SMART7
Installation and Operation
User Manual

SMART7 Installation and Operation User Manual

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GNSS Antenna Series	One (1) Year
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SMART7 Notices

The following notices apply to the SMART7 device.

Changes or modifications to this equipment, not expressly approved by NovAtel Inc., could void the user's authority to operate this equipment.

FCC

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.

SMART7 has been tested and found to comply with the radiated and conducted emission limits for a Class B digital device. The Class B limits are designed to provide reasonable protection against harmful interference in a residential installation.

The equipment listed 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 communications. 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:

- Re-orient or relocate the SMART7
- Increase the separation between the equipment and the SMART7
- Connect the equipment to an outlet on a circuit different from that to which the SMART7 is connected
- Consult the dealer or an experienced radio/TV technician for help

The SMART7 has been authorized for use in Mobile applications. At least 20 cm (8 inches) of separation between the SMART7 and the User must be maintained at all times.

Wi-Fi

SMART7 contains a Wi-Fi radio with the following approvals:

- FCC ID: UTU-01019715

Innovation, Science and Economic Development (ISED) Canada

SMART7 Class B digital device complies with Canadian ICES-003.

SMART7 appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

This device complies with ISED license-exempt RSS-GEN and RSS-247. Operation is subject to the following two conditions: (1) this device may not cause interference and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Cet appareil est conforme à la norme ISED RSS-GEN et RSS-247. Son fonctionnement est soumis aux deux conditions suivantes: (1) cet appareil ne doit pas provoquer d'interférences et (2)

cet appareil doit accepter toute interférence, y compris les interférences pouvant entraîner un fonctionnement indésirable de l'appareil.

The SMART7 has been authorized for use in Mobile applications. At least 20 cm (8 inches) of separation between the SMART7 and the User must be maintained at all times.

Le SMART7 a été autorisé pour une utilisation dans les applications mobiles. Au moins 20 cm (8 pouces) de séparation entre le SMART7 et l'utilisateur doit être maintenue à tous fois.

Wi-Fi

SMART7 contains a Wi-Fi radio with the following approvals:

- IC: 129A-01019715

European Union (EU)

SMART7 Wi-Fi

NovAtel Inc. declares that the SMART7 Wi-Fi transceiver is in compliance with Directive 2014/53/EU (Radio Equipment).

The full text of the EU Declaration of Conformity may be obtained from the NovAtel web site at:

www.novatel.com/products/compliance/eu-declaration-of-conformity

Radio Information

Description of Service: Wi-Fi (802.11b/g/n)

Operational Frequency: 2400 MHz to 2480 MHz

Modulation: OFDM

Rated Power: 13.4 dBm e.i.r.p

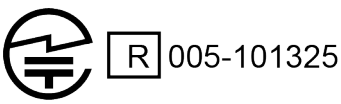
The full text of the EU Declaration of Conformity may be obtained from the NovAtel web site at:

www.novatel.com/products/compliance/eu-declaration-of-conformity

Japan

Wi-Fi

SMART7 contains a Wi-Fi radio with the following approvals:



Korea

Wi-Fi

SMART7 contains a Wi-Fi radio with the following approvals:

MSIP-CRM-
Rsi-RS9113SB

Ethernet Port

The Ethernet port is a safety extra-low voltage (SELV) circuit only and is suitable for connection to another SELV circuit. Do not connect to Telecommunications Network Voltage (TNV) circuits.

WEEE Notice

If you purchased your SMART7 product in Europe, please return it to your dealer or supplier at the end of its life. The objectives of the European Community's environment policy are, in particular, to preserve, protect and improve the quality of the environment, protect human health and utilise natural resources prudently and rationally. Sustainable development advocates the reduction of wasteful consumption of natural resources and the prevention of pollution. Waste electrical and electronic equipment (WEEE) is a regulated area. Where the generation of waste cannot be avoided, it should be reused or recovered for its material or energy. WEEE products may be recognized by their wheeled bin label ( ).

See www.novatel.com/products/compliance/environmental-compliance for more information.

RoHS

The SMART7 is in conformity with Directive 2011/65/EU of the European Parliament and of the council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

REACH

The SMART7 is compliant with Regulation (EC) No. 1907/2006 of the European Parliament and the Council of 18 December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH). The candidate list of Substances of Very High Concern (SVHC) published by the European Chemical Agency (ECHA) is available at: https://echa.europa.eu-/candidate-list-table

Conventions

The following conventions are used in this manual:

Information that supplements or clarifies text.

A caution that actions, operation or configuration may lead to incorrect or improper use of the hardware.

A warning that actions, operation or configuration may result in regulatory non-compliance, safety issues or equipment damage.

Customer Support

NovAtel Knowledge Base

If you have a technical issue, visit the NovAtel Support page at www.novatel.com/support. Through the *Support* page, you can contact Customer Support, find papers and tutorials or download current manuals and the latest firmware.

Before Contacting Customer Support

Before you contact NovAtel Customer Support about a software problem, perform the following steps:

If logging data over an RS-232 serial cable, ensure that the configured baud rate can support the data bandwidth (see **SERIALCONFIG** command). NovAtel recommends a minimum suggested baud rate of 230400 bps.

1. Log the following data to a file on your computer for 15 minutes:

```
RXSTATUSB onchanged
RAWEPHEMB onchanged
GLORAWEPHEMB onchanged
BESTPOSB ontime 1
RANGEB ontime 1
RXCONFIGA once
VERSIONA once
```

   For SPAN systems, add the following logs to the above list in the file created on your computer:

```
RAWIMUSXB onnew
INSUPDATESTATUSB onnew
INSPVAXB ontime 1
INSCONFIGA once
```

2. Send the data file to NovAtel Customer Support: support@novatel.com
3. You can also issue a **FRESET** command to the receiver to clear any unknown settings.

The **FRESET** command will erase all user settings. You should know your configuration (by requesting the RXCONFIGA log) and be able to reconfigure the receiver before you send the **FRESET** command.

If you are having a hardware problem, send a list of the troubleshooting steps taken and the results.

Contact Information

Log a support request with NovAtel Customer Support using one of the following methods:

Log a Case and Search Knowledge:

Website: www.novatel.com/support

Log a Case, Search Knowledge and View Your Case History: (login access required)

Web Portal: https://novatelsupport.force.com/community/login

E-mail:

support@novatel.com

Telephone:

U.S. and Canada: 1-800-NOVATEL (1-800-668-2835)

International: +1-403-295-4900

Chapter 1 SMART7 Overview

The SMART7 is a high performance GNSS receiver and antenna, capable of receiving and tracking all current GNSS signals on a maximum of 555 channels. Support for SBAS (Satellite Based Augmentation Systems) is standard and includes WAAS (North America), EGNOS (Europe) and MSAS (Japan). Refer to An Introduction to GNSS (on our website at www.novatel.com/an-introduction-to-gnss) for an overview of each of the above signal types. The SMART7 features Light Emitting Diodes (LEDs) for status indication.

Once properly powered, the SMART7 begins operating as a fully functional GNSS system.

1.1 Features and Models

The main features of the SMART7 are:

- an enhanced high performance multi-frequency, multi-constellation receiver
- a high performance GNSS multi-frequency, multi-constellation antenna
- a CAN port
- Emulated Radar Output

  three (3) RS-232 COM ports
- up to three (3) LED status indicators (model dependent)
- a water and dust tight enclosure
- enhanced interference mitigation

The SMART7 is available in several different hardware configuration and firmware models whose additional features may include:

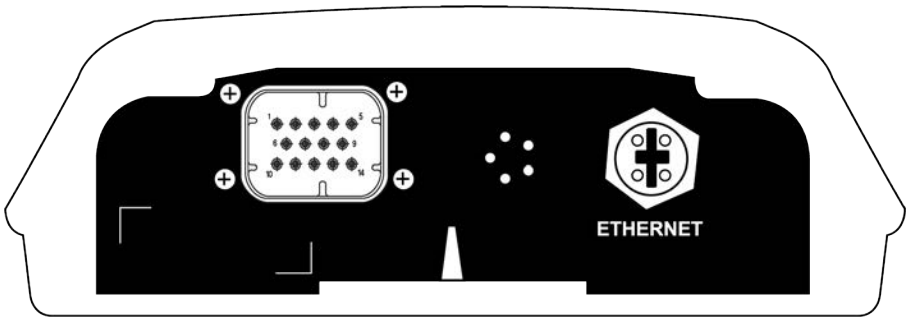
- Wi-Fi interface
- Ethernet port
- Integrated SPAN GNSS+INS functionality
- Web UI

Contact NovAtel Sales at www.novatel.com/where-to-buy/contact-us for information regarding available models, upgrading a model to increase feature/functionality or go to https://www.novatel.com/products/smart-antennas/smart7-products. Refer to *Firmware Updates and Model Upgrades* on page 116 for details.

Table 1: Model Variants

Product Hardware Model	Model
SMART7	SMART7
SMART7 with Wi-Fi and Ethernet	SMART7-I
SMART7 with Wi-Fi	SMART7-W
SMART7 with SPAN IMU	SMART7-S

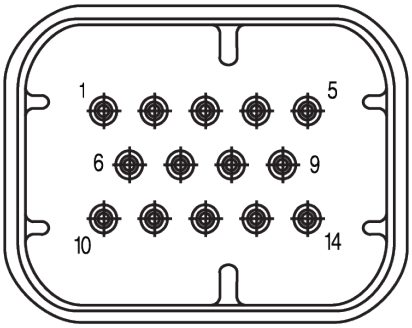
Figure 1: SMART7 with Ethernet Model (Back)



1.2 SMART7 Connectors Overview

All SMART7 models use the same connector for power and communication. Refer to *Table 27: SMART7 Connector Pin Out* on page 137 for pin outs.

Figure 2: SMART7 Interface Connector



The SMART7 Ethernet model has a M12 D-code male connector.

Figure 3: SMART7 Ethernet Connector (model dependent)

Table 2: Ethernet Connector Pin Outs

From P1	To J1	Signal Name
1	1	Tx+

From P1	To J1	Signal Name
2	2	Rx+
3	3	Tx-
4	4	Rx-
Shell	Shell	Chassis GND

1.3 SMART7 LEDs

The SMART7 has up to three LEDs (model dependent) to indicate receiver status.

The following tables provide information about the SMART7 LEDs and their states.

Figure 4: SMART7 LEDs Location

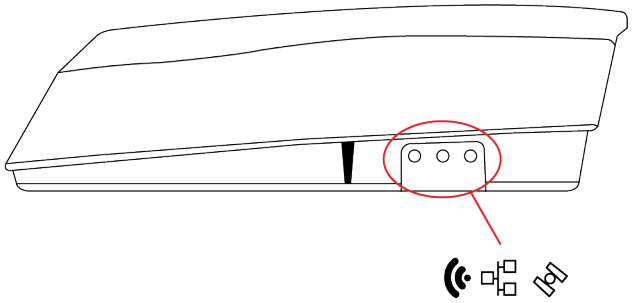


Table 3: SMART7 Status Indicators

Label	Description	Variants
	Wi-Fi mode (AP, Concurrent or Client)	SMART7-I and SMART7-W
	Ethernet (DATA)	SMART7-I
	Status (Power/GNSS)	All variants

Table 4: Wi-Fi LED

State	Description
Green Solid	Configured as an Access Point (default)

State	Description
Green Slow Flash	Configured as an Access Point with at least one client connection
Blue Solid	Configured as both an Access Point and a Client concurrently
Blue Slow Flash	Configured as both an Access Point and a Client concurrently, with at least one Client connected to the concurrent Access point or with the concurrent Client connected to an Access Point
White Solid	Configured as a Client
While Slow Flash	Configured as a Client and connected to an Access Point
Yellow Slow Flash	Wi-Fi Firmware Upgrade
Red Solid	No Configuration
Red Fast Flash	Error State

Table 5: Ethernet LED

State	Description
Green Solid	Link established
Green Slow Flash	Active (receiving or transmitting)

Table 6: Status LED

State	Description
Green Solid	Precise solution good (RTK/PPP, Fixed or RTK/PPP+INS)
Green Slow Flash (1 Hz)	Precise solution converging

State	Description
Yellow Solid	Basic solution (Single Point/SBAS/DGPS)
Yellow Slow Flash (1 Hz)	Tracking satellites and calculating initial position solution
Yellow Fast Flash (3 Hz)	Initialized and ready for communication
Red Solid (Initial)	Power On/Reset (for about 10 sseconds after power-on or reset)
Red Solid (Continuous)	Receiver system error, if indicator persists after 30 seconds
Red Slow Flash (1 Hz)	Position quality warning (unreliable/high error)
Red Fast Flash (3 Hz)	Positioning failure (unusable)

1.4 Related Documents and Information

After the OEM7 receiver is set up,the Agriculture Commands and Logs Reference Manual becomes the primary source for command and log information.

Each receiver has a specific set of features, so some commands and logs may not be supported by your model.

Refer to our web site docs.novatel.com/OEM7 for the latest documentation.

This manual does not cover OEM7 service and repair. Contact a local NovAtel dealer for service or repair inquiries (refer to *Customer Support* on page 14 for contact details).

1.5 SMART7 Emulated Radar

1.5.1 Emulated Radar (ER)

A typical radar sensor emits radio beams that bounce off the ground and computes ground speed based on the speed at which objects are passing in front of the sensor. The output of the sensor is a digital pulse, the frequency of which is proportional to the vehicle's ground speed. This is often used in agricultural applications such as planting and spraying. The SMART7 eliminates the need for separate ground-sensing radar equipment by converting the GPS-derived velocity to proportional frequency output. The following emulated radar signal parameters can be configured by the customer:

- Frequency Step: Specifies how the frequency output relates to the vehicle speed.
- Signal Update Rate: Specifies how often the frequency output is updated to match the vehicle speed.

- Response Mode: Specifies how quickly changes in velocity are reflected in the frequency output. Setting a slower response mode reduces spikes (noise) in the velocity but increases latency. Setting a higher response mode reduces latency, but may result in noisier frequency output.

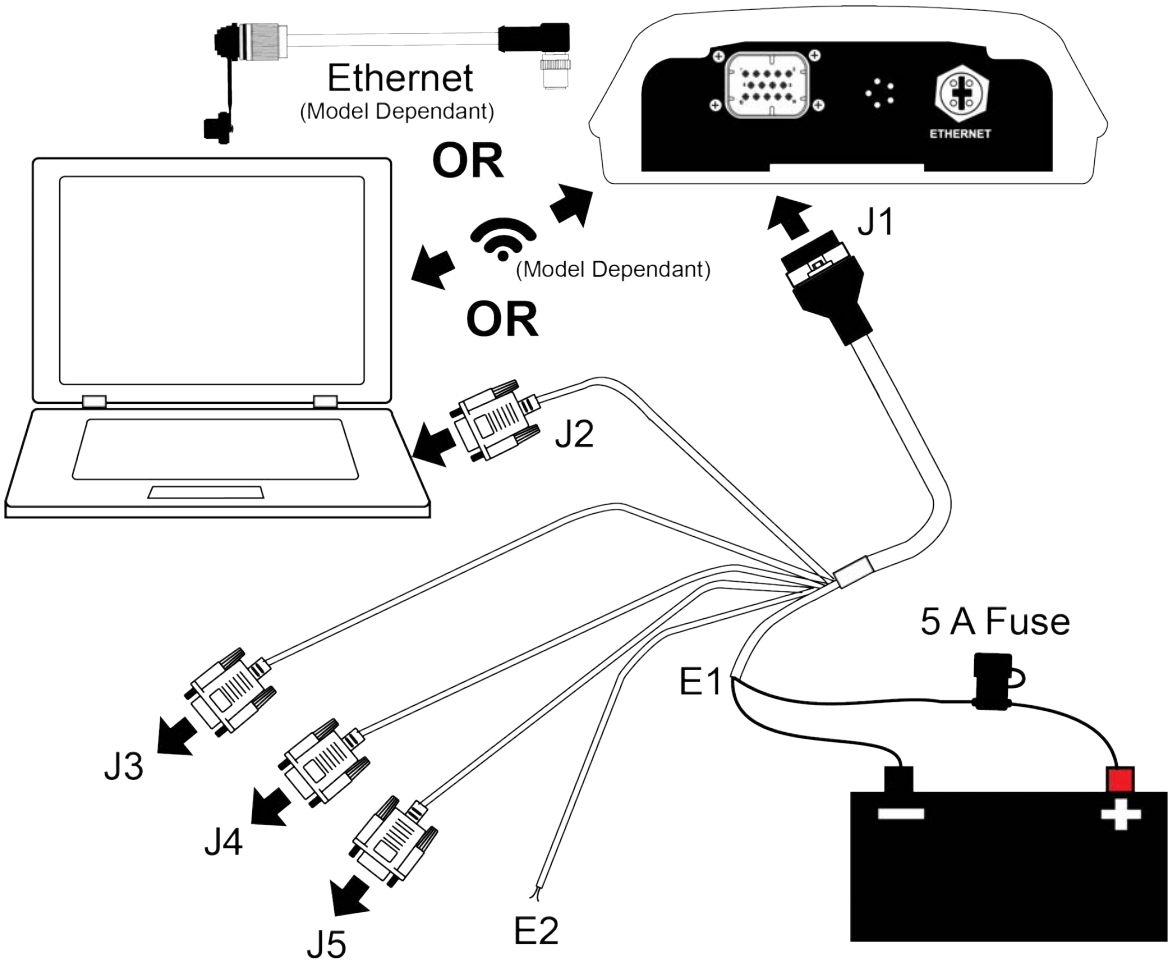
Refer to **RADARCONFIG** command for detailed information.

After it is configured using the **RADARCONFIG** command, Emulated Radar (ER) pulses are output through the SMART7 interface cable and the **RADARSTATUS** log.

Chapter 2 SMART7 Installation Overview

When the appropriate equipment is selected, complete the following steps to set up and begin using the NovAtel GNSS receiver.

Figure 5: SMART7 Installation



1. Mount the SMART7 receiver. Refer to *Mounting and Orienting the SMART7* on the next page for mounting details.
2. Connect other GNSS system components using the output lines.
   See *SMART7 Interface Cable (Optional Accessory)* on page 137.
3. Connect the receiver to other GNSS system components, such as a computer or data terminal, using the communication ports or Wi-Fi.
   See *Connect the SMART7 to Data Communication Equipment* on page 25.
4. Connect the supplied interface cable to the interface connector on the receiver and then connect the power cable to the power supply.
   Ensure a 5 A slow blow fuse is incorporated in the power wiring. Refer to *SMART7 Interface Cable (Optional Accessory)* on page 137 and *SMART7 Additional Equipment Required* on

page 29 for fuse recommendations.
See *Connect Power to the SMART7* on page 27 and *Power Supply Requirements for the SMART7* below for details.

Refer to *SMART7 LEDs* on page 18 for details of SMART7 LED states.

Refer to *SMART7 Additional Equipment Required* on page 29 for fuse recommendations.

2.1 Power Supply Requirements for the SMART7

The SMART7 requires a power supply that provides:

- a voltage in the range of +7 to +30 VDC
- at least 15 W of power (typical use: 3 W to 7 W)

See *SMART7 Environmental and Electrical Specifications* on page 134 for more power supply specifications.

The SMART7 has an internal power module that:

- filters and regulates the supply voltage
- protects against over-voltage, over-current and high-temperature conditions
- provides automatic reset circuit protection

If the voltage supplied is below the minimum specification, the receiver suspends operation. If the voltage supplied is above the maximum specification, the receiver may be permanently damaged, voiding the warranty.

The supply must be capable of providing enough current to operate the SMART7, including the initial inrush transient. The supply must also be current limited to 5 A with an external fuse.

The amount of power required depends on the number of constellations and signals tracked, and the features enabled.

Refer to *SMART7 Interface Cable (Optional Accessory)* on page 137 for details about the power cable.

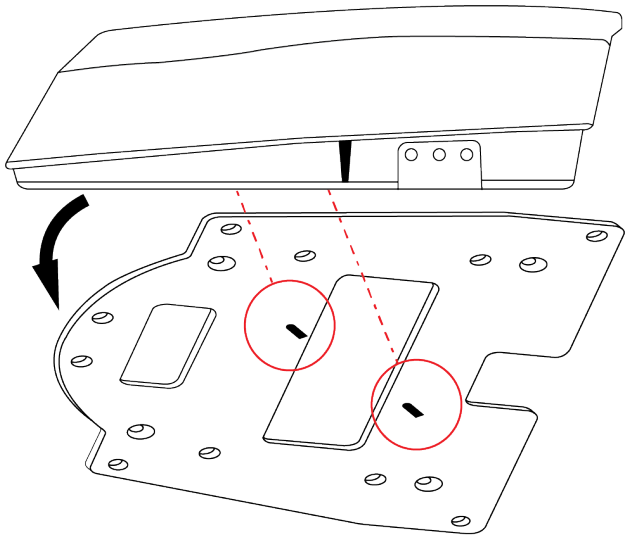
2.2 Mounting and Orienting the SMART7

2.2.1 Mounting

Mount on a secure, stable structure capable of safe operation in the specific environment.

- If installing on a vehicle, mount the SMART7 on the vehicle roof, ideally close to the pivot point of the vehicle. The SMART7 must be mounted with the connector facing the rear of the vehicle.

Figure 6: SMART7 Magnetic Mounting Plate



The SMART7 must be rigidly secured to the vehicle to avoid errors caused by vibration and motion.

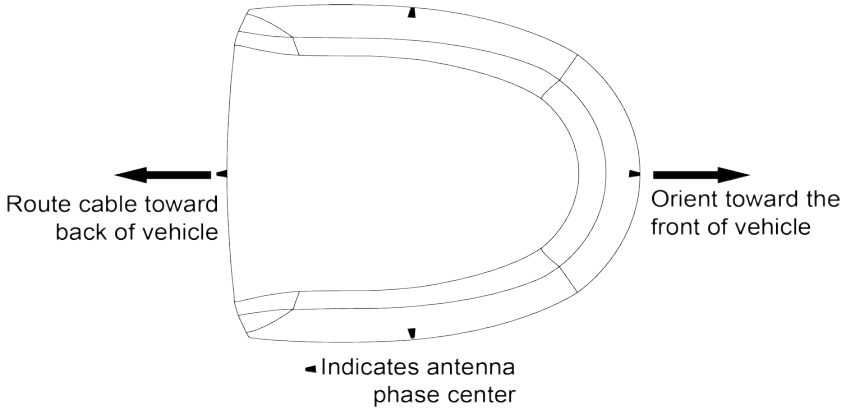
- If installing in a stationary location, mount the SMART7 in a location that has a clear view of the sky so that each satellite above the horizon can be tracked without obstruction. For more information, refer to An Introduction to GNSS.

Refer to *SMART7 Mounting Plate Specifications* on page 139 for plate dimensions and mounting hole locations.

2.2.2 Orienting

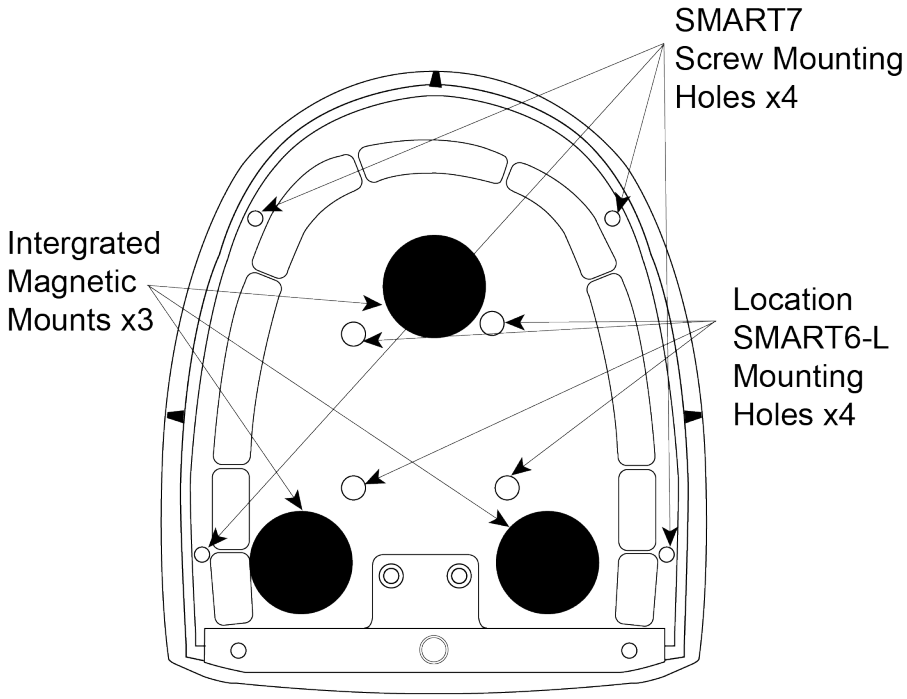
Ensure the SMART7 is oriented with the connector(s) facing the back of the vehicle.

Figure 7: SMART7 Orientation



2.2.3 SMART7 and SMART6 Mounting Hole Locations

Figure 8: SMART7 and SMART6 Mounting Hole Locations



2.3 Connect the SMART7 to Data Communication Equipment

The SMART7 can communicate with other devices in the system, such as computers Wi-Fi or Ethernet ports. The SMART7 also has a CAN bus port for communication with other CAN bus compatible devices.

Wi-Fi and Ethernet are model dependent.

2.3.1 Serial Ports

The SMART7 has three serial ports: COM1, COM2 and COM3. These ports are available on the 14-pin Tyco Ampseal connector. Refer to *Connect I/O Signals to the SMART7* on page 27 for the pin out of this connector.

Table 7: SMART7 Serial Port Protocol

Port	RS-232
COM1	Yes
COM2	Yes
COM3	Yes

Use the **SERIALCONFIG** command to configure the receiver's asynchronous serial port communications drivers.

Port settings (bit rate and parity, for example) are software configurable. See *Communications with the Receiver* on page 31 for information about configuring the serial ports. Also see *SMART7 Data Communication Specifications* on page 135 for the serial port specifications.

To connect to a serial port:

1. Connect the SMART7 Interface cable (PN: 01019944), or a custom made cable, to the 14-pin Tyco Ampseal connector.

   For information about the SMART7 interface cable refer to *Connect I/O Signals to the SMART7* on the next page.

2. Connect the appropriate DB9 connector (COM1, COM2 or COM3) to the serial port on the computer or other data communication device.

2.3.2 Wi-Fi

The SMART7 has a Wi-Fi Access Point that is enabled by default. This provides for easy connection to any laptop/tablet/smartphone with Wi-Fi capability and a web browser.

1. Once the receiver is installed and powered, use a Wi-Fi capable laptop/tablet/smartphone to locate the SMART7 in the list of detected Wi-Fi Networks and establish a connection.

   The SMART7 PSN of the receiver (SSID) is printed on a label located by the connector. The format of the PSN is *SMART7-<Receiver PSN>*, e.g. "SMART7-ABCDEF1234567".

2. A prompt for a password will appear. The default password is printed on a label on the bottom of the SMART7. The default password is specific to that SMART7 receiver.

3. Open up a web browser and enter any web address (e.g., novatel.com). The SMART7 automatically redirects you to the NovAtel Web User Interface which is hosted on the SMART7.

NovAtel Web User Interface is compatible with recent versions of Chrome, Firefox, Internet Explorer and Safari.

Cookies should always be on and never blocked on the browser being used to connect to the Wi-Fi network.

For more information about using the NovAtel Web User Interface, refer to the online OEM7 documentation (docs.novatel.com/OEM7).

To change the configuration of the Wi-Fi interface, including password, refer to *SMART7-I and SMART7-W Wi-Fi Configuration Overview* on page 82.

2.3.3 Ethernet Port

The SMART7 has an M12 D-code (female) socket that supports 10Base-T/100Base-TX Ethernet for communications with external data communications equipment such as computers and data loggers. The Ethernet port supports IPv4 Internet layer, TCP/IP transport, ping and connection from a Telnet client. Users can conduct remote debugging, accept MRTCA (modified RTCA) data and download firmware. OEM7 receivers are also equipped with NTRIP Version 2.0 (Networked Transport of RTCM via Internet Protocol) client and server capability.

Refer to *Ethernet Configuration* on page 92 for instructions on configuring Ethernet and NTRIP.

2.3.4 CAN Bus Port

The SMART7 has a CAN Bus port available on the 14-Pin interface connector.

To connect to the CAN Bus port:

1. Connect the SMART7 optional accessory cable or a custom made cable, to the main 14-Pin interface connector.

   For information about the SMART7 interface cable, see *SMART7 Interface Cable (Optional Accessory)* on page 137. This section also has the connector pin out and connector recommendations for making a custom cable.

2. Connect the CAN to the CAN Bus (J5) of the SMART7 interface cable, see *SMART7 Interface Cable (Optional Accessory)* on page 137.

> The SMART7 CAN bus port is unterminated. If the SMART7 is at the end of the bus, then the connecting cable must have 120 ohms integrated into the cable between CAN1+ and CAN1- in close proximity to the main 14-Pin interface connector.

2.4 Connect I/O Signals to the SMART7

The SMART7 has several outputs, also referred to as strobes, that provide status and synchronization signals.

- Pulse Per Second (PPS) output
- Emulated Radar Output

For more information about the I/O signals, refer to the .

To access the I/O signals, connect the SMART7 interface cable or a custom made cable, to the main 14-Pin interface connector. Refer to *SMART7 Interface Cable (Optional Accessory)* on page 137 for connector pin out and other details.

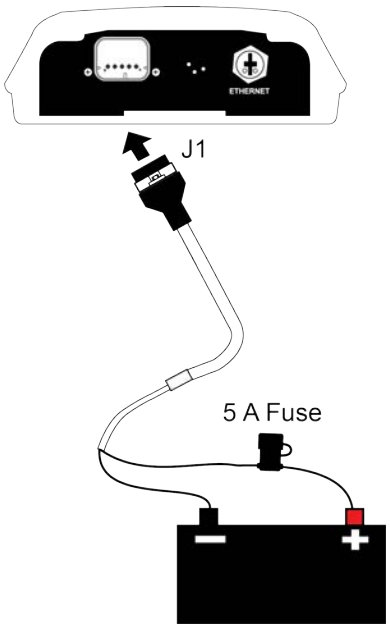
2.5 Connect Power to the SMART7

To connect power to the SMART7:

1. Connect the SMART7 Interface Cable (01019944) to the 14-Pin connector on the back of the SMART7. See *SMART7 Interface Cable (Optional Accessory)* on page 137 for information about this cable.
2. Connect the BATT+ and BATT- bare wires of the interface cable to a 7 to 30 VDC power supply.
   For details about the power supply required, see *Power Supply Requirements for the SMART7* on page 23.

2.5.1 Fuse for the Power Supply

Install a user supplied 5 A slow blow fuse in the positive line of the connection to the power source to protect the power supply wiring and your warranty.



Refer to *SMART7 Additional Equipment Required* on the next page for fuse recommendations.

2.6 Check that the SMART7 is Working

After the SMART7 is installed and powered up, use the following procedure to ensure the receiver is operating.

1. Check that the Status LED Fast Flashes Yellow (ready state).

   The Status LED may briefly flash as Red before moving quickly to the Fast Flash Yellow.

   See *SMART7 LEDs* on page 18 for the location of the LEDs.

2. Send the following command:

   ```
   LOG VERSION
   ```

   The VERSION log is returned.

```
[COM1]<VERSION COM1 0 92.5 UNKNOWN 0 6.784 02440000 3681 15089
<  8
<    GPSCARD "DDNRNNTBN" "BMHR18040357C" "OEM7700-1.01"
"OA7CR0501RN0000" "OM7BR0002RB0000" "2018/Sep/20" "05:37:06"
<    OEM7FPGA "" "" "" "OMV070001RN0000" "" "" ""
<    APPLICATION "" "" "" "ES7AR0501RN0000" "" "2018/Sep/20" "05:37:19"
<    DEFAULT_CONFIG "" "" "" "ES7CR0501RN0000" "" "2018/Sep/20"
"05:37:29"
<    PACKAGE "" "" "" "ES7PR0501RN0000" "" "2018/Sep/20" "05:37:24"
<    DB_WWWISO "WWWISO" "0" "" "WMC010204RN0001" "" "2018/Sep/26"
"10:07:36"
<    ENCLOSURE "" "NMPY18070006T" "0.0.0.0" "" "" "" ""
<    REGULATORY "US" "" "" "" "" "" ""
```

3. Check that the Time Status is **FINESTEERING** which represents that time is fine set and being steered.
4. Check the Receiver Status word (02004020 in this example). If the lowest bit (bit 0) is set, the receiver has errors.

> For information about the other digits in Receiver Status word, refer to the **RXSTATUS** log in the Agriculture Commands and Logs Reference Manual.

2.7 SMART7 Additional Equipment Required

In order for the SMART7 to perform optimally, the following additional equipment is required:

- A computer (user supplied)
- A cable harness for communicating with and powering the SMART7 (NovAtel SMART7 Interface cable is available with four DB-9 connectors, six bare cables and a SMART7 connector (refer to *SMART7 Accessories and Replacement Parts* on page 140
- A fused power supply (user supplied)

Table 8: SMART7 Recommended Fuse and Fuse Holders

Fuse	Recommended Fuse/Fuse Holder		
12 V System Fuse (standard size blade)	ATO Silver Blade Fuse 5 A (32 V) or equivalent	Littelfuse	0287005
12 V System Fuse (mini size blade)	Mini Blade Fuse 5 A (32 V) or equivalent	Littelfuse	0297005
24 V System Fuse High Reliability, Harsh Environment (standard size blade)	FKS ATO Blade Fuse 5A (80 V) or equivalent	Littelfuse	166.7000.450
Inline Fuse Holder, (for standard size blade)	Waterproof ATO Fuse Holder	Littelfuse	FHAC0001
Inline Fuse Holder, (for mini size blade)	Waterproof Mini Fuse Holder	Littelfuse	0FHM0001

The Recommended Fuse and Fuse Holders table details the part numbers for recommended fuses and fuse holders. These numbers are provided for information only and are not available from NovAtel as separate parts.

