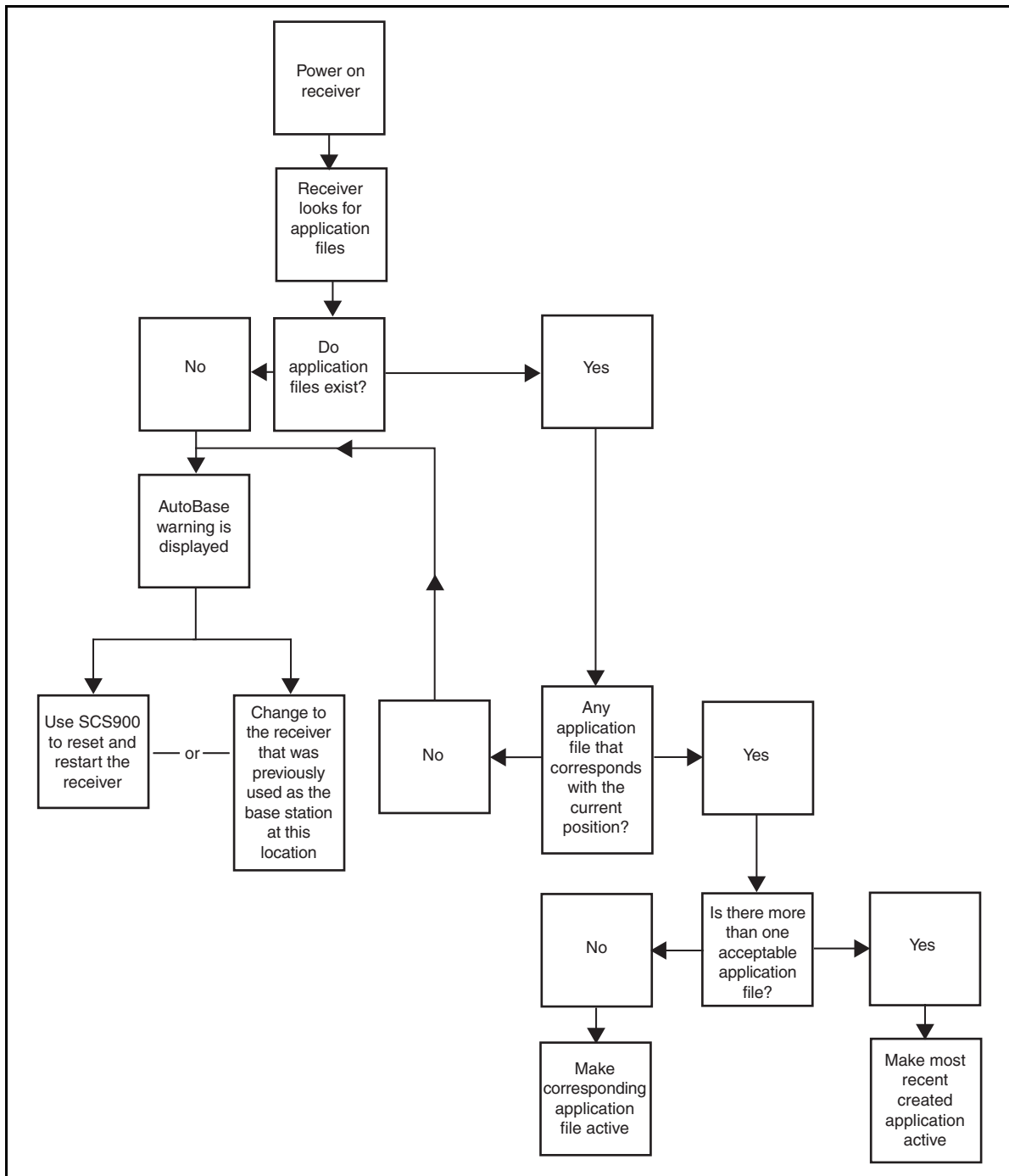


Figure 7.1 AutoBase flowchart

Default Settings

In this chapter:

- [Default receiver settings](#)
- [Resetting the receiver to factory defaults](#)
- [Default behavior](#)
- [Power up settings](#)
- [Logging data](#)

All Smart GPS antenna settings are stored in application files. The default application file, `Default.cfg`, is stored permanently in the receiver, and contains the factory default settings for the Smart GPS antenna. Whenever the receiver is reset to its factory defaults, the current settings (stored in the current application file, `Current.cfg`) are reset to the values in the default application file.

You cannot modify the default application file. However, you can create a power-up application file so that the settings in this file can be applied immediately after the default application file, overriding the factory defaults. For more information, see [Configuring the receiver using application files, page 55](#).


Default receiver settings

These settings are defined in the default application file.

Function		Factory default
SV Enable		All SVs enabled
General Controls:	Elevation mask	10°
	PDOP mask	7
	RTK positioning mode	Low Latency
	Motion	Kinematic
Serial Port 1:	Baud rate	38,400
	Format	8-None-1
	Flow control	None
Serial Port 2:	Baud rate	38,400
	Format	8-None-1
	Flow control	None
Input Setup:	Station	Any
NMEA/ASCII (all supported messages)		All ports Off
Streamed output		All Types Off Offset = 00
RT17/Binary		All ports Off
Reference position:	Latitude	0°
	Longitude	0°
	Altitude	0.00 m HAE
Antenna:	Type	Trimble SPS780, SPS781, SPS880 Extreme, SPS881 Extreme, Internal
	Height (true vertical)	0.00 m
	Group	All
	Measurement method	Antenna Phase Center

Resetting the receiver to factory defaults

To reset the receiver to its factory defaults, do one of the following:

- On the receiver, press  for 15 seconds.
- In the GPS Configurator software, select *Connect to Receiver* and then click **Reset receiver** in the *General* tab.
- In the Configuration Toolbox software, select the *General* tab and then click **Reset Receiver**.

Note – For more information on the GPS Configurator and Configuration Toolbox software which are supplied on the Trimble SPS GPS Receiver CD, see [Chapter 6, Configuring the Receiver Settings](#).

Default behavior

The factory defaults specified on [page 68](#) are applied whenever you start the receiver. If a power up application file is present in the receiver, its settings are applied immediately after the default settings, so you can use a power up file to define your own set of defaults. The factory defaults are also applied when you perform a full reset of the receiver because resetting the receiver deletes the power up files.

When starting any of the SPS GPS receivers as a base station or rover receiver using the Trimble SCS900 site controller software or the *HYDROpro*[™] software, the settings as required for those operations are automatically set and configured in that software. To change the receiver settings for special applications or for use with third-party software, use the GPS Configurator software or the Configuration Toolbox software.

Power up settings

When you turn off the receiver, any changes that you have made to logging settings are lost and these settings are returned to the factory defaults. Other settings remain as defined in the current file. The next time you turn on the receiver, the receiver checks for a power up file and, if one is present, applies the settings in this file.

Logging data

Logging data with the SPS GPS receivers is available as an option. By default, the data logging option is turned off. For information on how to enable the data logging option, and the necessary postprocessing software options, please contact your Trimble dealer.

Data logging using GPS receivers requires you to have access to suitable GPS postprocessing software such as the Trimble Business Center software, the Trimble Geomatics Office[™] software, or the Trimble Total Control[™] software. Data logging involves the collection of GPS measurement data over a period of time at a static point or points, and subsequent postprocessing of the information to accurately compute baseline information. Postprocessed GPS data is typically used for control network measurement applications and precise monitoring. The following information only applies if you have the Data Logging options enabled in the receiver, and that you intend to carry out GPS postprocessed measurement operations.

Logging data after a power loss

If the receiver loses power unexpectedly, when power is restored the receiver tries to return to the state it was in immediately before the power loss. The receiver does not reset itself to default settings. If the receiver was logging data when power was lost unexpectedly, it resumes logging data when power is restored.

Specifications

In this chapter:

- General specifications
- Physical specifications
- Electrical specifications
- Communication specifications
- GPS satellite signal tracking
- Integrated radio options
- Variable configuration options

This chapter details the specifications for the Smart GPS antenna.

Specifications are subject to change without notice.

General specifications

Feature	Specification
Keyboard and display	On/Off key for one button startup using AutoBase technology
LED indicators	For satellite tracking, radio link reception, and power monitoring
Receiver type	Fully-integrated "Smart" GPS antenna

Physical specifications

Feature	Specification
Dimensions (LxWxH)	19 cm (7.5 in) x 10 cm (3.9 in) including connectors
Weight	1.28 kg (2.88 lb) receiver only, with internal battery 3.70 kg (8.16 lbs) complete system weight, including controller and pole (when used as a rover)
Temperature ¹	
Operating	-40 °C to +65 °C (-40 °F to +149 °F)
Storage	-40 °C to +75 °C (-40 °F to +167 °F)
Humidity	100%, condensing
Waterproof	IP67 for submersion to depth of 1 m (3.28 ft)
Shock and vibration	Tested and meets the following environmental standards:
Shock, non operating	Designed to survive a 2 m (6.6 ft) pole drop onto concrete MIL-STD-810F, Fig.514.5C-17
Shock, operating	To 40 G, 10 msec, saw-tooth
Vibration	MIL-STD-810F, FIG.514.5C-1
Measurements	<ul style="list-style-type: none"> • Advanced Trimble Maxwell™ 5 Custom GPS chip • High-precision multiple correlator for L1 and L2/L2C pseudo-range measurements • Unfiltered, unsmoothed pseudo range measurements data for low noise, low multipath error, low time domain correlation and high dynamic response • Very low noise L1 and L2/L2C² carrier phase measurements with <1 mm precision in a 1 Hz bandwidth • Proven Trimble low elevation tracking technology • 24 channels L1/L2 full cycle carrier (SPS780 only) • 72 channels L1/L2/L2C full cycle carrier (SPS781 only) • 72 channels L1/L2/L2C/L5 GPS and L1/L2 GLONASS (SPS880 Extreme and SPS881 Extreme only) • L1 and L2/L2C signal-to-noise ratios reported in dB-Hz • Can be upgraded to GLONASS (SPS881 Extreme) • Can be upgraded to L5 GPS (SPS881 Extreme) • 4 channels SBAS (WAAS/EGNOS/MSAS) • RoHS compliant (SPSx81 only)
Code differential GPS positioning ³	
Horizontal accuracy	±(0.25 m + 1 ppm) RMS, ± (9.84 in + 1 ppm) RMS
Vertical accuracy	±(0.50 m + 1 ppm) RMS, ± (19.68 in + 1 ppm) RMS

Feature	Specification
SBAS (WAAS/ENGOS/MSAS) differential positioning accuracy ⁴	Typically <5 m (16.40 ft) 3D RMS
Real-time Kinematic (RTK) positioning ³	
Horizontal	±(10 mm + 1 ppm) RMS, ± (0.38 in +1 ppm) RMS
Vertical	±(20 mm + 1 ppm) RMS, ± (0.78 in +1 ppm) RMS
Initialization time	
Regular RTK operation with base station	Single/Multi-base minimum 10 sec + 0.5 times baseline length in km, <30 km
RTK operation with Scalable GPS infrastructure	<30 seconds typical anywhere within coverage area (SPS780 Basic rover may take longer)
Initialization reliability ⁵	Typically >99.9%

¹ Receiver will operate normally to -40 °C. Bluetooth module and internal batteries are rated to -20 °C.

