iG9

GNSS RTK Receiver with Internal 2-Watt UHF Radio & 4G Cell Modem

User Manual

This manual is for use with iG9 RTK GNSS receivers produced by iGage Mapping Corporation.

Receivers purchased from other sources that appear to be similar will not match devices provisioned by iGage.

The 'iGx Download Tool' supplied with iG receivers and available for download via the internet, only works with receivers purchased from iGage. This tool is not sold separately.

20 October 2020

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Copyright, Control and Safety

GNSS Safety Warning

The iG9 GNSS receiver tracks and utilizes signals from many space-based satellite navigation systems:

The Global Positioning System (GPS) is operated by the US Government which is solely responsible for the accuracy and maintenance of the GPS network. Accuracy can also be affected by bad satellite geometry and obstructions including buildings and tree canopy.

The GLONASS (GLObal NAvigation Satellite System), is a satellite navigation system operated by the Russian Aerospace Defense Forces.

The Galileo System is the global navigation satellite system (GNSS) that is operated by the European Union (EU) and European Space Agency (ESA)

BeiDou Navigation Satellite System (BDS) (also known as COMPASS or BeiDou-2) is operated by CNSA (China National Space Administration.)

SBAS (Satellite Based Augmentation Services) including WAAS (USA), MSAS (Japan), EGNOS (Europe), QZSS (Asia), and GAGAN (India) may also be utilized by the iG9 for carrier-phase corrections, in addition to differential corrections.

iGage Mapping Corporation is not responsible for, nor warrants the viability of the space segment portion of the GNSS system. The user is cautioned that they alone are responsible for determining the application of the iG9 to their task at hand.

Any of the GNSS system components can fail at any time. Be prepared for down time and failures. Do not us the iG9 receiver for any critical navigation purpose.

Export Controlled Device

The iG9 device should be considered to be an export-controlled device.

Because of the complex federal sanction regulations governing controlled countries, as well as the severe civil and criminal penalties for sanction violations, you should not attempt to interpret export licensing requirements or license exclusions for travel, or transactions with comprehensively embargoed countries. Before shipping, providing or hand carrying iG9 devices out of the United States, consult counsel who specializes in ITAR/DOD matters.

The following country list is not exhaustive:

Afghanistan, Balkans, Belarus, Burundi, Central African Republic, Cote d'Ivoire, **Crimea Region of Ukraine**, **Cuba**, Cyprus, Democratic Republic of the Congo, Eritrea, Fiji, Haiti, **Iran**, Lebanon, Liberia, Libya, Myanmar (formerly Burma), **North Korea**, Republic of the Sudan (Northern Sudan), Rwanda, Somalia, South Sudan, Sri Lanka, **Sudan**, **Syria**, Ukraine, Venezuela, Vietnam, Yemen, Zimbabwe

The countries in bold face type are comprehensively embargoed. Do not transport an iG9 receiver to one of these countries.

FCC Compliance

FCC Notice: iG9 receivers comply with the limits for a Class B digital device, pursuant to the Part 15 of the FCC rules when it is used in the Portable Mode.

FCC ID: SY4-A01020

Operation is subject to the following two conditions:

(1) This device may not cause harmful interference

(2) This device must accept any interference received, including interference that may cause undesired operation

An FCC License is required to use the iG9 as a UHF base. See the section '**Radio Notices**' on page 14.

Table of Contents

Introduction

Thank you very much for choosing to purchase and use an iG9 GNSS receiver from iGage Mapping Corporation!

With a ground-breaking price, outstanding performance, field ready case and easy-to-use features, we know that the iG9 receiver will be a valuable tool that will quickly pay for itself.

This guide is designed to help you become familiar with your new equipment and successfully use it in the field.

If you have questions or suggestions, don't hesitate to contact us:

iGage Mapping Corporation
1545 South 1100 East Suite 1
Salt Lake City UT 84105 USA
+1-801-412-0011
email: info@igage.com

Your input is extremely valuable, and we will listen to your suggestions!

Software updates and news are available from:

www.iGGPS.com

Click on 'Tools' for firmware, FAQs and other iG9 information. Don't hesitate to call iGage for assistance deploying, using or updating your device. Remote assistance is available.

iGage iG9 vs. CHC i90

The iGage iG9 is a variant of the CHC i90. There are many versions of the CHC i90 differing by hardware options:

- GNSS Antenna and Antenna Model
- GNSS OEM Engine
- Cell Phone Modem
- Wi-Fi and Bluetooth Modules
- IMU devices
- UHF Radio Modules
- Carlson SurvCE Geofencing

All iGage iG9 receivers share the same electronic internals and GNSS Antenna.

Specific naming conventions:

Model Name:	iG9
Model Number:	i90
Part Number:	118029040501020105
Relative NGS Antenna Model:	CHCI90 NONE
Absolute IGS Antenna Model:	IGAIG9 NONE

Because of the wide range of i90 possibilities, this User Manual is applicable only to the iG9 supplied by iGage.

Training Videos

If you are not familiar with these subjects:

US Survey Feet vs. International Feet (Video #1)
Grid vs. Ground Distance Measurements (Video #2)
Ellipsoid vs. Orthometric Heights (Video #3)

Check out the videos at:

www.igage.com/v

There are many Carlson SurvCE specific videos that address scale factors and aligning measured and record data.

Additional video and FAQ resources on Carlson SurvCE are available on the Carlson Software website:

www.carlsonsw.com

SurvCE / SurvPC

Throughout this User Manual SurvCE is used to reference both SurvCE and SurvPC. Most every screen and function are identical for these two data collection software as they are compiled from the same source. SurvCE and SurvPC are distributed by Carlson Software (www.carlsonsw.com) and Carlson maintains an extensive library of FAQs, Videos and Technical Documents on SurvCE / SurvPC.

We are excited to help with any SurvCE questions that you might encounter. Sometimes we won't know the answer and will suggest that you request help directly from Carlson. The easiest way to contact them is by sending email to support@carlsonsw.com.

You can download an electronic copy of the latest SurvCE User Manual from the Carlson website:

www.survce.com

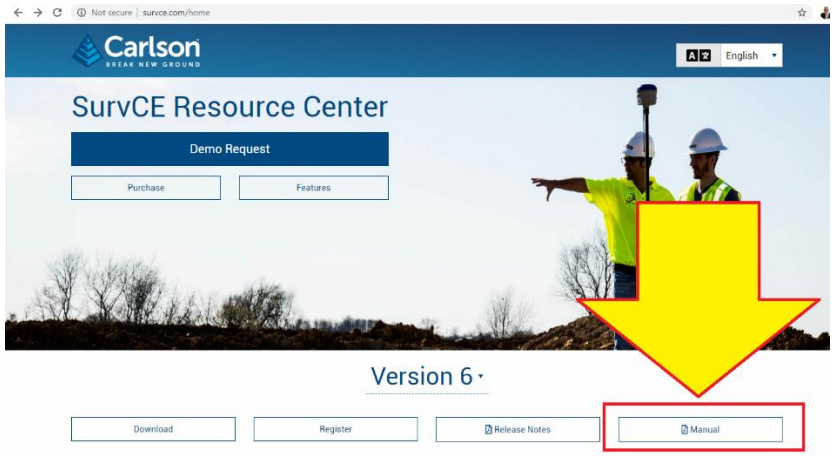
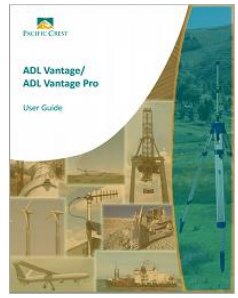


Figure 1 downloading the latest SurvCE Manual as a PDF file.

You can also purchase a printed copy of the User Manual from www.lulu.com.

ADL Vantage Pro UHF Radio Manual



Your iG9 receiver package may contain a high-powered Pacific Crest ADL Vantage Pro repeater.

The manual for Pacific Crest ADL Vantage Pro radios can be found online:

http://www.pacificcrest.com/library/User_Guide_ADL_VantagePro.pdf

Step-by-step setup instructions for the repeater can be found on page 91.

Data Collector

Your iG9 kit may contain a data collector provisioned by iGage.

You can download the collector specific User Manual from the manufacturer's website.

Handheld Nautix X8	Carlson RT4
www.handheldgroup.com	http://www.igage.com/RT4/RT4.htm
	
https://www.handheldgroup.com/handheld-rugged-mobile-computers/rugged-handhelds/nautiz-x8/manuals/	https://junipersys.com/products/mesa-rugged-tablet#support

Carlson Surveyor2	Carlson Mini2
www.carlsonsw.com	www.carlsonsw.com
	
https://junipersys.com/support/allegro-2/documentation	https://junipersys.com/support/archer-2/documentation

iGage preloads all software, activates SurvCE/PC, and bonds the data collector to the Rover and Base. If you purchased a data collector with the receiver package then it should be ready to use, out of the box.

Please don't reload software, it should already be loaded and activated. Call us if you have questions!

Important things to remember:

- Set the data collector to turn off the *backlight* after 30-seconds or more of inactivity.
- Set the data collector to NEVER automatically power off, it disrupts the Bluetooth connection.
- Tapping the ON/OFF key puts the data collector in Standby, a reduced power state
- Push and hold the ON/OFF key for two seconds to turn the data collector all the way OFF

About the iG9 GNSS Receiver

The iG9 GNSS receiver incorporates a GNSS engine, GNSS antenna, internal Rx/Tx UHF radio, Cellular modem, Bluetooth, Wi-Fi, and dual batteries in a ruggedized and miniature case that is easy to deploy and use. All-in-One iG9 Base Rover kits include two, identical receivers for use as Base and Rover.

The bright LCD panel enables you to check satellite-tracking, internal battery charge status, Wi-Fi, working mode, data logging status and basic receiver information. Bluetooth and Wi-Fi radios provide cable-free communication between the receiver and a data collector / controller.

You can change many of the basic settings of the receiver with the two front panel buttons and LCD panel. Additional configuration settings can be made via the web interface using Wi-Fi or with a Bluetooth connected data collector.

Front Panel

The Front Panel has a bright LCD screen, two indicator LED's and two pushbuttons.

Satellite LED	Indicates the number of satellites that the receiver is tracking: • When the receiver is searching and not tracking and satellites it blinks Blue once every 5 seconds. • When the receiver is tracking and has a position the left LED blinks Blue once for each tracked satellite.
Correction LED	Base Operation: Blinks amber when correction data is transmitted Rover Operation: Blinks amber when FLOAT or DGPS, green when FIXed
LCD Screen	Displays status and configuration options, controlled by the two pushbuttons
Fn Button	Move to the next line of the current menu Move to the next character of a setting Changes a setting or character after being selected by Enter
Power / **Enter** Button	Power (Red when turned on) • Press and Hold for 3-seconds to turn the receiver ON or OFF • Tap to accept a modified value: **Enter**

Receiver Back and Bottom

4G nano SIM Card

iG9 receivers have a NANO sized Sim Card slot. (NANO is the smallest sized slot.) Insert cards with gold contacts facing up and the notch leading. The data modem is a 4-G modem and should work with all providers, however the modem is NOT Verizon certified.

Batteries

There are slots for two batteries. Push the retaining bars to the side to release batteries, the battery will spring out. The batteries are hot-swappable. The battery with the higher charge is always used. (Both batteries will run down simultaneously.)

Battery Compartment

The battery compartment is sealed from the rest of the receiver. Theoretically if you submerse the receiver with the door open, the rest of the receiver will not be affected. However, the battery contacts and the SIM card contacts will be damaged.

Serial + Power

7-pin LEMO connector supports RS-232 communication and external power (9 to 28 VDC) input. **Note, even if external power is supplied at least one charged battery should be installed in the receiver**. (See “**iG9 Serial and USB IO Port Definitions**“ on page 127 for pinouts.)

Type C-USB

Standard USB-C connection to computer

When connected to a computer using a standard USB cable, the iG9 will mount as an external disk drive on the attached computer (no drivers required.)

What's in the Box

iG9 receivers are available in three standard configurations:

Base Rover Pair Kit:	complete Base / Rover pair
Network Rover Kit:	complete Network Rover, includes internal UHF radio
Base Fill Out Kit:	fills out a Network Rover kit to a complete Base / Rover pair

We structure our kits so that you can purchase a Network Rover Kit, then add a Base Fill-Out Kit later for the exact same price as purchasing a Base Rover pair.

In addition, any reasonable combination of receivers and accessories can be provided for specific needs.

Depending on your purchased configuration you will receive different accessories with your iG9 GNSS receivers:

iG9 GNSS Receiver The iG9 receiver includes a state of the art GNSS engine, a 2-watt Tx/Rx UHF radio, a 4G cellular GSM modem, Bluetooth radio, and Display. The Base and Rover are identical. Included with [Base and Rover]	
UHF Antenna PN: 0402 000 006 5/8 λend-fed-dipole Antennas with TNC Connector, one for each receiver. Included with [Base and Rover]	
Quad Battery Charger & Wall Adapter The Power Adapter can be used for the battery charger or as an external power source for iG9 Base with the serial cable. Included with [Rover]	
Lithium-Ion Batteries High Capacity 3,400 mAH 7.4 V Lithium Ion Included with [Base and Rover]	
External Heavy-Duty Power Cable 2.5 Meters long, connects to the Serial connector on the bottom of the receiver. Provides extended power to an RTK base. Included with [Base]	
SERIAL IO and Power Cable Connects the GNSS head to a computer serial port or an external UHF radio. Can be used to provide external power to the head. Included with [Rover]	

USB-C to USB-Female OTG Used to extend internal memory for huge occupation storage and to update the receiver firmware with a thumbdrive Included with [Rover]	
USB 2.0 Cable - A-Male to Type-C Used to connect the receiver to a PC and download occupations from the internal memory. Included with [Rover]	
Extension Pole Raises the Base iG9 GNSS receiver above a tribrach to allow the UHF antenna to be connected to the receiver. Included with [Base]	
TNC Extension Cable Allows you to elevate the Base UHF radio antenna further above the ground, greatly enhancing the radio range. Included with [Base]	
Hold-a-Pole We include a Hold-a-Pole with every Base. Can be used with a tripod and 2-meter pole to hold the Base at a fixed height and to calibrate the bubble on the pole. Included with [Base]	
SIM CARD We include a non-activated GSM SIM card with most iG9 receivers. If you are using the iG9 as a Network Rover you can activate your own cellular data service or iGage can optionally activate this included card with annual service. Included on request with [Base and Rover]	
This User Manual We include a printed copy of this User Manual with every iG9 kit. Included with [every kit]	
Field Ready Case Sealed rugged hard cases with custom foam inserts, and plenty of compartments to protect your receiver and accessories. Included with [Base and Rover]	

Safety Information

Before you use your receiver, please make sure that you have read and understand the following warnings and safety requirements.

An absence of specific alerts does not mean that there are no safety risks involved. Warning and Caution information is intended to minimize the risk of personal injury and/or damage to the equipment.

Use and Care

The iG9 receiver is a field ready instrument; however, it is also a delicate electronic instrument. Take suitable care to avoid damage to the instrument.

Please avoid dropping the receiver directly onto concrete, it can modify the phase center of the GNSS antenna.

Avoid storing the receiver at excessive temperatures (hot or cold) as it will damage the internal batteries.

Avoid storing the batteries at temperatures less than -40° F (-40° C) and temperatures higher than 160°F (70°C) as it will permanently reduce the battery capacity and life

DO NOT leave the iG9 or accessories inside a vehicle in the summer. Temperatures higher than 160°F will permanently reduce battery capacity and battery life.

GNSS receivers and especially Lithium-Ion batteries are like puppies: In the summer if you leave them in your vehicle with the windows rolled up, you will kill them.

Battery Warnings, Safety and Disposal

Figure 2 Lithium-Ion Batteries for iG9 receivers

The batteries are Lithium-Ion type cells.

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

To prevent injury or damage:

- Do not use or charge the battery if it appears to be discolored, warped, the case is bulging, or leaking battery fluid.
- Do not expose the battery to fire, high temperature, or direct sunlight.
- Do not immerse the battery in water.
- Do not store the battery inside a vehicle during hot weather.
- Do not drop or puncture the battery.
- Do not open the battery or short-circuit its contacts.
- Do not charge the batteries in chargers other than the supplied charger or a direct replacement.
- Do not charge similar batteries in the supplied charger, even if they fit well.
- WARNING - Avoid contact with the rechargeable Lithium-ion battery if it appears to be leaking. The battery fluid is extremely corrosive and contact with it will result in personal injury and/or property damage.
- If battery fluid gets into your eyes, immediately rinse your eyes with clean water and seek medical attention. Do not rub your eyes!
- If battery fluid gets onto your skin or clothing, immediately use clean water to wash off the battery fluid.

If you plan on running a Base receiver for an extended period, it is suggested that you use the supplied auxiliary power connector to connect to an external 12-volt battery. **Please keep at least one charged battery in the head when using auxiliary power.**

Fully charge the batteries using the supplied charger before first use. Batteries are shipped to you fully discharged.

Battery Charger

The supplied battery charger will charge 4 batteries at once.

Plug the charger into the supplied wall transformer or use the optional alligator-clip cable to connect to a 12 Volt battery.

The charger has a **RED** LED on each side to indicate that power is attached.

Next to each battery is a **GREEN** LED with the following meanings

GREEN LED	STATUS
Off	No Battery Inserted
Blinking	Battery Charging
ON Steady	Battery is fully charged

It is best to remove batteries from the charger when they have completed charging.

Radio Notices

FCC Notice: iG9 GNSS receivers comply with the limits for a Class B digital device, pursuant to the Part 15 of the FCC rules when it is used in the Portable Mode.

Operation is subject to the following two conditions:

- This device may not cause harmful interference
- this device must accept any interference received, including interference that may cause undesired operation

FCC Compliance:

Function	FCC-ID	Module Type
iG9 Device	SY4-A01020	Assembly

Figure 3 FCC ID's for iG9 receiver's internal radios.

Bluetooth Radio

Radiated output power from the internal Bluetooth radio is far below FCC radio frequency exposure limits. The Bluetooth radio operates within guidelines for radio frequency safety standards and recommendations, which reflect the consensus of the scientific community.

The level of energy emitted is far less than the electromagnetic energy emitted by wireless devices such as mobile phones. However, the use of wireless radios may be restricted in some situations or environments, such as on aircraft or near blasting areas.

UHF Radios

Every iG9 GNSS receiver includes a 2-watt Tx/Rx radio capable of broadcasting UHF radio transmissions.

UHF Safety and General Information

When used in the transmitting mode, even though the broadcast power is relatively low, you should take these additional precautions:

Medical Devices - Hearing Aids

Some digital wireless radios may interfere with some hearing aids. In the event of such interference, you may want to consult your hearing aid manufacturer to discuss alternatives.

Medical Devices - Pacemakers

The Advanced Medical Technology Association recommends that a minimum separation of 6 inches (15 cm) be maintained between a handheld wireless radio and a pacemaker. These recommendations are consistent with the independent research by, and recommendations of the U.S. Food and Drug Administration.

Persons with pacemakers should:

- ALWAYS keep the radio more than 6 inches (15 cm) from their pacemaker when the radio is turned ON.
- Not carry the radio in the breast pocket.
- Turn the device OFF immediately if you have any reason to suspect that interference is taking place.

Other Medical Devices

If you use any other personal medical device, consult the manufacturer of your device to determine if it is adequately shielded from RF energy. Your physician may be able to assist you in obtaining this information.

Blasting Caps and Blasting Areas

To avoid possible interference with blasting operations, turn off your radio when you are near electrical blasting caps, in a blasting area, or in areas posted: "Turn off two-way radio." Obey all signs and instructions.

FCC Licensing Information

The iG9 includes transmit / receive UHF radios and require FCC licensure for transmit operation in the United States. It is illegal to operate the iG9 device in Transmit mode (as a UHF Base) without a valid FCC license at any output power, in any area, under any non-emergency conditions.

This article describes the pitfalls of broadcasting without a license:

http://www.amerisurv.com/PDF/TheAmericanSurveyor_Silver-PirateSurveyors_Jan2014.pdf

If you did not have an FCC license when your receivers were shipped, a default frequency table may have been installed on your receiver. Without an FCC license you may only receive transmissions on these frequencies.

You may not legally use this product in a transmit application without:

- Obtaining a valid FCC License.
- Verifying the frequency tables match your license.
- Adding your FCC ID to the internal radios so that they can properly broadcast your license in Morse Code every 15 minutes.
- Putting a label on the devices with your FCC ID.
- Keeping a copy of your FCC License with the transmitting devices when they are in use as a transmitter.

In January 2020, the '**P**reventing **I**llegal **R**adio **A**buse **T**hrough **E**nforcement Act, or "PIRATE" Act (S.1228)' was signed raising the penalty for non-compliance to $100,000 per day with a $2,000,000 maximum!

If you choose to operate the iG9 as a UHF Base without obtaining an FCC license, you do so at your own risk.

Obtaining a New FCC License

If you don't have an existing FCC license to transmit UHF corrections and you will be using your receiver as a Base (no license is needed for Rover operation as it is receive only) you will likely use a 'Radio Licensing Company' to obtain frequency coordination and submit an application to the FCC.

The entire FCC application process typically costs around $600 of which includes $125 Frequency Coordination and $260 for the FCC filling fee. You may be asked these questions when applying for a license:

Question	Answer
Frequency Requested	"Standard RTK GPS Pool", Monitor: NO
Band	451-469, no splits
System	Conventional
Type	Base and Mobile Simplex FB.MO
Wattage	35 Watts Mobile; 35 Watts Base
Bandwidth	12.5 kHz
Interconnection	None
Emission Type	Digital Data
Location	The States where you might work or 'USA'
Antenna Mounted On	Survey Tripod, not to exceed 20 feet
Emission Designator	9K75F1D

Front Panel Operation

You can configure your iG9 receiver:

- from the front panel using the two-button interface
- from a data collector connected by Bluetooth to the receiver. See 'Using SurvCE to Control the iG9'

This section describes operation using the buttons from the front panel interface.

Main Menu

After the iG9 starts, the Overview Menu will be shown

Clicking either button 

or  will display the Main Menu:

You can move the current selection through each of the items '**Info**, **Sv**, **Mode**, **Power**, **Data**, **Set**' by clicking the **Fn** (Left) button:

Fn / Next

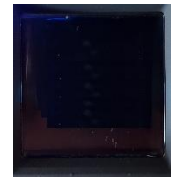
Once the desired item is selected, click the **Enter** (right) button:

Power / Enter

Some menu pages have too many lines to fit on the display, click the **Fn / Next** button to scroll down through the additional lines.

The Main Menu

If the overview menu is shown, or the screen is blank:



click the **Fn** button to display the Main Menu:

Use the **Fn** button to move through:

Info	General information on all operation modes
Sv	Information on satellite tracking by constellation and signal
Mode	Choose from common Base and Rover operation modes
Power	Display battery and external power status

Data Configure raw data recording
Set Display brightness, standby, sleep; Wi-Fi, 4G Cellular, OEM board reset, Language selection

When the desired item is selected, click the **Power/Enter** button to select.

Front Panel: Info

The Info screen shows:

Device Serial Number
Device Part Number, spread over 3 lines
Device Main Firmware
Registration Status

Operation Mode: Base / Rover
UHF Radio Channel / Frequency
UHF Radio Protocol
UHR Radio Baud Rate

Static Recording: On / Off
Static Sample Interval: default 1 Sec
Static Filetype: HCN / RINEX
Recording Elevation Mask: default 10 degrees

RTK Differential Age
Network Connection Information
4G IMEI number

These items are spread over four screens, use the **Fn** button to move through each of the screens. Click on the **Fn** button again to return to the main menu.

Front Panel: Sv

The **Sv** screen shows:

Total number of Satellites (Sv's) Used / Tracked
GPS number of Satellites (Sv's) Used / Tracked
BDS number of Satellites (Sv's) Used / Tracked
GLO number of Satellites (Sv's) Used / Tracked
GAL number of Satellites (Sv's) Used / Tracked

Click the **Fn** button to display status for:

GPS L1, L2, L5
BDS B1, B2, B3

Click the **Fn** button to display status for:

GLO L1, L2, L3
GAL L1, L2, L3

Click on the **Fn** button again to return to the main menu.

Front Panel: Receiver Mode

The Mode screen allows selection of the receiver operation mode:

- Base External UHF
- Base Internal UHF
- Base APIS
- Base External UHF & APIS
- Rover APIS
- Rover UHF
- Rover NTRIP
- (Back)

Use the **Fn** button to move down to the desired mode to modify. Then click **Enter** to select. Each mode has questions appropriate to the specific mode.

Note that if you select any of the Base modes, the receiver always does a 'Read GPS' and sets the base position to the current Autonomous or SBAS/WAAS value.

Mode Selection Descriptions:

Base External UHF

Format	sCMRx, RTCM2.3, RTCM3, RTCM3.2, RTD, CMR, CMR+
OK	
Cancel	

Base Internal UHF

Protocol	2AS, CHC, Transparent, TT450S
Channel	1 through ..
Baud	19200, 9600, 4800 (depends on Protocol)
Power	0.5W, 1W, 2W
Format	sCMRx, RTCM2.3, RTCM3, RTCM3.2, RTD, CMR, CMR+
OK	
Cancel	

Base APIS

Format	sCMRx, RTCM2.3, RTCM3, RTCM3.2, RTD, CMR, CMR+
IP:	select from common or custom
Port:	9901, 9902 .. 9920
OK	
Cancel	

Base External UHF & APIS

Format	sCMRx, RTCM2.3, RTCM3, RTCM3.2, RTD, CMR, CMR+
IP:	select from common or custom
Port:	9901, 9902 .. 9920
OK	
Cancel	

Rover APIS

Base ID:	(enter base SN)
IP:	select from common or custom
Port:	9901, 9902 .. 9920
OK	
Cancel	

Rover UHF
- Protocol 2AS, CHC, Transparent, TT450S
- Channel 1 through ..
- Baud 19200, 9600, 4800 (depends on Protocol)
- OK
- Cancel

Rover NTRIP
- Status Not Logging in
- OK (click on OK to select the last used NTRIP or DIP connection)
- Cancel

Front Panel: Power

The Power screen shows:
- Battery A charge status
- Battery B charge status
- Estimated Run time
- External Power Info xx.x volts
- Current Power Batter / External Power

Front Panel: Data

The raw Data Recording screen shows:
- Set On/Off
- Current file recording time in HH:MM
- Advanced
- OK
- Cancel

Click the **Enter** key to toggle recording On and Off. The action does not occur until you move to the **OK** line and click **Enter** to accept changes.

Select Advanced to control the recording file parameters:
- Recording Sample Interval: (default 1 second)
- Elevation Mask: (default 10 degrees)
- Maximum File Duration: (default 1440 minutes = 24 hours)
- Measurement Style: Phase Center, Slant, Vertical
- Antenna Height: (in Meters):
- File Format: HCN / RINEX
- OK
- Cancel

Advanced selections are not retained until you select OK and then click on Enter.

Front Panel: Set

From the device Setup screen, you can view and control device settings:

Display Brightness:	(High, Medium, Low)
Display Standby Time:	(default 30 seconds) time before returning to the Overview screen
Display Sleep Time:	time until the screen turns off
WIFI On/Off	Click Enter to toggle On and Off
WIFI Mode:	AP Access Point / STA Station
4G SIM number	
OEM Board Reset:	resets the OEM board, downloads new ephemeris
Language:	English, Russian, Chinese
(Back)	

Using SurvCE to Control the iG9

You can configure your iG9 receiver

- from the front panel using the two-button interface (see page 16)
- from a data collector with SurvCE connected by Bluetooth to the receiver
- via Wi-Fi using a standard web browser

The next sections describe operation of the iG9 from SurvCE:

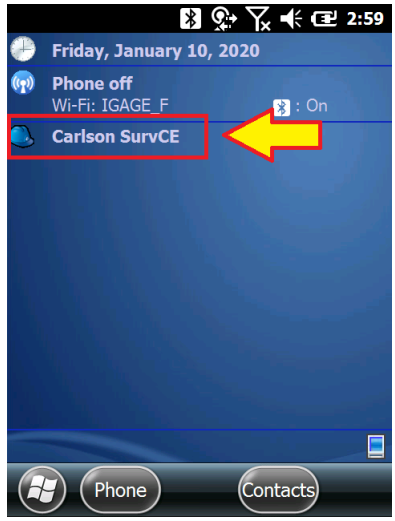
Starting a New SurvCE Job

iG9 GNSS Receivers are typically sold with Carlson SurvCE or SurvPC field data collection software running on a stand-alone data collector or stand-alone tablet computer. **The iG9 requires SurvCE / SurvPC Version 6.06 or higher**.

Throughout this manual, it is assumed that you have a SurvCE job open on your data collector when you begin setting up Base and Rover configurations.

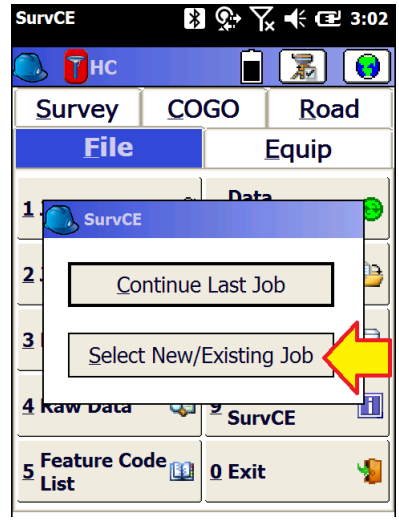
This section describes in detail how to setup a new SurvCE job. If you are using SurvPC, the screens, buttons, actions and operation are identical to those shown below.

1. Turn on the Data Collector, wait for it to boot.
2. Start SurvCE by clicking on **Carlson SurvCE** from the main screen:



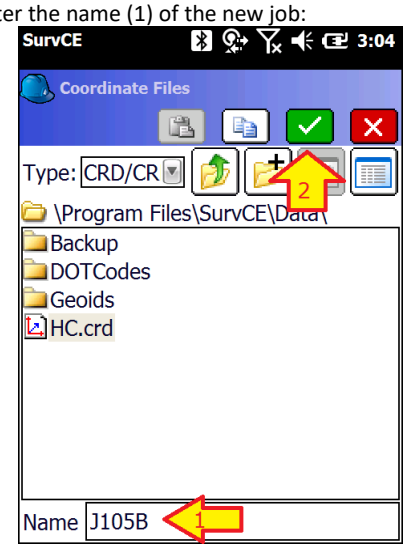
On some installations you may need to click on the 'Start' icon is the windows flag in **the upper left** or **lower left corner** of the screen.

3. The opening screen will be shown, click on **Continue** or **Select New/Existing Job** as appropriate:



For this example, choose a '**Select New/Existing Job**'.

4. Enter the name (1) of the new job:



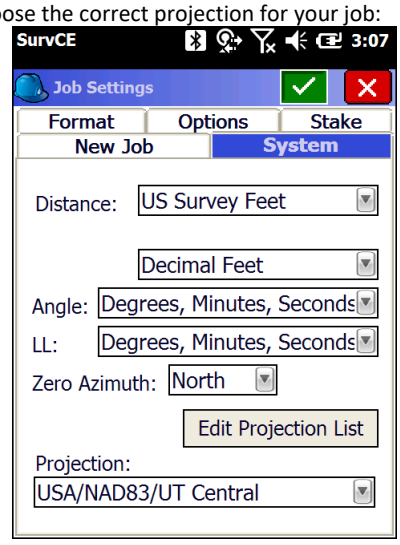
Then click (2) the green check mark.

SurvCE jobs are stored as a collection of files. The primary file is a '**Card File**' with .CRD file extension. When you create a new job, several supporting files are created in the same folder as the .CRD file.

Some users prefer to keep jobs in separate folders, which you can manage from the '**Coordinate Files**' menu.

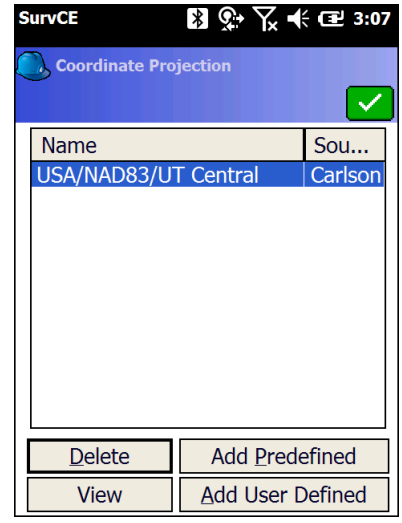
Hint: If you set the extension to '**.CRDB'** your point descriptions can be up to 255 characters in length.

5. Choose the correct projection for your job:

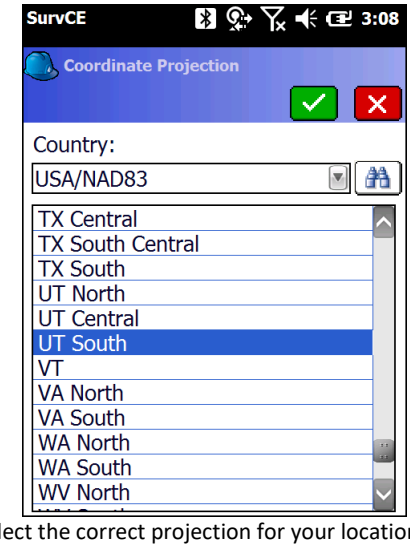


Choose **Distance** units from **Metric**, **US Survey Feet** or **International Feet**.
The projection drop box displays a list of often used projections.

If the projection you need is not listed in the drop-down list click on **Edit Projection List**:

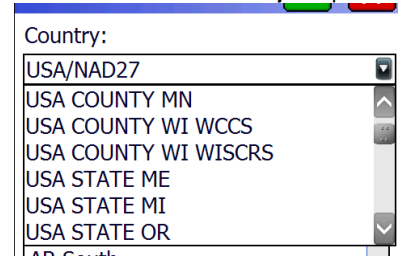


Then click on '**Add Predefined**':

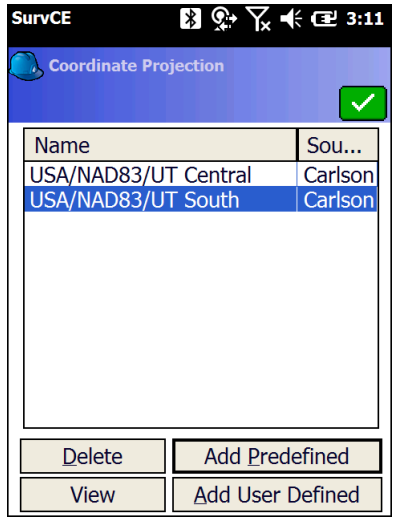


Select the correct projection for your location from the list, then click the green check mark.

Hint: UTM and county codes for Oregon, Main, Wisconsin, Michigan, Oregon and other special areas can be found under the '**Country**' dropdown:

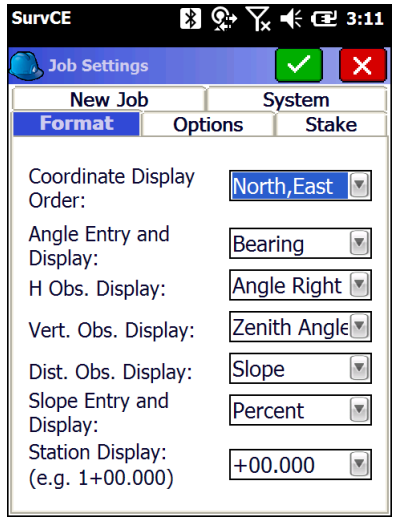


6. The coordinate projection list will now include your new projection.



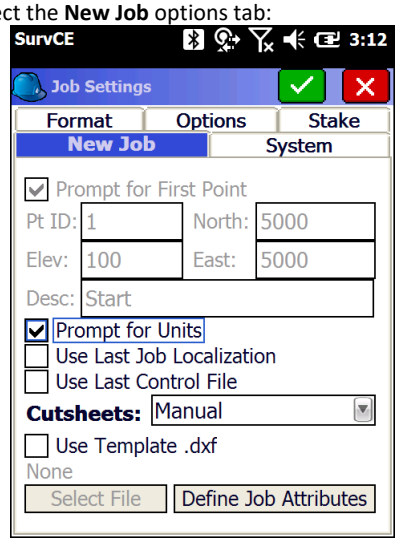
Click on the green checkmark to return to **Job Settings**.

