Precision-IQ: GNSS and Correction Services

USER GUIDE

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Easier Farming with Precision

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GNSS (**Global Navigation Satellite System**) is a satellite system that is used to pinpoint the geographic location of a user's receiver anywhere in the world. GFX/XCN/TME displays connect to and manage a NAV-900 navigation controller to connect to the various GNSS constellations.

This document contains some basic concepts for selecting the best connectivity for your configuration.

Tap the **GNSS** tile on the *Home* screen to begin:

Supported GNSS Constellations and Correction Services

Constellations	Corrections	Correction Formats

• GPS
• GLONASS
• Galileo
• BeiDou (COMPASS)
• QZSS
	Terrestrial Corrections
	
	  • CenterPoint® RTK
	  • CenterPoint VRS
	
	Satellite Corrections
	
	  • CenterPoint RTX
	  • RangePoint® RTX
	  • SBAS (WAAS, EGNOS, MSAS)
		• CMR+
		• sCMR+
		• sCMR+ with SecureRTK
		• CMRx
		• RTCM3
		   ◦ AG-820 (with firmware v11.22)
		   ◦ with third-party radio

GNSS Details in Precision-IQ

From the Precision-IQ *Home* screen, the GNSS tile provides a high-level, "at-a-glance" overview of the status of your GNSS connection. These details are:

Selected correction service: By default, Autonomous is selected as your correction service.

Satellites connection status: In the upper-right corner of the tile, the following colors indicate the GNSS status:

- **Green**: This status indicates a strong satellite connection, with enough connected satellites in a constellation for the correction service to respond accurately.

- **Yellow**: This status indicates a weak satellite connection, with fewer connected satellites in a constellation. Because there are fewer connected satellites, the correction service accuracy will be reduced.

- **Red**: A red status indicates that there are no satellites connected. You cannot enter the Run screen when the GNSS status is red.

Tap the **GNSS** tile for a full summary of the configuration.

From the GNSS screen, you can review all details about the GNSS settings and configuration. Tap the **Edit** button if you need to adjust the correction service or messaging.

GNSS Diagnostics

From the Precision-IQ activity bar, tap the **Diagnostics** icon to display the *Diagnostics* screen.
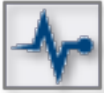
On the *Diagnostics* screen, tap **Performance** under *GNSS Receiver* to display overview details about the GNSS connection:

> **CAUTION –** The GNSS antenna may experience interference if you operate the vehicle within 100 m (300 ft) of any power line, radar dish, or cell phone tower.

Overview Tab

On the *Overview* tab, the following GNSS details are provided:

Solution Information

- **Satellites used:** Indicates number of satellites currently being used.
- **Correction Type:** The correction service indicated at setup.
- **Correction Source:** Modem, satellite / fast, satellite /SBAS.
- **Correction Status:** Fixed, Float or xFill.
- **Position Quality:** Tap to change. Favor accuracy, balance quality or favor availability.

HDOP (Horizontal Dilution of Precision)

This image indicates:

- Good (green): <1
- Moderate (yellow): 1 - 3
- Poor (red): >3

Estimated Horizontal Error

Current value in feet/inches or meters/centimeters

Additional Diagnostics	Description
Correction Age	• Good (green): <5 • Moderate (yellow) 5 - 10 • Poor (red) >10
Iono Scintillation	Amount of scintillation in the ionosphere: • Good (green): <2 • Moderate (yellow): 2.0 - 4.0 • Poor (red): >4.0
Max Correction Age	Shows highest value over the last 100 seconds
Cell Signal Strength	Strength of cell signal
CMR %	Shows current CMR percentage
Cell Data Packets Send/Received	Shows the amount of packets sent and received
VDOP	Vertical Dilution of Precision: • Good (green): <2 • Moderate (yellow): 2- 6 • Poor (red): >6
ANTENNA	Connection is on (green checkmark) or off (red X).
Correction Status	Status of the correction
Subscription Status	Shows date the subscription ends

Skyplot Tab

Tap **Skyplot** to view the number of satellites nearest to your position:

This screen shows satellites used and unused from all supported GNSS constellations.

Tracking Table Tab

Tap the **Tracking Table** tab for location and connection details for all used and unused satellites from supported GNSS constellations.

Radar Output Tab

Tap the **Radar Output** tab for details on adjusting the radar output frequency.

GNSS Troubleshooting

Conditions Affecting GNSS Accuracy

The GNSS positioning method influences the accuracy of the GNSS position reflected in your GNSS receiver. Additionally, the following conditions can affect GNSS accuracy.

Condition	Description
Atmospheric effects	GNSS signals are degraded as they travel through the ionosphere. The error introduced is in the range of 10 meters. The error is removed by using a differential or RTK positioning method.
Number of satellites used	To calculate a 3D position (latitude and longitude, altitude, and time), four or more satellites must be visible. To calculate a 2D position (latitude and longitude, and time), three or more satellites must be visible. For RTK positioning, five satellites are needed for initialization. Once initialized, four or more satellites provide RTK positions. The number of visible satellites constantly changes and is typically in the range 5 through 9. The receiver can track up to 44 satellites simultaneously.
Condition Explanation	Maximum PDOP Position Dilution of Precision (PDOP) is a unitless, computed measurement of the geometry of satellites above the current location of the receiver. A low PDOP means that the positioning of satellites in the sky is good, and therefore good positional accuracy is obtained.
Signal-to-noise ratio	Signal-to-noise ratio (SNR) is a measure of the signal strength against electrical background noise. A high SNR gives better accuracy. SNR can be degraded by other electronic equipment operating nearby, including transmitters, cell phones, or data modems. It may also be degraded by solar flares and changing atmospheric conditions.
Minimum elevation	Satellites that are low on the horizon typically produce weak and noisy signals and are more difficult for the receiver to track. Satellites below the minimum elevation angle are not tracked.
Multipath environment	Multipath errors are caused when GNSS signals are reflected off nearby objects and reach the receiver by two or more different paths.
RTK Base station coordinate accuracy	For RTK positioning, it is important to know the base station coordinates accurately. Any error in the position of the base station affects the position of the rover; every 10 m of error in a base station coordinate can introduce up to 1 ppm scale error on every measured baseline. For example, an error of 10 m in the base station position produces an error of 10 mm over a 10 km baseline to the rover. For more information about how to make sure the position of your base station is accurate, refer to the manual for your base station receiver.
Multiple RTK base stations	If you are using several base stations to provide RTK corrections to a large site area, all base stations must be coordinated relative to one another. If they are not, the absolute positions at the rover will be in error.

Poor Accuracy (Multipath)

Poor accuracy can be due to GNSS signals reflecting off nearby trees and/or metal buildings and horizontal surfaces. (Reflection is also called multipath.)