² The availability of the L2C code GPS signal is dependent on the US government.

³ Accuracy and reliability may be subject to anomalies such as multipath, obstructions, satellite geometry, and atmospheric conditions. Always follow recommended practices.

⁴ Depends on WAAS/EGNOS/MSAS system performance.

⁵ May be affected by atmospheric conditions, signal multipath, and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.

Electrical specifications

Feature	Specification
Power, internal	11 to 28 V DC external power input with over-voltage protection on Port 1 (7-pin Lemo)
Battery	Rechargeable, removable 7.4 V, 2.4 Ah Lithium-ion battery in internal battery compartment
Power consumption	<2.5 W, in RTK rover mode with internal radio
Rover operation time on internal battery	
450 MHz	5.5 hours; varies with temperature (Rx only)
900 MHz	5.5 hours; varies with temperature (Rx only)
2.4 GHz	5.5 hours; varies with temperature (Rx only)

Feature	Specification
Base station operation times on internal battery	
450 MHz	4.2 hours; varies with temperature (Tx/Rx)
900 MHz	5.5 hours; varies with temperature (External Tx radio)
2.4 GHz	5.5 hours; varies with temperature (External Tx radio)
Regulatory approvals	Class B Part 15, 22, 24FCC certification Canada FCC CE mark approval C-tick approval WEEE RoHS compliant (SPSx81 only)

Communication specifications

Feature	Specification
Communications	
Port 1 (7-pin 05 Lemo)	3-wire RS-232
Port 2 (D-sub 9-pin)	Full RS-232
Bluetooth	Fully-integrated, fully-sealed 2.4 GHz Bluetooth ¹
Integrated radios	Fully-integrated, fully-sealed internal 450 MHz, TX, RX, or Tx/Rx ² Fully-integrated, fully-sealed internal 900 MHz, Rx ³
450 MHz transmitter radio power output	0.5 W
2.4 GHz transmitter radio power output	0.064 W
External GSM/GPRS, cellular phone support	Supported for direct dial and Internet-based VRS correction streams Cell phone or GSM/GPRS modem inside a TSC2 controller
Receiver position update rate	
SPS780 Basic and SPS781 Basic	1 Hz and 2 Hz positioning
SPS780 Max and SPS781 Max	1 Hz, 2 Hz, 5 Hz, and 10 Hz positioning
SPS880 Extreme	1 Hz, 2 Hz, 5 Hz, 10 Hz, and 20 Hz positioning
Correction data input	CMR, CMR+, RTCM 2.0–RTCM 2.3, RTCM 3.0
Correction data output	CMR, CMR+, RTCM 2.0–2.3.
Data outputs	NMEA, GSOE, RT17 and BINEX (optional upgrade).
Carrier	Supports BINEX and smoothed carrier (SPS880 Extreme and SPS881 Extreme only)

¹ Bluetooth type approvals are country specific. Contact your local Trimble office or representative for more information.

² Tx only or Rx only with SPS780 Basic and SPS781 Basic; Tx/Rx with SPS780 Max, SPS781 Max, SPS880 Extreme, and SPS881 Extreme.

³ 900 MHz is Rx only with SPS780 and SPS781, external transmit radio must be used when configured as a base.

GPS satellite signal tracking

This table shows the GPS satellite signal tracking capability for each Smart GPS antenna in the SPSx80 Smart GPS antenna family.

GPS signal type	Class	SPS780 Basic	SPS780 Max	SPS880 Extreme
GPS signals	L1/L2	✓	✓	✓
	L2C	✗	✗	✓
	L5	✗	✗	✓
GLONASS signals	L1/L2	✗	✗	✓
GPS SBAS corrections	WAAS	✓	✓	✓
	EGNOS	✓	✓	✓
	MSAS	✓	✓	✓

This table shows the GPS satellite signal tracking capability for each Smart GPS antenna in the SPSx81 Smart GPS antenna family.

GPS signal type	Class	SPS781 Basic	SPS781 Max	SPS881 Extreme
GPS signals	L1/L2	✓	✓	✓
	L2C	✓	✓	✓
	L5	✗	✗	Optional
GLONASS signals	L1/L2	✗	✗	Optional
GPS SBAS corrections	WAAS	✓	✓	✓
	EGNOS	✓	✓	✓
	MSAS	✓	✓	✓

Integrated radio options

This table shows the radio options available for each receiver type in the SPSx80 Smart GPS antenna family.

Radio option	SPS780 Basic base	SPS780 Basic rover	SPS780 Max	SPS880 Extreme
No radio	✓	✓	✓	✓
450 MHz Transmit	✓	✗	✓	✓
450 MHz Receive	✗	✓	✓	✓
900 MHz Transmit	✗	✗	✗	✗
900 MHz Receive	✗	✓	✓	✓
External 450 MHz Transmit	✗	✗	Optional	Optional
External 900 MHz Transmit	Optional	Optional	Optional	Optional
2.4 GHz Transmit	✗	✗	✗	✗
2.4 GHz Receive	✗	✗	✗	✗

This table shows the radio options available for each receiver in the SPSx81 Smart GPS antenna family

Radio option	SPS781 Basic base	SPS781 Basic rover	SPS781 Max	SPS881 Extreme
No radio	✓	✓	✓	✓
450 MHz Transmit	✓	✗	✓	✓
450 MHz Receive	✗	✓	✓	✓
900 MHz Transmit	✗	✗	✗	✗
900 MHz Receive	✗	✓	✓	✓
External 450 MHz Transmit	Optional	Optional	Optional	Optional
External 900 MHz Transmit	Optional	Optional	Optional	Optional
2.4 GHz Transmit	✗	✗	✗	✓
2.4 GHz Receive	✗	✗	✗	✓

Variable configuration options

This table lists the default options for each receiver type in the SPSx50 Modular GPS receiver family.

Configuration option	SPS780 Basic base	SPS780 Basic rover	SPS780 Max	SPS881 Extreme
CMR inputs (Rover)	x	✓	✓	✓
CMR outputs (Base)	✓	x	✓	✓
RTCM inputs (Rover)	x	✓	✓	✓
RTCM outputs (DGPS Base)	✓	x	✓	✓
10 Hz measurements	x	x	✓	✓
20 Hz measurements	x	x	x	✓
Data logging (postprocessed)	x	x	Optional	Optional
VRS capable	x	x	✓	✓
RTK range limit	x	2.4 km (1.5 miles)	None	None
GLONASS	x	x	x	✓
L5	x	x	x	✓

This table lists the default options for each Smart GPS antenna in the SPSx81 Smart GPS antenna family.

Configuration option	SPS781 Basic base	SPS781 Basic rover	SPS781 Max	SPS881 Extreme
CMR inputs (Rover)	x	✓	✓	✓
CMR outputs (Base)	✓	x	✓	✓
RTCM inputs (Rover)	x	✓	✓	✓
RTCM outputs (DGPS Base)	✓	x	✓	✓
10 Hz measurements	x	x	✓	✓
20 Hz measurements	x	x	x	✓
Data logging (postprocessed)	x	x	Optional	Optional
VRS capable	x	x	✓	✓
RTK range limit	x	2.4 km (1.5 miles)	None	None
GLONASS	x	x	x	Optional
L5		x	x	Optional

NMEA-0183 Output

In this appendix:

- [NMEA-0183 message overview](#)
- [Common message elements](#)
- [NMEA messages](#)

This appendix describes the formats of the subset of NMEA-0183 messages that are available for output by the receivers. For a copy of the NMEA-0183 Standard, go to the National Marine Electronics Association website at www.nmea.org.

NMEA-0183 message overview

When NMEA-0183 output is enabled, a subset of NMEA-0183 messages can be output to external instruments and equipment connected to the receiver serial ports. These NMEA-0183 messages let external devices use selected data collected or computed by the GPS receiver.

All messages conform to the NMEA-0183 version 3.01 format. All begin with \$ and end with a carriage return and a line feed. Data fields follow comma (,) delimiters and are variable in length. Null fields still follow comma (,) delimiters but contain no information.

An asterisk (*) delimiter and checksum value follow the last field of data contained in an NMEA-0183 message. The checksum is the 8-bit exclusive of all characters in the message, including the commas between fields, but not including the \$ and asterisk delimiters. The hexadecimal result is converted to two ASCII characters (0–9, A–F). The most significant character appears first.

The following table summarizes the set of NMEA messages supported by the receiver, and shows the page that contains detailed information about each message.

Message	Function	Page
ADV	Position and Satellite information for RTK network operations	82
GGA	Time, position, and fix related data	83
GSA	GPS DOP and active satellites	84
GST	Position error statistics	85
GSV	Number of SVs in view, PRN, elevation, azimuth, and SNR	86
HDT	Heading from True North	87
PTNL,AVR	Time, yaw, tilt, range, mode, PDOP, and number of SVs for Moving Baseline RTK	88
PTNL,GGK	Time, position, position type and DOP values	89
PTNL,PJK	Local coordinate position output	90
PTNL,VGK	Time, locator vector, type and DOP values	91
PTNL,VHD	Heading Information	92
RMC	Position, Velocity, and Time	93
ROT	Rate of turn	94
VTG	Actual track made good and speed over ground	95
ZDA	UTC day, month, and year, and local time zone offset	96

To enable or disable the output of individual NMEA messages, do one of the following:

- Create an application file in the GPS Configurator software that contains NMEA output settings and then send the file to the receiver.
- Add NMEA outputs in the *Serial outputs* tab of the GPS Configurator software and then apply the settings. (You cannot use the GPS Configuration software to load application files to the SPSx50 Modular GPS receivers.)
- For SPSx50 and SPSx51 Modular GPS receivers, set up the NMEA output using the keypad and display or a web browser.