SMART7 Operation

Before operating the receiver for the first time, refer to *SMART7 Installation Overview* on page 22 for SMART7 installation instructions.

Refer to *Communications with the Receiver* below to begin configuring the SMART7 for operation.

3.1 Communications with the Receiver

Communication is established with the receiver using a data terminal or computer connected to the receiver by a variety of methods:

- *SMART7-I and SMART7-W Wi-Fi Configuration Overview* on page 82
- *Serial Port Communications* below
- *Ethernet Communications* on page 33
- *ICOM Communications* on page 33
- *CAN Bus Communications* on page 34

When connected to the receiver, enter commands directly from a terminal or through terminal emulation software on a computer. For example:

- **NovAtel Web User Interface** - The NovAtel Web User Interface is installed on OEM7 receivers. Refer to the online OEM7 documentation (docs.novatel.com/OEM7) for instructions.
- **NovAtel Connect** - NovAtel Connect is a software application used to monitor and configure NovAtel receivers. For information about installing and using NovAtel Connect, refer to the help file included with the application.

  NovAtel Connect version 2.0 or greater is required for OEM7 receivers. Download the latest NovAtel Connect software and documentation from www.novatel.com/novatel-connect.

- Any console/command line application

To maximize the application of the receiver's capabilities, become familiar with the commands and logs described in Agriculture Commands and Logs Reference Manual.

3.1.1 Serial Port Communications

The receiver can communicate with a computer or terminal via a serial port. For communication to occur, both the receiver and the operator interface have to be configured properly. The receiver's default port settings are:

- 9600 bps
- no parity
- 8 data bits
- 1 stop bit

- no handshaking
- echo off
- break on

The data transfer rate determines how fast information is transmitted. Take for example a log whose message byte count is 96. The default port settings allows 10 bits/byte (8 data bits + 1 stop bit + 1 framing bit). It therefore takes 960 bits per message. To get 10 messages per second then requires 9600 bps. Also remember that even if you set the bps to 9600, the actual data transfer rate may be lower and depends on the number of satellites being tracked, data filters in use, and idle time. It is therefore suggested that you leave yourself a margin when choosing a data rate.

The minimum suggested baud rate for most applications is 115200 bps for GNSS only or 230400 bps for GNSS+INS. If the buffer overrun flag is present in the **RXSTATUS** log, (refer to the Agriculture Commands and Logs Reference Manual). , log at a higher baud rate if possible, or change to a medium supporting higher bandwidth (Ethernet).

Although the receiver can operate at data transfer rates as low as 300 bps, this is not recommended. For example, if several data logs are active (that is, a significant amount of information needs to be transmitted every second) but the bit rate is set too low, data overflows the serial port buffers, causing an error condition in the receiver status that results in lost data.

The following ports are supported and can be configured using the commands listed. Refer to the commands listed in the Agriculture Commands and Logs Reference Manual for detailed instructions.

Table 9: Serial Ports Supported

Receiver Type	Port Supported	Configuration Command
SMART7	COM1, COM2, COM3	SERIALCONFIG

Change the COM Port Settings

To change the settings on a COM port, use the **SERIALCONFIG** command. For example:

- To change the data rate of COM2 to 115200, enter:

```
SERIALCONFIG COM2 115200
```

- To change the data rate of COM1 to 57600 and enable even parity, enter:

```
SERIALCONFIG COM1 57600 E
```

Communicating using a Remote Terminal

One method of communicating with the receiver is through a remote terminal. To communicate with the terminal, the receiver requires only the RX, TX and GND lines be used. Ensure the terminal's communications set up matches the receiver's port settings.

Communicating using a Computer

A computer can emulate a remote terminal as well as provide the added flexibility of supporting multiple command batch files and data logging storage files. Use any standard communications software package that emulates a terminal to establish bidirectional communications with the receiver. Examples include NovAtel Connect and PuTTY. All data is sent as raw 8-bit binary or ASCII characters.

Refer to *Communicating with the Receiver* on the next page for details.

3.1.2 Ethernet Communications

The SMART7-I is equipped with a 10-Base-T/100-Base-TX Ethernet port that supports IPv4 Internet layer, TCP/IP transport and telnet. Users can conduct remote debugging, accept MRTCA (modified RTCA) data and update firmware. OEM7 receivers are also equipped with NTRIP Version 2.0 (Networked Transport of RTCM via Internet Protocol) client and server capability.

The Ethernet port must be configured before using. Refer to *Ethernet Configuration* on page 92 for configuration details.

The Ethernet ports are Safety Extra-Low Voltage (SELV) circuits only and are suitable for connection within a building only. Do not connect them to Telephone Network Voltage (TNV) circuits.
If intra-building connections are required, or the OEM7 receiver is installed in an outdoor enclosure, a suitably rated Ethernet router or switch should be installed between the receiver Ethernet port and the network connection.

Issue the **SAVEETHERNETDATA ETHA** command to ensure port settings are retained after a reset and automatically used at boot time. The **SAVEETHERNETDATA ETHA** command is not applicable to the **ICOMCONFIG** and **NTRIPCONFIG** command settings. The **SAVEETHERNETDATA ETHA** command takes precedence over the **SAVECONFIG** command configuration.

3.1.3 ICOM Communications

ICOM ports are virtual ports used for Ethernet connections. The transport/application layer of the ICOM ports can be configured to use Transmission Control Protocol (TCP) for internet IP or User Datagram Protocol (UDP) a slower and less reliable IP protocol.

Refer to **DNSCONFIG** command for Ethernet DNS configuration. If using DHCP, DNS is automatically set.

The following are the default ICOM configurations:

- ICOMCONFIG ICOM1 TCP :3001
- ICOMCONFIG ICOM2 TCP :3002
- ICOMCONFIG ICOM3 TCP :3003
- ICOMCONFIG ICOM4 TCP :3004
- ICOMCONFIG ICOM5 TCP :3005

- ICOMCONFIG ICOM6 TCP :3006
- ICOMCONFIG ICOM7 TCP :3007

Each ICOM port can act as a server (waiting for an external connection to be made) or as a client (actively establishing a connection to a specific port).

For details on the ICOM port commands, refer to **IPCONFIG** command, **ICOMCONFIG** command and **ETHCONFIG** command in the Agriculture Commands and Logs Reference Manual.

3.1.4 CAN Bus Communications

The OEM7 receiver supports J1939 and NMEA2000 CAN protocols.

Proper bus termination is required.

Refer to *CAN Bus* on page 100 for detailed instructions.

3.2 Getting Started

The receiver's software resides in flash memory. When first powered, it undergoes a complete self-test. If an error condition is detected during the self-test, the status word changes. This self-test status word can be viewed in the header of any data output log. Refer to Chapter in the Agriculture Commands and Logs Reference Manual for header information. If a persistent error occurs, contact your local NovAtel dealer. If the dealer cannot resolve the problem, contact NovAtel Customer Support directly using one of the methods listed in *Customer Support* on page 14.

3.2.1 Communicating with the Receiver

You can communicate with the receiver using NovAtel Web User Interface, NovAtel Connect or a terminal emulation program.

Detailed instructions for using NovAtel Connect are available from the Help system built into NovAtel Connect.

For instructions on using NovAtel Web User Interface, refer to the online OEM7 documentation (docs.novatel.com/OEM7).

When the receiver is first turned on, no data is transmitted from the COM ports except for the port prompt.

Any of the COM port prompts indicate that the receiver is ready and waiting for command input. The screen may display other port names for other port types (e.g., ICOM1).

1. Output from receiver self-tests may take some time. On startup, the OEM7 receiver is set to log the RXSTATUSEVENTA log ONNEW on all ports. See *RXSTATUSEVENT Log* on page 78 for more details.
2. If NovAtel Connect is unable to locate the OEM7 receiver, use a different COM port to communicate with the receiver. When communication has been established, issue a **FRESET STANDARD** command. The original communications port should be ready for use. See the **FRESET** command for more information.

An example of a response to an input **FIX POSITION** command:

```
[COM2] FIX POSITION 51.11635 -114.0383 1048.2 [Carriage Return]
<OK
```

In this example, [COM2] is the port prompt.

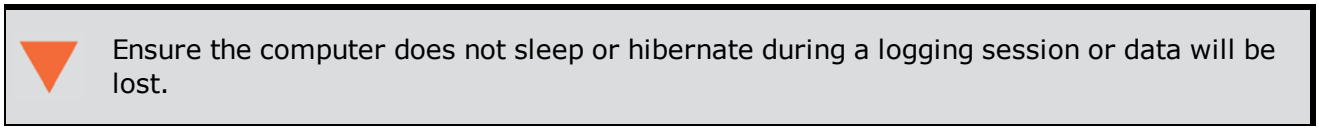
This example illustrates command input to the base receiver's COM2 port that sets the position of the base station receiver for differential operation.

If the command was accepted, the receiver responds with:

```
<OK
```

If a command is entered incorrectly, the receiver responds with:

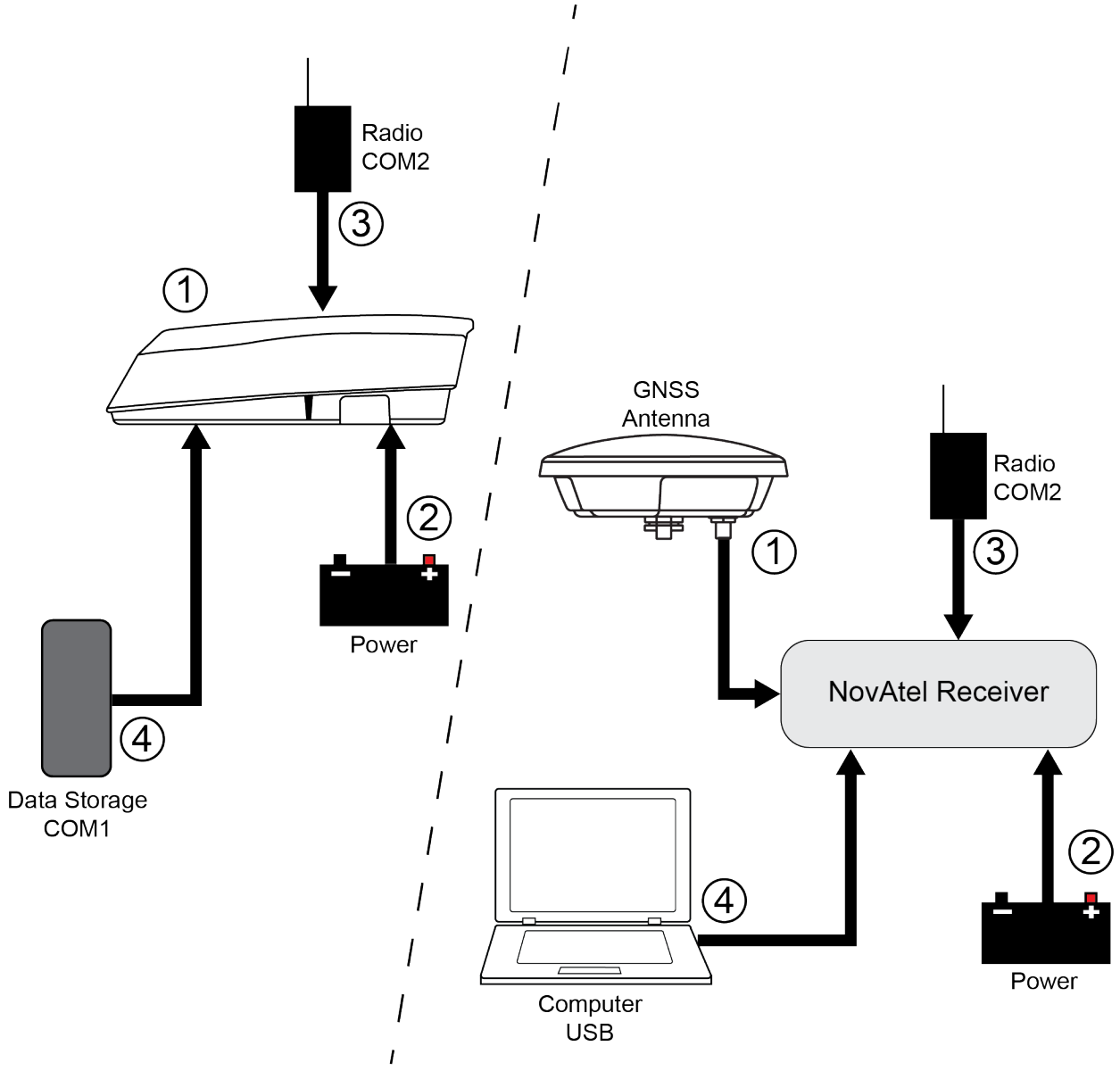
```
<ERROR:Invalid Message ID
```
(or a more detailed message)



3.3 Transmitting and Receiving Corrections

Corrections can be transmitted from a base station to a rover station to improve position accuracy. The base station is the GNSS receiver that acts as the stationary reference. The stationary reference has a known position and transmits correction messages to the rover station. The rover station is the GNSS receiver that does not know its exact position and requires correction messages from a base station to calculate differential GNSS positions. An example of a differential setup is shown in *Figure 9: Basic Differential Setup* on the next page.

Figure 9: Basic Differential Setup



Rover Setup

1 Mount the SMART7
2 Connect a fused power supply (user supplied)
3 Connect a radio device to COM2 (user supplied)
4 Connect a storage device to COM1 (user supplied)

Base Setup

1 Mount and connect a GNSS antenna
2 Connect a fused power supply (user supplied)
3 Connect a radio device to COM2 (user supplied)
4 Connect a computer to COM1 for setup and monitoring (user supplied)

To receive corrections, a data link between the base station and the rover station is required. The base and rover stations can both be NovAtel receivers, however NovAtel receivers will work with some other brands. Contact Customer Support for further details (refer to *Customer Support* on page 14 for details).

The data link should support a rate of at least 19200 bits per second, but a rate of 115200 bits per second, with less than 4.0 s latency, is recommended.

Unlike the base/rover concept, SBAS and L-Band corrections can be applied directly to a single receiver.

When the base and rover are set up, configure them as shown in the configuration examples in *Base Station Configuration* below and *Rover Station Configuration* on the next page.

3.3.1 Defining Antenna and Base Antenna

The type of antenna for the receiver and/or the base receiver can be defined using the **THISANTENNATYPE** command and **BASEANTENNATYPE** command respectively.

The Phase Center Variation (PCV) and the Phase Center Offset (PCO) for each can also be specified using the **THISANTENNAPCV** command and **THISANTENNAPCO** command or the **BASEANTENNAPCV** command and **BASEANTENNAPCO** command.

Refer to the Agriculture Commands and Logs Reference Manual for command details.

3.3.2 Base Station Configuration

At the base station, enter the following commands:

`serialconfig [port] baud [parity[databits[stopbits[handshaking[break]]]]]`

`interfacemode port rx_type tx_type [responses]`

`fix position latitude longitude height` (enter your own lat, long and hgt values)

`log port message [trigger [period]]` (port = COM2 / refer to *Figure 9: Basic Differential Setup* on the previous page)

`saveconfig` (optional)

For example:

RTK Automated Correction Generation

`fix position lat lon hgt` (enter your own lat, lon, hgt)

`generatertkcorrections rtcmv3 com2`

RTCM V3

`serialconfig com2 19200 N 8 1 N on`

`interfacemode com2 none rtcmv3 off`

`fix position lat lon hgt` (enter your own lat, lon, hgt)

`log com2 rtcm1004 ontime 1`

`log com2 rtcm1006 ontime 10`

`log com2 rtcm1019 ontime 120`

`saveconfig` (optional)

RTCM V3 with GLONASS

`serialconfig com2 19200 N 8 1 N on`

```
interfacemode com2 none rtcmv3 off
fix position lat lon hgt (enter your own lat, lon, hgt)
log com2 rtcm1004 ontime 1
log com2 rtcm1012 ontime 1
log com2 rtcm1006 ontime 10
log com2 rtcm1033 ontime 10
log com2 rtcm1019 ontime 120
log com2 rtcm1020 ontime 120
saveconfig (optional)
```

NOVATELX

```
serialconfig com2 19200 N 8 1 N on
interfacemode com2 none novatelx off
fix position lat lon hgt (enter your own lat, lon, hgt)
log com2 novatelxobs ontime 1
saveconfig (optional)
```

3.3.3 Rover Station Configuration

At the rover station, enter the following commands:

```
serialconfig [port] baud [parity[databits[stopbits[handshaking[break]]]]]
interfacemode port rx_type tx_type [responses]
saveconfig (optional)
```

For example, if COM2 was connected to the correction source:

RTK Automated Correction Detection

```
interfacemode com2 auto none off
```

RTCM V3

```
interfacemode com2 rtcmv3 none off
```

RTCM V3 with GLONASS

```
interfacemode com2 rtcmv3 none off
```

NOVATELX

```
interfacemode com2 NOVATELX none off
```

3.3.4 Configuration Notes

For compatibility with other GNSS receivers and to minimize message size, use the standard form of RTCMV3 corrections shown in the base and rover examples in *Transmitting and Receiving Corrections* on page 35. This requires using the **INTERFACEMODE** command to dedicate one direction of a serial port to one message type only. When the **INTERFACEMODE** command

is used to change the mode from the NOVATEL default, the NovAtel format messages can no longer be used.

To mix NovAtel format messages and RTCM V3 messages on the same port, leave the interface mode set to NOVATEL and log out variants of the standard correction messages with a NovAtel header. ASCII or binary variants can be requested by appending an A or B to the standard message name. For example, on the base station:

```
interfacemode com2 novatel novatel
fix position 51.11358042 -114.04358013 1059.4105
log com2 rtcm1004b ontime 2
```

1. Interface mode must be set to NOVATEL for the receiver to issue logs with an A or B suffix.
2. Using the receiver in NOVATEL mode consumes more CPU bandwidth than using the native differential messages as shown in *Base Station Configuration* on page 37.
3. To find information on how to send multiple commands and log requests from a computer, search our knowledge database available at www.novatel.com/support/.

At the rover, leave the interface mode default settings (interfacemode com2 novatel novatel). The rover recognizes the default and uses the corrections it receives with a NovAtel header.

The **PSRDIFFSOURCE** command and **RTKSOURCE** command set the station ID values that identify the base stations from which to accept pseudorange or RTK corrections. They are useful commands when the rover station is receiving corrections from multiple base stations.

3.4 ALIGN Heading Master and Remote Configurations

ALIGN technology combines two or more receivers to generate high precision heading and pitch angles between two receivers for real-time navigation.

This section provides instructions for setting up a master station with an ALIGN capable rover receiver for applications that require heading output. Refer to APN-048 ALIGN Overview and Setup, available at www.novatel.com/support/.

Dual antenna receivers, such as the , can provide an ALIGN solution without additional receivers or configuration.

This section is for applications that require additional rover receivers.

A dual frequency capable GNSS antenna is required to use SPAN, RTK, ALIGN or dual frequency GLIDE.

3.4.1 Automatic Set Up for Direct-Wire Connection between Master and Rover via COM2

The **ALIGNAUTOMATION** command must only be sent to the rover.

```
ALIGNAUTOMATION ENABLE
```

or

```
ALIGNAUTOMATION ENABLE COM2 230400 10 ON
```

3.4.2 Manual Set Up via COM2

Master:

```
serialconfig com2 230400 N 8 1 N on
interfacemode com2 novatel novatelx off
movingbasestation enable
log com2 novatelxobs ontime 1
log com2 novatelxref ontime 1
log headinga onnew
log gphdt onnew
```

Rover:

```
serialconfig com2 230400 N 8 1 N on
interfacemode com2 novatelx novatel off
rtkportmode com2 ALIGN
log com2 headingext2b onnew
log headinga onnew
log gphdt onnew
hdtoutthreshold 1.0
```

3.5 GLIDE

NovAtel's GLIDE® is a positioning algorithm for single-frequency GPS and GPS/GLONASS applications. GLIDE produces a smooth position output tuned for applications where time relative accuracy (pass-to-pass) is more important than absolute accuracy. Because of this, it is well suited for agricultural applications.

Multipath signals tend to induce time varying biases and increase the measurement noise on the L1/L2 pseudorange measurements. Carrier phase measurements are much less susceptible to the effects of multipath. The GLIDE algorithm fuses the information from the L1 code and the L1 phase measurements into a Position Velocity Time (PVT) solution.

GLIDE includes settings for a dynamic mode, a static mode and an "auto" mode, where the filtering parameters are automatically adjusted as vehicle velocity varies between stationary and dynamic states.

3.5.1 Dual-Frequency GLIDE

NovAtel's dual-frequency GLIDE technology adds to the superior pass-to-pass performance provided by single-frequency GLIDE. Dual-frequency GLIDE is ideal for agricultural and machine guidance applications where relative positioning is critical. Using GLIDE significantly reduces the variation in position errors to less than 1 cm from one epoch to the next. Dual-frequency GLIDE improves the absolute accuracy of the GLIDE position and creates a robust solution resistant to the effects of high ionospheric activity. GLIDE works in all code positioning modes, including single point, DGNSS and SBAS.

Refer to the NovAtel white paper on GLIDE Technology for more information on GLIDE and APN-038 Pseudorange/Delta-Phase (PDP) and GLIDE Filters along with other information available from www.novatel.com/support/search/.

3.5.2 PDP and GLIDE Configurations

Pseudorange/Delta-Phase (PDP) and GLIDE position filters can be used for single-frequency single point, WAAS or DGNSS positioning. Refer to the **PDPFILTER** command and **PDPMODE** command in the Agriculture Commands and Logs Reference Manual.

To reset the PDP or GLIDE filter:

```
pdpfilter reset
```

To enable the PDP filter:

```
pdpfilter enable
```

Ensure the **PDPFILTER** command is used before the **PDPMODE** command. Set the PDP type and kinematic type according to the application. For most kinematic applications:

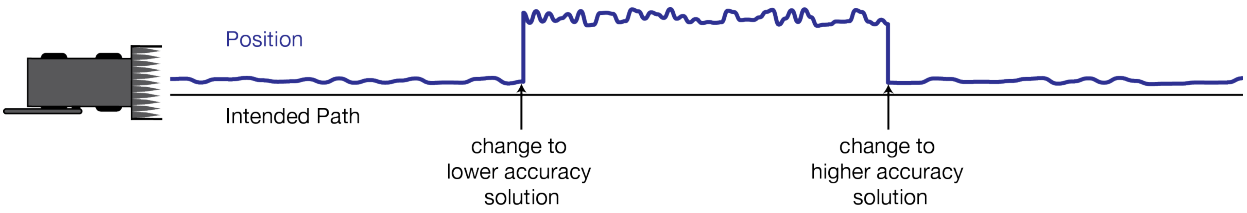
`pdpmode relative dynamic` or `pdpmode relative auto`

The rest of the setup is position type and log dependent according to the application. For example, details of the **PSRDIFFSOURCE**, **INTERFACEMODE**, **SERIALCONFIG** and other configuration commands are outlined in the Agriculture Commands and Logs Reference Manual. Also refer to the NovAtel application note APN-038 Pseudorange/Delta-Phase (PDP) and GLIDE available from our web site at www.novatel.com/support/.

3.6 STEADYLINE

The STEADYLINE® functionality helps mitigate the discontinuities that often occur when a GNSS receiver changes positioning modes. The effect is especially evident when a receiver transitions from an RTK position mode solution to a lower accuracy "fall back" solution, such as DGPS, WAAS+GLIDE or even autonomous GLIDE (see *Figure 10: Positioning Change Without STEADYLINE* below). Smooth transitions are particularly important for agricultural steering applications where sudden jumps are problematic.

Figure 10: Positioning Change Without STEADYLINE



The STEADYLINE feature internally monitors the position offsets between all the positioning modes present in the receiver. When the current positioning mode becomes unavailable, the receiver transitions to the next most accurate positioning mode.

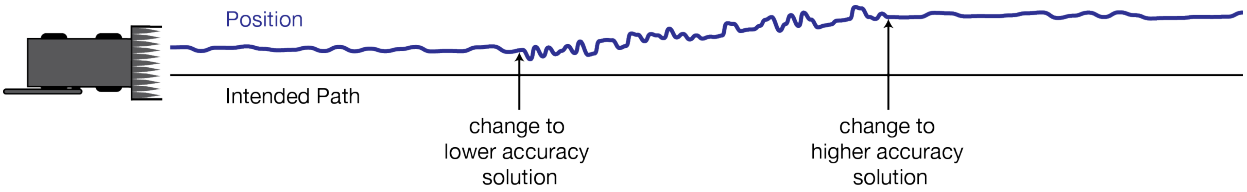
The setting in the **STEADYLINE** command determines how the receiver transitions to the next positioning mode. The following sections describe the STEADYLINE modes.

Refer to the Agriculture Commands and Logs Reference Manual for log and command details.

3.6.1 Maintain

When the receiver transitions to a different positioning mode, it maintains the position offset calculated to limit a potential real position jump. The receiver continues to apply the position offset to all positions calculated in the new positioning mode.

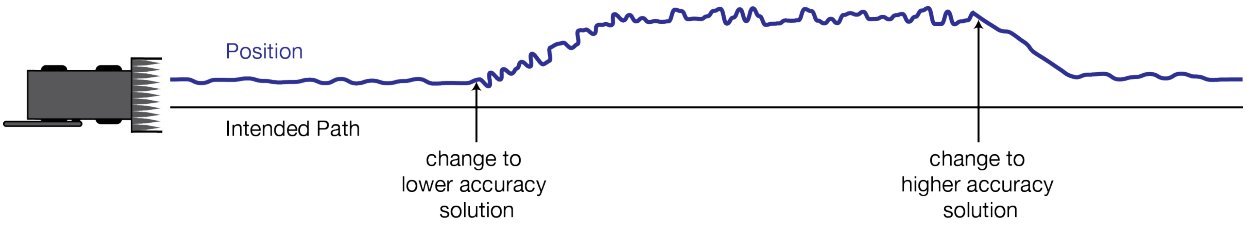
Figure 11: STEADYLINE Maintain



3.6.2 Transition

When the receiver transitions to a different positioning mode, the position offset is applied to the calculated position to limit a potential real position jump. The position then slowly transitions to the new reference position type over a specified period of time. This time period is specified by the Transition time parameter in the **STEADYLINE** command.

Figure 12: STEADYLINE Transition



3.6.3 Prefer Accuracy

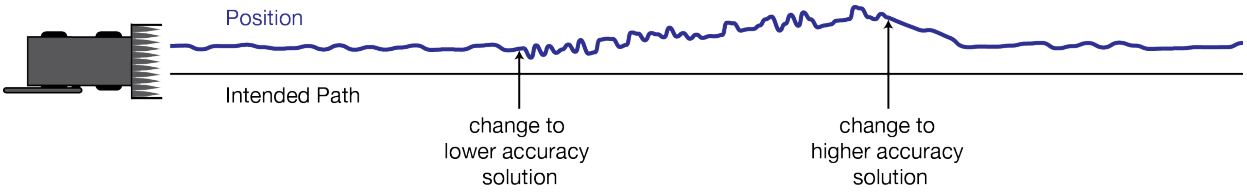
The positioning mode change depends on the accuracy level of the positioning modes.

When the position mode is changing from a more accurate mode to a less accurate mode (e.g., changing from RTK to GLIDE), the receiver uses the Maintain option.

When the position mode is changing from a less accurate mode to a more accurate mode (e.g., GLIDE to RTK), the receiver uses the Transition option.

For example, a receiver is configured to do both RTK and GLIDE. If this receiver has a fixed RTK position and experiences a loss of correction data causing the loss of the RTK solution it will immediately apply the offset between the two position modes and uses the GLIDE position stability to maintain the previous trajectory. Over time the GLIDE (or non-RTK) position will experience some drift. Once the RTK position is achieved again the receiver will start using the RTK positions for position stability and will slowly transition back to the RTK positions at a default rate of 0.005 m/s or the time specified in the **STEADYLINE** command.

Figure 13: STEADYLINE Prefer Accuracy



3.6.4 UAL

> User Accuracy Level (UAL) mode will not function unless UALCONTROL is enabled using the **UALCONTROL** command.

The STEADYLINE mode used depends on the BESTPOS and GPGGA solution types.

When the solution type is OPERATIONAL, the receiver uses the Maintain option.

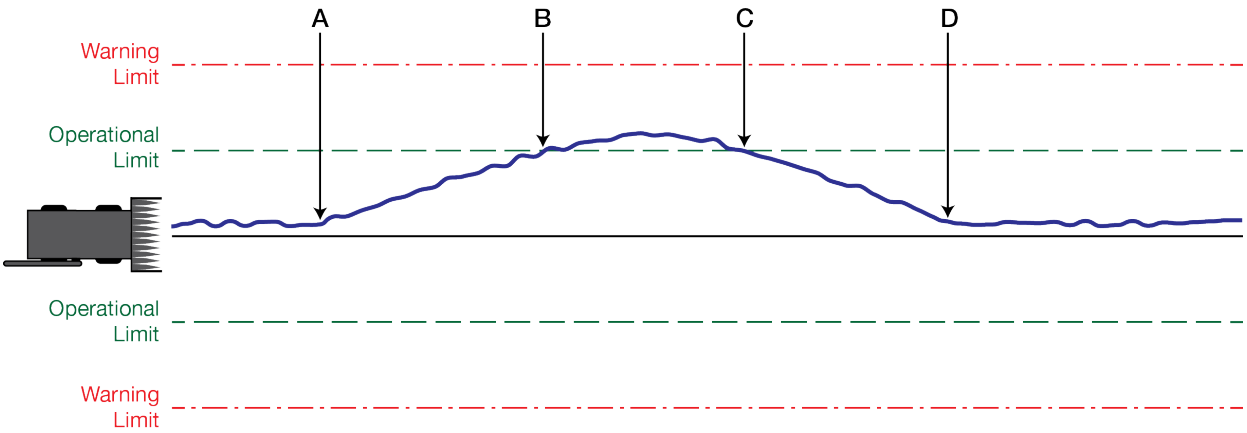
When the solution type is WARNING, the receiver uses the Prefer Accuracy option. When the receiver changes from WARNING to OPERATIONAL, it will continue to use the Prefer Accuracy option until any existing offset is gone.

When the solution type is OUT_OF_BOUNDS, the STEADYLINE feature is disabled.

The thresholds used to determine the solution type (OPERATIONAL, WARNING or OUT_OF_BOUNDS), can be specified using the **UALCONTROL** command. Refer to the Agriculture Commands and Logs Reference Manual.

Figure 14: STEADYLINE UAL- Warning Limit Example below and *Figure 15: STEADYLINE UAL - Out of Bounds Example* on the next page show examples of STEADYLINE using the UAL mode.

Figure 14: STEADYLINE UAL- Warning Limit Example



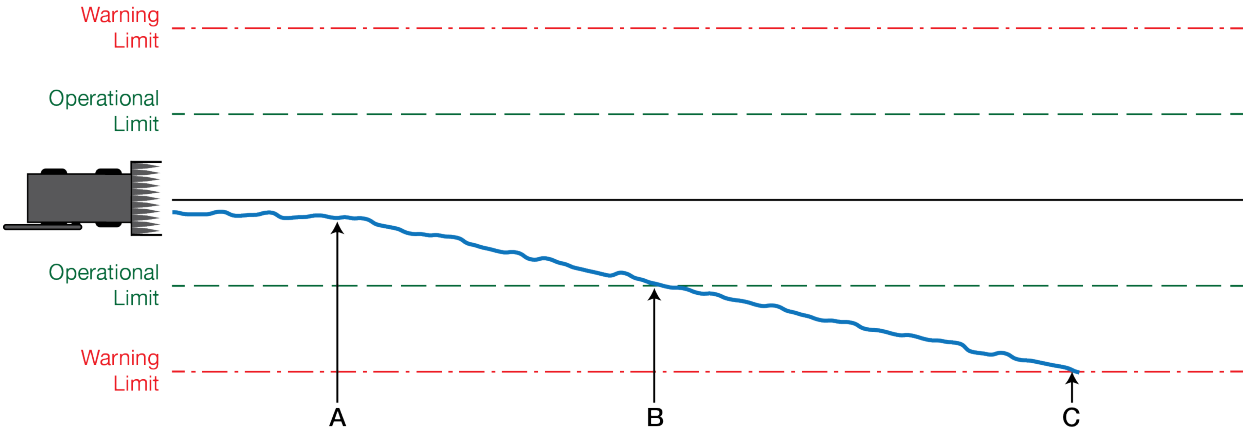
A Position type is OPERATIONAL.
Higher accuracy corrections are lost. The receiver changes to a lower accuracy solution. STEADYLINE operates in Maintain mode while the solution accuracy remains within the Operational limit.

B The solution accuracy exceeds the operational limit. The position type changes to WARNING. The STEADYLINE mode changes from Maintain to Prefer Accuracy.

C The solution accuracy moves back within the operational limit. The position type changes to OPERATIONAL.
The STEADYLINE mode remains in Prefer Accuracy mode.

D The solution offset is removed.
The STEADYLINE mode changes from Prefer Accuracy to Maintain.

Figure 15: STEADYLINE UAL - Out of Bounds Example



A The position type is OPERATIONAL.
Higher accuracy corrections are lost. The receiver changes to a lower accuracy solution. STEADYLINE operates in Maintain mode while solution accuracy remains within the Operational limit.

B The solution accuracy exceeds the operational limit. The position type changes to WARNING.
The STEADYLINE mode changes from Maintain to Prefer Accuracy.

C The solution accuracy exceeds the warning limit. The position type changes to OUT_OF_BOUNDS.
STEADYLINE is disabled.

3.7 Enabling SBAS Positioning

OEM7 receivers are capable of SBAS positioning. This positioning mode is enabled using the **SBASCONTROL** command:

```
sbascontrol enable auto
```

When the command is entered, the OEM7 receiver automatically tracks the SBAS that is operating in the region (e.g., WAAS or EGNOS) and applies the corrections from the service. On a simulator, leave the test mode parameter off or specify NONE explicitly. For more on SBAS, refer to application note APN-051 Positioning Modes of Operation (additional Application Notes available at www.novatel.com/support/).