To reduce multipath noise, mount the GNSS receiver so that it has a clear view of the sky. The receiver must be away from trees and large metal objects.

Intermittent Loss of Lock on Satellite

- The receiver loses the satellite signal from time to time: Make sure that the receiver is mounted on the highest point of the vehicle and is clear of metal surfaces.

- Signal takes a long time to initialize:

  - In RTK mode, longer baselines require longer initialization times. (The baseline is the distance between the base receiver and the rover receivers.)

  - Wait for the receiver to initialize or consider repositioning the base receiver to shorten the baseline. Make sure the rover receiver is in a clear area.

Loss of Initialization

In RTK mode initialization can be lost when the rover receiver is close to trees or buildings and the number of satellites falls below four. Additionally, initialization may be lost if the receiver has not been tracking RTK corrections for some time.

- Move away from trees and obstructions to initialize. Once initialized, approach the obstructed area again. If the obstructions are severe, GNSS positioning may not work in that area.

- Because the GNSS satellites move, there may be times of the day when you are working in an area with obstructions.

Not Tracking RTK Corrections

The radio link is down or intermittent. Ensure that:

- The line-of-sight between the base and rover receivers is not obstructed.

- The rover receiver is within range of the radio.

- The radio power supply is on.

Poor Signal/Not Receiving a Clear Signal

Problem	Resolution
Interference from 2-way radios	Transmitting FM 2-way radios can interfere with WAAS and GNSS signal reception. Make sure that there is at least 1 m (3 ft) between the FM 2-way radio antenna and the receiver.
Vehicle issues	An unshielded ignition system can cause enough noise to block reception of a differential signal. Use resistor spark plug wires on the vehicle ignition system. An alternator can cause noise that interferes with a differential signal. **NOTE –** Before replacing engine parts in an attempt to solve this problem, make sure that the problem is not caused by a computer or power source near the receiver. Some computers and their power sources cause noise that disrupts GNSS and satellite DGNSS signals. Possible solutions include:

Problem	Resolution
	- Use bypass capacitors, commonly available in automotive stores for cleaning up interference to CB and other radios. If the problem persists, shield engine components with aluminum foil. - Relocate the antenna on the machine. Determine the optimal antenna location.
GNSS receiver issues	**Mounting location:** The receiver may not be picking up a clear signal due to mounting location. Mount the receiver on the centerline of the vehicle, away from any sources of interference and with a clear view of the sky. **Cable problems:** Use an ohmmeter to check the cable. The resistance of a good cable between connector pins at each end of the cable is zero. If the cable is sound, but the problem persists, try exchanging the cable with one that you know is working. If the cable is defective, contact your local Trimble Reseller for an RMA number (if the Trimble product is still under warranty), or to purchase a replacement cable. **Battery:** A lithium-ion battery in the receiver powers the internal real-time clock. This clock enables the receiver to get an initial fix faster. The battery has a life of 7.5 years. When the battery fails, the internal clock cannot keep accurate time and the receiver may take longer to output GNSS positions. Please contact your local Trimble Reseller to get the batteries replaced. You cannot replace the battery yourself.

The Receiver is Not Tracking Any Satellites

Possible Cause	Solution
The GNSS antenna does not have clear line of sight to the sky.	Ensure the antenna has a clear line of sight.
The cable between the receiver and the GNSS antenna is damaged.	Replace the cable.
The cable connections at receiver or antenna are not tightly seated, or are connected incorrectly.	Check all cable connections.

Messaging

CAN Messaging

If you wish to send messages from the GNSS receiver in the NAV-900 guidance controller, you can set up what messages will be sent from CAN port A or B. If you are using an ISO-certified implement, use this setting to send information to the implement such as speed.

1. From the GNSS *Edit* screen, tap **CAN Messaging**.

2. Tap the CAN port that you want to change settings for. Choose the messages for the GNSS receiver in the NAV-900 to send to ISO-certified equipment. The list that displays for each CAN port shows the messages and their parameter group number (PGN). For each message, you can choose how often the message is sent:

   - Off (never sent)

   - 10 Hz, 5 Hz or 1 Hz

   - Every 5, 10, 30 or 60 seconds

3. When you are finished, tap the green check mark.

To use ISO-certified equipment, set up what messages will be sent from the GNSS receiver to the implement, such as speed:

1. From the Activity bar on the Home screen, tap the **Universal Terminal** icon to open the Universal Terminal.

2. In the upper right corner, tap the **Menu** icon, then tap the **Messaging** tab.

3. Turn on the settings appropriate for your setup:

   - GNSS Vehicle Position (PGN 65267)

   - GNSS Vehicle Direction/Speed (PGN 65256)

   - Wheel-based Speed (PGN 65096)

   - Ground-based Speed (PGN 65097)

4. When you are finished, tap the green check mark.

NMEA Output Messaging

Setting	Explanation
Message Rate	How often the message is sent. Options are: • Off • 1 Hz • 1 min • 3 Hz • 30 sec • 5 Hz • 10 sec • 10 Hz
Output Port	Use the NMEA port on your cable harness.
Baud Rate	Baud rate. Options are: • 2400 • 19200 • 4800 • 38400 • 9600 • 57600
Maximum CGA Quality	How high the quality of the message should be.
Latitude/Longitude Precision	Options are **1** through **10**.
Messaging	Choose which messages are **on** or **off**.

NMEA Message Calculation

The calculation of the GPS position depends on your configuration.

Type of Steering	Source / Port
Manual guidance	N/A
Autopilot system	Cable harness
Autopilot system	NavController

Supported NMEA Messages

Message	Description	Information Contained
GGA	Fix information	• UTC date and time • Position
GSA	Overall satellite data	• UTC date and time • Position
GST	GPS Pseudorange Noise Statistics	
RMC	Recommended minimum data for GPS	• UTC date and time • Position • Course • Speed
VTG	Vector track and Speed over the Ground	• Course • Speed
ZDA	Date and time	

NMEA Input Messaging

The NMEA [0183] Input feature allows Precision-IQ users to use GNSS position data from a receiver configured to provide NMEA messages.

The NMEA [0183] messages are transmitted serially and input to the Precision-IQ application through the serial port of the display.

When using NMEA [0183], a display can be configured for manual guidance only.

> **NOTE –** Auto guidance functionality requires the use of a NAV-900 or NAV-500 receiver.

NMEA Input Technical Requirements

To be able to use the NMEA [0183] messages of a position source with Precision-IQ, the following requirements apply, if necessary the position source must be configured accordingly.