Common message elements

Each message contains:

- a message ID consisting of *\$GP* followed by the message type. For example, the message ID of the GGA message is *\$GPGGA*.
- a comma
- a number of fields, depending on the message type, separated by commas
- an asterisk
- a checksum value

Below is an example of a simple message with a message ID (*\$GPGGA*), followed by 13 fields and a checksum value:

```
$GPGGA,172814.0,3723.46587704,N,12202.26957864,W,2,6,1.2,18.893,M,-  
25.669,M,2.0,0031*4F
```

Message values

NMEA messages that the receiver generates contains the following values.

Latitude and longitude

Latitude is represented as *ddmm.mmmm* and longitude is represented as *dddmm.mmmm*, where:

- *dd* or *ddd* is degrees
- *mm.mmmm* is minutes and decimal fractions of minutes

Direction

Direction (north, south, east, or west) is represented by a single character: *N*, *S*, *E*, or *W*.

Time

Time values are presented in Universal Time Coordinated (UTC) and are represented as *hhmmss.cc*, where:

- *hh* is hours, from 00 through 23
- *mm* is minutes
- *ss* is seconds
- *cc* is hundredths of seconds

NMEA messages

When NMEA-0183 output is enabled, the following messages can be generated.

ADV Position and Satellite information for RTK network operations

An example of the ADV message string is shown below. [Table A.1](#) and [Table A.2](#) describe the message fields. The messages alternate between subtype 110 and 120.

```
$PGPPADV,110,39.88113582,-105.07838455,1614.125*1M
```

Table A.1 ADV subtype 110 message fields

Field	Meaning
0	message ID \$PPGPADV
1	Message sub-type 110
2	Latitude
3	Longitude
4	Ellipsoid height
6	Elevation of second satellite, in degrees, 90° maximum
7	Azimuth of second satellite, degrees from True North, 000° through 359°
8	The checksum data, always begins with *

```
$PGPPADV,120,21,76.82,68.51,29,20.66,317.47,28,52.38,276.81,22,42.26,198.96*5D
```

Table A.2 ADV subtype 120 message fields

Field	Meaning
0	message ID \$PPGPADV
1	Message sub-type 120
2	First SV PRN number
3	Elevation of first satellite, in degrees, 90° maximum
4	Azimuth of first satellite, degrees from True North, 000° through 359°
5	Second SV PRN number
6	Elevation of second satellite, in degrees, 90° maximum
7	Azimuth of second satellite, degrees from True North, 000° through 359°
8	The checksum data, always begins with *

GGA Time, Position, and Fix Related Data

An example of the GGA message string is shown below. [Table A.3](#) describes the message fields.

Note – *The following data string exceeds the NMEA standard length.*

```
$GPGGA,172814.0,3723.46587704,N,12202.26957864,W,
2,6,1.2,18.893,M,-25.669,M,2.0,0031*4F
```

Table A.3 GGA message fields

Field	Meaning
0	message ID \$GPGGA
1	UTC of position fix
2	Latitude
3	Direction of latitude: N: North S: South
4	Longitude
5	Direction of longitude: E: East W: West
6	GPS Quality indicator: 0: Fix not valid 1: GPS fix 2: Differential GPS fix 4: Real Time Kinematic, fixed integers 5: Real Time Kinematic, float integers
7	Number of SVs in use, range from 00 through 12
8	HDOP
9	Orthometric height (MSL reference)
10	M: unit of measure for orthometric height is meters
11	Geoid separation
12	M: geoid separation is measured in meters
13	Age of differential GPS data record, Type 1 or Type 9. Null field when DGPS is not used.
14	Reference station ID, ranging from 0000 through 1023. A null field when any reference station ID is selected and no corrections are received.
15	The checksum data, always begins with *

GSA GPS DOP and active satellites

An example of the GSA message string is shown below. [Table A.4](#) describes the message fields.

```
$GPGSA,<1>,<2>,<3>,<3>,,,,,<3>,<3>,<3>,<4>,<5>,<6>*<7><CR><LF>
```

Table A.4 GSA message fields

Field	Meaning
0	message ID \$GPGSA
1	Mode 1, M = manual, A = automatic
2	Mode 2, Fix type, 1 = not available, 2 = 2D, 3 = 3D
3	PRN number, 01 through 32, of satellite used in solution, up to 12 transmitted
4	PDOP-Position dilution of precision, 0.5 through 99.9
5	HDOP-Horizontal dilution of precision, 0.5 through 99.9
6	VDOP-Vertical dilution of precision, 0.5 through 99.9
7	The checksum data, always begins with *

GST **Position Error Statistics**

An example of the GST message string is shown below. [Table A.5](#) describes the message fields.

```
$GPGST,172814.0,0.006,0.023,0.020,273.6,0.023,0.020,0.031*6A
```

Table A.5 GST message fields

Field	Meaning
0	message ID \$GPGST
1	UTC of position fix
2	RMS value of the pseudorange residuals; includes carrier phase residuals during periods of RTK(float) and RTK(fixed) processing
3	Error ellipse semi-major axis 1 sigma error, in meters
4	Error ellipse semi-minor axis 1 sigma error, in meters
5	Error ellipse orientation, degrees from true north
6	Latitude 1 sigma error, in meters
7	Longitude 1 sigma error, in meters
8	Height 1 sigma error, in meters
9	The checksum data, always begins with *

GSV Satellite Information

The GSV message string identifies the number of SVs in view, the PRN numbers, elevations, azimuths, and SNR values. An example of the GSV message string is shown below. [Table A.6](#) describes the message fields.

```
$GPGSV,4,1,13,02,02,213,,03,-3,000,,11,00,121,,14,13,172,05*67
```

Table A.6 GSV message fields

Field	Meaning
0	message ID \$GPGSV
1	Total number of messages of this type in this cycle
2	Message number
3	Total number of SVs visible
4	SV PRN number
5	Elevation, in degrees, 90° maximum
6	Azimuth, degrees from True North, 000° through 359°
7	SNR, 00–99 dB (null when not tracking)
8–11	Information about second SV, same format as fields 4 through 7
12–15	Information about third SV, same format as fields 4 through 7
16–19	Information about fourth SV, same format as fields 4 through 7
20	The checksum data, always begins with *

HDT **Heading from True North**

The HDT string is shown below, and [Table A.7](#) describes the message fields.

```
$GPHDT,123.456,T*00
```

Table A.7 Heading from true north fields

Field	Meaning
0	message ID \$GPHDT
1	Heading in degrees
2	T: Indicates heading relative to True North
3	The checksum data, always begins with *

PTNL,AVR**Time, Yaw, Tilt, Range for Moving Baseline RTK**

The PTNL,AVR message string is shown below, and [Table A.8](#) describes the message fields.

```
$PTNL,AVR,181059.6,+149.4688,Yaw,+0.0134,Tilt,,,60.191,3,2.5,6*00
```

Table A.8 AVR message fields

Field	Meaning
0	message ID \$PTNL,AVR
1	UTC of vector fix
2	Yaw angle in degrees
3	Yaw
4	Tilt angle in degrees
5	Tilt
6	Reserved
7	Reserved
8	Range in meters
9	GPS quality indicator: 0: Fix not available or invalid 1: Autonomous GPS fix 2: Differential carrier phase solution RTK (Float) 3: Differential carrier phase solution RTK (Fix) 4: Differential code-based solution, DGPS
10	PDOP
11	Number of satellites used in solution
12	The checksum data, always begins with *

PTNL,GGK**Time, Position, Position Type, DOP**

An example of the PTNL,GGK message string is shown below. [Table A.9](#) describes the message fields.

```
$PTNL,GGK,172814.00,071296,3723.46587704,N,12202.26957864,W,3,06,1.7,EHT-6.777,M*48
```

Table A.9 PTNL,GGK message fields

Field	Meaning
0	message ID \$PTNL,GGA
1	UTC of position fix
2	Date
3	Latitude
4	Direction of latitude: N: North S: South
5	Longitude
6	Direction of Longitude: E: East W: West
7	GPS Quality indicator: 0: Fix not available or invalid 1: Autonomous GPS fix 2: RTK float solution 3: RTK fix solution 4: Differential, code phase only solution (DGPS) 5: SBAS solution – WAAS, EGNOS, MSAS 6: RTK Float 3D Network solution 7: RTK Fixed 3D Network solution 8: RTK Float 2D in a Network solution 9: RTK Fixed 2D Network solution 10: OmniSTAR HP/XP solution 11: OmniSTAR VBS solution
8	Number of satellites in fix
9	DOP of fix
10	Ellipsoidal height of fix
11	M: ellipsoidal height is measured in meters
12	The checksum data, always begins with *

Note – The PTNL,GGK message is longer than the NMEA-0183 standard of 80 characters.

PTNL,PJK**Local Coordinate Position Output**

An example of the PTNL,PJK message string is shown below. [Table A.10](#) describes the message fields.

```
$PTNL,PJK,010717.00,081796,+732646.511,N,+1731051.091,E,1,05,2.7,EHT-
28.345,M*7C
```

Table A.10 PTNL,PJK message fields

Field	Meaning
0	message ID \$PTNL,PJK
1	UTC of position fix
2	Date
3	Northing, in meters
4	Direction of Northing will always be N (North)
5	Easting, in meters
6	Direction of Easting will always be E (East)
7	GPS Quality indicator: 0: Fix not available or invalid 1: Autonomous GPS fix 2: RTK float solution 3: RTK fix solution 4: Differential, code phase only solution (DGPS) 5: SBAS solution – WAAS, EGNOS, MSAS 6: RTK Float 3D network solution 7: RTK Fixed 3D network solution 8: RTK Float 2D network solution 9: RTK Fixed 2D network solution 10: OmniSTAR HP/XP solution 11: OmniSTAR VBS solution
8	Number of satellites in fix
9	DOP of fix
10	Ellipsoidal height of fix
11	M: ellipsoidal height is measured in meters
12	The checksum data, always begins with *

Note – The PTNL,PJK message is longer than the NMEA-0183 standard of 80 characters.