7. Select the **Format** tab:



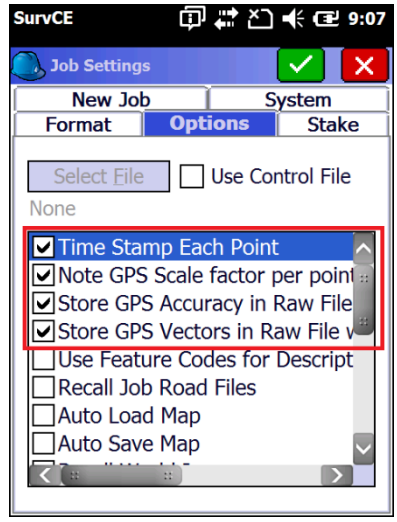
Most defaults will be fine.
You may want to change the default **Angle Entry and Display** from **Azimuth** to **Bearing**:
Bearing "N 45 12 52 W"
Azimuth "315 12 52"

8. Select the **New Job** options tab:

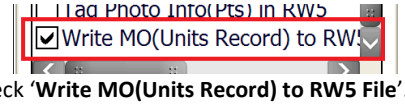


Unless you setup at the same location for every job (like a mine site) you will want to have '**Prompt for Units**' checked and '**Use Last Job Localization**' and '**Use Last Control File**' unchecked as shown.

9. While not required, these four settings on the 'Options' tab:



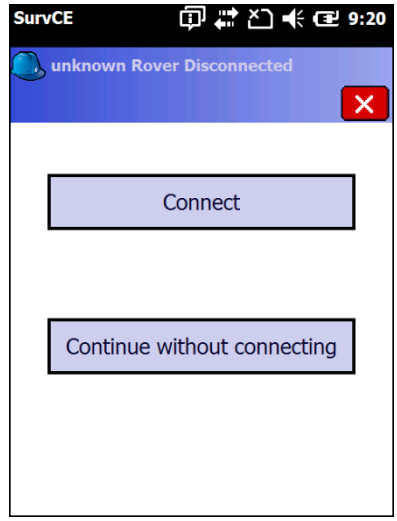
Check '**Time Stamp Each Point**'.
Check '**Note GPS Scale factor in Raw File'**.
Check '**Store GPS Accuracy in Raw File**'.
Check '**Store GPS Vectors in Raw File…**'.



Check '**Write MO(Units Record) to RW5 File**'.

Each of these settings makes debugging errant jobs simpler if anything goes wrong.

10. Click the green check mark again to get to the '**Main Menu**'.
The '**Connecting to Instrument**' dialog may be shown:

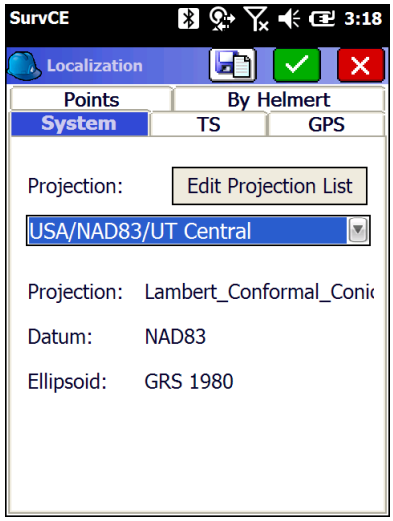


11. Click on '**Continue without connecting**' to reach the main menu without connecting to an instrument.

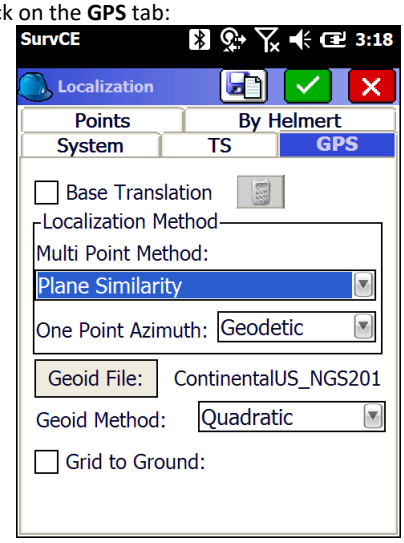
12. Verify that a GEOID file is loaded.
Click on the **Equip** tab:

Then click on '**6. Localization**'

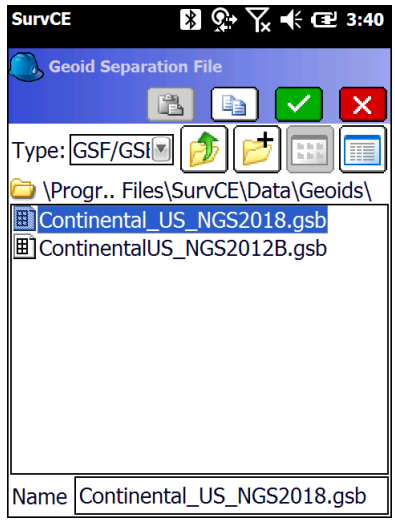
13. The **Localization** menu is shown:



14. Click on the **GPS** tab:



Make sure that the latest NGS Geoid File **Continental_US_NGS20xx** is listed to the right of the '**Geoid File:**' button. If it is not, click on the '**Geoid File**' button:



then select the latest NGS **Contenental_US_NGS20xx** file which covers the entire USA.

15. Finally click the green check mark to return to the Main Menu.

You are now ready to configure a Base or a Rover.

Setting up an iG9 UHF Base Rover Pair

The iG9 system includes an internal 2-watt Transmit / Receive radio in all Base and Rover receivers.

'Base' and 'Rover' receivers are identical, interchangeable and are labeled for setup convenience.

Configuring the iG9 UHF Base

Choose a Great Location for the Base

The location of your Base greatly impacts the success of your survey. There are two primary concerns:

1. Minimizing multipath and obstructions between the Base and the sky
2. Maximizing the effective range of the UHF radio which is broadcasting corrections to the Rover

The Base does not need to be located at a control point or parcel corner. You can locate the Base at an optimum location for tracking GNSS signals and broadcasting corrections, then perform a single (or multiple) point Rover localization. It is better to localize your Rover than to use a Base that is under canopy or in a deep canyon.

Any multipath or obstructions at your Base will affect every single shot at your Rover, just as if the multipath existed at the Rover. Rover and Base multipath are effectively added together. Your **primary** concern should be finding an open location for the Base that minimizes canopy and multipath.

A clear view of the sky above a 10-degree mask is very important. Partially obstructed/masked satellites (through tree branches) will increase the range of elevation measurements that the Rover observes and result in slower fixes.

When using a UHF radio, your ability to place the UHF antenna in a high location with the minimum of obstructions to your working area is also important however the best location for your Base is the spot that provides the clearest view of the sky.

Base Radio Battery

iGage does not provide an external battery for use with the Base, you can easily procure a suitable battery locally or online.

Two internal batteries will run the iG9 Base for approximately 6 to 8 hours depending on the configured UHF output power.

For extended operation use an external 12-Volt battery. We recommend a battery similar to 'ExpertPower EXP12180 12 Volt 18 Ah Rechargeable Battery' which is available from Amazon for under $40.

Figure 4 12V, 18-amp hour sealed lead acid battery with nut/bolt connections

You can use the supplied dedicated Heavy-Duty External Power Cable to provide extended power to the Base:

Figure 5 Included Heavy Duty External Power Cable attached to external battery

You may also use the wall transformer supplied with the battery charger and plug it directly into the included serial cable to power the iG9 Base from wall power.

Or, you can use the Serial cable supplied with the iG9, combined with an optional battery clip cable to provide external power.

Figure 6External Power Cable (optional) connected to serial cable for iG9 Base

iG9 Base Configuration: Step by Step

Additional Base Configuration information can be found on Page 60.

1. Setup the Base:
    a. Choose a suitable location for the Base.

       A clear view of the sky and satellites is the most important consideration.

       If the location is not high enough for UHF Radio propagation, then a repeater may be required to propagate UHF radio corrections to the Rover.

    b. Put freshly charged batteries in the base receiver. Even if you connect external power, **you must have at least one charged battery in the receiver**.

    c. Attach the receiver to a tripod or pole as appropriate.

    d. Rotate the receiver so the buttons face to the North.

    e. Connect the UHF radio antenna to the bottom of the receiver.

       If you are going to be working more than ½ mile from the Base, use the included TNC extension cable to move the UHF antenna to the top of a mast placed to the North of the receiver.

       The higher the UHF antenna, the better.

       Make sure that you are not placing the antenna near power lines!

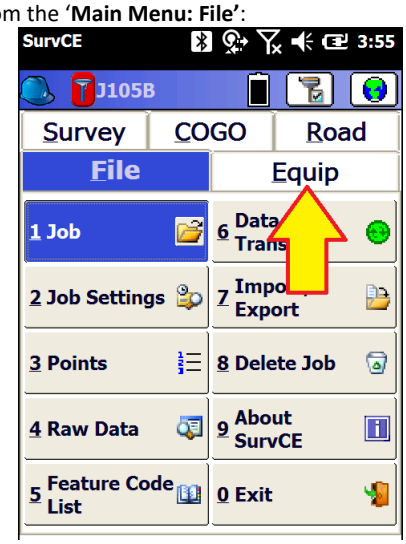
Figure 7Raising the UHF antenna for additional range.

    f. If you are going to be working longer than 4-hours attach the external power connector and connect an external battery source.

    g. Turn on the Base, it will begin to track Satellites.

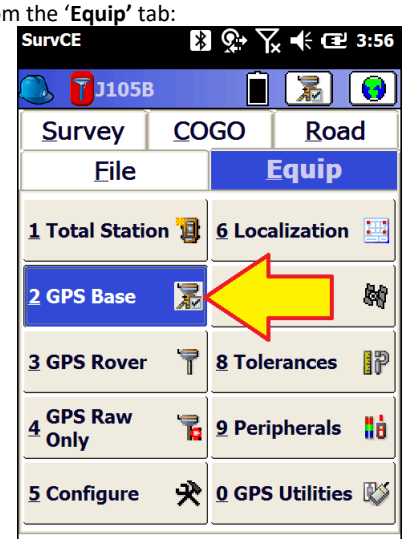
2. Refer to the section '***Starting a New SurvCE Job***' on Page 21 to start and configure a new job.

3. From the '**Main Menu: File**':



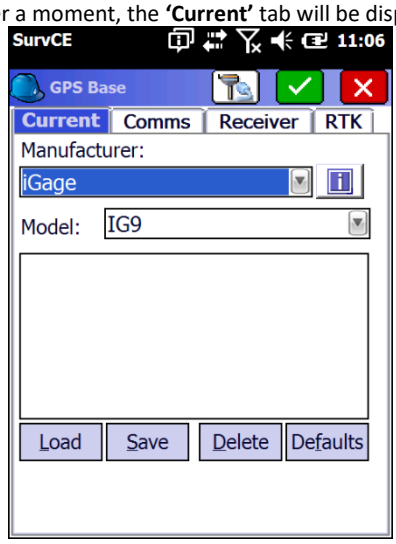
   Click on the '**Equip**' tab.

4. From the '**Equip'** tab:



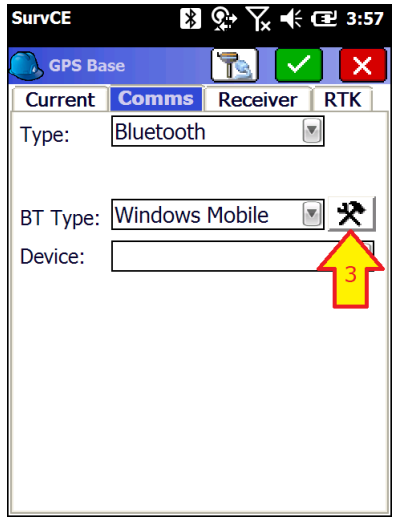
Click on the '**GPS Base'** button.

5. After a moment, the **'Current'** tab will be displayed:



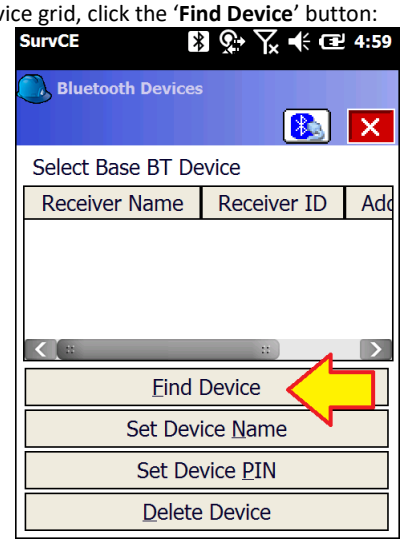
Set the **Manufacture** to **'iGage**' and the **Model** to **'IG9**'as shown above.

6. Click on the **'Comms**' tab:



(1) set the **'Type**' to **'Bluetooth**'.
(2) Set the **'BT Type**:' to '**Windows Mobile**', then (3) click the **Configuration** button (the 'hammer / wrench' icon) to the right of the '**BT Type**'.

7. If your Base receiver is not already listed in the BT Device grid, click the '**Find Device**' button:

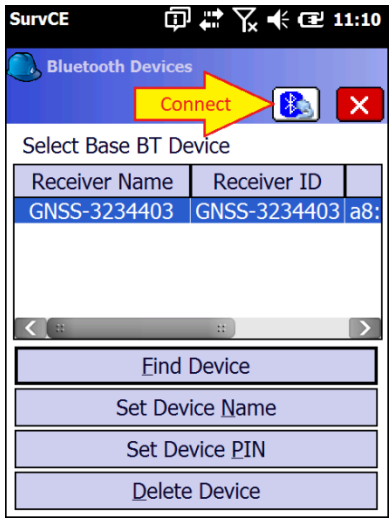


Wait up to 30-seconds while the data collector searches and identifies Bluetooth devices:

8. A list of nearby devices will be shown.

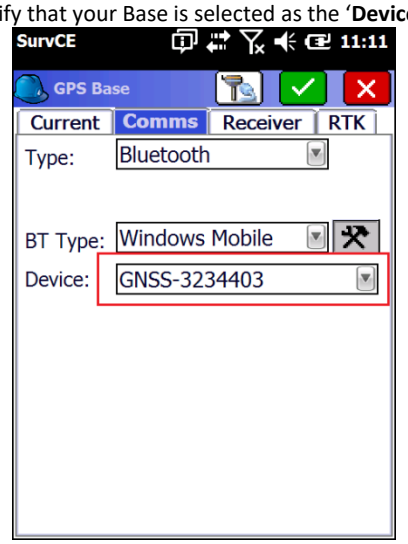
(1) Click the correct Base receiver to select it, then (2) click on the green check mark.

9. Your device should now be selected and highlighted on the device list:



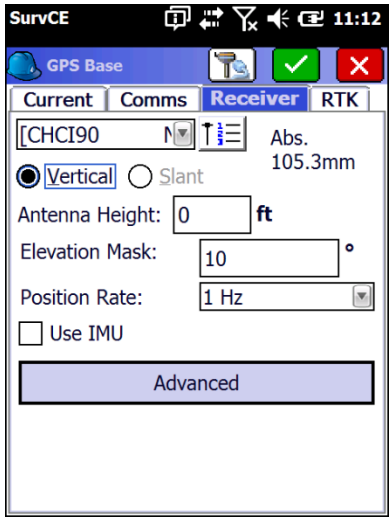
Click on the '**Bluetooth Connect'** button (it looks like a Bluetooth symbol with a connector on a cable.)

10. Verify that your Base is selected as the '**Device**':



then click on the '**Receiver**' tab.

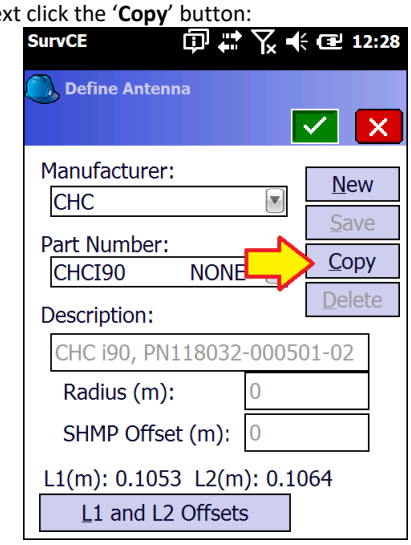
11. The GPS Base Receiver configuration tab will be shown:



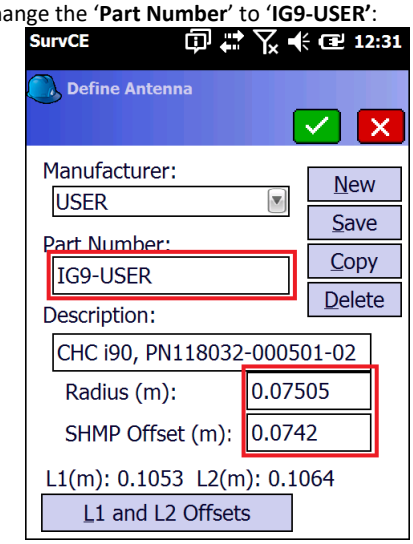
12. The default NGS Absolute Antenna calibration does not include a Radius or SHMP offset.

If you plan on using a 'Slant' measurement, you will need to edit the antenna model and enter the device radius and SHMP. Click the antenna button:

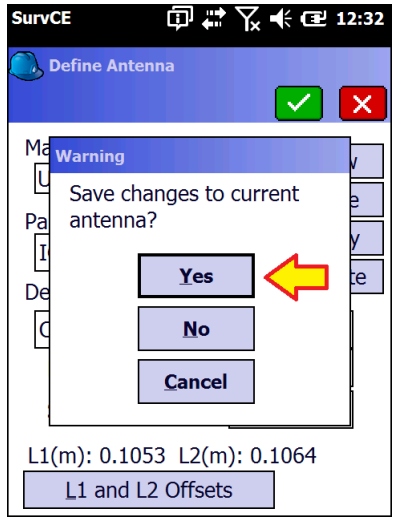
Next click the '**Copy**' button:



Change the '**Part Number**' to '**IG9-USER**':



Enter the **Radius** and **SHMP** Offset as shown above, then click the green check mark.

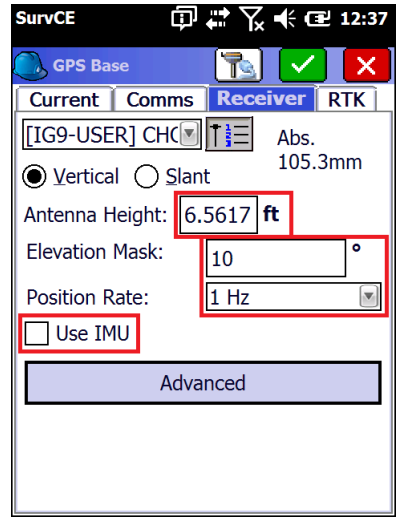


Click on '**Yes**'. A new antenna model is now available that includes the information required to use Slant antenna height measurements.

13. Enter the correct '**Antenna Height**' (the distance from the Ground Mark to the receiver head.)

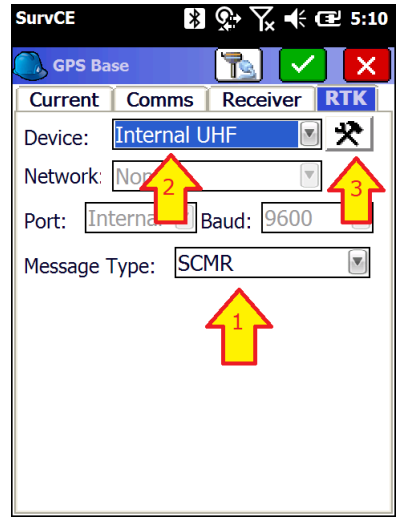
If the Base receiver is mounted on a fixed height pole, select '**Vertical**' and enter the vertical distance from the Ground Mark to the bottom of the antenna as shown in **blue** above.

If the Base receiver is mounted on a tripod and you can't make a direct vertical measurement, select '**Slant**' and enter the slanted tape distance from the ground mark to the bottom of the blue band that separates the white top from the gray bottom as shown in **red** above.



If the receiver is mounted on a fixed height metric tripod or pole, you can enter the '**Antenna Height**' in meters followed by 'm' and it will be converted to the current job units.
Set the '**Position Rate**' at 1 Hz.
Uncheck the '**Use IMU**' (Tilt / Heading Compensation) as this is a 'Base' receiver and you should carefully level the head for all setups.

14. Click on the '**RTK**' tab:



(1) Set the '**Message Type**' to '**sCMR**'.

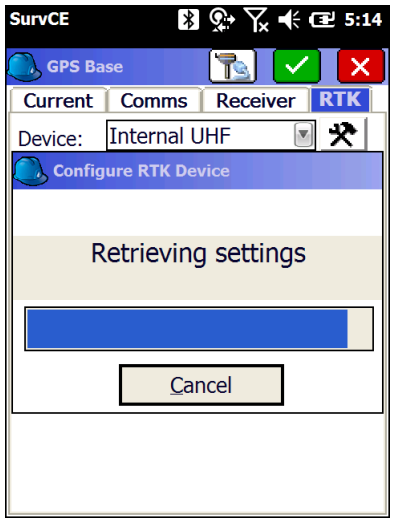
The only two choices that provide full corrections for all tracked satellites and signals are '**sCMR**' and '**RTCM3.2**'. Choose '**RTCM3.2**' if you are operating with receivers that don't support '**sCMR**'. The '**RTCM3.2**' selection generates correction messages that are twice as long as **sCMR** which doubles the radio power consumption.

Note that '**sCMR**' and '**sCMRx**' are equivalent.

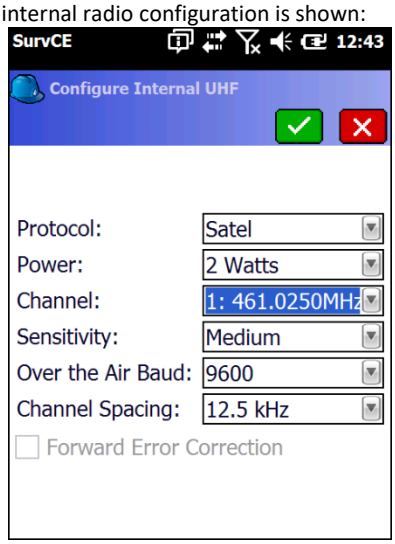
The iG9's **sCMR/sCMRx**' protocol (scrambled CMRx) is NOT compatible with the Trimble '**CMRx**' (not scrambled **CMRx**.)

(2) Set the **Device** to '**Internal UHF**'.

15. (3) Click the **Settings** (hammer/wrench) button to the right of **Device**. Wait a moment while the data collector retrieves the current radio configuration from the Base:



16. The internal radio configuration is shown:



iG9 pairs work great with the Base radio settings shown above.

The Base and the Rover MUST have matching UHF radio Protocol, Frequency, Over the Air Baud, Channel Spacing and Forward Error Correction.

The '**Satel**' **Protocol** has excellent range and low overhead. Other protocols may be required when operating with other brands of equipment.

Choose the lowest **Power** that allows you to move around the job without a loss of radio corrections. Select '**2 Watts**' for maximum range.

You can use a handheld UHF radio to check the selected **Channel** / frequency for other users (Voice or Data.) It is best to use frequencies with no other users.

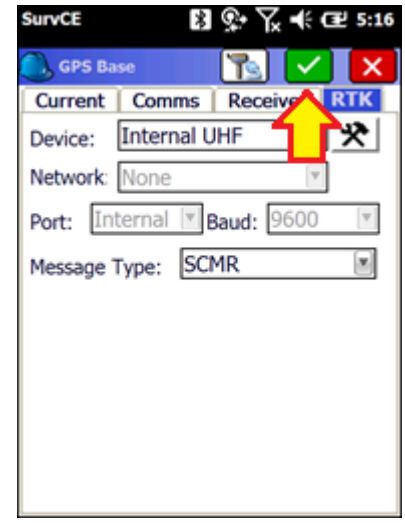
You must have FCC license authority to transmit on the selected frequency.

The '**Sensitivity**' setting is not implemented on the iG9 and can be ignored.

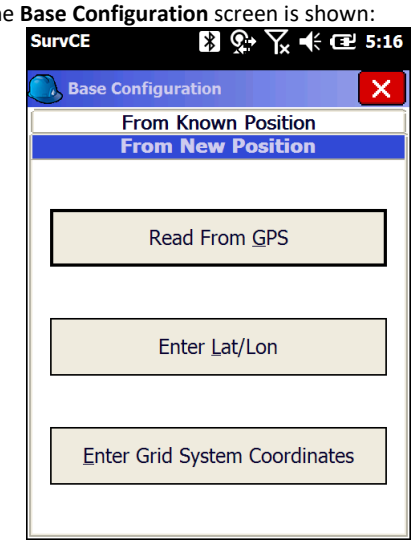
For operation in the United States the '**Channel Spacing**' must be **12.5 kHz** (unless you have a special FCC License.)

Click on the green check mark to return to the **RTK** tab.

17. From the '**GPS Base**' screen, click on the green-check mark:



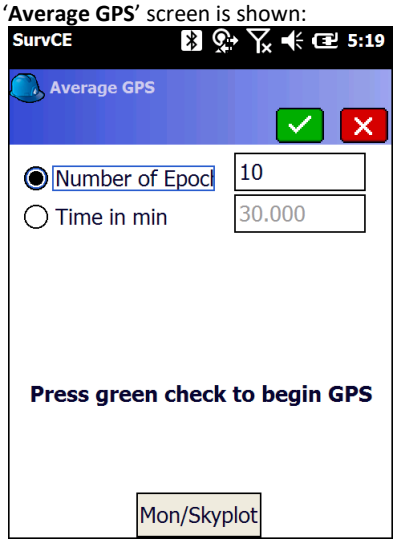
18. The **Base Configuration** screen is shown:



In this example, we will read an autonomous position from the GNSS receiver by clicking the '**Read from GPS**' button.

Please check out the '**Advanced Base Configuration**' section of this manual on page 59 for a discussion of configuring Base positions using other methods in SurvCE.

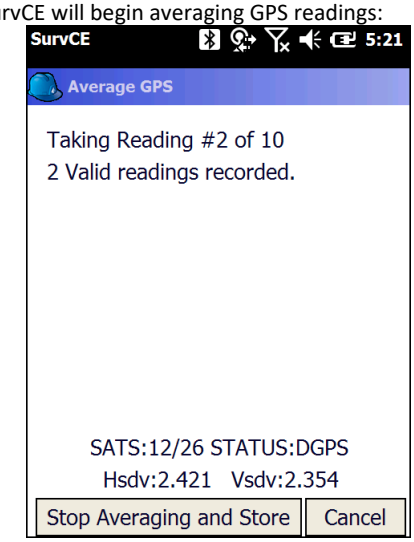
19. The '**Average GPS**' screen is shown:



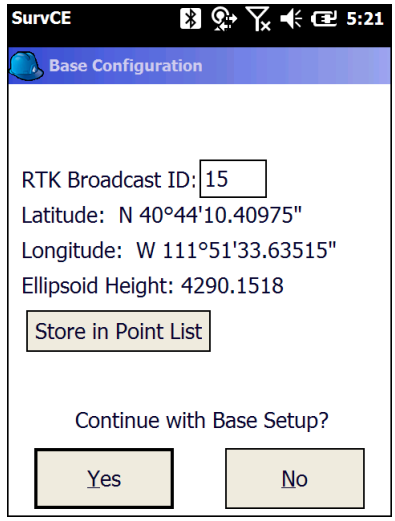
A 10-second average is sufficient to get a position for the Base. Choose '**Number of Epochs'** and enter **10** samples.

Click the green check mark.

20. SurvCE will begin averaging GPS readings:



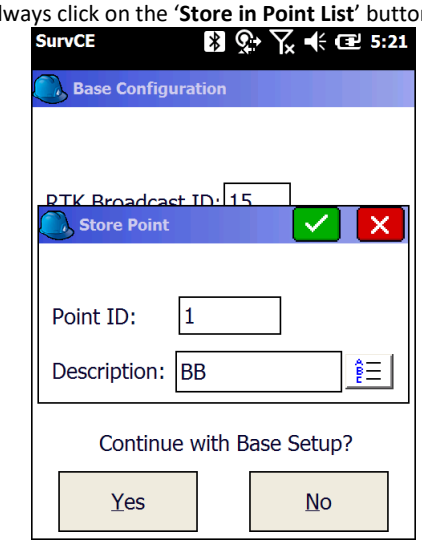
21. After 10-seconds, the average position will be shown:



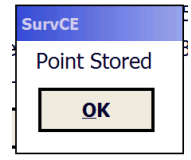
Set the '**Broadcast ID**' to a unique integer number between 0 and 4095.

In most scenarios, this '**RTK Broadcast ID**' ends up being a point ID / number in your job file.

22. Always click on the '**Store in Point List**' button:

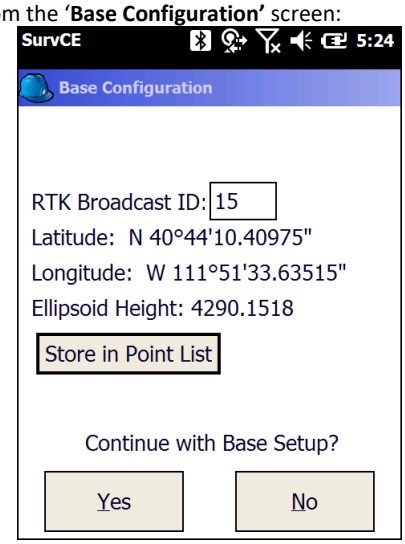


A '**Point ID**' of '**1**' and a '**Description**' of '**BB**' (Broadcast Base) is reasonable. Click on the green check mark.



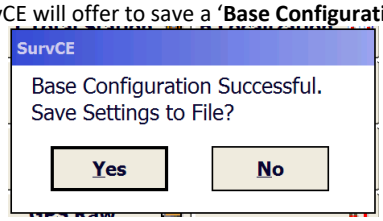
Click on '**OK**'.

23. From the '**Base Configuration'** screen:



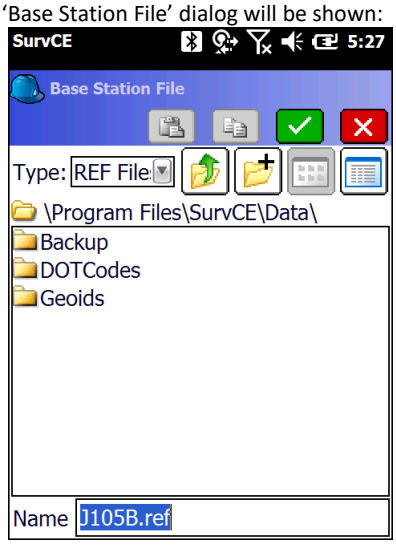
Click on the '**Yes**' button to accept the displayed position.

24. SurvCE will offer to save a '**Base Configuration'** file:



Always answer '**Yes'** when given a choice.

25. The 'Base Station File' dialog will be shown:

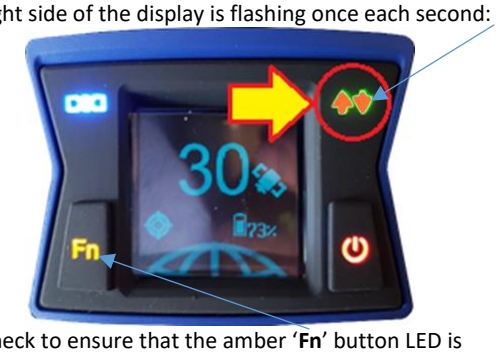


The filename will default to the job name with a ".REF" extension. The "**.REF"** file contains the Latitude, Longitude and Ellipsoid Height of the Ground Mark. The "**.REF"** file is valuable when you want to setup the Base at a later time on the same mark.

Click the green check mark to accept the filename.

26. Your Base is now configured and should be broadcasting corrections.

27. Check to ensure that the orange LED on the top-right side of the display is flashing once each second:



Check to ensure that the amber '**Fn**' button LED is flashing once per second. This indicates that the receiver is storing raw data for post-processing if needed.

If the Fn LED is not flashing, then the receiver is NOT storing observation data.

Best Practices for Extending UHF Radio Range

The UHF radio in the iG9 has excellent range. However, range is greatly reduced by other users on the same frequency, damaged antennas, damaged cables and configuration issues.

The most common range issues are listed below. If you need to dependably operate at more than 3-miles from your Base, consider purchasing a repeater (see the section "*Setting* Up the Optional ADL Vantage Pro Repeater Kit" on page 91.)

Multiple Users on Same Radio Frequency

If there is someone or something else on the same frequency using voice or data, they will greatly reduce the distance you can move from your Base. This the most common cause of bad radio range.

Use a Handheld UHF radio to check if the frequency is unused before you start. Carry the Handheld radio with you all day so that you can check if someone sets up on your frequency after your session begins.

The 'BaoFeng UV-5R' is available from Amazon for less than $35 and is a good-enough choice for monitoring frequencies:

Become familiar with what it sounds like if you are the only user on a frequency and what it sounds like if there are more than one user on the same frequency.

Sources of interference include:

- other surveyors and engineers
- voice users (truckers, businesses, railroads, schools, service companies)
- wireless microphones
- SCADA equipment (like water or oil pipeline infrastructure)
- control backhauls on com links
- nearby AM or FM radio transmitters

- nearby radar systems

The radio frequencies that are usually assigned (by the FCC in conjunction with frequency coordination) are not exclusive and are assigned to multiple users in the same area.

By FCC rules, even unlicensed voice transmissions have a higher priority than licensed data transmissions. Your radio (the radio built into your Base) will wait for other users before it transmits (this is called CSMA: collision sense multiple avoidance.)

If you find that the frequency that you were going to transmit is busy, you can change the channel/frequency of your Base and Rover to an alternate frequency. The radio frequency is set on the Rover is under "Equip: GPS Rover: RTK (tab): Internal UHF Radio Settings".

Base Output Power Setting

You probably will want the radio in your Base to output as high of power as possible. The setting for the Base output power is under "Equip: GPS Base: RTK (tab): Internal UHF Radio Settings".

If 2-watts with an elevated antenna is not sufficient, we recommend purchasing a high-power repeater.

Bad Antennas

The UHF antennas on most GNSS equipment get beat around quite a bit. The antennas on the Base and extension pole get whipped around in the wind a lot.

If you suspect that your antenna has gone bad, we recommend that you purchase two spare antennas and change out both your Base and Rover. If the problem goes away, then you know that one (or perhaps both) of your original antenna have failed.

We recommend that you not use ¼ wavelength antennas:

They require a ground plane at the Base of the antenna and have significantly (about 1/3) the range of the ½ wavelength dipole antennas we supply. The ¼ wavelength antenna are not compatible with the antenna extensions that we supply with a Base. iGage has both factory replacement and heavy-duty super gain antennas available.

External Antenna Extension (Top of Pole Extension)

If you are having range issues, try removing the external antenna extension cable and mount the Base antenna directly on the bottom of the Base receiver. We expect at least 1-mile open range with the Base and Rover antenna mounted directly to the heads. (Assuming no other users are on the same frequency.)

