AX940/AX940i

GNSS-Inertial Receivers

USER GUIDE

Revision C
September 2020

TRANSFORMING THE WAY THE WORLD WORKS

Trimble

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Release Notice

This is the September 2020 release (Revision C) of the AX940/AX940i GNSS-Inertial Receiver User Guide.

LIMITED WARRANTY TERMS AND CONDITIONS

Product Limited Warranty

Subject to the following terms and conditions, Trimble Inc. ("Trimble") warrants that for a period of one (1) year from date of purchase unless otherwise specified, this Trimble product (the "Product") will substantially conform to Trimble's publicly available specifications for the Product and that the hardware and any storage media components of the Product will be substantially free from defects in materials and workmanship.

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If the Trimble Product fails during the warranty period for reasons covered by this limited warranty and you notify Trimble of such failure during the warranty period, Trimble will repair OR replace the nonconforming Product with new, equivalent to new, or reconditioned parts or Product, OR refund the Product purchase price paid by you, at Trimble's option, upon your return of the Product in accordance with Trimble's product return procedures then in effect.

How to Obtain Warranty Service

To obtain warranty service for the Product, please contact your local Trimble authorized dealer. Alternatively, you may contact Trimble to request warranty service by e-mailing your request to GNSSOEMSupport@trimble.com. Please be prepared to provide:

– your name, address, and telephone numbers

– proof of purchase

– a copy of this Trimble warranty

– a description of the nonconforming Product including the model number

– an explanation of the problem

The customer service representative may need additional information from you depending on the nature of the problem.

Warranty Exclusions or Disclaimer

This Product limited warranty shall only apply in the event and to the extent that (a) the Product is properly and correctly installed, configured, interfaced, maintained, stored, and operated in accordance with Trimble's applicable operator's manual and specifications, and; (b) the Product is not modified or misused. This Product limited warranty shall not apply to, and Trimble shall not be responsible for, defects or performance problems resulting from (i) the combination or utilization of the Product with hardware or software products, information, data, systems, interfaces, or devices not made, supplied, or specified by Trimble; (ii) the operation of the Product under any specification other than, or in addition to, Trimble's standard specifications for its products; (iii) the unauthorized installation, modification, or use of the Product; (iv) damage caused by: accident, lightning or other electrical discharge, fresh or salt water immersion or spray (outside of Product specifications); or exposure to environmental conditions for which the Product is not intended; (v) normal wear and tear on consumable parts (e.g., batteries); or (vi) cosmetic damage. Trimble does not warrant or guarantee the results obtained through the use of the Product, or that software components will operate error free.

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Official Language

THE OFFICIAL LANGUAGE OF THESE TERMS AND CONDITIONS IS ENGLISH. IN THE EVENT OF A CONFLICT BETWEEN ENGLISH AND OTHER LANGUAGE VERSIONS, THE ENGLISH LANGUAGE SHALL CONTROL.

COCOM limits

This notice applies to the AX940/AX940i GNSS-Inertial Receiver receivers.

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.

Notices

FCC Class B - Notice to Users. This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation

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.

This equipment must be installed and operated in accordance with provided instructions and the antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm (for Bluetooth) from all persons and must not be co-located or operated in conjunction with any other antenna or transmitters (except in accordance with the FCC multi -transmitter product procedures).

⚠ CAUTION – The Trimble designed cable, P/N 115352 v2 with ferrite beads, was used in the FCC Part 15, Radiated Emission test set up. Trimble recommends that you verify your final system set up to maintain compliant with the FCC Rules & Regulations for Title 47, Part 15, if the Trimble designed cable is not used.

Canada

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

This apparatus complies with Canadian RSS-GEN, RSS-247, and RSS-119.

Cet appareil est conforme à la norme CNR-GEN, CNR-247, et CNR-119 du Canada.

Europe

The products covered by this guide may be operated in all EU member countries (BE, BG, CZ, DK, DE, EE, IE, EL, ES, FR, HR, IT, CY, LV, LT, LU, HU, MT, NL, AT, PL, PT, RO, SI, SK, FI, SE, UK), Norway and Switzerland. Products been tested and found to comply with the requirements for a Class B device pursuant to European Council Directive 2014/30/EU on EMC, thereby satisfying the requirements for CE Marking and sale within the European Economic Area (EEA). Contains a Bluetooth radio module. These requirements are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential or commercial environment.

CE Declaration of Conformity

Hereby, Trimble Inc., declares that the GPS receivers are in compliance with the essential requirements and other relevant provisions of Radio Equipment Directive 2014/53/EU.

English

Hereby, Trimble Inc., declares that this receiver is in compliance with the essential requirements and other relevant provisions of Directive 2014/53/EU.

Finnish

Trimble Inc.vakuuttaa täten että vastaanotin tyyppinen laite on direktiivin 2014/53/EU oleellisten vaatimusten ja sitä koskevien direktiivin muiden ehtojen mukainen.

Dutch

Hierbij verklaart Trimble Inc. dat het toestel ontvanger in overeenstemming is met de essentiële eisen en de andere relevante bepalingen van richtlijn 2014/53/EU.

Bij deze verklaart Trimble Inc. dat deze ontvanger voldoet aan de essentiële eisen en aan de overige relevante bepalingen van Richtlijn 2014/53/EU.

French

Par la présente Trimble Inc. déclare que l'appareil récepteur est conforme aux exigences essentielles et aux autres dispositions pertinentes de la directive 2014/53/EU.

Par la présente, Trimble Inc. déclare que ce récepteur est conforme aux exigences essentielles et aux autres dispositions de la directive 2014/53/EU qui lui sont applicables

Swedish

Härmed intygar Trimble Inc. att denna mottagare står I överensstämmelse med de väsentliga egenskapskrav och övriga relevanta bestämmelser som framgår av direktiv 2014/53/EU.

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Undertegnede Trimble Inc. erklærer herved, at følgende udstyr modtager overholder de væsentlige krav og øvrige relevante krav i direktiv 2014/53/EU.

German

Hiermit erklärt Trimble Inc., dass empfänger in Übereinstimmung mit den grundlegenden Anforderungen und den anderen relevanten Vorschriften der Richtlinie 2014/53/EU befindet". (BMWi)

Hiermit erklärt Trimble Inc. die Übereinstimmung des Gerätes empfänger mit den grundlegenden Anforderungen und den anderen relevanten Festlegungen der

	Richtlinie 2014/53/EU. (Wien)
Greek	ΜΕ ΤΗΝ ΠΑΡΟΥΣΑ Trimble Inc ΔΗΛΩΝΕΙ ΟΤΙ δέκτης ΣΥΜΜΟΡΦΩΝΕΤΑΙ ΠΡΟΣ ΤΙΣ ΟΥΣΙΩΔΕΙΣ ΑΠΑΙΤΗΣΕΙΣ ΚΑΙ ΤΙΣ ΛΟΙΠΕΣ ΣΧΕΤΙΚΕΣ ΔΙΑΤΑΞΕΙΣ ΤΗΣ ΟΔΗΓΙΑΣ 2014/53/EU.
Italian	Con la presente Trimble Inc. dichiara che questo ricevitore è conforme ai requisiti essenziali ed alle altre disposizioni pertinenti stabilite dalla direttiva 2014/53/EU.
Spanish	Por medio de la presente Trimble Inc. declara que el receptor cumple con los requisitos esenciales y cualesquiera otras disposiciones aplicables o exigibles de la Directiva 2014/53/EU.
Portuguese	Trimble Inc. declara que este receptor está conforme com os requisitos essenciais e outras disposições da Directiva 2014/53/EU.

Australia and New Zealand

This product conforms with the regulatory requirements of the Australian Communications and Media Authority (ACMA) EMC framework, thus satisfying the requirements for RCM Marking and sale within Australia and New Zealand.