PTNL,VGK**Vector Information**

An example of the PTNL,VGK message string is shown below. [Table A.11](#) describes the message fields.

```
$PTNL,VGK,160159.00,010997,-0000.161,00009.985,-0000.002,3,07,1,4,M*0B
```

Table A.11 PTNL,VGK message fields

Field	Meaning
0	message ID \$PTNL,VGK
1	UTC of vector in hhmmss.ss format
2	Date in mmddyy format
3	East component of vector, in meters
4	North component of vector, in meters
5	Up component of vector, in meters
6	GPS Quality indicator: 0: Fix not available or invalid 1: Autonomous GPS fix 2: RTK float solution 3: RTK fix solution 4: Differential, code phase only solution (DGPS) 5: SBAS solution – WAAS, EGNOS, MSAS 6: RTK Float 3D network solution 7: RTK Fixed 3D network solution 8: RTK Float 2D network solution 9: RTK Fixed 2D network solution 10: OmniSTAR HP/XP solution 11: OmniSTAR VBS solution
7	Number of satellites if fix solution
8	DOP of fix
9	M: Vector components are in meters
10	The checksum data, always begins with *

PTNL,VHD

Heading Information

An example of the PTNL,VHD message string is shown below. [Table A.12](#) describes the message fields.

```
$PTNL,VHD,030556.00,093098,187.718,-22.138,-76.929,-
5.015,0.033,0.006,3,07,2.4,M*22
```

Table A.12 PTNL,VHD message fields

Field	Meaning
0	message ID \$PTNL,VHD
1	UTC of position in hhmmss.ss format
2	Date in mmdyy format
3	Azimuth
4	Δ Azimuth/ Δ Time
5	Vertical Angle
6	Δ Vertical/ Δ Time
7	Range
8	Δ Range/ Δ Time
9	GPS Quality indicator: 0: Fix not available or invalid 1: Autonomous GPS fix 2: RTK float solution 3: RTK fix solution 4: Differential, code phase only solution (DGPS) 5: SBAS solution – WAAS, EGNOS, MSAS 6: RTK Float 3D network solution 7: RTK Fixed 3D network solution 8: RTK Float 2D network solution 9: RTK Fixed 2D network solution 10: OmniSTAR HP/XP solution 11: OmniSTAR VBS solution
10	Number of satellites used in solution
11	PDOP
12	The checksum data, always begins with *

RMC Position, Velocity, and Time

The RMC string is shown below, and [Table A.13](#) describes the message fields.

```
$GPRMC,123519,A,4807.038,N,01131.000,E,022.4,084.4,230394,003.1,W*6A
```

Table A.13 GPRMC message fields

Field	Meaning
0	message ID \$GPRMC
1	UTC of position fix
2	Status A=active or V=void
3	Latitude
4	Longitude
5	Speed over the ground in knots
6	Track angle in degrees (True)
7	Date
8	Magnetic variation in degrees
9	The checksum data, always begins with *

ROT **Rate and Direction of Turn**

The ROT string is shown below, and [Table A.14](#) describes the message fields.

\$GPROT,35.6,A*4E

Table A.14 ROT message fields

Field	Meaning
0	message ID \$GPROT
1	Rate of turn, degrees/minutes, "-" indicates bow turns to port
2	A: Valid data V: Invalid data
3	The checksum data, always begins with *

VTG Track Made Good and Speed Over Ground

An example of the VTG message string is shown below. [Table A.15](#) describes the message fields.

```
$GPVTG,,T,,M,0.00,N,0.00,K*4E
```

Table A.15 VTG message fields

Field	Meaning
0	message ID \$GPVTG
1	Track made good (degrees true)
2	T: track made good is relative to true north
3	Track made good (degrees magnetic)
4	M: track made good is relative to magnetic north
5	Speed, in knots
6	N: speed is measured in knots
7	Speed over ground in kilometers/hour (kph)
8	K: speed over ground is measured in kph
9	The checksum data, always begins with *

ZDA UTC Day, Month, And Year, and Local Time Zone Offset

An example of the ZDA message string is shown below. [Table A.16](#) describes the message fields.

```
$GPZDA,172809,12,07,1996,00,00*45
```

Table A.16 ZDA message fields

Field	Meaning
0	message ID \$GPZDA
1	UTC
2	Day, ranging between 01 and 31
3	Month, ranging between 01 and 12
4	Year
5	Local time zone offset from GMT, ranging from 00 through ± 13 hours
6	Local time zone offset from GMT, ranging from 00 through 59 minutes
7	The checksum data, always begins with *

Fields 5 and 6 together yield the total offset. For example, if field 5 is -5 and field 6 is $+15$, local time is 5 hours and 15 minutes earlier than GMT.

GSOF Messages

In this appendix:

- [Supported message types](#)
- [General Serial Output Format](#)
- [Reading binary values](#)
- [GSOF message definitions](#)

This appendix provides information on the General Serial Output Format (GSOF) messages. GSOF messages are a Trimble proprietary format and can be used to send information such as position and status to a third-party device.

For information on how to output GSOF messages, see [Chapter 7, Configuring the Receiver Settings](#).

Supported message types

This table summarizes the GSOF messages that are supported by the receiver, and shows the page that contains detailed information about each message.

Message	Description	Page
TIME	Position time	101
LLH	Latitude, longitude, height	102
ECEF	Earth-Centered, Earth-Fixed position	102
ECEF DELTA	Earth-Centered, Earth-Fixed Delta position	102
NEU DELTA	Tangent Plane Delta	103
Velocity	Velocity data	103
PDOP	PDOP info	104
SIGMA	Position Sigma info	104
SV Brief	SV Brief info	105
SV Detail	SV Detailed info	105
UTC	Current UTC time	106
BATT/MEM	Receiver battery and memory status	107
ATTITUDE	Attitude info	107

General Serial Output Format

Table B.1 Report packet 40h structure (GENOUT)

Byte	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission.
1	STATUS	CHAR	See Table B.2	Receiver status code.
2	PACKET TYPE	CHAR	40h	Report Packet 40h (GENOUT).
3	LENGTH	CHAR	00h–FAh	Data byte count.
4	TRANSMISSION NUMBER	CHAR		Unique number assigned to a group of record packet pages. Prevents page mismatches when multiple sets of record packets exist in output stream.
5	PAGE INDEX	CHAR	00h–FFh	Index of current packet page.
6	MAX PAGE INDEX	CHAR	00h–FFh	Maximum index of last packet in one group of records.
<i>One or more GSOF messages</i>				
	Output record type	CHAR	01h	(e.g., Time (Type 1 Record))
	Record length	CHAR	0Ah	Bytes in record
<i>Various fields depending on Output record type</i>				
There can be multiple records in one GENOUT packet. There could be multiple GENOUT packets per epoch. Records may be split over two consecutive packets.				

Table B.1 Report packet 40h structure (GENOUT)

Byte	Item	Type	Value	Meaning
Length + 4	CHECKSUM	-	-	(Status + type + length + data bytes) modulo 256
Length + 5	ETX (03h)	-	-	End transmission

Each message begins with a 4-byte header, followed by the bytes of data in each packet. The packet ends with a 2-byte trailer. Byte 3 is set to 0 (00h) when the packet contains no data. Most data is transmitted between the receiver and remote device in binary format.

Table B.2 Receiver Status code

Byte number	Message	Description
Bit 0	1	Reserved
Bit 1	1	Low battery
Bit 2-7	0-63	Reserved

Reading binary values

The receivers store numbers in Motorola format. The byte order of these numbers is the opposite of what personal computers (PCs) expect (Intel format). To supply or interpret binary numbers (8-byte DOUBLES, 4-byte LONGS, and 2-byte INTEGERS), the byte order of these values must be reversed. This section contains a detailed description of the Motorola format.

INTEGER data types

The INTEGER data types (CHAR, SHORT, and LONG) can be signed or unsigned. By default, they are unsigned. All integer data types use two's complement representation. The following table lists the integer data types.

Type	# of bits	Range of values (Signed)	(Unsigned)
CHAR	8	-128 to 127	0 to 255
SHORT	16	-32768 to 32767	0 to 65535
LONG	32	-2147483648 to 2147483647	0 to 4294967295

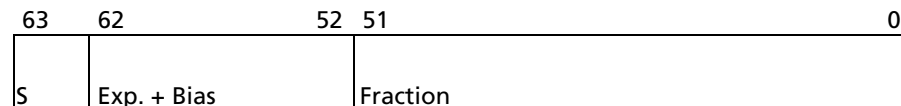
FLOATING-POINT data types

Floating-point data types are stored in the IEEE SINGLE and DOUBLE precision formats. Both formats have a sign bit field, an exponent field, and a fraction field. The fields represent floating-point numbers in the following manner:

$$\text{Floating-Point Number} = \langle \text{sign} \rangle 1. \langle \text{fraction field} \rangle \times 2^{\langle \text{exponent field} \rangle - \text{bias}}$$

DOUBLE

The DOUBLE data type is stored in the IEEE double-precision format which is 64 bits long. The most significant bit is the sign bit, the next 11 most significant bits are the exponent field, and the remaining 52 bits are the fractional field. The bias of the exponent is 1023. The range of single precision format values is from 2.23×10^{-308} to 1.8×10^{308} . The floating-point number is precise to 15 decimal digits.



```

0 000 0000 0000 0000 0000 ... 0000 0000 0000 = 0.0
0 011 1111 1111 0000 0000 ... 0000 0000 0000 = 1.0
1 011 1111 1110 0110 0000 ... 0000 0000 0000 = -0.6875
1 111 1111 1111 1111 1111 ... 1111 1111 1111 = NaN

```

GSOE message definitions

When GSOE output is enabled, the following messages can be generated.