3.8 Enabling NovAtel CORRECT with PPP

L-Band equipped receivers can achieve sub-metre position accuracy using correction data received from geostationary satellites. To use the L-Band corrections, an L-Band-capable receiver model is required (refer to our web site www.novatel.com/products/gnss-antennas for information on NovAtel L-Band-capable antennas).

For more information on L-Band positioning, refer to:

- NovAtel Application Notes: *APN-061: NovAtel CORRECT with PPP using TerraStar Corrections* or *APN-062 NovAtel CORRECT with Veripos* (service dependent) available from www.novatel.com/support/search/items/Application%20Note
- the Agriculture Commands and Logs Reference Manual for log/command details

  and/or
- visit www.novatel.com/support
- visit www.novatel.com/products/novatel-correct

3.8.1 TerraStar Subscriptions

A subscription is required to use TerraStar service for land, airborne and near shore applications. Near shore applications are defined as vessels operating within 10 km of shore. To obtain a subscription, contact your local NovAtel sales representative or visit www.novatel.com/products/terrastar-gnss-corrections. The NovAtel product serial number (PSN) is needed to obtain a subscription. To obtain the receiver serial number, enter the following command:

```
log versiona once
```

To activate a subscription, the receiver must be powered and tracking an L-Band TerraStar satellite prior to the planned activation time. Use the **ASSIGNLBANDBEAM** command to configure the receiver to track the TerraStar satellite.

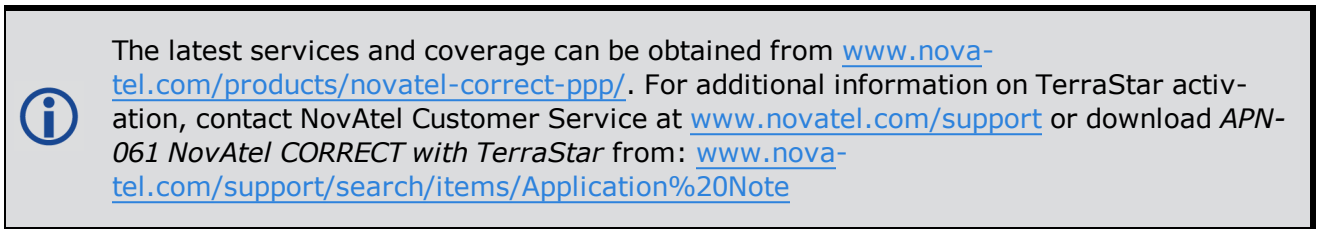
```
ASSIGNLBANDBEAM auto
```

To confirm tracking of an L-Band signal, log the L-Band tracking status information by entering the following command:

```
log lbandtrackstata
```

```
#LBANDTRACKSTATA,COM1,0,73.5,FINESTEERING,1769,328196.000,00000000,29fd,
12602;1,"98W",1539902500,1200,974c
00c2,0,-316.186,43.842,4.3840,61.920,1088,2,2,138176,79,0.0001*3e43cb7d
```

If receiving an L-Band signal from a geostationary satellite, the sixth field following the header (tracking status word) of the LBANDTRACKSTAT log will be 00c2, as shown in the example.



The latest services and coverage can be obtained from www.novatel.com/products/novatel-correct-ppp/. For additional information on TerraStar activation, contact NovAtel Customer Service at www.novatel.com/support or download *APN-061 NovAtel CORRECT with TerraStar* from: www.novatel.com/support/search/items/Application%20Note

To confirm the TerraStar subscription status, send the **TERRASTARSTATUS** log:

```
log terrastarstatus
```

```
[COM1]<TERRASTARSTATUS COM1 0 74.0 FINESTEERING 1886 418216.025 00000020 fdc1
13386 ENABLE LOCKED 0 IN_RANGE DISABLED
[COM1]
```

The first field after the log header will be ***ENABLED*** to indicate the TerraStar subscription is valid. The second field after the log header will be ***LOCKED*** to indicate the decoder is locked to the data format.

To monitor the PPP convergence, send the **PPPPOS** log:

```
log ppppos ontime 1
```

```
[COM1]<PPPPOS COM1 0 76.0 FINESTEERING 1886 418465.000 00000020 ec34 13386 SOL_
COMPUTED PPP_CONVERGING 51.11679035745 -114.03886212905 1064.9475 -16.9000
WGS84 0.7097 0.6867 1.2333 "TSTR" 25.000 0.000 18 17 17 17 00 00 00 33
[COM1]
```

3.8.2 Veripos Subscriptions

> Subscriptions to the Veripos Apex and Apex^2 marine services must be obtained directly from Veripos. A unit with a marine subscription can not be switched to a land subscription and vice versa.

A subscription is required to use the Veripos services for offshore marine applications. Contact Veripos sales at veripos.com/support to obtain a Service Access License (SAL) number. To activate the service, contact the Veripos Help Desk at +44 (0) 1224 527 104 or visit veripos.com/support. Provide the SAL number and the receiver's Veripos Serial Number (VSN). To obtain the receiver-specific VSN, enter the following command:

```
log veriposinfo
```

The log displays the VSN in the first field following the log header and also displays the status of your subscription.

To activate a subscription, the receiver must be powered and tracking an L-Band Veripos satellite prior to the planned activation time. Use the **ASSIGNLBANDBEAM** command to configure the receiver to track the Veripos satellite.

```
assignlbandbeam auto
```

> The latest services and coverage can be obtained from www.veripos.com. For additional information on Veripos activation, contact NovAtel Customer Service at www.novatel.com/support or download the APN-062 NovAtel CORRECT with Veripos from: www.novatel.com/support/search/items/Application%20Note

3.9 RTK ASSIST

RTK ASSIST™ is a feature that enables centimetre-level accuracies to be maintained through extended RTK correction outages. With RTK ASSIST, RTK-dependent operations can continue through RTK correction outages as long as 20 minutes.

RTK ASSIST uses correction data provided by TerraStar. To obtain these corrections, an L-Band capable receiver is required and L-Band tracking must be enabled using the **ASSIGNLBANDBEAM** command.

RTK ASSIST also requires a subscription to the RTK ASSIST service. To obtain a subscription, contact your local NovAtel sales representative or visit www.novatel.com/products/terrastar-gnss-corrections/. The NovAtel Product Serial Number (PSN) is needed to obtain a subscription. The PSN is available from the **VERSION** log.

RTK ASSIST is available as soon as the rover receiver has at least one valid RTK solution and has received the RTK ASSIST correction data. If an RTK correction outage occurs, then RTK ASSIST will maintain RTK mode until the subscription-permitted RTK ASSIST duration is exceeded. A shorter, user-defined RTK ASSIST time out can also be set using the **RTKASSISTTIMEOUT** command. Normal RTK operation will seamlessly resume if RTK corrections are restored at any point while RTK ASSIST is operating.

RTK ASSIST will report the RTK solution type that was present before RTK corrections were lost, unless the estimated solution standard deviation exceeds the threshold set by the **RTKINTEGERCRITERIA** command. If this occurs, then integer RTK solutions will be downgraded to their float RTK equivalent.

RTK ASSIST is enabled by default, but can be disabled using the **RTKASSIST** command. To monitor the status of RTK ASSIST, view the **RTKASSISTSTATUS** log.

Refer to the Agriculture Commands and Logs Reference Manual for log and command details.

RTK ASSIST typically provides 4 cm accuracy. However, if the RTK outage occurs during the first 30 minutes of receiver operation, the position accuracy provided by RTK ASSIST may be lower.

Additional information about enabling and using RTK ASSIST is available in the RTK ASSIST Application Note (available from our website: www.novatel.com/assets/Documents/Bulletins/APN-073-RTK-ASSIST.pdf).

3.10 Logging Using NovAtel Connect

NovAtel Connect is a computer program used to configure and monitor NovAtel receivers.

The Logging Control Window in NovAtel Connect provides an interface to configure logging and to collect logs from the receiver. The collected logs can be output to one of the receiver communication ports or stored on the computer running NovAtel Connect.

For details about using NovAtel Connect, refer to the Help file available within NovAtel Connect.

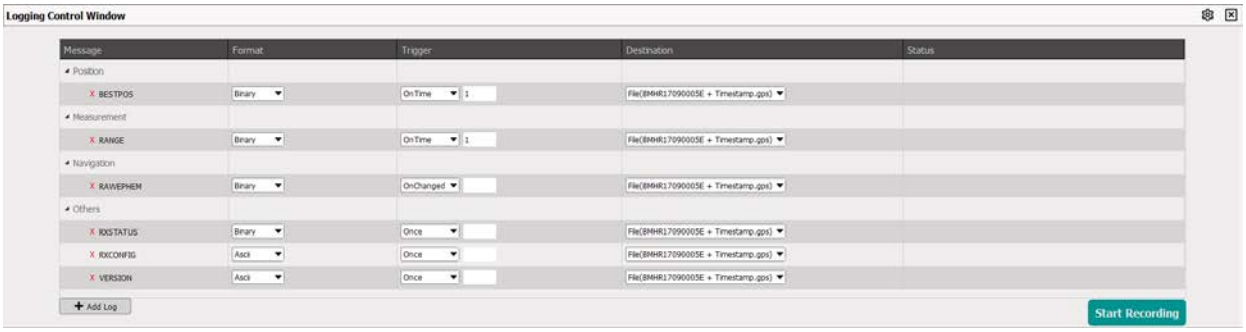
NovAtel Connect version 2.0 or greater is required for OEM7 receivers. Download the latest NovAtel Connect software and documentation from www.novatel.com/novatel-connect.

To open the Logging Control window:

1. Open NovAtel Connect.
2. Establish a connection to the receiver.

3. Click the

button to open the Logging Control Window.



3.10.1 Selecting the Logs to Collect

The logs configured to be collected are shown in the bottom portion of the screen.

To add logs:

1. Click the **+ Add Log** button. The *Add Logs* dialog box opens.
2. Click the check box for each log you want to add.

   The logs are listed alphabetically and are organized on tabs by category.

   If the log name is known, enter the log name, or a portion of the log name, in the search box. The search starts as soon as text is entered. The search works within the selected tab, so if the log is not found, click on the other tabs to search those tabs.
3. After the logs required are selected, click the **Add** button.

   The selected logs are added to the Logging Control Window with default logging parameters.

To remove a log from the set of logs to be collected:

1. Click the red **X** button beside the log.

3.10.2 Modify the Logging Parameters

Each log on the Logging Control Window has three parameters that affect how the log is collected.

- **Format**

  Logs can be generated in Binary or ASCII format. For information about these formats, refer to Binary and ASCIIin the Agriculture Commands and Logs Reference Manual.

- **Trigger**

  The trigger determines the schedule on which the log is collected. The trigger selected depends on the information required and the type of log. For more information about triggers, refer to Log Types and the **LOG** commandin the Agriculture Commands and Logs Reference Manual.

- **Destination**

  The destination determines where the log is sent. The log can be sent to any communication port on the receiver or a file on the computer running NovAtel Connect.

If a communication port is selected, ensure that a device to receive the log is connected to that port.

The filename and directory used when collecting to a file is configured in the *Settings* dialog box. Refer to *Change the Log File Settings* below.

3.10.3 Start Collecting Logs

To start collecting logs:

1. Ensure that the logs you want to collect are shown on the Logging Control Window.
2. Click the **Start Recording** button.

   The button changes to Stop Recording.

   If logs are being collected in a file on the computer, the file name used and a running total of the file size appears.

3.10.4 Stop Collecting Logs

To stop collecting logs:

1. Click the **Stop Recording** button.

3.10.5 Change the Log File Settings

When logging to a file on the NovAtel Connect computer, the file used is determined by the log file settings. To change the log file settings:

1. Click the button in the Logging Control Window.

   The *Settings* dialog box appears.

2. Modify the log file settings.

File Path	The path of the directory in which the log files are stored. Enter the path directly in the text box or click the **Browse** button and use the dialog box to select the directory.
File Name	The file name used for the log file. You can enter a name or allow NovAtel Connect to generate a name. To enter a file name, clear the **Auto** check box and enter the name in the text box. The next logging session will save the logs using the entered name. For subsequent logging sessions, you will be prompted whether you want to replace the existing file or add the new session to the existing log file. To allow NovAtel Connect to generate a unique name for each logging session, ensure the **Auto** check box is selected. NovAtel Connect will generate a new file for each logging session. The file is named with the product serial number (PSN) and the time when the logging session started.
Hold Type	Enable or disable Hold on the logs started using the Logging Control Window. When the Hold Type is set to **No**, the logs started using the Logging Control Window can be unlogged when an **UNLOGALL** command is sent. When the Hold Type is set to **Yes**, the logs started using the Logging Control Window can not be unlogged when an **UNLOGALL** command is sent.
File Split	If a large amount of logging data is being collected, the data can be split into multiple files by collection time or file size. To enable file splitting, select the **Enable** check box and then select **Time** and enter a value in hours or select **Size** and enter a value in MB.

3. Click the **Save** button.

SMART7 with SPAN Operation

NovAtel's Synchronous Position, Attitude and Navigation (SPAN®) technology brings together two very different but complementary positioning and navigation systems namely Global Navigation Satellite System (GNSS) and an Inertial Navigation System (INS). By combining the best aspects of GNSS and INS into one system, SPAN technology is able to offer a solution that is more accurate and reliable than either GNSS or INS could provide alone. The combined GNSS+INS solution has the advantage of the absolute accuracy available from GNSS and the continuity of INS through traditionally difficult GNSS conditions.

A SPAN system consists of the following components:

- NovAtel GNSS receiver
  The NovAtel OEM7 GNSS receiver uses a combination of GPS, GLONASS, Galileo, BeiDou, NavIC and QZSS signals to calculate an accurate GNSS position. The OEM7 receiver also supports the timing requirements of the IMU and runs the real-time INS filter.
- IMU
  The Inertial Measurement Unit (IMU) consists of three accelerometers and three gyroscopes (gyros) so that accelerations along specific axes and angular rotations can be measured.
- GNSS antenna

In the SMART7-S, all of three of these components are included in the SMART7 enclosure. After the SMART7 is installed, the appropriate power supply is attached, and a few simple configuration commands are entered, the SPAN system will be ready to navigate.

4.1 Fundamentals of GNSS+INS

GNSS positioning observes range measurements from orbiting GNSS satellites. From these observations, the receiver can compute position and velocity with high accuracy. NovAtel GNSS positioning systems are highly accurate positioning tools. However, GNSS in general has some restrictions which limit its usefulness in some situations. GNSS positioning requires line of sight view to at least four satellites simultaneously. If these criteria are met, differential GNSS positioning can be accurate to within a few centimetres. If however, some or all of the satellite signals are blocked, the accuracy of the position reported by GNSS degrades substantially, or may not be available at all.

In general, an INS uses forces and rotations measured by an IMU to calculate position, velocity and attitude. This capability is embedded in the firmware of OEM7 receivers. Forces are measured by accelerometers in three perpendicular axes within the IMU and the gyros measure angular rotation rates around those axes. Over short periods of time, inertial navigation gives very accurate acceleration, velocity and attitude output. The INS must have prior knowledge of its initial position, initial velocity, initial attitude, Earth rotation rate and gravity field. Since the IMU measures changes in orientation and acceleration, the INS determines changes in position and attitude, but initial values for these parameters must be provided from an external source. Once these parameters are known, an INS is capable of providing an autonomous solution with no external inputs. However, because of errors in the IMU measurements that accumulate over time, an inertial-only solution degrades with time unless external updates such as position, velocity or attitude are supplied.

The SPAN system’s combined GNSS+INS solution integrates the raw inertial measurements with all available GNSS information to provide the optimum solution possible in any situation. By

using the high accuracy GNSS solution, the IMU errors can be modeled and mitigated. Conversely, the continuity and relative accuracy of the INS solution enables faster GNSS signal reacquisition and RTK solution convergence.

The advantages of using SPAN technology are its ability to:

- Provide a full attitude solution (roll, pitch and azimuth)
- Provide continuous solution output (in situations when a GNSS-only solution is impossible)
- Provide faster signal reacquisition and RTK solution resolution (over stand-alone GNSS because of the tightly integrated GNSS and INS filters)
- Output high-rate (up to the IMU data rate depending on your logging selections) position, velocity and attitude solutions for high-dynamic applications, see also *Logging Restriction Important Notice* on page 72
- Use raw phase observation data (to constrain INS solution drift even when too few satellites are available for a full GNSS solution)

For more information about GNSS and INS, refer to www.novatel.com/an-introduction-to-gnss/

4.2 Definition of Reference Frames Within SPAN

The reference frames that are most frequently used throughout the SPAN documentation are the following:

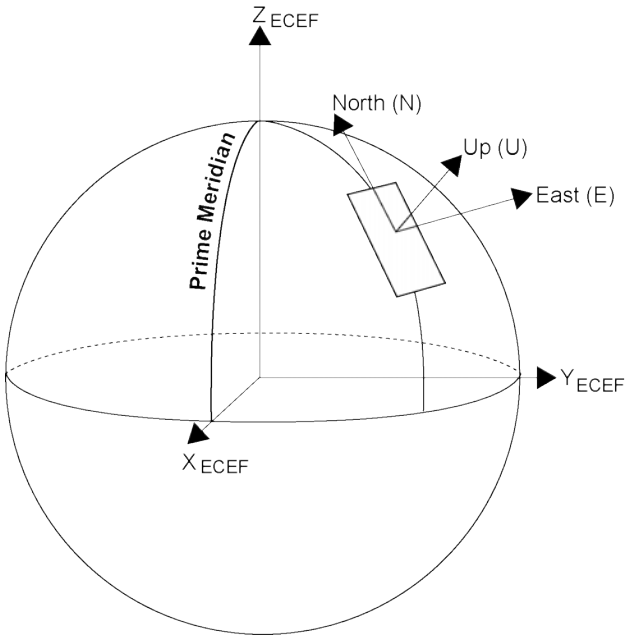
- *The Local-Level Frame (ENU)* below
- *The IMU Body Frame* on the next page
- *The Vehicle Frame* on the next page
- *The User Output Frame* on page 54

4.2.1 The Local-Level Frame (ENU)

The definition of the local level coordinate frame is as follows:

- z-axis – pointing up (aligned with gravity)
- y-axis – pointing north
- x-axis – pointing east

Figure 16: Local-Level Frame (ENU)



4.2.2 The IMU Body Frame

The definition of the IMU Body frame is given by the physical axes of the IMU and represents how the sensors are mounted inside the IMU. Refer to *SMART7 Mechanical Specifications* on page 132 for illustrations of the IMU Body frame axes.

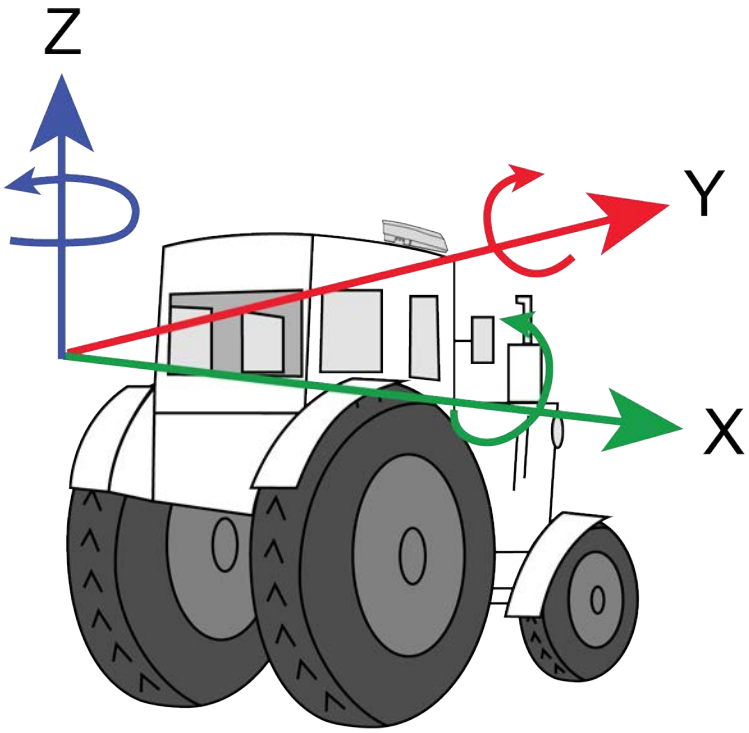
The origin of this frame is not the enclosure center, but the center of navigation (sensor center).

4.2.3 The Vehicle Frame

The definition of the vehicle frame is as follows:

- z-axis – points up through the roof of the vehicle perpendicular to the ground
- y-axis – points out the front of the vehicle in the direction of travel
- x-axis – completes the right-handed system (out the right-hand side of the vehicle when facing forward)

Figure 17: Vehicle Frame



4.2.4 The User Output Frame

The user output frame is an arbitrary frame, which can be optionally defined to transfer inertial output to a more useful position or reference frame.

By default, SPAN position and velocity output is given at the center of navigation of the IMU. To output position and velocity at a different location, specify a user offset translation using the **SETINSTRANSLATION** command.

By default, SPAN attitude output is the rotation from the Local-Level frame to the Vehicle frame. If attitude output is desired relative to another frame, specify a user offset rotation using the **SETINSROTATION** command.

4.3 SPAN Translations and Rotations

A SPAN system combines GNSS and INS into a single system. In a GNSS system, the position is reported relative to the phase center of the GNSS antenna. In an INS system, the position, velocity and attitude data is reported relative to the center of navigation of the IMU. For a SPAN system to provide a combined GNSS+INS position, velocity and attitude, it must know where the GNSS antenna is positioned relative to the IMU.

The orientation of the IMU relative to the forward direction of the vehicle is also needed to convert the velocity and attitude changes sensed by the IMU into the actual motion of the vehicle.

If the SPAN system incorporates other devices, the SPAN system also needs to know the location and orientation of these additional devices relative to the IMU.

4.3.1 Translational Offsets

The three dimensional distances between the IMU and other SPAN components are called translational offsets.

The translational offsets are measured in three directions, X axis, Y axis and Z axis, typically relative to the IMU Body frame. Translational offsets can also be entered relative to the Vehicle frame.

The X, Y and Z axes of the IMU Body frame are indicated on the SMART7 mechanical drawings. See *SMART7 Mechanical Specifications* on page 132.

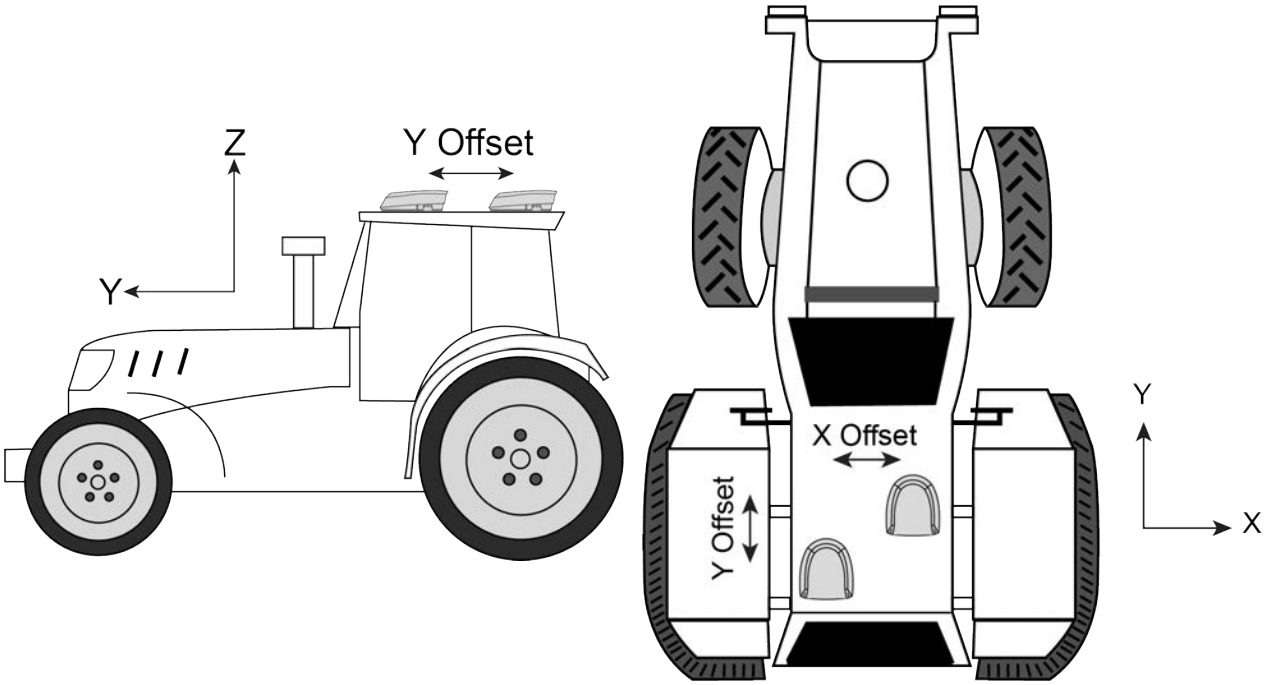
The translational offsets from the IMU to the GNSS antenna are required for all SPAN systems. Since the IMU and GNSS antenna are inside the SMART7 enclosure, the IMU to antenna offset is configured at the factory. No additional translational offset configuration is needed on the SMART7, unless there are additional SPAN system components that require an offset.

Do not use the SETINSTRANSLATION ANT1 command to change the IMU to primary antenna offset. Changing this value from the factory default will impair SPAN system performance.

Some SPAN systems may have other sensors or devices integrated into the system for which the SPAN needs translational offsets. For example, a second receiver and GNSS antenna in a SPAN ALIGN system. The offsets to these additional sensors and devices are also entered using the **SETINSTRANSLATION** command.

Figure 18: ALIGN Translation Offset on the next page shows an example of the translational offsets between a SMART7-S and a SMART7 in an ALIGN configuration. In this example, the SMART7-S is mounted at rear left corner of the tractor roof and the IMU Body Frame of the SMART7-S (indicated by the small arrows) has the Y axis pointing in the direction of the vehicle motion and the z axis pointing up.

Figure 18: ALIGN Translation Offset



If the distances measured in this example were X Offset = 1.5 m, Y Offset = 1 m and Z Offset = 0 m, the following values would be entered, based on the IMU Body Frame:

- x = 1.5
- y = 1.0
- z = 0

The translational offsets are entered using the **SETINSTRANSLATION** command. For this example, the command to enter these offsets is:

```
SETINSTRANSLATION ANT2 1.5 1.0 0
```

The measurements for the translational offsets should be done as accurately as possible, preferably to within millimeters especially for RTK operation. Any error in the offsets will translate into an error in the INS position.

By default, the translational offsets are entered in the IMU Body frame. However, in some systems the IMU Body frame may not be known precisely. For these cases, the **SETINSTRANSLATION** command has an option that allows the offsets to be entered relative to the Vehicle frame. In these cases, the rotation from the IMU Body frame to the Vehicle frame (RBV) is used to rotate offsets into the default IMU Body frame as required. To achieve the best results, this means that the RBV rotation must be known very precisely. Typically this is achieved through the SPAN RBV Calibration procedure. See *Body to Vehicle Frame Rotation Calibration Routine* on page 72 or *Multi-Line Body to Vehicle Frame Rotation Calibration Routine* on page 73 for information about this calibration procedure.

4.3.2 Rotational Offsets

The differences in orientation between the SMART7 and other SPAN components are called rotational offsets. Rotational offsets are given as the rotation from the IMU Body frame to the frame of interest.

The order of rotations is Z-X-Y and all rotations are right handed.

Generally, frames of reference are defined as Z up, with Y forward, and X completing the right-handed system. An example is the Vehicle frame, where Z is always considered to be upwards, Y forward through the direction of travel, and X to the right.

If the SMART7 is installed with the front of the SMART7 facing the direction of forward motion for the vehicle (as shown in *Figure 7: SMART7 Orientation* on page 24), an IMU Body frame to Vehicle frame rotation is not required. The necessary rotations are configured at the factory.

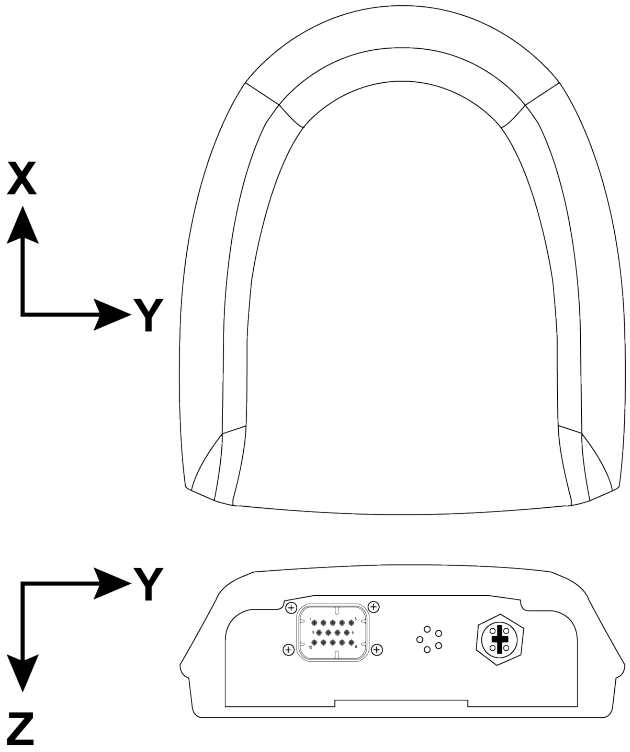
An IMU Body frame to Vehicle frame calibration routine should be run to on all SMART7 installations, whether an IMU Body frame to Vehicle frame rotation is required or not. See *Body to Vehicle Frame Rotation Calibration Routine* on page 72 or *Multi-Line Body to Vehicle Frame Rotation Calibration Routine* on page 73 for more information. This calibration routine should be done each time the SMART7 is remounted.

Non-Standard Installation

The SMART7 is intended to be installed with the front of the SMART7 facing the direction of vehicle travel. If the installation location does not allow this orientation, the **SETINSROTATION RBV** command must be used to align the SMART7 IMU Body frame with the Vehicle frame.

The IMU Body frame of the SMART7-S is shown in *Figure 19: SMART7-S IMU Body Frame* on the next page.

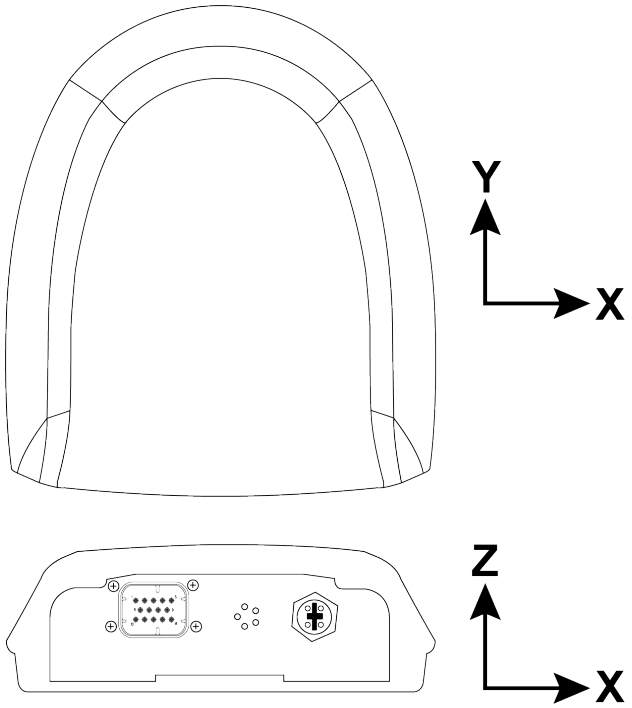
Figure 19: SMART7-S IMU Body Frame



At the factory, the following command is entered to configure rotations required to align the IMU Body frame so that the Z axis points up and the Y axis points out the front of the SMART7-S. See *Figure 20: SMART7-S IMU Body Frame with Factory Configured Rotation* on the next page.

```
SETINSROTATION RBV 180 0 90
```

Figure 20: SMART7-S IMU Body Frame with Factory Configured Rotation

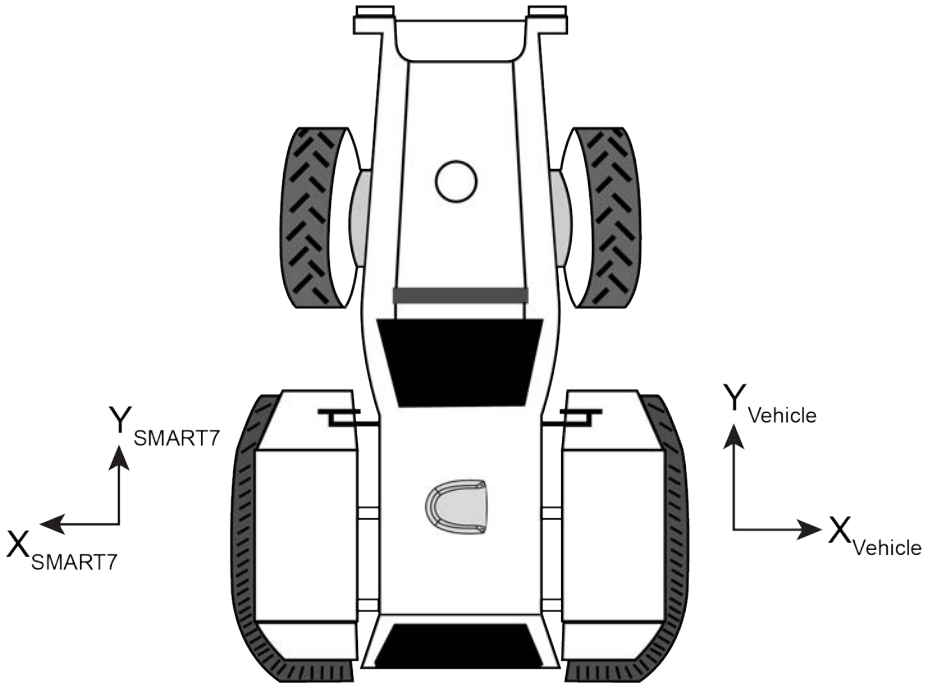


If SMART7-S is not installed with the front of the SMART7-S facing the direction of vehicle travel, a different set of rotations must be entered using the **SETINSROTATION RBV** command.