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

Trimble products in this guide comply 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/Corporate/Environmental_Compliance.aspx.

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 B.V. & Trimble International B.V.
Industrieweg 187a
5683 CC Best
The Netherlands

Contents

1

Introduction

This manual describes how to set up, configure, and use the Trimble® AX940/AX940i GNSS-Inertial receivers. The receiver uses advanced navigation architecture to achieve real-time centimeter accuracies with minimal latencies.

Even if you have used other GNSS or GNSS-Inertial 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 GNSS or GPS, visit the Trimble website (www.trimble.com).

Technical support

If you have a problem and cannot find the information you need in the product documentation, send an email to GNSSOEMSupport@trimble.com.

Documentation, firmware, and software updates are available at www.trimble.com/Precision-GNSS/Index.aspx.

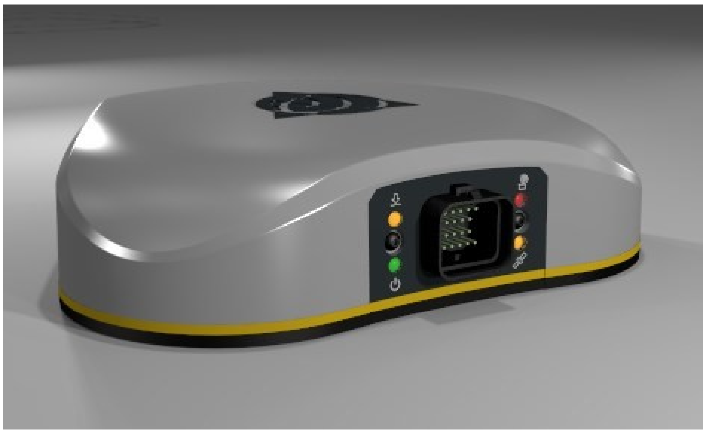
About the Trimble AX940/AX940i receivers

The receiver is sold in two hardware configurations:

- AX940 GNSS
- AX940i GNSS+Wi-Fi/Bluetooth+INS

NOTE – References to Wi-Fi/Bluetooth or INS in this documentation relate to the AX940i receiver, not the AX940 receiver.

The AX940/AX940i receivers are designed to be robust and waterproof. The receivers can be used as either a base station or a rover. The Trimble AX940i receiver leverages the power of Trimble Maxwell™ 7 processing technology. The receivers supports triple-frequency from both GPS and GLONASS constellations plus dual-frequency from BeiDou and Galileo.



The receivers provides reliable operation in all environments, and a positioning interface to an office computer, external processing device, or control system. You can control the receiver through a serial, USB, CAN or Ethernet port using binary interface commands or the web interface.

The Trimble AX940i GNSS-Inertial receiver also combines a triple-frequency GNSS receiver with inertial sensors and high-performance antenna in a rugged smart antenna design for vehicle-mounted applications. This enables OEM and system integrator customers to rapidly integrate high-accuracy GNSS-Inertial into their applications. The receiver is also suited for applications that require precise heading and attitude information in addition to position.

About Trimble Maxwell 7 technology

The Trimble AX940/AX940i GNSS receivers support the GPS, GLONASS, BeiDou, Galileo, QZSS, and NAVIC constellations. As the number of satellites in the constellations grows the receiver is ready to take advantage of the additional signals. This delivers the quickest and most reliable RTK and RTX initializations for centimeter positioning. With the latest Trimble Maxwell™ 7 Technology, the receivers provide:

- 336 tracking channels
- Trimble EVEREST™ Plus multipath mitigation
- Advanced RF Spectrum Monitoring and Analysis
- Proven low-elevation tracking technology

With the option of utilizing OmniSTAR or RTX services, the GNSS receivers delivers varying levels of performance down to centimeter level without the use of a base station.

Flexible interfacing

The receivers are designed for easy integration and rugged dependability.

Customers benefit from the Ethernet connectivity available on the board, allowing high speed data transfer and configuration via standard web browsers. USB, CAN, and RS-232 are also supported. Just like other Trimble embedded technologies; easy to use software commands simplify integration and reduce development times.

Different configurations of the module are available. These include everything from an autonomous GPS/GLONASS L1 unit all the way to an all-constellation triple-frequency RTK unit. All features are password-upgradeable, allowing functionality to be upgraded as your requirements change.

Features

The receivers have the following features.

- Advanced Trimble Maxwell™ 7 Custom Survey GNSS Technology
- On-board Advanced MEMS inertial sensors (AX940i only)
- On-board Wi-Fi/Bluetooth module (AX940i only)
- 336 Tracking Channels:
  - GPS: L1 C/A, L2E, L2C, L5
  - BeiDou: B1, B2
  - GLONASS: L1 and L2 C/A, L3 CDMA
  - Galileo: E1, E5A, E5B, E5AltBOC
  - NAVIC: L5
  - QZSS: L1 C/A, L1 SAIF, L2C, L5, LEX
  - SBAS: L1 C/A, L5
  - MSS L-Band: OmniSTAR, Trimble RTX
- High-precision multiple correlator for GNSS pseudorange measurements
- Trimble EVEREST Plus multipath mitigation
- Advanced RF Spectrum Monitoring and Analysis
- Unfiltered, unsmoothed pseudorange measurements data for low noise, low multipath error, low time domain correlation and high dynamic response
- Very low noise GNSS carrier phase measurements with <1 mm precision in a 1 Hz bandwidth
- Proven Trimble low elevation tracking technology
- Reference outputs/inputs
  - CMR, CMR+™, sCMRx, RTCM 2.1, 2.2, 2.3, 3.0, 3.112, 3.
- Navigation outputs:
  - ASCII: NMEA-0183 GSV, AVR, RMC, HDT, VGK, VHD, ROT, GGK, GGA, GSA, ZDA, VTG, GST, PJT,PJK, BPQ, GLL, GRS, GBS and Binary: Trimble GSOF, NMEA2000.
- 1 Pulse Per Second Output
- Event Marker Input Support

- Supports Fault Detection & Exclusion (FDE), Receiver Autonomous Integrity Monitoring (RAIM)

NOTE – Galileo support is developed under a license of the European Union and the European Space Agency.

NOTE – There is no public GLONASS L3 CDMA ICD. The current capability in the receivers is based on publicly available information. As such, Trimble cannot guarantee that these receivers will be fully compatible.

NOTE – The functionality to input or output any of these corrections depends on the installed options.

NOTE – Different manufacturers may have established different packet structures for their correction messages. Thus, the AX940i receiver may not receive corrections from another manufacturer's receiver, and another manufacturer's receiver may not be able to receive corrections from the AX940i receiver.

Typical applications

The receiver can be used in a multitude of applications that require robust high-precision positioning. The receiver can be used within systems being developed for:

- Precision agriculture
- Autonomous vehicles
- Unmanned aircrafts
- Field robotics
- Machine guidance and control
- Construction

Default settings

All settings are stored in application files. The default application file, Default.cfg, is stored permanently in the receiver, and contains the factory default settings. 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.

These settings are defined in the default application file.

Function	Settings	Factory default
SV Enable	-	All SVs enabled
General Controls	Elevation mask	10°
	PDOP mask	99
	RTK positioning mode	Low Latency
	Motion	Kinematic
Ports	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	Unknown
	Height (true vertical)	0.00 m
	Measurement method	Antenna Phase Center
1PPS		Disabled

If a factory reset is performed, the above defaults are applied to the receiver. To perform a factory reset:

- From the web interface, select **Receiver Configuration** / **Reset** and then clear the **Clear All Receiver Settings** option.
- Send the Command 58h with a 03h reset value.
- Use the WinFlash software and select the **Reset to factory default** option.
- Use the Configuration Toolbox utility and from the **Communications** menu, select **Reset Receiver**. Select both the **Erase Battery-Backed RAM** and **Erase File System options**.