TIME

This message describes position time information. It contains the following data:

- GPS time, in milliseconds of GPS week
- GPS week number
- Number of satellites used
- Initialization counter

Table B.3 Time (Type 1 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	01h	Position time output record
1	Record length	Char	0Ah	Bytes in record
2-5	GPS time (ms)	Long	msecs	GPS time, in milliseconds of GPS week
6-7	GPS week number	Short	number	GPS week count since January 1980
8	Number of SVs used	Char	00h-0Ch	Number of satellites used to determine the position (0-12)
9	Position flags 1	Char	See Table B.16	Reports first set of position attribute flag values
10	Position flags 2	Char	See Table B.17	Reports second set of position attribute flag values
11	Initialized number	Char	00h-FFh	Increments with each initialization (modulo 256)

LLH

This message describes latitude, longitude, and height. It contains the following data:

- WGS-84 latitude and longitude, in radians
- WGS-84 height, in meters

Table B.4 Latitude, longitude, height (Type 2 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	02h	Latitude, longitude, and height output record
1	Record length	Char	18h	Bytes in record
2–9	Latitude	Double	Radians	Latitude from WGS-84 datum
10–17	Longitude	Double	Radians	Longitude from WGS-84 datum
18–25	Height	Double	Meters	Height from WGS-84 datum

ECEF

This message describes the ECEF position. It contains the following data:

- Earth-Centered, Earth-Fixed X, Y, Z coordinates, in meters

Table B.5 ECEF position (Type 3 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	03h	Earth-Centered, Earth-Fixed (ECEF) position output record
1	Record length	Char	18h	Bytes in record
2–9	X	Double	Meters	WGS-84 ECEF X-axis coordinate
10–17	Y	Double	Meters	WGS-84 ECEF Y-axis coordinate
18–25	Z	Double	Meters	WGS-84 ECEF Z-axis coordinate

ECEF DELTA

This message describes the ECEF Delta position. It contains the following data:

- Earth-Centered, Earth-Fixed X, Y, Z deltas between the rover and base position, in meters.

Table B.6 ECEF Delta (Type 6 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	06h	Earth-Centered, Earth-Fixed (ECEF) Delta output record
1	Record length	Char	18h	Bytes in record
2–9	Delta X	Double	Meters	ECEF X-axis delta between rover and base station positions
10–17	Delta Y	Double	Meters	ECEF Y-axis delta between rover and base station positions
18–25	Delta Z	Double	Meters	ECEF Z-axis delta between rover and base station positions

NEU DELTA

This message contains Tangent Plane Delta information. It contains the following data:

- North, East, and Up deltas of the vector from the base to the rover (in meters) projected onto a plane tangent to the WGS-84 ellipsoid at the base receiver.

Note – These records are only output if a valid DGPS/RTK solution is computed.

Table B.7 NEU Delta (Type 7 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	07h	Tangent Plane Delta output record
1	Record length	Char	18h	Bytes in record
2–9	Delta east	Double	meters	East component of vector from base station to rover, projected onto a plane tangent to the WGS-84 ellipsoid at the base station
10–17	Delta north	Double	meters	North component of tangent plane vector
18–25	Delta up	Double	meters	Difference between ellipsoidal height of tangent plane at base station and a parallel plane passing through rover point

Velocity

This message provides velocity information. It contains the following data:

- Horizontal velocity, in meters per second
- Vertical velocity, in meters per second
- Heading, in radians, referenced to WGS-84 True North

Table B.8 Velocity (Type 8 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	08h	Velocity data output record
1	Record length	Char	0Dh	Bytes in record
2	Velocity flags	Char	See Table B.19	Velocity status flags
3–6	Speed	Float	Meters per second	Horizontal speed
7–10	Heading	Float	Radians	True north heading in the WGS-84 datum
11–14	Vertical velocity	Float	Meters per second	Vertical velocity

PDOP

This message describes the PDOP information. It contains the following data:

- PDOP
- HDOP
- VDOP
- TDOP

Table B.9 PDOP (Type 9 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	09h	PDOP information output record
1	Record length	Char	10h	Bytes in record
2-5	PDOP	Float		Positional Dilution of Precision
6-9	HDOP	Float		Horizontal Dilution of Precision
10-13	VDOP	Float		Vertical Dilution of Precision
14-17	TDOP	Float		Time Dilution of Precision

SIGMA

This message describes the Position Sigma information. It contains the following data:

- Position RMS
- Sigma east, in meters
- Sigma north, in meters
- Sigma up, in meters
- Covariance east-north
- Error Ellipse Semi-major axis, in meters
- Error Ellipse Semi-minor axis, in meters
- Orientation of Semi-major axis in degrees from True North
- Unit variance
- Number of epochs

Table B.10 Sigma (Type 12 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	0Ch	Position sigma information output record
1	Record length	Char	26h	Bytes in record
2-5	Position RMS	Float		Root means square of position error calculated for overdetermined positions
6-9	Sigma east	Float	Meters	
10-13	Sigma north	Float	Meters	
14-17	Covar. east-north	Float	number	Covariance east-north (dimensionless)

Table B.10 Sigma (Type 12 record)

Field	Item	Type	Value	Meaning
18–21	Sigma up	Float	Meters	
22–25	Semi-major axis	Float	Meters	Semi-major axis of error ellipse
26–29	Semi-minor axis	Float	Meters	Semi-minor axis of error ellipse
30–33	Orientation	Float	degrees	Orientation of semi-minor axis, clockwise from True North
34–37	Unit variance	Float		Valid only for over-determined solutions. Unit variance should approach 1.0 value. A value of less than 1.0 indicates that apriori variances are too pessimistic.
30–39	Number of epochs	short	count	Number of measurement epochs used to compute the position. Could be greater than 1 for positions subjected to static constraint. Always 1 for kinematic.

SV Brief

This message provides brief satellite information. It contains the following data:

- Number of satellites tracked
- The PRN number of each satellite
- Flags indicating satellite status

Table B.11 SV brief (Type 13 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	0Dh	Brief satellite information output record
1	Record length	Char		Bytes in record
2	Number of SVs	Char	00h-18h	Number of satellites included in record ¹
The following bytes are repeated for Number of SVs				
	PRN	Char	01h-20h	Pseudorandom number of satellites (1-32)
	SV Flags1	Char	See Table B.20	First set of satellite status bits
	SV Flags2	Char	See Table B.21	Second set of satellite status bits

¹Includes all tracked satellites, all satellites used in the position solution, and all satellites in view.

SV Detail

This message provides detailed satellite information. It contains the following data:

- Number of satellites tracked
- The PRN number of each satellite
- Flags indicating satellite status
- Elevation above horizon, in degrees
- Azimuth from True North, in degrees

- Signal-to-noise ratio (SNR) of L1 signal
- Signal-to-noise ratio (SNR) of L2 signal

Table B.12 SV detail (Type 14 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	0Eh	Detailed satellite information output record
1	Record length	Char	1 + 8x(number of SVs)	Bytes in record
2-9	Number of SVs	Char	00h-18h	Number of satellites included in record ¹
The following bytes are repeated for Number of SVs				
	PRN	Char	01h-20h	Pseudorandom number of satellites (1-32)
	Flags1	Char	See Table B.20	First set of satellite status bits
	Flags2	Char	See Table B.21	Second set of satellite status bits
	Elevation	Char	Degrees	Angle of satellite above the horizon
	Azimuth	Short	Degrees	Azimuth of satellite from True North
	SNR L1	Char	dB * 4	Signal-to-noise ratio of L1 signal (multiplied by 4) ²
	SNR L2	Char	dB * 4	Signal-to-noise ratio of L2 signal (multiplied by 4) ²

¹Includes all tracked satellites, all satellites used in the position solution, and all satellites in view.

²The SNR L1 and SNR L2 items are set to zero for satellites that are not tracked on the current frequency.

UTC

This message describes current time information. It contains the following data:

- GPS time, in milliseconds of GPS week
- GPS week number
- GPS to UTC time offset, in seconds

Table B.13 UTC (Type 16 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	10h	
1	Record length	Char	09h	Bytes in record
2-5	GPS millisecond of week	Long	msecs	Time when packet is sent from the receiver, in GPS milliseconds of week
6-7	GPS week number	Short	number	Week number since start of GPS time
8-9	UTC offset	Short	seconds	GPS to UTC time offset
10	Flags	Char	See Table B.18	Flag bits indicating validity of Time and UTC offsets

Batt/Mem

This message provides information relating to the receiver battery and memory. It contains the following data:

- Remaining battery power
- Remaining memory

Table B.14 Batt/Mem (Type 37 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	25h	
1	Record length	Char	0Ah	Bytes in record
2–3	Battery capacity	Unsigned short	percentage	Remaining battery capacity in percentage
4–11	Remaining memory	Double	hours	Estimated remaining data logging time in hours

Attitude

This message provides attitude information relating to the vector between the Heading antenna and the Moving Base antenna. It contains the following data:

- Tilt or vertical angle, in radians, from the Heading antenna to the Moving Base antenna relative to a horizontal plane through the Heading antenna
- Heading or yaw, in radians, relative to True North
- Range or slope distance between the Heading antenna and the Moving Base antenna

Table B.15 Attitude (Type 27 record)

Field	Item	Type	Value	Meaning
0	Output record type	Char	1Bh	Attitude information
1	Record length	Char	2Ah	Bytes in record
2–5	GPS time	Long	msecs	GPS time in milliseconds of GPS week
6	Flags	Char	See Table B.22	Flag bits indicating validity of attitude components
7	Number of SVs used	Char	00h–0Ch	Number of satellites used to calculate attitude
8	Calculation mode	Char	See Table B.23	Positioning mode
9	Reserved			Reserved
10–17	Tilt	Double	radians	Tilt relative to horizontal plane
18–25	Yaw	Double	radians	Rotation about the vertical axis relative to True North
26–33	Reserved			Reserved
34–41	Range	Double	meters	Distance between antennas
42–43	PDOP	Short	0.1	Position Dilution of Precision

Flags

Table B.16 Position flags 1: bit values

Bit	Meaning
0	New position 0: No. 1: Yes.
1	Clock fix calculated for current position 0: No. 1: Yes.
2	Horizontal coordinates calculated this position 0: No. 1: Yes.
3	Height calculated this position 0: No. 1: Yes.
4	Weighted position 0: No. 1: Yes.
5	Overdetermined position 0: No. 1: Yes.
6	Ionosphere-free position 0: No. 1: Yes.
7	Position uses filtered L1 pseudoranges 0: No. 1: Yes.