Rotational Offsets – Example

Consider a SMART7-S installed as shown in the following diagram. In this installation, the factory configured rotation does not align the IMU Body frame with the Vehicle frame. Therefore, a new IMU Body to Vehicle frame rotation must be entered using the **SETINSROTATION RBV** command.

Figure 21: SMART7-S Installed with Orientation Not Aligned with Vehicle Frame



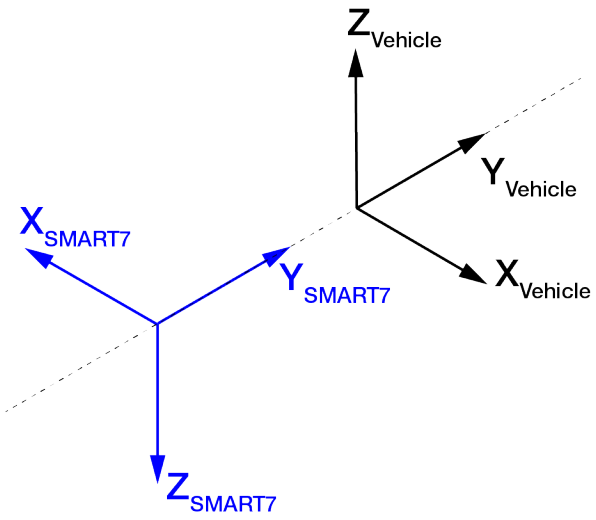
In this example, the Euler Angles to rotate from the IMU Body frame (*Figure 19: SMART7-S IMU Body Frame* on page 58) to the Vehicle frame (RBV) are:

- X: 0
- Y: 180
- Z: 0

To reach this answer, keep in mind the following rules:

- You must rotate from the IMU Body frame to the Vehicle frame.
- You must rotate in the order Z, X, Y. Specifically Z, X', Y"
- Positive rotation is defined according to the right hand rule.

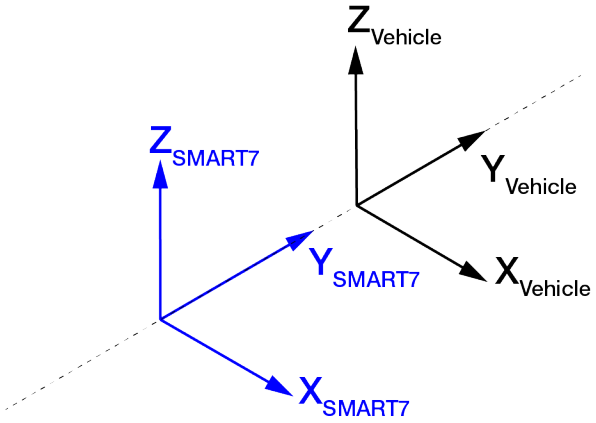
The following diagram shows the IMU Body frame of the SMART7-S and the Vehicle frame for the example installation shown in *Figure 21: SMART7-S Installed with Orientation Not Aligned with Vehicle Frame* above.



Z Rotation:
Since the Y axis of the IMU Body frame is collinear with vehicle Y axis, a Z rotation is not required.

X Rotation:
Since the Y axis of the IMU Body frame is collinear with the vehicle Y axis, an X rotation is also not required

Y Rotation:
Observe that if a 180 degree rotation is performed about the IMU Body frame Y axis, the rotated IMU Z axis is now collinear with the Vehicle Z axis, and the rotated IMU X axis is also collinear with the Vehicle X axis.



This solution is not unique. Due to the properties of Euler Angles, there are usually multiple sets of equivalent rotations.

The rotational offsets are entered using the **SETINSROTATION** command. For this example, the command to enter the rotations for the previous example is:

```
SETINSROTATION RBV 0 180 0
```

4.3.3 Importance of RBV Calibration

For the SMART7 to provide the best performance, the rotation offset of the IMU body to the Vehicle frame (RBV) should be known as accurately as possible. Since constraints happen at the vehicle level, any error in the offset will translate into worse performance.

If the SMART7 is installed as described in *Mounting and Orienting the SMART7* on page 23, the IMU Body frame is aligned with the Vehicle frame. However, aspects of the vehicle design, such as roof camber or tilt, and slight misalignments in installation can cause the IMU Body frame to be slightly out of alignment with the Vehicle frame. The misalignment of the IMU Body frame from the Vehicle frame will add a bias to the SPAN solution.

The following diagrams show a SMART7 on the roof of a vehicle with the three issues mentioned above.

Figure 22: Rear view of SMART7 on a Vehicle – Roof Camber

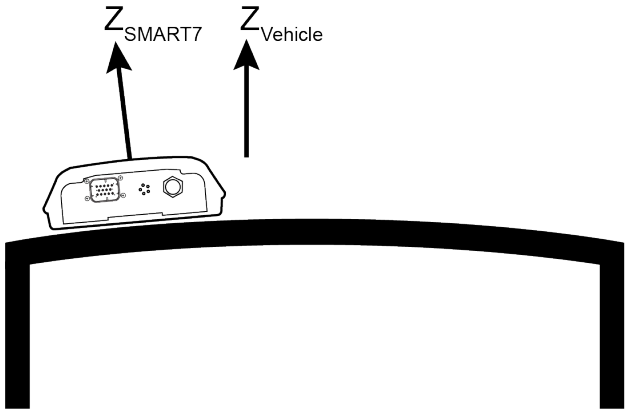


Figure 23: Side View of SMART7 on a Vehicle – Roof Tilt

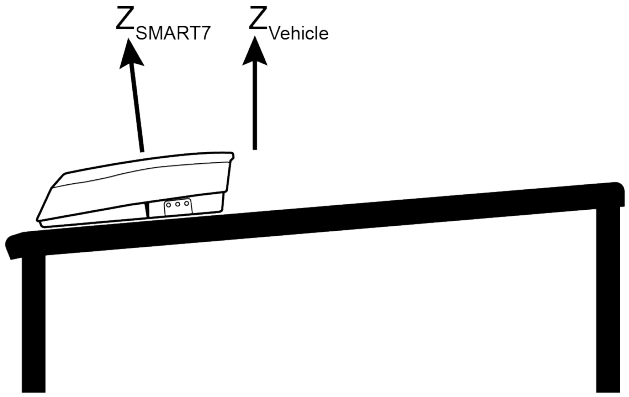
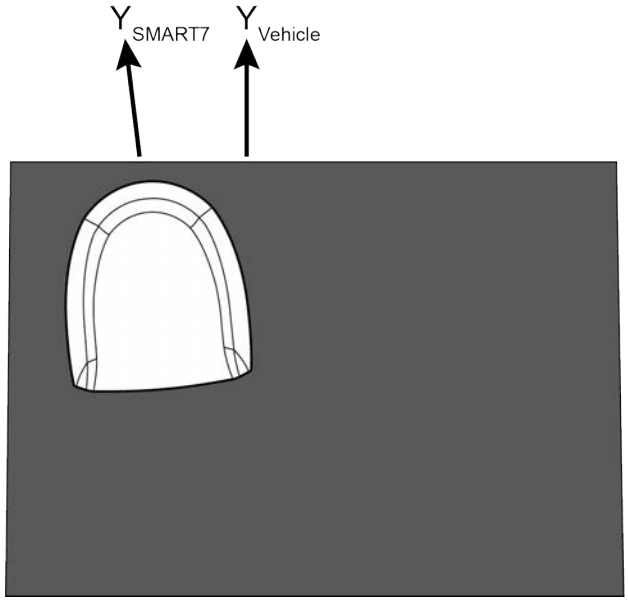


Figure 24: Top View of SMART7 on a Vehicle – SMART7 Misalignment



In a typical SMART7 installation, the slight misalignments described in the examples above are hard to detect and difficult to measure. For this reason, it is recommended that a Body to Vehicle Frame rotation calibration routine be used so the SPAN system can determine and compensate for these angles. Refer to *Body to Vehicle Frame Rotation Calibration Routine* on page 72 or *Multi-Line Body to Vehicle Frame Rotation Calibration Routine* on page 73 for more information.

These parameters are estimated in the background when the system is fully converged, however it is always better to have this measured as precisely as possible before mission critical data is collected.

Since slight variations in alignment can be introduced when the SMART7 is remounted, a Body to Vehicle Frame calibration should be performed each time the SMART7 is remounted.

An accurate RBV is especially important if the position is being transferred to an implement.

4.4 Software Configuration

On a SPAN system, both the GNSS receiver and the IMU must be configured.

4.4.1 Minimum Recommended Configuration

When configuring your SMART7 SPAN system for first time use, the following is the minimum amount of information required to ensure proper operation of a SPAN system.

Required Information	Required Command
IMU to vehicle frame rotation	SETINSROTATION RBV

While this is the minimum amount of information required, additional information is typically needed for SPAN systems. The following commands are commonly used to configure SPAN systems.

Common User Settings	Appropriate Command	Notes
IMU to output position offset	SETINSTRANSLATION USER	Default output position is at the IMU center
IMU to output frame rotation	SETINSROTATION USER	Default output frame is the vehicle frame
IMU to secondary antenna lever arm	SETINSTRANSLATION ANT2	Only required if the SMART7 is part of an ALIGN system.
Minimum alignment velocity	SETALIGNMENTVEL	

4.4.2 GNSS Configuration

The GNSS configuration can be set up for different accuracy levels such as single point, SBAS, DGPS, PPP and RTK. Refer to the *SMART7 Operation* on page 31 for details on DGPS, RTK, L-Band or SBAS setup and operation.

With no additional configuration, the system operates in single point mode.

4.4.3 SPAN Configuration

- *Configure SPAN Manually* below
- *SPAN Configuration with NovAtel Connect* on the next page
- *SPAN Configuration with NovAtel Web User Interface* on the next page

Configure SPAN Manually

To enable INS as part of the SPAN system using software commands:

The SMART7 must be mounted with a clear view of the sky and tracking satellites for operation.

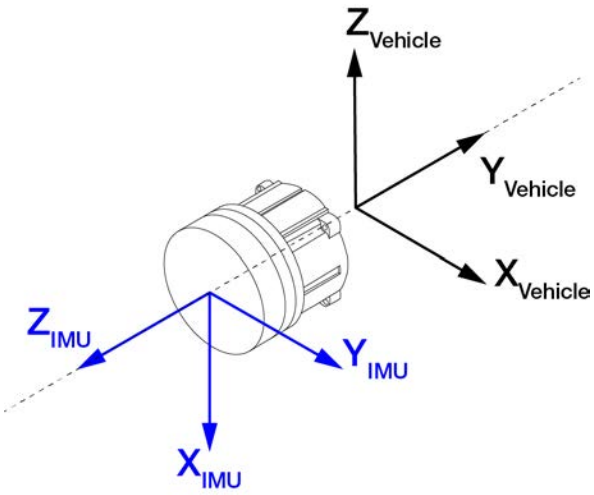
1. Issue the **SETINSROTATION** command, using the **RBV** parameter, to enter the Euler Angle rotation from the IMU Body frame of the SMART7 to the Vehicle frame. See the **SETINSROTATION** command in the Agriculture Commands and Logs Reference Manual for more information.

   Accurate knowledge of the rotational offset between the IMU Body frame and the Vehicle frame (the RBV rotation) is critical to correctly computing an attitude solution, and is required before a Kinematic alignment is possible.

   The SETINSROTATION parameters are (where the standard deviation fields are optional):

   ```
   RBV x_rotation y_rotation z_rotation [x_stdev] [y_stddev] [z_stdev]
   ```

The order of rotations is Z-X-Y. All rotations are right handed.



For an example of how to solve for the IMU Body to Vehicle frame rotation refer to *Rotational Offsets* on page 57.

If the rotation between the IMU Body frame and the Vehicle frame is not precisely known, enter an approximate rotation (to the nearest 45 degrees). The precise offset can be estimated by carrying out the *Body to Vehicle Frame Rotation Calibration Routine* on page 72.

SPAN Configuration with NovAtel Connect

NovAtel Connect provides a wizard that takes you through the steps required to configure a SPAN system. For information about using the SPAN Configuration wizard in NovAtel Connect, refer to the help file available within NovAtel Connect.

NovAtel Connect version 2.0 or greater is required for SMART7 receivers. Download the latest NovAtel Connect software and documentation from www.novatel.com/novatel-connect.

SPAN Configuration with NovAtel Web User Interface

The SPAN parameters can be configured using the NovAtel Web User Interface. For information about using the NovAtel Web User Interface, refer to the online OEM7 documentation (docs.novatel.com/OEM7).

4.5 Real-Time Operation

SPAN operates through the OEM7 command and log interface. Refer to the Agriculture Commands and Logs Reference Manual log and command details. .

Real-time operation notes:

- By default, raw IMU data will begin to output as soon as the IMU is connected. However an initial position is required to begin the INS alignment process. This position is typically set by GNSS. The GNSS position will not be used until the FINESTEERING time status is reached. This requires a GNSS antenna connected with a clear view of the sky. See *System Start-Up and Alignment Techniques* on page 67 for more details.
- The inertial solution is computed separately from the GNSS solution. The GNSS solution is

available from the SPAN system through the GNSS-specific logs, even without SPAN running. The integrated GNSS+INS solution is available through special INS logs documented in in the OEM7 Commands and Logs Reference ManualAgriculture Commands and Logs Reference Manual.

- The IMU raw data is available at the maximum rate of output of the IMU. Because of this high data rate, a shorter header format was created. These shorter header logs are defined with an S (RAWIMUSXB rather than RAWIMUXB). We recommend you use these logs instead of the standard header logs to save throughput on the COM port.

Status of the inertial solution can be monitored using the inertial status field in the INS logs, see *Table 10: Inertial Solution Status* below.

Table 10: Inertial Solution Status

Binary	ASCII	Description
0	INS_INACTIVE	IMU logs are not yet present or the alignment routine is not yet initialized. INS state is inactive.
1	INS_ALIGNING	INS is in alignment mode.
2	INS_HIGH_ VARIANCE	The INS solution uncertainty contains outliers and the solution may be outside specifications. The solution is still valid but you should monitor the solution uncertainty in the **INSSTDEV** log. It may be encountered during times when GNSS is absent or poor.
3	INS_ SOLUTION_ GOOD	The INS solution is in navigation mode and has converged sufficiently to be within specifications. For a more rigorous check of the INS solution, examine bit 6 of the Extended Solution Status word. The Extended Solution Status word is available in several logs, including **INSATTX** log, **INSPOSX** log, **INSSTDEV** log, **INSSTDEVS** log, **INSVELX** log and **INSUPDATESTATUS** log
6	INS_ SOLUTION_ FREE	The INS filter is in navigation mode and the GNSS solution is suspected to be in error. This may be due to multipath or limited satellite visibility. The inertial filter has rejected the GNSS position and is waiting for the solution quality to improve.
7	INS_ ALIGNMENT_ COMPLETE	The INS filter is in navigation mode, but not enough vehicle dynamics have been experienced for the system to be within specifications.
8	DETERMINING_ ORIENTATION	INS is determining the IMU axis aligned with gravity.
9	WAITING_ INITIALPOS	The INS filter has determined the IMU orientation and is awaiting an initial position estimate to begin the alignment process.

Binary	ASCII	Description
10	WAITING_ AZIMUTH	The INS filter has determined the IMU orientation, received an initial position and completed initial bias estimates. Azimuth input (from vehicle motion, dual antenna or command) is required for alignment.
11	INITIALIZING_ BIASES	The INS filter has determined the IMU orientation, received an initial position and is conducting an initial IMU bias estimate.
12	MOTION_ DETECT	Vehicle motion has been detected during the alignment procedure.

4.5.1 System Start-Up and Alignment Techniques

The system requires an initial position, velocity and attitude estimate to start the navigation filter. This is called system alignment. On start-up, the system has no position, velocity or attitude information. When the system is first powered up, the following sequence of events happens:

1. The first satellites are tracked and coarse time is solved.
2. Enough satellites are tracked to compute a position.
3. Receiver "fine time" is solved, meaning the time on board the receiver is accurate enough to begin timing IMU measurements.
4. The INS Status field changes from INS_INACTIVE through DETERMINING_ORIENTATION and WAITING_INITIALPOS.
5. Once a GNSS position is available, an initial IMU bias estimate is conducted. During this period, the INS Status field reports INITIALIZING_BIASES.
6. After the bias estimate is complete, the coarse alignment routing starts. Bias estimates will be refined and a static alignment completed, if IMU quality allows. During this period the INS Status field reports INS_ALIGNING.
7. If static coarse alignment is not possible or is locked out by command, the system will require an external azimuth input, either from vehicle motion, dual antenna input or command input. While in this state the INS Status field reports WAITING_AZIMUTH.

   If vehicle movement is detected, any ongoing static coarse alignment will be reset, and the INS Status field will report MOTION_DETECT.
8. After an alignment is completed, the INS Status field changes to INS_ALIGNMENT_ COMPLETE. The system transitions to navigation mode.
9. The solution is refined using updates from GNSS. Once the system is operating within specifications and after some vehicle movement, the INS Status field changes to INS_ SOLUTION_GOOD. This indicates that the INS filter has successfully converged to within performance specifications.

Kinematic Alignment

The kinematic or moving alignment is performed by estimating the heading from the GNSS velocity vector and injecting it into the SPAN filter as the initial system heading.

For the kinemtic alignment routine to work optimally, the course-over-ground azimuth must not include any bias from the defined Vehicle Frame. (For example, a plane being blown in the wind

has a a large 'crab angle' and the course-over ground trajectory will not match the direction the IMU is pointing.)

The rotation from the IMU Body frame to the Vehicle frame (RBV) must be set to enable kinematic alignment. In order to simplify this configuration it is strongly suggested that you mount the IMU in parallel to the vehicle frame. The SMART7 should be oriented as shown in *SMART7 Orientation* on page 24.

The kinematic alignment begins when the receiver has a good GNSS position, fine time is solved, the Body to Vehicle frame rotation is known and a GNSS velocity of at least 5 m/s (~ 18 km/h) is observed. During kinematic alignment, keep the vehicle roll at less then 10°.

5 m/s is the default alignment velocity. If a different alignment velocity is required, it can be changed using the **SETALIGNMENTVEL** command. Refer to the Agriculture Commands and Logs Reference Manual for more information.

While it is possible to lower the minimum speed required for kinematic alignment to take place, the higher the value, the more closely the course-over-ground estimate will match the vehicle heading.

The accuracy of the initial attitude of the system following the kinematic alignment varies and depends on the dynamics of the vehicle. The attitude accuracy will converge to within specifications once some motion is observed by the system. This transition can be observed by monitoring the INS Status field in the INS logs.

Dual Antenna Alignment

SPAN can also use heading information available from a NovAtel Dual Antenna ALIGN solution to rapidly perform an alignment.

NVM Seeded Alignment

SPAN can use the alignment information from a previous power up to quickly perform an alignment. For information about enabling and using an NVM Seeded Alignment, refer to *INS Seed / Fast INS Initialization* below.

Manual Alignment

If the initial azimuth of the system is known, it can be entered manually using the **SETINITAZIMUTH** command. Refer to the Agriculture Commands and Logs Reference Manual for more information about this command.

A manual alignment should be used only if the azimuth is accurately known.

4.5.2 INS Seed / Fast INS Initialization

The INS Seed functionality is an alignment method whereby INS alignment information from a previous powerup can be injected into the system at startup to achieve an INS alignment very quickly. This is especially useful for systems that previously required a kinematic alignment.

When INS Seed is enabled, alignment data is automatically saved when appropriate, with no specific action required from the user. During subsequent power ups, the saved solution is com-

pared to the current position of the system, and if valid, the saved solution is used to immediately initialize the inertial filter, making it ready for use.

Error model information is also saved with the seed data. Even if full alignment cannot be achieved, this information will still be used to aid filter convergence, although another method of alignment will be required.

This feature is enabled via the **INSSEED** command. This command setting must be saved to NVM via the **SAVECONFIG** command to be used upon next system boot-up.

Criteria

For the INS seed functionality to be enabled, the **INSSEED ENABLE** command must be sent.

Saving

The following criteria must be met for valid alignment data to be saved into receiver NVM.

- The INS solution status must be converged, as indicated by the INS solution convergence flag in the inertial Extended Solution Status.
- The system velocity is less than 0.2 m/s.

When these conditions are met, the required information is automatically saved to NVM. If these conditions cease to be met, the saved alignment data is automatically discarded. If the alignment data is discarded, error model information is automatically retained as appropriate.

Use at Boot-up

Upon boot, several checks are done to verify that any seed data existing in NVM is appropriate for use. These checks require a GNSS position to be computed, so an NVM seed will never be injected prior to achieving a GNSS position. The following criteria must be met in order to use a seed:

- Seed data from NVM must be valid
- The system must be stationary
- The system must not have moved significantly from the seed position: <10 metres position and 10 degrees in roll and pitch

If a valid error model is present in the seed data from NVM, this will always be used, even if the system is not stationary or exceeded the movement thresholds.

INJECT Option (Advanced Users Only)

There is an advanced option available to skip the second and third validation steps described in the boot-up section above. This can be used if GNSS is not available on power-up or if speed to achieve an alignment is imperative.

This option is for advanced users only. Forcing an injection of an NVM seed without the validation checks can cause an unstable INS solution if the vehicle has moved.

Apart from injecting the seed at startup without validation, this will also remove some requirements typically asserted to allow the filter to converge. This will allow the system to run without GNSS adequately at startup.

Example Usage

Enabling functionality after FRESET:

1. Send the following command.

```
INSSEED ENABLE VALIDATE
```

2. Send the following command.

```
SAVECONFIG
```

Saving valid INS information:

1. Operate the system as normal, until the filter completes convergence.
2. Bring the system to a complete stop before powering off or resetting.

Using valid INS information on start-up:

1. Remain static while initializing.
2. Wait for the system to receive a valid position from GNSS.
3. If valid, alignment data will be injected.

System Indicators

The **INSSEEDSTATUS** log reports the seed injection status for the current power up and information on current seed validity. Refer the OEM7 Commands and Logs Reference Manual for more information about the **INSSEEDSTATUS** log.

The Extended Solution Status field has bits that indicate the Alignment type that occurred and NVM seed injection status.

Alignment Type: Bits 26-28

These bits indicate how the INS system reached INS_ALIGNMENT_COMPLETE. When the INS system aligns using saved INS solution data from NVM, bits 26-28 will be set to 101

NVM Seed Status: Bits 29-31

These bits indicate the current status of the seeding process at start-up, as described in the table below:

Table 11: NVM Seed Indication

Bit 29-31 Values	Hex Value	NVM Seed Type
000	0x00	NVM Seed Inactive
001	0x01	Seed stored in NVM is invalid
010	0x02	NVM Seed failed validation check
011	0x03	NVM Seed is pending validation (awaiting GNSS)
100	0x04	NVM Seed Injected (includes error model data)
101	0x05	NVM Seed data ignored due to a user-commanded filter reset or configuration change
110	0x06	NVM Seed error model data injected

4.5.3 Navigation Mode

Once the alignment routine has successfully completed, SPAN enters navigation mode.

SPAN computes the solution by accumulating velocity and rotation increments from the IMU to generate position, velocity and attitude. SPAN models system errors by using a filter. The GNSS solution, phase observations and automatic zero velocity updates (ZUPTs) provide updates to the filter. Peripheral updates can also be supplied; wheel sensor for displacement updates or an external receiver for heading updates.

Following the alignment, the attitude is coarsely defined, especially in heading. Vehicle dynamics, specifically turns, stops and starts, allow the system to observe the heading error and allows the heading accuracy to converge. The amount of dynamics required for filter convergence vary by the alignment quality, IMU quality, and maneuvers performed. The INS Status field changes to INS_SOLUTION_GOOD once convergence is complete. If the filter decreases in its system accuracy, the INS Status field changes to INS_HIGH_VARIANCE. When the accuracy converges again, the INS status continues as INS_SOLUTION_GOOD.

4.5.4 Data Collection

The INS solution is available in the INS-specific logs with either a standard or short header. Other parameters are available in the logs shown in *Table 12: Solution Parameters* below:

Table 12: Solution Parameters

Parameter	Logs	
Position	INSPOS or INSPOSS INSPVA or INSPVAS	INSPOSX or INSPVAX
Velocity	INSVEL or INSVELS INSSPD or INSSPDS INSPVA or INSPVAS	INSVELX or INSPVAX
Attitude	INSATT or INSATTS INSPVA or INSPVAS	INSATTX or INSPVAX
Solution Uncertainty	INSSTDEV or INSSTDEVS	

The **INSATTX** log, **INSPOSX** log, **INSPVAX** log and **INSVELX** log contain solution and variance information and are therefore large logs. Use a low logging rate (<20 Hz) only. These logs also contain solution uncertainty in standard deviation format.

Note that the position, velocity and attitude are available together in the **INSPVA** log, **INSPVAS** log and **INSPVAX** log.

The inertial solution is available up to a rate of 200 Hz. Data can be requested at a specific synchronous time interval, asynchronously matching the IMU output rate, or can be triggered by the mark input trigger at rates up to 200 Hz.

The GNSS-only solution is still available through the GNSS-only logs such as RTKPOS and PSRPOS. Refer to the Agriculture Commands and Logs Reference Manual. INS-only data logging and output can be at rates of up to the rate of the IMU data.

The highest rate that you should request GNSS logs (RANGE, BESTPOS, RTKPOS, PSRPOS, and so on) while in INS operation is 5 Hz. If the receiver is not running INS (no IMU is attached), GNSS logs can be requested at rates up to 20 Hz.

Ensure that all windows, other than the Console, are closed in NovAtel Connect and then use the **SAVECONFIG** command to save settings in NVM. Otherwise, unnecessary data logging occurs and may overload your system.

Logging Restriction Important Notice

Logging excessive amounts of high rate data can overload the system. When configuring the output for SPAN, NovAtel recommends that only one high rate (>50 Hz) message be configured for output at a time. It is possible to log more than one message at high rates, but doing so could have negative impacts on the system. Also, if logging 100/200 Hz data, always use the binary format and, if possible, the short header binary format (available on most INS logs).

For optimal performance, log only one high rate output at a time. These logs could be:

- Raw data for post processing
  RAWIMUXSB ONNEW
  - RAWIMU logs are not valid with the ONTIME trigger. The raw IMU observations contained in these logs are sequential changes in velocity and rotation. As such, you can only use them for navigation if they are logged at their full rate. Refer to the Agriculture Commands and Logs Reference Manual for log and command details.
- Real time INS solution (not available on SMART7)
  IMURATEPVA ONNEW or IMURATEPVAS ONNEW
  (These logs require asynchronous logging to be enabled. See **ASYNCHINSLOGGING** command in the OEM7 Commands and Logs Reference Manual.)
  - Other possible INS solution logs available at high rates are: INSPVASB, INSPOSSB, INSVELSB, INSATTSB

Specific logs need to be collected for post-processing. See *Data Collection for Post Processing* on page 77.

To store data from an OEM7 receiver, connect the receiver to a computer running NovAtel Connect or other terminal program capable of recording data.

4.5.5 Body to Vehicle Frame Rotation Calibration Routine

Kinematic alignment requires that the rotational offset between the vehicle and IMU Body frame (RBV) is known. If the angles are simple (that is, a simple rotation about one axis) the values

can easily be entered manually through the **SETINSROTATION RBV** command. If the rotational offset is more complex (that is, rotation is about 2 or 3 axis), then the calibration routine provides a more accurate estimation of the values.

The steps for the calibration routine are:

1. Apply power to the SMART7.
2. Configure the SPAN system including an approximate IMU Body to Vehicle frame (RBV) rotation. See *SPAN Configuration* on page 64.
3. Ensure that an accurate lever arm has been entered into the system.
4. Perform an initial system alignment using one of the methods described in *System Start-Up and Alignment Techniques* on page 67. Ensure the system reaches Solution Good.
5. Enable calibration using the **INSCALIBRATE** command with an optional standard deviation target.

   ```
   INSCALIBRATE RBV NEW [target_stdev]
   ```

6. To monitor the calibration, log **INSCALSTATUS** using the ONCHANGED trigger.
7. Start to move the system. Movement of the system is required for the observation of the angular offsets.

   Drive a straight course on level ground (remember that most roads have a crown resulting in a constant roll of a few degrees). Avoid driving on a surface with a constant, non-zero, slope to prevent biases in the computed angles. Vehicle speed must be greater than 5 m/s (18 km/hr) for the calibration to complete.
8. When the calibration is complete, either because the accuracy requirement has been met, or the calibration been halted by user command, the calibrated offset value can be viewed in either the **INSCALSTATUS** log or the **INSCONFIG** log.

To save a calibrated rotation for subsequent start ups, issue the **SAVECONFIG** command after calibration is complete. Each time the IMU is re-mounted this calibration should be performed again. See also *Kinematic Alignment* on page 67 for details on kinematic alignment.

After the **INSCALIBRATE RBV ENABLE** command is entered, there are no body-vehicle rotation parameters present and a kinematic alignment is NOT possible. Therefore this command should only be entered after the system has performed a kinematic alignment and has a valid INS solution.

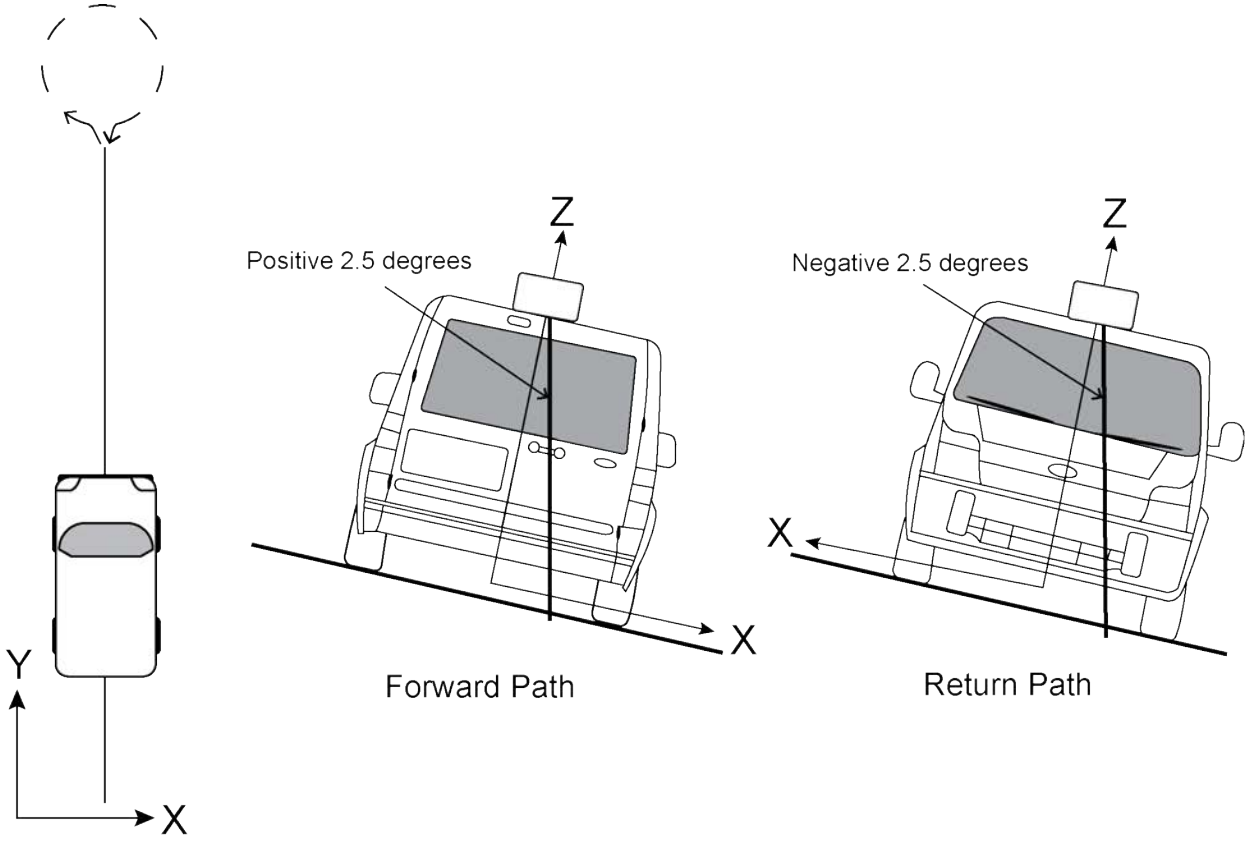
For information about the logs and commands used in this procedure, refer to the OEM7 Commands and Logs Reference Manual.

4.5.6 Multi-Line Body to Vehicle Frame Rotation Calibration Routine

The single pass Body to Vehicle frame offset calibration feature assumes flat ground when estimating the roll offsets between the IMU Body and Vehicle frames, as this component of the rotational offset is difficult to observe through typical ground vehicle motion. In practice this can result in an outstanding roll offset error as high as several degrees. For applications where vehicle roll must be well known, or pass-to-pass accuracy of a highly offset position is especially important, the Multi-Line IMU Body to Vehicle frame offset calibration routine offers higher

calibrated accuracy in roll. This is done by running independent calibrations over the same ground path in opposite directions; averaging the results cancels out the effect of any terrain induced roll. A minimum of two iterations are required. Additional iteration pairs can be executed for increased reliability.