Receiver accessories

The following accessories can be ordered.

P/N	Description
115352	Cable, AX940/AX940i, Breakout. See page 29.
119273	Mounting Plate, 5/8"-11, AX940/AX940i, Black

2

Specifications

This chapter details the specifications for the receivers.

Specifications are subject to change without notice.

Positioning specifications

NOTE – The following specifications are provided at 1 sigma level. These specifications may be affected by atmospheric conditions, signal multipath, and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.

Feature		Specification	
Initialization time		Typically <10 seconds	
Initialization accuracy		>99.9%	
Mode	**Accuracy**	**Latency (at max. output rate)**	**Maximum Rate**
Single Baseline RTK (<30 km)	0.008 m + 1 ppm horizontal	<20 ms	50 Hz
	0.015 m + 1 ppm vertical		
DGPS	0.25 m + 1 ppm horizontal	<20 ms	50 Hz
	0.5 m + 1 ppm vertical		
SBAS[1]	0.5 m horizontal	<20 ms	50 Hz
	0.85 m vertical		
Autonomous	1.00 m horizontal	<20 ms	50 Hz
	1.50 m vertical		
INS-Autonomous	1.00 m horizontal	<20 ms	50 Hz
	1.50 m vertical		
	roll/pitch	0.1°	
INS-SBAS	0.50 m horizontal	<20 ms	50 Hz
	0.85 m vertical		
	roll/pitch	0.1°	

[1] GPS only and depends on SBAS system performance. FAA WAAS accuracy specifications are <5 m 3DRMS.

Feature		Specification	
INS-DGNSS	0.40 m horizontal	<20 ms	50 Hz
	0.60 m vertical		
	roll/pitch	0.1°	
INS-RTK	0.05 m horizontal	<20 ms	50 Hz
	0.03 m vertical		
	roll/pitch	0.1°	

Performance specifications

NOTE – The Time to First Fix specifications are typical observed values. A cold start is when the receiver has no previous satellite (ephemerides/almanac) or position (approximate position or time) information. A warm start is when the ephemerides and last used position is known.

Feature	Specification	
Time to First Fix (TFF 95% typical)	Cold start	<45 seconds
	Warm start	<30 seconds
	Signal re-acquisition	<5 seconds
Velocity Accuracy[1]	Horizontal	0.007 m/sec
	Vertical	0.020 m/sec
Maximum Operating Limits[2]	Velocity	515 m/sec
	Altitude	18,000 m
Acceleration	11 g	
RTK initialization time	Typically <8 seconds	
RTK initialization reliability	>99 %	
Position latency	<20 ms	
Maximum position/attitude update rate	50 Hz (AX940) 100 Hz (AX940i)	

[1] 1 sigma level when using a Trimble Zephyr 3 antenna. These specifications may be affected by atmospheric conditions, signal multipath, and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.

[2] As required by the US Department of Commerce to comply with export licensing restrictions.

Physical and electrical characteristics

Feature	Specification
Dimensions (L × W × H)	221 mm × 218 mm × 52 mm
Power	9 V DC to 30 V DC
Weight	66 grams
Connectors - I/O	26-pin Tyco SUPERSEAL. See page 21.

Environmental specifications

Feature	Specification
Temperature	Operating: -40 °C to 70 °C
	Storage: -40 °C to 85 °C
Vibration	9.8 gRMS operating
Mechanical shock	MIL810D +/- 40 g 10 ms operating +/- 75 g 6 ms survival
Operating humidity	5 % to 95 % R.H. non-condensing, at +60 °C
IP rating	IP67

Communication specifications

Feature	Specification
Communications	1 × LAN port Supports links to 10BaseT/100BaseT networks. All functions are performed through a single IP address simultaneously including web interface access and data streaming.
	2 × RS-232 ports. Baud rates up to 460,800 bps.
	1 × CAN port. Control software: HTML web browser such as Google Chrome, Microsoft Edge, Firefox, Safari, Opera.
	1 × USB 2.0 port
Receiver position update rate	1 Hz, 2 Hz, 5 Hz, 10 Hz, 20 Hz, and 50 Hz positioning
Correction data input	CMR, CMR+, sCMRx, RTCM 2.0 DGPS (select RTCM 2.1), RTCM 2.1, 2.2, 2.3, 3.0, 3.1, 3.2)
Data outputs	1PPS, ASCII: NMEA-0183 GSV, AVR, RMC, HDT, VGK, VHD, ROT, GGK, GGA, GSA, ZDA, VTG, GST, PJT,PJK, BPQ, GLL, GRS, GBS and Binary: Trimble GSOF, NMEA2000

Receiver pinout information

26-pin Tyco connector pin out

Pin	Signal name	Signal description
1	PGND	Power supply ground. Max current 0.5 A. Do not connect to SIG_GND or USB_GND.
2	EXT_PWR_IN	Power supply input 9 to 32 V referenced to PGND. Max current 0.5 A steady state.
3	PPS_OUT	Pulse per second output. 8 us pulse configurable as positive or negative.
4	RJ45_NC5	Connect to unused RJ45 pin 5 for proper termination.
5	RJ45_NC8	Connect to unused RJ45 pin 8 for proper termination.
6	ET_TD+	Ethernet transmit+. ET_TD+ and ET_TD- differential 100 ohm. Connect to RJ45 pin 1.
7	ET_TD-	Ethernet transmit-. ET_TD+ and ET_TD- differential 100 ohm. Connect to RJ45 pin 2.
8	EVENT_IN	Event input. 3.3 V logic level but tolerant to 10 V.
9	SIG_GND	Ground reference for all digital signals except USB. Do not connect to PGND or USB_GND. Can be connected to other SIG_GND pins.
10	RJ45_NC4	Connect to unused RJ45 pin 4 for proper termination.
11	RJ45_NC7	Connect to unused RJ45 pin 7 for proper termination.
12	ET_RD+	Ethernet receive+. ET_RD+ and ET_RD- differential 100 ohm. Connect to RJ45 pin 3.
13	ET_RD-	Ethernet receive-. ET_RD+ and ET_RD- differential 100 ohm. Connect to RJ45 pin 6.
14	UART_TX_RS232	COM44 RS-232 transmit output. Max 115 k baud.
15	UART_RX_RS232	COM44 RS-232 receive input. Max 115 k baud.
16	SIG_GND	Ground reference for all digital signals except USB. Do not connect to PGND or USB_GND. Can be connected to other SIG_GND pins.
17	UART2_TX_RS232	COM1 RS-232 transmit output. Max 460 k baud.