Table B.17 Position flags 2: bit values

Bit	Meaning
0	Differential position 0: Differential position is an autonomous or a WAAS solution. 1: Position is a differential solution.
1	Differential position method 0: Code 1: Phase including RTK, HP or XP OmniSTAR (VBS is not derived from Phase).
2	Differential position method 0: Code (DGPS) or a float position (RTK). Uncorrected position is Autonomous (if bit 0 = 0). 1: Position is fixed integer phase position (RTK). Uncorrected position is WAAS (if bit 0 = 0).
3	OmniSTAR solution 0: Not active 1: OmniSTAR differential solution (including HP, XP, and VBS)
4	Position determined with static as a constraint 0: No. 1: Yes.
5	Position is network RTK solution 0: No. 1: Yes.
6–7	Reserved (set to zero)

Table B.18 Flags: Bit values

Bit	Meaning
0	Time information (week and millisecond of week) validity 0: Not valid 1: Valid
1	UTC offset validity 0: Not valid 1: Valid

Table B.19 Velocity flags: Bit values

Bit	Meaning
0	Velocity data validity 0: Not valid 1: Valid
1	Velocity computation 0: Computed from doppler 1: Computed from consecutive measurements
2-7	Reserved (set to zero)

Table B.20 SV flags: 1 bit values

Bit	Meaning
0	Satellite Above Horizon 0: No. 1: Yes.
1	Satellite Currently Assigned to a Channel (trying to track) 0: No. 1: Yes.
2	Satellite Currently Tracked on L1 Frequency 0: No. 1: Yes.
3	Satellite Currently Tracked on L2 Frequency 0: No. 1: Yes.
4	Satellite Reported at Base on L1 Frequency 0: No. 1: Yes.
5	Satellite Reported at Base on L2 Frequency 0: No. 1: Yes.
6	Satellite Used in Position 0: No. 1: Yes.
7	Satellite Used in Current RTK Process (Search, Propagate, Fix Solution) 0: No. 1: Yes.

Table B.21 SV flags: 2 bit value

Bit	Meaning
0	Satellite Tracking P-Code on L1 Band 0: No. 1: Yes.
1	Satellite Tracking P-Code on L2 Band 0: No. 1: Yes.
2-7	Reserved. Set to zero.

Table B.22 Attitude flags

Bit	Meaning
0	Calibrated 0: No. 1: Yes.
1	Tilt valid 0: No. 1: Yes.
2	Yaw valid 0: No. 1: Yes.
3	Reserved
4	Range valid 0: No. 1: Yes.
5–7	Reserved

Table B.23 Attitude calculation flags

Bit	Meaning
0	0: No position 1: Autonomous position 2: RTK/Float position 3: RTK/Fix position 4: DGPS position

Adding Internal Radio Frequencies

In this appendix:

- [Adding receive frequencies for the 450 MHz internal radio](#)

If you have installed the optional internal 450 MHz radio in your GPS receiver, use the WinFlash utility to add the relevant **receive** frequencies to the default list of frequencies. To install the WinFlash utility, see [Installing the WinFlash utility, page 116](#).

If you have also purchased the **transmit** option, Trimble must specify and configure the (FCC-approved) transmit broadcast frequencies at the factory. You cannot configure these yourself.

Adding receive frequencies for the 450 MHz internal radio

1. Start the WinFlash utility. The *Device Configuration* screen appears.
2. From the *Device type* list, select the appropriate receiver.
3. From the *PC serial port* field, select the serial (COM) port on the computer that the receiver is connected to.
4. Click **Next**. The *Operation Selection* dialog appears. The *Operations* list shows all of the supported operations for the selected device. A description of the selected operation is shown in the *Description* field.
5. Select **Configure Radio** and then click **Next**. The *Frequency Selection* dialog appears:
6. In the *Wireless Format* group, select the appropriate channel and wireless mode. The Wireless mode must be the same for all radios in your network.
7. In the *Specify Frequency* field, enter the frequency you want to add.
8. Click **Add**. The new frequency appears in the *Selected Frequencies* list.

Note – The programmed frequencies must conform to the channel spacing and minimum tuning requirements for the radio. To view this information, click **Radio Info**. You can select 12.5 kHz or 25 kHz channel spacing. All radios in your network must use the same channel spacing.

Frequency Selection COM1

You have connected to an SPSx70 Internal

Frequency Band: 450.0 - 470.0 MHz

Wireless Format

Current Channel: 1 - 461.025 MHz

Wireless Mode: TRIMMARK 3 at 19200 bps

Note: Wireless mode must be common among all radios in your network.

Channel Frequency

Specify Frequency: 464.6000 MHz

Selected Frequencies:

Channel	Frequency
1	461.0250
2	461.0750
3	461.1000
4	462.1250
5	462.3750
6	462.4000
7	464.5000
8	464.5500
9	464.6000
10	464.6250
11	464.6500
12	464.7000
13	464.7250

9. Once you have configured all the frequencies that you require, click **OK**. The WinFlash utility updates the receiver radio frequencies and then restarts the receiver.

Real-Time Data and Services

In this appendix:

- [RT17 Streamed Data service](#)
- [Login authentication](#)

The real-time Binary Output option (also known as RT17 messages or raw data) is available as an optional upgrade. The RT17 Streamed Data service is available only with the SPS780 Max, SPS781 Max, SPS880 Extreme, and the SPS881 Extreme GPS receivers.

By default, the Binary Output option is not enabled in the GPS receivers. The option must be enabled before RT17 messages can be streamed from the receiver. To enable the option, please contact your local Trimble dealer.

RT17 Streamed Data service

An RT17 service provides GPS observations, ephemerides, and other information, as defined for that service. When a “client” connects to the service, all data flow is from the Smart GPS antenna to the client.

Login authentication

If you interface to the receivers using binary commands over serial communications, you may need login authentication. This has been added to most SPSx51 and SPSx81 receiver models that run firmware version 3.30 or later.

If your utilities such as the WinFlash utility or the Configuration ToolBox software do not work with the receivers running firmware version 3.30 or later, then go to the Trimble website and download the latest versions of these utilities. If your own application software no longer communicates with the receiver, please contact Trimble Support for information about how to use the receiver in these cases.

Upgrading the Receiver Firmware

In this appendix:

- [The WinFlash utility](#)
- [Upgrading the receiver firmware](#)

Your receiver is supplied with the latest version of receiver firmware installed. If a later version becomes available, upgrade the firmware installed on your receiver using the WinFlash utility.

If you have a SPSx50 or SPSx51 Modular GPS receiver, you can also upgrade it through the web interface.

The WinFlash utility

The WinFlash utility communicates with Trimble products to perform various functions including:

- installing software, firmware, and option upgrades
- running diagnostics (for example, retrieving configuration information)
- configuring radios

For more information, online help is also available when using the WinFlash utility.

Note – *The WinFlash utility runs on Microsoft Windows 95, 98, Windows NT®, 2000, Me, or XP operating systems.*

Installing the WinFlash utility

You can install the WinFlash utility from the *Trimble SPS GPS Receiver CD*, or from the Trimble website.

To install the WinFlash utility from the CD:

1. Insert the disk into the CD drive on your computer.
2. From the main menu select *Install individual software packages*.
3. Select *Install WinFlash*.
4. Follow the on-screen instructions.

The WinFlash utility guides you through the firmware upgrade process, as described below. For more information, refer to the WinFlash Help.

Upgrading the receiver firmware

1. Start the WinFlash utility. The *Device Configuration* screen appears.
2. From the *Device type* list, select your receiver.
3. From the *PC serial port* field, select the serial (COM) port on the computer that the receiver is connected to.
4. Click **Next**.

The *Operation Selection* screen appears. The *Operations* list shows all of the supported operations for the selected device. A description of the selected operation is shown in the *Description* field.

5. Select *Load GPS software* and then click **Next**.

The *GPS Software Selection* window appears. This screen prompts you to select the software that you want to install on the receiver.

6. From the *Available Software* list, select the latest version and then click **Next**.

The *Settings Review* window appears. This screen prompts you to connect the receiver, suggests a connection method and then lists the receiver configuration and selected operation.

7. If all is correct, click **Finish**.

Based on the selections shown above, the *Software Upgrade* window appears and shows the status of the operation (for example, **Establishing communication with <your receiver>. Please wait.**).

8. Click **OK**.

The *Software Upgrade* window appears again and states that the operation was completed successfully.

9. To select another operation, click **Menu**; to quit, click **Exit**.

If you click **Exit**, the system prompts you to confirm.

10. Click **OK**.

Data Logging and Postprocessed Measurement Operations

In this appendix:

- Connecting to the office computer
- Transferring files directly from a CompactFlash card
- Deleting files in the receiver
- Supported file types

By default, the SPS GPS receivers cannot log data unless you purchase the Data Logging option.

A Smart GPS antenna uses the internal memory of the receiver to store this data. The data files cannot be processed until you transfer them to your office computer.

Note – The SPS780 Max has an available memory of 2 MB. The SPS880 Extreme has an available memory of 6 MB. The SPS781 and SPS881 Extreme have a maximum of 11 MB memory. None of the receivers have a maximum file quantity limit.

Connecting to the office computer

The Smart GPS antenna can communicate with the office computer using a serial connection from the DB9 connector on the receiver to a LEMO connector on the computer (see [Figure F.1](#)). You can also use the supplied DB9 to DB9 cable (P/N 18532 or 59046 (RoHS compliant)). Before you connect to the office computer, ensure that the receiver battery is fully charged.

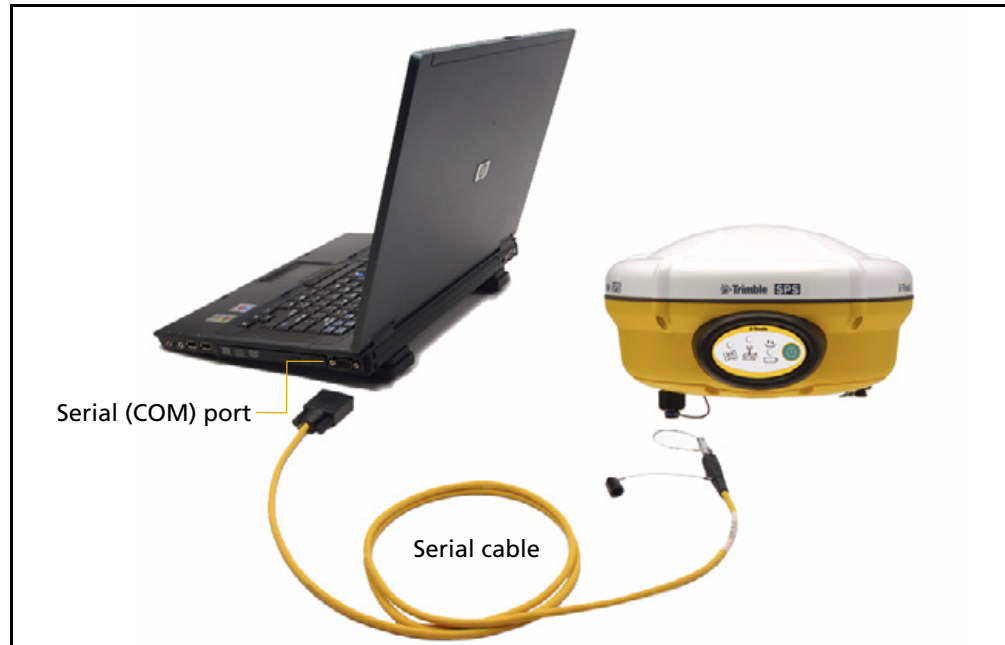


Figure F.1 Connecting the SPS881 Extreme Smart GPS antenna to a computer for serial data transfer

Transferring files directly from a CompactFlash card

Data is stored in the internal flash memory. To transfer files between the receiver and your office computer, connect the receiver to the office computer and use the Data Transfer utility to transfer files.