Required NMEA messages (adjustable at the position source):

- $GPGGA
- $GPVTG

Required update rate of the NMEA messages

- min. 5 Hz update rate for the above messages

Transmission rate (baud rate) of the serial interface:

- min. 19200 bps to max. 115200 bps

A license is required on the display, and the following cable is recommended:

Part Number	Description	
93451-81	License, Display-Multi-type:NMEA Position Input: No Expiry	
114078	Cable Assy, GFX/XCN, Expansion Port I , Dig I/O, RS232, Analog AgCam, 2.5m	

NMEA Input: Display Wiring Instructions

Connect the position source to the display as follows:
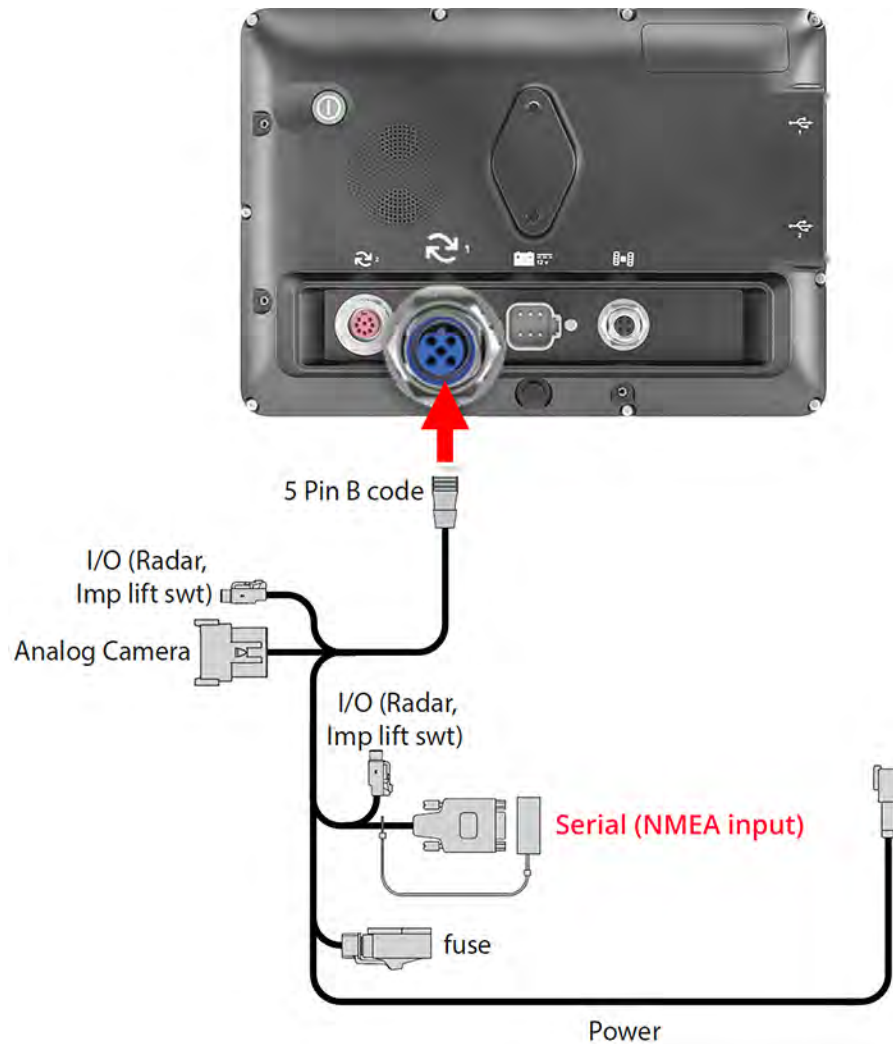
Connect the receiver configured to provide NMEA messages to the **Serial (NMEA input)** connector of the cable.

> **NOTE –** Make sure that the position source is supplied with voltage.

You may need to use a null modem cable between the position source and the Serial (NMEA input) connector to establish the correct polarity of the connections.

NMEA Input: Configuration and UI Instructions

Follow the steps below to use an NMEA [0183] position source with Precision-IQ:

1. On the Precision-IQ *Home* screen, tap the **GNSS** tile:
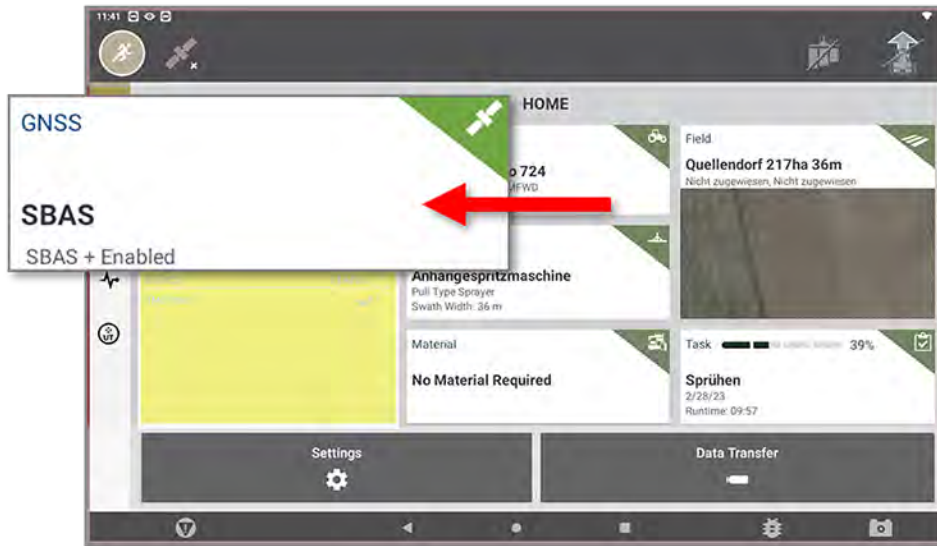
2. On the GNSS *screen* tap the **Edit** button:
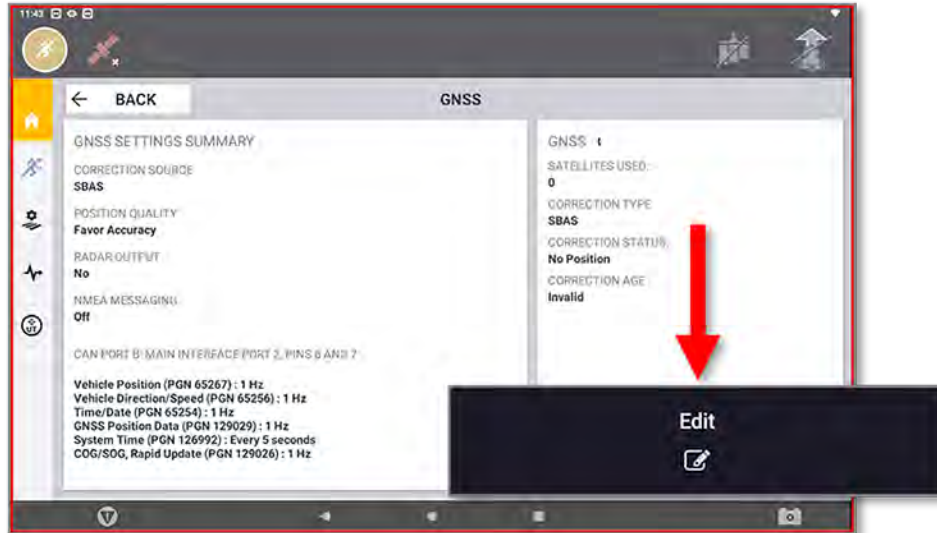
3. On the *GNSS : Edit* screen tap the **Receiver Type** field and select **NMEA [0183]** from the dialog window:
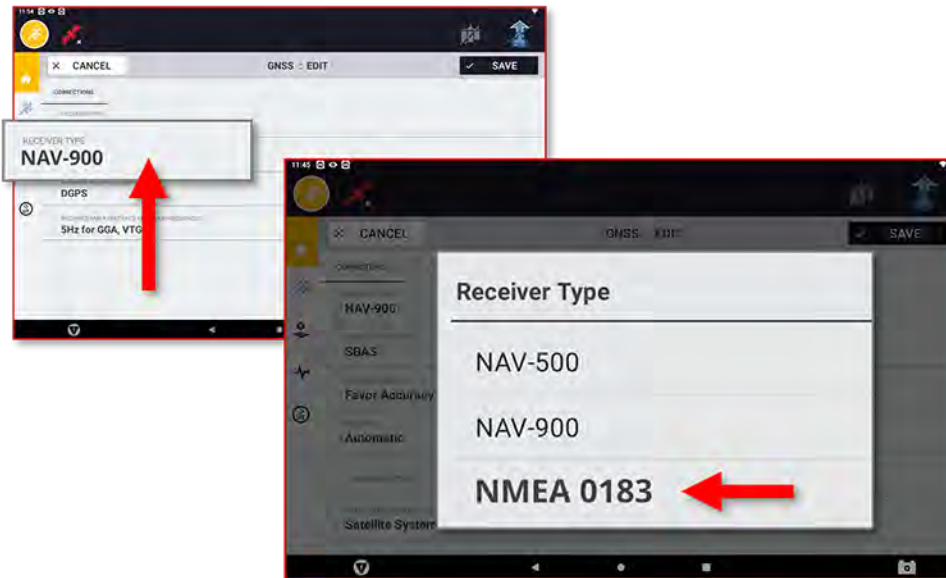
4. Next, tap the **Serial Port Baud Rate** field and select the desired transmission rate:
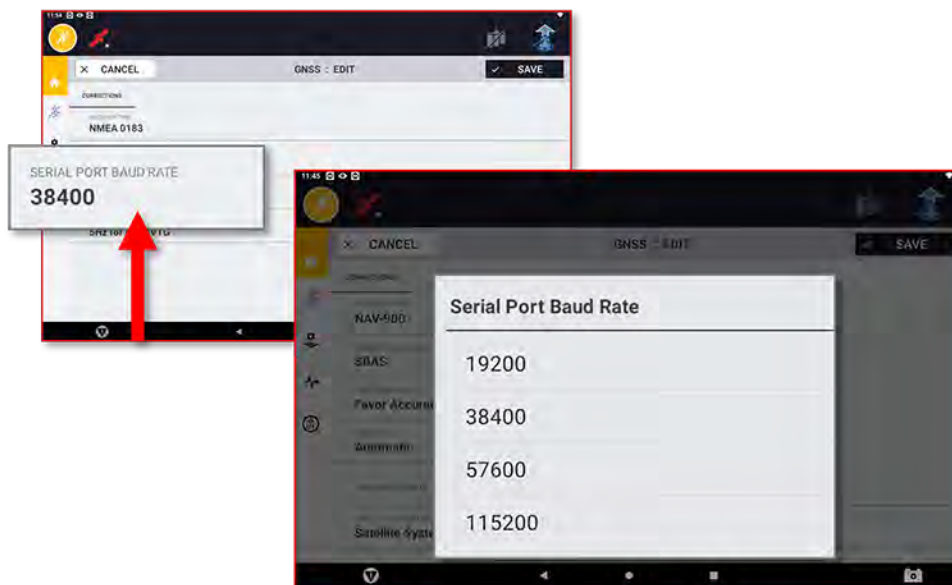
> **NOTE –** The transmission rate (baud rate) must be identical for position source and display.

5. Next, tap the **Minimum Required Signal Quality** field and select the GNSS signal quality that is required as a minimum for your work:
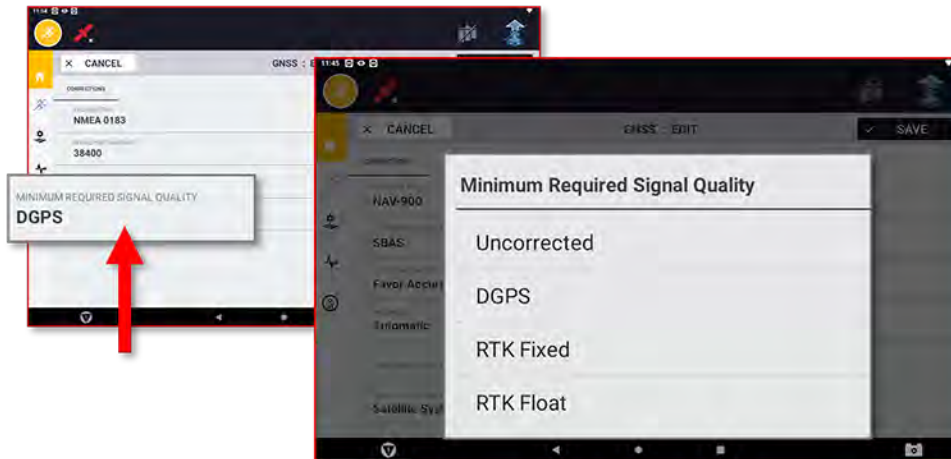
6. Finally, tap the **Save** button to save the GNSS settings:
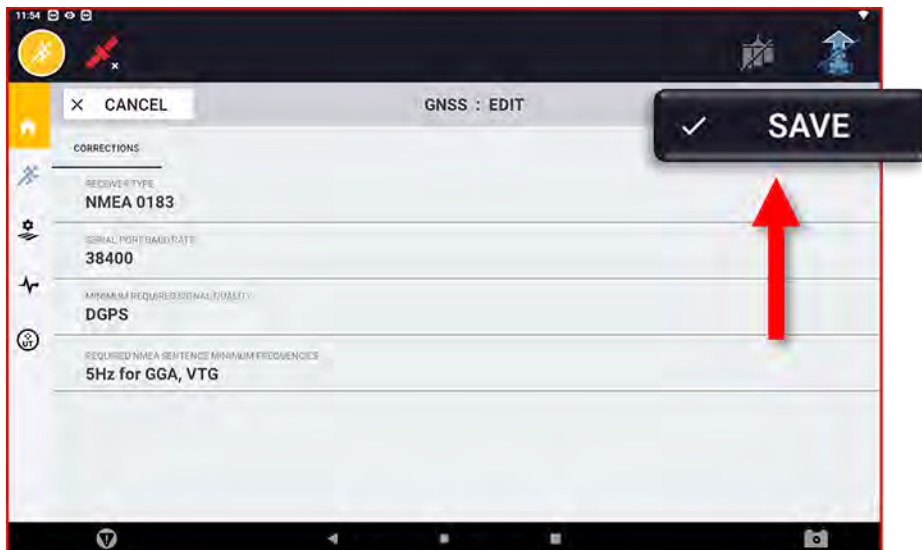
    You will be returned to the GNSS screen.