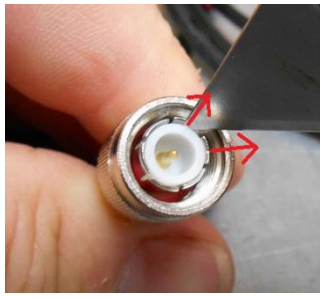
The most common cause of External Antenna Extension Wire failure is the termination on the pole side adapter due to excessive wind-whipping. The second most common failure is closing the extension wire in the hinge of the carry case which smashes the cable.

Loose TNC Antenna Connections

The antenna connector can become intermittent and not make a solid connection. If antenna is over-tightened, then the connection points shown below can become 'sprung' and won't make good contact unless the antenna is screwed in even tighter.

This issue is very difficult to diagnose; however, it is very simple to fix.

On the antenna connector bend the grounding sleeves 'out' to make better contact:



Bending 'out' the ground contacts on the antenna connector.

On the TNC connector, attached to the bottom of the GNSS receiver, bend the small gold fingers 'in' to make better contact:

Bending the center contacts 'in' towards the center.

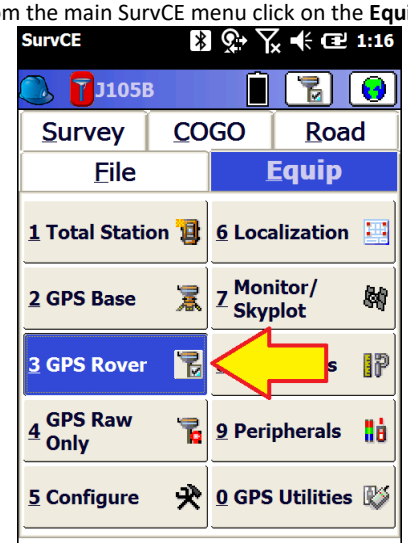
Configuring an iG9 UHF Rover

For information on setting up a Network Rover (a Rover that uses a network or server Base) please turn to "**Configuring an iG9 Network Rover**" on page 45.

1. Setup the Rover:
   a. Attach the receiver to the range pole.
   b. Attach the UHF antenna to the receiver head.
   c. Put one or two charged batteries into the head.
   d. Turn on the Rover receiver.
   e. Attach the Data Collector to the range pole, turn it on and start SurvCE / SurvPC.

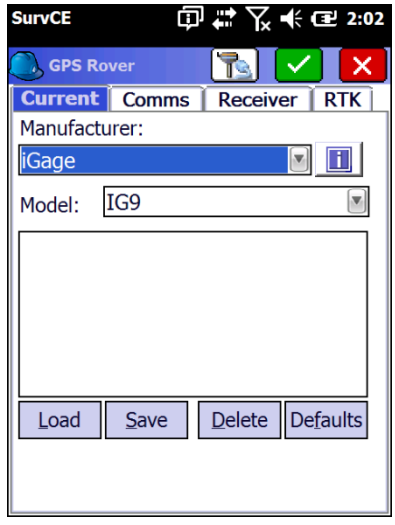
2. If you have not already started a new job or opened an existing job, refer to the section '**Starting a New SurvCE Job**' on page 21 to start and configure a new project.

3. From the main SurvCE menu click on the **Equip** tab:

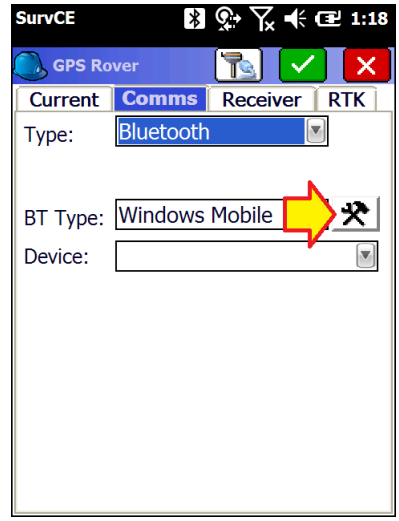


   Then click on '**3 GPS Rover**'

4. Choose the correct **Manufacturer** 'iGage' and **Model** '**iG9**':

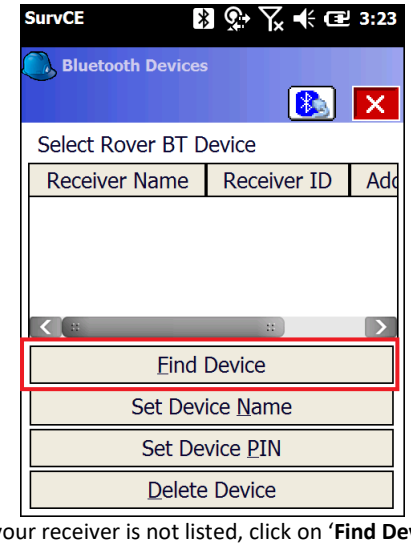


5. Select the **Comms** tab:



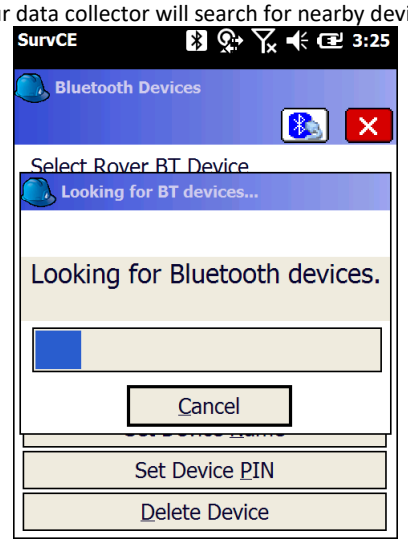
   Choose '**Type**' = '**Bluetooth**', '**BT Type**' = '**Windows Mobile**', then click on the Settings button (hammer/wrench) button to the right of '**BT Type**'.

6. The **Bluetooth Devices** menu is shown:



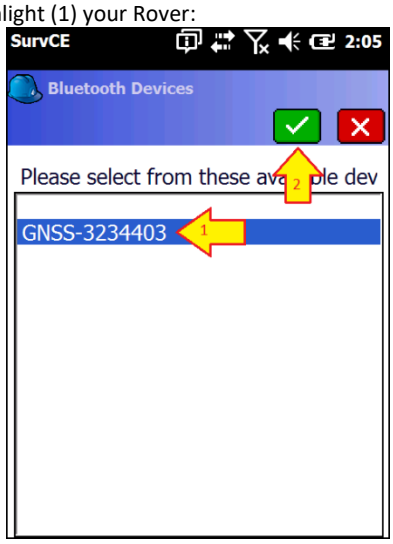
   If your receiver is not listed, click on '**Find Device**'

7. Your data collector will search for nearby devices:



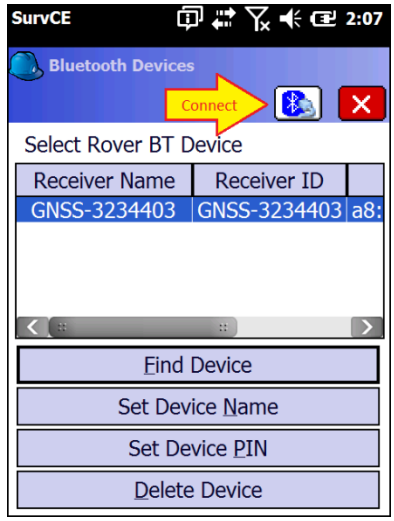
After short wait, all the Bluetooth devices in range of the data collector are listed:

8. Highlight (1) your Rover:

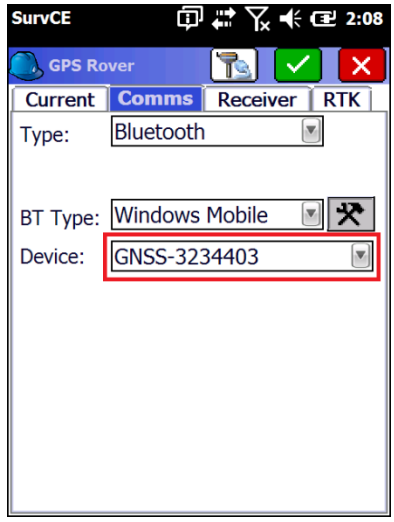


Then (2) click on the green checkmark.

9. Click on the **Bluetooth Connect** button, just to the left of the red-X:

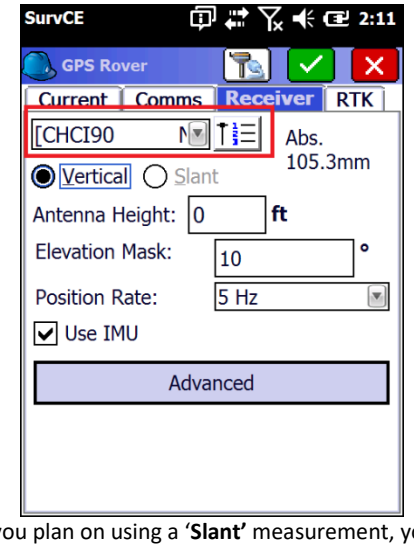


SurvCE will return to the **Comms** tab:



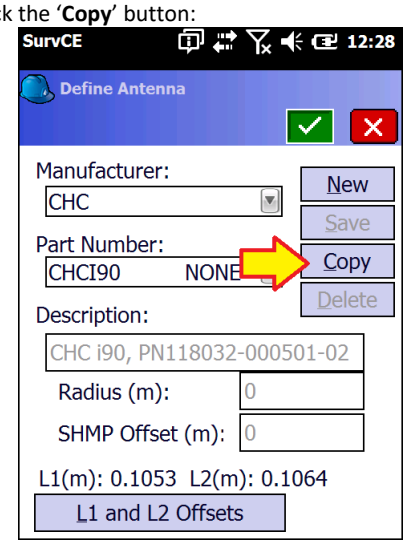
Verify that the correct Rover device / SN is selected. Then click on the **Receiver** tab.

10. The default NGS Absolute Antenna calibration does not include a Radius or SHMP offset.

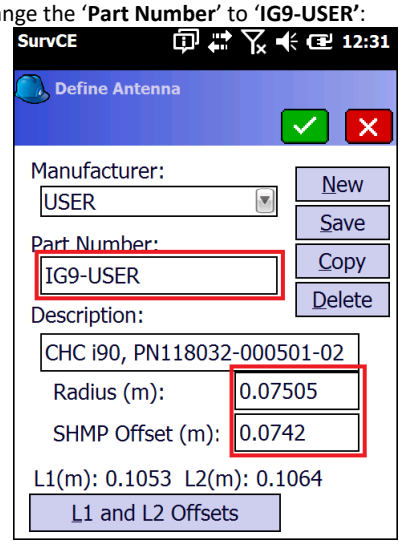


If you plan on using a '**Slant**' measurement, you will need to edit the antenna model and enter the device radius and SHMP. Click the antenna button:

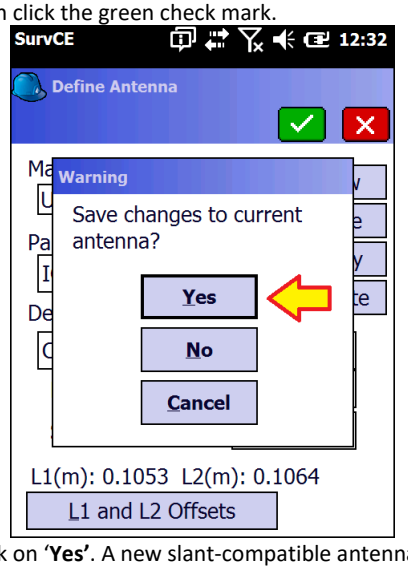
If you have already made a '**USER**' '**IG9-USER**' antenna you can select if by choosing '**Manufacturer** = **USER**' and '**Part Number** = **IG9-USER**'; otherwise click the '**Copy**' button:



Change the '**Part Number**' to '**IG9-USER**':

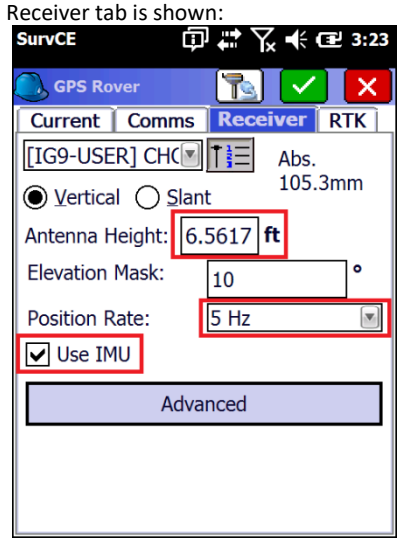


Enter the **Radius** and **SHMP Offset** as shown above, then click the green check mark.



Click on '**Yes**'. A new slant-compatible antenna type is added.

11. The Receiver tab is shown:

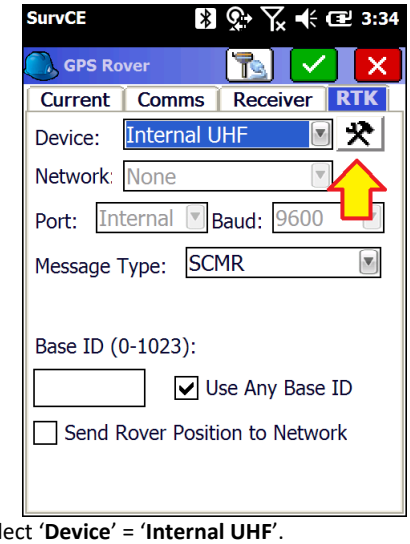


Enter the **Antenna Height**, if you are using a 2-meter fixed height pole enter "2M" and the height will automatically convert to feet.

Set the '**Elevation Mask**' to a reasonable value, 10 to 15 is typical.

If you want to use the IMU to display the electronic bubble, or compensate for pole tilt set the 'Position Rate' to 5 Hz and check the 'Use IMU' checkbox. Additional information on IMU operation can be found in the section '**Using the IMU Tilt Sensor on an iG9**' on page 60.

12. Click on the **RTK** tab:

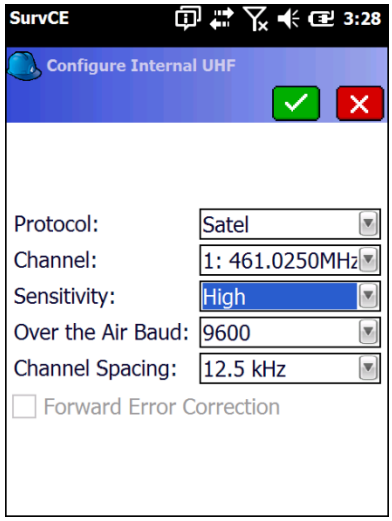


Select '**Device**' = '**Internal UHF**'.

The '**Message Type**' should match the selection made at the Base. (If you don't know the Base setting, don't worry about it—the Rover will automatically figure it out.)

Leave 'Use Any Base ID' Checked!

13. Click on the **Settings** button (hammer / wrench) to the right of the '**Device**':

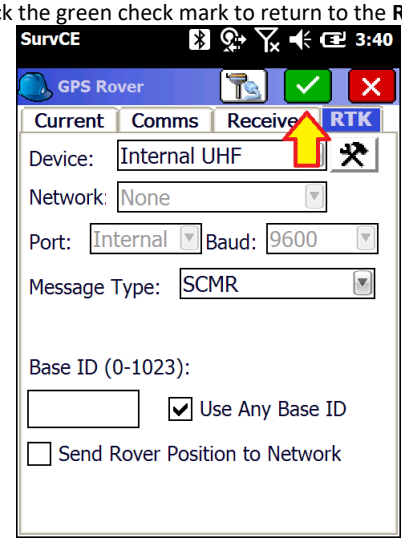


The Sensitivity will always revert to **Medium** on the iG9. Sensitivity is not implemented.

The '**Protocol**', '**Frequency**', '**Forward Error Correction**' and '**Channel Spacing**' must match the Base.

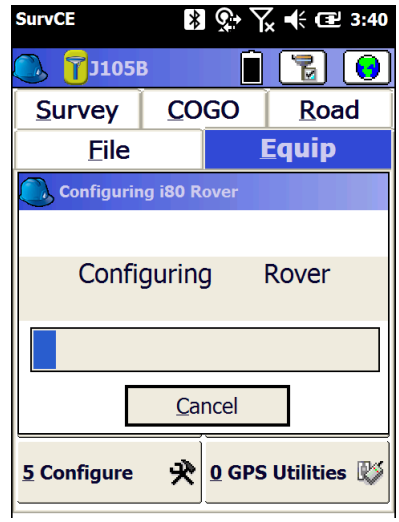
The Base and Rover channel numbers don't have to match, **but the 'Frequency' must match exactly!**

14. Click the green check mark to return to the **RTK** tab:



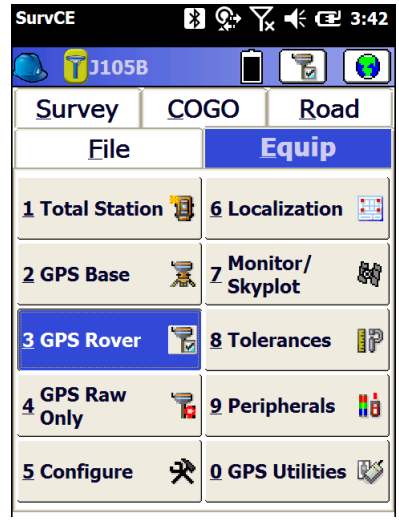
Click on the green check mark to configure the Rover.

15. After a few moments:



the receiver will be configured…

16. You will be returned to the main menu:



17. Continue to the next section to verify operation.

Troubleshooting a UHF Base / Rover Pair

Verify that the Base is Transmitting

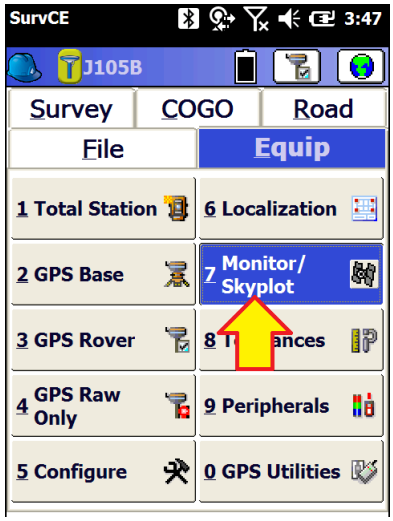
Check to ensure that the orange LED above the display on the top-right side is flashing once each second on the Base and the Rover:

Debugging Rover: FLOAT, DGPS, DGPS, AUTO

A Rover that will not '**FIX**' is a common issue. This section will help you determine what is wrong.

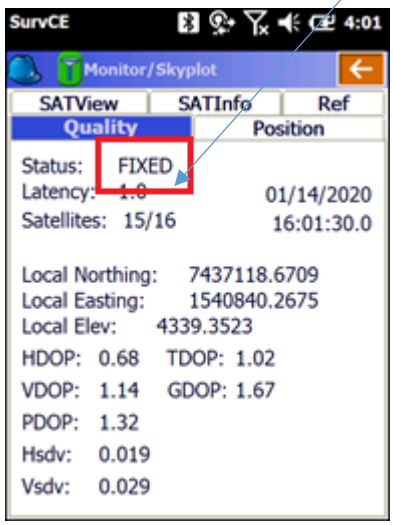
If you are configuring a UHF Rover, check the previous section '**Verify that the Base is Transmitting**' on page 38 to make sure your Base is transmitting UHF corrections.

On the Rover, from the main menu click on the 'Equip' tab:



Click on '**7 Monitor Skyplot**', check the '**Status**' on the '**Quality**' tab.

Status = 'FIXED':



If the **Status** is **FIXED**, then the front panel of the iG9 receiver:

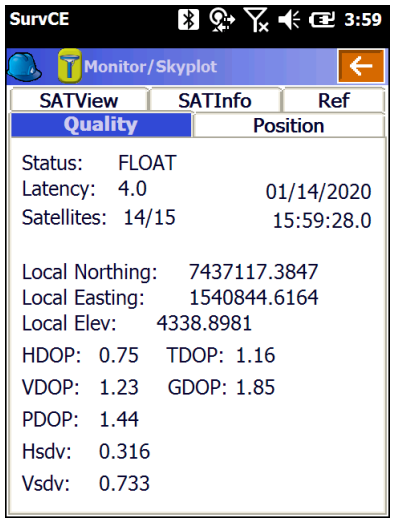
Will show '**Fix'** (you may need to click a front panel button to turn the display on.)

Great! You are ready to survey.

If Base and Rover are properly configured and running, the '**Status**' is '**FIXED**', the Hsdv and Vsdv should be low and the Latency will be less than 5 seconds.

Your Base and Rover are properly configured, you are ready to survey.

Status = 'FLOAT':



If the Rover reports '**Float**' then the connection to the Base (UHF radio or Network connection) is properly configured and working. (This is great news!) Corrections are being received, however the GNSS engine cannot resolve ambiguities to fix the solution.

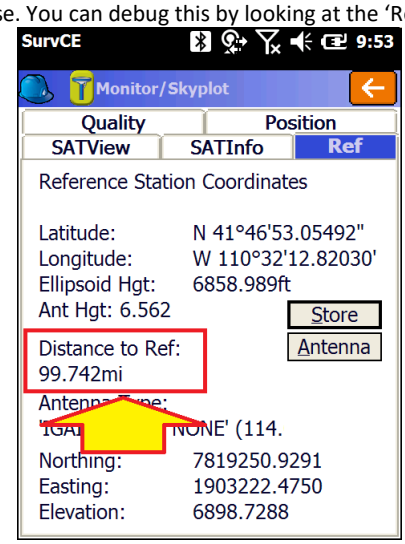
1. If the Rover is FLOATing, but never fixes, the programmed Base position could be more than 100 meters from the actual Base location. This happens when any Base setup method other than '**Read GPS**' is used. If you got an error message like '**Warning: Base position is 100 meters distant from reading**' when setting up the Base then your Rover may never fix.

   In other words: 'the entered Base horizontal and vertical location must be within 100 meters of the true Base position.'

2. Is the Base within 30 miles of the Rover position? Extremely long Baseline distances will keep the Rover from fixing.

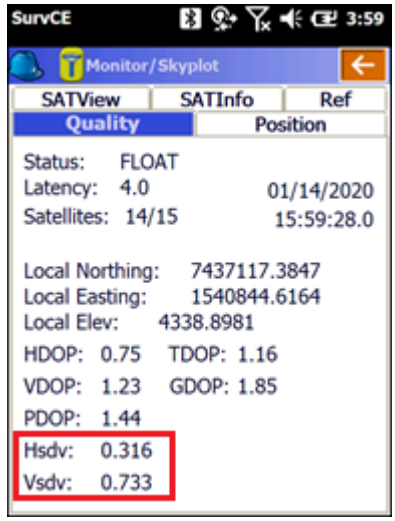
   The distance is displayed on the '**Ref**' tab of Monitor/Skyplot.

   There a chance that the Rover is receiving corrections from an unintended network source or someone else's UHF Base. You can debug this by looking at the 'Ref' tab:



   Is the '**Distance to Ref**' correct for your Base? In this example, the Base in use is nearly 100 miles away, the Rover will probably never fix and the correction source is probably unintentional!

3. If your Rover is under moderate or heavy canopy, it may take a while for it to FIX ambiguities. Watch the '**Hsdv**' and '**Vsdv**' (Horizontal and Vertical estimated errors):



If they are dropping, then the receiver may FIX after some time and it is worth waiting. If Hsdv / Vsdv continuously reset from low to high, there may be too much canopy for the GNSS engine to fix.

You might be able to move to the open, get a FIX, then carefully move back to the obstructed location and make an accurate measurement.

Changing the elevation mask on the '**Receiver**' tab may help. Dumping the receiver (turning upside down then right side up) may help.

Raising the rod height may help.

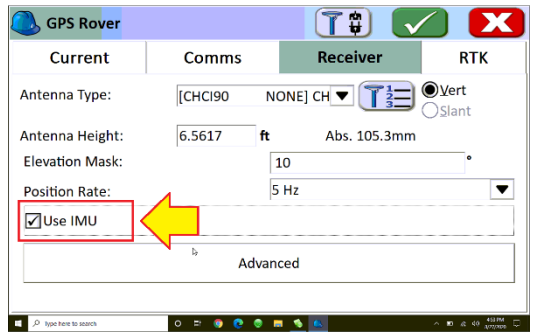
Waiting a while for a better satellite constellation may help. (See the Mission Planning section below.)

4. If the Rover is FLOATing, but never fixes, there could be high multipath or canopy at the Base. Remember that ANY canopy obstructions at the Base affects EVERY Rover location and every measurement.
5. Is the Latency less than 4 seconds? If the Latency builds up to values larger than 4 seconds there may be someone else on the same UHF radio frequency or the UHF radio signal is not strong enough to reach the Rover dependably. Use a handheld radio to monitor the frequency.

   If you are using a network connection, then the cell connection may be unstable.
6. Have you checked Mission Planning? See section '**Using the** IMU Tilt Sensor on an iG9

The iG9 has an IMU (Inertial Measurement Unit) based Tilt sensor. This IMU will work in any Rover mode (UHF, Network Server) when the receiver is Fixed and the IMU has been initialized. Heading is derived from the Rover's movement and GNSS based position.

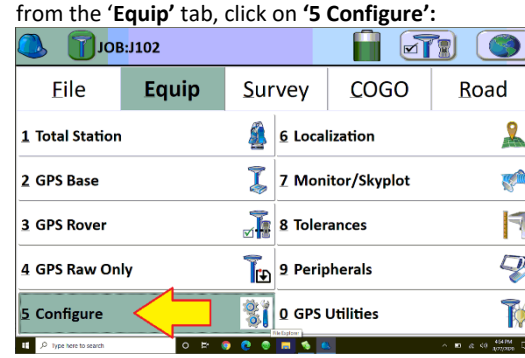
To use the IMU, when configuring the iG9 Rover under '**Equip: GPS Rover'** on the '**Receiver'** tab, check the '**Use IMU'** checkbox:



This will automatically set the '**Position Rate'** to **5-Hz.**

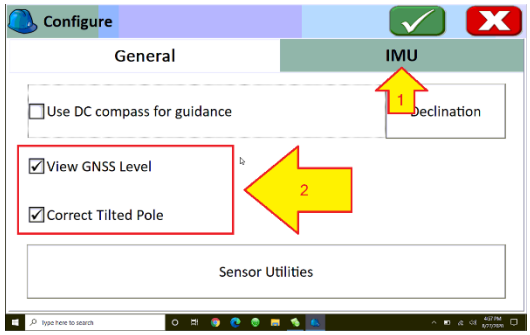
After configuring the iG9 as a Rover, you can enable/disable the tilted pole calibration:

1. from the '**Equip'** tab, click on **'5 Configure':**



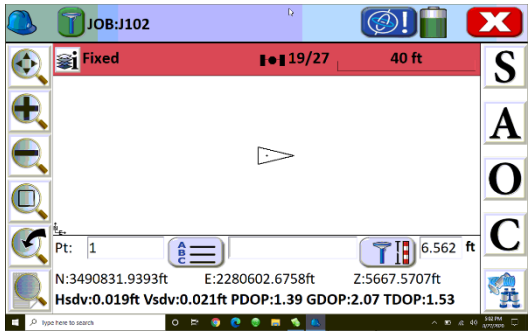
2. from the '**C'** (Configure) button on the Store and Stake screens:

Select the IMU tab (1):



Check both the **'View GNSS Level'** and **'Correct Tilted Pole'** check boxes.

When in the Store or Stake screens, the top line of the display will display an icon with the current IMU initialization state.



If this icon is shown on the top line:

the IMU needs to be initialized.

The IMU can be initialized by allowing the receiver to sit level for 15 or more seconds, then dip the receiver in any direction 30 degrees and return to level, wait 15 seconds, the IMU will initialize and the icon will change to green:

Once the IMU is initialized it will remain initialized if the receiver stays Fixed and pole has some movement.

If the pole is held static for more than 30-seconds, the IMU will report that it is uninitialized, the smallest shake (0.01') of the pole will reinitialize the IMU for another 30-seconds.

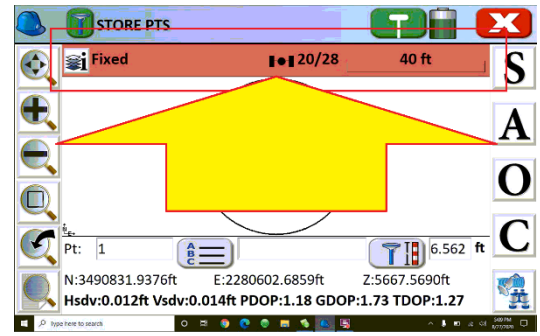
If the receiver drops to a FLOAT or DGPS solution, the IMU initialization will be lost, however the smallest shake of the pole after a 15-second period of FIXED readings will typically reinitialize the IMU.

You may also see these IMU related icons:

	Tilt is larger than the configured 'Level Tolerance' or 'Incline Tolerance', see 'Equip: Tolerances'.
	Excessive pole motion during measurement.

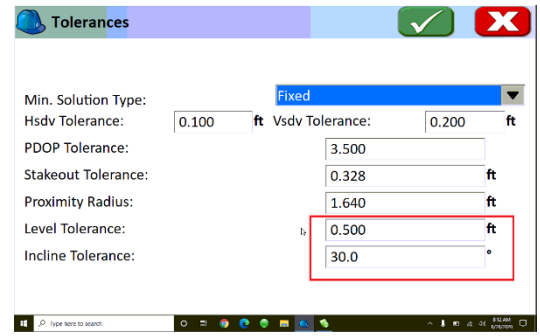
IMU Tolerance Settings

There are several IMU / Tolerance related settings that will cause the top status line to 'Go Red':



When the top line is red, any one or multiple tolerance conditions will prevent you from storing a shot, without overriding the action.

To configure the Tolerance settings, from the main menu **'Equip: 8 Tolerances'**:

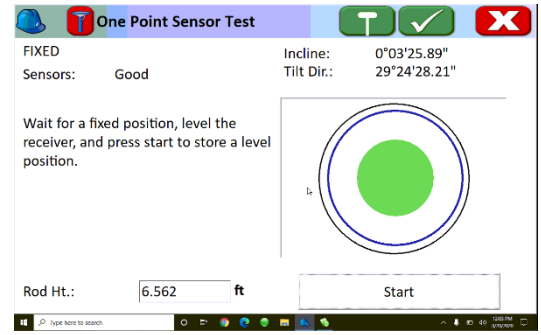


The **'Level Tolerance'** is the maximum allowable linear ground distance error allowable.

The **'Incline Tolerance'** is the maximum allowable pole tilt in degrees.

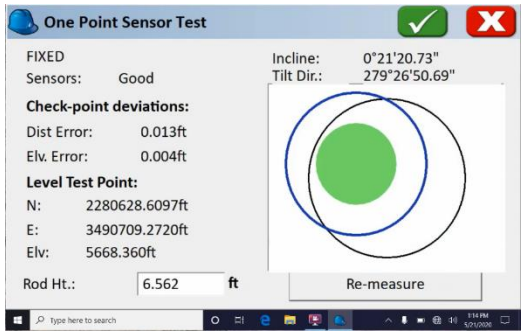
Verifying the Tilt Function

SurvCE has a **'One Point Sensor Test'** accessible from **'Equip: GPS Utilities: Sensor Utilities: One Point Sensor Test'**:



Enter the correct rod height, ensure that the receiver is FIXED and the IMU is initialized, then click **'Start'**. A short average position will be computed.

The dialog will then display the Distance and Elevation errors assuming the tip of the pole remains in a fixed location. Ideally, they will both be nearly zero:



Tilt Related Raw Data Records

Raw files (.RW5) will have additional measurement records when tilt is enabled:

```
--GSRD,TXD-1.221,TYD-
1.412,THD287.171,TDTiGage_IG9
--GSRL,TXL-
0.250,TYL0.078,T2D0.262,TTL0.050
--GSAL,TEL-
0.250,TNL0.078,TZL0.005,T2D0.262,TT
L0.050
```

GSRD: Raw IMU Sensor Data Record

Included when 'Use IMU' is checked. Raw tilt measurements.

Header	Description
--GSRD	GNSS Sensors Raw Data, direct readings
TXD	Tilt X reading perpendicular to front display (degrees)
TYD	Tilt Y reading parallel to front display (degrees)
THD	IMU compass reading (degrees)
TDT	Tilt Sensor device name (degrees)

GSRL: Computed Deviation from Ground Mark – Digital Level Mode, no Corrections Applied

Included in Digital Level mode when no corrections are applied. Distance from GNSS Phase Center (PC) to pole point Ground Mark (GM).

Header	Description
--GSRL	GNSS Sensors Relative Linear deviations
TXL	Tilt X relative distance to point (feet, meters)
TYL	Tilt Y relative distance to point (feet, meters)
T2D	Tilt 2D distance PC to GM (feet, meters)
TTL	Tilt tolerance in linear units (feet, meters)

GSAL: Computed Deviation from Ground Mark – Corrections Applied

The reported '**Incline'** is the pole tilt angle. The '**Tilt Dir'** is the direction the pole is leaning assuming the display is pointing towards the operator.

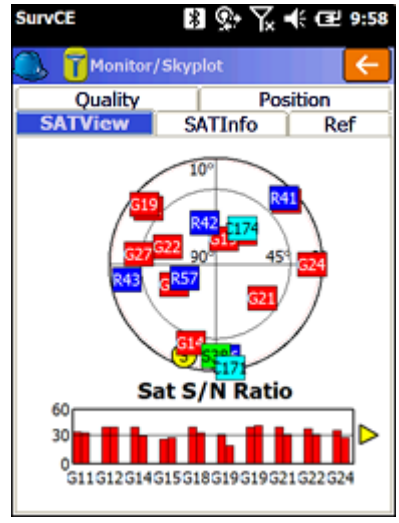
The '**One Point Sensor Test'** is valuable for field crews to understand the limitations of tilt compensation.

Included in Digital Level mode when corrections are applied. Distance from GNSS Phase Center (PC) to pole point Ground Mark (GM).

Header	Description
--GSAL	GNSS Sensors Absolute Linear deviations
TXL	Tilt X relative distance to point (feet, meters)
TYL	Tilt Y relative distance to point (feet, meters)
T2D	Tilt 2D distance PC to GM (feet, meters)
TTL	Tilt tolerance in linear units (feet, meters)

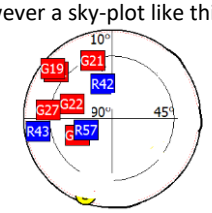
7. Mission Planning' on page 60.

Check the '**SATView**' under '**Monitor/Skyplot'**. A satellite distribution like this:



is good and the receiver should FIX within 30 seconds if in open sky.

However a sky-plot like this:

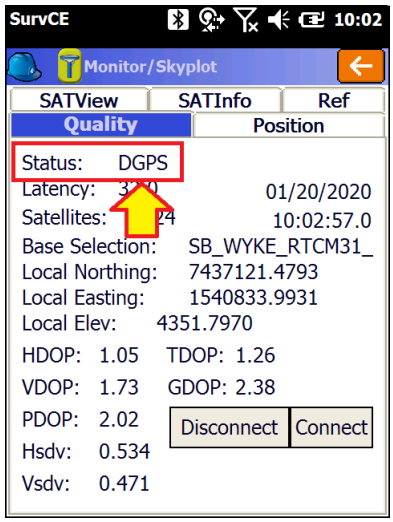


where all of the satellites are in one quadrant, or the

satellite count is very low, just won't be sufficient to get a FIXED solution.

Status = 'AUTONOMOUS', 'WAAS' or 'DGPS':

The **Monitor/Skyplot** display on the data collector will show '**AUTONOMOUS'**, '**WAAS'** or '**DGPS'**:



The Rover is NOT receiving Base corrections, or the Rover is indoors or under very-very heavy canopy.

When the Rover is in WAAS or DGPS mode, the latency will cycle through 3, 4, 5, 6, 3, 4, 5, 6, … This is the latency of the WAAS correction, NOT the latency of the UHF radio correction.