When you use the Data Transfer utility to transfer data files from the receiver, the Data Transfer utility converts the raw receiver data (.T01) files you select into the Trimble DAT file format.

You can convert receiver data files by using a Windows Explorer extension which is installed on your computer when you install the Data Transfer utility.

Deleting files in the receiver

You can delete files stored in the receiver at any time. Do one of the following:

- Press **Ⓢ** for 30 seconds *after* the receiver is turned on. (When you use this method, *all* data is deleted.)

- Use the Data Transfer utility
- With the SPSx50 or SPSx51 Modular GPS receiver, use the Web interface.

Supported file types

Table F.1 shows the file types that you can transfer to or from a SPS GPS receiver, and the software or utility that you must use to transfer each file type.

Table F.1 Supported file types

File Type	Extensions	Transfer from receiver	Transfer to receiver	Software
Ephemeris	.eph	Yes	No	Data Transfer
Raw observations	.T01, .dat	Yes	No	Data Transfer Web interface (SPSx50/SPSx51)
Receiver firmware files	.elf	No	Yes	WinFlash utility
Application files (SPSx80 Smart GPS antenna)	.cfg	Yes	Yes	GPS Configurator Configuration Toolbox

Troubleshooting

In this appendix:

- LED conditions
- Receiver issues
- Base station setup and static measurement problems

Use this appendix to identify and solve common problems that may occur with the receiver.

Please read this section before you contact technical support.

LED conditions

The Smart GPS antenna has a simple display panel with LEDs to indicate the current status of the receiver. If you need more detailed information about what the receiver is doing, use a Trimble controller or laptop computer running the SCS900, GPS Configurator, or Configuration Toolbox software.

The following section describes how the LED lights are used on the receiver to indicate current status. An LED that is flashing quickly indicates a condition that may require attention, and an unlit LED indicates that no operation is occurring. This section describes some LED conditions, possible causes, and how to solve them.


Condition	Possible cause	Solution
The SV Tracking LED is lit solidly and the Logging/Memory LED is flashing slowly.	The receiver is in Monitor mode, ready for new firmware to be loaded or new options to be added.	Turn on or turn off the receiver. Load the latest version of the firmware, which you can download from the Trimble website (www.trimble.com/sps780.shtml / Support / Downloads).
The SV Tracking LED is not flashing.	The receiver is tracking fewer than four satellites.	Wait until the SV Tracking LED is flashing slowly.

Receiver issues

This section describes some possible receiver issues, possible causes, and how to solve them.

Issue	Possible cause	Solution
The receiver does not turn on.	External power is too low.	Check the charge on the external battery, and check the fuse if applicable. If necessary, replace the battery.
	Internal power is too low.	<ul style="list-style-type: none"> Check the charge on the internal batteries and replace if necessary. Ensure battery contacts are clean.
	External power is not properly connected.	<ul style="list-style-type: none"> Check that the Lemo connection is seated properly. Check for broken or bent pins in the connector.

Issue	Possible cause	Solution
	Faulty external power cable.	<ul style="list-style-type: none"> Try a different cable. Check pinouts with multimeter to ensure internal wiring is intact.
Receiver does not log data.	Insufficient memory on either internal memory or the CompactFlash card.	Delete old files using the GPS Configurator software, or press Ⓢ for 30 seconds.
	No CompactFlash card is inserted. (SPS770 only)	Insert a CompactFlash card in the receiver.
	The CompactFlash card is not seated properly.	Remove the Compact Flash card and reinsert it. Ensure that it slides into the housing easily and seats into the connector.
	The CompactFlash card is not formatted, or has been corrupted.	Format the CompactFlash card using the GPS Configurator software, or press Ⓢ for 30 seconds. If the problem persists, use the GPS Configurator software to perform a full format.
	The receiver is tracking fewer than four satellites.	<ul style="list-style-type: none"> Wait until the SV Tracking LED is flashing slowly. Use the SCS900 software. Go to the <i>SkyPlot</i> screen and press Ctrl+M to access the current elevation mask settings. Reduce the mask value to make more satellites available. <p>The default mask setting for receiver is 10° above the horizon. Change the value to a lower setting temporarily while you are waiting for a better constellation availability.</p>
	The data logging option is not enabled.	Check the original purchase order or the receiver configuration using WinFlash. If data logging is not enabled on the receiver, you can order the option from your local Trimble Site Positioning Systems dealer, and upgrade the receiver using the WinFlash utility.
Receiver is not tracking any satellites	GPS antenna does not have clear line of sight to the sky.	Ensure that the antenna has a clear line of sight.
	The cable between receiver and the GPS antenna is damaged.	Replace the cable.
	Cable connections at receiver or antenna are not tightly seated, or are connected incorrectly.	Check all cable connections.

Issue	Possible cause	Solution
The receiver is not responding.	Receiver needs a soft reset.	Turn off the receiver and then turn it back on again.
	Receiver needs a full reset.	Press  for 30 seconds. Note – To retain data files, download the files (SPS780) first.

Base station setup and static measurement problems

This section describes some possible station setup and static measurement issues, possible causes, and how to solve them.

Trimble recommends that you use the SCS900 software to restart or configure base and rover receivers. The SCS900 software sets up all radio and receiver operating parameters, and is the most likely route to a successful problem resolution once you have checked all connections, cables, and batteries.

Issue	Possible cause	Solution
Base station is not broadcasting.	Port settings between base receiver and external radio are incorrect. Note – The Smart GPS antenna has the option for an integrated Tx radio that allows it to be used without an external radio at the base and rover location. The Smart GPS antenna can also be connected to an external high power radio in certain countries.	Using the Trimble SCS900 Site Controller software connect to the radio through the receiver. If no connection is made, connect directly to the radio and change the port settings. Try to connect through the receiver again to ensure that they are communicating. Note – The SCS900 software does not support direct connection to the external radio; it only allows configuration through the receiver. The TRIMMARK 3 and SNB900 radios can be configured directly using the keypad and display. The Trimble PDL or Trimble HPB radios can be configured using the accompanying configuration software through a laptop computer.
	Faulty cable between receiver and external radio	<ul style="list-style-type: none"> • Try a different cable • Examine the ports for missing pins • Use a multimeter to check the pins
	No power to radio	If the radio has its own power supply, check the charge and connections.
	No Bluetooth connections	Make sure that the radio and receiver are within Bluetooth range of each other and that the Bluetooth antennas are visible to each other.

Issue	Possible cause	Solution
Roving receiver is not receiving radio from the base station.	The base station is not broadcasting.	See Base station is not broadcasting .
	Incorrect over air baud rates between base station and rover.	Connect to the roving receiver's radio and make sure that it has the same setting as the base station receiver.
	Mismatched channel or network number selection.	Match the base station and rover radio channels/network number and try again.
	Incorrect port settings between the rover external radio and receiver.	If the radio is receiving data (the Radio LED is flashing) and the receiver is not receiving data, check the port settings of the receiver and radio using the Trimble SCS900 Site Controller software; match the settings and try again.
	The radio antenna cable and GPS antenna cable are mixed up.	Make sure that the radio antenna cable (with the blue over-mould) is connected between the blue TNC connector marked RADIO and the radio antenna.

Glossary

1PPS	Pulse-per-second. Used in hardware timing. A pulse is generated in conjunction with a time stamp. This defines the instant when the time stamp is applicable.
almanac	A file that contains orbit information on all the satellites, clock corrections, and atmospheric delay parameters. The almanac is transmitted by a GPS satellite to a GPS receiver, where it facilitates rapid acquisition of GPS signals when you start collecting data, or when you have lost track of satellites and are trying to regain GPS signals. The orbit information is a subset of the ephemeris / ephemerides data.
AutoBase	AutoBase technology uses the position of the receiver to automatically select the correct base station; allowing for one button press operation of a base station. It shortens setup time associated with repeated daily base station setups at the same location on jobsites.
base station	Also called <i>reference station</i> . A base station in construction, is a receiver placed at a known point on a jobsite that tracks the same satellites as an RTK rover, and provides a real-time differential correction message stream through radio to the rover, to obtain centimeter level positions on a continuous real-time basis. A base station can also be a part of a virtual reference station network, or a location at which GPS observations are collected over a period of time, for subsequent postprocessing to obtain the most accurate position for the location.
BINEX	Binary EXchange format. BINEX is an operational binary format standard for GPS/ GLONASS / SBAS research purposes. It has been designed to grow and allow encapsulation of all (or most) of the information currently allowed for in a range of other formats.
broadcast server	An Internet server that manages authentication and password control for a network of VRS servers, and relays VRS corrections from the VRS server that you select.
carrier	A radio wave having at least one characteristic (such as frequency, amplitude, or phase) that can be varied from a known reference value by modulation.
carrier frequency	The frequency of the unmodulated fundamental output of a radio transmitter. The GPS L1 carrier frequency is 1575.42 MHz.
carrier phase	Is the cumulative phase count of the GPS or GLONASS carrier signal at a given time.
cellular modems	A wireless adaptor that connects a laptop computer to a cellular phone system for data transfer. Cellular modems, which contain their own antennas, plug into a PC Card slot or into the USB port of the computer and are available for a variety of wireless data services such as GPRS.
CMR	Compact Measurement Record. A real-time message format developed by Trimble for broadcasting corrections to other Trimble receivers. CMR is a more efficient
CMR+	alternative to RTCM .
covariance	A statistical measure of the variance of two random variables that are observed or measured in the same mean time period. This measure is equal to the product of the deviations of corresponding values of the two variables from their respective means.