7. Check the information on the GNSS screen:
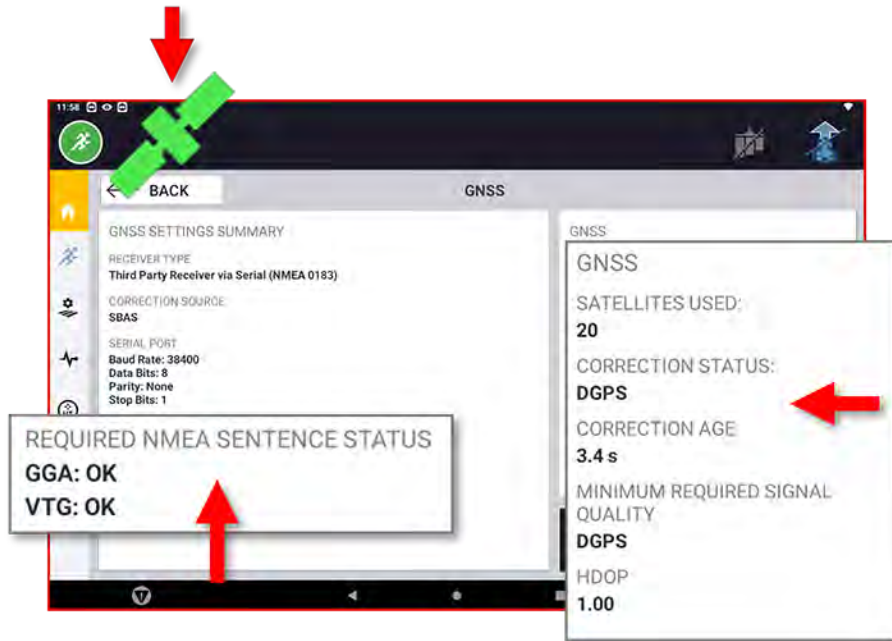
- When NMEA messages are successfully received from the position source, the *Required NMEA Sentence Status* will update to show:

  GGA: OK

  VTG: OK

- A green satellite symbol appears in the header of the application.

- Information about the received data is available in the *GNSS* info window on the right side of the screen.

8. Tap the **Back** button to exit the *GNSS* screen and return to the Precision-IQ *Home* screen.

NMEA Input: Diagnostic Instructions

More information about incoming NMEA messages is available through the Precision-IQ *Diagnotics* screen:

1. On the Precision-IQ *Home* screen, tap the **Diagnostics** icon on the left side of the screen:

2. On the *Diagnostics* screen, tap **Performance** for the *GNSS Receiver (External)* option:

A page with further diagnostic information on the incoming NMEA messages appears:

NMEA Data Logging Instructions

Follow the steps below to record NMEA messages to the TME display:
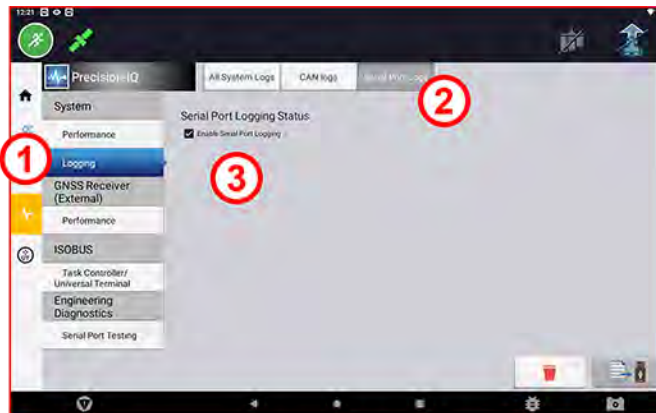
1. On the *Diagnostic* screen, tap **Logging** for the *System* option.

2. Tap the **Serial Port Logs** tab.

3. Tap to enable the **Enable Serial Port Logging** option.

> **NOTE –** The log files are stored on the display and can be transferred to a USB memory device.

Transfer NMEA Log Files

Once the NMEA messages have been recorded, follow the steps below to transfer the log files from the display to a USB memory device.

1. Insert a USB memory device into one of the USB ports of the display:

2. On the *Diagnostics* screen, tap the **Transfer** icon at the bottom right of the screen.

> **NOTE –** Only if the USB memory device was successfully detected, the USB memory device icon is displayed in green.

3. The following message is displayed in the lower edge of the screen after the log file(s) are successfully transferred to the USB memory device:
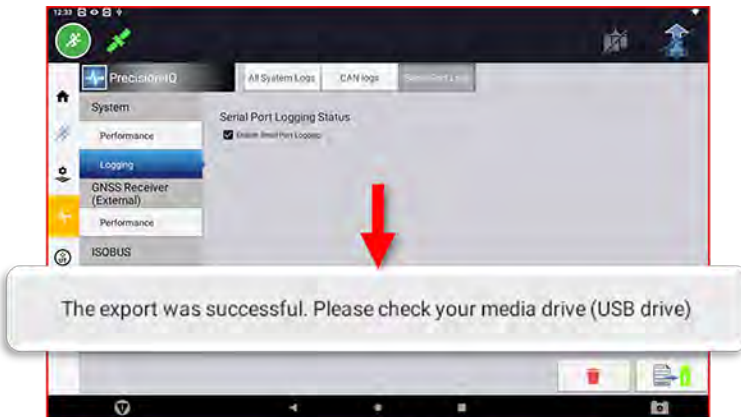
4. Remove the USB memory device and insert it into your Windows PC to check whether the log file(s) are on it. The log file(s) are located in the **serial_logs** folder and are named according to the date and time they were created:

3
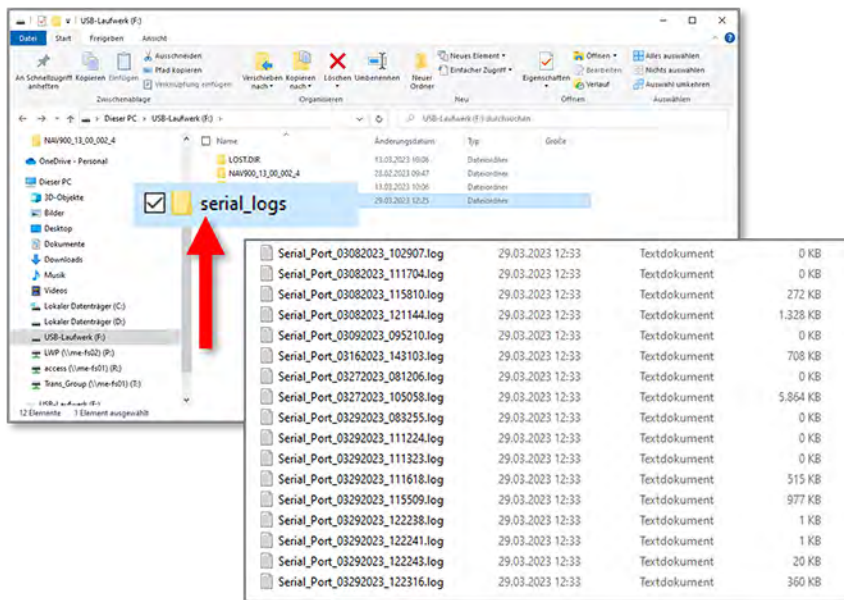
Correction Services Supported by Precision-IQ

Correction Services Overview

GNSS satellites are in continuous motion as they orbit the earth twice per day in a repeated pattern. Satellites transmit signals that the GNSS receiver translates to determine its position.

While performing field activities, you may notice differences in:

- Where the crop row is located.
- Where the guidance line was established.
- Where the display is indicating the guidance line is now located.

This happens because GNSS satellite constellation patterns change over time and can experience interference, such as local and atmospheric conditions, temperature and humidity, etc.

Precision-IQ supports a variety of correction services that are available to compensate for deviations in GNSS constellation patterns as well as interference with the satellite signal.

Tap the **Edit** button on the GNSS details screen to display the GNSS Edit screen. By default, the Corrections option is selected. With this option, you can change the correction service, position quality, and radar output.

Correction Service: Tap this item for a pop-up list of all available correction services.

By default, **Autonomous** is selected as the correction source. Tap a different correction source to select it.

> **NOTE –** Most correction services require a license.

If you change the correction service, then you may need to adjust additional settings, depending on your selection.

Position Quality: Tap this item to allow Precision-IQ to give preference to:

- Favor Accuracy: Use for operations needing highest accuracy (such as row crop planting and strip-till). This option is selected by default.
- Favor Availability: Expands production time further with potential for reduced accuracy.
- Balanced Quality: Trades potential accuracy for longer production time.

Radar Output: Tap to enable radar output. If enabled, then tap **Radar Output Frequency** to enter a specific radar frequency. You can choose between **27.36** and **96.56** Hz/mph.

Correction Services Licensing Requirements

The following permanent licenses, subscriptions, and VRS daemon licenses are required to enable the following features on supported displays:

Correction Service	License	License Type Required
RangePoint RTX	Basic	Permanent license (installed at factory)
	Valid RangePoint	Subscription
CenterPoint RTX Std-Cell	Intermediate	Permanent license (purchased)
	Valid Std-Cell, Std-Sat, or Fast-Sat	Subscription
	DCM Correction Services	VRS daemon licenses
CenterPoint RTX Std-Sat	Intermediate	Permanent license (purchased)
	Valid Std-Sat or Fast-Sat	Subscription
CenterPoint RTX Fast-Sat	Intermediate & High	Permanent licenses (purchased)
	Valid Fast-Sat	Subscription
CenterPoint RTK (SBL)	Intermediate & High	Permanent licenses (purchased)
CenterPoint VRS	Intermediate & High	Permanent licenses (purchased)
	VRS daemon	May be required on display if using third-party modem. Not required for Trimble GX450 modem.
xFill Premium	Intermediate & High	Permanent licenses (purchased)
	Valid xFill Premium or Std-Sat or Fast-Sat	Subscription

SBAS Corrections

The satellite-based augmentation systems (SBAS) with free correction services are:

- WAAS (Wide Area Augmentation System) in North America
- EGNOS (European Geostationary Navigation Overlay Service) in Europe
- MSAS (Multi-functional Satellite Augmentation System) in Asia Pacific regions

From the GNSS *Edit* screen, tap **Correction Services** and then tap **SBAS** from the pop-up list to select it. Tap **Setup** to:

- **Correction Satellite Select:** By default, *Automatically selected from current location* is selected. Tap this item to select a specific correction satellite from a pop-up list.
- **SBAS+:** Tap to enable. This feature uses uncorrected satellites in addition to SBAS.

RangePoint RTX Corrections

> **NOTE –** This feature is optional and requires a subscription.

RangePoint® RTX is a satellite-based subscription service for corrections with pass-to-pass accuracy < 6" (15 cm) and GLONASS compatibility.

The GNSS receiver in the NAV-900 and TM-200 Module receives these signals.

From the GNSS *Edit* screen, tap **Correction Services** and then tap **RangePoint RTX** from the pop-up list to select it. Update the appropriate specific RangePoint RTX options, then tap **Home** to return to the *Home* screen.

CenterPoint RTX Corrections

> **NOTE –** This feature is optional and requires a license and a subscription.

The types of CenterPoint® RTX correction are:

- CenterPoint RTX Satellite Corrections: Standard convergence, fast convergence for US, fast convergence for EU.
- CenterPoint RTX Modem Corrections

CenterPoint RTX Satellite Corrections

CenterPoint RTX satellite broadcast subscription services for corrections have a **< 1.5"** (3.8 cm) accuracy and GLONASS compatibility. The RTX satellite corrections available are:

- CenterPoint RTX Satellite Standard.
- CenterPoint RTX Satellite Fast for US and EU.

CenterPoint RTX Modem Corrections

CenterPoint RTX Modem/Standard is a cellular broadcast subscription service for corrections with **< 1.5"** (3.8 cm) accuracy and GLONASS compatibility. A connected wireless modem receives these signals.