The right-hand LED on the Rover receiver will not be blinking:

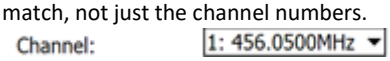
1. UHF: Is a UHF antenna connected to both the Base and Rover?

2. UHF: Is the Base broadcasting corrections? See '**Verify the Base is Transmitting'** above.

3. Is the Rover receiving the Base corrections? (Probably not!) The orange / green LED on the Rover should blink once each second.

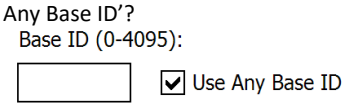
If the Rover orange LED is not flashing, check these items:

a. UHF: Do the frequencies match on the Base and Rover? The frequencies must match, not just the channel numbers.



b. UHF: Does the radio protocol match? Typically, 'SATEL' on both Base and Rover.

c. UHF: Is the Rover's 'Base ID' set to 'Use Any Base ID'?



d. UHF: Is there someone else using the same frequency? Both Voice and Data in use by others on the same frequency will block your Rover from receiving corrections from the Base.

e. Network: Is the cell connection reliable?

f. Network: is the connection valid? Try clicking on 'Disconnect' then 'Connect' to re-establish the connection.

If the Rover is not receiving corrections (the top-right-hand LED flashing), do not waste your time waiting for a FLOAT or FIX solution. Look for the reason that corrections are not active.

A receiver that is not receiving corrections will never move to the FLOAT or FIX status.

Configuring an iG9 Network Rover

If your work area is in the service area for a GNSS Network Server and has suitable cellular data coverage you won't necessarily need to setup your own Base. You can use the network to supply corrections. The benefits of a GNSS network include:

Someone else takes care of getting coordinates correct

No Base to setup, faster deployment

No Base to steal, no worry about theft of Base

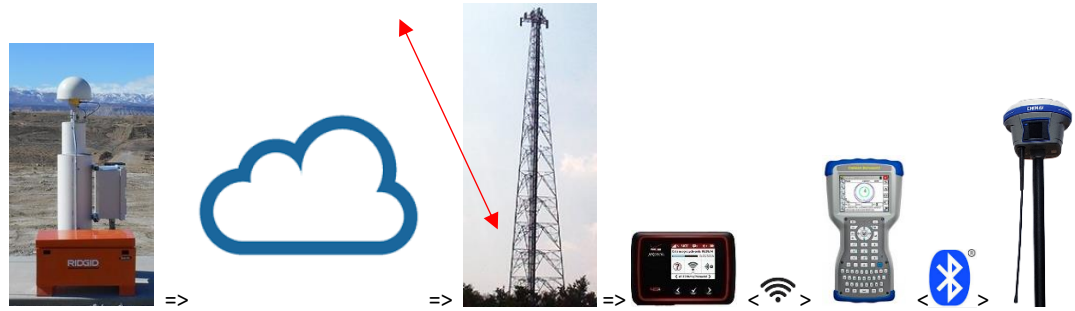
Networks generally provide GPS and GLONASS corrections only. Your Rover may not perform as well as when using a matched local Base. If the nearest physical network Base is a long distance from your work area, the performance will also suffer from the effective long Baseline from the Base to your Rover.

DCI (Data Collector Internet)

DCI (Data Collector Internet) is a very common network Rover connection method.

Your data collector is connected to a Wi-Fi hotspot (your smartphone or a dedicated Mi-Fi) and your data collector brokers the connection to the Server and passes correction via Bluetooth to the iG9 head:

DCI Method (Data Collector Internet)

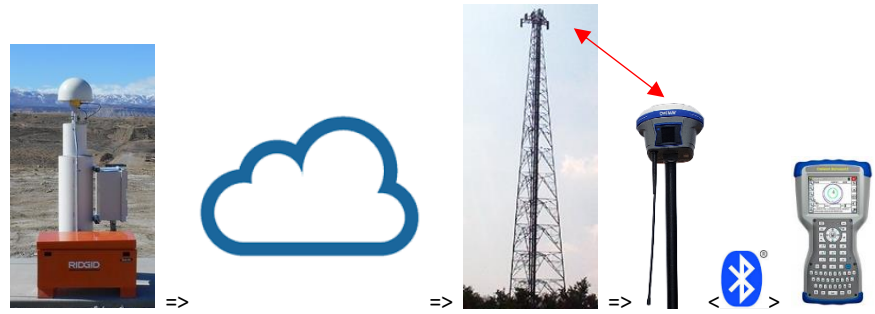


Internal GSM

Another connection method is to use the 4G cellular modem (Internal GSM) built into the iG9 head to connect to the network. This is a great connection method because:

- the data collector does not have to broker the correction stream with the network server
- the cellular antenna is at the top of the iG9 receiver and may have a better view to the cell tower
- the iG9 can be programmed to be a Hotspot and share its data connection with other devices.

Internal GSM Method



There are two common types of network servers:

NTRIP Requires an IP Address, Port, User Name and Password

DIP Requires an IP Address and Port

The iG9 supports both connection types.

If you are using the DCI connection method, continue to the next section "**Connecting your Data Collector to a Wi-Fi Hotspot**" on page 46.

If you are using 'Internal GSM' skip to section '**Configuring the iG9 Internal Cellular Modem**' on page 51.

Connecting your Data Collector to a Wi-Fi Hotspot

iPhone / iOS Wi-Fi Hotspot Notes

If you are connecting your data collector to an iPhone or iOS device, you may need to change the name of the iOS device which controls the SSID to NOT include spaces or "' (the possessive apostrophe.) From the main menu on your iOS device, click on 'Settings: General: About'. Change the device name from:

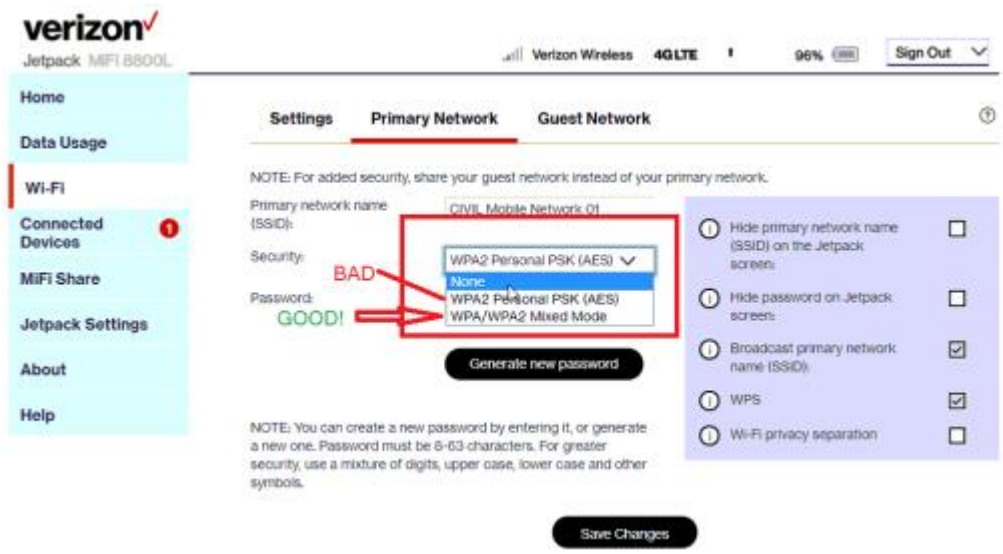
"**Mark's iPhone**" to "**MarksiPhone**"

or some other simple ID that does not contain multi-byte characters. Most Windows Mobile Devices will not support multi-byte special characters like "'" (apostrophe), in the SSID. The data collector will connect once but fail to connect on subsequent attempts.

Verizon JetPack Issues

Windows Mobile devices have a hard time connecting to some Verizon Jet Packs (with specific firmware updates.)

If you cannot see or log into a JetPack from your data collector, log into the JetPack from a computer attached to the JetPack (typically the address is 192.168.1.1 using an internet browser, the admin account name and password can be obtained from one of the display screens.)



Find the '**Security**:' drop down. It will be set to **WPA2**. Change it to **WPA/WPA2**. (None works great too, but offers no security.) Click on **Save Changes**'.

Item #2: Make sure the SSID is simple. An SSID like "**Mark's JetPack-#01**" is probably not OK. Keep the SSID really simple like "**MARKJP**" using all upper-case letters and numbers with no punctuation marks.

Bonding your Data Collector to a Wi-Fi Hotspot

The first time your data collector is connected to an external Hotspot you will need to configure the data collector to connect to the Wi-Fi access point and password.

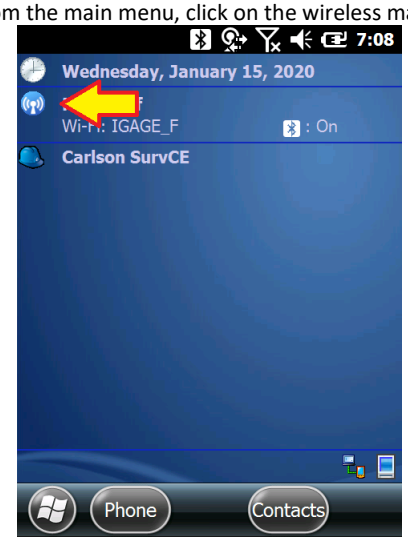
If your data collector is the **Nautix X8** the procedure for connecting to Wi-Fi is slightly different, please follow the instructions in section '**Nautix X8 Wi-Fi Setup**' on page 48.

Typical Data Collector Wi-Fi Setup

The following general instructions should work for most Windows Mobile data collector devices (other than the **Nautix X8**.)

NOTE: Disconnect the USB cable from your PC to the data collector before setting up Wi-Fi. Wi-Fi will not coexist with a USB-computer connection: when you plug the USB connection into your computer, the Wi-Fi connection is disabled.

From the main menu, click on the wireless manager icon:



(or from the Start menu: Settings: Connections: Wireless Manager.)

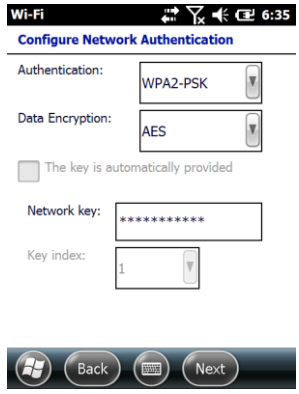
Make sure that Wi-Fi is enabled:

Click on **Menu**: **Wi-Fi Settings**,

Then click on the access point you want to connect to (IGAGE_F in this example.)

The '**Configure Wireless Network**' screen is shown:

Click on **Next**:

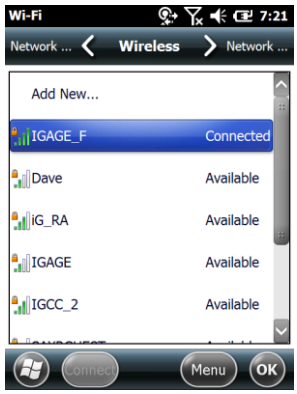


Enter the network key (this is the secret passcode for your access point.) The passcode is case-sensitive and must be correct.

Click on **Next**:

Finally click on **Finish**:

The data collector will show '**Connecting'** for a while and then switch to '**Connected**:



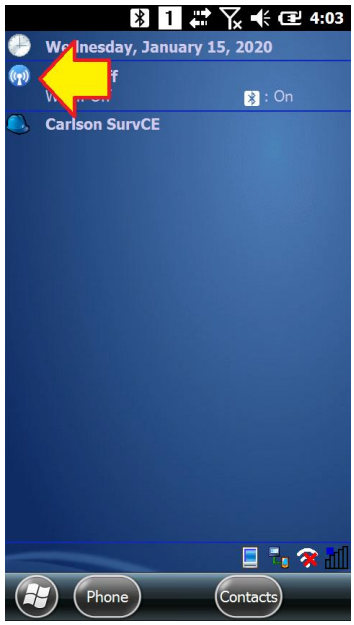
If your data collector has successfully connected to the internet you should be able to browse to any non-secure (HTTP not HTTPS) site (like www.igage.com) using the 'Internet Explorer' on the data collector:

Continue the Network Rover setup at "**Network (NTRIP and DIP) Rover Configuration**" on Page 52.

Nautix X8 Wi-Fi Setup

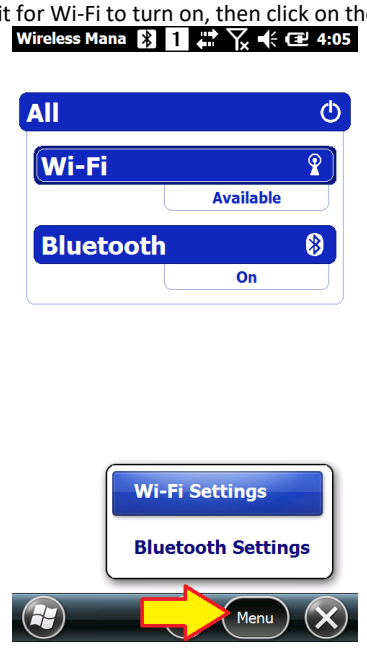
NOTE: Disconnect the USB cable from your PC to the X8 before setting up Wi-Fi. Wi-Fi will not coexist with a USB connection: when you plug the USB connection into your computer, the Wi-Fi connection is turned off automatically.

On the main menu of the device, click on the '**Wireless Manager**':



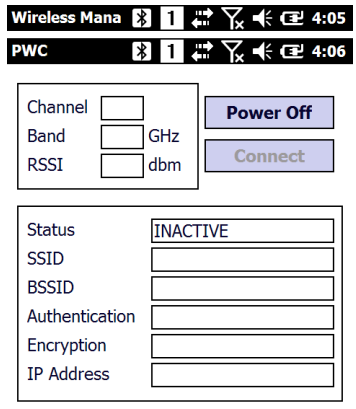
If the Wi-Fi bar is not solid color, click on it to turn on Wi-Fi:

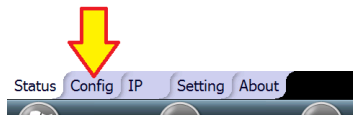
Wait for Wi-Fi to turn on, then click on the '**Menu**' button:



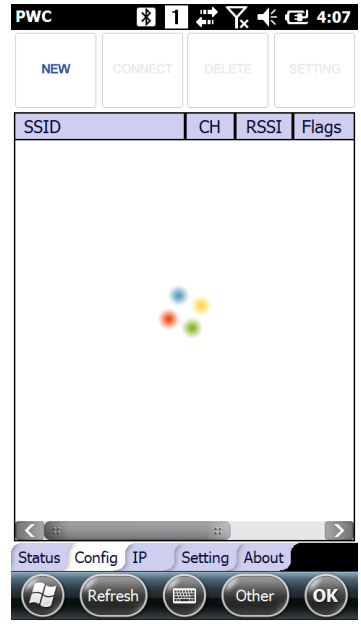
The menu-flyout will be shown:

Click on '**Wi-Fi Settings**'

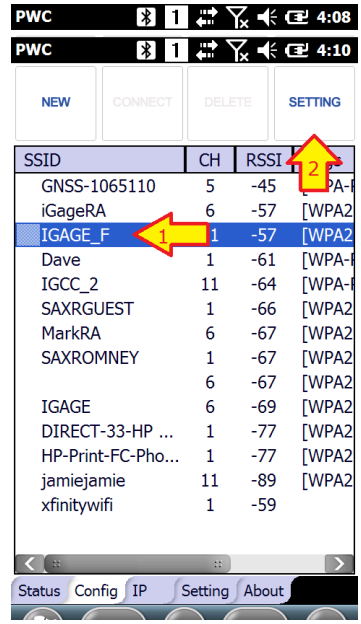




Click on the '**Config**' tab:



Wait for the SSID list to populate and the spinning balls to go away:



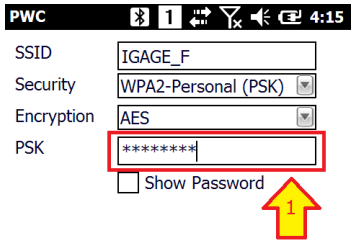
Now (1) click to highlight the correct access point, then (2) click the **SETTING** button in upper right-hand corner.

You may or may not see the next screen:

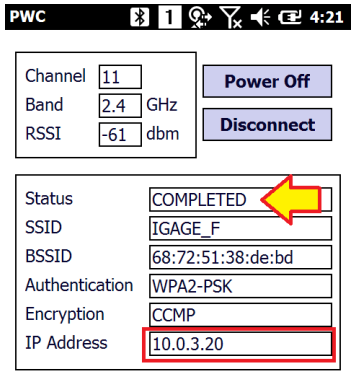
This menu is asking is "Your Access Point has a WPS button if you want to use it, click on Yes."

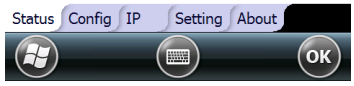
If you know the passcode for your hotspot click on **No**. (You will not see this question if your access point does not have a WPS button.)

If you click on **No** (recommended) the password screen is shown:



(1) Enter your password in the **PSK** (Pre-Shared-Key) box, then (2) click on **OK**.

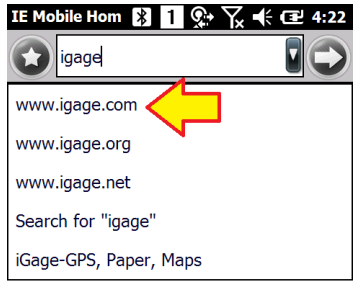




If you entered your password correctly, after a few seconds you will see '**Completed'** in the **Status**.

Click on **OK**.

Finally, start the internet explorer and browse to the iGage web site:



If you type in "**igage**", then you can directly click on '**www.igage.com'**.

If you see the iGage website:

then your data collector is connected to the internet and you are ready to setup a Network Rover.

Continue to the Network Rover setup at "**Network (NTRIP and DIP) Rover Configuration**" on Page 52.

Configuring the iG9 Internal Cellular Modem

Internal GSM Method:

If you use the internal Cellular Modem in the iG9 receiver, you will need to insert an activated 4G NANO GSM sim card into the card slot in the battery compartment.

While the modem is compatible with the Verizon system, it is not Verizon certified and it is probably not possible to activate in the Verizon network.

If you are removing the SIM card from the credit card sized distribution holder:

Use a knife blade to extract the correct nano sized card, the smallest punch out.

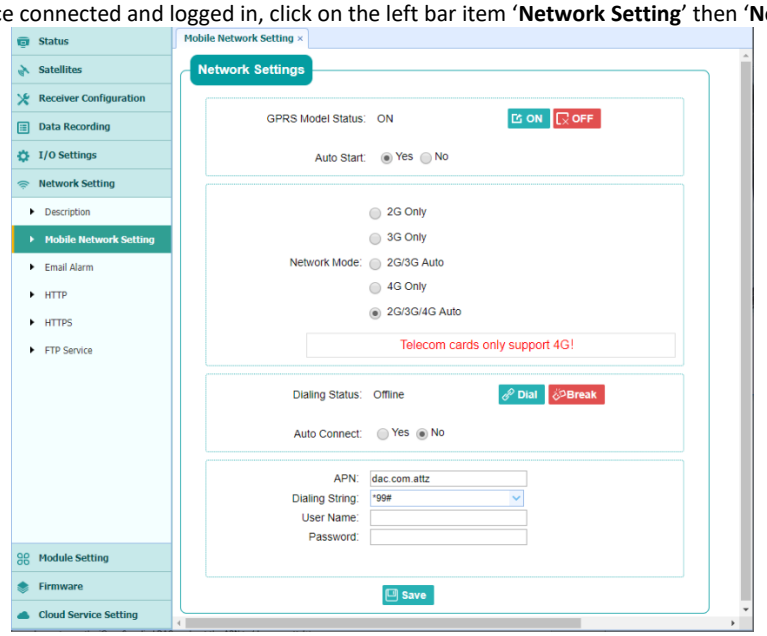
With the iG9 head battery door swung UP, looking into the battery compartment the SIM card is inserted with the gold connectors facing UP and the cut-corner is inserted into the hole first. Push the card into the slot all the way and it will click into position.

Warning: it is difficult to manipulate the small card into the slot. Remove the batteries and attempt in a location with good lighting.

Optional: Configuring the APN and Cellular Modem with the Web Interface

Typically, you will allow SurvCE to provision the SIM card, however you can also provision the card with a web browser via the Wi-F connection.

Once connected and logged in, click on the left bar item '**Network Setting**' then '**Network**: **Mobile Network Setting**'



1. Click ON to turn on the cellular modem. Set **Auto Start** to Yes, set **Auto Connect** to Yes.
2. If you are using an iGage Supplied DAC card: set the APN to 'dac.com.attz'
   If you use a 'True ATT' SIM card: set the **APN** to 'Broadband' (with capital-'B'). If you use another type of SIM card enter the appropriate APN for the card.
3. Set the **Dial String** to **'*99#'**, leave the **User Name** and **Password** empty. Click **Save**.
4. Turn off the GPRS Modem by clicking OFF, wait 10 seconds then turn the GPRS Modem on again by clicking ON. This resets the network connection with the correct APN active and forces the network to reinitialize the data connection.

5. Click on **Dial** to attempt to connect. After about 30 seconds, the **Dialing Status** will change to '**Connected'** after the iG9 is registered on the cellular network.

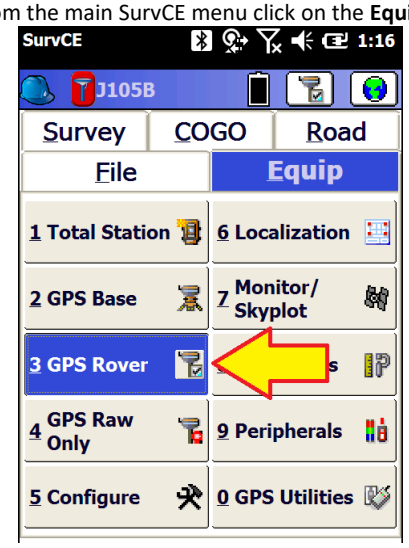
Alternatively, you can configure the Cellular modem with SurvCE when setting the iG9 as a network Rover as described in the next section.

Network (NTRIP and DIP) Rover Configuration

1. Setup the Rover:
   a. Attach the receiver to the range pole.
   b. Attach the UHF antenna to the receiver head.
   c. Put one or two charged batteries into the head.
   d. Turn on the Rover receiver.
   e. Attach the Data Collector to the range pole. Turn on the Data Collector and start SurvCE / SurvPC.

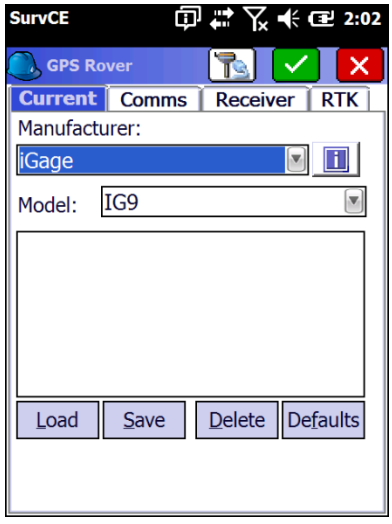
2. If you have not already started a new job, refer to the section '**Starting a New SurvCE Job**' on Page 21 to start and configure a new project.

3. From the main SurvCE menu click on the **Equip** tab:

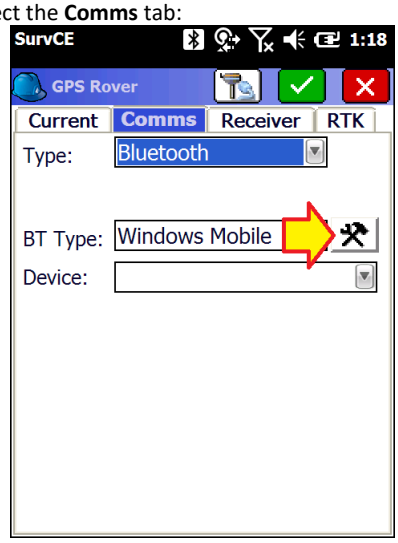


Then click on '**3 GPS Rover**'

4. Choose the correct **Manufacturer** '**iGage'** and **Model** '**iG9'**:

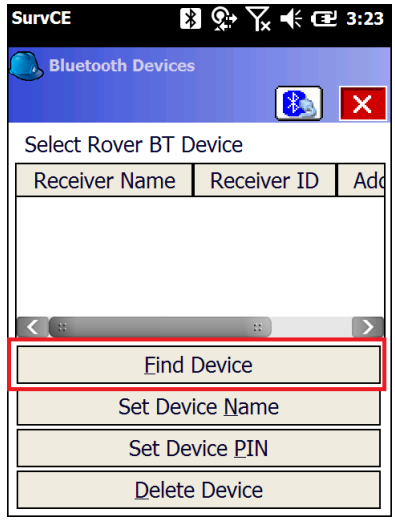


5. Select the **Comms** tab:



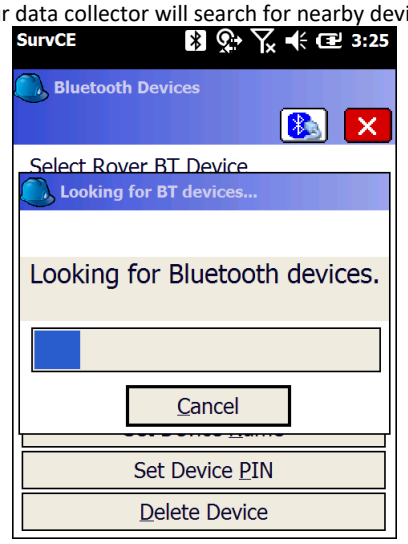
Choose '**Type**' = '**Bluetooth**', '**BT Type**' = '**Windows Mobile**', then click on the Settings button (hammer/wrench) button to the right of '**BT Type**'.

6. The **Bluetooth Devices** menu is shown:



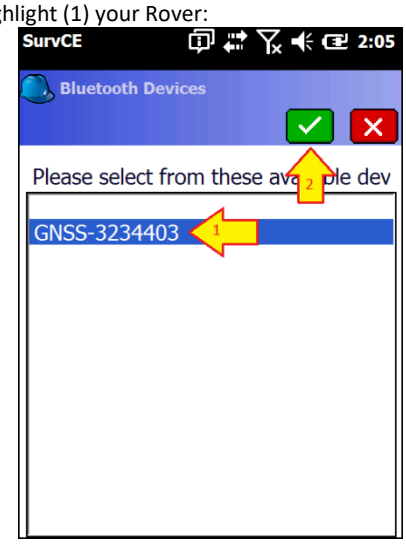
If your receiver is not listed, click on '**Find Device**'.

7. Your data collector will search for nearby devices:



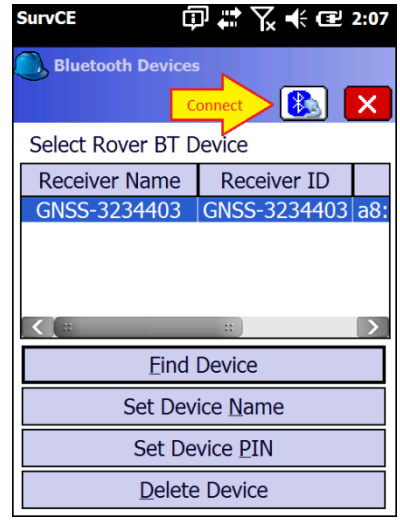
After short wait, all the Bluetooth devices in range of the data collector are listed:

8. Highlight (1) your Rover:

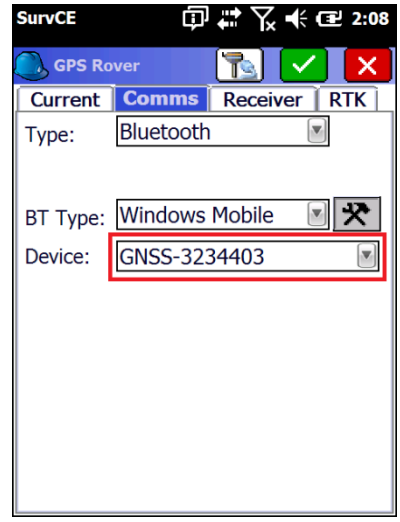


Then (2) click on the green checkmark.

9. Click on the **Bluetooth Connect** button, just to the left of the red-X:

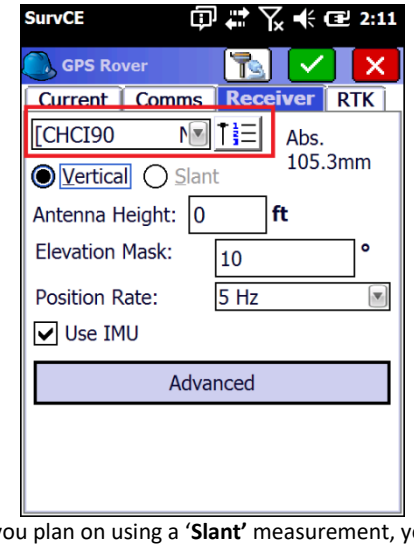


SurvCE will return to the **Comms** tab:



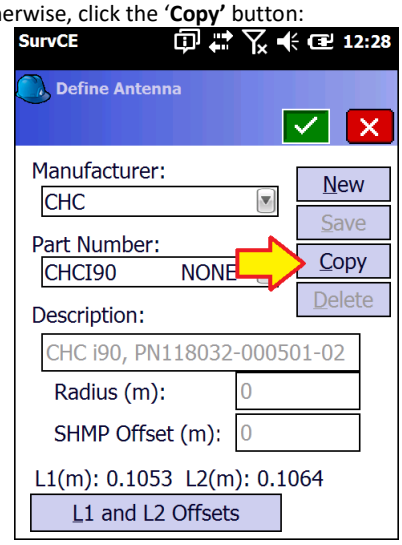
Verify that the correct Rover device is selected. Then click on the **Receiver** tab.

18. The **Receiver** configuration tab is shown:

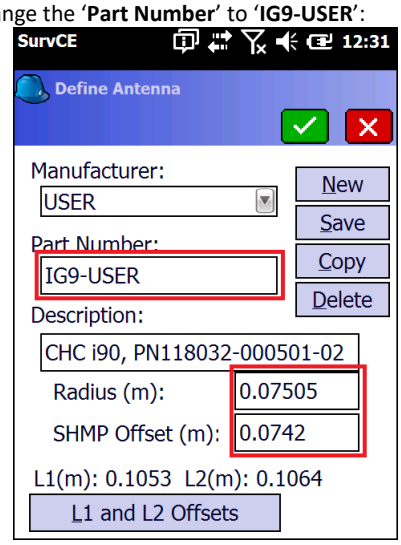


If you plan on using a '**Slant**' measurement, you will need to edit the antenna model and enter the device radius and SHMP. Click the antenna button:

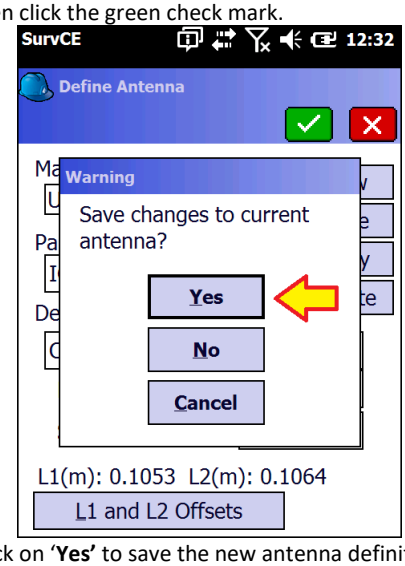
If you have already made a '**USER' 'IG9-USER'** antenna you can select if by choosing '**Manufacturer = USER**' and '**Part Number**' = '**IG9-USER**'. Otherwise, click the '**Copy'** button:



Change the '**Part Number**' to '**IG9-USER**':

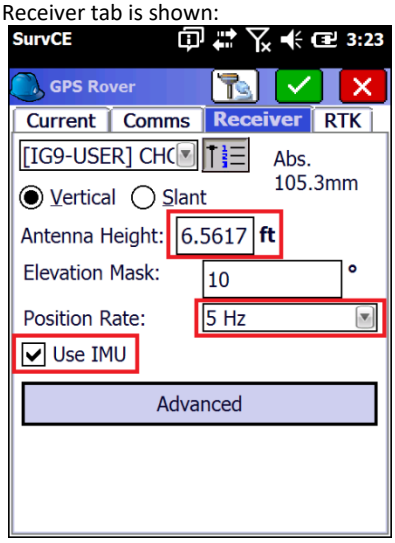


Enter the **Radius** and **SHMP Offset** as shown above, then click the green check mark.



Click on '**Yes'** to save the new antenna definition.

19. The Receiver tab is shown:

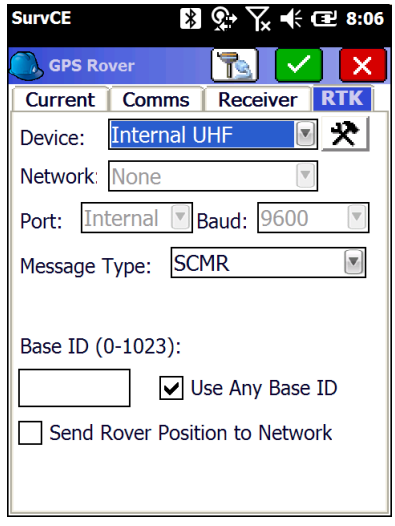


Enter the '**Antenna Height**', if you are using a 2-meter fixed height pole enter "**2M**" and the height will automatically convert to job units.

Set the '**Elevation Mask**' to a reasonable value, 10 to 15 is typical.

If you want to use the IMU to display the electronic bubble, or compensate for pole tilt set the '**Position Rate**' to 5 Hz and check the '**Use IMU**' checkbox. Additional information on IMU operation can be found in the section '**Using the IMU Tilt Sensor on an iG9**' on page 60.