Figure 25: Multi-Line IMU Body to Vehicle Calibration



The steps for the calibration routine are:

1. Apply power to the SMART7.
2. Configure the SPAN system, see .
3. Ensure that an accurate lever arm has been entered into the system.
4. Perform an initial system alignment using one of the methods described in *System Start-Up and Alignment Techniques* on page 67. Ensure the system reaches Solution Good.
5. Enable a new calibration using the **INSCALIBRATE** command, with the optional standard deviation target omitted:

   ```
   INSCALIBRATE RBV NEW
   ```

6. Start to move the vehicle. Drive a straight course, at a vehicle speed greater than 5 m/s (18 km/hr). A distance of approximately 250 metres is recommended.

   To monitor the calibration, log **INSCALSTATUS** using the ONCHANGED trigger.

7. When the end of the available distance is reached, stop the vehicle. Halt the ongoing calibration by sending the **INSCALIBRATE** command again:

```
INSCALIBRATE RBV STOP
```

8. At this point **INSCALSTATUS** will report a source status of CALIBRATED. Turn the vehicle around and come to a stop on the finishing point of the previous line.
9. Initiate the second pass of the calibration by issuing the **INSCALIBRATE** command with the **ADD** parameter:

```
INSCALIBRATE RBV ADD
```

10. Drive the vehicle back along the original course, until you reach the starting point for the first pass. Stop the vehicle, and re-issue the **INSCALIBRATE** command, with the **STOP** parameter. **INSCALSTATUS** will again indicate a source status of CALIBRATED.

    At this point the multi-line calibration can be considered complete, but more iterations can be repeated until the desired accuracy level is reached.
11. When the calibration is complete, the calibrated offset value can be viewed in either the **INSCALSTATUS** log or the **INSCONFIG** log.

To save a calibrated rotation for subsequent start ups, issue the **SAVECONFIG** command after calibration is complete. Each time the IMU is re-mounted this calibration should be performed again.

After the **INSCALIBRATE RBV ENABLE** command is entered, there are no body-vehicle rotation parameters present and a kinematic alignment is NOT possible. Therefore this command should only be entered after the system has performed a kinematic alignment and has a valid INS solution.

For information about the logs and commands used in this procedure, refer to the OEM7 Commands and Logs Reference Manual.

4.6 Azimuth Sources on a SPAN System

The SPAN system use three different methods to calculate the azimuth.

- Course Over Ground
- Inertial Azimuth
- ALIGN Azimuth

4.6.1 Course Over Ground

The course over ground azimuth is determined using the position delta between two position solutions computed by the OEM7 receiver. This is the simplest way to compute an azimuth and is done using either the GNSS solution or the INS solution. This method does not work when the vehicle is stationary as any position difference is due to position error and the computed azimuth is meaningless.

Course over ground azimuth is of greatest advantage in aerial or marine environments where the actual direction of travel may not match the forward axis of the aircraft/boat due to winds or currents. This effect is known as the crab angle. Course over ground azimuth is a great way to compute the offset if another means of computing the vehicle azimuth is available.

Course over ground azimuths are available in several different velocity logs. See *Table 13: Logs with Azimuth Data* below.

4.6.2 Inertial Azimuth

The inertial azimuth computed by the SPAN inertial navigation filter. It uses the sensors in the IMU to compute the azimuth of the IMU (this can be rotated to another reference if desired). For more information, see the **SETINSROTATION** command in the Agriculture Commands and Logs Reference Manual.

This azimuth is the one provided in the majority of the INS logs available to a SPAN user. See *Table 13: Logs with Azimuth Data* below.

4.6.3 ALIGN Azimuth

On SPAN systems with dual antennas, an azimuth is available from the dual antenna baseline. This is the same azimuth that is used as an update to the SPAN solution. It is noisier than the inertial azimuth and is available at a much lower rate, but will have a stable mean. This azimuth is computed from the master antenna to the rover antenna based on how the antennas are oriented on the vehicle.

There is a specific subset of logs that output this azimuth. See *Table 13: Logs with Azimuth Data* below.

Table 13: Logs with Azimuth Data

Log	Log Format	Azimuth Source
BESTGNSSVEL	NovAtel	Course Over Ground From the best GNSS only solution
BESTVEL	NovAtel	Course Over Ground From the best system solution which could be either GNSS or INS
GPHDT	NMEA	ALIGN
GPVTG	NMEA	Course Over Ground From the best system solution which could be either GNSS or INS
HEADING2	NovAtel	ALIGN
INSATT / INSATTS / INSATTX	NovAtel	Inertial
INSPVA / INSPVAS / INSPVAX	NovAtel	Inertial
INSSPD	NovAtel	Course Over Ground Computed using the INS solution only
PASHR	NMEA	Inertial

4.7 Data Collection for Post Processing

Some operations, such as aerial measurement systems, do not require real-time information from SPAN. These operations are able to generate the position, velocity or attitude solution post-mission in order to generate a more robust and accurate solution than is possible in real-time.

In order to generate a solution in post-processing, data must be simultaneously collected at a base station and each rover. The following logs must be collected in order to successfully post process data.

From a base:

- RANGECMPB ONTIME 1
- RAWEPHEMB ONCHANGED
- GLOEPHEMERISB ONCHANGED (if using GLONASS)
- GALFNAVEPHEMERIS ONCHANGED (if using Galileo)
- GALINAVEPHEMERIS ONCHANGED (if using Galileo)
- BDSEPHEMERIS ONCHANGED (if using BeiDou)

From a rover:

- RANGECMPB ONTIME 1
- RAWEPHEMB ONCHANGED
- GLOEPHEMERISB ONCHANGED (if using GLONASS)
- GALFNAVEPHEMERIS ONCHANGED (if using Galileo)
- GALINAVEPHEMERIS ONCHANGED (if using Galileo)
- BDSEPHEMERIS ONCHANGED (if using BeiDou)
- INSCONFIGB ONCHANGED
- RAWIMUSXB ONNEW
- HEADING2B ONNEW (if using ALIGN dual antenna solution)

Post processing is performed through the Waypoint Inertial Explorer® software package available from the NovAtel Waypoint Products Group. Visit our Web site at www.novatel.com for details.

The highest rate that you should request GNSS logs (RANGE, BESTPOS, RTKPOS, PSRPOS, and so on) while in INS operation is 5 Hz. If the receiver is not running INS (no IMU is attached), GNSS logs can be requested at rates up to 20 Hz.

Chapter 5 Built-In Status Tests

The Built-In Status Test monitors system performance and status to ensure the receiver is operating within specifications. The test detects an exceptional condition and informs the user through one or more indicators. The receiver status system is used to configure and monitor the indicators:

1. Receiver status word (included in the header of every message)
2. RXSTATUSEVENT log
3. RXSTATUS log

When a fatal event occurs (for example, a receiver hardware failure), a bit is set in the receiver error word, part of the **RXSTATUS** log, to indicate the cause of the problem. An **RXSTATUSEVENT** log is generated on all ports to show the cause of the error. Receiver tracking is disabled but command and log processing continues to allow error diagnosis. Even if the source of the error is corrected, the receiver must be reset to resume normal operation.

5.1 RXSTATUSEVENT Log

The **RXSTATUSEVENT** log is used to output event messages, as indicated in the **RXSTATUS** log.

On start up, the OEM7 receiver is set to log **RXSTATUSEVENTA ONNEW** on all ports. You can remove this message using the **UNLOG** command.

Refer to the **RXSTATUSEVENT** log in the Agriculture Commands and Logs Reference Manual for log and command details. for a more detailed description of this log.

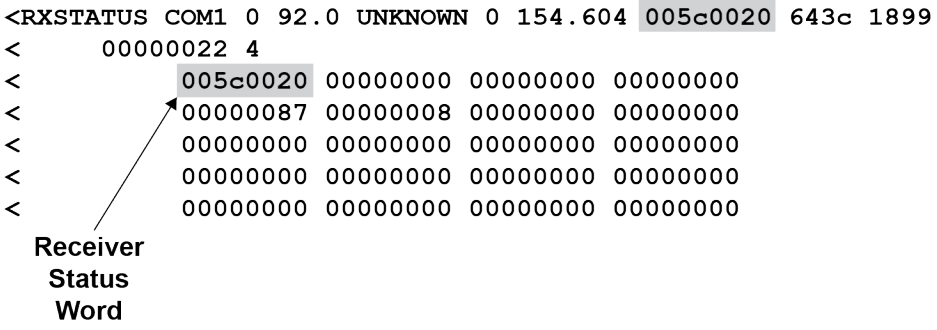
5.2 RXSTATUS Log

The Receiver Status log (RXSTATUS) provides system status and configuration information in a series of hexadecimal words.

5.2.1 Status Word

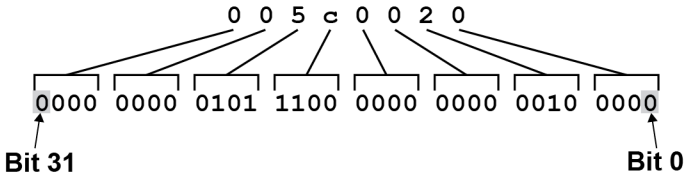
The status word is the third field after the header, as shown in the example in *Figure 26: Location of Receiver Status Word* below.

Figure 26: Location of Receiver Status Word



Each bit in the status word indicates the status of a specific receiver condition or function. If the status word is 00000000, the receiver is operating normally. The numbering of the bits is shown in *Figure 27: Reading the Bits in the Receiver Status Word* below.

Figure 27: Reading the Bits in the Receiver Status Word



If the receiver status word indicates a problem, see *Examining the RXSTATUS Log* on page 108.

5.2.2 Error Word

The error field contains a 32-bit word. Each bit in the word is used to indicate an error condition. Error conditions may result in damage to the hardware or erroneous data, so the receiver is put into an error state. If any bit in the error word is set, the receiver broadcasts the **RXSTATUSEVENT** log on all ports (unless the user has unlogged it), idles all channels, turns the antenna off and disables the RF hardware. To override the error state, reset the receiver.

The receiver can be configured to generate event messages triggered by status conditions. Receiver Error words automatically generate event messages. These event messages are output in the **RXSTATUSEVENT** log (see also *Set and Clear Mask for all Status Code Arrays* on page 81).

The error word is the first field after the log header in the **RXSTATUS** log, as shown in the example in *Figure 28: Location of Receiver Error Word* below.

Figure 28: Location of Receiver Error Word

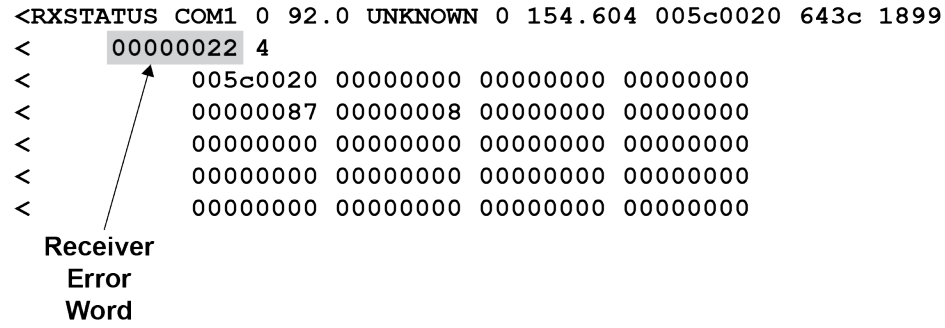
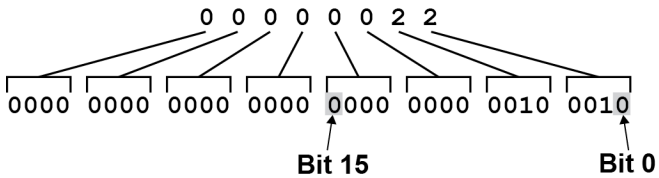


Figure 29: Reading the Bits in the Receiver Error Word below shows an example of a receiver error word.

Figure 29: Reading the Bits in the Receiver Error Word



Refer to the **RXSTATUS** log and **RXSTATUSEVENT** log in the Agriculture Commands and Logs Reference Manual for more detailed log descriptions. If the receiver error word indicates an error, refer to *Examining the RXSTATUS Log* on page 108.

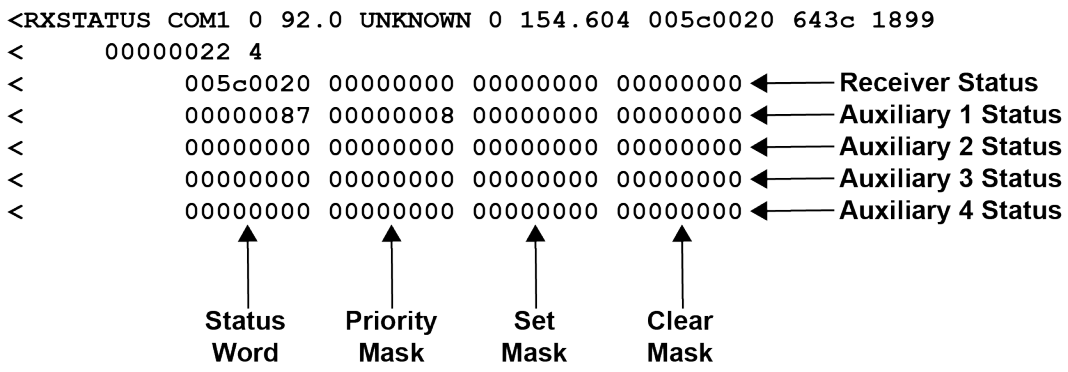
5.2.3 Status Code Arrays

There are currently 5 status code arrays:

- receiver status word
- auxiliary 1 status
- auxiliary 2 status
- auxiliary 3 status
- auxiliary 4 status

Each status code array consists of four 32-bit words (the status word, a priority mask, a set mask and a clear mask). The status word is similar to the error word, with each of the 32 bits indicating a condition. The priority mask words are used to modify the behavior caused by a change in one of the bits in the associated status words. Each bit, in any mask, operates on the bit in the same position in the status word. For example, setting bit 3 in the priority mask changes the priority of bit 3 in the status word.

Figure 30: Status Code Arrays



5.2.4 Receiver Status Code

The receiver status word is included in the header of all logs. It has 32 bits that indicate certain receiver conditions. If any of these conditions occur, a bit in the status word is set. Unlike the error word bits, the receiver continues to operate, unless the priority mask for the bit has been set. The priority mask bit changes the bit in the receiver status word into an error bit. Anything that results from an error bit becoming active also occurs if a receiver status and its associated priority mask bits are set.

5.2.5 Auxiliary Status Codes

The auxiliary status codes are only in the **RXSTATUS** log. The four arrays that represent the auxiliary status codes indicate the receiver state for information purposes only. The events represented by these bits typically do not cause receiver performance degradation. The priority mask for the auxiliary codes does not put the receiver into an error state. Setting a bit in the auxiliary priority mask results in the corresponding bit in the receiver status code to be set if any masked auxiliary bit is set. Bit 31 of the receiver status word indicates the condition of all

masked bits in the auxiliary 1 status word. Likewise, bit 30 of the receiver status word corresponds to the auxiliary 2 status word and bit 29 to the auxiliary 3 status word.

Refer also to the **RXSTATUS** log in the Agriculture Commands and Logs Reference Manual for a more detailed description.

5.2.6 Set and Clear Mask for all Status Code Arrays

The other two mask words in the status code arrays operate on the associated status word in the same way. These mask words are used to configure the bits in the status word that result in a **RXSTATUSEVENT** log broadcast. The set mask is used to turn logging on temporarily while the bit changes from the 0 to 1 state. The clear mask is used to turn logging on temporarily while the bit changes from a 1 to a 0 state. Note the error word does not have any associated mask words. Any bit set in the error word results in a **RXSTATUSEVENT** log broadcast (unless unlogged).

Refer also to the **RXSTATUS** log in the Agriculture Commands and Logs Reference Manual for a more detailed description.

SMART7-I and SMART7-W Wi-Fi Configuration Overview

Wi-Fi is a Wireless Local Area Network (WLAN) used to exchange data wirelessly over a computer network.

The SMART7-I and SMART7-W models have a Wi-Fi transceiver that works as a 2.4 GHz 802.11 Access Point (AP). On startup, SMART7 automatically configures itself as an AP. The Wi-Fi AP is configured with the settings shown in *Table 14: Wi-Fi Default Configuration* on the next page and is enabled when the SMART7 is powered on. The default AP configuration can be over ridden using the **WIFIMODE** command and **SAVECONFIG** command. Refer to the Agriculture Commands and Logs Reference Manual for command details.

The SMART7 supports three modes of operation plus On and Off.

By default, the SMART7 receiver is configured to run as a 2.4 GHz 802.11 Access Point (AP) capable of accepting up to four client connections.

When the SMART7 receiver starts up, the AP starts automatically with no special configuration required. The SSID and the password/passkey are printed on a label located by the connectors of the unit. The SSID is "SM7-<Receiver PSN>" (e.g. "SM7-ABCDEF12345678E").

Once a Wi-Fi connection is established, open a browser and navigate to the receiver's URL which is 192.168.19.1 by default. The receiver WebUI homepage opens.

In addition, it is possible to connect to an ICOM port by establishing a terminal connection to the receiver's IP address using TCP ports 3001 through 3007.

5.3 Wi-Fi Modes

5.3.1 Access Point (AP)

AP is the Wi-Fi default mode at start up. This mode is used by the SMART7 to wirelessly connect to devices defined as clients or concurrent. Refer to *Enable the Wi-Fi Client* on page 84 for detailed instructions.

5.3.2 Client

When in Client mode, the SMART7 can only communicate with APs. Refer to *Enable the Wi-Fi Client* on page 84 for detailed instructions.

5.3.3 Concurrent

When set to Concurrent mode, the SMART7 can act as both an AP and a Client. Refer to *Enable the Wi-Fi Concurrent* on page 85 for detailed instructions.

The term passkey and password are the same.

Table 14: Wi-Fi Default Configuration

Parameter	Default
Mode	AP
SSID	Printed on the SMART7 label ("SM7-<Receiver PSN>")
Passkey	Printed on the SMART7 label
Channel	11
IP address	192.168.19.1
Netmask	255.255.255.0

To view the current Wi-Fi settings, use the **WIFIAPSETTINGS** log. Refer to the Agriculture Commands and Logs Reference Manual

Also refer to *SMART7-I and SMART7-W Wi-Fi Changes* on page 86 for instructions on changing the various default settings. Refer to *SMART7-I and SMART7-W ALIGN Over Wi-Fi Overview* on page 88 for instructions on configuring ALIGN corrections.

5.4 SMART7-I and SMART7-W Wi-Fi Modes

On start-up the SMART7 configures itself as an access point by default. This can be overridden with the **WIFIMODE** command and **SAVECONFIG** command. The **WIFIMODE** command supports three modes of operation (in addition to Off and On):

- *Enable the Wi-Fi Access Point* below
- *Enable the Wi-Fi Client* on the next page
- *Enable the Wi-Fi Concurrent* on page 85

The term passkey and password are the same.

5.4.1 Enable the Wi-Fi Access Point

By default, the SMART7 is an Access Point.

1. Start a command line interface (CLI) session with the receiver.
   Use a Ethernet or Serial (COM) port connection.
2. Use the **WIFIMODE** command to enable the Wi-Fi transceiver as an AP.

   ```
   WIFIMODE AP
   ```

3. Use the **SAVECONFIG** command to store the change in Non-Volative Memory.
   This ensures the changes are kept when the receiver is restarted.

The SMART7 has the ability to override the Access Point SSID to the existing Access Point. By default, the SSID is the enclosure PSN prefixed by 'SM7-' (e.g. SM7-NMPX17500010L). Refer to *Change the SSID* on page 87 for detailed instructions.

5.4.2 Enable the Wi-Fi Client

The SMART7 can also be configured as a client/station capable of connecting to an access point such as another SMART7 receiver. The primary reason for configuring a SMART7 receiver as a client is to allow the transmission of corrections from one receiver to another over Wi-Fi.

Prior to connecting to an Access Point, note the following information found on the label by the SMART7 connectors:
The SSID in the form "SM7-<Receiver PSN>" (e.g. "SM7-ABCDEF1234567").
The Wi-Fi password (also known as passkey).

The information for up to four Access Points can be stored in the SMART7 using the **WIFINETCONFIG** command.

To configure the SMART7 as a client and connect it to an access point, follow these steps:

1. Start a command line interface (CLI) session with the receiver.
   Use a Ethernet or Serial (COM) port connection.
2. Use the **WIFIMODE** command to enable the Wi-Fi transceiver as a Client.

   ```
   WIFIMODE CLIENT
   ```

3. Configure the SMART7 as a Client to connect to the desired access point by issuing:

   ```
   WIFINETCONFIG 1 ENABLE "<ssid>" "<password>"
   ```

   Where <ssid> and <password> are the SSID and password of the Access Point to which the Client should connect. The "1" can be a value of 1-4 depending on the Access Point being configured.
4. Use the **SAVECONFIG** command to store the change in Non-Volative Memory.
   This ensures the changes are kept when the receiver is restarted.

The SMART7 receiver will automatically connect to the access point (if it is in range).

The connection status of the receiver can be monitored by entering the following command and waiting for it to report CONNECTED_TO_AP

```
LOG WIFISTATUS ONCHANGED
```

The access points in range can be monitored by entering this command:

```
LOG WIFINETLIST ONCHANGED
```

A SMART7 operating as a client can be configured to automatically connect to one of several Access Points which may or may not be another SMART7 receiver. This functionality is similar to what is provided by Smart phones which automatically connect to known Access Points. In the case of the SMART7 receiver, each access point is assigned a network id value so that when more than one Access Point is in range, the client connects to the Access Point with the lowest network ID.

The command to do this is **WIFINETCONFIG** command:

```
WIFINETCONFIG <network_id> <enabled> <ssid> <passkey> <dhcp_mode> <ip_
address> <netmask> <gateway> <dns>
```

If the **WIFIALIGNAUTOMATION** command is enabled, the only Access Point the Client will connect to is the ALIGN Master Access Point.

When configured for Client Mode, the SMART7 initiates background scanning to periodically receive a list of nearby Access Points. Whenever a list of Access Points is received they are published in the **WIFINETLIST** log. If the Client is not currently connected to an Access Point, the list of available Access Points is compared to the Access Point specified by the **WIFIALIGNAUTOMATION** command or the list of Access Points in the **WIFINETCONFIG** command and automatically establishes a connection. If there is more than one match, the Client automatically connects to the Access Point with the lowest network ID.

5.4.3 Enable the Wi-Fi Concurrent

When operating in Concurrent mode, the receiver acts as both a Wi-Fi client and an access point at the same time. This makes it possible to configure the receiver using either the Web UI or an ICOM port in the event that the receiver is unable to establish a connection to any of its pre-configured access points.

When configured as a Client, communication with the SMART7 receiver is limited to either physical communications such as serial or Ethernet or through the Access Point to which it is connected. This can be problematic if none of the access points stored in the SMART7 receiver are in range. To ensure the receiver is accessible over a Wi-Fi connection, it is possible to configure it in Concurrent mode, which allows it to operate as both an access point (for configuration/monitoring purposes) and as a Client (for the transfer of corrections).

1. Start a command line interface (CLI) session with the receiver.
   Use a Ethernet or Serial (COM) port connection.
2. Use the **WIFIMODE** command to enable the Wi-Fi transceiver in concurrent mode. The SMART7 automatically connects to any Access Point in range which has been stored in the SMART7 receiver with **WIFINETCONFIG** command and also accepts up to four incoming client connections.

   ```
   WIFIMODE CONCURRENT
   ```

3. Use the **SAVECONFIG** command to store the change in Non-Volative Memory.
   This ensures the changes are kept when the receiver is restarted.

If the Access Point chosen by the Concurrent Client is using a channel different than the one used by the Concurrent Access Point, the Wi-Fi module will be rebooted and configured to use the channel of the chosen access point. Any clients connected to the Concurrent Mode Access Point will lose their connection and may or may not automatically reconnect.

If the access point chosen by the Client, the Client is configured with the same IP address as the Concurrent Access Point, communication with the chosen access point will be blocked. To detect this situation, check the IPSTATUS log to verify that the IP address of the Concurrent Access Point is different than the Gateway IP address assigned to the Concurrent Client. To correct this situation, the IP address of the Concurrent Access Point should be updated using the **WIFIAPIPCONFIG** command followed by the **WIFIMODE CONCURRENT** command. In the image below, the IP address of the Concurrent Access point is changed from 192.168.19.1 to 192.168.20.1 to enable a communication path between the two receivers to be established.

```
<OK
[COM1]<WIFISTATUS COM1 0 74.0 FINESTEERING 2011 337605.032 02000000 8a58 32768
<     CONCURRENT_CONNECTED_TO_AP "SM7-NMPX18070011D" -31 11 "88:da:1a:04:c5:0c" WPA2 0
<
[COM1]log ipstatus

<OK
[COM1]<IPSTATUS COM1 0 75.5 FINESTEERING 2011 337611.000 02000000 7fe2 32768
<     3
<          ETHA "10.129.32.50" "255.255.255.0" ""
<          WIFI "192.168.19.1" "255.255.255.0" ""
<          WIFI_CLIENT "192.168.19.100" "255.255.255.0" "192.168.19.1"
<          1
<          "192.168.19.1"
[COM1]wifiapipconfig 192.168.20.1 255.255.255.0

<OK
[COM1]wifimode concurrent

<OK
[COM1]log ipstatus

<OK
[COM1]<IPSTATUS COM1 0 75.0 FINESTEERING 2011 337726.000 02000000 7fe2 32768
<     3
<          ETHA "10.129.32.50" "255.255.255.0" ""
<          WIFI "192.168.20.1" "255.255.255.0" ""
<          WIFI_CLIENT "192.168.19.100" "255.255.255.0" "192.168.19.1"
<          1
<          "192.168.19.1"
[COM1]
```

5.5 SMART7-I and SMART7-W Wi-Fi Changes

Various default Wi-Fi settings can be changed and Wi-Fi can be disabled.

5.5.1 Change the Wi-Fi Passkey

> The term passkey and password are the same.

1. Start a CLI session with the receiver.
   Use a Ethernet or Serial (COM) port connection.
2. Use the **WIFIAPPASSKEY** command to change the Wi-Fi passkey.

   ```
   WIFIAPPASSKEY NewPasskey
   ```

   The new passkey must be a null terminated ASCII string that is 8 to 64 characters long.

   > The passkey will not change until the Wi-Fi transceiver has been restarted.

3. Use the **WIFIMODE** command to restart the Wi-Fi transceiver.

   ```
   WIFIMODE AP
   ```

4. Use the **SAVECONFIG** command to store the change in Non-Volative Memory.
   This ensures the new passkey is kept when the receiver is restarted.

5.5.2 Change the SSID

Use the **WIFIAPSSID** command to change the default SSID if required.

```
WIFIAPSSID <ssid>
```

Issue the **SAVECONFIG** command and restart the SMART7 to change the SSID.

5.5.3 Change the Wi-Fi Channel

1. Start a CLI session with the receiver.
   Use a Ethernet or Serial (COM) port connection.
2. Use the **WIFIAPCHANNEL** command to change the Wi-Fi channel.

   ```
   WIFIAPCHANNEL 3
   ```

   The channel must be a number from 1 to 14.

   > The Wi-Fi channel will not change until the Wi-Fi transceiver has been restarted.

3. Use the **WIFIMODE** command to restart the Wi-Fi transceiver.

   ```
   WIFIMODE AP
   ```

4. Use the **SAVECONFIG** command to store the change in Non-Volative Memory.
   This ensures the new channel is kept when the receiver is restarted.

5.5.4 Change the Wi-Fi IP Address

1. Start a CLI session with the receiver.
   Use a Ethernet or Serial (COM) port connection.
2. Use the **WIFIAPIPCONFIG** command to change the Wi-Fi IP address and netmask.

   ```
   WIFIAPIPCONFIG xxx.xxx.xxx.xxx yyy.yyy.yyy.yyy
   ```

   In the command above xxx.xxx.xxx.xxx represents the IP address and yyy.yyy.yyy.yyy represents the netmask. For example:

   ```
   WIFIAPIPCONFIG 192.162.55.20 255.255.0.0.
   ```

   > The Wi-Fi IP address and netmask will not change until the Wi-Fi transceiver has been restarted.

3. Use the **WIFIMODE** command to restart the Wi-Fi transceiver.

   ```
   WIFIMODE AP
   ```

4. Use the **SAVECONFIG** command to store the change in Non-Volative Memory.
   This ensures the new IP address and netmask are kept when the receiver is restarted.

5.5.5 Disable Wi-Fi

1. Start a CLI session with the receiver.
   Use a Ethernet or Serial (COM) port connection.
2. Use the **WIFIMODE** command to disable the Wi-Fi transceiver.

```
WIFIMODE OFF
```

3. Use the **SAVECONFIG** command to store the change in Non-Volative Memory. This ensures the changes are kept when the receiver is restarted.

5.6 SMART7-I and SMART7-W ALIGN Over Wi-Fi Overview

ALIGN can be configured over Wi-Fi by the following methods:

- *SMART7-I and SMART7-W Automatic Wi-Fi ALIGN Corrections* below
- *SMART7-I and SMART7-W Manual Set Up for Wi-Fi Connection between Master and Rover via ICOM1* on the next page
- *Configure ALIGN Master* on the next page
- *Configure ALIGN Rover* on page 90
- *DHCP Configuration* on page 90
- *Static IP Address Configuration* on page 91

5.6.1 SMART7-I and SMART7-W Automatic Wi-Fi ALIGN Corrections

The **WIFIALIGNAUTOMATION** command is provided to simplify configuration of a pair of NovAtel Wi-Fi enabled receivers, one acting as an ALIGN Master and one acting as an ALIGN Rover.

The ALIGN Rover, acting as a Wi-Fi Client, connects to the specified Wi-Fi Access Point and configures it as the ALIGN Master. Use the **WIFIALIGNAUTOMATION** command to configure.

```
WIFIALIGNAUTOMATION <enable_disable> <master_networkid> <icom_port> <data_
rate> <send_heading> <interface_mode>
```

Where:

- **enable_disable** turns the feature on or off
- **master_networkid** is the network ID associated with the SSID of the ALIGN Master as previously configured using the **WIFINETCONFIG** command.
- **icom_port** is the ICOM port to be used for ALIGN corrections on both the Rover and the Master. It is assumed that the Master's ICOM port is configured with its factory default settings.
- **data_rate** is as defined in the **ALIGNAUTOMATION** command.
- **interface_mode** is as defined in the **ALIGNAUTOMATION** command.

The term passkey and password are the same.

If this feature is enabled and the **SAVECONFIG** command issued, when the Client is searching for an Access Point (either after startup or if the connection is lost), it will connect to the Access Point specified by <master_networkid> even if another Access Point with a preferred network_id (as entered by the **WIFINETCONFIG** command) is in range.

If interface_mode is omitted, it is assumed that the ALIGN MASTER Access Point is already configured to transmit the desired corrections over the specified ICOM port.

Note that up to four rovers can be associated to the same Master, each using a different ICOM port.

Example:

Enable Wi-Fi ALIGN corrections using receiver SM7-NMND17190003B as the Master.

Using a serial port connected to the Client, enter the following commands:

```
WIFINETCONFIG 1 ENABLE SM7-NMND17190003B SM7_PWD
WIFIALIGNAUTOMATION ENABLE 1 ICOM5 20 ON NOVATELX
SAVECONFIG
```

Internally, the SMART7 client does the following:

- switches to Concurrent mode if currently configured as an Access Point or Client
- scans for available Access Points until SM7-NMND17190003B is detected
- connects to the SM7-NMND17190003B Access Point
- configures itself as follows:

```
ICOMCONFIG ICOM5 TCP 192.168.19.1:3005
INTERFACEMODE ICOM5 NOVATEL NOVATEL ON
```

- sends the following commands over ICOM5 to the Master:

```
UNLOGALL ICOM5 TRUE
MOVINGBASESTATION ENABLE
LOG ICOM5 NOVATELXOBS ONTIME .05
LOG ICOM5 NOVATELXREF ONTIME .05
INTERFACEMODE ICOM5 NOVATEL NOVATELX
```

- configures itself as follows:

```
INTERFACEMODE ICOM5 NOVATELX NOVATEL OFF
LOG ICOM5 HEADINGEXTB ONNEW
```

5.6.2 SMART7-I and SMART7-W Manual Set Up for Wi-Fi Connection between Master and Rover via ICOM1

In this setup, the ALIGN Rover acts as a Wi-Fi Client to the ALIGN Master which, by default, is configured as a Wi-Fi Access Point.

Configure ALIGN Master

By default, the Master provides an Access Point with IP address of 192.168.19.1. No special configuration is required to enable this functionality. The only configuration required at the Master is to enable ALIGN corrections on ICOM1 as shown below:

```
interfacemode icom1 novatel novatelx off
movingbasestation enable
log icom1 novatelxobs ontime 1
log icom1 novatelxref ontime 1

log headinga onnew
saveconfig
```

Configure ALIGN Rover

The ALIGN rover can be configured to connect to the Master Access Point over Wi-Fi using either DHCP (default) or by specifying static IP parameters. Configuration consists of the following steps:

1. Establish a Wi-Fi connection from the Rover (Client) to the Master (Access Point).
2. Establish a TCP connection between the ICOM port to be used for ALIGN corrections and the Access Point.
3. Configure the interface of the ICOM port to accept ALIGN corrections.