From the GNSS *Edit* screen, tap **Correction Services** and then tap **CenterPoint RTX Modem (Standard Convergence)** from the pop-up list to select it. Update the appropriate specific CenterPoint RTX Modem options, then tap **Home** to return to the *Home* screen.

The GNSS receiver in the TM-200 and NAV-900 guidance controller receives these signals.

From the GNSS *Edit* screen, tap **Correction Services** and then tap **CenterPoint RTX Satellite (Standard Convergence)** from the pop-up list to select it. Update the appropriate specific CenterPoint RTX Satellite options, then tap **Home** to return to the *Home* screen.

CenterPoint RTX Frequency and Baud Rates

The CenterPoint RTX frequencies and baud rates for regions are:

Region	Frequency	Baud Rate
Asia/Pacific	1539.8325 MHz	600
Central North America	1557.8150 MHz	2400
Eastern North America	1557.8590 MHz	600
Western North America	1557.8615 MHz	600
Europe/Africa	1539.9525 MHz	600
Europe (RTX EU)	1529.7250 MHz	2400
Latin America	1539.8325 MHz	600

CenterPoint VRS Corrections

NOTE – This feature is optional and requires a license.

CenterPoint® VRS™ is a cellular-broadcast RTK correction service from a ground-based reference station using the a modem. (Requires a connected wireless modem.)

From the GNSS *Edit* screen, tap **Correction Services** and then tap **CenterPoint VRS** from the pop-up list to select it. Update the appropriate specific CenterPoint VRS options, then tap **Home** to return to the *Home* screen.

RTK Corrections

RTK is a radio-broadcast correction service originating from a ground-based reference station, and received by radio signal. Follow the steps below to set RTK options:

1. From the GNSS *Edit* screen, tap **Correction Services**.

2. Tap **RTK** from the pop-up list to select it.

3. Update the appropriate specific RTK options.

4. Tap **Home** to return to the *Home* screen.

About VRS

VRS™, an integrated system available with a subscription, is complementary to RTK and provides RTK corrections over a large geographic area, where robust cellular data coverage is available. Network processing ensures high accuracy throughout the whole coverage area.

VRS consists of:

- GPS/GNSS reference stations spread out over a large area, typically 30-45 miles (50-70 km) apart.

- A central server that uses Trimble proprietary software to create a correction model for the region covered by the network. GPS rovers communicate using a cell modem with the VRS server and receive RTK type corrections. The data from the reference stations is used to model errors throughout your region. The model is used to:

  - Create a network of virtual reference stations near your current location.

  - Provide a localized set of standard format correction messages for your roving receiver. Since the error models are updated every second, all rovers receive an optimal correction model after connecting on to the network. This ensures a high quality correction, and accuracy.

All reference stations used in a VRS system can be interpreted as a network of continuously operating reference stations. The difference between VRS and CORS is that VRS provides a network solution. The position accuracy is maintained even if you move away from the single base but are still within the network.

Due to the longer range, fewer base stations can cover a greater region. Additionally, VRS networks may offer better signal coverage in rough terrain if the local cellular network is robust and provides good data coverage.

xFill Premium

The xFill® Premium service allows continued field operations during RTK/VRS signal interruptions, delivering Trimble RTX position accuracy for the duration of the interruption. This service extends the Trimble standard xFill service, which is limited to 20 minutes.

In the RTK configuration setup, make sure that **xFill** is switched on. Turning on xFill will also turn on xFill Premium.

The xFill Premium service will converge in the background and then calibrate itself as a backup to the specific RTK base station or VRS stream that is being used. This automatic calibration process typically takes between 15 and 60 minutes.

Once the automatic calibration is complete, if the display experiences RTK/VRS corrections outages, then the display will initially transition into standard xFill service, and subsequently transition into xFill Premium

service. The display will continue to operate in the xFill Premium service until the RTK/VRS corrections resume.

> **NOTE –** The basic xFill feature is a free add-on for those using VRS or RTK corrections.

About xFill Technology

xFill technology uses Trimble RTX technology to "fill in" for RTK corrections when there are temporary radio or Internet connection outages. xFill technology is a standard feature and is compatible with the AG25 GNSS antenna. The xFill technology can function with corrections from single-baseline RTK, VRS and CORS systems.

When there is an interruption of the RTK correction signal (either from the radio base station or from the VRS cellular network), the xFill technology performs corrections. xFill technology uses the last-known RTK position combined with the RTX precision satellite data to maintain a high level of horizontal positioning accuracy for up to 20 minutes. There is a smooth transition from RTK to xFill technology and back to RTK.

Automatic Guidance Systems Using xFill

If an auto-steering system is engaged using RTK, the auto-steer system will stay engaged during the 20 minute xFill coverage. As soon as an RTK signal is available, the receiver will switch back to the RTK correction service and xFill will remain on standby in the background. If the system cannot resume an RTK Fixed status within 20 minutes the system will fall back to DGPS correction and the auto-steer system will disengage.

Accuracy When xFill Engaged

xFill technology can maintain a relatively high level of horizontal accuracy throughout the RTK outage period. However, accuracy is primarily dependent on three factors:

- GNSS satellite availability and obstructions between the satellite and receiver (trees, buildings, and so on).
- Exactness of the base station position.
- Length of time since the last RTK position (maximum allowable time is 20 minutes).

If you are concerned with maintaining sub-inch precision, disable the xFill feature. Estimated accuracy over time while the xFill function has been active (with base station accuracy <20 cm) is as follows:

- xFill runtime - no RTK corrections estimated error
- 1-5 minutes 1-5 cm
- 6-10 minutes 5-9 cm
- 11-20 minutes 10-15 cm

Dependence on Satellite

xFill technology requires correction data from at least 5 satellites higher than 10 degrees from the horizon. If GLONASS is unlocked at the RTK level, xFill technology will also be able to use GLONASS satellites. Additionally, large objects such as trees, buildings, and grain bins will significantly decrease or completely block signal reception from all satellite types, including GPS, GLONASS, and corrections satellites. If these same obstructions are between the receiver and the satellite, they may also block xFill signals.

> **WARNING –** Many large and sudden changes in satellite geometry caused by blocked satellites can cause significant position shifts. If operating under these conditions, auto-guidance systems can react abruptly. To avoid possible personal injury or damage to property under these conditions, disable the auto-guidance system and take manual control of the vehicle until conditions have cleared.

Dependence on Base Station Position

When the RTK correction signal is lost, the RTX satellite begins providing correction based on the last RTK position. When you set up xFill and select the datum in which you surveyed your base station, the firmware translates your position into the ITRF datum reference frame to minimize drift. Any other inaccuracies in the base station position can cause a drift in position over time.