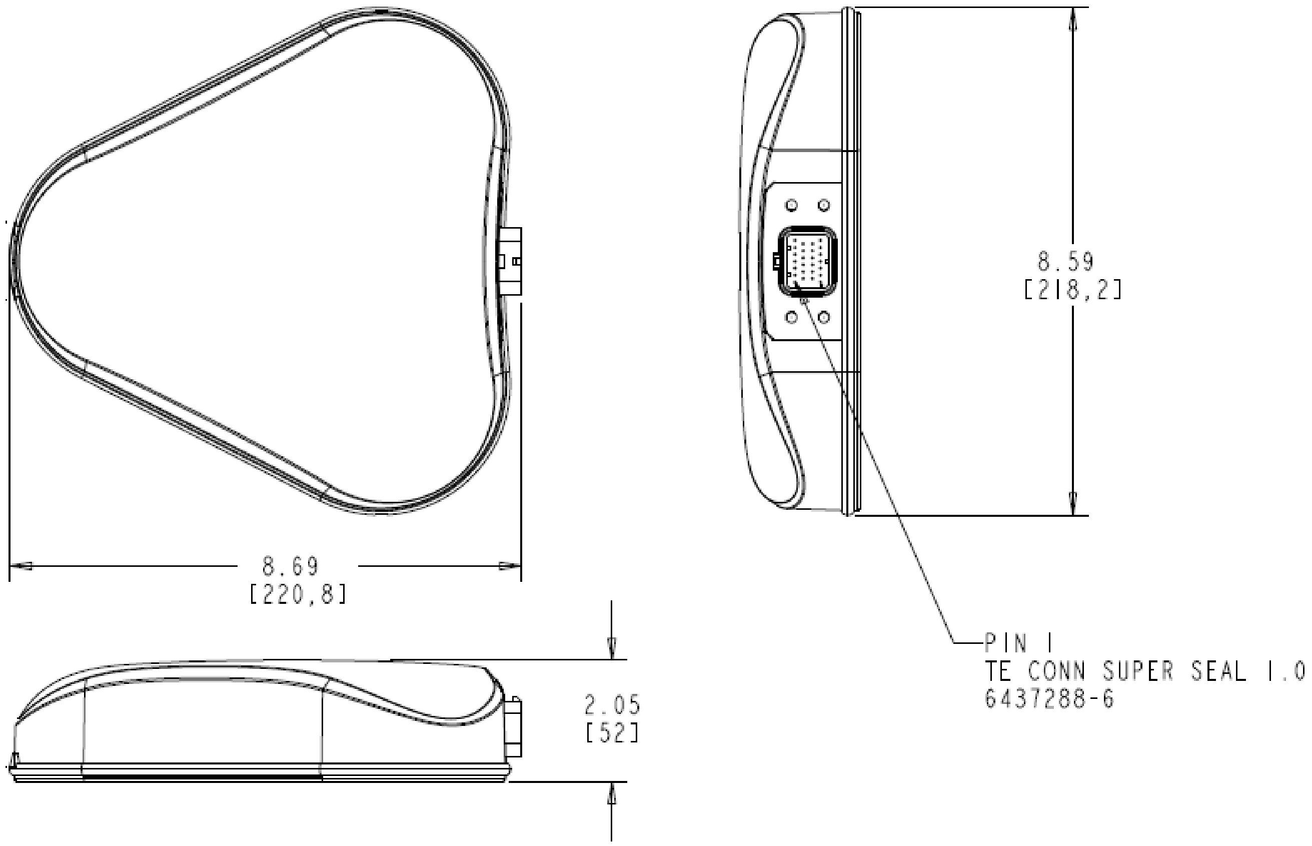
Pin	Signal name	Signal description
18	UART2_RX_RS232	COM1 RS-232 receive input. Max 460 k baud.
19	USB_GND	Ground reference for USB. Do not connect to SIG_GND or PGND.
20	CAN_H	CAN_H and CAN_L differential with configurable 120 ohm resistor on-board. 250 kbit/s.
21	CAN_L	CAN_H and CAN_L differential with configurable 120 ohm resistor on-board. 250 kbit/s.
22	SIG_GND	Ground reference for all digital signals except USB. Do not connect to PGND or USB_GND. Can be connected to other SIG_GND pins.
23	Reserved	–
24	BOOT_MON	Boot monitor pin. If this pin is grounded on power-up, then the system will boot into monitor mode.
25	USB_DP	USB_DP and USB_DM differential 90 ohm. High-speed bus. Device only.
26	USB_DM	USB_DP and USB_DM differential 90 ohm. High-speed bus. Device only.

Recommended mating connector

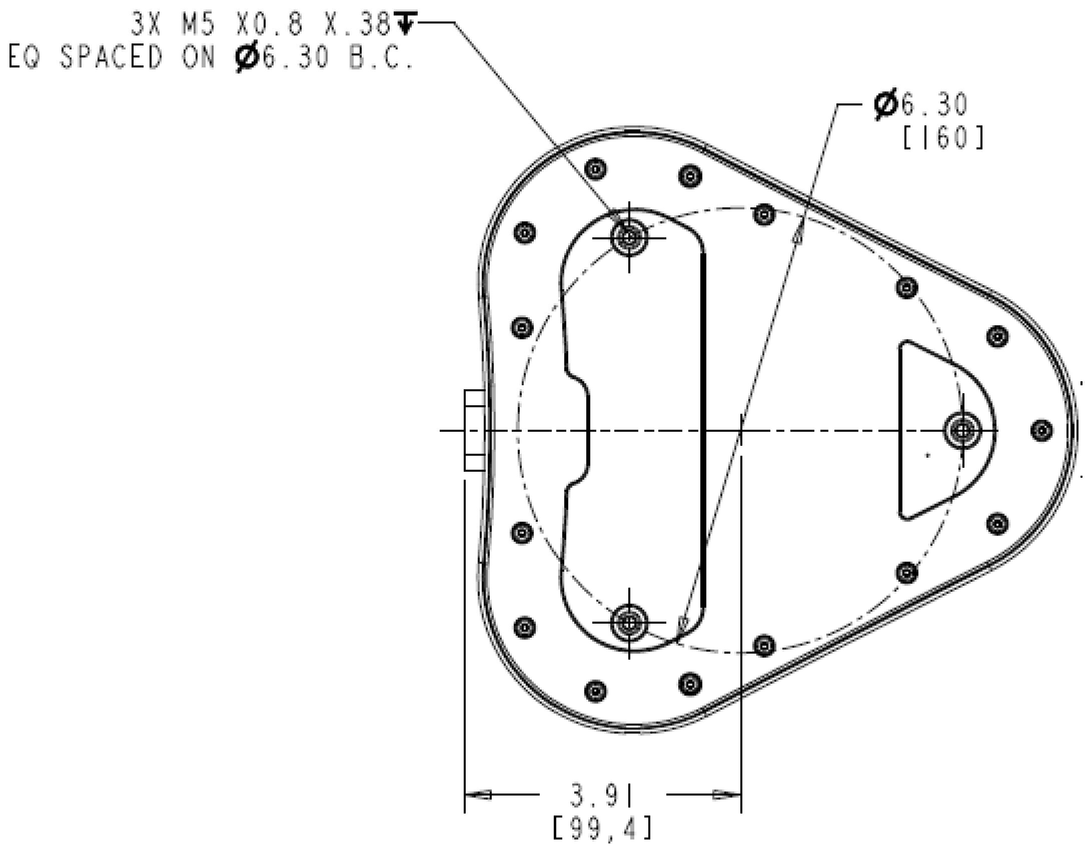
MFG - TE Connectivity #: 3-1437290-7

Mechanical specifications

Below is an overview of the key dimensions of the receiver. If you require a 3D CAD model of the module, please send a request to GNSSOEMSupport@trimble.com.



The receiver can be mounted to a main mounting plate using M5 bolts with a max torque rating of 8 Nm. The receiver mounting hole pattern is shown below:



3

Installation

Follow the guidelines in this chapter for installing and mounting the receiver.

Unpacking and inspecting the shipment

Visually inspect the shipping cartons for any signs of damage or mishandling before unpacking the receiver. Immediately report any damage to the shipping carrier.

Shipment carton contents

The shipment will include one or more cartons depending on the number of optional accessories ordered. Open the shipping cartons and make sure that all of the components indicated on the bill of lading are present.

Reporting shipping problems

Report any problems discovered after you unpack the shipping cartons to both Trimble Customer Support and the shipping carrier.

Trimble's customer support for the GNSS receiver can be reached at GNSSOEMsupport@trimble.com.

Installation guidelines

In order for the receivers to perform optimally, the following precautions should be taken or followed.

Considering environmental conditions

Install the receiver in a location situated in a dry environment. Avoid exposure to extreme environmental conditions. This includes:

- Water or excessive moisture
- Excessive heat greater than 75 °C (167 °F)
- Excessive cold less than –40 °C (–40 °F)
- Corrosive fluids and gases

Avoiding these conditions improves the receiver's performance and long-term product reliability.