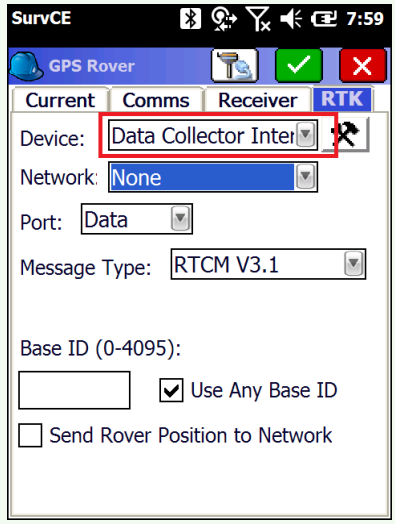
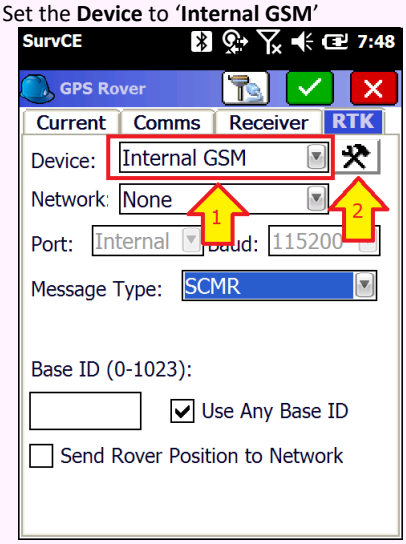
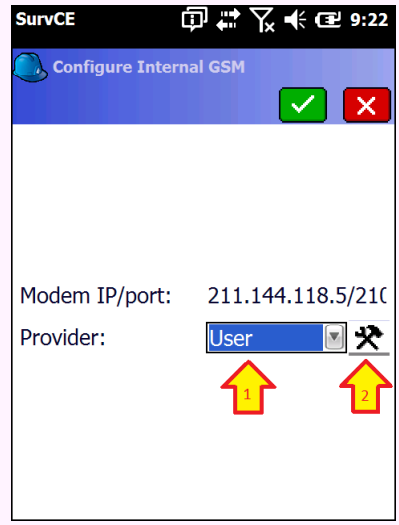
20. Click on the **RTK** tab:

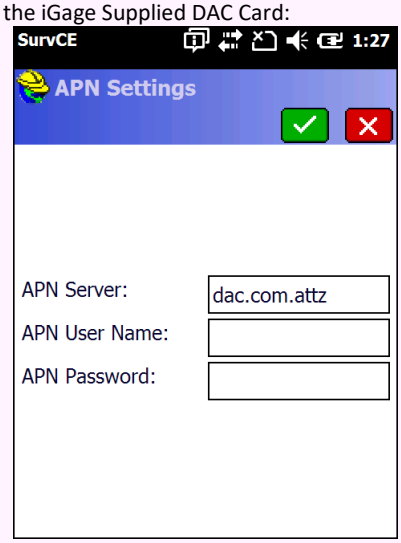


21. The previous RTK device will be shown to the right of the **Device**. Continue below…

Choose Internet Data Source

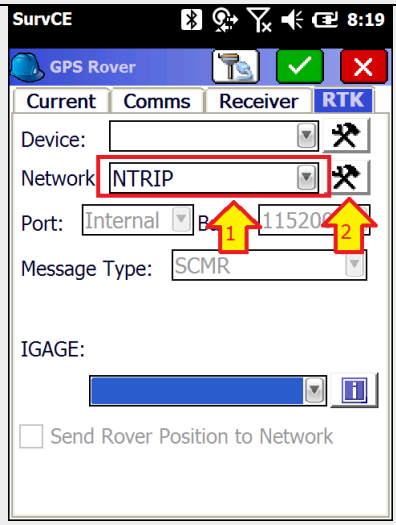
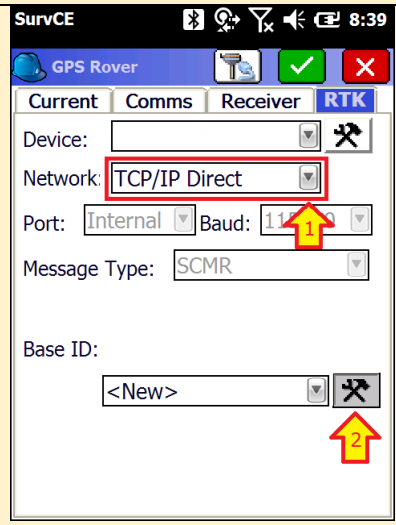
You can connect to the internet via Data Collector Internet (DCI) or with the Internal GSM Cellular Modem:

DCI (Data Collector Internet)	Internal GSM
You should have already connected the data collector to a Wi-Fi hotspot as shown in the section '**Connecting your Data Collector to a Wi-Fi Hotspot**' on page 46.	You should have already installed a GSM SIM card as shown in the section 'Configuring the iG9 Internal Cellular Modem' on page 51.
 Set **Device** to **'Data Collector Internet'** The connection to the NTRIP or DIP host will be made via the data collector Wi-Fi (or internal modem's) data connection.	(1) Set the **Device** to '**Internal GSM**'  then (2) click the **Settings** (hammer / wrench) button to the right of the Device.  (1) Select the '**Provider**'='**User**', then (2) click the **Settings** (hammer/wrench) button.
	Common 4G provider settings are: AT&T 4G Broadband APN = Broadband AT&T 3D Broadband APN = broadband iGage DAC APN = dac.com.attz T-Mobile APN = fast.t-mobile.com The '**APN User Name**' and '**APN Password**' typically are blank for all providers.

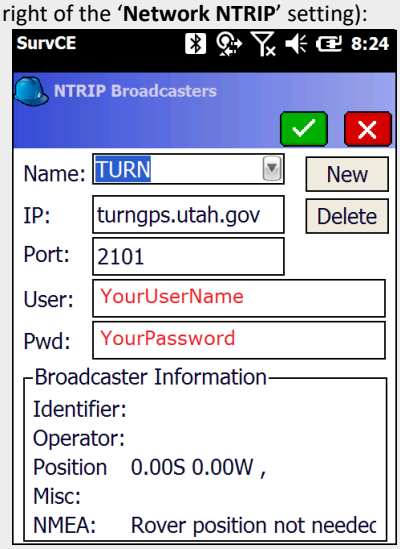
	For the iGage Supplied DAC Card:  Set the **APN Server** to '**dac.com.attz'**, leave the **APN User Name** and **APN Password** blank. Click the green check mark. Click the green check mark again to save the APN settings

After setting the APN, choose a NTRIP or DIP server source:

- If you have an **Address**, **IP Port**, **User Name** and **Password** then the connection is probably 'NTRIP'.
- If you only have an **Address** and **IP Port** then the connection is probably DIP (Direct IP.)

NTRIP Server	DIP (Direct IP) Server
 **Device** should already be '**Data Collector Internet**' or '**Internal GSM**' from previous step (1) The **Network** should be **NTRIP**. (2) Click on the **Network Settings** button (hammer / wrench button to	 **Device** should already be '**Data Collector Internet**' or '**Internal GSM**' from previous step

the right of the '**Network NTRIP**' setting):



Enter the correct service **Name**, **IP Address**, **Port**, **User Name** and **Password** for your network.

The **Name** is a description of the network source which you can assign freely.

The '**IP'** can be either a dotted value like '168.179.231.9' or a resolvable network name like 'turngps.utah.gov'. The port is supplied by the network operator.

Both the '**User Name**' and '**Password'** are case sensitive and must match your network credentials exactly.

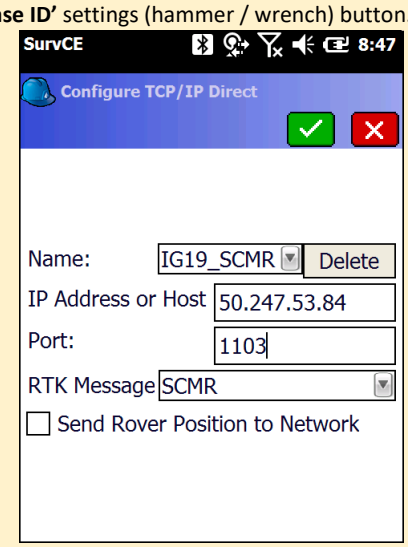
Double-check your settings and then click on the green checkmark.

The data collector will load the mount table via the internet and display the list of available Bases.

If you are using a GSM SIM card that has not previously been activated, the process may fail (as the network conducts background security authorizations.)

If provisioning fails, cancel, and then cycle the head power to reset the GSM Cellular Modem. The network connection will typically work on the second try.

(1) Set the **Network** to '**TCP/IP Direct**'. (2) Click on the '**Base ID'** settings (hammer / wrench) button.



Set the **Name**, **IP Address**, **Port** and **RTK Message** Type to match the DIP Base you are attaching to.

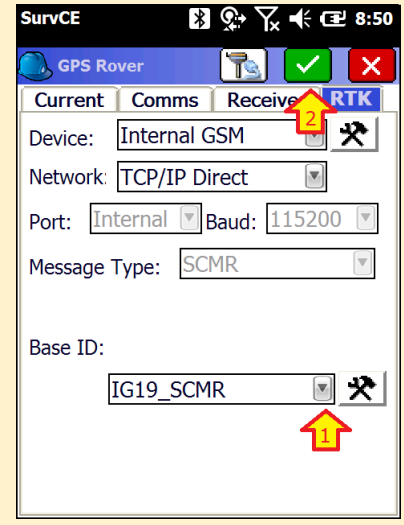
The **Name** is a description of the network source which you can assign freely.

The '**IP'** can be either a dotted value like '50.247.53.84.' or a resolvable network name like 'apis1.us'.

The port is supplied by the network operator.

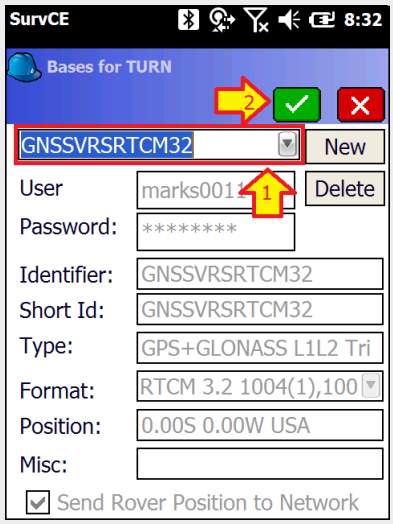
The RTK Message Type is not critical as the receiver will automatically adjust to the stream.

Double-check your settings and then click on the green checkmark.



(1) Check the '**Base ID**' then (2) click the green check mark to complete the DIP setup and connect to the network server.

After a moment, you should see a list of 'Mount Points' for the RTK Network:

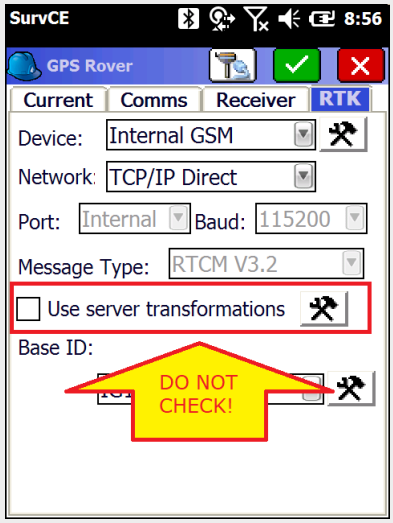


Use the drop-down list to choose the best mount point for your area.

Usually you will want to choose a VRS mount point, with GNSS (as many constellations as possible.) Typically, it will be 'RTCM 3.2 MSM', 'RTCM 3' or 'CMR+' mount points. RTCM2 and CMR mount points probably only have corrections for GPS satellites.

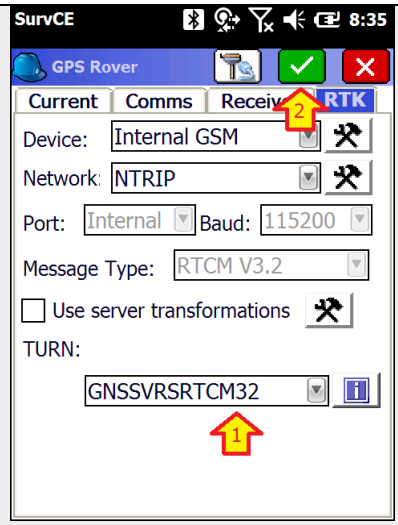
After selecting the correct network mount point, click the green checkmark to return to the **RTK** tab.

If shown DO NOT check the 'Use server transformations' check box:



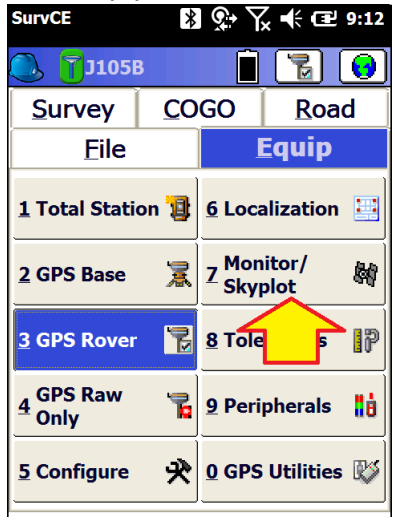
This selection is available ONLY if the correction source is RTCM3 and should VERY rarely be used.

Click the green check mark to return back to the **RTK** tab:

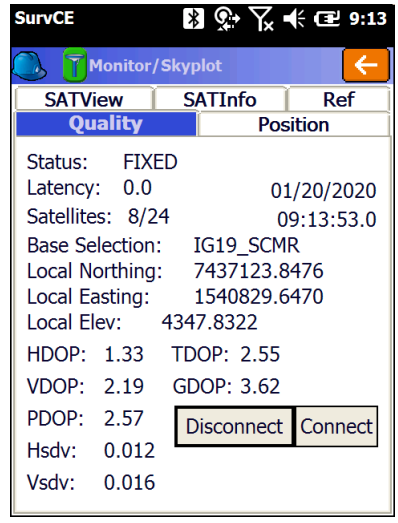


(1) verify the mount point and then (2) click the green checkmark to configure the iG9 NTRIP Network Rover and connect to the selected network source.

10. When the network Rover setup is complete you will return to the **Equip** menu:



11. You can check your configuration using "**Equip: 7 Monitor Skyplot**":



The receiver status should be FIXED if the connection was successfully made and you are in the open.

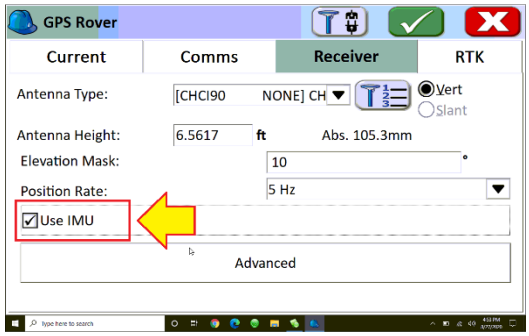
If the status is '**FLOAT**' wait a minute to see if the '**Hsdv**' drops and the status eventually changes to '**FIXED**'

Otherwise refer to the section '**Debugging Rover: FLOAT, DGPS, DGPS, AUTO**' on page 39 for troubleshooting assistance.

Using the IMU Tilt Sensor on an iG9

The iG9 has an IMU (Inertial Measurement Unit) based Tilt sensor. This IMU will work in any Rover mode (UHF, Network Server) when the receiver is Fixed and the IMU has been initialized. Heading is derived from the Rover's movement and GNSS based position.

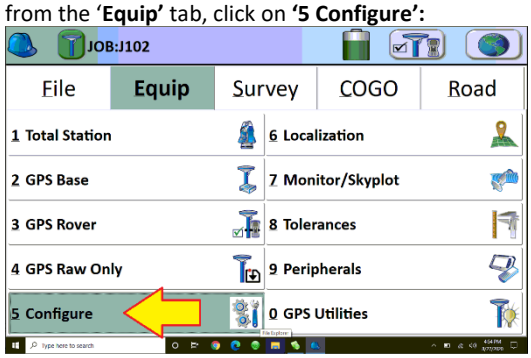
To use the IMU, when configuring the iG9 Rover under '**Equip: GPS Rover**' on the '**Receiver**' tab, check the '**Use IMU**' checkbox:



This will automatically set the '**Position Rate**' to **5-Hz**.

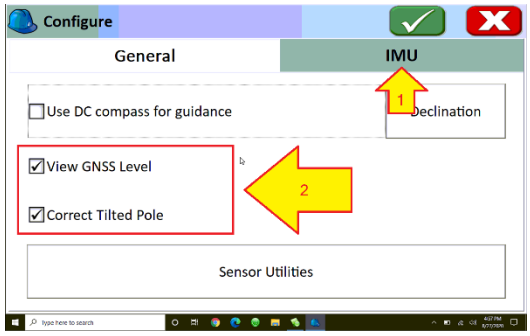
After configuring the iG9 as a Rover, you can enable/disable the tilted pole calibration:

3. from the '**Equip**' tab, click on **'5 Configure':**



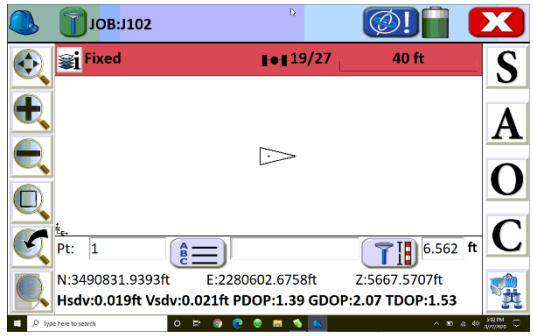
4. from the '**C**' (Configure) button on the Store and Stake screens:

Select the IMU tab (1):



Check both the '**View GNSS Level**' and '**Correct Tilted Pole**' check boxes.

When in the Store or Stake screens, the top line of the display will display an icon with the current IMU initialization state.



If this icon is shown on the top line:

the IMU needs to be initialized.

The IMU can be initialized by allowing the receiver to sit level for 15 or more seconds, then dip the receiver in any direction 30 degrees and return to level, wait 15 seconds, the IMU will initialize and the icon will change to green:

Once the IMU is initialized it will remain initialized if the receiver stays Fixed and pole has some movement.

If the pole is held static for more than 30-seconds, the IMU will report that it is uninitialized, the smallest shake (0.01') of the pole will reinitialize the IMU for another 30-seconds.

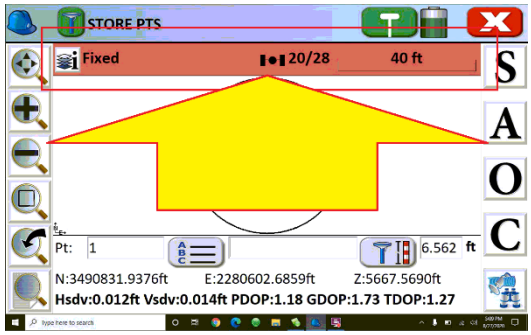
If the receiver drops to a FLOAT or DGPS solution, the IMU initialization will be lost, however the smallest shake of the pole after a 15-second period of FIXED readings will typically reinitialize the IMU.

You may also see these IMU related icons:

	Tilt is larger than the configured 'Level Tolerance' or 'Incline Tolerance', see 'Equip: Tolerances'.
	Excessive pole motion during measurement.

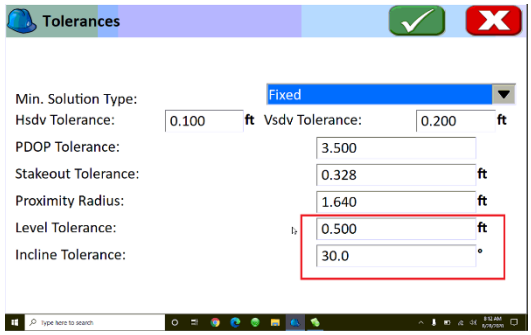
IMU Tolerance Settings

There are several IMU / Tolerance related settings that will cause the top status line to 'Go Red':



When the top line is red, any one or multiple tolerance conditions will prevent you from storing a shot, without overriding the action.

To configure the Tolerance settings, from the main menu '**Equip: 8 Tolerances**':

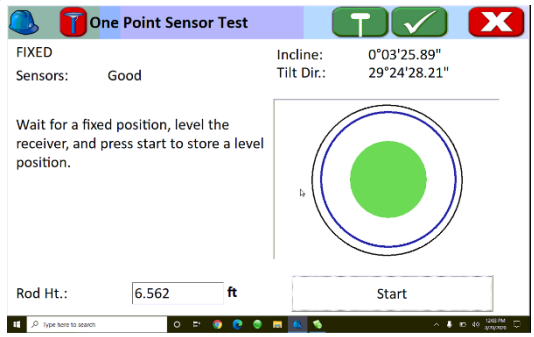


The '**Level Tolerance**' is the maximum allowable linear ground distance error allowable.

The '**Incline Tolerance**' is the maximum allowable pole tilt in degrees.

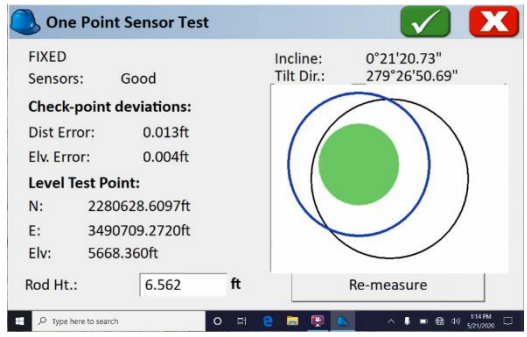
Verifying the Tilt Function

SurvCE has a '**One Point Sensor Test**' accessible from '**Equip: GPS Utilities: Sensor Utilities: One Point Sensor Test**':



Enter the correct rod height, ensure that the receiver is FIXED and the IMU is initialized, then click '**Start**'. A short average position will be computed.

The dialog will then display the Distance and Elevation errors assuming the tip of the pole remains in a fixed location. Ideally, they will both be nearly zero:



The reported '**Incline**' is the pole tilt angle. The '**Tilt Dir**' is the direction the pole is leaning assuming the display is pointing towards the operator.

The '**One Point Sensor Test**' is valuable for field crews to understand the limitations of tilt compensation.

Tilt Related Raw Data Records

Raw files (.RW5) will have additional measurement records when tilt is enabled:

```
--GSRD,TXD-1.221,TYD-1.412,THD287.171,TDTiGage_IG9
--GSRL,TXL-0.250,TYL0.078,T2D0.262,TTL0.050
--GSAL,TEL-0.250,TNL0.078,TZL0.005,T2D0.262,TTL0.050
```

GSRD: Raw IMU Sensor Data Record

Included when 'Use IMU' is checked. Raw tilt measurements.

Header	Description
--GSRD	GNSS Sensors Raw Data, direct readings
TXD	Tilt X reading perpendicular to front display (degrees)
TYD	Tilt Y reading parallel to front display (degrees)
THD	IMU compass reading (degrees)
TDT	Tilt Sensor device name (degrees)

GSRL: Computed Deviation from Ground Mark – Digital Level Mode, no Corrections Applied

Included in Digital Level mode when no corrections are applied. Distance from GNSS Phase Center (PC) to pole point Ground Mark (GM).

Header	Description
--GSRL	GNSS Sensors Relative Linear deviations
TXL	Tilt X relative distance to point (feet, meters)
TYL	Tilt Y relative distance to point (feet, meters)
T2D	Tilt 2D distance PC to GM (feet, meters)
TTL	Tilt tolerance in linear units (feet, meters)

GSAL: Computed Deviation from Ground Mark – Corrections Applied

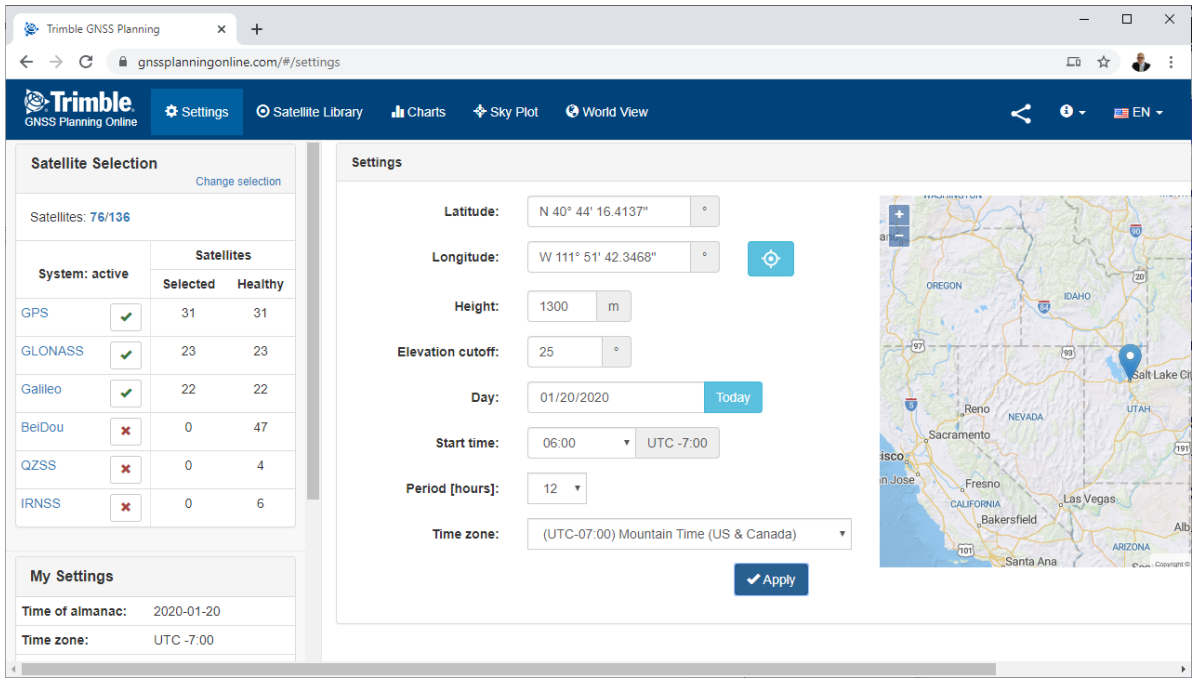
Included in Digital Level mode when corrections are applied. Distance from GNSS Phase Center (PC) to pole point Ground Mark (GM).

Header	Description
--GSAL	GNSS Sensors Absolute Linear deviations
TXL	Tilt X relative distance to point (feet, meters)
TYL	Tilt Y relative distance to point (feet, meters)
T2D	Tilt 2D distance PC to GM (feet, meters)
TTL	Tilt tolerance in linear units (feet, meters)

Mission Planning

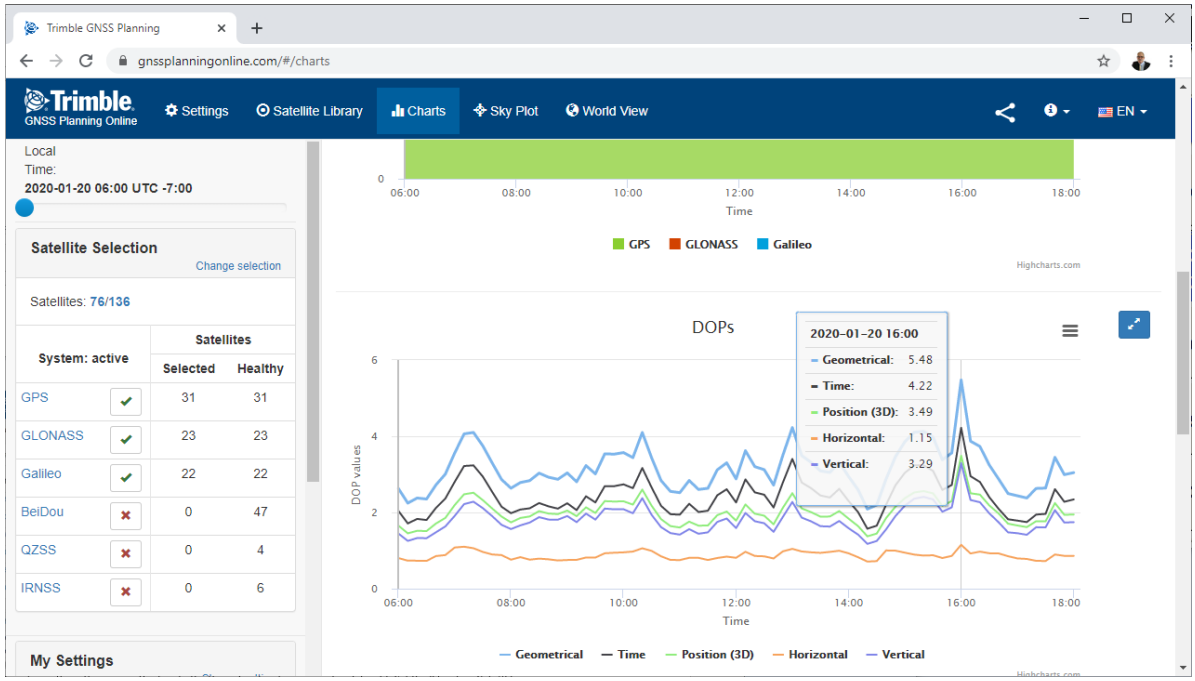
Sometimes when working under canopy (urban or forest) there will be periods during the day when the Rover will be unable or very slow to FIX. These unproductive periods can easily be predicted using 'Online Mission Planning'. While not usually necessary when working in open conditions, high canopy and multipath can make Mission Planning worthwhile.

There are many web and computer Based mission planning tools. The online resource https://www.gnssplanningonline.com/ is used for this example.



First configure the settings: pay attention to the 'Time Zone' and approximate job elevation. Set the 'Elevation Cutoff' to a high value like 25 - 30 degrees to simulate heavy canopy. Check GPS, GLONASS and Galileo leaving BeiDou unchecked (as it probably will have minimal contribution.) Click 'Apply'.

Click on 'Charts' and roll down to the PDOP chart:

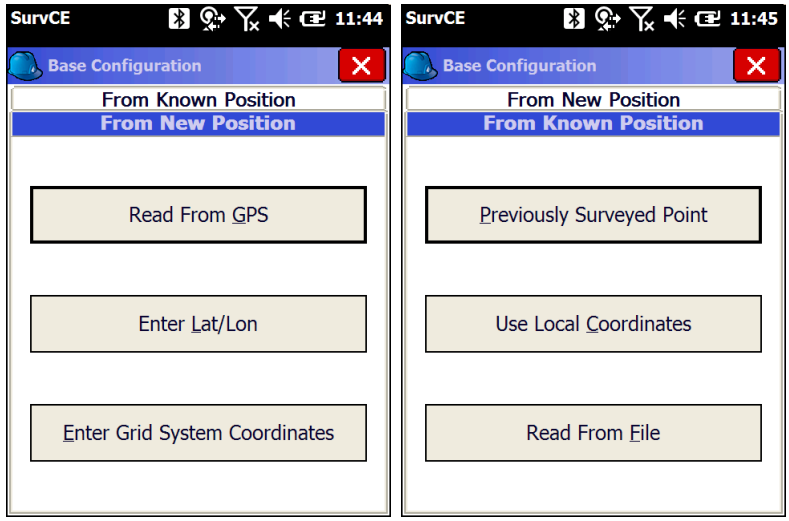


GDOPs higher than 3 will present difficult operation, GDOPS higher than 5 may not fix under canopy. Typically, as shown above, waiting 20 minutes can make a huge difference.

Advanced Base Configuration

The Quick Start Guide

When you are configuring a Base in SurvCE, you are given 6 choices for initializing the Base position:



In general:

- '**Read From GPS**': If you don't know the position of the Base, click on '**Read From GPS**' to use an 'Autonomous Base Position'. With WAAS corrections the autonomous position will be within 2-meters of the true ITRF2014 position. If absolute coordinates are needed, you can translate the job to an OPUS position after collecting raw observation data on the Base. See the section '**Adjusting an Autonomous Base Project to an OPUS Position**' on page 75. '**Read From GPS'** is the most common method for configuring a Base at a new job where control is not available.
- '**Enter Lat/Lon**': If you know the **geographic coordinates** (Latitude, Longitude and ellipsoid or Orthometric height) from a control sheet use '**Enter Lat/Lon**'.
- '**Enter Grid System Coordinates**': If you know the State Plane coordinates and you are working in State Plane use this option. You can also recall previously stored point coordinates with this option. This should be the most common method for moving a Base to a previously surveyed mark in an existing job.
- '**Previously Surveyed Point**': If you have been working on a job and have surveyed your new Base position as part of a previous setup, then you should be able to use '**Previously Surveyed Point**'. WARNING: This option uses **raw data** for a selected point, if you have adjusted your job or added a calibration since storing the point it may be safer to use '**Enter Grid System Coordinates**' on the '**From New Position**' tab.
- '**Use Local Coordinates**': If you want to have Local Coordinates (like 10,000, 10,000, 0) for the Base with a geodetic or state plane basis of bearings, at Grid or at Ground then select '**Use Local Coordinates**'.

  WARNING: be careful with '**Use Local Coordinates**' it is completely different than '**Enter Grid System Coordinates**'. '**Use Local Coordinates**' requires a localization to be in play. If there is not already a .LOC file defined, this option will make a new one. If your local coordinates are actually State Plane coordinates, use the 'Enter Grid System Coordinates' option instead.

- '**Read From File**': If you have previously setup on the job, and you stored a .REF file, use '**Read From File**'

But the correct method is: 'It depends...'

Carlson SurvCE/SurvPC User Manual

Setting a Base is covered in the Carlson SurvCE User Manual on page 147 in section '**5.4 GPS Base**.' You can download the latest version of this User Manual from the website: www.survce.com.

Base Configuration: The Bottom Line

When you configure the Base, the goal is 'tell the Base receiver what the actual coordinates for the electrical phase center (PC) of the GNSS antenna is, including the actual ellipsoid elevation.'

If you specify a projected Grid Coordinate, then SurvCE will convert it to the equivalent Latitude / Longitude / Ellipsoid Height.

In SurvCE you always provide the Ground Mark (GM) elevation. SurvCE will convert an Orthometric height to Ellipsoid height if needed then add the vertical rod height HI (which may need to be derived from a slant measurement) and finally add the L1 offset (determined by the antenna model) which describes the offset from the receiver's ARP at the bottom (Antenna Reference Point) to the electrical phase center (PC) of the internal antenna.

In other words: you supply the X, Y, Orthometric Height of the point on the ground and SurvCE computes the Latitude, Longitude and Ellipsoid Height of the antenna phase center. This antenna position is transmitted to the GNSS engine with a command to 'Be a Base' and corrections are generated for transmission to the Rover based on this computed position.

Programmed Position Must Match True Position

It would make things simple if you could enter any position and elevation into the GNSS receiver and it would just work.

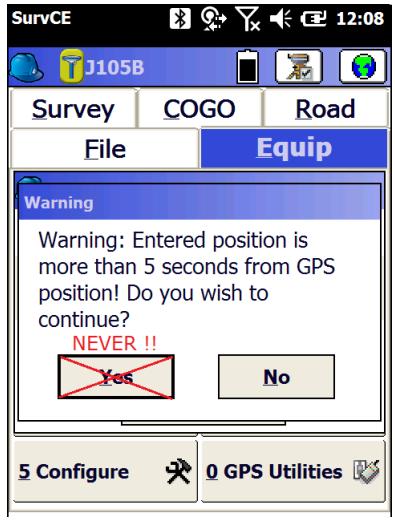
This is exactly how the '**Use Local Coordinates**' button works.

Each of the other Base setup options require that the entered position be very close to the true antenna position. SurvCE enforces a 5-second rule: the programmed Phase Center position has to be within 5-seconds of the True location of the receiver. In Salt Lake City Utah:

5 seconds is around 500 feet of northing

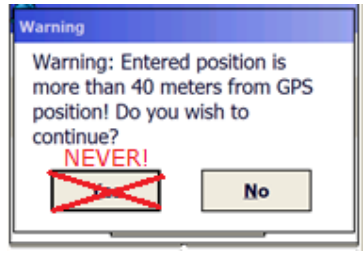
5 seconds is around 385 feet of easting

If you exceed this tolerance, the following error message will be displayed by SurvCE:



You should NEVER click **Yes** to continue. Always click **No** and fix the problem.

SurvCE / SurvPC also enforces a 40-meter height error rule. If the entered height is in error by more than 130 feet this error message is shown:



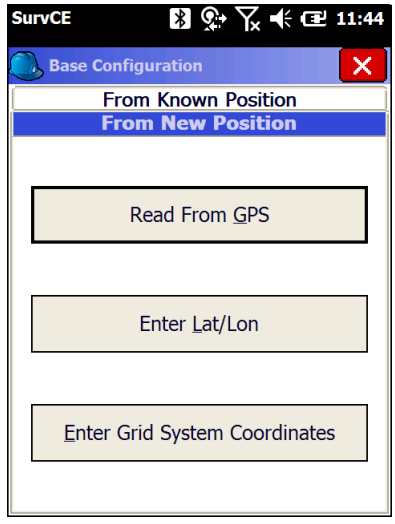
You should NEVER click **Yes** to continue. Always click **No** and fix the problem.

If you configure the Base with an errant position, your Rover will take a very long time to FIX and you will have a horrible day in the field.

Quick Tip: Double Check Your Base Position

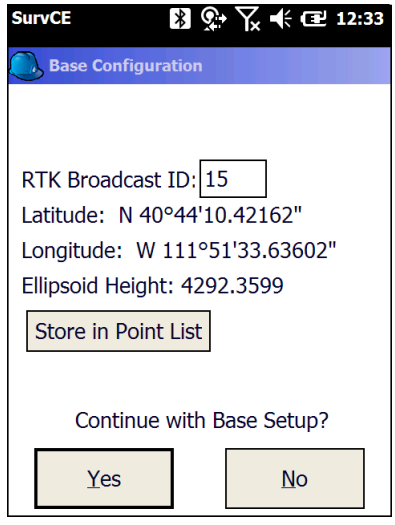
When you use any method other than '**Read From GPS**' to set a Base, it is recommended that you follow the following procedure to double-check that your 'known position' is correct.