As time elapses, correction data from the satellites causes drift from the RTK line. The larger the difference in surveyed base station position, the larger the drift as shown in the table below.

The following table shows how the xFill drift over time is impacted by the accuracy of the base station survey coordinates:

xFill Elapsed Time	Survey Accuracy <20cm	Survey Accuracy <2m	Survey Accuracy <5m
0 to 5 min	0 to 5 cm	0 to 15 cm	0 to 25 cm
5 to 15 min	2 cm to 12 cm	10 cm to 0.3 m	15 cm to 0.5 m
15 to 20 min	9 cm to 15 cm	15 cm to 0.4 m	0.3 m to 0.8 m

If you discover that the surveyed location of your base station is not accurate, your options are:

- Turn off xFill (recommended).
- Resurvey your base station. However, this will cause the movement of any stored AB lines that are reloaded/reused which is very undesirable to many RTK customers.

Base Station Survey

At initial base station installation, it is recommended that you survey base stations by taking a 24-hour log and processing the data to receive position on your local datum. The accuracy of this position is stated in the report. Over time, primarily due to normal geological events, the base station position may change up to 7 cm per year.

When you select the datum used to survey your base station during the xFill technology setup, the receiver will automatically convert your position in the datum you select to the equivalent position in ITRF2008.

If your base station was properly surveyed within the last five years using one of the following coordinate systems, the xFill technology accuracy error will typically be less than 15 cm over 20 minutes.

- WGS84/ITRF2008

- NAD83

- ETRS89

- GDA94

When working within an area with several RTK base stations, each base station should have a unique Base ID. When moving in range of another base station, go to the GPS setup on the display and enter the Base ID. This enables the receiver to recognize the new base station.

Base Station Survey with AutoBase™

If the Trimble AutoBase feature was used to survey the base, the accuracy can be >5 m, which decreases the xFill technology accuracy. The datum used for this feature is WGS84. Trimble recommends testing xFill prior to using it in an application where the base station has only been surveyed with AutoBase.

VRS Base Station

If using VRS, the accuracy is typically <1 cm . Contact your VRS network owner to determine the datum used for surveying and enter this datum during the xFill technology set-up. Trimble VRS Now™ network uses the following:

- VRS Now US: NAD83

- VRS Now Europe: ETRS89

- VRS Now TEC Europe: ETRS89

Base Station, Survey Unknown - If you do not know if your base station has been surveyed or the datum used for surveying, you should perform testing to approximate your base station errors or turn off xFill technology.

Estimating Base Station Errors

To estimate the error in the position of the base station, options include:

- **Calculate Current Position and Compare to Set Position:** Collect two hours of position logs and submit them for post-processing (using the same coordinate system as previously used). Then enter the current set position and the newly calculated position into a GPS distance tool calculator.

- x**Fill Accuracy Detection Using Cross Track Error:** Set-up your antenna and receiver in an open air environment (field or parking lot). Create an A+ line based on your parked position with RTK fixed. Unplug the radio or the modem if using cellular signal. xFill technology will engage. Watch your cross

track error (XTE) for a maximum of 20 minutes. Repeat several times. Keep in mind that this static test only tests the error in one direction (N/S or E/W).

- **xFill Accuracy During Passes in a Field:** To best see the drift of the xFill position over time:

> **NOTE –** This procedure will only be accurate if you have already completed the Roll Calibration for auto-steering.

1. Create an A/B line in your field (or use an existing line). See Guidance Patterns: AB Line.

2. Drive the line and once your cross track error (XTE) is very small, stop and drop a flag in the center of your hitch.

3. Turn off RTK by changing the network ID or frequency.

4. Drive around the field for several minutes (to represent your typical outage time) and return to the A/B line.

5. Engage on the line and then when XTE is small and you're over you previous flag, stop and drop another flag. Compare the distance.

6. Make a pass in the other direction on the same A/B line and drop a third flag. Compare the distance.

When Not to use xFill Technology

xFill technology is not recommended for:

- Land leveling and water management applications where a high degree of vertical accuracy is required.

- Any operation where you need accuracy better than 1" (2.4 cm).

- When the base station has not been properly surveyed, or has been surveyed only with the AutoBase functionality and no tests have been performed to assess the risk of using xFill technology with that base station.

Data Sheets

NAV-900 Guidance Controller Data Sheet

Physical	
Dimensions	213 mm (length) x 213 mm (width) x 80 mm (height)
	83.9 in (length) x 83.9 in (width) x 31.5 in (height)
Weight	1.2 kilograms (2.6 lbs)
Housing Material	Low-profile, chemical-resistant plastic casing with UV-resistant paint
Electrical	
Power	9 VDC to 16 VDC external power with over-voltage protection on input ports
Power Consumption	5.5 watts
	17.5 watts with external accessories connected
Power Out	12 VDC (nominal), 1 amp limit for external radio = 12 watts
Connectors	
To Display	M12 4-pin connector
To External Radio	M12 5-pin connector
For I/O	Deutsch 12-pin connector
Operational Range	
Operating Temperature	-40 °C to 70 °C (-40 °F to 158 °F)
Storage Temperature	-40 °C to 85 °C (-40 °F to 185 °F)
Humidity	Up to 100%, condensing
Ingress Protection	IP66, dustproof, waterproof, IPx9K
Communication and I/O	
Bluetooth®	Version 4.1, enabled
Serial Ports	1 Tx/Rx, 1 Tx only
CAN Ports	2
BroadR-Reach® Port	1
Digital Out	Sonalert
Analog In	Remote engage
NMEA Output	1, 5, 10, Hz
Inertial Measurement Unit (IMU)	
Gyroscope	3-axis, 200 Hz
Accelerometer	3-axis, 200 Hz
GNSS Receiver Specifications	
Satellite Signals	GPS: L1 C/A, L2C, L2E, L5
	GLONASS: L1 C/A, L1P, L2 C/A, L2P, L3 CDMA

	Galileo: E1, E5AltBOC
	BeiDou (COMPASS): B1, B2
Satellite Corrections	CenterPoint® RTX Fast, CenterPoint RTX, RangePoint® RTX, SBAS (WAAS, EGNOS, MSAS), xFill
Land-Based Corrections	CenterPoint RTK, CenterPoint VRS
Correction Formats	CMR+, sCMR+, sCMR+ with SecureRTK, CMRx, RTCM 3.0, RTCM 3.1, RTCM 3.2
Guidance	
Electric	Autopilot™ Motor Drive (APMD)
Guidance Ready	CANBus J1939
Hydraulic	External NAV III Autopilot