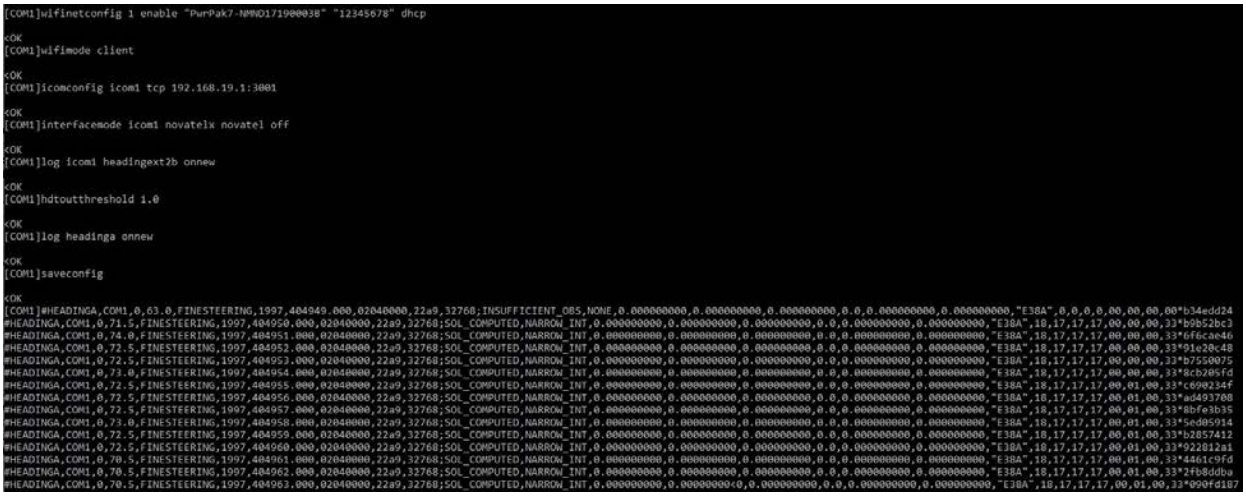
In the following examples, the ALIGN Rover is configured as a Wi-Fi Client connecting to the Master's Access Point. The Master's SSID is "PwrPak7-NMND17190003B", its password (pass-key) is "12345678" and its IP address is the default 192.168.19.1. The SSID and password (pass-key) information is printed on the label of the Master receiver or it can be obtained by requesting the **WIFIAPSETTINGS** log from the Master. The SSID is the receiver's PSN starting with the SM7-prefix.

DHCP Configuration

In this example, the **WIFINETCONFIG** command is used to enable the Client to connect to the Master's Access Point using DHCP addressing. The **IPSTATUS** log is used to determine when an IP address has been assigned to the Wi-Fi client.

It can take several seconds for the IP parameters to be set.

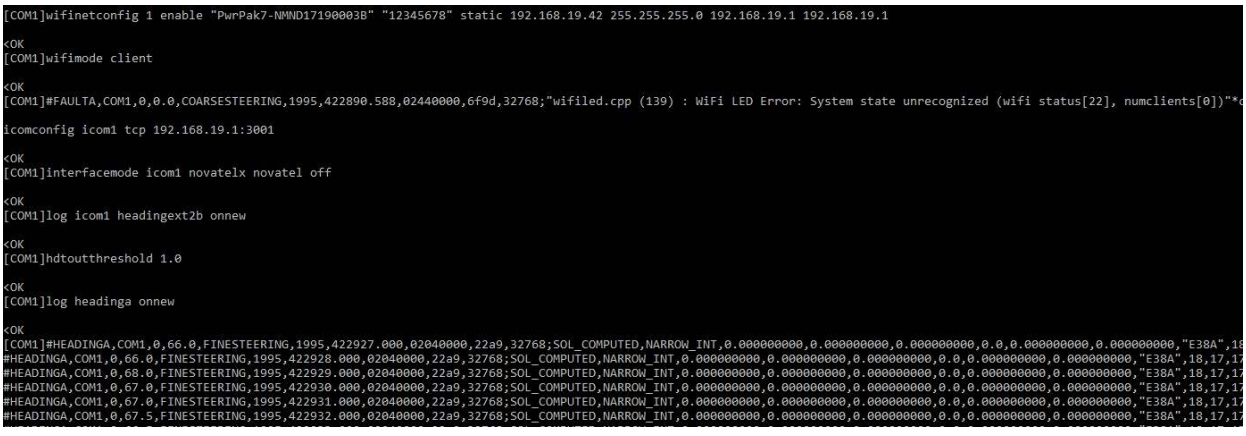
```
wifinetconfig 1 enable "PwrPak7-NMND17190003B" "12345678" dhcp
wifimode client
icomconfig icom1 tcp 192.168.19.1:3001
interfacemode icom1 novatelx novatel off
log icom1 headingext2b onnew
hdtoutthreshold 1.0

log headinga onnew
saveconfig
```



Static IP Address Configuration

In this example, the **WIFINETCONFIG** command is used to enable the Client to connect to the Master's Access Point using a static IP address on the same subnet as the Master - 192.168.19.42 in this example. The Master's IP address (192.168.19.1 by default) is used as both the gateway and DNS server.

```
wifinetconfig 1 enable "PwrPak7-NMND17190003B" "12345678" static
192.168.19.42 255.255.255.0 192.168.19.1 192.168.19.1

wifimode client

icomconfig icom1 tcp 192.168.19.1:3001

interfacemode icom1 novatelx novatel off

log icom1 headingext2b onnew

hdtoutthreshold 1.0


log headinga onnew

saveconfig
```



Chapter 6 Ethernet Configuration

This chapter describes how to configure the Ethernet port on an OEM7 receiver. It provides the step-by-step process for connecting to the OEM7 receiver through the Ethernet interface, setting up a base/rover configuration through Ethernet connectivity and utilizing the NTRIP interface. The Ethernet port connections for a computer connected to the receiver are also described for Windows 7 operating systems.

In this chapter, references to OEM7 receivers includes the SMART7-I.

The **SAVEETHERNETDATA** command can be issued to retain the Ethernet configuration settings after a RESET/FRESET command. The **ETHCONFIG** command and **IPCONFIG** command must be issued prior to using **SAVEETHERNETDATA** command. Refer to the Agriculture Commands and Logs Reference Manual.

6.1 Required Hardware

The following hardware is required to set up an Ethernet interface to an OEM7 receiver:

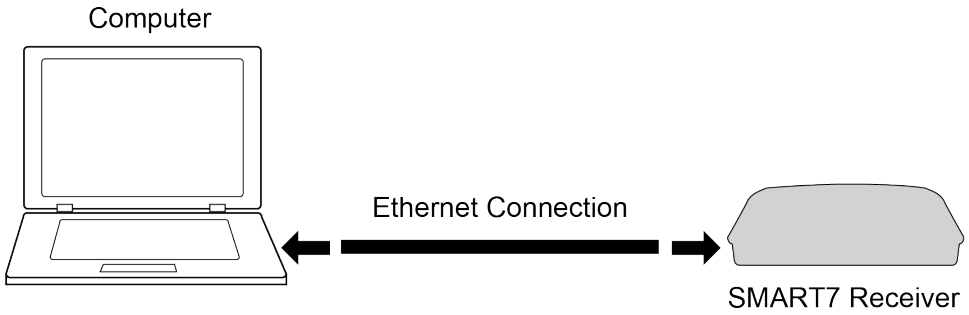
- a user supplied computer with an available Ethernet or serial
- an Ethernet capable OEM7 receiver
- an RS-232 null modem cable
- one or two CAT5 Ethernet cables
- a user supplied Ethernet network, hub or wired router (optional)
- a GNSS antenna
- a coaxial antenna cable (50 Ω)

6.2 Static IP Address Configuration

For a static IP address configuration, unique IP addresses are assigned to both the OEM7 receiver and the computer. TCP/IP is used for the connection in this simple network. This configuration can also be used in a bench test environment to confirm Ethernet functionality.

For connections when an OEM7 receiver uses a static IP address configuration, refer to *Figure 31: Cross-Over Ethernet Cable Configuration—OEM7 Receiver* on the next page.

Figure 31: Cross-Over Ethernet Cable Configuration—OEM7 Receiver



6.2.1 Static IP Address Configuration—Receiver

Follow these steps to set up a static IP address on the OEM7 receiver:

1. Connect a computer to the OEM7 receiver using a null modem serial cable.
2. Establish a connection to the receiver using either NovAtel Connect or another terminal program. This connection is used to send the commands in this procedure to the receiver.

> For information about establishing a connection using NovAtel Connect, refer to the Help within NovAtel Connect.

> NovAtel Connect version 2.0 or greater is required for OEM7 receivers. Download the latest NovAtel Connect software and documentation from www.novatel.com/novatel-connect.

3. Enable the Ethernet port on the receiver by entering:

```
ETHCONFIG ETHA AUTO AUTO AUTO AUTO
```

4. Assign the TCP/IP port number used for the connection by entering:

```
ICOMCONFIG ICOM1 TCP :2000
```

5. Assign the receiver IP address, subnet mask and default gateway by entering:

```
IPCONFIG ETHA STATIC 192.168.74.10 255.255.255.0 192.168.74.1
```

> The command assigns the following values to the OEM7 receiver:
>
> ```
> IP address = 192.168.74.10
> Subnet mask = 255.255.255.0
> Gateway = 192.168.74.1
> ```
>
> These settings are examples only. The settings appropriate to your system may be different.

6. Save the new Ethernet settings by entering:

```
SAVEETHERNETDATA
```

7. Log the **IPCONFIG** command and confirm the TCP/IP configuration by entering:

```
LOG IPCONFIG ONCE
```

8. Configure your computer with a static IP address.
   Refer to *Static IP Address Configuration—Windows 7* below.

6.2.2 Static IP Address Configuration—Windows 7

Follow these steps to set up a static IP address on a computer:

1. Click **Start** | **Control Panel**.
2. Click **Network and Sharing Center**.
3. Click the **Local Area Connection** link.
   The Local Area Connection Status window appears.
4. Click the **Properties** button.
   The Local Area Connection Properties window appears.
5. Select **Internet Protocol Version 4 (TCP/IPv4)** and then click the **Properties** button.
   The Internet Protocol Version 4 (TCP/IPv4) Properties window appears.
6. Click the **Use the Following IP Address** radio button, then enter the IP address, Subnet mask and Default gateway for the Ethernet port on the computer.

> Ensure the Ethernet settings used for the computer are compatible with the Ethernet settings on the OEM7 receiver.
>
> For example, the following settings are compatible with the OEM7 receiver settings used in *Static IP Address Configuration—Receiver* on the previous page:
>
> ```
> IP address = 192.168.74.11
> Subnet mask = 255.255.255.0
> Gateway = 192.168.74.1
> ```

7. Click the **OK** button.
   The Local Area Connection Properties window appears.
8. Click the **Close** button.
   The Local Area Connection Status window appears.
9. Click the **Close** button.
10. Proceed to *Confirming Ethernet Setup* below.

6.2.3 Confirming Ethernet Setup

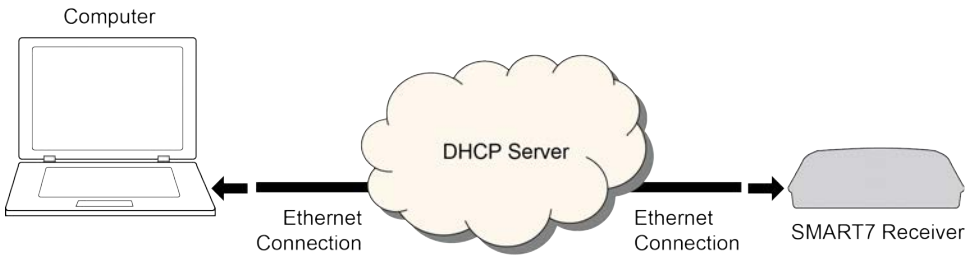
1. Connect the computer to the OEM7 receiver using an Ethernet cross-over cable.
   See *Figure 31: Cross-Over Ethernet Cable Configuration—OEM7 Receiver* on the previous page.
2. Connect to the receiver using NovAtel Connect or any third party terminal program that supports TCP/IP connections. Use the static IP address and port number assigned to the OEM7 receiver in *Static IP Address Configuration—Receiver* on the previous page.

> NovAtel Connect version 2.0 or greater is required for OEM7 receivers. Download the latest NovAtel Connect software and documentation from www.novatel.com/novatel-connect.

6.3 Dynamic IP Address Configuration

Figure 32: Dynamic IP Address Configuration through a DHCP Server—OEM7 Receiver below shows the connections when an OEM7 receiver uses a dynamic IP address configuration.

Figure 32: Dynamic IP Address Configuration through a DHCP Server—OEM7 Receiver



To set up a dynamic IP address configuration, follow these steps:

1. Connect a computer to the OEM7 receiver using a null modem serial cable or USB cable (model dependent).
2. Establish a connection to the receiver using either NovAtel Connect or another terminal program. This connection is used to send the commands in this procedure to the receiver.

> For information about establishing a connection using NovAtel Connect, refer to the Help within NovAtel Connect.

> NovAtel Connect version 2.0 or greater is required for OEM7 receivers. Download the latest NovAtel Connect software and documentation from www.novatel.com/novatel-connect.

3. Enable the Ethernet port by entering:

```
ETHCONFIG ETHA AUTO AUTO AUTO AUTO
```

4. Obtain the IP address assigned to the OEM7 receiver by the DHCP server.

```
LOG IPSTATUS ONCE
```

> Make a note of the IP address returned with this log.

5. Assign the TCP/IP port number by entering:

```
ICOMCONFIG ICOM1 TCP :2000
```

6. Confirm the port number assigned to ICOM1 by entering:

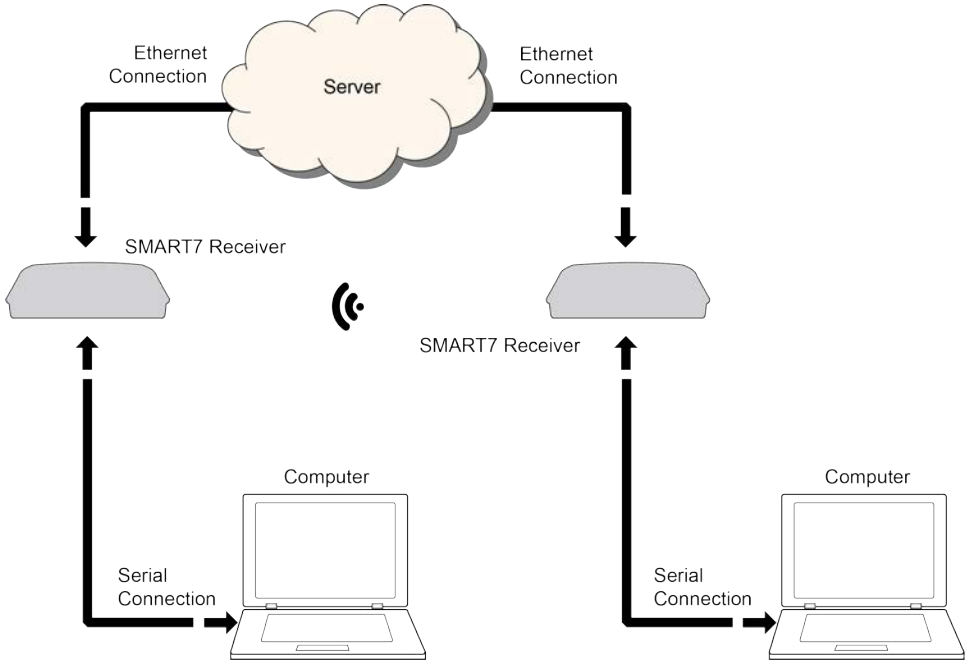
```
LOG ICOMCONFIG ONCE
```

6.4 Base/Rover Configuration through Ethernet Connectivity

You can use an Ethernet connection to provide communication between a base and rover receiver.

Figure 33: Base/Rover Ethernet Setup—OEM7 Receiver below shows the connections when a base and rover OEM7 receiver are connected using Ethernet.

Figure 33: Base/Rover Ethernet Setup—OEM7 Receiver



1. Connect your computer to both OEM7 receivers using null modem serial cables or USB cables.
2. Establish a connection to the receiver using either NovAtel Connect or another terminal program. This connection is used to send the commands in this procedure to the receivers.

> For information about establishing a connection using NovAtel Connect, refer to the Help within NovAtel Connect.

> NovAtel Connect version 2.0 or greater is required for OEM7 receivers. Download the latest NovAtel Connect software and documentation from www.novatel.com/novatel-connect.

3. Connect the power cables to both of the OEM7 receivers and apply power to the receivers.
4. Connect the Ethernet cables to the Ethernet ports on both OEM7 receivers.
5. Establish an Ethernet connection, either static or dynamic configurations. Refer to *Static IP Address Configuration* on page 92 or *Dynamic IP Address Configuration* on the previous page for more information.
6. Send the following commands to each receiver either through serial or USB ports:

   Base:

```
FIX POSITION <lat> <long> <height>
INTERFACEMODE ICOM1 NONE RTCA off
LOG ICOM1 RTCAOBS2 ONTIME 1
```

```
LOG ICOM1 RTCAREF ONTIME 10
LOG ICOM1 RTCA1 ONTIME 5
SAVECONFIG
```

Rover:

```
ICOMCONFIG ICOM1 TCP <base ip address>:<base port #>
INTERFACEMODE ICOM1 RTCA NONE OFF
LOG BESTPOSA ONTIME 1 (optional)
SAVECONFIG
```

Use the **BESTPOS** log to confirm that the OEM7 rover is in RTK mode.

6.5 Large Ethernet Port Data Throughput

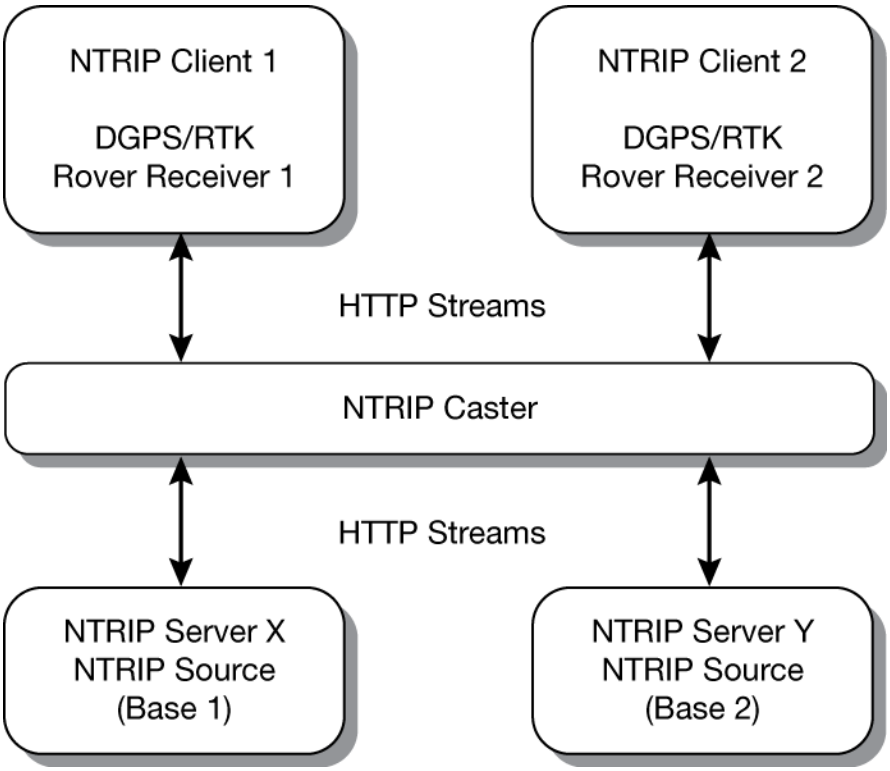
For high data rate Ethernet logging using TCP/IP, disable Windows Delayed Ack Algorithm (DAA) for complete data logging. If you do not disable DAA, there will be data gaps due to the Windows Ethernet buffer.

If done incorrectly, changing the Windows Registry may impair the operation of the computer. Editing the Windows Registry is for advanced Microsoft Windows users only. NovAtel Inc. is not able to provide any technical support for any actions taken regarding information found in Microsoft's Knowledge Base.

6.6 NTRIP Configuration

An OEM7 receiver can be configured as either an NTRIP server or an NTRIP client. For more information about NovAtel's NTRIP, refer to www.novatel.com/products/firmware-options/ntrip/.

Figure 34: NTRIP System



The NTRIP caster is an HTTP internet service that acts as a communication medium between NTRIP servers and NTRIP clients. The NTRIP caster is provided by third party sources. For a full list of NTRIP casters, refer to the following link: http://www.rtcm-ntrip.org/home.

The following procedure describes how to configure a NovAtel base and a NovAtel rover through a third party NTRIP caster. This configuration is recommended for optimal RTK performance.

1. Establish a connection to the receiver using either NovAtel Connect or another terminal program. This connection is used to send the commands in this procedure to the receiver.

> For information about establishing a connection using NovAtel Connect, refer to the Help within NovAtel Connect.

> NovAtel Connect version 2.0 or greater is required for OEM7 receivers. Download the latest NovAtel Connect software and documentation from www.novatel.com/novatel-connect.

2. Connect the Ethernet cable to the Ethernet ports on both OEM7 receivers. For this setup, use a cross-over Ethernet cable.
3. Establish a static or dynamic Ethernet connection.
   For information about creating the connection, refer to *Static IP Address Configuration* on page 92 or *Dynamic IP Address Configuration* on page 95.
4. Use the following commands to enable the base receiver as an NTRIP Server:

```
NTRIPCONFIG NCOM1 SERVER V2 <endpoint> <mountpoint> <username>
<password> ETHA
INTERFACEMODE NCOM1 NONE RTCA OFF
FIX POSITION <lat> <long> <height>
LOG NCOM1 RTCAOBS2 ONTIME 1
LOG NCOM1 RTCAREF ONTIME 10
LOG NCOM1 RTCA1 ONTIME 1
SAVECONFIG
```

5. Use the following commands to enable the rover receiver as an NTRIP Client:

```
ETHCONFIG ETHA AUTO AUTO AUTO AUTO
NTRIPCONFIG NCOM1 CLIENT V1 <endpoint> <mountpoint> <username>
<password > ETHA
```

If using a specific Network RTK system, certain National Marine Electronics Association (NMEA) strings are required to be sent from the rover back to the RTK network. For example, if connected to the VRS mount point, the rover is required to send its position to the network in a standard NMEA GGA message. This is achieved by issuing the following commands: **LOG NCOMx GPGGA ONTIME 5**, until data is received by the caster. For more information about Network RTK options and properties, refer to the application note APN-041 Network RTK for the OEMV Receivers and APN-074: NTRIP on NovAtel OEM6/OEM7.

The following is an NTRIP Client configuration example without the use of a Network RTK system:

```
INTERFACEMODE NCOM1 RTCA NONE OFF
RTKSOURCE AUTO ANY
PSRDIFFSOURCE AUTO ANY
LOG BESTPOS ONTIME 1 (optional)
SAVECONFIG
```

Refer to the **NTRIPCONFIG** command in the Agriculture Commands and Logs Reference Manual for further command details.

Chapter 7 CAN Bus

The OEM7 receivers support the following CAN protocols:

- J1939 Transport and Extended Transport Protocol: used for corrections and NovAtel messages (both transmitting and receiving)
- NMEA2000: used for standard as well as NovAtel-proprietary messages (transmitting only)

By default, CAN is disabled on OEM7 receivers. Critical CAN configuration parameters such as Parameter Group Numbers (PGNs), addresses and priorities are system-specific and must be explicitly configured.

The addresses and PGNs are typically allocated when the overall CAN bus topology is determined. A Node has a unique CAN J1939 NAME and address.

The SMART7 has internal CAN transceivers, however they still require proper bus terminations.

Refer to *Table 27: SMART7 Connector Pin Out* on page 137 for pin-out information.

OEM7 receivers support the following NMEA2000 Parameter Group Messages (PGN) over the CAN bus:

- PGN 126992 System Time
- PGN 129025 GNSS Position Rapid Update
- PGN 129026 COG & SOG Rapid Update
- PGN 129027 Position Delta High Precision Rapid Update
- PGN 129029 GNSS Position
- PGN 129551 GNSS Differential Signal

The following commands and logs are used for CAN configuration:

- **CANCONFIG** command: controls the CAN transceiver hardware and places the receiver *on bus* or *off bus*
- **J1939CONFIG** command: assigns the CAN J1939 NAME and address parameters to a Node
- **J1939STATUS** log: reports the status a Node on the J1939 CAN network, such as the claimed address
- **LOG CCOMx PGNabcd**: configures the NMEA2000 messages
- **PGNCONFIG** command: configures the NovAtel-proprietary NMEA2000 messages (change the PGN and its priority)
- **CCOMCONFIG** command: configures the parameters used by the NovAtel command interface to interact with the CAN Bus

CCOM ports with a lower port number have a higher transmission priority.

For information about these commands, see the Agriculture Commands and Logs Reference Manual.

Details for the PGN messages can be found in the NMEA2000 specification which can be purchased directly from the National Marine Electronics Association (www.nmea.org/).

7.1 Default Configuration

After a FRESET, the receiver has the following CAN configuration:

- All CAN physical ports are disabled
- No J1939 addresses are configured
- CCOM ports are configured for NMEA2000 messages only

Table 15: Default NAME

Parameter	Value
Address	0xFE
Industry Group	2
Device Class	0
Device Class Instance	0
Function	23
Function Instance	0
ECU Instance	0
Manufacturer Code	0
Identity Number	0

7.2 Configuring the CAN Bus

To enable an OEM7 receiver to communicate over the CAN bus, configure CAN and place the receiver *on bus*, triggering a J1939 *Address Claim Procedure*.

1. Use the **J1939CONFIG** command to specify J1939 NAME and desired address.
2. Use the **CANCONFIG** command to place the receiver *on bus*.
3. Optionally, use the **J1939STATUS** log to monitor CAN status on the receiver.

7.2.1 Configuration Notes

- The **J1939CONFIG** and **CANCONFIG** commands can be entered in any order. After the **CANCONFIG** command is used to place the receiver on the CAN bus, **J1939CONFIG**

commands take effect immediately whether entered before or after CANCONFIG. Until then, J1939CONFIG can be entered many times to change the settings because they have not taken affect yet (the receiver is not yet on the bus).

- The J1939 Address claim procedure is executed if and only if both J1939CONFIG NODEx CANx and CANCONFIG CANx ON are entered.
- Use J1939STATUS log to determine the receiver's CAN status and the actual address claimed by a particular node.
- Once the receiver is "on bus", it must be taken "off-bus" using CANCONFIG for any further configuration changes using J1939CONFIG.
- The receiver is fully "on-bus" only once the J1939 address has been successfully claimed. This is reported as "CLAIMED" status by J1939STATUS log.
- No messages will be sent or received until the receiver is "online" and an address is claimed. Outgoing messages are not buffered; they are discarded until the receiver is online.

7.2.2 Example of Enabling the CAN Bus

1. **LOG J1939STATUS ONCHANGED**
2. **J1939CONFIG NODE1 CAN1 <addresses>**
3. **CANCONFIG CAN1 ON 250K**
4. **SAVECONFIG**

```
< J1939STATUS NODE1 DISABLED 0 0xFE
< J1939STATUS NODE1 CLAIMING 1 <address>
< J1939STATUS NODE1 CLAIMED <attempt count> <address>
```

7.2.3 Example of Modifying the CAN Bus Parameters

1. **LOG J1939STATUS ONCHANGED**
2. **CANCONFIG CAN1 OFF**
3. **J1939CONFIG NODE1 CAN1 <addresses>**
4. **CANCONFIG CAN1 ON**
5. **SAVECONFIG**

```
< J1939STATUS NODE1 DISABLED 0 0xFE
< J1939STATUS NODE1 CLAIMING 1 <address>
< J1939STATUS NODE1 CLAIMED <attempt count> <address>
```

7.2.4 Example of Detecting an Address Claim Failure and Reconfiguring

1. **LOG J1939STATUS ONCHANGED**
2. **J1939CONFIG NODE1 CAN1 <addresses>**
3. **CANCONFIG CAN1 ON**

```
< J1939STATUS NODE1 DISABLED 0 0xFE
< J1939STATUS NODE1 CLAIMING 1 <address>
```

```
< J1939STATUS NODE1 FAILED <attempt count> 0xFE
```

4. **CANCONFIG CAN1 OFF**

```
< J1939STATUS NODE1 DISABLED 0 0xFE
```

5. **J1939CONFIG NODE1 CAN1 <addresses>**
6. **CANCONFIG CAN1 ON**

```
< J1939STATUS NODE1 CLAIMING 1 <address>
< J1939STATUS NODE1 CLAIMED <attempt count> <address>
```

7.2.5 Address Claim Procedure

To become operational on the CAN bus, an OEM7 receiver must claim a J1939 address. The preferred address and a range of alternative addresses are specified using the **J1939CONFIG** command. When a configured receiver is placed *on bus*, it may make multiple attempts to claim an address. It may also have its address bumped by a higher priority device claiming the same address.

While the device is attempting to claim an address, the **J1939STATUS** log reports a status of *CLAIMING* and automatically tries to claim the next allowed address. Depending on the **J1939CONFIG** parameters, an address different from the **J1939CONFIG** *preferred address* may be claimed or the address claim procedure can fail entirely. If no addresses could be claimed, a *FAILED* status is reported and the receiver takes no further action. To recover from this failure, take the receiver *off bus* using the **CANCONFIG** command and change the CAN address configuration using the **J1939CONFIG** command.

The address can also be assigned using J1939 *Commanded Address* message sent by another ECU on the bus, such as a tester unit. The commanded address always overrides the address specified using **J1939CONFIG** command. When the *Commanded Address* is received, the receiver reports a status of *CLAIMING* followed by *CLAIMED*. Restarting CAN using the **J1939CONFIG** command or **CANCONFIG** command clears the commanded address; the Address Claim procedure will be executed again based on parameters specified in the **J1939CONFIG** command.

7.3 NMEA2000 Logging

OEM7 receivers support both a subset of the standard NMEA2000 PGNs, as well as NovAtel proprietary PGNs.

All NMEA2000 logs are configured using the **LOG** command, where the COM port is a CAN port (CCOM). The CCOM port must be associated with a J1939 node using the **CCOMCONFIG** command. If only NMEA2000 logs are needed, **CCOMCONFIG** parameters other than J1939NODE may be ignored.

To enable NMEA2000 logs:

1. Configure the CAN bus. See *Configuring the CAN Bus* on page 101.
2. Enable the CCOM port on the CAN bus node using the **CCOMCONFIG** command.
3. Optionally, specify a custom PGN for the OEM7 specific NMEA2000 logs using the **PGNCONFIG** command.
4. Enable the desired NMEA2000 logs.

NMEA2000 logs can be requested regardless of the on/off bus status of the receiver or the J1939 configuration. They are output if and only if the receiver is online.

7.3.1 Example of NMEA2000 Log Configuration

1. `CCOMCONFIG CCOM1 NODE1`
2. `LOG CCOM1 PGN129025 ONTIME 0.5`
3. `LOG CCOM1 PGN129026 ONTIME 0.25`
4. `SAVECONFIG`

7.3.2 Example of Custom PGN Configuration

The following is an example of the optional specification of a custom PGN for the OEM7 specific **INSPVACMP** NMEA2000 log.

1. `PGNCONFIG INSPVACMP 129500 3`
2. `LOG CCOM1 INSPVACMP ONTIME 1`
3. `SAVECONFIG`
4. `RESET`

It is strongly recommended to RESET the receiver after using the **PGNCONFIG** command. This prevents PGN ambiguities and conflicts.

7.4 Corrections Over CAN

All NovAtel supported correction types are supported over CAN ports (CCOM).

To send or receive corrections:

1. Configure the CAN Bus. See *Configuring the CAN Bus* on page 101.
2. Use the **CCOMCONFIG** command to configure the PGN and other CAN parameters used by the RTK corrections CAN messages.

   PGN: Use the PGN designated for corrections.

   Address:

   - Use 0xFF to receive corrections from any CAN address and to broadcast corrections to all CAN nodes.
   - Use 0x00 to 0xFE to send corrections to or receive corrections from a specific CAN node.
3. Use the **INTERFACEMODE** command to configure the CCOM interface mode.
   - To transmit corrections, use the desired INTERFACEMODE, e.g. RTCMV3
   - To receive corrections, it is recommended to use INTERFACEMODE AUTO.

Corrections configuration (**CANCONFIG** and **INTERFACEMODE**) for a particular CCOM port do not affect its NMEA2000 configuration. NMEA2000 logs coexist with correction messages, both incoming and outgoing.

7.4.1 Example for Receiving Corrections from Any Source

1. `CCOMCONFIG CCOM2 NODE1 J1939 61184 6 0xFF`
2. `INTERFACEMODE CCOM2 AUTO NONE OFF`

7.4.2 Example for Transmitting Corrections to 0x1C Node

1. `CCOMCONFIG CCOM2 NODE1 J1939 61184 6 0x1c`
2. `INTERFACEMODE CCOM2 NONE RTCMV3 OFF`

7.5 NovAtel Messages Over CAN

Standard NovAtel messages (commands, logs, responses) can be sent and received on the CAN Bus using CAN ports (CCOM). To reduce CAN Bus loading, NovAtel messages are sent using NovAtel standard binary format over J1939(default).

The CCOM port requires special configuration and has the following limitations:

- A single CCOM port cannot be used for both Binary and ASCII / NovAtel ASCII messages.
- A single CCOM port cannot be used for both Binary messages and corrections.
- If the CCOM port is configured as *NOVATEL*, all input is interpreted as NovAtel ASCII or Abbreviated ASCII. Unlike other COM ports, the receiver will not distinguish between ASCII and binary input.
- To use CAN NOVATELMINBINARY, the CCOM port must be placed into NOVATELMINBINARY using the **INTERFACEMODE** command.

It is recommended to use one dedicated CCOM port for NovAtel messages and another dedicated CCOM port for corrections.

NovAtel UI configuration does not affect NMEA2000. Any CCOM port can be used for NMEA2000 logs irrespective of CCOMCONFIG settings.

To configure NovAtel User Interface over CAN:

1. Configure the CAN Bus. See *Configuring the CAN Bus* on page 101.
2. Use the **CCOMCONFIG** command to configure the PGN and other CAN parameters.
3. Use the **INTERFACEMODE** command to configure the CCOM port for **NOVATELMINBINARY**.

Example: Configuring CCOM2 for NovAtel messages:

1. `CCOMCONFIG CCOM2 NODE1 1234 6 0x1C`
2. `INTERFACEMODE CCOM2 NOVATELMINBINARY NOVATELMINBINARY OFF`

7.6 Configuring OEM7 Receivers to Use OEM6 CAN Settings

CAN Bus functionality has been enhanced on OEM7 receivers. To accommodate the enhancements in functionality and flexibility, several new commands and logs have been added. Also,

the **SETCANNAME** command has been removed and the **CANCONFIG** command has been modified.