Sources of electrical interference

Avoid the following sources of electrical and magnetic noise:

- Gasoline engines (spark plugs)
- Television and computer monitors
- Alternators and generators
- Electric motors
- Propeller shafts
- Equipment with DC-to-AC converters
- Fluorescent lights
- Switching power supplies

Mounting the receiver

Choosing the correct location for the receiver is critical for a high-quality installation. Poor or incorrect placement of the antenna can influence accuracy and reliability and may result in damage during normal operation. Follow these guidelines to select the receiver location:

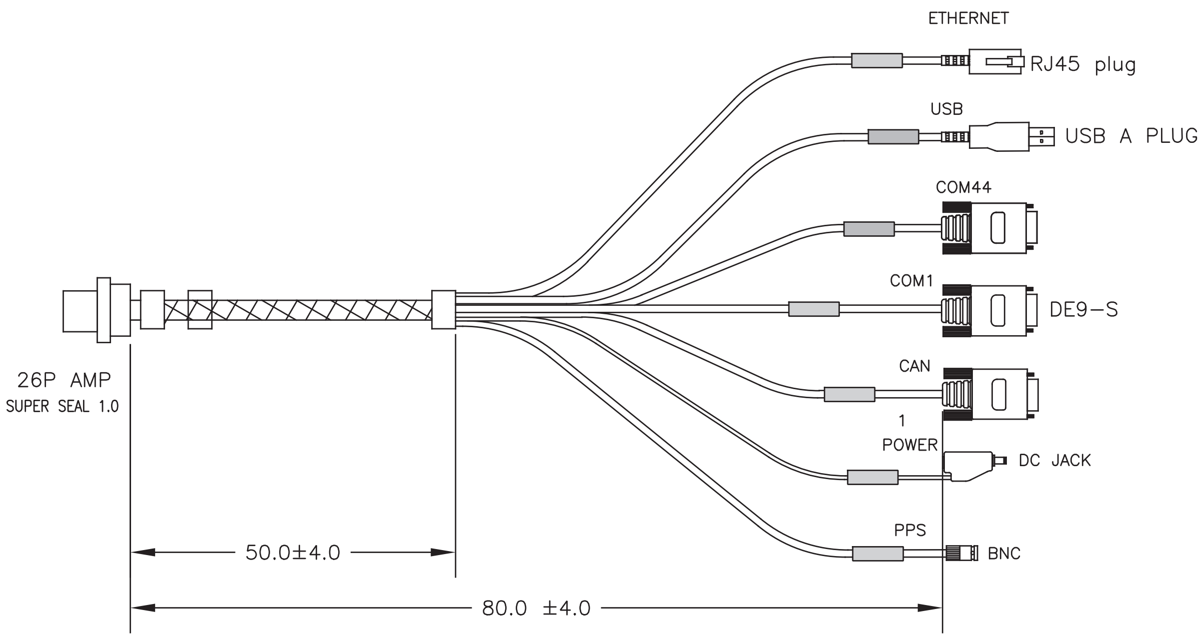
- If the application is mobile, place the receiver on a flat surface along the centerline of the vehicle.
- Choose an area with clear view to the sky above metallic objects.

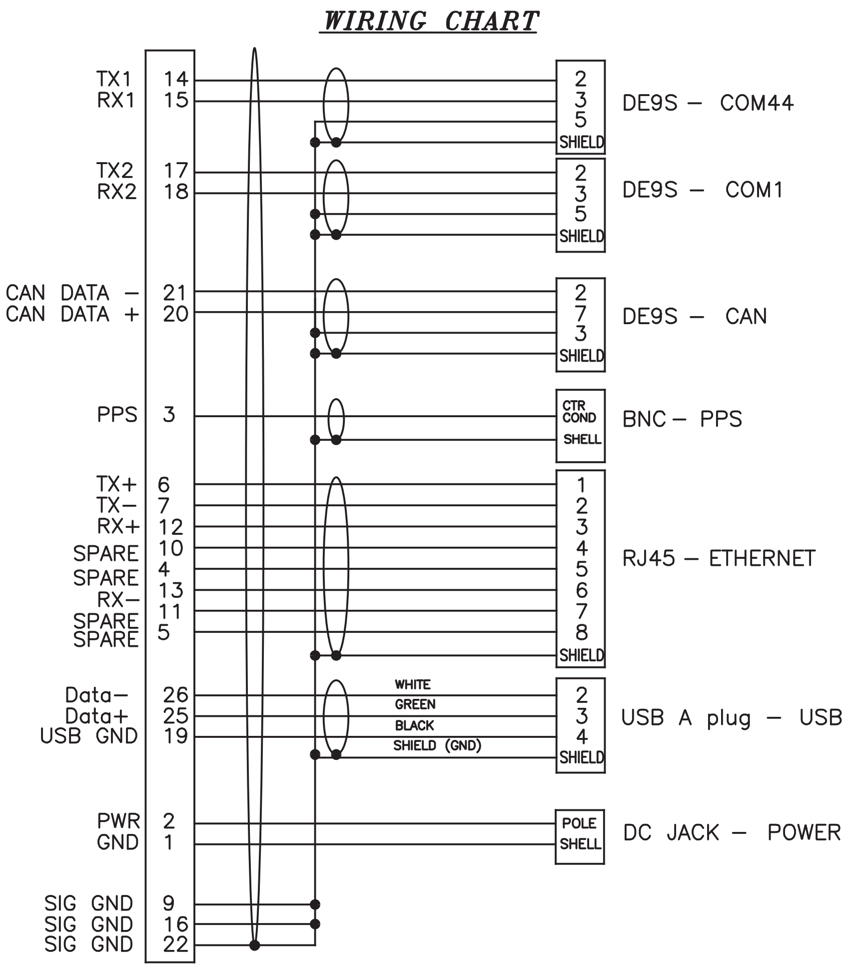
- *Avoid* areas with high vibration, excessive heat, electrical interference, and strong magnetic fields.
- *Avoid* mounting the receiver close to stays, electrical cables, metal masts, and other antennas.
- *Avoid* mounting the receiver near transmitting antennas, radar arrays, or satellite communication equipment.

Interface cable

An optional interface cable is available for testing and evaluation. It is not intended that this cable be used by customers in their production phase. The interface cable provides access to the following:

- DC power
- Two serial ports through DB9 connectors
- Ethernet through an RJ45 connector
- USB port through Type A receptacle
- CAN port through a DB9 connector
- 1PPS output on BNC connector




WIRING CHART
TX1 14
RX1 15
DE9S — COM44
TX2 17
RX2 18
DE9S — COM1
CAN DATA — 21
CAN DATA + 20
DE9S — CAN
PPS 3
CTR COND
SHELL
BNC — PPS
TX+ 6
TX— 7
RX+ 12
SPARE 10
SPARE 4
RX— 13
SPARE 11
SPARE 5
RJ45 — ETHERNET
Data— 26
Data+ 25
USB GND 19
WHITE
GREEN
BLACK
SHIELD (GND)
USB A plug — USB
PWR 2
GND 1
POLE
SHELL
DC JACK — POWER
SIG GND 9
SIG GND 16
SIG GND 22
SHIELD

4

LED Functionality

This chapter provides an overview of the LED functionality.

LED functionality and operation

The receiver has LEDs to indicate satellite tracking, RTK reception, and power. The initial boot-up sequence for a receiver lights three LEDs for about three seconds followed by a brief duration where all three LEDs are off. Thereafter, use the following table to confirm tracking of satellite signals or for basic troubleshooting.