datum	<p>Also called <i>geodetic datum</i>. A mathematical model designed to best fit the geoid, defined by the relationship between an ellipsoid and, a point on the topographic surface, established as the origin of the datum. World geodetic datums are typically defined by the size and shape of an ellipsoid and the relationship between the center of the ellipsoid and the center of the earth.</p> <p>Because the earth is not a perfect ellipsoid, any single datum will provide a better model in some locations than in others. Therefore, various datums have been established to suit particular regions.</p> <p>For example, maps in Europe are often based on the European datum of 1950 (ED-50). Maps in the United States are often based on the North American datum of 1927 (NAD-27) or 1983 (NAD-83).</p> <p>All GPS coordinates are based on the WGS-84 datum surface.</p>
deep discharge	<p>Withdrawal of all electrical energy to the end-point voltage before the cell or battery is recharged.</p>
DGPS	<p>See real-time differential GPS.</p>
differential correction	<p>Differential correction is the process of correcting GPS data collected on a rover with data collected simultaneously at a base station. Because the base station is on a known location, any errors in data collected at the base station can be measured, and the necessary corrections applied to the rover data.</p> <p>Differential correction can be done in real-time, or after the data has been collected by postprocessing.</p>
differential GPS	<p>See real-time differential GPS.</p>
DOP	<p>Dilution of Precision. A measure of the quality of GPS positions, based on the geometry of the satellites used to compute the positions. When satellites are widely spaced relative to each other, the DOP value is lower, and position accuracy is greater. When satellites are close together in the sky, the DOP is higher and GPS positions may contain a greater level of error.</p> <p>PDOP (Position DOP) indicates the three-dimensional geometry of the satellites. Other DOP values include HDOP (Horizontal DOP) and VDOP (Vertical DOP), which indicate the accuracy of horizontal measurements (latitude and longitude) and vertical measurements respectively. PDOP is related to HDOP and VDOP as follows: $PDOP^2 = HDOP^2 + VDOP^2$</p>
dual-frequency GPS	<p>A type of receiver that uses both L1 and L2 signals from GPS satellites. A dual-frequency receiver can compute more precise position fixes over longer distances and under more adverse conditions because it compensates for ionospheric delays.</p>
EGNOS	<p>European Geostationary Navigation Overlay Service. A satellite-based augmentation system (SBAS) that provides a free-to-air differential correction service for GPS. EGNOS is the European equivalent of WAAS, which is available in the United States.</p>
elevation mask	<p>The angle below which the receiver will not track satellites. Normally set to 10 degrees to avoid interference problems caused by buildings and trees, atmospheric issues, and multipath errors.</p>
ellipsoid	<p>An ellipsoid is the three-dimensional shape that is used as the basis for mathematically modeling the earth's surface. The ellipsoid is defined by the lengths of the minor and major axes. The earth's minor axis is the polar axis and the major axis is the equatorial axis.</p>

ephemeris / ephemerides	A list of predicted (accurate) positions or locations of satellites as a function of time. A set of numerical parameters that can be used to determine a satellite's position. Available as broadcast ephemeris or as postprocessed precise ephemeris.
epoch	The measurement interval of a GPS receiver. The epoch varies according to the measurement type: for real-time measurement it is set at one second; for postprocessed measurement it can be set to a rate of between one second and one minute. For example, if data is measured every 15 seconds, loading data using 30-second epochs means loading every alternate measurement.
feature	A feature is a physical object or event that has a location in the real world, which you want to collect position and/or descriptive information (attributes) about. Features can be classified as surface or non-surface features, and again as points, lines/breaklines, or boundaries/areas.
firmware	The program inside the receiver that controls receiver operations and hardware.
GLONASS	Global Orbiting Navigation Satellite System. GLONASS is a Soviet space-based navigation system comparable to the American GPS system. The operational system consists of 21 operational and 3 non-operational satellites in 3 orbit planes.
GNSS	Global Navigation Satellite System.
GSOFF	General Serial Output Format. A Trimble proprietary message format.
HDOP	Horizontal Dilution of Precision. HDOP is a DOP value that indicates the accuracy of horizontal measurements. Other DOP values include VDOP (vertical DOP) and PDOP (Position DOP). Using a maximum HDOP is ideal for situations where vertical precision is not particularly important, and your position yield would be decreased by the vertical component of the PDOP (for example, if you are collecting data under canopy).
L1	The primary L-band carrier used by GPS and GLONASS satellites to transmit satellite data.
L2	The secondary L-band carrier used by GPS and GLONASS satellites to transmit satellite data.
L2C	A modernized code that allows significantly better ability to track the L2 frequency.
L5	The third L-band carrier used by GPS satellites to transmit satellite data. L5 will provide a higher power level than the other carriers. As a result, acquiring and tracking weak signals will be easier.
Moving Base	Moving Base is an RTK positioning technique in which both reference and rover receivers are mobile. Corrections are sent from a "base" receiver to a "rover" receiver and the resultant baseline (vector) has centimeter-level accuracy.
MSAS	MTSAT Satellite-Based Augmentation System. A satellite-based augmentation system (SBAS) that provides a free-to-air differential correction service for GPS. MSAS is the Japanese equivalent of WAAS , which is available in the United States.
multipath	Interference, similar to ghosts on an analog television screen, that occurs when GPS signals arrive at an antenna having traversed different paths. The signal traversing the longer path yields a larger pseudorange estimate and increases the error. Multiple paths can arise from reflections off the ground or off structures near the antenna.
NMEA	National Marine Electronics Association. NMEA 0183 defines the standard for interfacing marine electronic navigational devices. This standard defines a number of 'strings' referred to as NMEA strings that contain navigational details such as positions. Most Trimble GPS receivers can output positions as NMEA strings.

OmniSTAR	The OmniSTAR HP/XP service allows the use of new generation dual-frequency receivers with the OmniSTAR service. The HP/XP service does not rely on local reference stations for its signal, but utilizes a global satellite monitoring network. Additionally, while most current dual-frequency GPS systems are accurate to within a meter or so, OmniSTAR with XP is accurate in 3D to better than 30 cm.
PDOP	<p>Position Dilution of Precision. PDOP is a DOP value that indicates the accuracy of three-dimensional measurements. Other DOP values include VDOP (vertical DOP) and HDOP (Horizontal Dilution of Precision).</p> <p>Using a maximum PDOP value is ideal for situations where both vertical and horizontal precision are important.</p>
postprocessing	Postprocessing is the processing of satellite data after it has been collected, in order to eliminate error. This involves using computer software to compare data from the rover with data collected at the base station.
real-time differential GPS	<p>Also known as <i>real-time differential correction</i> or <i>DGPS</i>. Real-time differential GPS is the process of correcting GPS data as you collect it. Corrections are calculated at a base station and then sent to the receiver through a radio link. As the rover receives the position it applies the corrections to give you a very accurate position in the field. Most real-time differential correction methods apply corrections to code phase positions.</p> <p>While DGPS is a generic term, its common interpretation is that it entails the use of single-frequency code phase data sent from a GPS base station to a rover GPS receiver to provide sub-meter position accuracy. The rover receiver can be at a long range (greater than 100 kms (62 miles)) from the base station.</p>
rover	A rover is any mobile GPS receiver that is used to collect or update data in the field, typically at an unknown location.
Roving mode	Roving mode applies to the use of a rover receiver to collect data, stakeout, or control earthmoving machinery in real time using RTK techniques.
RTCM	Radio Technical Commission for Maritime Services. A commission established to define a differential data link for the real-time differential correction of roving GPS receivers. There are three versions of RTCM correction messages. All Trimble GPS receivers use Version 2 protocol for single-frequency DGPS type corrections. Carrier phase corrections are available on Version 2, or on the newer Version 3 RTCM protocol, which is available on certain Trimble dual-frequency receivers. The Version 3 RTCM protocol is more compact but is not as widely supported as Version 2.
RTK	real-time kinematic. A real-time differential GPS method that uses carrier phase measurements for greater accuracy.
SBAS	Satellite-Based Augmentation System. SBAS is based on differential GPS, but applies to wide area (WAAS/EGNOS and MSAS) networks of reference stations. Corrections and additional information are broadcast via geostationary satellites.
signal-to-noise ratio	SNR. The signal strength of a satellite is a measure of the information content of the signal, relative to the signal's noise. The typical SNR of a satellite at 30° elevation is between 47 and 50 dBHz.
skyplot	The satellite skyplot confirms reception of a differentially corrected GPS signal and displays the number of satellites tracked by the GPS receiver, as well as their relative positions.

SNR	See signal-to-noise ratio .
triple frequency GPS	A type of receiver that uses three carrier phase measurements (L1 , L2 , and L5).
UTC	Universal Time Coordinated. A time standard based on local solar mean time at the Greenwich meridian.
VRS	<p>Virtual Reference Station. A VRS system consists of GPS hardware, software, and communication links. It uses data from a network of base stations to provide corrections to each rover that are more accurate than corrections from a single base station.</p> <p>To start using VRS corrections, the rover sends its position to the VRS server. The VRS server uses the base station data to model systematic errors (such as ionospheric noise) at the rover position. It then sends RTCM correction messages back to the rover.</p>
WAAS	<p>Wide Area Augmentation System. WAAS was established by the Federal Aviation Administration (FAA) for flight and approach navigation for civil aviation. WAAS improves the accuracy and availability of the basic GPS signals over its coverage area, which includes the continental United States and outlying parts of Canada and Mexico.</p> <p>The WAAS system provides correction data for visible satellites. Corrections are computed from ground station observations and then uploaded to two geostationary satellites. This data is then broadcast on the L1 frequency, and is tracked using a channel on the GPS receiver, exactly like a GPS satellite.</p> <p>Use WAAS when other correction sources are unavailable, to obtain greater accuracy than autonomous positions. For more information on WAAS, refer to the FAA website at http://gps.faa.gov.</p> <p>The EGNOS service is the European equivalent and MSAS is the Japanese equivalent of WAAS.</p>
WGS-84	<p>World Geodetic System 1984. Since January 1987, WGS-84 has superseded WGS-72 as the datum used by GPS.</p> <p>The WGS-84 datum is based on the ellipsoid of the same name.</p>



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