Configure the Base up to the point where you are prompted for a Base position:



Click '**Read From GPS**'.

Do a 5-point average, then record the displayed 'Base Configuration' Lat/Long/Ellipsoid Height results in your field book:

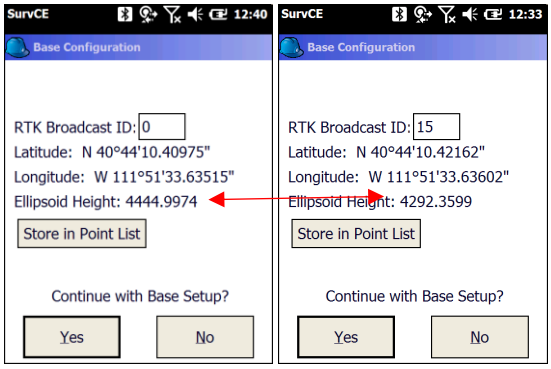


If you don't carry a field book, take a picture of the screen with your smartphone.

Now click on '**No**' and SurvCE will return back to the '**From New/Known Position**' screen, you can use the Base initialization method that you really want to use.

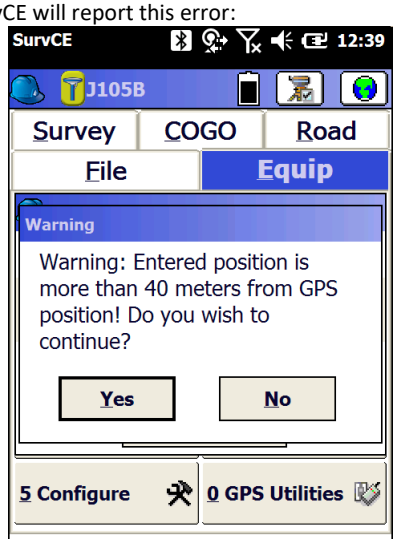
After selecting a known position, you will return back to the Base Configuration screen again. Compare the computed position to the measured position. They should be very close.

This is an example of a known position failure:



The Latitude and Longitude are both within an arc-second. **But the Ellipsoid Height is in error by more than 152 feet from the averaged position.** This is an error because we would expect the autonomous position to be within 20 feet of the known elevation!

SurvCE will report this error:



NEVER click '**Yes'**, this is a serious error!

Always click '**No'**, find the source of the error, fix it and try again. In this example, the operator probably entered an orthometric elevation but called it ellipsoid.

If the elevation or horizontal position in your Base will not broadcast corrections and the right-hand LED will not blink. Bad Base position initializations have the effect of making the Base appear to 'hang' —correctors simply can't be computed.

Even just the difference of the Geoid height (typically 30 to 90 feet) will severely hinder the Rover's ability to fix. For this reason, it is important that you select the correct elevation type (Ellipsoid or Orthometric) and enter the matching height when you enter an elevation.

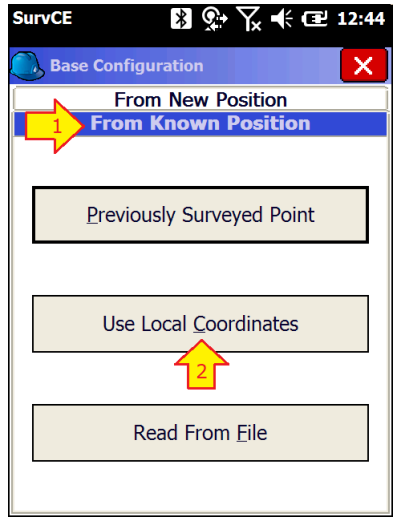
Starting a Base with Local Coordinates

"Okay, I understand that I MUST set my Base to a geodetic location that is within 5-seconds of my Base's TRUE geodetic location X, Y and Z. But I still want to set the Base at a known position (1000, 1000, 0.) I swear I can do this in other field software packages!"

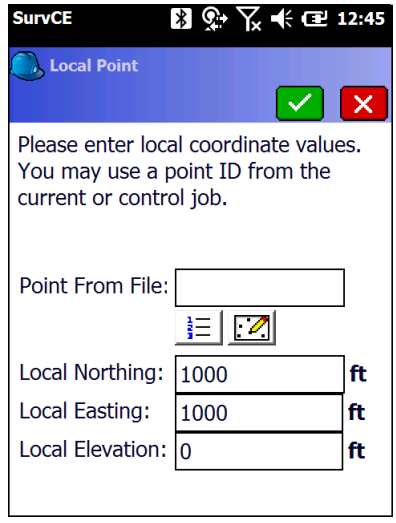
You can do it in SurvCE.

Do the standard Base configuration steps: '**Equip: GPS Base**' then configure the **Current**, **COMS**, **Receiver** and **RTK** tabs normally.

The '**Base Configuration**' screen with two tabs is shown. Select the (1) '**From Known Position**' tab:

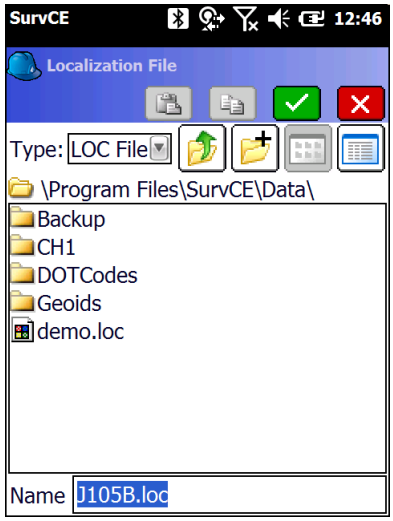


Then (2) click '**Use Local Coordinates**' and enter or recall the local coordinates that you want the Base to appear to have.



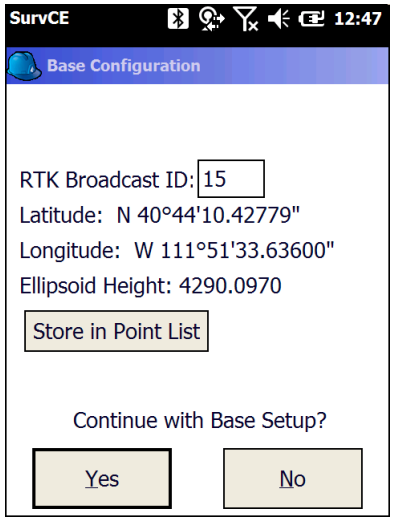
After entering the coordinates, click on the green check mark.

SurvCE will ask you what name to use for the localization file. The default is the job name with a '.LOC' extension:



Click on the green check mark.

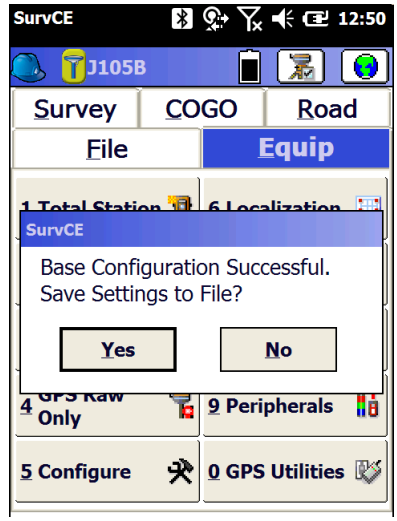
SurvCE will read the current autonomous Latitude, Longitude, Ellipsoid Height position from the Base. (In the USA this position will be WAAS corrected and within a few feet of the ITRF2014 current epoch true position.)



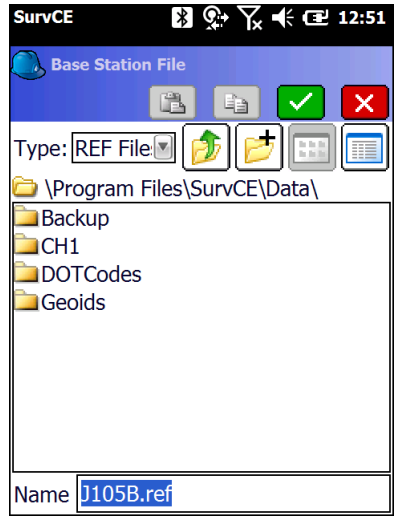
Click on 'Store in Point List' to store the local coordinate you previously entered into your point list if it is not already there. This will store the Base position in project coordinates.

Click on '**Yes**' to continue.

The Base will be configured and SurvCE will ask if you want to store a reference file:



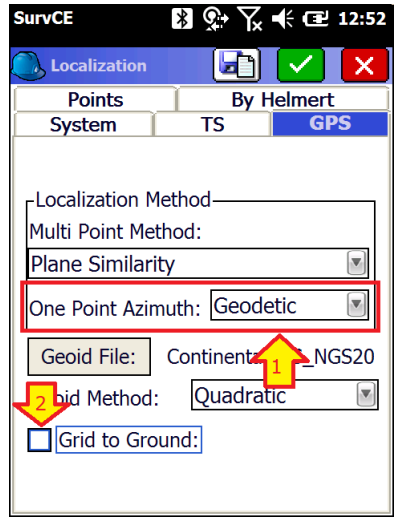
Always click on '**Yes**'.



The .REF file contains the Latitude, Longitude and Ellipsoid Height of the Ground Mark. You will use this .REF file to setup at this same location in the future. Click on the green check mark to complete the Base configuration.

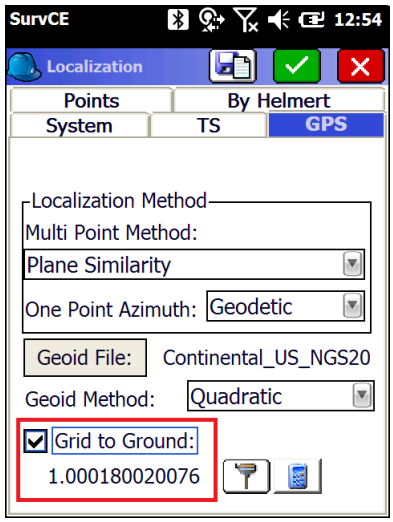
Next choose what to use for the basis of bearings.

Go to "**Equip: 6 Localization: GPS (tab)**":

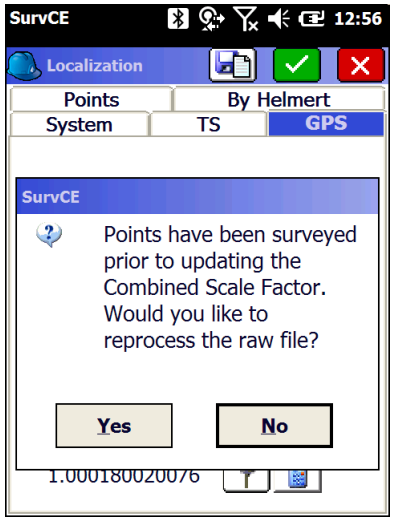


If you are going to use a system like (1000, 1000, 0) then you probably want to (1) set '**One Point Azimuth**' to '**Geodetic**'. That way the basis of bearings will be True North at the Base location.

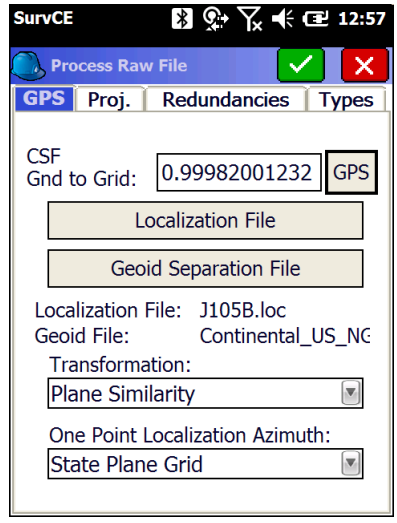
You probably also want to add a scale factor so that you are surveying with ground distances. Check (2) the '**Grid to Ground**' checkbox. SurvCE will automatically read the Base and set an appropriate Combined Scale Factor Based on your location in the state plane zone and your elevation:



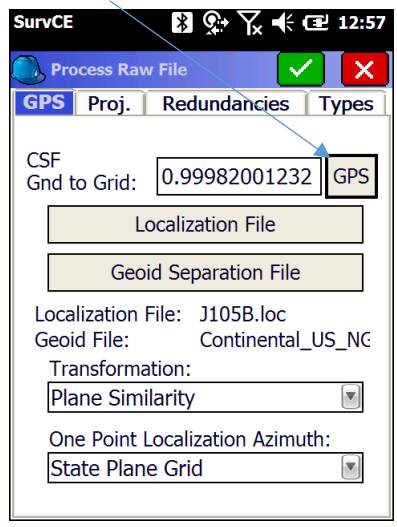
Click on the green check mark to return to the **Equip** tab. If you have any points stored in the current job SurvCE will ask if you would like to reprocess the Raw File:



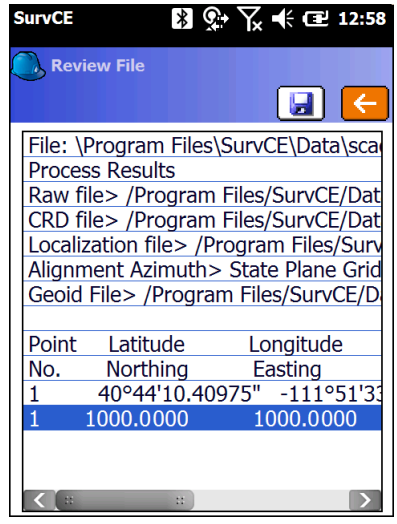
Answer '**Yes**'



Click on the 'GPS' button to load the grid-to-ground CSF:



SurvCE will recalculate any previously stored points:



The Base is now broadcasting corrections and the Ground Mark (GM) under the Base has the local position '1000.00, 1000.00, 0.00'.

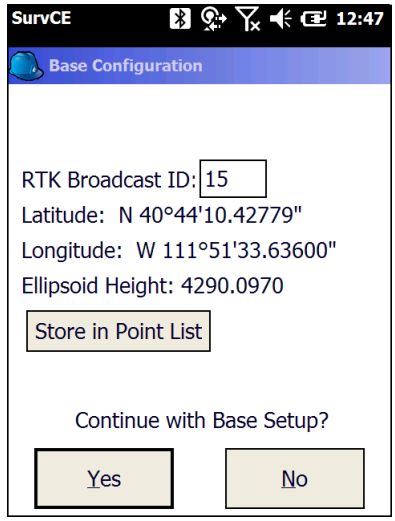
A single point localization has been computed with a True Geodetic North basis-of-bearings at the Base and a scale factor has been applied so that all coordinates and COGO measurements will be scaled to ground distances.

You are ready to survey, but let's spend a few extra moments and address two things:

- what is going on in the background?
- how do I setup on this same Base point the following day?

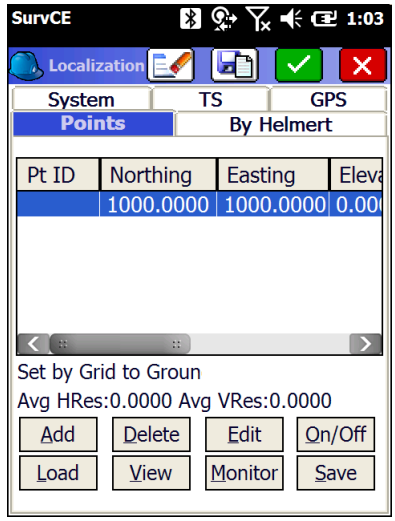
Local Coordinate Base Configuration: what is happening in the Background?

SurvCE has done a '**Read GPS**' and used the autonomous location to initialize the Base. The Base does not think that it is at 1000, 1000, 0; the Base thinks it is at the autonomous position that is at a Geodetic (Latitude, Longitude, Ellipsoid Height) very close to its TRUE position:



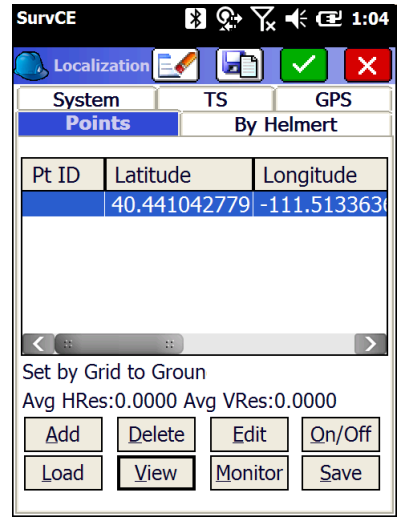
SurvCE automatically sets up a single point localization in the background.

You can view it by going to "**Equip: Localization: Points**":



The local coordinates (shown above as Northing, Easting, Elevation) are the same coordinates that were hand entered.

Click on the '**View**' button to see the GPS coordinates associated with the Local Coordinate:



This corresponding geodetic position is the autonomous Base point. This Base point location is also saved in the .REF file.

How do I setup on a Previous Base Point on a Subsequent Day?

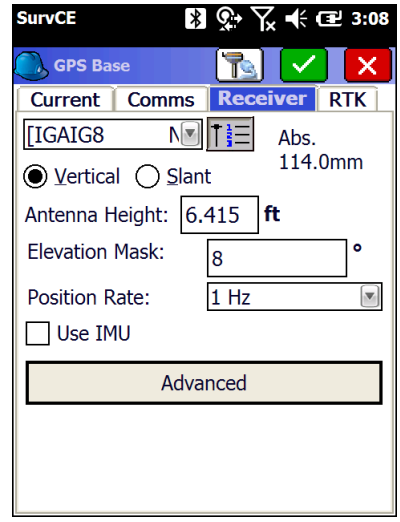
The best way is to use the .REF file to ensure that the Base is initialized with the exact same geodetic position that was used on the first day.

> *Warning: If you have adjusted the job (perhaps Based on an OPUS solution) the .REF file will not be valid after the adjustment. After adjustment, you could use the 'Use Grid System Coordinates' method instead.*

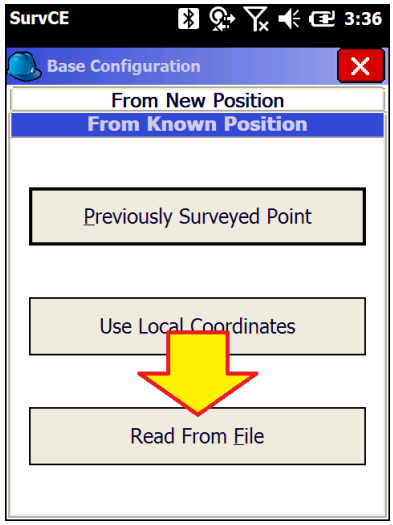
When you return the second day, setup the Base over the EXACT same X-Y location as the first day.

The HI does not need to match.

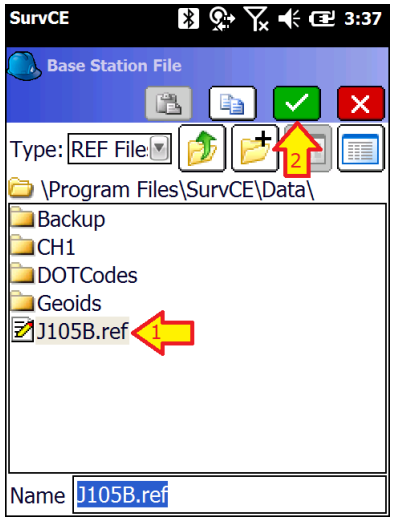
Start the **Base: Equip** (tab), **GPS Base**: then enter the new HI on the '**Receiver**' tab:



When you click on the green check mark, you will go to '**Base Configuration**' dialog. Select the '**From Known Position**' **tab**:

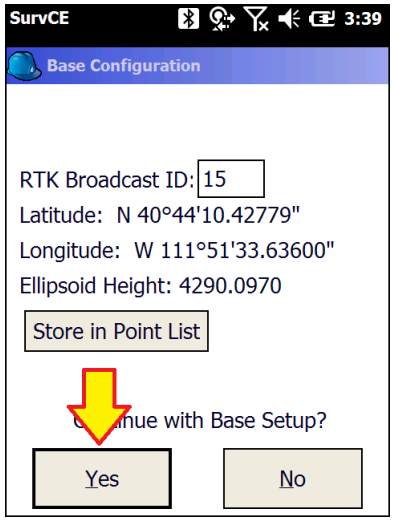


Then click on the '**Read From File'** button at the bottom:

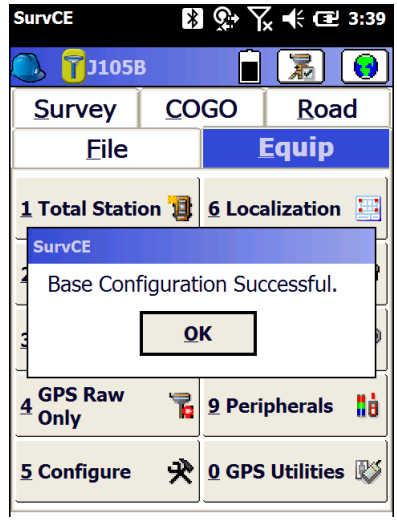


Select the same reference file (1) that you saved on the first day, then (2) click the green check mark.

SurvCE will check to ensure that the current receiver position is within 5 seconds of the file location and then display the position read from the file:



Click on **Yes**:



The Base is reconfigured exactly as it was the first day. The effective Ground Mark elevation under the receiver is identical to the previous survey. Since you are still using the original job file, the correct localization is automatically used.

What Happens in the Raw File
When You Configure a GNSS Base

What exactly happens when you setup a Base in SurvCE? While this example is for an iG8 receiver it is entirely applicable to an iG9.

There are several files that are written for every job: .CRD, .REF, .LOC and .RW5 files are common:

.CRD	Job 'Card' file. May also have a .CRDB extension (new style)
.REF	Base Reference file
.LOC	Contains the points used a localization
.RW5	Contains a text description of most actions taken in the field

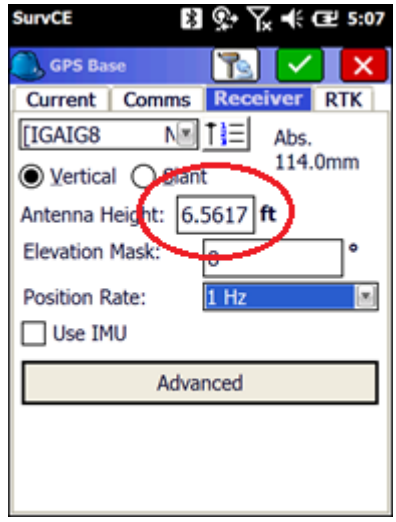
Information you may need when looking at this discussion and example:

iG8	Receiver Type		IGAIG8
PC	GM + HI + L1		Electrical Phase Center of GNSS antenna element
	4297.0875'	(1309.7549m) **Ellip**	Ellipsoid Height
L1	0.3740'	(0.1140m)	L1 Offset (distance from ARP to PC) on IGAIG8
HR / LS	6.9357'	(2.1140m)	HR = (HI + L1) ; Distance from GM to PC, AKA LS
HI	6.5617'	(2.0000m)	Vertical distance from GM to ARP, the Rod height
SlantHeight	6.8405'	(2.0850m)	Slant Height from GM to bottom of blue band
SHMP	0.2753'	(0.0839m)	Slant Height Measurement Point (distance from ARP) at bottom of receiver to the slant measurement point
R	0.2218'	(0.0676m)	radius of receiver at the SHMP
ARP	4296.7135'	(1309.6409m) **Ellip**	GM + HI, Antenna Reference Point (bottom of receiver)
GM	4290.1518'	(1307.6409m) **Ellip**	Ground Mark (the point on the ground, under the receiver)
	4344.9974'	(1324.3579m) **Ortho**	
GEOID	-16.717m = -54.8457'		GEOID18 separation at the GM (OrthoH = EllipsoidH – GEOID)

The Base position for this example is:

40 44 10.40975179	-111 51 33. 63514941	DMS: DD MM SS.ssssssss
40.7362249208	-111.8593433129	Decimal Deg: DDD.ddddddddd
7437123.6609 N	1540829.5613 E sFeet	SPC UT Central NAD83 US Survey Feet

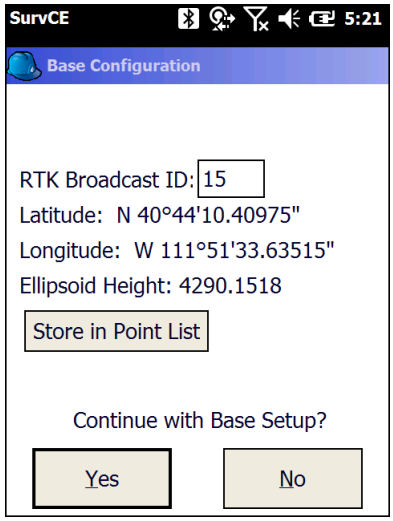
When you setup a Base, the HI is entered on the Receiver tab.



In this example the Base is on a fixed height 2-meter rod, so the Antenna Height is:

HI	2.0000 m = 6.5617 sFeet	Vertical distance from GM to ARP

After configuring the 'RTK' tab, and then doing a 10-point average, this is the displayed '**Base Configuration**' screen:



The displayed Ellipsoid height (4290.1518) is the Ground Mark (GM) elevation.

Ground Mark (GM) 4290.1518 sFeet = 1307.6409 m Ellipsoid

When you click on the '**Store in Point List**' button, the point is stored in the .RW5 file with raw data (it is not just a Stored Point (SP).)

Here is a snippet showing the two lines that '**Store in Point List**' generates:

```
GPS,PN1,LA40.441040975179,LN-111.513363514941,EL1309.754897,--BB
--GS,PN1,N 7437123.6609,E 1540829.5613,EL4344.9974,--BB
```

Description:

This 'GPS,' line has the Base position in DD.MMSSssssssss, the height is the ellipsoid height of the antenna L1 Phase Center (PC) in meters. This is the 'raw' data for the Base point.

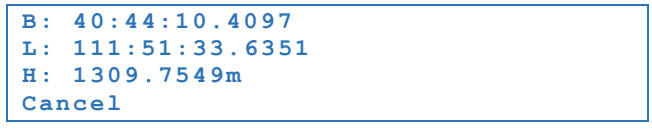
This '--GS line' is the grid coordinates and Orthometric Height of the Ground Mark in sFeet: 4344.9974

The point list entry (**File**: **Points**) looks like this:

Northing	Easting	Elevation
7437123.661	1540829.561	4344.997

This point matches the --GS line in the raw file. Note that the elevation is the orthometric height of the Ground Mark.

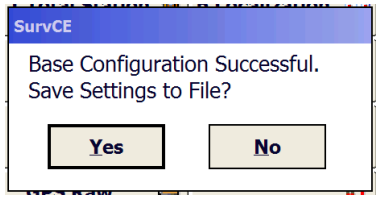
After the Base begins transmitting, the **Base Info** screen on the iG8 display displays the Phase Center with Ellipsoid Height in meters:



The displayed height 'H:' is the antenna Phase Center (PC) ellipsoid height in meters.

.REF File Description

When you finish setting up the Base, SurvCE prompts you to 'Save Settings to File':



You always should click on '**Yes**'.

This is the .REF file that is generated:

```
VERSION2
40.7362249208
-111.8593433129
1298.9422114

15
```

The .REF file has decimal (DD.ddddddd) values for Latitude, Longitude and the Ellipsoid Height of the Ground Mark in meters. The '15' on the last line is the 'RTK Broadcast ID' entered by the user.

The .REF file is extremely useful for setting the Base on the same Ground Mark on subsequent days, you only need to supply the antenna height with the correct receiver model and the Base can be loaded with exact coordinates matching previous setups on the same mark.

.RW5 File Description

SurvCE tracks everything you do in the .RW5 file.

The file below shows the raw file entries for the example Base setup. Each section is color coded to match the description lines which follow:

```
--Entered Base HR: 6.5617 ft, Vertical
LS,HR6.9357
GPS,PN1,LA40.441040975179,LN-111.513363514941,EL1309.754897,--BB
--GS,PN1,N 7437123.6609,E 1540829.5613,EL4344.9974,--BB
--Base Configuration by Reading GPS Position
--DT01-10-2020
--TM17:22:21
--Entered Base HR: 6.5617 ft, Vertical
--Antenna Type: [IGAIG8          NONE],RA0.0676m,SHMP0.0839m,L10.1140m,L20.0911m,--L1/L2 Internal Antenna
BP,PN15,LA40.441040975179,LN-111.513363514941,EL1309.754897,AG2.0000,PA0.1140,ATAPC,SRBASE,--
--GS,PN15,N 7437123.6609,E 1540829.5613,EL4344.9974,--Base
--GT,PN15,SW1964,ST310997000,EW1964,ET310997000
```

A comment that details the HI (GM to ARP) height entered by the user.

LS is the HI + L1 (6.9357 = 6.5617 + 0.3740) in the Distance units (SFeet)

The following two lines were stored by pressing **Store in Point List:**

'**GPS**' The Base position in DD.MMSSssssssss, the height is the ellipsoid height of the PC in meters.

'**--GS**' The grid coordinates and Orthometric Height of the Ground Mark in SFeet
4316.4974 = 4261.6129 – (-54.8818) Ortho = Ellipsoid – Geoid

The red section is the final Base Configuration entry. It details the method, the date (DT), the time (TM.)
The HR (Receiver Height) is shown with the measurement method: Vertical or Slant.
The `--Antenna Type` message includes everything needed to compute the PC from the GM for Vertical and Slant measurements:

- The 20-character antenna name: `[IGAIG8          NONE]`
- the receiver radius at the SHMP: `RA0.0676m`
- the distance from the ARP to the SHMP: `SHMP0.0839m`
- the L1 offset (distance from the ARP to the L1 PC): `L10.1140m`
- the L1 offset (distance from the ARP to the L2 PC): `L20.0911m`

The final three lines include a BP (Base Point) 3-record set which includes

BP record:

PN	Point ID
LA	Latitude in DD.MMSSssssssss
LN	Longitude in DDD.MMSSssssssss formant
EL	Elevation of PC in meters
AG	Antenna-Ground, HI (GM to ARP), Instrument Height in meters
PA	Phase Center to Antenna: L1 Offset in meters
ATAPC	broadcast point Phase Center: broadcast coordinate is for PC

A --GS comment record:

PN	Point ID
N	Projected Northing
W	Projected Easting
EL	Orthometric Elevation of the Ground Mark in job units
--	Description 'Base'

A – GT comment record (included if 'Store GPS Accuracy' is enabled)

PN	Point ID
SW	Start Week
ST	Start Time

EW	End Week
ET	End Time

Adjusting an Autonomous Base Project to an OPUS Position

Often when you first visit a site, you will use '**Read GPS**' to initialize your Base position because no additional position control is available. The resulting position will likely be within 6-feet of the True position for the Base point, it will not be exact.

This stored / broadcast Base location will have some ΔNorthing ΔEasting ΔHeight from the True NAD83_2011 Epoch 2010.0 framed coordinate.

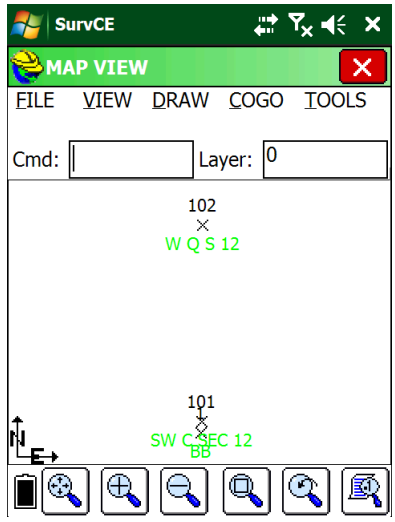
Every point that you store will include this positional offset however the vectors between the Base and the Rover points will all be exact.

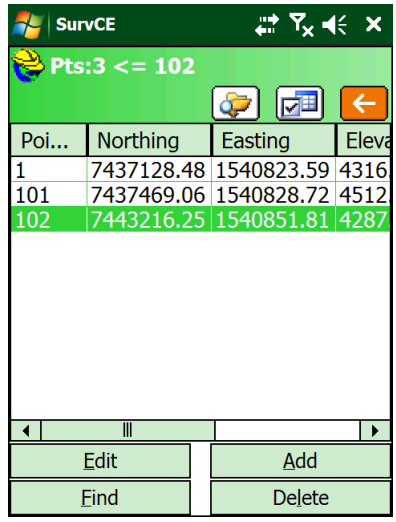
The entire job will be shifted around the True position by the ΔNorthing ΔEasting ΔHeight. Since this is a GPS Based job and you get a 'Free Basis of Bearing' there will be no rotation and no scale factor change, just a NEH translation.

This section details a simple workflow to adjust your autonomous Base day's work to exactly match an OPUS position.

For this example:

A hub and tack have been set at a random point south of a job site
The Base was initialized using '**Read GPS**' as point ID 1 with description of '**BB**' as shown in the previous section
Two points: the South West Corner Pt 101 and West Quarter of Section 12 Pt 102 have been stored:





The Static Occupation file from the Base has been downloaded and submitted to OPUS using the tools and procedures described in the '**Downloading, Processing and Archiving Static Data**' section found on page 102.