For single-antenna configurations, the following LED patterns apply:

Power LED	RTK Corrections LED	SV Tracking LED	Status
On (continuous)	Off	Off	The receiver is turned on, but not tracking satellites.
On (continuous)	Off	Blinking at 1 Hz	The receiver is tracking satellites, but no incoming RTK corrections are being received.
On (continuous)	Blinking at 1 Hz	Blinking at 1 Hz	The receiver is tracking satellites and receiving incoming RTK corrections.
On (continuous)	Off or blinking (receiving corrections)	Blinking at 5 Hz for a short while	Occurs after a power boot sequence when the receiver is tracking less than 5 satellites and searching for more satellites.
On (continuous)	Blinking at 1 Hz	Off	The receiver is receiving incoming RTK corrections, but not tracking satellites.
On (continuous)	Blinking at 5 Hz	Blinking at 1 Hz	The receiver is receiving Moving Base RTK corrections at 5 Hz.
On (continuous)	On (continuous)	Blinking at 1 Hz	The receiver is receiving Moving Base RTK corrections at 10 or 20 Hz (the RTK LED turns off for 100 ms if a correction is lost).
On (continuous)	On, blinking off briefly at 1 Hz	Blinking at 1 Hz	The receiver is in a base station mode, tracking satellites and transmitting RTK corrections.
On	Blinking at 1 Hz	On	The receiver is in Boot Monitor

Power LED	RTK Corrections LED	SV Tracking LED	Status
(continuous)		(continuous)	Mode. Use the WinFlash utility to reload application firmware onto the board. For more information, contact technical support.

IMU LED

The AX940i receiver has an additional LED. This blue led shows the status of the IMU. The following table shows the different modes of this LED:

IMU navigation status	LED behavior
Signal status unknown or no GNSS/INSS solution	LED is off
Coarse leveling	LED blinks at 5 Hz
Degraded solution	LED blinks at 2 Hz
Aligned solution	LED blinks at 1 Hz

5

GNSS and RTK Basics

In order to understand how to set up Trimble's GNSS and inertial systems, this chapter describes the basics of the different protocols, various terminologies, and concepts that are used.

Autonomous GNSS

Autonomous or standalone GNSS operation uses radio signals from GNSS satellites alone. No other sources of augmentation or correction are used in the position computation. While this is theoretically the poorest accuracy mode of GNSS, recent improvements in satellite orbits and receiver performance result in positions close to one meter in accuracy. Autonomous GNSS provides robust positioning as it is does not rely on the reception of data from secondary data links.

SBAS

The receiver supports SBAS (Satellite Based Augmentation Systems) that conform to RTCA/DO-229C, such as WAAS, EGNOS, or MSAS. The receiver can use the WAAS (Wide Area Augmentation System) set up by the FAA (Federal Aviation Administration). WAAS was established for flight and approach navigation for civil aviation. WAAS improves the accuracy, integrity, and availability of the basic GPS signals over its coverage area, which includes the continental United States and outlying parts of Canada and Mexico.

SBAS can be used in surveying applications to improve single point positioning when starting a reference station, or when an RTK radio corrections link is down. SBAS corrections should be used to obtain greater accuracy than autonomous positioning, not as an alternative to RTK positioning.

The SBAS 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 BD9xx receiver, exactly like a GPS satellite.

For more information on WAAS, refer to the FAA home page at http://gps.faa.gov.

The receiver also contains an SBAS+ mode which allows it to use pseudoranges of satellites for which SBAS corrections are present as well as pseudoranges from uncorrected satellites in the position solution. The SBAS+ solution can minimize occurrences of the solution mode switching back and forth between SBAS and Autonomous solution modes; however, the SBAS+ position solution may perform more poorly at times because uncorrected satellites have an influence in the position solution.

NOTE – To receive SBAS corrections, you must be within the official service volume of that SBAS service. Receiver manufacturers often set SBAS correction volumes to be slightly larger than the ones specified by the respective SBAS service but this may depend on each receiver manufacturer. For example, Trimble receivers situated in the MSAS correction zones can use MSAS corrections between the latitudes 20 and 60 degrees North and between longitudes 110 and 150 degrees East. Hence, *receivers situated within this window will track and use MSAS while a receiver situated outside this window may track but not use MSAS corrections.*

DGPS/DGNSS

Differential GPS/GNSS encompasses a series of techniques that improves the relative accuracy of GNSS by referencing to a single or network of stations. In its most common form a fixed reference station broadcasts the difference between the measured satellite pseudorange and the calculated pseudorange. These differences or corrections are applied to the rover receiver pseudoranges to calculate a more accurate position. Accuracies at the decimeter level can be achieved.

RTK

Real-Time Kinematic (RTK) positioning is positioning that is based on at least two GPS receivers—a base receiver and one or more rover receivers. The base receiver takes measurements from satellites in view and then broadcasts them, together with its location, to the rover receiver(s). The rover receiver also collects measurements to the satellites in view and processes them with the base station data. The rover then estimates its location relative to the base.

The key to achieving centimeter-level positioning accuracy with RTK is the use of the satellite carrier phase signals. Carrier phase measurements are like precise tape measures from the base and rover antennas to the satellites. In the receiver, carrier phase measurements are made with millimeter-precision. Although carrier phase measurements are highly precise, they contain an unknown bias, termed the *integer cycle ambiguity*, or *carrier phase ambiguity*. The rover has to resolve, or initialize, the carrier phase ambiguities at power-up and each time the satellite signals are interrupted.

Carrier phase initialization

The receiver can automatically initialize the carrier phase ambiguities as long as at least five common satellites are being tracked at base and rover sites. *Automatic initialization* is sometimes termed *On-The-Fly (OTF)* or *On-The-Move (OTM)*, to reflect that no restriction is placed on the motion of the rover receiver throughout the initialization process.

The receiver uses L1 (or for dual-frequency receivers L1 and L2) carrier-phase measurements plus precise code-phase measurements to the satellites to automatically initialize the ambiguities. The initialization process generally takes a few seconds.

As long as at least four common satellites are continuously tracked after a successful initialization, the ambiguity initialization process does not have to be repeated.

TIP – Initialization time depends on baseline length, multipath, and prevailing atmospheric errors. To minimize the initialization time, keep reflective objects away from the antennas, and make sure that baseline lengths and differences in elevation between the base and rover sites are as small as possible.

Update rate and latency

The number of position fixes delivered by an RTK system per second also defines how closely the trajectory of the rover can be represented and the ease with which position navigation can be accomplished. The number of RTK position fixes generated per second defines the *update rate*. Update rate is quoted in Hertz (Hz). The maximum update rate will vary based on the receiver used and the options purchased, and will range between 5 Hz and 50 Hz.

Solution latency refers to the lag in time between when the satellite measurements were made and when the position was displayed or output. For precise navigation, it is important to have prompt position estimates, not values from 2 seconds ago. Solution latency is particularly important when guiding a moving vehicle. For example, a vehicle traveling at 25 km/h moves approximately 7 m/s. Thus, to navigate to within 1 m, the solution latency must be less than 1/7 (= 0.14) seconds. For BD9xx receivers, the latency is less than 0.03 seconds in low-latency mode.

With low-latency positioning, the rover receiver uses the last received base measurement and extrapolates this correction for up to 20 seconds. The receivers can also be put in synchronized mode where the rover waits until the base measurements have been received before it computes a position. This mode results in a slightly more accurate position, however the latency is higher due to the delay in receiving the base measurement.

Data link

The base-to-rover data link serves an essential role in an RTK system. The data link must transfer the base receiver carrier phase, code measurements, plus the location and description of the base station, to the rover.

The receiver supports two data transmission standards for RTK positioning: the Compact Measurement Record (CMR) format and the RTCM/RTK messages. The CMR format was designed by Trimble and is supported across all Trimble RTK products.

⚠ CAUTION – Mixing RTK systems from different manufacturers can result in degraded performance.

Factors to consider when choosing a data link include:

- Throughput capacity
- Range
- Duty cycle
- Error checking/correction
- Power consumption

The data link must support at least 4800 baud, and preferably 9600 baud throughput. Your Trimble representative can assist with questions regarding data link options.