The following sections describes how to configure CAN on OEM7 receivers to operate like OEM6 receivers.

7.6.1 Configuration on OEM6

On OEM6 receivers, the **SETCANNAME** command, with minimal parameters, could be used to configure CAN.

```
SETCANNAME 305
```

Once entered, a limited address claim procedure would take place and NMEA2000 logs would be generated automatically at a fixed logging rate and fixed CAN port bit rate.

7.6.2 Configuration on OEM7

To configure an OEM7 receiver to log the same commands and use the same logging rate and CAN port bit rate, enter the following commands:

```
CCOMCONFIG CCOM1 NODE1 NMEA2000

CANCONFIG CAN1 ON 250K

LOG CCOM1 PGN129025 ONTIME 0.1

LOG CCOM1 PGN129026 ONTIME 0.1

LOG CCOM1 PGN129029 ONTIME 1.0

SAVECONFIG
```

On OEM7 receivers, nothing is automatically logged when CAN is enabled. Regular log requests must be made for each log required.

A full address claim procedure with default values is initiated with the **CANCONFIG ON** command. The J1939CONFIG command can be used to modify the default address claim parameters including the ManufacturingCode (set to 603 in the SETCANNAME example above, now defaults to 305 in the new J1939CONFIG) but it's not necessary.

Chapter 8 Troubleshooting

There are simple ways to diagnose and resolve problems. In many cases, the issue can be resolved within a few minutes, avoiding the inconvenience and loss of productivity that results from having to return the receiver for repair. This section discusses troubleshooting issues and includes cross-references to other sections of the manual that may help resolve problems.

If unsure of the symptoms or if the symptoms do not match any of those listed, use the RXSTATUS log to check the receiver status and error words. See *Examining the RXSTATUS Log* on the next page.

Try to resolve the problem using the troubleshooting guide in *Table 16: Troubleshooting Based on Symptoms* below, then try our Knowledge Base at www.novatel.com/support/. If you are still not able to resolve the problem, see *Customer Support* on page 14 for troubleshooting logs and contact information.

Table 16: Troubleshooting Based on Symptoms

Symptom	Related Section
The receiver is not properly powered	Check the power cable. Replace if faulty. See: • *Power Supply Requirements for the SMART7* on page 23
The receiver cannot establish communication	Check the serial cables and ports. Replace if faulty See *CAN Bus* on page 100. Refer also to the **SERIALCONFIG** command in the Agriculture Commands and Logs Reference Manual
The receiver is not tracking satellites	Ensure that the antenna has an unobstructed view of the sky from horizon to horizon. Check the RXSTATUS error states. See *Examining the RXSTATUS Log* on the next page. If the receiver is in error mode, it does not track. Use the Interference Toolkit to check if there is an interference signal present. Go to the Interference Toolkit section in the NovAtel Documentation portal: docs.novatel.com/OEM7.
No data is being logged	See *CAN Bus* on page 100 and *Communications with the Receiver* on page 31
Random data is being output by the receiver or binary data is streaming	Check the baud rate on the receiver and in the communication software. Refer to the **SERIALCONFIG** command and **FRESET** command in the Agriculture Commands and Logs Reference Manual See also *CAN Bus* on page 100

Symptom	Related Section
A command is not accepted by the receiver	Check for correct spelling and command syntax. See *Communications with the Receiver* on page 31 and refer to the **FRESET** command in the Agriculture Commands and Logs Reference Manual
Differential mode is not working properly	See *Transmitting and Receiving Corrections* on page 35 and refer to the **SERIALCONFIG** command in the Agriculture Commands and Logs Reference Manual
There appears to be a problem with the receiver's memory	Refer to the **NVMRESTORE** command in the Agriculture Commands and Logs Reference Manual
An environmental or memory failure. The receiver temperature is out of acceptable range or the internal thermometer is not working	Move the receiver to within an acceptable temperature range. See: • *SMART7 Environmental and Electrical Specifications* on page 134
Overload and overrun problems. Either the CPU or port buffers are overloaded	Reduce the amount of logging or increase the baud rate.
The receiver is indicating that an invalid authorization code has been used	Refer to the **VERSION** log or **VALIDMODELS** log and the **MODEL** command or **AUTH** command in the Agriculture Commands and Logs Reference Manual
The receiver is being affected by jamming	Move the receiver away from any possible jamming sources
The receiver is being affected by interference	Go to the Interference Toolkit section in the NovAtel Documentation portal: docs.novatel.com/OEM7. Move the GNSS antenna away from the source of the interference signal. If the interference mitigation feature is enabled on the receiver, configure a filter within the Interference Toolkit to filter out the interference signal.
The receiver's Automatic Gain Control (AGC) is not working properly	See the jamming symptom in this table

8.1 Examining the RXSTATUS Log

The RXSTATUS log provides detailed status information about your receiver and can be used to diagnose problems. Refer to the in the Agriculture Commands and Logs Reference Manualfor details on this log and on how to read the receiver error word and status word. *Table 17: Resolving a Receiver Error Word* on the next page, *Table 18: Resolving an Error in the Receiver Status Word* on page 110 and *Table 19: Resolving an Error in the AUX1 Status Word* on page 111 have

actions to take when your receiver has an error flag in these words. If you are not able to resolve the condition, contact *Customer Support* on page 14.

Table 17: Resolving a Receiver Error Word

Bit Set	Action to Resolve
0-2	Issue a **FRESET** command (for bit 1, reload new firmware).
4	Contact *Customer Support* on page 14
5	Check the **VERSION** log. The VERSION log will indicate "Invalid authcode". Upgrade the auth-code as described in *Upgrading Using the AUTH Command* on page 126
6	Issue a **FRESET** command
7	See • *Power Supply Requirements for the SMART7* on page 23
8	Reserved
9	Check the temperature ranges in: The operating temperatures are ambient air temperatures. The temperature sensors on the receiver PCB will reflect higher operating temperatures (refer to the **HWMONITOR** log). The PCB temperature sensors will trigger a receiver warning and receiver error at 100°C and 110°C respectively. The warning and error conditions are captured using the **RXSTATUS** log.
10	Possible hardware or environmental condition. If you cannot resolve the problem, contact *Customer Support* on page 14.
11	Possible hardware or environmental condition. If you cannot resolve the problem, contact *Customer Support* on page 14. Also, check the Auxiliary 2 Status word to determine which PLL is in error.
12-14	Reserved
15	Issue a **FRESET** command and power cycle the unit. If the bit is still present, contact *Customer Support* on page 14.
16	Monitor CPU idle time. Reduce number of logs or the rate of data logging.
17	Ensure that the Version log is consistent with the hardware.
18-19	Reserved
20	SoftLoad is in progress. See *Updating Using SoftLoad Commands* on page 120.
21	You may be exceeding the receiver's velocity limit. If so, reduce velocity. This error can only be cleared by resetting the receiver.

Bit Set	Action to Resolve
22	Reload firmware using WinLoad or the SoftLoad commands.
23-30	Reserved
31	Possible hardware failure. Contact *Customer Support* on page 14.

Table 18: Resolving an Error in the Receiver Status Word

Bit Set	Action to Resolve
0	Check the Error Word in the **RXSTATUS** log. See also *Table 17: Resolving a Receiver Error Word* on the previous page
1	Check the temperature ranges in • *SMART7 Environmental and Electrical Specifications* on page 134
2	See • *Power Supply Requirements for the SMART7* on page 23
3	For SMART7, contact *Customer Support* on page 14
4	
5	
6	
7	Check the CPU idle time. Check for unnecessary logging. Check for simultaneous use of functionality.
8	See *Table 9: Serial Ports Supported* on page 32 Also, check the Auxiliary 2 Status word to determine which COM port has overrun its buffer.
9-11	Reserved
15	Check the Auxiliary 1 status word to determine which RF channels are jammed.
16-17	Reserved
18	When the receiver has tracked GNSS satellites long enough for a valid almanac to be received, this bit will be set to 0.
19	None. This bit only indicates if the receiver has calculated a position.
20	None. This bit is a status bit indicating if the receiver's position has been manually fixed and does not represent a problem. Refer also to the **FIX** command in the Agriculture Commands and Logs Reference Manual.

Bit Set	Action to Resolve
21	None. This bit indicates if clock steering has been manually disabled. Refer also to the **FRESET** command in the Agriculture Commands and Logs Reference Manual.
22	None. This bit only indicates if the clock model is valid. Refer also to the **FRESET** command in the Agriculture Commands and Logs Reference Manual.
23	None. This bit indicates if the phase-lock-loop is locked when using an external oscillator. Refer also to the **FRESET** command in the Agriculture Commands and Logs Reference Manual.
24	Check the CPU idle time. Check for unnecessary logging. Check for simultaneous use of functionality.
25-26	None. These bits identify the receiver family. For OEM7 receivers, bit 25 is set to 1 and bit 26 is set to zero.
27	Interference Toolkit HDR mode status. When this bit is set to 1, Interference Toolkit HDR mode is enabled.
28	Digital filter status. When this bit is set to 1, an Interference Toolkit digital filter is enabled.
29	None. This bit indicates if any bits in the auxiliary 3 status word are set. The auxiliary 3 word provides status information and does not contain any new information on problems. Refer also to the **FRESET** command in the Agriculture Commands and Logs Reference Manual.
30	None. This bit indicates if any bits in the auxiliary 2 status word are set. The auxiliary 2 word provides status information and does not contain any new information on problems. Refer also to the **FRESET** command in the Agriculture Commands and Logs Reference Manual.
31	None. This bit indicates if any bits in the auxiliary 1 status word are set. The auxiliary 1 word provides status information and does not contain any new information on problems. Refer also to the **FRESET** command in the Agriculture Commands and Logs Reference Manual.

8.2 Examining the AUX1 Status Word

Table 19: Resolving an Error in the AUX1 Status Word below provides actions to take when your receiver has an error flag in the AUX1 status word.

Table 19: Resolving an Error in the AUX1 Status Word

Bit Set	Action to Resolve
0-2	Jammer detected
3	None. This bit indicates that Position Averaging is ON
4-6	Jammer detected

Bit Set	Action to Resolve
7	Connect the receiver via USB (not applicable to SMART7)
8-10	Reduce the amount of logging on the USB ports (not applicable to SMART7)
11	(Reserved bit)
12	None. This bit indicates a Profile set using the **PROFILE** command is activated.
13	Throttled Ethernet Reception Check for unusually high Ethernet traffic being directed to the Receiver. This does not represent an error condition on the receiver, but suggests there may be an issue in the network environment on the receiver.
14-17	AGC error on RF1 through RF4 respectively.. Contact NovAtel Customer Support.for additional information.
18	Connect the receiver via Ethernet. See *Ethernet Port* on page 26
19-21	Reduce the amount of logging on the Ethernet ports
22-24	Reduce the amount of logging on the NTRIP ports
25-27	Reduce the amount of logging on the Virtual COM ports
28-29	AGC error on RF5 (bit 28) or RF6 (bit 29).. Contact NovAtel Customer Support.for additional information.
30-31	(Reserved bits)

8.3 High Temperature Environments

The operating temperature of OEM7 receivers increases as more features (channels used, HDR mode, etc.) are enabled.

When the receiver is operating in an environment that is near its maximum ambient temperature, an increase in the ambient air temperature or enabling additional features may cause the receiver to exceed its maximum operating temperature and generate a Temperature Status error. When a Temperature Status error occurs, the receiver idles all channels, turns off the antenna and disables the RF hardware. The communication interfaces continue to function so commands can be sent and logs received.

8.3.1 Indicators of an Error State

The indications that the receiver is in an error state, such as a Temperature Status error, are:

- Logs that have a solution status will show INSUFFICIENT_OBS as the Solution Status.
- The **RXSTATUSEVENT** log is output on all communication ports. This log will indicate an error condition in the Receiver Error word of the log.
- All logs output have Bit 0 set in the Receiver Status word of the log header.

To determine the cause of the error, log the **RXSTATUS** log and check the Receiver Error word. If Bit 9 is set, it is a Temperature Status error. For information about reading the Error Word, refer to *Error Word* on page 79.

8.3.2 Recovering from a Temperature Status Error

The receiver must be reset or power cycled to recover from a receiver error such as a Temperature Status error.

Log information is lost when the receiver is reset. Therefore, any logs required to identify and troubleshoot the error, such as the **RXSTATUS** log, should be collected before resetting the receiver.

Also, steps should be taken to reduce the cause of the receiver temperature error to prevent the error from occurring again. See *Mitigating High Receiver Temperature* below.

8.3.3 Mitigating High Receiver Temperature

If the receiver has a high temperature warning or error, use one or more of the following suggestions to reduce the receiver temperature.

- If possible, reduce the ambient temperature around the receiver or move the receiver to an area with a lower ambient temperature.
- Disable the receiver features that are not required for the current operation of the receiver.

8.3.4 Monitoring the Receiver Temperature

If the receiver is operating in a high ambient temperature environment, you can monitor the receiver temperature using the RXSTATUS and HWMONITOR logs.

1. Log the **RXSTATUS** log and check Bit 1 of the Receiver Status word.

```
   LOG RXSTATUS onchanged

<RXSTATUS USB1 0 81.5 FINESTEERING 1990 326146.020 0a104020 2ae1 14434
<     00000000 4
<     0a104020 00000000 00030000 00030000    (Receiver Status)
<     00062000 00001008 00000000 00000000
<     00000000 00000000 80000000 00000000
<     80000000 00000000 00000000 00000000
<     00000000 00000000 00000000 00000000
```

   For information about reading the Receiver Status word, refer to *Status Word* on page 78.

2. If Bit 1 is 0, the temperature is okay. Continue monitoring, but no action is required.

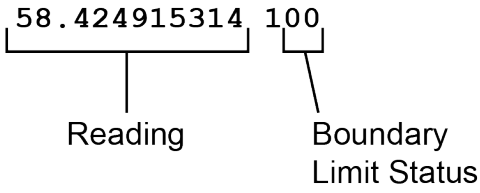
   If Bit 1 is 1, the receiver temperature has exceeded the warning limit.

3. Log the **HWMONITOR** log and check the two temperature status fields (0x01 and 0x16).

```
   LOG HWMONITOR ontime 30

<HWMONITOR USB1 0 77.5 FINESTEERING 1990 326851.000 0a104020 52db 14434
<   10
<       58.424915314 100    (Temperature 0x01)
<       0.000122100 200
<       3.296703339 600
<       5.169230938 700
<       1.192307711 800
```

```
<       3.300366402 f00
<       1.833943844 1100
<       5.159462929 1500
<       1.555555582 1700
<       58.485961914 1600    (Temperature 0x16)
```

Pay attention to the reading and the boundary limit status.



Refer to Table: HWMONITOR Status Table in the **HWMONITOR** log section for a description of the Boundary Limit Status.

4. Use the suggestions in *Mitigating High Receiver Temperature* on the previous page to reduce the receiver temperature.
5. Continue monitoring the **HWMONITOR** log to see if receiver temperature is dropping.
6. Check the **RXSTATUS** log to see if the temperature status changes to Okay (Bit 1 in the Receiver Status word changes to 0).

8.4 Safe Mode

Safe Mode is an error condition triggered on the OEM7 receiver if it encounters certain critical problems during start-up. The receiver does not track GNSS satellites in this state, but the user interface is still available to allow for diagnosis of the problem.

The receiver will enter Safe Mode under certain rare cases including the following:

- Corrupted or bad data within the receiver Non-Volatile Memory (NVM).
- An unsupported Auth Code.
- The expected main firmware image could not be found by the boot code. This is possibly due to an error during the main firmware loading process (i.e. WinLoad, SoftLoad, etc.).

Safe Mode exists to allow users to take steps to recover the receiver after such an error occurs. Potential recovery steps are described in *Recovery Steps* below.

Safe Mode is indicated by an error bit in the **RXSTATUS** log.

8.4.1 Reset Loop Detection

In order to determine when the Safe Mode error should be triggered, OEM7 receivers have the ability to detect when an unexpected reset has occurred during the boot process. If a Reset Loop is detected, the **Reset Loop Detected** bit is set in the **RXSTATUS** log.

This bit is only a warning and the receiver may still be able to operate correctly. The receiver will allow several unexpected resets to occur before triggering the Safe Mode Error, at which point the receiver will not track GNSS satellites.

8.4.2 Recovery Steps

If the **Safe Mode** error bit or the **Reset Loop Detected** warning bit are set in the **RXSTATUS** log, take the following steps to diagnose and recover the system:

1. Request the **SAFEMODESTATUS** log and determine the current *Safe Mode State* of the system.
2. Reference Table: Safe Mode States in the Agriculture Commands and Logs Reference Manual and find the suggested actions for the current Safe Mode State.
3. If the suggested actions do not resolve the issue, contact NovAtel Customer Support.

Chapter 9 NovAtel Firmware and Software

Download the most recent versions of the NovAtel firmware and receiver software from the Downloads section of www.novatel.com/support/search/.

OEM7 Firmware and Software

Refer to *Transferring Firmware Files* on page 118 for descriptions of the Update and OEM versions.

NovAtel Software

The following software is available from the NovAtel website:

- NovAtel Connect (a GUI interface)
- Convert (converts receiver data logs into different formats)

NovAtel Connect version 2.0 or greater is required for OEM7 receivers. Download the latest NovAtel Connect software and documentation from www.novatel.com/novatel-connect.

Firmware and Software included

- Firmware *.shex file
- WinLoad software utility

WinLoad and SoftLoad instructions follow.

9.1 Firmware Updates and Model Upgrades

A local NovAtel dealer can provide all the information needed to upgrade or update a receiver. Refer to www.novatel.com/where-to-buy for contact information or contact sales@novatel.com or support@novatel.com directly.

9.1.1 Firmware Updates

Firmware updates are firmware releases that include fixes and enhancements to the receiver functionality. Firmware updates are released on the NovAtel web site as they become available. Firmware upgrades can be performed using the WinLoad utility, SoftLoad commands, NovAtel Web UI, NovAtel Connect or with a custom loader application. Contact NovAtel Customer Support (support@novatel.com) for details on custom loader requirements.

9.1.2 Model Upgrades

Model upgrades enable purchased receiver features.

Contact a local NovAtel dealer to assist in selecting the upgrade options that best suit your GNSS needs at www.novatel.com/where-to-buy. Contact NovAtel Customer Support www.nova-

tel.com/support or NovAtel Sales to request a temporary upgrade authorization code for trial purposes.

Model upgrades can be applied to the receiver with an authorization code and the **AUTH** command without returning the receiver to the dealer.

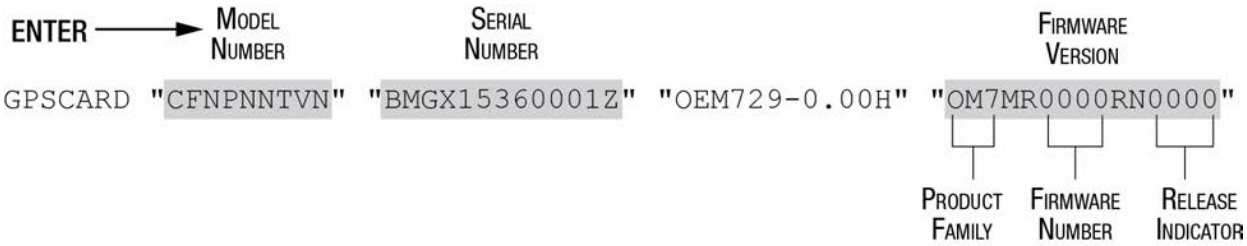
9.2 Authorization Code

An authorization code, commonly known as an auth-code, is required to upgrade an OEM7 family receiver. Auth-codes are obtained by contacting NovAtel Customer Support. Upon contact, NovAtel Customer Support requires:

- the receiver model number
- the receiver serial number
- the receiver firmware version

Enter the **LOG VERSION** command to determine the receiver model, serial number and firmware version.

Example:



After determining the appropriate model and firmware version, the authorization code (auth-code) is issued. The auth-code is required to unlock the features on the new model type.

To upgrade to a new model with the same firmware version, use the **AUTH** command with the issued auth-code, as outlined in *Upgrading Using the AUTH Command* on page 126.

To upgrade to a new model with a new firmware version, the new firmware needs to be loaded into the OEM7 receiver. Refer to *Updating or Upgrading Using the WinLoad Utility* on the next page for use instructions or to *Updating Using SoftLoad Commands* on page 120.

Auth-codes work with any signed firmware image. Therefore, if a receiver has an auth-code for the old version of firmware, that same auth-code will work for the new version of firmware, provided both images are digitally signed by NovAtel.

Signed firmware images are distributed in *.shex files. The new download package includes a signed firmware file type that uses an extension designated as ".shex" (example OM7MR0200RN0000.shex), as well as the latest WinLoad utility and What's New file containing firmware update change details.

Temporary auth-codes may be provided by NovAtel for evaluation purposes. Once the trial period has expired, the functionality provided by the auth-code is removed. The expiration date for temporary auth-codes is in the form YYMMDD, where YY = year, MM = month and DD =day. The date is the last day that the auth-code is valid and expires at the end of day, UTC time.

Once the trial period has expired, a new auth-code will need to be obtained from NovAtel Customer Support (support@novatel.com).

Firmware images may also have auth-codes embedded within them. The models provided by such firmware images will be valid only on receivers with certain PSNs and Hardware Versions.

9.3 Updating or Upgrading Using the WinLoad Utility

WinLoad is the simplest and most common way to update or upgrade an OEM7 receiver.

9.3.1 Transferring Firmware Files

To proceed with an update or possibly an upgrade, obtain the latest version of firmware by downloading the (OEM Version) for your product from www.novatel.com/support/firmware-downloads/.

Format of Firmware Files

All of the firmware available on the downloads website are packaged in .zip files with the following name:

- OEM7XXX.zip for firmware to be installed on OEM7 receivers

NovAtel Customer Service may generate and provide the required authorization code. Authorization codes are obtained by contacting support@novatel.com or at www.novatel.com/support/.

For convenience, unzip the update file to a GNSS sub-directory (for example, C:\GNSS\LOADER). If the firmware update file is password protected, NovAtel Customer Support provides the required password.

The zip archive includes the following files:

winload.exe	WinLoad utility program
howto.txt	Instructions on how to use the WinLoad utility
whatsnew.rtf	Information on the changes made in the firmware since the last revision
x..x.shex	Firmware version upgrade file, where x..x defines the product name and release (e.g., OM7MR0200RN0000.shex)
NovAtel Software License Agreement.rtf	License agreement for the firmware

NovAtel has an online video tutorial that explains firmware updating at: www.novatel.com/support/videos.

If loading a firmware that is currently installed on an OEM7 receiver (i.e. reloading the same version of firmware on a receiver), ensure that *Optimized Loading* option is unchecked in WinLoad under *Settings* | *Options* | *Optimized Loading*.

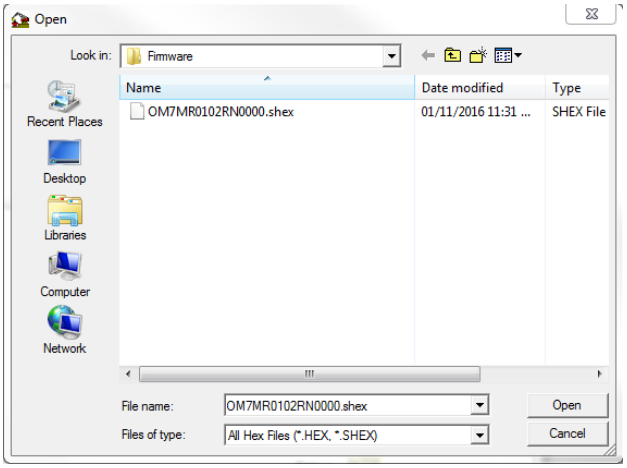
9.3.2 Using the WinLoad Utility

If opening WinLoad for the first time, ensure the file and communications settings are correct.

Open a File to Download

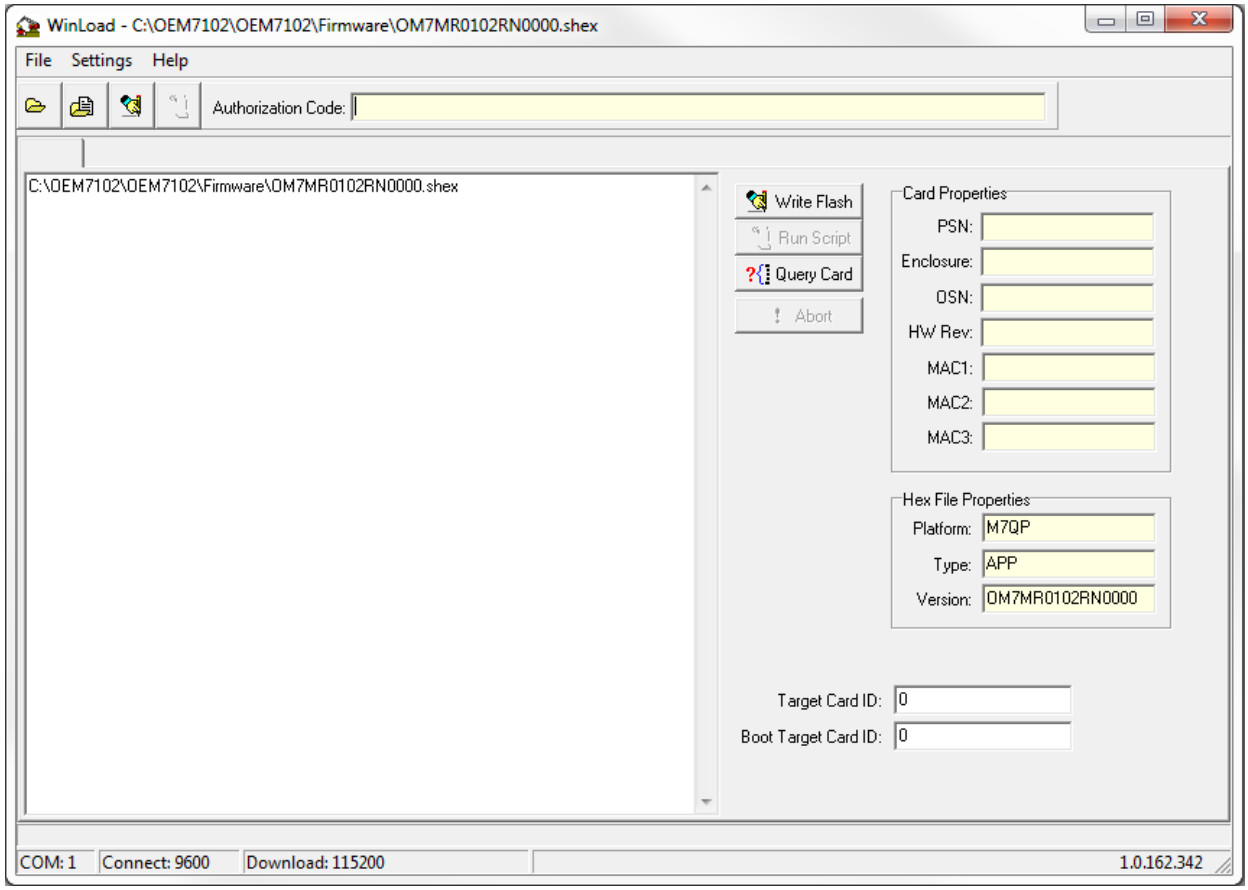
Select File | File Open. Navigate to the file to open (*Figure 35: WinLoad's Open Window* below).

Figure 35: WinLoad's Open Window



When a file is selected, the *filename* appears in the main WinLoad display area and in the title bar (*Figure 36: Open File in WinLoad* below).

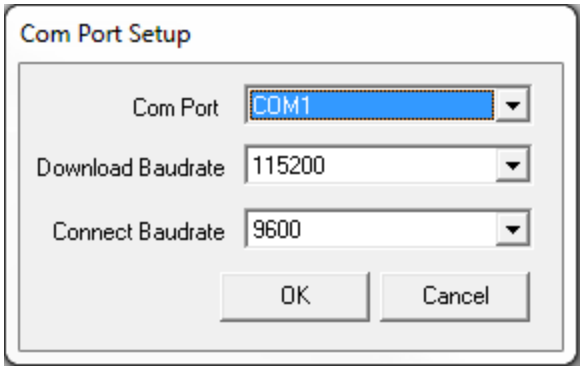
Figure 36: Open File in WinLoad



Communications Settings

To set the communications port and baud rate, select Settings | COM Settings. Choose the computer port to use from the Com Port drop down list and the baud rate from the Download Baudrate drop down list. Set the baud rate as high as possible (the default of 115200 is preferred if a higher baud rate is not available).

Figure 37: COM Port Setup



Downloading Firmware

1. Select the file to download according to *Open a File to Download* on the previous page.
2. Ensure the file path and name are displayed in main display area (see *Figure 36: Open File in WinLoad* on the previous page).
3. Click **Write Flash** to download the firmware.
4. When *Searching for card* appears in the main display, power cycle the receiver.
5. If the Authorization Code window appears, enter the auth-code and click **OK**. See *Authorization Code* on page 117 for further information about the Authorization Code.
6. The receiver finishes the download and then resets. The process is complete when *Done* appears in the main display area.
7. Close WinLoad.

9.4 Updating Using SoftLoad Commands

Firmware can be updated on a running receiver using a process called SoftLoad. Any available communication ports on the receiver (COM, USB, ICOM, etc.) can be used. The SoftLoad process is made up of a set of commands and logs that are used to send new firmware data to a receiver and check the progress of the update. Use SoftLoad if automated loading is desired or if a connection is only possible through USB or Ethernet.

The receiver stops tracking GNSS satellites during the SoftLoad process. Do not attempt to SoftLoad when GNSS satellite tracking on the unit is required. If the unit is connected to the NovAtel Connect utility, only the Console and ASCII Message windows may remain open in the Connect Utility.

9.4.1 SoftLoad Commands and Logs

Refer to the Agriculture Commands and Logs Reference Manual detailed log and command information.

Command	Description
SOFTLOADRESET	Initiate a new SoftLoad process
SOFTLOADSREC	Send an S-Record to the receiver for the SoftLoad process
SOFTLOADDATA	Send firmware image data to the receiver for the SoftLoad process
SOFTLOADCOMMIT	Complete the SoftLoad process
SOFTLOADSETUP	Send configuration information to the receiver for the SoftLoad process. This command is not required when working with a *.shex file

Log	Description
SOFTLOADSTATUS	Provides status updates for the ongoing SoftLoad process

Each command and log can be used in abbreviated ASCII, ASCII or binary format, with the exception of SOFTLOADDATA, which should only be used in binary format.

File Types

Firmware data is stored in *.shex files as ASCII data in the form of S-Records, based on the Motorola S-Record format. The *.shex file includes a digital signature for the firmware.

9.4.2 Working With S-Records

Each S-Record has a header indicating the type of information contained in the record.

Records beginning with S0, S5 and S7 contain metadata about the firmware image, such as version information and which card types are supported by the firmware image.

Example S0 Record

```
S0~V~OM7MR0400RN0000
```

Example S5 Records

```
S50000
S503D9FE25
S5033158D5A
```

Example S7 Records

```
S70000
S70500000000FA
```

Records beginning with S3 contain the actual firmware image data. Aside from the header, each pair of characters forms the ASCII representation of a binary byte. The format is as follows:

S3	**LL**	**AAAAAAAA**	**DDDDDDDD...DDDDDDDD** **CC**
			Check Sum
			Little Endian Data. These bytes are copied into the "data" field of the **SOFTLOADDATA** command
		4 - Byte Address. Set this as the value of "offset" in the SOFTLOADDATA command	
	Length. This is the hexadecimal number of character pairs to follow in the record. This value minus 4 bytes for the address and 1 byte for the check sum is copied into the "data length" field of the **SOFTLOADDATA** command		
Header			

9.4.3 Sending Firmware Data

C++ source code is available to provide example code of processing S-Records and converting them to NovAtel format commands, as well as providing help with the SoftLoad process. Contact NovAtel Customer Support and ask about the srec2softload utility.

The **SOFTLOADSREC** and **SOFTLOADDATA** commands can be used to send firmware data from *.shex files to the receiver.

S0, S5 and S7 S-Records should be sent directly to the receiver using the **SOFTLOADSREC** command, by enclosing the S-Record in quotation marks and issuing the command to the receiver, as follows:

```
SOFTLOADSREC "<S-RECORD>"
```

S3 records can be sent individually to the receiver using the **SOFTLOADSREC** command. Alternatively, the data from an S3 record can be parsed and packaged together with data from other S3 records into a binary **SOFTLOADDATA** command. Packaging data parsed from multiple S3 records into a binary **SOFTLOADDATA** command can result in improved firmware update times as each S3 record contains only a small number of bytes of firmware data. A single **SOFTLOADDATA** command can package up to 4096 bytes of firmware data from multiple S3 records, whereas a single **SOFTLOADSREC** command contains a maximum of 28 bytes of firmware data from a single S3 record.

Multiple S3 records can be packaged into a single **SOFTLOADDATA** command as long as the data from one S3 record follows immediately after the previous record. That is, the address from the current S3 record must equal the address from the previous S3 record plus the data length of the previous S3 record. If the data is not consecutive then the **SOFTLOADDATA** command can be sent with the amount of data it has packaged up to that point. Subsequent data can be packaged in a new **SOFTLOADDATA** command. Within the **SOFTLOADDATA** command, the "offset" field remains the address of the first S3 record and the "data" and "data length" are updated to include the new data. Refer to the Agriculture Commands and Logs Reference Manual for command details.

The *.shex file data may contain many gaps and jumps. For example, in many NovAtel *.shex files, data for address 0x000_00000 is stored near the very end of the file.