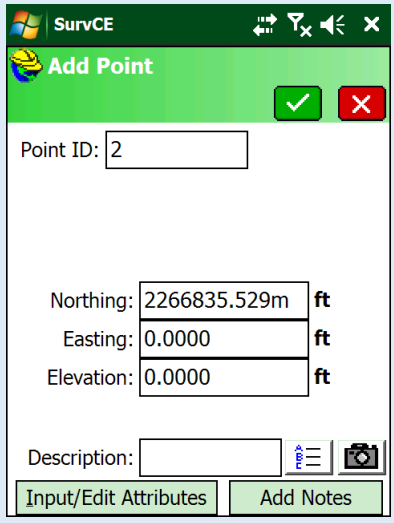
NGS's OPUS has returned an OPUS report which is shown below:

```
REF FRAME: NAD_83(2011)(EPOCH:2010.0000)              IGS08 (EPOCH:2017.6624)

         X:     -1802337.501(m)    0.013(m)          -1802338.395(m)    0.013(m)
         Y:     -4492708.224(m)    0.013(m)          -4492706.940(m)    0.013(m)
         Z:      4141119.504(m)    0.007(m)           4141119.412(m)    0.007(m)

       LAT:    40 44 10.27259      0.007(m)         40 44 10.28846      0.007(m)
     E LON:   248  8 27.05615      0.007(m)        248  8 27.00042      0.007(m)
     W LON:   111 51 32.94385      0.007(m)        111 51 32.99958      0.007(m)
    EL HGT:          1304.150(m)    0.017(m)              1303.439(m)    0.017(m)
 ORTHO HGT:          1320.877(m)    0.032(m) [NAVD88 (Computed using GEOID12B)]

                          UTM COORDINATES     STATE PLANE COORDINATES
                           UTM (Zone 12)          SPC (4302 UT C)
Northing (Y) [meters]       4509826.918          2266835.529
Easting (X)  [meters]        427456.339           469661.993
Convergence  [degrees]      -0.56068672          -0.23006449
Point Scale                  0.99966477           1.00002259
Combined Factor              0.99946031           0.99981805
```

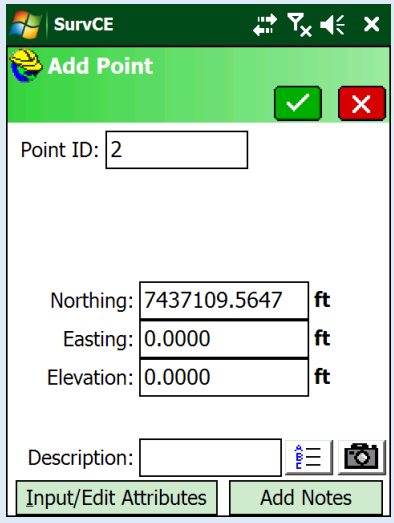
The method for entering a new point, #2 differs depending on if the projection (the coordinate system) is the State Plane projection returned in the OPUS solution, or a Localized Coordinate System:

State Plane Coordinate System This is the most common adjustment type:	**Localized Coordinate System** This is an uncommon adjustment:

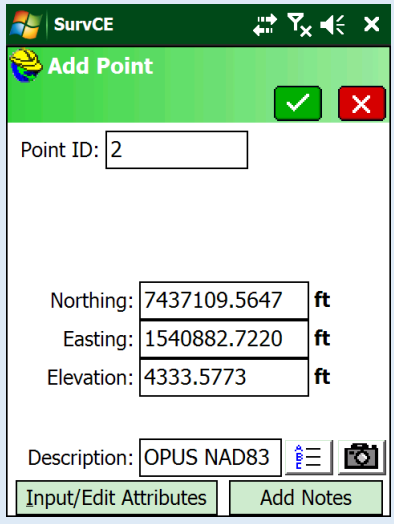
Enter a new point from '**File**: **Points**' by pressing '**Add**':



Enter the Northing from the OPUS result with a 'm' after the number, when you click to the Easting the coordinate will automatically change to Feet:

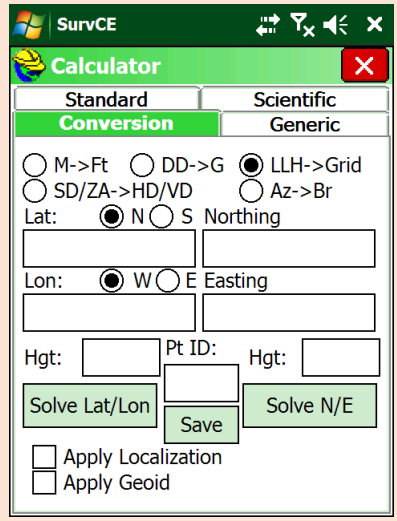


Do the same for the Easting and **Orthometric** elevation, don't forget to enter a 'm' after each metric value:



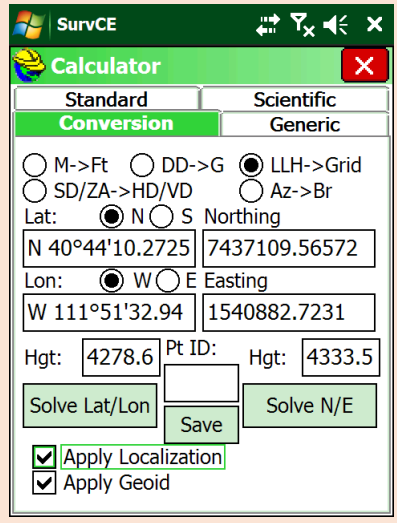
Click the green check mark to accept and store the new point.

Go to the '**COGO**' tab and click on the '**8 Calculator**' button, then select the '**Conversion**' tab and click the '**LLH->Grid**' button:

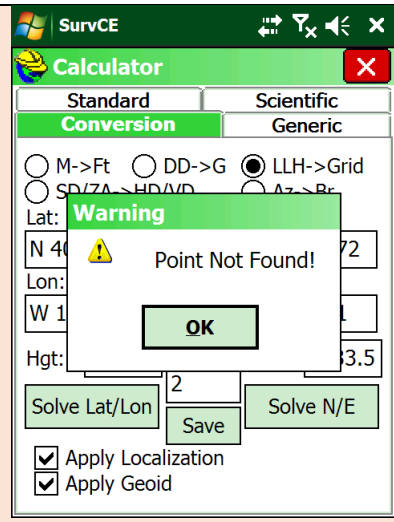


Click the '**Apply Localization**' and '**Apply Geoid**' checkboxes.

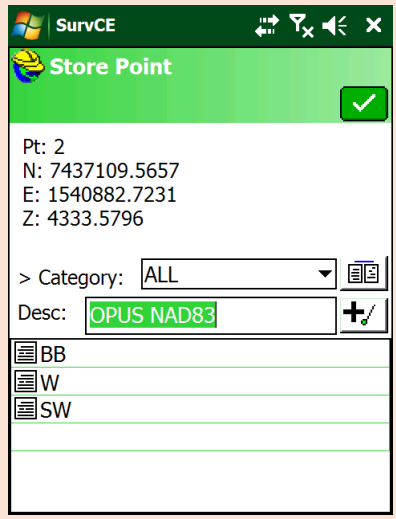
Enter the NAD83 Latitude, Longitude, and Ellipsoid Height on the left side (highlighted in Cyan above.) Be sure to put an 'm' after the metric ellipsoid height:



Click the 'Solve N/E' button on the right, then enter 2 in the 'Pt ID:' box:'

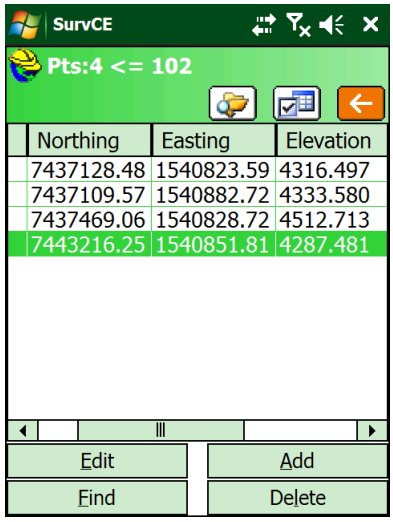


SurvCE will note that point #2 does not exist, click OK, then click the 'Save' button:



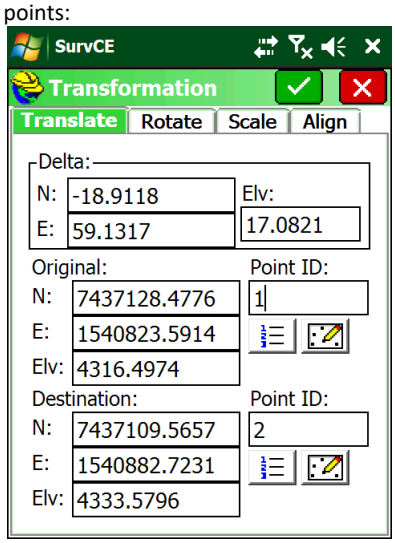
Enter a description, click the green check mark.

You will return to the 'File: Points' list and can view the differences from the OPUS result to the autonomous Base:

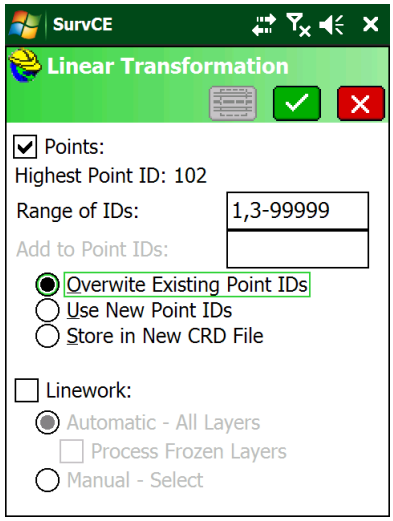


Click the red back button to return to the main menu.

Go to the '**COGO**: **7 Transformation**' tool from the main menu. Enter the '**Original Point ID:**' as '**1**' and the '**Destination Point ID**' as '**2**'. SurvCE will automatically calculate the ΔNorthing ΔEasting ΔHeight between the two points:

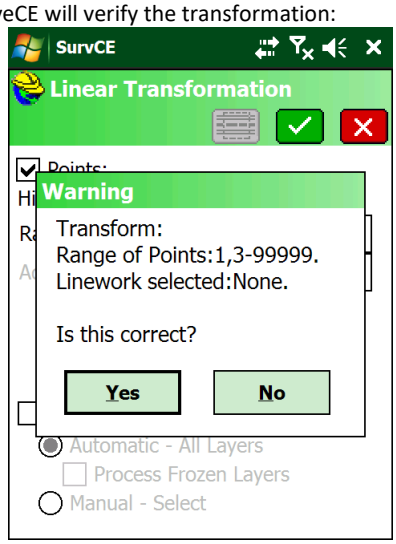


Click the green check mark:



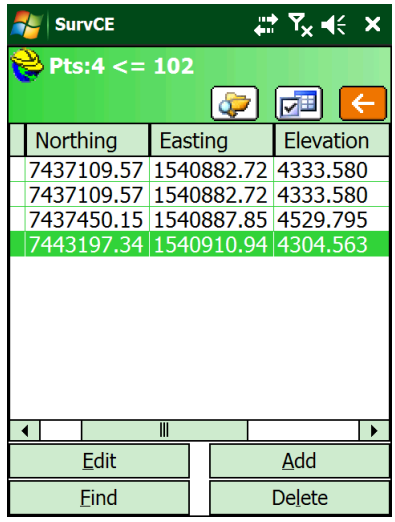
Change the '**Range of IDs**' to **NOT** include the OPUS point #2 that we just hand entered (no need to translate it), then click the green check mark.

SurveCE will verify the transformation:



Click 'Yes'. The adjustment will be completed, and the job coordinates will be modified to match the OPUS solution.

You can verify that it was successful by returning to the 'File: Points' list:



Points 1 and 2 are now identical and points 101 and 102 have been adjusted.

The '.CRD' (projected point values) have now been adjusted to exactly match the OPUS solution.

Remember that the underlying .RW5 and .REF have not been adjusted. For this reason, if you return to this job on a later date, you must use the 'Enter Grid System Coordinates' for re-setting a Base, or hand enter the Lat/Lon/Height from the OPUS solution directly.

Localizing SurvCE Projects

SurvCE provides a rich system to localize project coordinates to match existing coordinate and design systems. The two most common requirements are:

Localize at a single point, set scale factor to Ground, align the basis of bearings to Geodetic North.

Localize at a single point, set scale factor to ground, align the basis of bearing to match a section line or job boundary.

These two localization schemes are described in detail in the next sections.

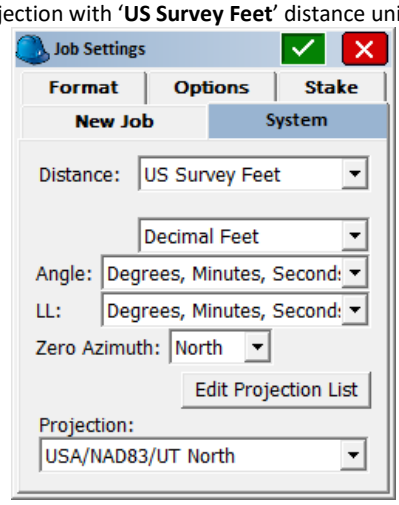
Localization: Geodetic North with Ground Distances

Description

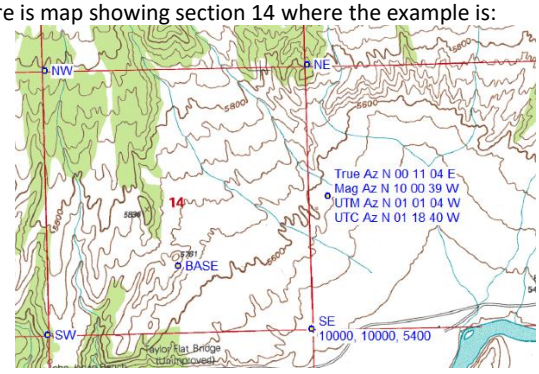
Setup a Base at a random location near the center of a section. Assign the coordinate 10,000, 10,000 to the Southeast corner of the section, rotate the basis of bearings to Geodetic north at the Southeast corner and apply the correct scale factor so that reported distances are 'Ground Distances'.

Solution

This survey is in the 'Utah North' state plane zone, so make a new job and select '**Utah North**' as the underlying projection with '**US Survey Feet**' distance units:



Here is map showing section 14 where the example is:

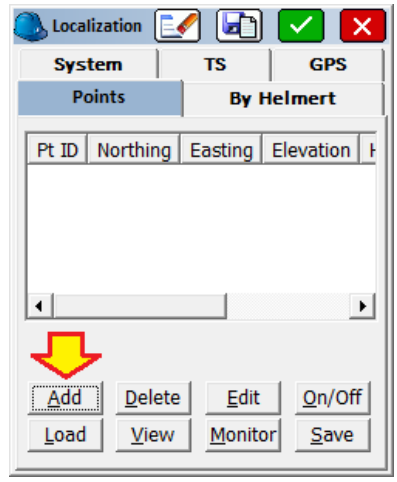


Setup the Base (shown above as 'BASE') with a 'Read GPS' (autonomous) position.

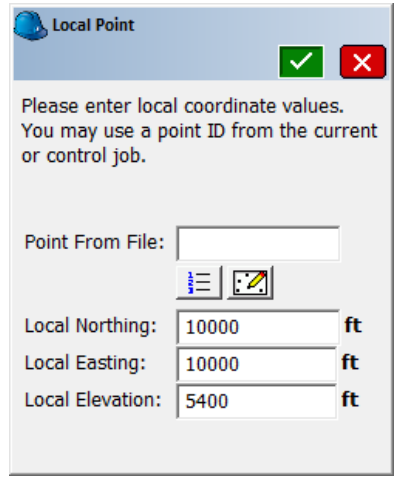
At the Southeast corner of section, find the BLM resurvey aluminum cap alongside the original stone monument. Set the Rover receiver on a 2-meter rod at the center of X marked on the BLM aluminum cap using bipod to hold receiver exactly level.

Localize the Southeast Corner

From the main menu, click on 'Equip: Localization', then click on the '**Points**' tab:

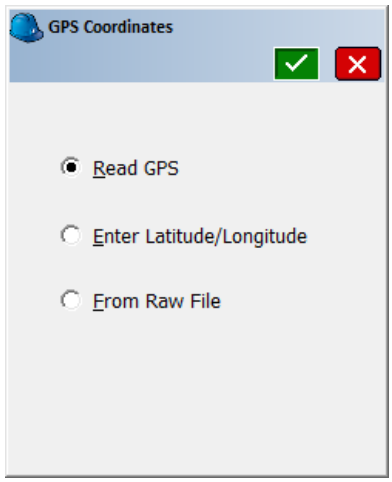


Click on the '**Add**' button:



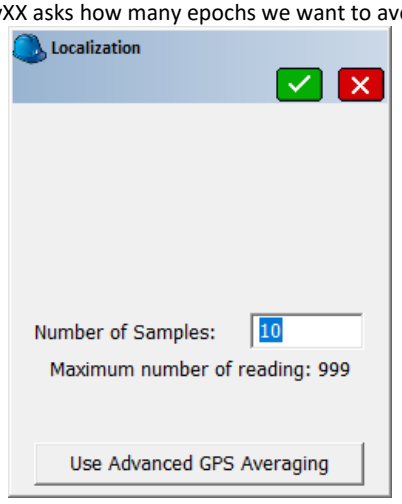
Enter the 'Local' (desired) coordinates that we want the SE corner to have, 10,000 1,000 5,400 as shown above.

Click the green checkmark. SurvXX asks where to get the GPS coordinates from:

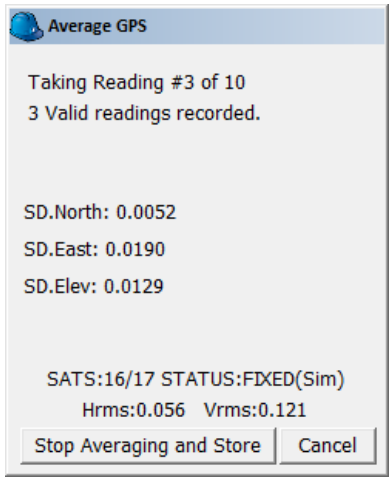


We are occupying the point, so just choose '**Read GPS**' then click the green check mark.

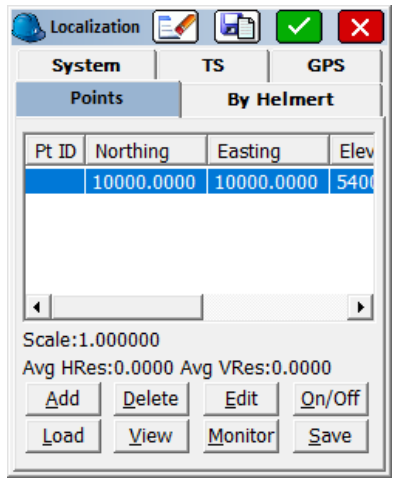
SurvXX asks how many epochs we want to average:



10 should be fine. Click the green checkmark at the top of the screen.

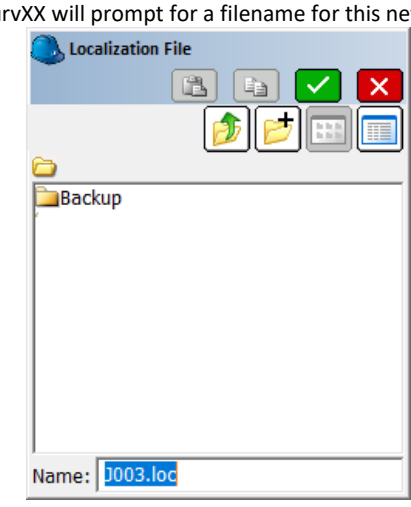


Wait for all of the samples to be collected. The results of the localization are shown:

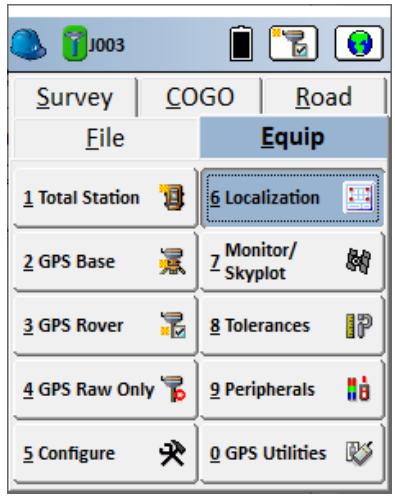


Click the green check mark in the upper-right corner.

SurvXX will prompt for a filename for this new localizaton:

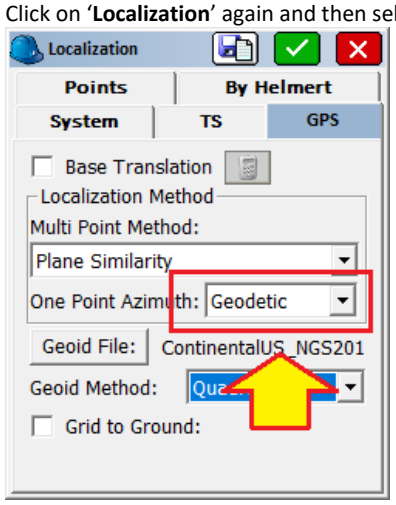


Accept the default (which is the Job name with a '.loc' extension) and click on the green checkmark at the upper-right corner of the screen to return to the main menu.



Set 'Grid to Ground'

Click on '**Localization**' again and then select the **GPS** tab:

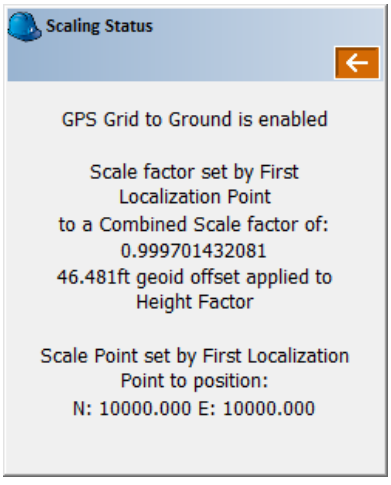


Set '**One Point Aziumuth**' to '**Geodetic**'.

Make sure a '**Geoid File**' is selected and in use.

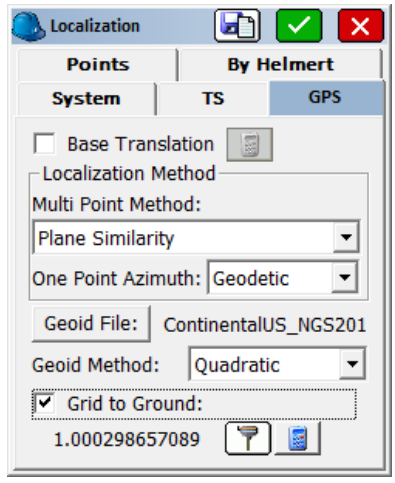
Click on the 'Grid to Ground' checkbox (bottom left), then click on the '**Read GPS**' button:

SurvXX will read the GPS current position and based on the location and elevation compute the correct combined scale factor:



The combined 'Ground to Grid' scale factor (CSF) will be shown.

Click on the red back button at the top of the screen to return to the GPS tab. Note that the 'Grid to Ground' factor is shown:

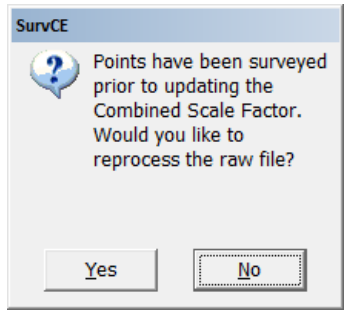


Remember that 'Grid to Ground' is the inverse of 'Ground to Grid':

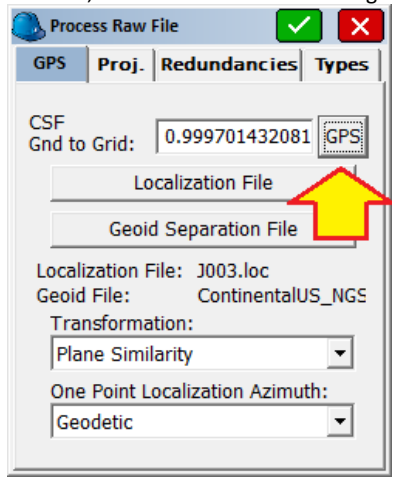
$$1.000298657089 = \frac{1.0}{0.999701432081}$$

We have succesfully applied the correct CSF for the Southeast corner of this section. Click the green checkmark in the upper righthand corner.

SurvXX will ask:

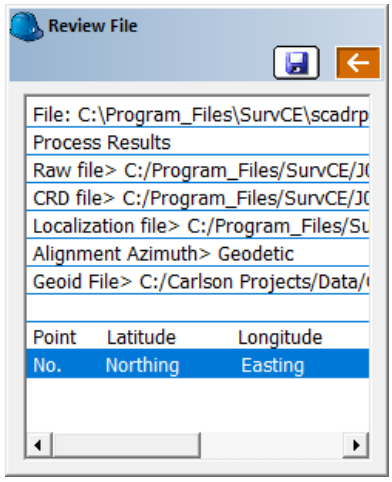


Click on '**Yes**', the '**Process Raw File**' dialog will be shown:



Click the '**GPS**' button recall the new (but sofar unused) CSF, then click the green checkmark.

You can review the reprocessed file (if you did not previously store the base position the point listing will be empty):

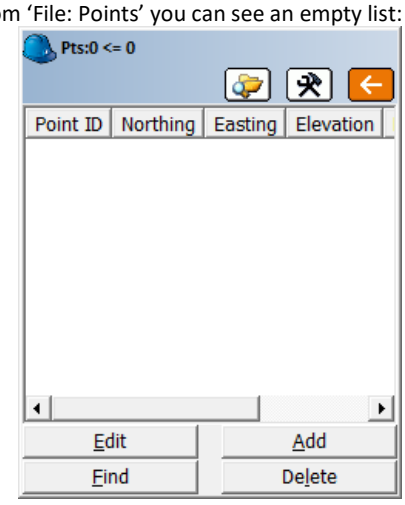


Click the red back button to return to the main menu.

Further Discussion

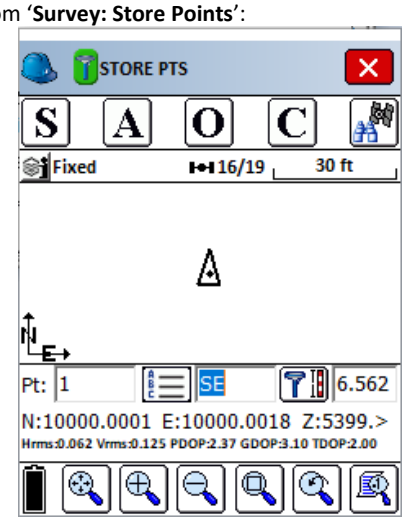
Note that at this point, there are NO points in the job.

From 'File: Points' you can see an empty list:



Let's store our current position, the Southeast corner of the section which we are still occupying.

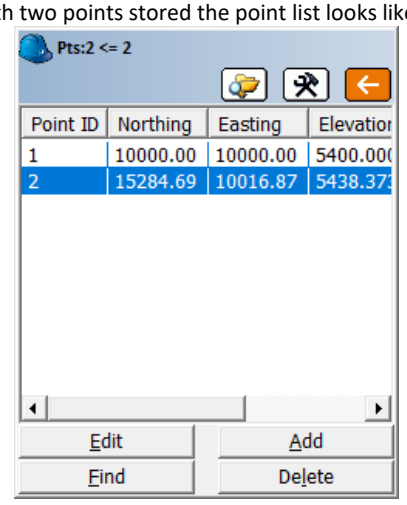
From '**Survey: Store Points**':



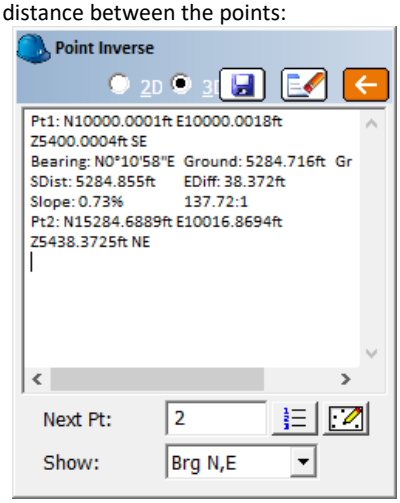
Enter '**SE**' as the description, then click the '**S**' button to store this location.

Next store the Northeast Corner.

With two points stored the point list looks like this:



Now we can use the '**COGO: Inverse**' function to compute the distance between the points:



Both the Ground and Grid distances are shown:

```
Ground: 5284.716ft   Grid: 5283.138ft
```

The Ground distance is the Grid distance multiplied by the Grid to Ground Combined Scale Factor:

5284.716 = 5283.138 * 1.00029866

The Bearing:

```
Bearing: N0°10'58"E
```

Is the bearing from the the measured vector from the Southeast corner to the Northeast corner to the vector orignating at the Southeast corner pointing to Geodetic North.

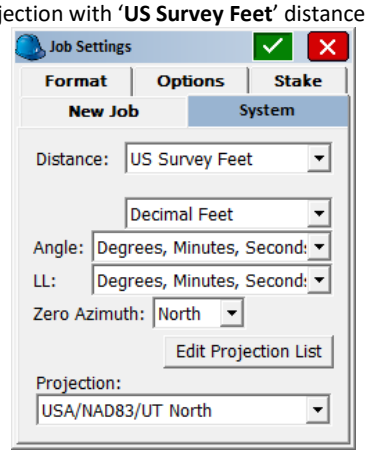
Localization: Match East Line Bearing with Ground Distances

Description

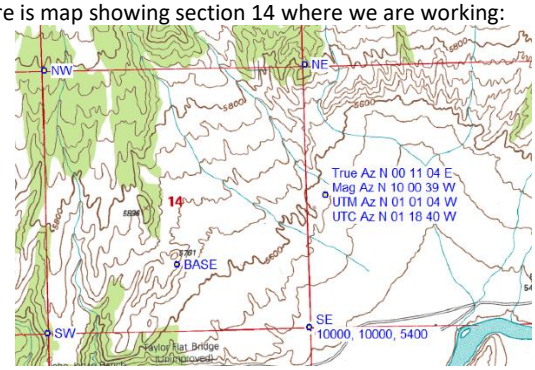
Setup a Base at a random location. Assign the coordinate 10,000, 10,000 to the Southeast corner of the section, rotate the basis of bearings to match the East line of the section and apply the correct Combined Scale Factor so that reported distances are true 'Ground Distances'.

Solution

This survey is in the 'Utah North' state plane zone, so make a new job and select '**Utah North**' as the underlying projection with '**US Survey Feet**' distance units:

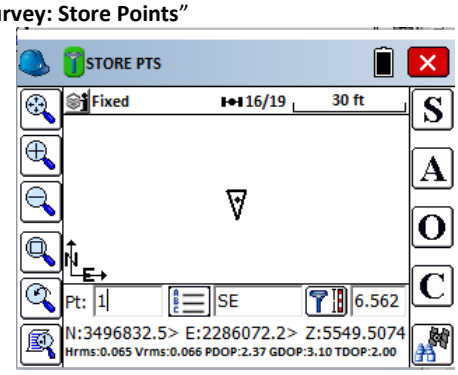


Here is map showing section 14 where we are working:



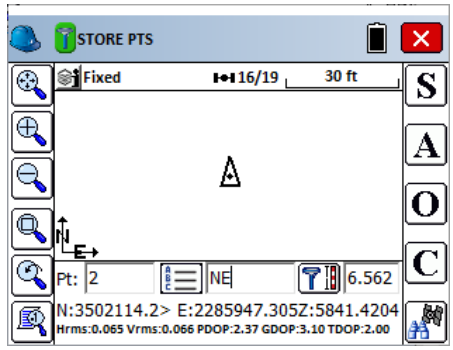
Setup the Base at a random location (shown above as 'BASE') with a '**Read GPS**' (autonomous) position.

Find the BLM resurvey aluminum cap alongside the original stone monument at the Southeast corner of the section. Set the receiver on a 2-meter rod at the center of X marked on the BLM aluminum cap using bipod to hold receiver exactly level. From the main menu, select "**Survey: Store Points**"



Set the description to '**SE**' and click on the '**S**' button to store the SE corner location as point 1.

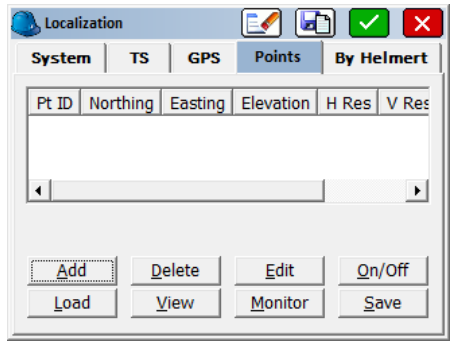
Travel to the Northeast corner of the section:



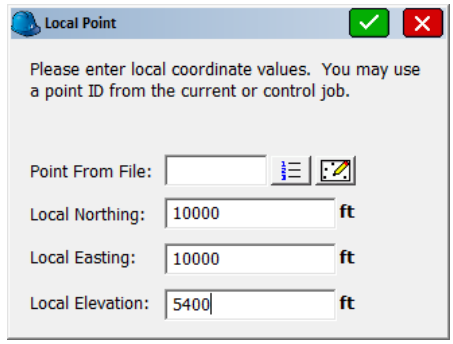
Store the NE corner monument as point number 2 with a description of '**NE**'.

Localize the Southeast Corner

From the main menu, click on '**Equip: Localization**', then click on the '**Points**' tab:

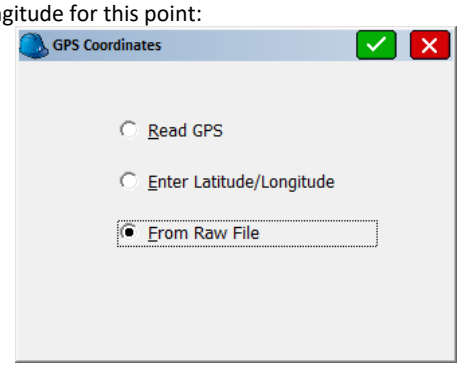


Click on the '**Add**' button:

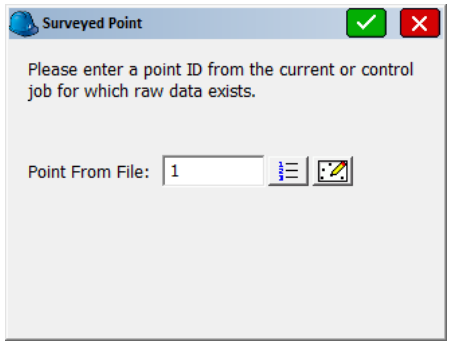


Enter the local Northing, Easting and Height (10,000 10,000 5,400) of the SE corner then click on the green checkmark. SurvXX will ask where to find the Latitude and

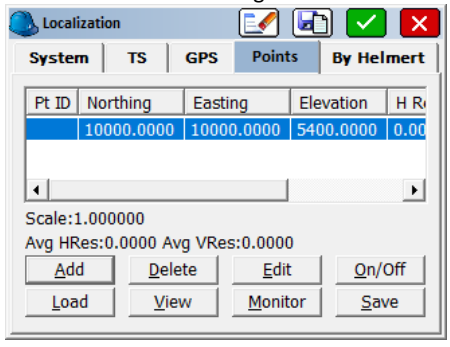
Longitude for this point:



Select '**From Raw File**' then click on the green checkmark. SurvXX will request the point number where it can find the raw data:

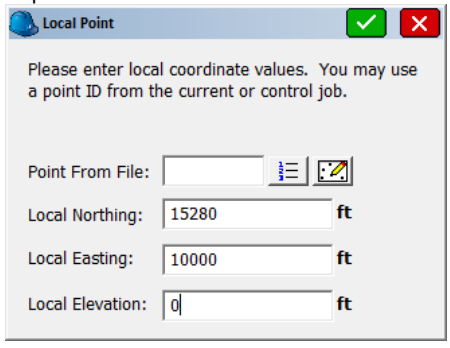


Enter '**1**' and then click on the green check mark.



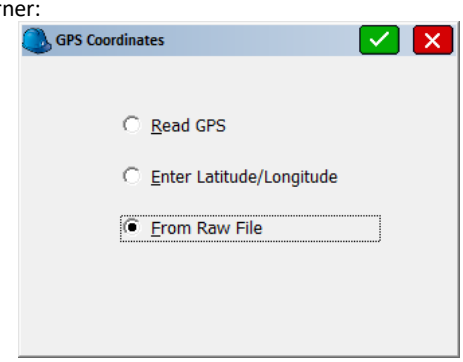
The base point will be shown.

Click the '**Add**' button to add local coordinates for the second point:

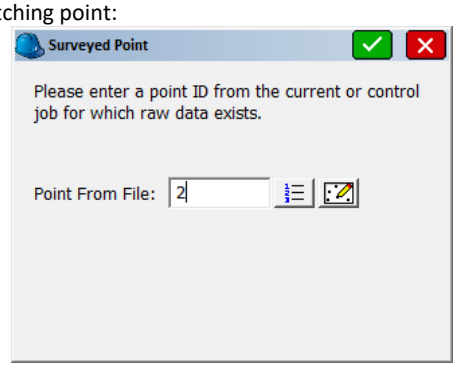


If the local coordinate system is aligned to match the East line of the section, then the local northing for the Northeast corner will be 'about' 10,000 + 5,280 = 15,280 and the Easting will exactly match the Southeast corner 10,000. We will tell the localization to ignore this second point elevation.

Click on the green checkmark. SurvXX will request the source of the latitude and longitude for the Northeast corner:

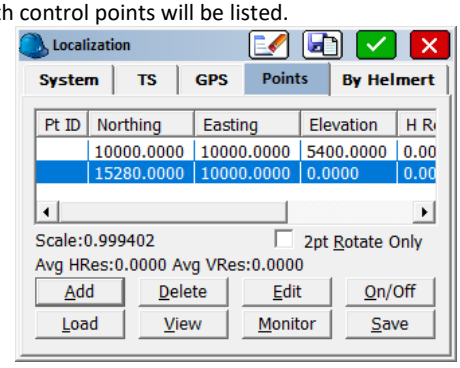


Select '**From Raw File**' and then click on the green checkmark. SurvXX will ask for the point ID of the matching point:

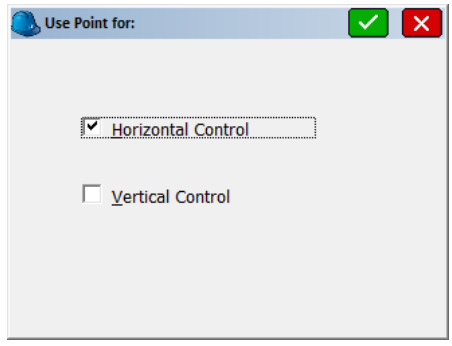


Enter 2, then click on the green checkmark.