Moving baseline RTK positioning

In most RTK applications, the reference receiver remains stationary at a known location, and the rover receiver moves. However, Moving Baseline RTK is an RTK positioning technique in which both reference and rover receivers can move. The receiver uses the Moving Baseline RTK technique to determine the heading vector between its two antennas. Internally raw code and carrier measurements from GPS and GLONASS satellites are processed at a rate up to 20 Hz when linking two independent receivers. The BD982 and BX982 can produce 50Hz moving baseline solutions.

Moving baseline RTK can be used in applications where the relative vector between two antennas is precisely known to centimeter level, while the absolute position of the antennas will depend on the accuracy of the positioning service it uses (RTK, OmniSTAR, RTX, DGPS, SBAS, or Autonomous).

Critical factors affecting RTK accuracy

The following sections present system limitations and potential problems that could be encountered during RTK operation.

Base station receiver type

⚠ CAUTION – Trimble recommends that you always use a Trimble base station with a AX940i roving receiver. Using a non-Trimble base receiver can result in suboptimal initialization reliability and RTK performance.

The receiver uses a state-of-the-art tracking scheme to collect satellite measurements. The receiver is compatible with all other Trimble RTK-capable systems.

Base station coordinate accuracy

The base station coordinates should be known to within 10 m in the WGS-84 datum for optimal system operation. Incorrect or inaccurate base station coordinates degrade the rover position solution. It is estimated that every 10 m of error in the base station coordinates introduces one part per million error in the baseline vector. This means that if the base station coordinates have a height error of 50 m, and the baseline vector is 10 km, then the additional error in the rover location is approximately 5 cm, in addition to the typical specified error. One second of latitude represents approximately 31 m on the earth surface; therefore, a latitude error of 0.3 seconds equals a 10 m error on the earth's surface. The same part per million error applies to inaccuracies of the base station's latitude and longitude coordinates.

Number of visible satellites

A GNSS position fix is similar to a distance resection. Satellite geometry directly impacts the quality of the position solution estimated by the receiver. The Global Positioning System is designed so that at least 5 satellites are above the local horizon at all times. For many times throughout the day, as many as 8 or more satellites might be above the horizon. Because the satellites are orbiting, satellite geometry changes during the day, but repeats from day-to-day.

A minimum of 4 satellites are required to estimate user location and time. If more than 4 satellites are tracked, then an over-determined solution is performed and the solution reliability can be measured. The more satellites used, the greater the solution quality and integrity.

The Position Dilution Of Precision (PDOP) provides a measure of the prevailing satellite geometry. Low PDOP values, in the range of 4.0 or less, indicate good satellite geometry, whereas a PDOP greater than 7.0 indicates that satellite geometry is weak.

Even though only 4 satellites are needed to form a three-dimensional position fix, RTK initialization demands that at least 5 common satellites must be tracked at base and rover sites. Furthermore, L1 (and L2, for dual-frequency RTK) carrier phase data must be tracked on the 5 common satellites for successful RTK initialization. Once initialization has been gained, a minimum of 4 continuously tracked satellites must be maintained to produce an RTK solution.

When additional constellations such as GLONASS are tracked, one of the satellites will be used to resolve the timing offsets between that constellation and the GPS constellation. Tracking additional satellites will aid in the RTK solution.

Elevation mask

The elevation mask stops the receiver from using satellites that are low on the horizon. Atmospheric errors and signal multipath are largest for low elevation satellites. Rather than attempting to use all satellites in view, the receiver uses a default elevation mask of 10 degrees. By using a lower elevation mask, system performance may be degraded.

Environmental factors

Environmental factors that impact GPS measurement quality include:

- Ionospheric activity
- Tropospheric activity
- Signal obstructions
- Multipath
- Radio interference

High ionospheric activity can cause rapid changes in the GPS signal delay, even between receivers a few kilometers apart. Equatorial and polar regions of the earth can be affected by ionospheric activity. Periods of high solar activity can therefore have a significant effect on RTK initialization times and RTK availability.

The region of the atmosphere up to about 50 km is called the troposphere. The troposphere causes a delay in the GPS signals which varies with height above sea level, prevailing weather conditions, and satellite elevation angle. The receiver includes a tropospheric model which attempts to reduce the impact of the tropospheric error. If possible, try to locate the base station at approximately the same elevation as the rover.

Signal obstructions limit the number of visible satellites and can also induce signal multipath. Flat metallic objects located near the antenna can cause signal reflection before reception at the GPS antenna. For phase measurements and RTK positioning, multipath errors are about 1 to 5 cm. Multipath errors tend to average out when the roving antenna is moving while a static base station may experience very slowly changing biases. If possible, locate the base station in a clear environment with an open view of the sky. If possible use an antenna with a ground plane to help minimize multipath.

The receiver provides good radio interference rejection. However, a radio or radar emission directed at the GPS antenna can cause serious degradation in signal quality or complete loss of signal tracking. Do not locate the base station in an area where radio transmission interference can become a problem.

Operating range

Operating range refers to the maximum separation between base and rover sites. Often the characteristics of the data link determine the RTK operating range. There is no maximum limit on the baseline length for RTK with the receiver, but accuracy degrades and initialization time increases with range from the base. Specifications given for receivers specify the distance within which those specifications are valid, and specifications are not given beyond that range.

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 GNSS satellite to a GNSS receiver, where it facilitates rapid acquisition of GNSS signals when you start collecting data, or when you have lost track of satellites and are trying to regain GNSS signals. The orbit information is a subset of the ephemeris/ephemerides data.
Base station	Also called *reference station*. In construction, a base station 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 GNSS observations are collected over a period of time, for subsequent postprocessing to obtain the most accurate position for the location.
BeiDou	The BeiDou Navigation Satellite System (also known as BDS) is a Chinese satellite navigation system. The first BeiDou system (known as BeiDou-1), consists of four satellites and has limited coverage and applications. It has been offering navigation services mainly for customers in China and from neighboring regions since 2000. The second generation of the system (known as BeiDou-2) consists of satellites in a combination of geostationary, inclined geosynchronous, and medium earth orbit configurations. It became operational with coverage of China in December 2011. However, the complete Interface Control Document (which specifies the satellite messages) was not released until

	December 2012. BeiDou-2 is a regional navigation service which offers services to customers in the Asia-Pacific region. The third generation of the system (known as Beidou-3) consists of 3 geostationary satellites, 3 geosynchronous, and 24 Medium Earth orbit (MEO) satellites. As of 2018, 15 Beidiou-3 satellites have been launched. The Chinese government plans on having Beidou-3 fully operational in 2020.
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 adapter 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.
Clock steering	When enabled, the receiver clock is steered to GPS system time rather than periodically introducing 1 ms steps and constraining the clock to ± 0.5 ms. Disabled by default; this setting does not affect performance.
CMR/CMR+	Compact Measurement Record. A real-time message format developed by Trimble for broadcasting corrections to other Trimble receivers. CMR is a more efficient alternative to RTCM.
CMRx	A real-time message format developed by Trimble for transmitting more satellite corrections resulting from more satellite signals, more constellations, and more satellites. Its compactness means more repeaters can be used on a site.
CMR ID	A unique identifier for the CMR message. It can be any value between 0 through 31.

CMR input filter	Shows whether or not CMR corrections are being used from a specific base station.
Code Diff	Code differential solution. Typically a single-frequency solution.
Constrained height	An external height constraint for the antenna position. The receiver will produce a height value within the constraints provided by the external application.
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	Also called *geodetic datum*. 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. 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. 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). All GPS coordinates are based on the WGS-84 datum surface.
Deep discharge	Withdrawal of all electrical energy to the end-point voltage before the cell or battery is recharged.
DGPS	See real-time differential GPS.
Differential correction	Differential correction is the process of correcting GNSS 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.