Example Packaging Multiple S3 Records In A SOFTLOADDATA Command

Start a new **SOFTLOADDATA** command

```
S32100407AD48FCA63034B80F5CE0C36507DE3D8DCC0C6C0C00515D74BCACF2F2949E1
```

Address: 0x00407AD4 Num Data Bytes: 0x21 – 0x01 – 0x04 = 0x1C

```
S32100407AF04CCA4985F0F7B081E41D9B7D806C26989AE2D4E4CCBCB47C10FBFD3E43
```

Previous Address + Previous Num Bytes = 0x00407AD4 + 0x1C = 0x00407AF0

Address: 0x00407AF0 Num Data Bytes: 0x1C

Add data to existing **SOFTLOADDATA** command

```
S30D00407B0CDE0400A6374D5BFFC5
```

Previous Address + Previous Num Bytes = 0x00407AF0 + 0x1C = 0x00407B0C

Address: 0x00407B0C Num Data Bytes: 0x0D – 0x01 – 0x04 = 0x08

Add data to existing **SOFTLOADDATA** command

```
S3210000000007F0A7F1F4060000147B4000F49217813C7BB00014493F005C00000009
```

Previous Address + Previous Num Bytes = 0x00407B0C + 0x08 = 0x00407B14

Address: 0x00000000 Num Data Bytes: 0x1C

Requires new **SOFTLOADDATA** command because address does not match previous address + previous number of data bytes

Send existing **SOFTLOADDATA** command, and start a new **SOFTLOADDATA** command

```
S3210000001C80040000E00100003000000082B0100D8060000E4060000C806000063
```

Address: 0x0000001C Num Data Bytes: 0x1C

Previous Address + Previous Num Bytes = 0x00000000 + 0x1C = 0x0000001C

Add data to existing **SOFTLOADDATA** command

The **SOFTLOADDATA** command must be sent as a NovAtel binary format command.

9.4.4 SoftLoad Update Method

This section describes the sequence of commands that are issued to the receiver when updating using a *.shex file.

The response for each command must be processed before sending the next command so as to determine if the command was accepted or rejected, and to wait for the receiver to complete the operation. Responses to SoftLoad commands are guaranteed to be output from the receiver within a specific time, which varies by command. Refer to specific SoftLoad command Agriculture Commands and Logs Reference Manual for more information on responses and the timeout values for SoftLoad commands.

1. Open a connection to any port on the receiver (COM, USB or ICOM) with the input and output INTERFACEMODE set to NOVATEL.
2. Request the SOFTLOADSTATUS log using the following command:

   ```
   LOG SOFTLOADSTATUSA ONCHANGED
   ```
3. Initialize SoftLoad with a **SOFTLOADRESET** command. This command stops all tracking on the receiver to ensure sufficient memory is available for the loading process. An RXSTATUSEVENTA log reports a SoftLoad In Progress status.
4. Open the *.shex firmware file.
5. Read each line of the *.shex firmware file.

a. Send S0, S5 and S7 S-Records directly to the receiver using the **SOFTLOADSREC** command. The S-Record must be enclosed in quotation marks:
SOFTLOADSREC "<S-RECORD>"
Data within S0 records can also be sent to the receiver by converting them to **SOFTLOADSETUP** commands. Refer to the in the Agriculture Commands and Logs Reference Manual for details on how to convert from S0 S-Records to **SOFTLOADSETUP** commands.

b. S3 S-Records should be parsed and packaged into a **SOFTLOADDATA** command.

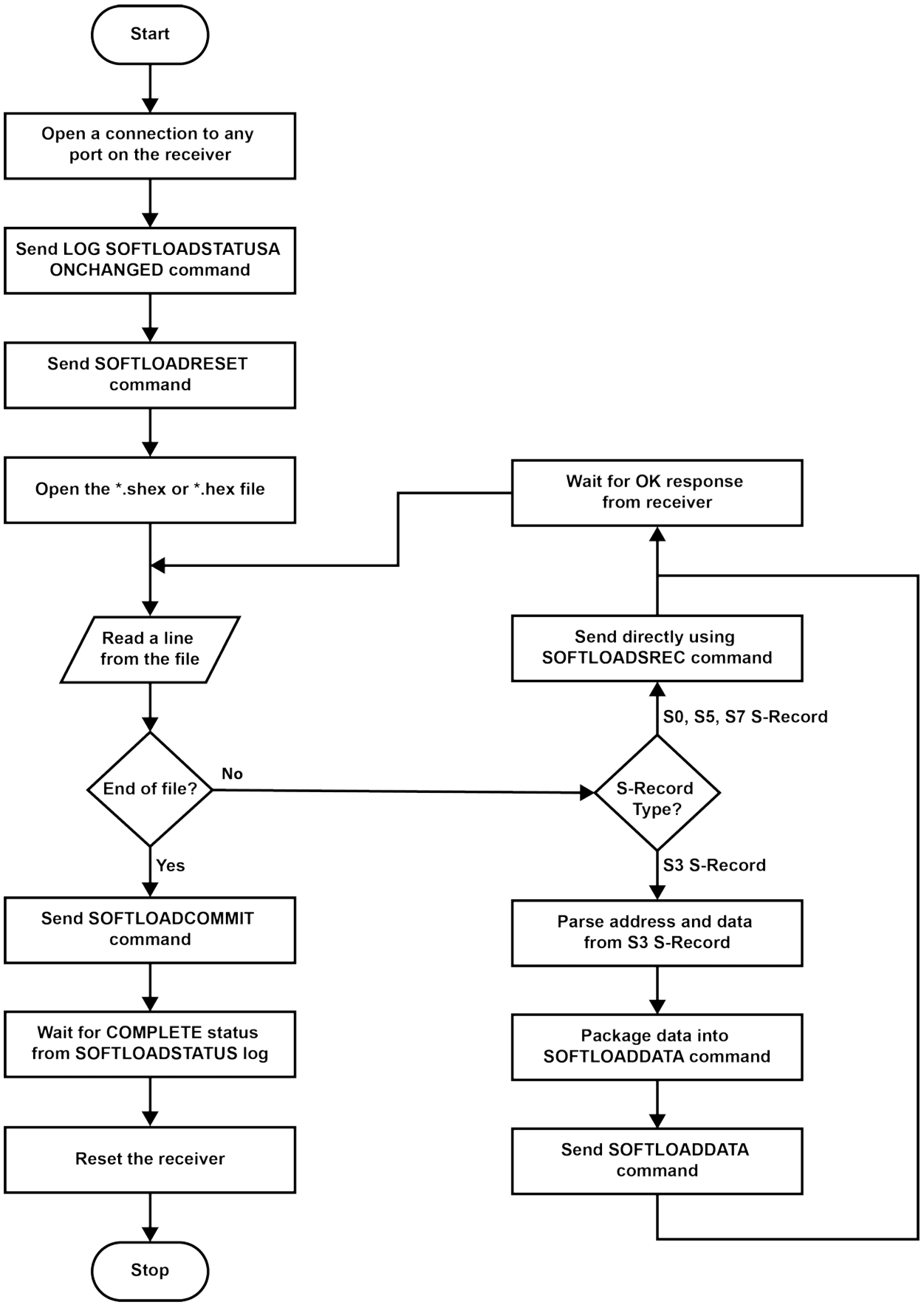
6. Send the **SOFTLOADCOMMIT** command after all data from the *.shex file has been transferred to the receiver. The SOFTLOADSTATUS log reports the status of the loading process. Wait for a SOFTLOADSTATUS log to indicate the status is COMPLETE. The COMPLETE status or an error is guaranteed to be output from the receiver within 300 seconds from the time the **SOFTLOADCOMMIT** command was received by the receiver.
7. Send the auth code for the newly downloaded image using the **AUTH** command. This is only required if there is not already a signature auth code on the receiver as signature auth codes are maintained through a SoftLoad update. See *Authorization Code* on page 117 for details on Auth Codes.

```
AUTH ADD_DOWNLOAD <AUTH CODE>
```

8. Reset the receiver using any of the following methods:
   - Enter the **RESET** command
   - Enter the **FRESET** command
   - Power-cycle the receiver

Once the receiver resets, the new version of firmware is active.

The SoftLoad process can be safely canceled at any time using the **SOFTLOADRESET** command or by otherwise resetting the receiver. Once the COMPLETE status is reported by SOFTLOADSTATUS, the new firmware image will be run after the receiver is reset.


Start
Open a connection to any port on the receiver
Send LOG SOFTLOADSTATUSA ONCHANGED command
Send SOFTLOADRESET command
Open the *.shex or *.hex file
Read a line from the file
End of file?
No
Yes
Send SOFTLOADCOMMIT command
Wait for COMPLETE status from SOFTLOADSTATUS log
Reset the receiver
Stop
Wait for OK response from receiver
Send directly using SOFTLOADSREC command
S0, S5, S7 S-Record
S-Record Type?
S3 S-Record
Parse address and data from S3 S-Record
Package data into SOFTLOADDATA command
Send SOFTLOADDATA command

9.4.5 SoftLoad Errors

It is possible for errors to occur during the SoftLoad update. All command responses should be checked to verify all issued commands were accepted. The SoftLoad status should also be monitored in the SOFTLOADSTATUS log. Any status enum value greater than the ERROR status indicates an error has occurred during the SoftLoad update. In the event of an error, the SoftLoad update should be restarted by issuing a **SOFTLOADRESET** command or normal operation can be restored by resetting the receiver.

In rare cases after a SoftLoad error, the boot code may not be able to determine which is the latest firmware to be executed. To protect against this, SoftLoad does not erase the previous valid firmware image from flash on the receiver. In such cases, the boot code will execute the old image and raise the "Safe Mode" error (see RXSTATUS log). If that error is detected, simply restart the SoftLoad process to reload the new firmware image and the error will be resolved.

9.5 Upgrading Using the AUTH Command

The **AUTH** command is used to upgrade to a new OEM7 receiver model with an authorization code that enables (unlocks) model features. This command only functions with a valid auth-code assigned by NovAtel Customer Support.

The upgrade can be performed directly through the NovAtel Connect command line or from any other communications program.

Refer to *Format of Firmware Files* on page 118 for details on updating versus upgrading.

9.5.1 Upgrade Procedure

1. Power up the OEM7 receiver and establish communications.
2. Issue the **LOG VERSION** command to verify the current model, firmware version and serial number (refer to *Authorization Code* on page 117 for instructions on obtaining).
3. Issue the **AUTH** command, followed by the auth-code and model type (refer to *Authorization Code* on page 117 for details on obtaining any auth-code). The syntax is as follows:

   ```
   auth <your auth-code here>
   ```

   where **auth** is a command that enables model upgrades and auth-code is the upgrade authorization code, expressed as follows:

   ```
   XXXXXX,XXXXXX,XXXXXX,XXXXXX,XXXXXX,MODEL,EXPDATE
   ```

   where:

   - Each X character is a case-insensitive ASCII character.
   - The MODEL string is a maximum of 15 characters long and represents the model enabled by the auth-code.
   - The EXPDATE string is the auth-code's expiry date, in YYMMDD format

   Example:

   ```
   auth 7WBMBK,887CB6,K5J3FH,5DF5P2,42PW8G,D1SB0GTT0,121211
   ```

When the **AUTH** command is executed, the OEM7 receiver reboots. Issuing the **LOG VERSION** command confirms the new upgrade model type and firmware version number.

If communicating using NovAtel Connect, the communication path must be closed and reopened using the Device menu.

APPENDIX A SMART7 Technical Specifications

Table 20: SMART7 Physical Description

Size		220 L mm x 192 W mm x 66 H mm
Weight	SMART7	<1.1 kilograms
NovAtel Models	SMART7	
	SMART7-I	
	SMART7-W	
	SMART7-S	

These specifications apply to the SMART7 and SMART7-S.

See the following sections for more information about the SMART7:

- *SMART7 Performance Specifications* on the next page
- *SMART7 Mechanical Specifications* on page 132
- *SMART7 Environmental and Electrical Specifications* on page 134
- *SMART7 Data Communication Specifications* on page 135
- *SMART7 Strobe Specifications* on page 135

For information about the cable available for the SMART7, see the following:

- *SMART7 Interface Cable (Optional Accessory)* on page 137

A.1 SMART7 Performance Specifications

All specifications subject to GNSS system characteristics.

These specifications apply to the SMART7 and SMART7-S.

Table 21: SMART7 Receiver Performance

Horizontal Position Accuracy[1]			**RMS**	**95%**
	Single Point	L1 only	1.5 m	2.4 m
		L1/L2	1.2 m	2.0 m
	NovAtel CORRECT	SBAS[2]	0.4 m	0.6 m
		DGPS	0.4 m	0.8 m
		PPP TerraStar-L[3] TerraStar-C PRO[3]	 40 cm 2.5 cm	 50 cm 3 cm
		RTK	1 cm + 1 ppm	2.5 cm + 2 ppm
Pass to Pass Accuracy[2]			**RMS**	**95%**
	Single Point[4]	L1/L2 GLIDE	-	≤35 cm
	NovAtel CORRECT[3]	TerraStar-L	-	≤15 cm
		TerraStar-C PRO	-	<2.0 cm
		RTK	1 cm + 1 ppm	2.5 cm + 2 ppm

[1]Typical values. Performance specifications in open sky conditions and are subject to GPS system characteristics, US DOD operational degradation, ionospheric and tropospheric conditions, satellite geometry, baseline length, multipath effects and the presence of intentional or unintentional interference sources.
[2]GPS only.
[3]TerraStar subscriptions are available from NovAtel or TerraStar. RMS/95% accuracy under ideal conditions and may vary upon users geographic region, ionosphere activity, scintillation levels or unintentional interference sources.
[4]Pass-to-pass accuracy over a period of 900 seconds when using GLIDE. GLIDE is a relative positioning filter specifically designed for use in open sky pass to pass applications. Absolute accuracy is not guaranteed.

			Code	Carrier
Measurement Precision (RMS)	GPS	L1 C/A	4 cm	0.5 mm
		L2 P(Y)	8 cm	1.0 mm
		L2C	8 cm	1.0 mm
	GLONASS	L1 C/A	15 cm	1.5 mm
		L2 P	8 cm	1.5 mm
		L2 C/A	8 cm	1.5 mm
Channel Configuration	555 Channels			
Signals Tracked	GPS	L1 C/A, L2P, L2C		
	GPS (optional)	L1C, L5		
	GLONASS	L1C/A, L2 C/A, L2P		
	GLONASS (optional)	L3 CDMA		
	BeiDou (optional)	B1I, B1C, B2I, B2a		
	Galileo (optional)	E1, E5 AltBOC, E5a, E5b		
	SBAS	L1		
	SBAS (optional)	L5		
	QZSS	L1 C/A, L2C		
	QZSS (optional)	L1C, L5		
	L-Band	Up to 5 channels[1]		
Maximum Data Rate	Measurements	up to 20 Hz		
	Position	up to 20 Hz		
Time to First Fix	Hot: <20 s typical (Almanac and recent ephemeris saved and approximate position and time entered) Cold: <40 s typical (No almanac or ephemeris and no approximate position or time)			

[1]Currently the receiver can track up to 3 L-Band channels.

Signal Reacquisition	L1	0.5 s typical
	L2	<1.0 s typical
Time Accuracy[1]	20 ns RMS	
Velocity Accuracy[2]	<0.03 m/s RMS	

The IMU performance specifications apply to the SMART7-S only.

Table 22: SMART7-S IMU Performance

Gyroscope Performance		
Input Rate (max)	±150 °/second	
Bias Repeatability	0.5 °/second	
Bias Instability	3.5 °/hour	
Angular Random Walk	0.1 °/√hour	
Accelerometer Performance		
Accelerometer Range	±5 g	
Bias Repeatability	15 mg	
Bias Instability	0.1 mg	
Velocity Random Walk	0.05 m/s/√hour	
Attitude Accuracy (SMART7-S)		
	RMS	**95%**
Roll	0.03	0.06
Pitch	o.03	0.06
Heading	o.1	0.5

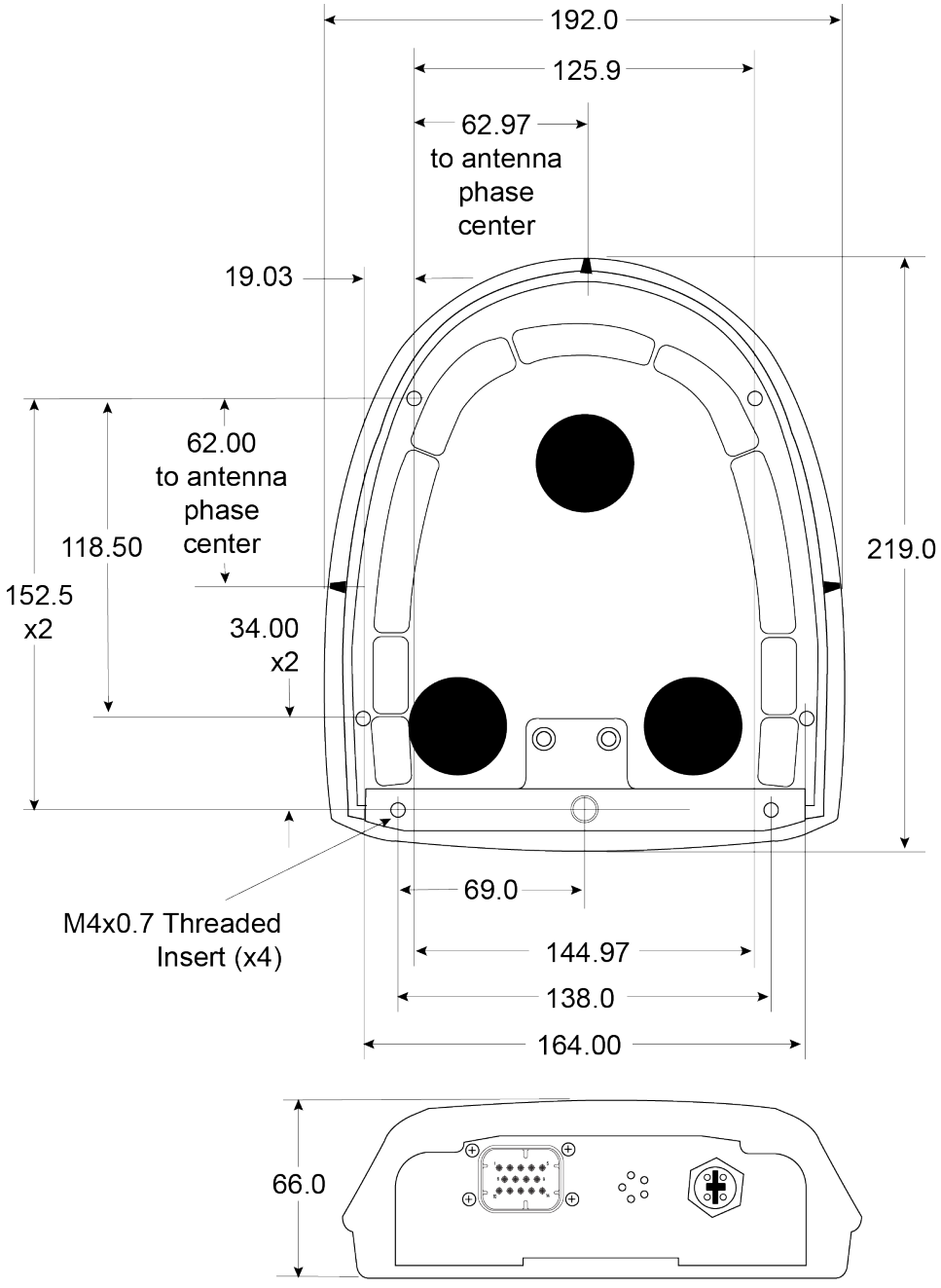
[1]Time accuracy does not include biases due to RF or antenna delay.

[2]Export licensing restricts operation to a maximum of 515 metres per second.

A.2 SMART7 Mechanical Specifications

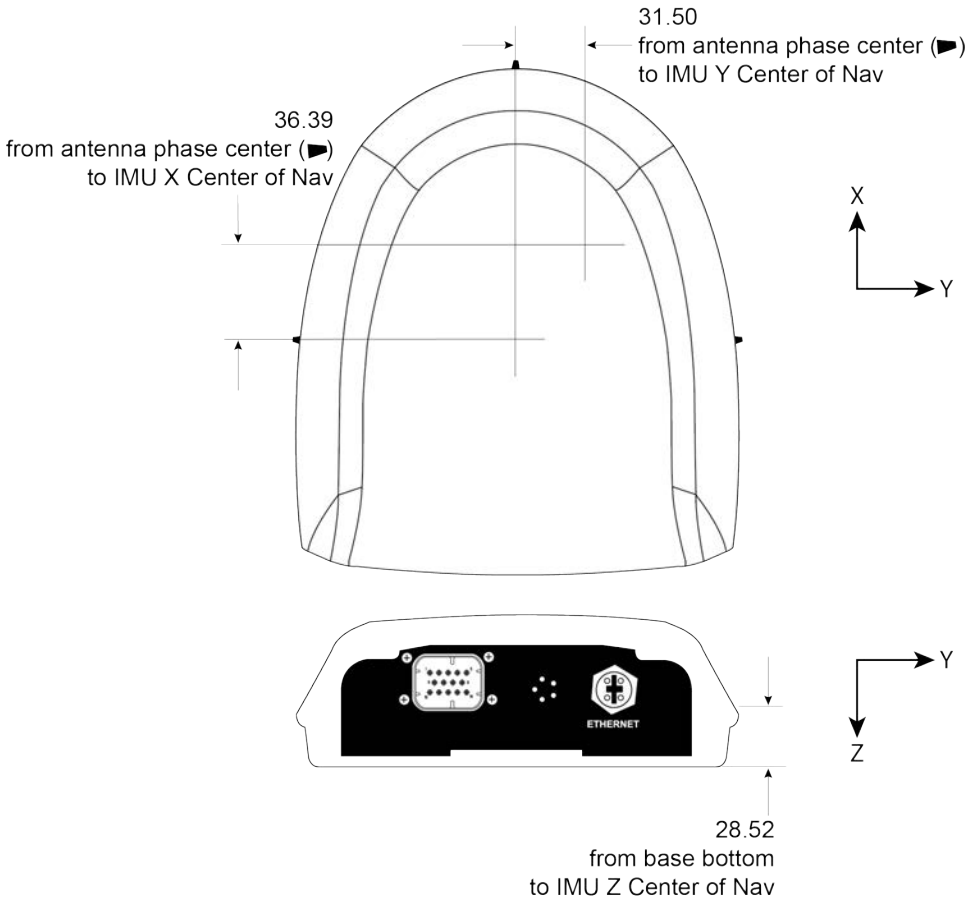
- *Figure 38: SMART7 Dimensions* below
- *Figure 39: SMART7-S Center of Navigation* on the next page

Figure 38: SMART7 Dimensions



Dimensions are in millimetres.

Figure 39: SMART7-S Center of Navigation



A.3 SMART7 Environmental and Electrical Specifications

These specifications apply to the SMART7, SMART7-I, SMART7-W and SMART7-S.

Table 23: SMART7 Environmental Specifications

Operating Temperature	-40°C to +70°C
Storage Temperature	-45°C to +80°C
Humidity	MIL-STD-810G(CH1), Method 507.6
Immersion	MIL-STD-810G(CH1), Method 512.6
Ingress Protection Rating	IP69
Shock	MIL-STD-810G(CH1), Method 516.7
Solar Radiation	EN60950-22 8.2, ISO 9022-9, Method 20, Severity Degree 03
Salt Fog	IEC 60068-2-11
Sand and Dust	MIL-STD-810G(CH1), Method 510.5
Random Vibration	MIL-STD-810G(CH1), Method 514.7

Table 24: SMART7 Power Requirements

Voltage	+7 to +30 VDC
Power Consumption	4 W typical, value for GPS L1/L2 These are typical values using serial ports without interference mitigation. These values can change with the number of satellites in view, firmware version, data logging rates and features in use. Use them as a guide for what you might expect but not as absolute values

A.4 SMART7 Data Communication Specifications

Table 25: Data Communications Interfaces

COM1, COM2, COM3	
Electrical format	RS-232
Data rates[1]	2400, 4800, 9600 (default), 19200, 38400, 57600, 115200, 230400 bit/s
Signals supported	COM1_Tx, COM1_Rx, COM2_Tx, COM2_Rx, COM3_Tx, COM3_Rx
SMART7 port	14-Pin Tyco Ampseal
CAN Bus	
Electrical Format	ISO 11898-2
Data rates	1 Mbps maximum CAN Bus throughput is determined by slowest device on the bus
SMART7 port	14-Pin Tyco Ampseal
ETHERNET	
Physical layer	10BASE-T/100BASE-TX
SMART7 port	M12 D-code male
Wi-Fi Access Point	
Security	WPA2
Encryption	AES
Wi-Fi Client Point	
Security	OPEN, WPA, WPA2
Encryption	TKIP, AES CCMP

A.5 SMART7 Strobe Specifications

All of the SMART7 strobe signals are available on the 14-Pin Interface connector. Pulse Per Second (PPS) strobes provide synchronization signal.

Refer to *SMART7 Interface Cable (Optional Accessory)* on page 137 for pin out details.

[1]Data rates higher than 115200 bit/s are not supported by standard PC hardware. Special PC hardware may be required for higher rates, including 230400 bit/s and 460800 bit/s.

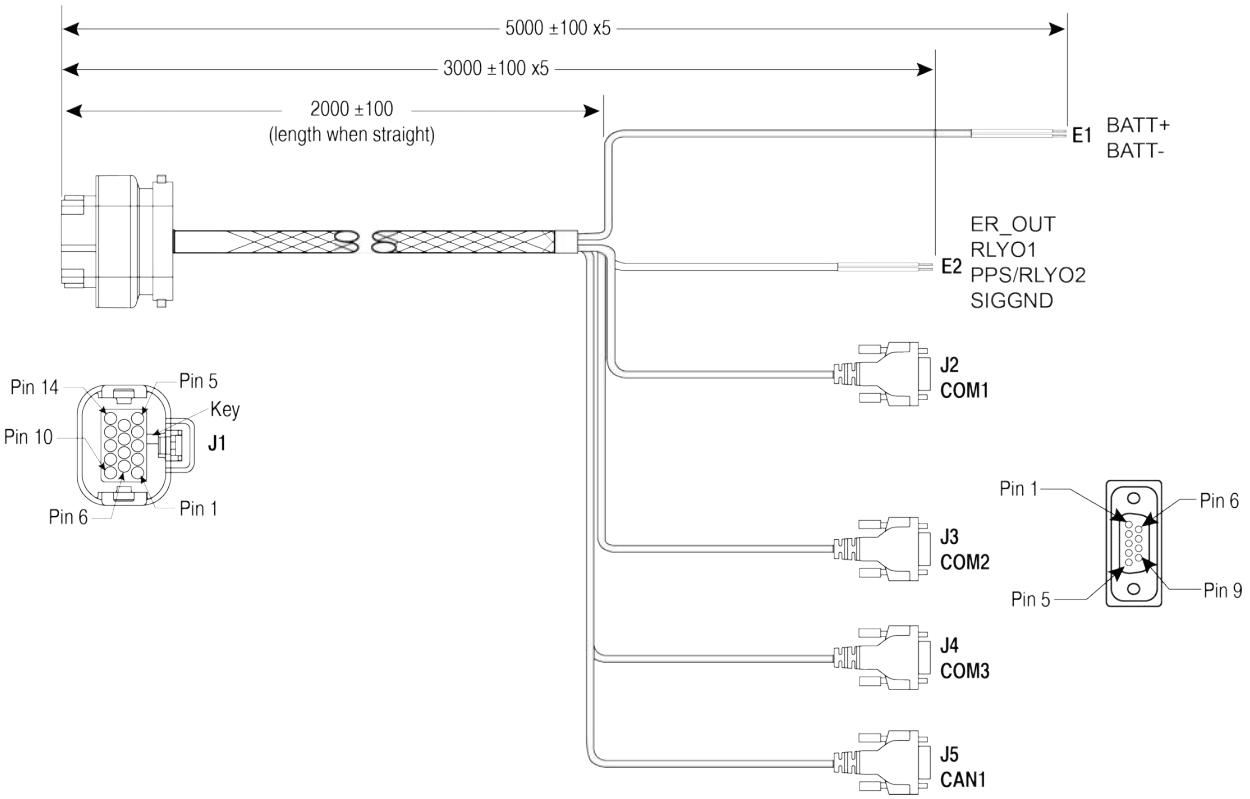
Table 26: SMART7 Strobes Description

Strobes	Input/Output	Comment
Emulated Radar (ER)	Output	0VDC to VBATT+ (also refer to *SMART7 Interface Cable (Optional Accessory)* on the next page)
PPS	Output	3.3V CMOS A time synchronization output. This is a pulse where the leading edge is synchronized to receiver calculated GNSS Time. The polarity, period and pulse width can be configured using the **PPSCONTROL** command

A.6 SMART7 Interface Cable (Optional Accessory)

The NovAtel part number for the SMART7 interface cable is 01019944. This cable provides access to all of the signals available on the SMART7 14-pin Tyco Ampseal connector. The exposed wires (BATT+ and BATT-) can then be connected to a vehicular power circuit (or equivalent) protected by a 5 A slow blow fuse (user supplied).

Figure 40: SMART7 Interface Cable



Dimensions are in millimeters.

Table 27: SMART7 Connector Pin Out

Signal Name	J1	J2	J3	J4	J5	E1	E2
COM1-TXD	1	2					
COM1-RXD	2	3					
COM2-TXD	3		2				
COM2-RXD	4		3				

Signal Name	J1	J2	J3	J4	J5	E1	E2
COM3-TXD	8			2			
COM3-RXD	13			3			
CAN1+	6				7		
CAN1-	7				2		
SIGGND	5	5					
SIGGND	5		5				
SIGGND	5			5			
SIGGND	5				3		
SIGGND	5						SIGGND
EMD RADAR OUT (E2)	10						ER_OUT
Reserved (E2)	11						
PPS (E2)	12						PPS
PWR RET (GND) (E1)	9					BATT-	
PWR INPUT (E1)	14					BATT+	

Table 28: 14-Pin Interface Connector

CAN	SAE J1939/ ISO 11783/ ISO 11898 Compatible
PPS Output	3.3 V CMOS Logic Compatible
Emulated Radar Output	High= Supply Voltage Maximum Low= 1.5 V Maximum Load= 3K Ohm Minimum

A.0.1 SMART7 Custom Cable Recommendation

To create a custom cable for the J1 port, a specific connector is required on the SMART7 end of the cable. See the following table for information about this connector.

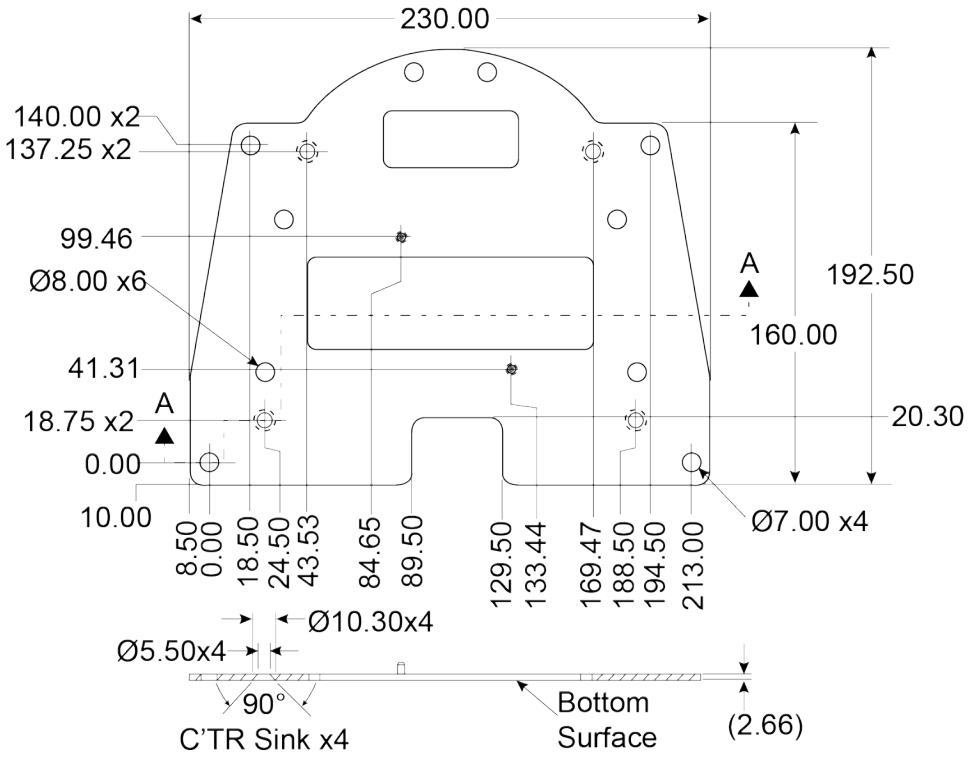
Table 29: I/O Connector

Connector	Description	Commercial Part Number
J1	AMP Seal 14-Pin Plug	776273-4

A.7 SMART7 Mounting Plate Specifications

The optional SMART7 mounting plate is NovAtel part number 1020089. The optimal screw penetration into the SMART7 mounting holes is 6 mm (±1 mm) deep. When selecting screws for mounting the SMART7, ensure the screw penetration does not exceed this specification. Using excessively long screws can damage the SMART7 enclosure.

Figure 41: SMART7 Mounting Plate Dimensions (Optional)



Refer to *Mounting and Orienting the SMART7* on page 23 for installation details.

APPENDIX B SMART7 Accessories and Replacement Parts

The following tables list the replacement parts available for your NovAtel SMART7 receiver. For assistance or to order additional components, contact your local NovAtel dealer or NovAtel Customer Support.

Table 30: SMART7 Products

Model/Part	Description
SMART7	
SMART7-I	Wi-Fi and Ethernet
SMART7-S	SPAN
SMART7-W	Wi-Fi
01020089	SMART7 Mounting Plate Kit
01019944	SMART7 Interface Cable