	Differential correction can be done in real-time, or after the data is collected by postprocessing.
Differential GPS	See real-time differential GPS.
DOP	Dilution of Precision. A measure of the quality of GNSS 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 precision is greater. When satellites are close together in the sky, the DOP is higher and GNSS positions may contain a greater level of error. 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 precision of horizontal measurements (latitude and longitude) and vertical measurements respectively. PDOP is related to HDOP and VDOP as follows: $PDOP^2 = HDOP^2 + VDOP^2$.
Dual-frequency GPS	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.
EGNOS	European Geostationary Navigation Overlay Service. A Satellite-Based Augmentation System (SBAS) that provides a free-to-air differential correction service for GNSS. EGNOS is the European equivalent of WAAS, which is available in the United States.
Elevation	The vertical distance from a geoid such as EGM96 to the antenna phase center. The geoid is sometimes referred to as Mean Sea Level.
Elevation mask	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.
Ellipsoid	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.
EHT	Height above ellipsoid.
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 GNSS 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/break lines, or boundaries/areas.
Firmware	The program inside the receiver that controls receiver operations and hardware.
Galileo	Galileo is a GNSS system built by the European Union and the European Space Agency. It is complimentary to GPS and GLONASS.
Geoid	The geoid is the equipotential surface that would coincide with the mean ocean surface of the Earth. For a small site this can be approximated as an inclined plane above the Ellipsoid.
GHT	Height above geoid.
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.
GPS	Global Positioning System. GPS is a space-based satellite navigation system, owned by the United States government, consisting of multiple satellites in six orbit planes.

GSOF	General Serial Output Format. A Trimble proprietary message format.
HDOP	Horizontal Dilution of Precision. HDOP is a DOP value that indicates the precision 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).
Height	The vertical distance above the ellipsoid. The classic ellipsoid used in GPS is WGS-84.
IBSS	Internet Base Station Service. This Trimble service makes the setup of an Internet-capable receiver as simple as possible. The base station can be connected to the Internet (cable or wirelessly). To access the distribution server, the user enters a password into the receiver. To use the server, the user must have a Trimble Connected Community site license.
IRNSS	The Indian Regional Navigation Satellite System (IRNSS) with an operational name of NAVIC ("sailor" or "navigator" in Sanskrit, Hindi and many other Indian languages, which also stands for NAVigation with Indian Constellation) is an autonomous regional satellite navigation system that provides accurate real-time positioning and timing services
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.
Mountpoint	Every single Ntrip Source needs a unique mountpoint on an Ntrip Caster. Before transmitting GNSS data to the Ntrip

	Caster, the Ntrip Server sends an assignment of the mountpoint.
MSAS	MTSAT Satellite-Based Augmentation System. A Satellite-Based Augmentation System (SBAS) that provides a free-to-air differential correction service for GNSS. 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 GNSS 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.
NavIC (IRNSS)	Navigation with Indian Constellation. Previously the Indian Regional Navigation Satellite System. An autonomous regional satellite navigation system that covers India and surrounding areas.
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 GNSS receivers can output positions as NMEA strings.
Ntrip Protocol	Networked Transport of RTCM via Internet Protocol (Ntrip) is an application-level protocol that supports streaming Global Navigation Satellite System (GNSS) data over the Internet. Ntrip is a generic, stateless protocol based on the Hypertext Transfer Protocol (HTTP). The HTTP objects are extended to GNSS data streams.
Ntrip Caster	The Ntrip Caster is basically an HTTP server supporting a subset of HTTP request/response messages and adjusted to low-bandwidth streaming data. The Ntrip Caster accepts request messages on a single port from either the Ntrip Server or the Ntrip Client. Depending on these messages, the Ntrip Caster decides whether there is streaming data to receive or to send. Trimble Ntrip Caster integrates the Ntrip Server and the Ntrip Caster. This port is used only to accept requests from Ntrip Clients.

Ntrip Client	An Ntrip Client will be accepted by and receive data from an Ntrip Caster, if the Ntrip Client sends the correct request message (TCP/UDP connection to the specified Ntrip Caster IP and listening port).
Ntrip Server	The Ntrip Server is used to transfer GNSS data of an Ntrip Source to the Ntrip Caster. An Ntrip Server in its simplest setup is a computer program running on a PC that sends correction data of an Ntrip Source (for example, as received through the serial communication port from a GNSS receiver) to the Ntrip Caster. The Ntrip Server - Ntrip Caster communication extends HTTP by additional message formats and status codes.
Ntrip Source	The Ntrip Sources provide continuous GNSS data (for example, RTCM-104 corrections) as streaming data. A single source represents GNSS data referring to a specific location. Source description parameters are compiled in the source-table.
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 GNSS systems are accurate to within a meter or so, OmniSTAR with XP is accurate in 3D to better than 30 cm.
Orthometric elevation	The Orthometric Elevation is the height above the geoid (often termed the height above the 'Mean Sea Level').
PDOP	Position Dilution of Precision. PDOP is a DOP value that indicates the precision of three-dimensional measurements. Other DOP values include VDOP (vertical DOP) and HDOP (Horizontal Dilution of Precision). Using a maximum PDOP value is ideal for situations where both vertical and horizontal precision are important.
Postprocessing	Postprocessing is the processing of satellite data after it is collected, in order to eliminate error. This involves using computer software to compare data from the rover with data collected at the base station.

QZSS	Quasi-Zenith Satellite System. A Japanese regional GNSS, eventually consisting of three geosynchronous satellites over Japan.
Real-time differential GPS	Also known as *real-time differential correction* or *DGPS*. 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. While DGPS is a generic term, its common interpretation is that it entails the use of single-frequency code phase data sent from a GNSS base station to a rover GNSS receiver to provide submeter position . The rover receiver can be at a long range (greater than 100 kms (62 miles)) from the base station.
Rover	A rover is any mobile GNSS 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 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 GNSS receivers. There are three versions of RTCM correction messages. All Trimble GNSS 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 .
SBAS	Satellite-Based Augmentation System. SBAS is based on differential GPS, but applies to wide area (WAAS, EGNOS, MSAS, and GAGAN) networks of reference stations. Corrections and additional information are broadcast using

	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 dB-Hz.
skyplot	The satellite skyplot confirms reception of a differentially corrected GNSS signal and displays the number of satellites tracked by the GNSS receiver, as well as their relative positions.
SNR	See signal-to-noise ratio.
Source-table	The Ntrip Caster maintains a source-table containing information on available Ntrip Sources, networks of Ntrip Sources, and Ntrip Casters, to be sent to an Ntrip Client on request. Source-table records are dedicated to one of the following: • data STReams (record type STR) • CASters (record type CAS) • NETworks of data streams (record type NET) All Ntrip Clients must be able to decode record type STR. Decoding types CAS and NET is an optional feature. All data fields in the source-table records are separated using the semicolon character.
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.
xFill	Trimble xFill® is a service that extends RTK positioning for several minutes when the RTK correction stream is temporarily unavailable. The Trimble xFill service improves field productivity by reducing downtime waiting to re-establish RTK corrections in black spots. It can even expand productivity by allowing short excursions into valleys and other locations where continuous correction messages were not previously possible. Proprietary Trimble xFill corrections are broadcast by satellite and are generally available globally where the GNSS constellations are also visible. It applies to any positioning task being performed with a single-base, Trimble Internet Base

Station Service (IBSS), or VRS RTK correction source.

VRS	Virtual Reference Station. A VRS system consists of GNSS 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. 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.
WAAS	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 GNSS signals over its coverage area, which includes the continental United States and outlying parts of Canada and Mexico. 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 GNSS receiver, exactly like a GNSS satellite. 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. The EGNOS service is the European equivalent and MSAS is the Japanese equivalent of WAAS.
WGS-84	World Geodetic System 1984. Since January 1987, WGS-84 has superseded WGS-72 as the datum used by GPS. The WGS-84 datum is based on the ellipsoid of the same name.