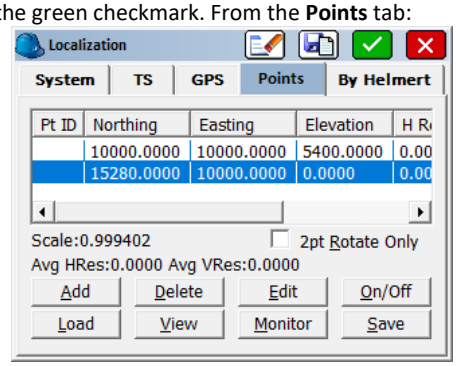
Both control points will be listed.



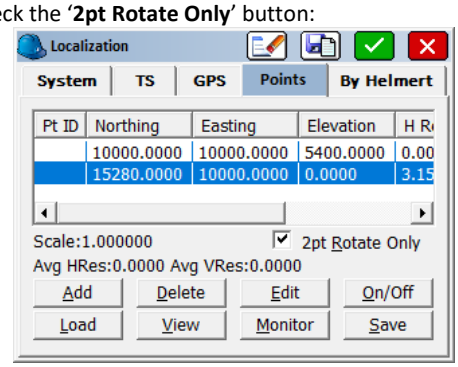
Turn off vertical control on the second point so that it does not contribute to the vertical calibration. Click on '**On/Off**':



Make sure that '**Vertical Control**' is unchecked, then click on the green checkmark. From the **Points** tab:

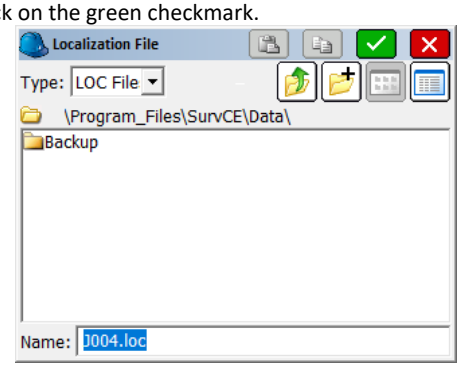


Check the '**2pt Rotate Only**' button:

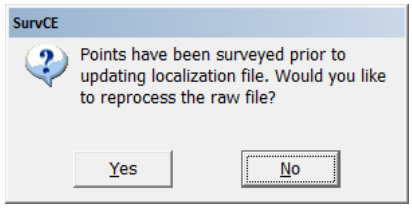


'**2pt Rotate Only**' when checked tells the localization to ignore the entered distance for the 2nd point. Only the bearing contributes. This checkbox is only available when two and only two localization points are listed.

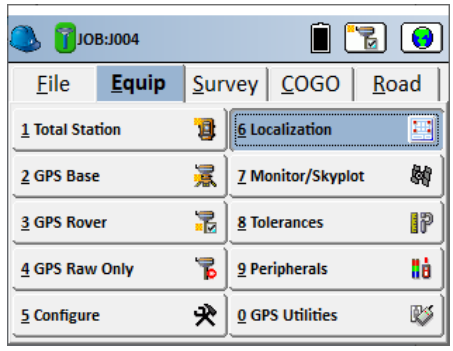
Click on the green checkmark.



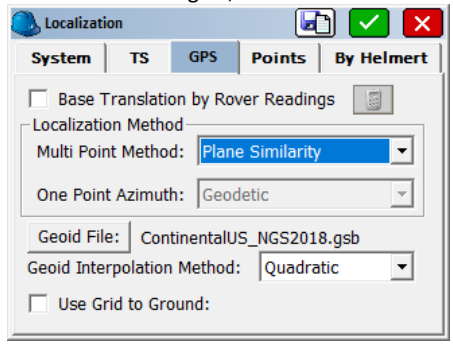
Accpet the default filename for the localization file. Then clik the green check mark. SurvXX will ask if we want to reprocess the raw file:



Click on '**No**', we will process the raw file in a moment after entering a combined scale factor. SurvXX will return to the Main Menu:

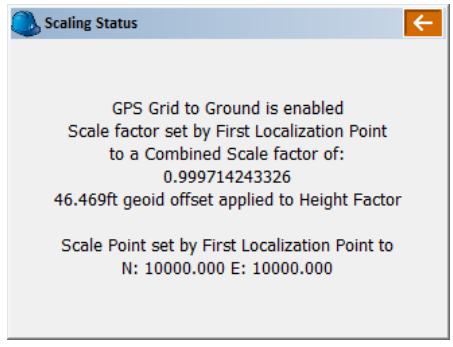


Click on '**Localization**' again, then select the '**GPS**' tab:

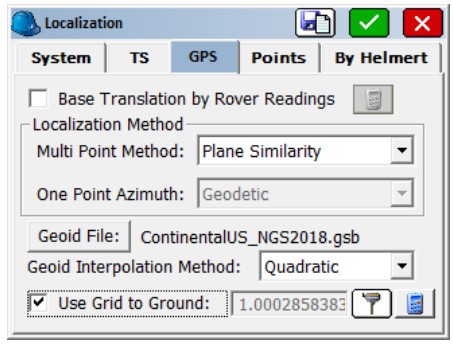


Make sure that a '**Geoid File**' is selected and in use.

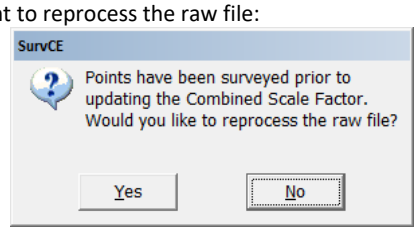
Click on the '**Use Grid to Ground**' checkmark, SurvXX will automatically compute the correct Combined Scale Factor for the first localization point, the Southeast corner of the Section:



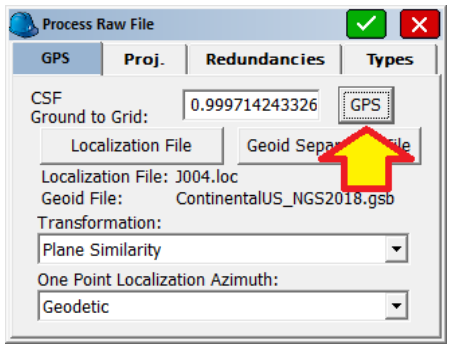
Click on the red back button:



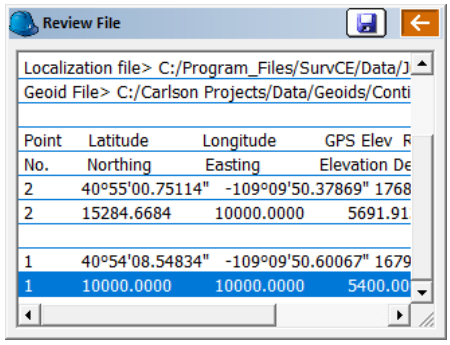
Click on the green checkmark. SurvXX will again ask if we want to reprocess the raw file:



Click on '**Yes**':



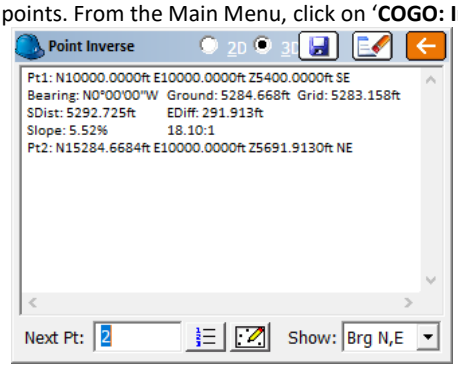
Click on the '**GPS**' button to load the Combined Scale Factor, then click on the green checkmark in the upper right corner. SurvXX will recompute the two points to match our localization:



Click the red back button to return to the Main Menu.

Verify Localization

Use the Inverse function to compute the distance between the points. From the Main Menu, click on '**COGO: Inverse**':



Enter **1**, then **2**. SurvXX reports:

```
Bearing: N0°00'00"W
Ground: 5284.668ft
Grid: 5283.158ft
```

We have succesfully aligned our coordinate system to the East line of the section and the reported Ground distance reflects the CSF at the SE corner of the section.

Connecting the iG9 to a PC or Smartphone via Wi-Fi

The iG9 receiver has an internal Wi-Fi Access Point which can be used in conjunction with a PC or smartphone to setup and control every feature of the receiver including firmware updates.

First make sure that the Wi-Fi hotspot in the iG9 is turned on.

From the receiver's Front panel navigate to the '**Set'** menu by pressing the **Fn** button until '**Set**' is highlighted:

If WIFI is not 'On', click the **Fn** button three times to move down and highlight 'WIFI Off' and click the **Enter** button to turn WIFI On.

Connect a computer to the iG9 receiver using Wi-Fi.

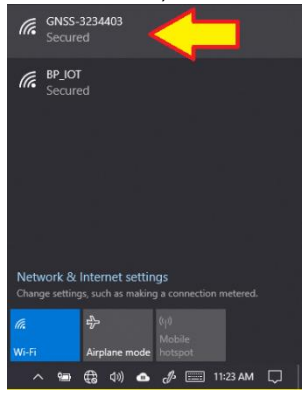
Device Wi-Fi Overview:

SSID:	GNSS-#######	device-serial-number
Wi-Fi Key:	12345678	the Wi-Fi Password
Address:	192.168.1.1	
port:	80	
User Name:	admin	lower case
password:	password	lower case

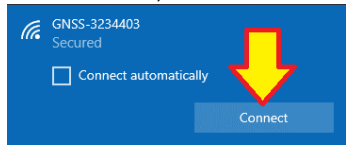
To connect the iG9 to your PC with Wi-Fi:

Click on the Network icon in the System Tray

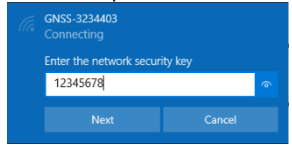
1. Find the iG9 receiver, it will be named 'GNSS-' followed by the full serial number of your device:



2. Click on the receiver, then click on '**Connect**':

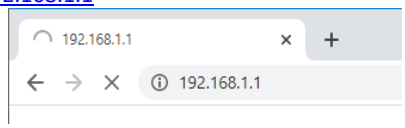


3. Enter the Wi-Fi password "**12345678**"



4. Click on '**Next**' to connect by Wi-Fi to the GPS head.

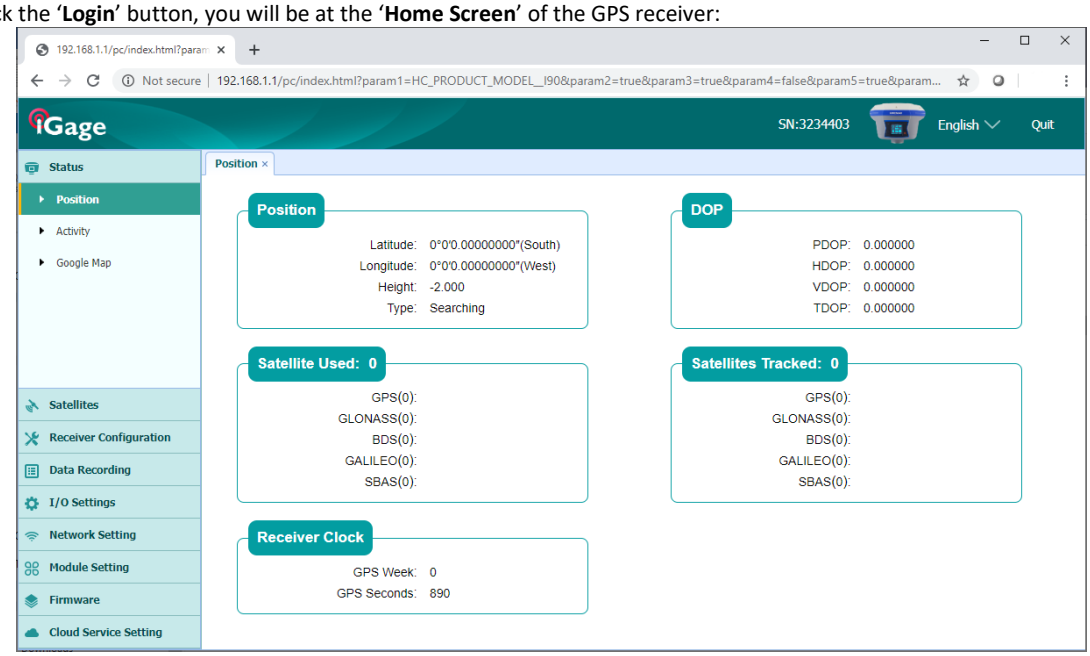
5. Open a browser window on your PC and type in the GPS IP address:
   http://192.168.1.1



6. A Login screen will be shown:

The **Login Account** is '**admin**' and the **Password** is '**password**'.

7. Click the '**Login**' button, you will be at the '**Home Screen**' of the GPS receiver:

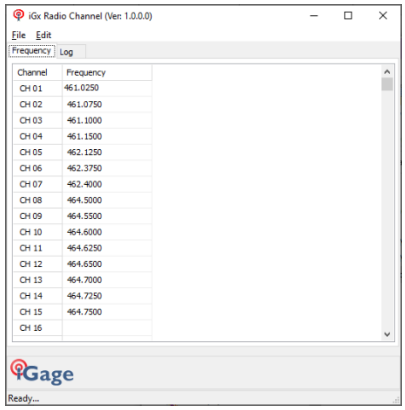


From the Wi-Fi interface, you can configure nearly every aspect of the receiver's operation using the left-hand section tabs and sub-items.

Programming iG9 Radio Frequencies and FCC ID

In the United States an FCC license is required to operate the UHF radio at any power, on any frequency. Your FCC license will specify one or more frequencies and a 'Call Sign' which must be broadcast at least once every 15-minutes.

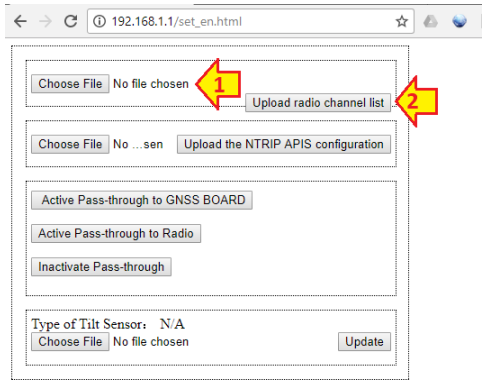
You can download the iGx_RadioChannel.exe tool from the iGage.com website. This tool will run on any PC:



With this tool you can create a standard list, modify frequencies, and reorder the frequency list. When the frequency list matches your FCC License, then you can save a .CFG file for uploading to the iG9 receiver.

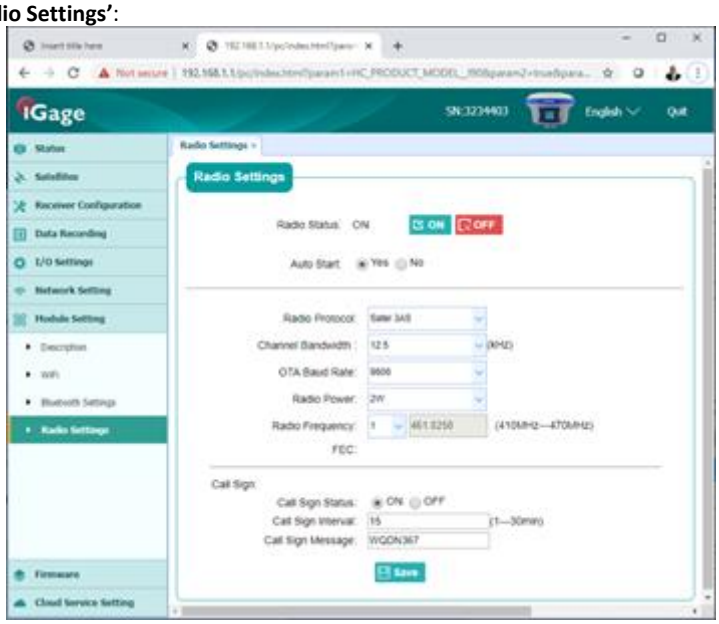
You must login to the GPS receiver using the instructions '**Connecting the iG9 to a PC or Smartphone via Wi-Fi**' found on Page 87.

Open a browser and go to this address http://192.168.1.1/set_en.html :



(1) Click on '**Choose File**' and browse to the settings file, then (2) click on '**Upload radio channel list**' the new radio table list will be installed in the head.

To set the broadcast FCC Call Sign, return to the main menu (http://192.168.1.1) then click on '**Module Setting'** then '**Radio Settings'**:



If the '**Radio Status'** is **Off**, click **On** to turn on the radio power.

The '**Call Sign Status'** should be set to **ON**, the '**Call Sign Interval'** should be 15 minutes or less, the '**Call Sign Message'** should be your FCC Assigned Call Sign. Once entered, click on **Save** to commit the changes to the internal radio.

Setting Up the Optional ADL Vantage Pro Repeater Kit

iG9 RTK receivers include 2-watt internal Transmit / Receive radios. For many jobs, 2-watts will be sufficient power to blanket the survey area with UHF corrections. To cover larger areas, an optional repeater can be used to extend surveying range.

Typically, the repeater will receive a full correction message from the Base and immediately retransmit the corrections at a higher power on the same channel as it is received. It is also possible to receive corrections on one frequency and transmit on another.

The repeater does not need to be located near the Base, it only needs to be able to dependably listen to the Base signal. This is great for applications where it is convenient to place the Base on a job corner or control point, and then place the repeater on a nearby hill that has excellent radio coverage.

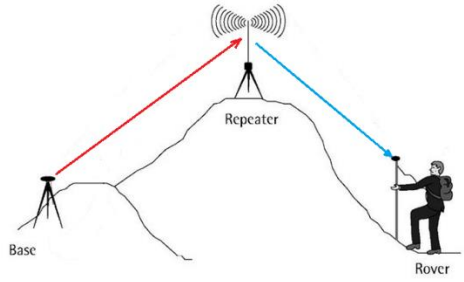


Figure 8 Using a Repeater to extend UHF correction range.

Important Protocol Note

If you are going to use a repeater, you **must** use 'SCMRx' message type:

on your Base or alternatively **raise the elevation mask to limit the message length** to under 450 characters per second.

Repeater Radio Battery

The duty cycle of the radio in normal operation is about 50% and the radio draws about 8 amps at full output power. So, a 9-hour day requires 40-amp hours. However, the battery requirement is greatly increased for operation in cold weather and the battery's capacity is reduced after several discharge cycles. The less the battery is discharged as a function of its maximum capacity, the more charge cycles the battery will accept. For these reasons, when purchasing a battery for the Base: **big**-is-certainly-better.

Large deep cycle marine batteries with screw terminals that will directly accept the lug connectors of the cables supplied are available at reasonable cost from many local sources.

Figure 9 Deep Cycle Battery

Before plugging in the UHF radio, always ensure that the UHF antenna has been connected to the radio. Double check that the polarity (RED = +; BLACK = -) is correct before attaching the power connector:

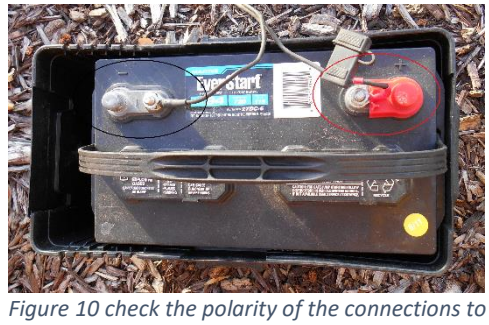


Figure 10 check the polarity of the connections to the battery before use.

You may receive alligator clip connectors with your repeater:

Figure 11 Alligator-clip connections won't support full output power!

These temporary **connectors will not provide** sufficient power to run the repeater at full power. If you plan on using output power higher than 8-watts, please use the spade connectors.

NOTE: The ADL repeater requires a low resistance battery source. The #1 cause of repeater issues is old batteries with terminal voltage less than 12 volts when under heavy load. Typically, this means the battery need to be less than three years old.

Setting up the Repeater

Place the repeater and antenna on a tripod or other suitable mount. If the Base is nearby, set the UHF radio antenna to the North of the GNSS receiver so that the UHF radio antenna does not block the GNSS receiver's view of the southern sky.

This picture shows the antenna mounted both on an adjustable prism pole through the center of a tripod and on an extension on top of a tripod:

Repeater

Extension on plate

or

Prism pole through tripod head

Figure 12 UHF Repeater Configuration

The repeater includes a bale hook for hanging on a tripod leg.

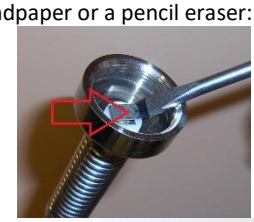
Mounting the antenna as high as possible will result in better radio range. Doubling the height of the antenna is much more effective than quadrupling the output power.

The radio automatically drops the output power as required to keep the case at a reasonable temperature. For operation in extreme heat, a fan cage is available to force cool the fins on the radio back:

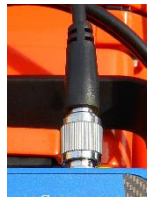
Figure 13 Fan option for use at very high ambient temperatures.

Setting up the Repeater

1. Check the spring clip on the bottom of the antenna, if it is smashed down too far pry it back up so that it will make good contact with the cable base. Check both the spring clip and the contact on the pole mount to insure they make a clean connection, if they are corroded clean them lightly with fine sandpaper or a pencil eraser:



2. Connect the UHF Radio antenna to the radio mast, connect the TNC cable end to the ADL Vantage Pro.



DO NOT plug power into the ADL radio until the UHF antenna has been connected and placed on the mast.

DO NOT hold the antenna or touch the antenna when the ADL power is on. The radio will output sufficient power to burn you.

Put the antenna at an elevation above your head to reduce the EMI field transmitted into your brain. 35-watts will burn you. If you have a pacemaker, use extreme caution with the repeater power set higher than 2-watts.

DO NOT place the UHF antenna to the South of the receiver. The UHF antenna will block the GNSS antenna's view of satellites to the South. Place the UHF antenna to the North of the GNSS Base. (There are very few SV's to the North of your GNSS receiver so the impact is minimized.)

3. Connect the power connector to the radio:

4. The radio will turn on when power is applied. IMPORTANT: Before you remove power from the radio, ALWAYS turn the radio off with the power switch. Push and hold the Power ON/OFF button for five seconds, then wait for the radio to power down:

Alternatively you can disconnect power at the SAE (the flat two-pin connector.)

5. After 5 minutes, the LCD display is placed in sleep mode. Tap the ON/OFF button to turn the LCD display back on.
6. If your Base is already configured and broadcasting corrections, the repeater should begin operation within 30-seconds of being turned on. You should see the RX LED blink, then the TX LED will immediately blink. This pattern should repeat every second.
7. If the repeater does not start working, verify that the Base is transmitting, then check the repeater settings as shown below.

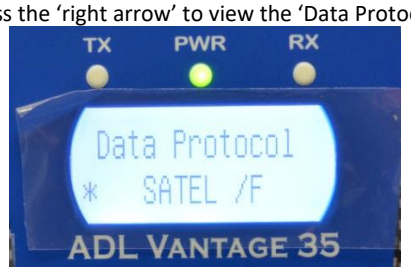
NOTE**: If you change a value, be sure to press the center Enter button to store the change.**

8. When you turn on the receiver, the device status will be shown. The status should be 'Battery: Normal'

9. Press the 'right-arrow' to move the next screen. The current channel will be shown

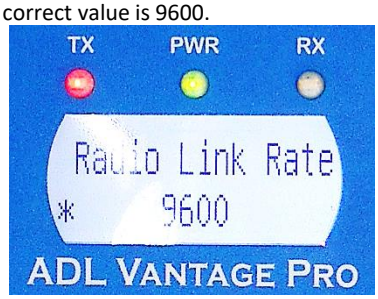
The Base and Rover frequencies should match this setting. Note that the channel number may be different, only the frequency must match.

10. Press the 'right arrow' to view the 'Data Protocol'



"**SATEL /F**" is the correct setting corresponding to the 'SATEL' setting on the Base and Rover.

11. The Radio Link Rate is the 'over the air' baud rate. The correct value is 9600.



12. Set the Repeater Mode to '**ON**':

13. Set the RX Sensitivity (for the Base) to High. This allows the repeater to easily hear the Base transmissions:

14. Set the Transmit Power to the lowest power that will cover your job.
Use the up and down arrow keys to select, press enter when the proper selection is made.

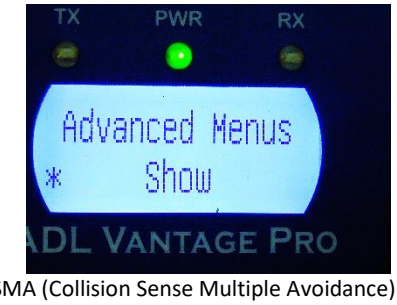
15. Set RX LED to 'Signal Received':

The RX LED will blink when any signal (voice or data) is present on the selected frequency.

16. The Serial Baud is the baud rate over the serial cable to the GNSS receiver. For a repeater, which does not have a serial cable, this setting is meaningless:

17. Press the 'right-arrow' to skip Signal Strength:

18. Set '**Advanced Menus**' to '**Show**':



19. CSMA (Collision Sense Multiple Avoidance) must be left ON in the USA to meet FCC requirements:

When CSMA is turned ON, the radio will listen for other data or voice users on the programmed frequency, the radio will wait until other users stop broadcasting before transmitting. **FCC rules require CSMA to be ON for operation in the United States**.

20. Set 'Edit Config' to 'Enabled':

21. Set Scrambling to 'OFF' (this setting must match the setting on the Base and Rover):

Enabling Scrambling lengthens each data packet.

22. Set FEC (Forward Error Correction) to 'OFF' (this setting must match the setting on the Base and Rover):

Turning FEC ON lengthens each data packet.

23. Choose the appropriate language

24. Leave 'Antenna Detect' set to 'Disabled'.
If you have concerns about your antenna or antenna cable, set 'Antenna Detect' to 'Enabled'. This will allow the radio to detect the antenna and cable efficiency and automatically reduce the output power to 2-watts when issues are found:

There is a slight chance that a good antenna will be detected as bad, which will result in inadvertent lower output power and reduced Rover range.
If you know your antenna and cable are in good condition leave 'Antenna Detect' set to 'Disabled' to insure continuous high output power.

25. The Antenna VSWR displays the Standing Wave Ratio. Any value less than 10:1 is reasonable. The lower the first number, the better:

Values higher than 8:1 result in a 'no antenna connected message.'
Note: if 'Antenna Detect' is 'Disabled' this screen will not be shown.

26. One last right click and you are back to the Device Status:

27. Clicking the 'down-arrow' will display the owner's name or telephone number:

28. Down arrow to the FCC ID which is transmitted in Morse Code (CW) every 15 minutes:

A valid FCC license is required for operation in the United States and the FCC assigned ID must be transmitted by continuous wave (CW) Morse Code every 15-minutes.

29. Press the down arrow to view the current modulation type:

The modulation type will change Based on the selected protocol.

30. In almost all cases for all current FCC licenses in the United States, the channel bandwidth must be 12.5 KHz or less to meet FCC requirements:

31. This screen indicates if the transmitter is enabled and what the output power is:

On hot days, it is possible that the radio power setting is higher than the enabled value. Power will also be reduced if Antenna Detect is enabled and a fault is detected.

32. This is the internal temperature of the receiver:

Automatic power management becomes active when this temperature is higher than 85 C.

33. 15-seconds after you switch to the Duty Cycle screen, the transmit duty cycle of the receiver is shown:

34. This is the firmware revision currently running in the radio:

NOTE: **The current (Jan 2020) firmware version is 5.02.** You can check for updated firmware online at www.pacificcrest.com

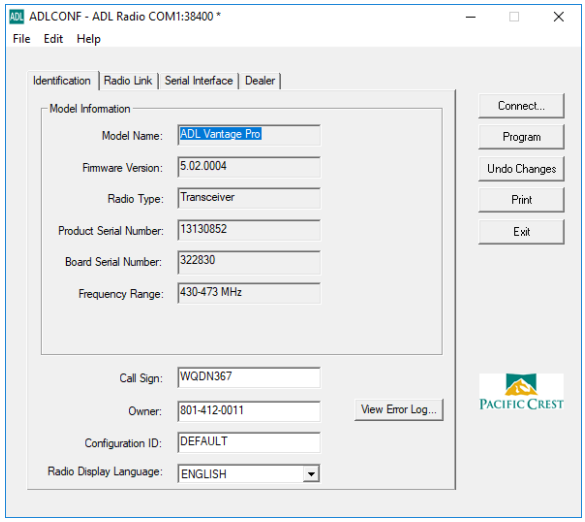
35. Finally, the regulatory region code is displayed:

The RC may be as shown above or 'RC:EU/ROW' Do not be concerned that it lists countries that do not include the USA.

Dealer Programming the ADL Vantage Pro or 35 Radio

These instructions are for radios with firmware 5.02 or higher. Please use the current radio firmware with the current programming tool. Both are available from the Pacific Crest website: www.paccrest.com

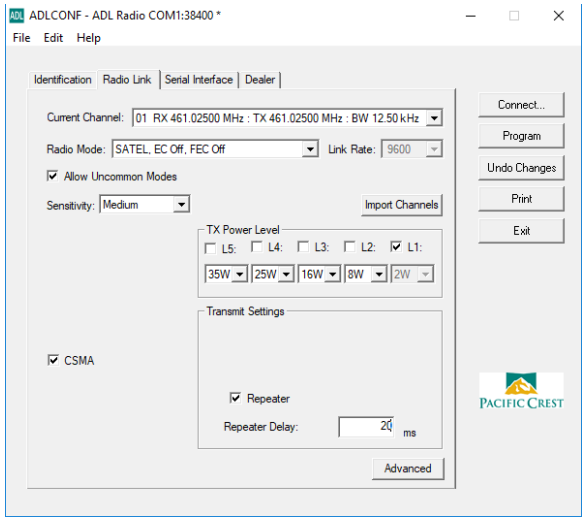
Identification (tab)

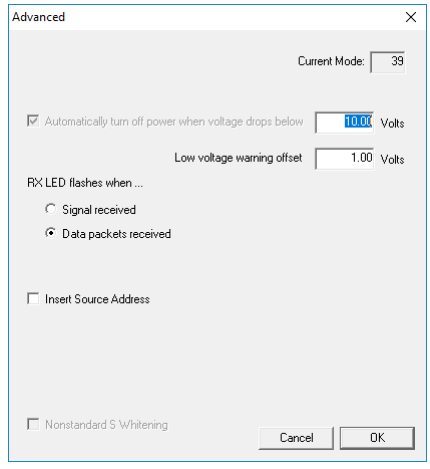


We put the owner's phone number in the Owner box. You must have an FCC license to broadcast, and the FCC call sign must be transmitted every 15 minutes. Put your FCC call sign in the appropriate box.

Radio Link (tab)

Initially 'Allow Uncommon Modes' may not be checked. You may need to program the radio (by clicking Program) and then re-connect (by clicking Connect) and re-read the radio configuration after checking 'Allow Uncommon Modes'.

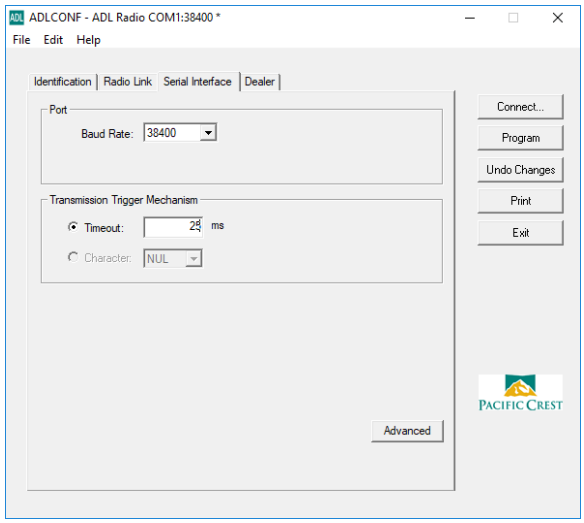


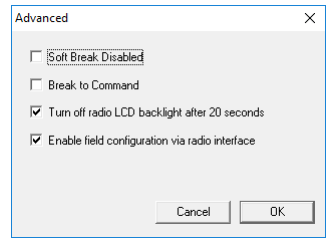


Select 'SATEL, EC Off, FEC Off' which is the default Satel / 3AS mode used for iGage iG and CHC receivers. CSMA should be checked for legal operation in the USA unless you have a dedicated, unshared channel. Set the Sensitivity to Medium to keep low power noise from throttling the repeater's output.

Check the 'Repeater' check box.

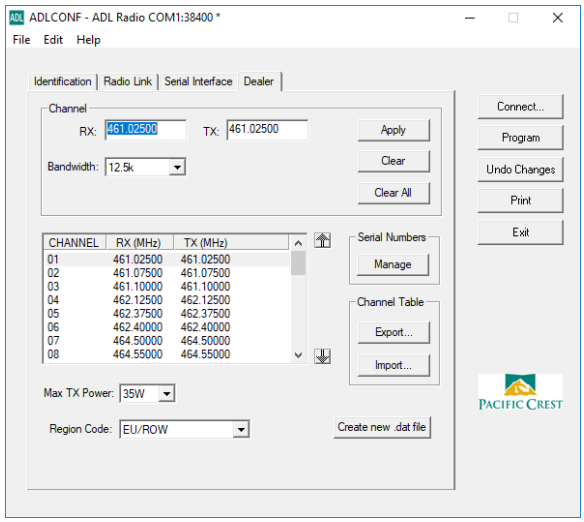
Serial Interface (tab)





Dealer (tab)

A programming dongle is required to configure the values on the Dealer tab.



Don't change the Region Code, there is a known issue when modified.

The Bandwidth must be set to 12.5 KHZ for operation in the USA. You may need to make this change and then return to the 'Radio Link' tab to get the baud rate to register correctly.

It is illegal to program a radio with unlicensed frequencies. It is illegal to program a radio to 25 KHz unless your FCC license allows 25 KHz operation.

In addition to simplex channels (the Rx and Tx frequencies are the same) you may want to program some cross-channel pairs like: Rx 461.025 Tx 464.700.

Backing up Carlson Jobs:
Never Loose Data in SurvCE

There is, a risk of losing data that you collect in any field program.

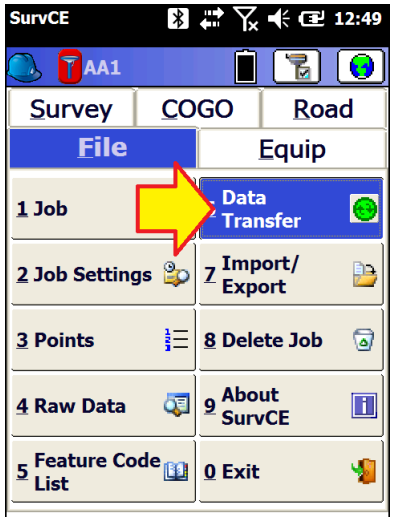
If anything goes wrong with the system, you must reinstall the operating system from scratch. This wipes out your program installations and it may wipe out all of the data that is stored on the device memory. (However, data on the internal SD Card should be safe.)

Luckily SurvCE has a simple mechanism that allows you to continuously back-up your work during the day.

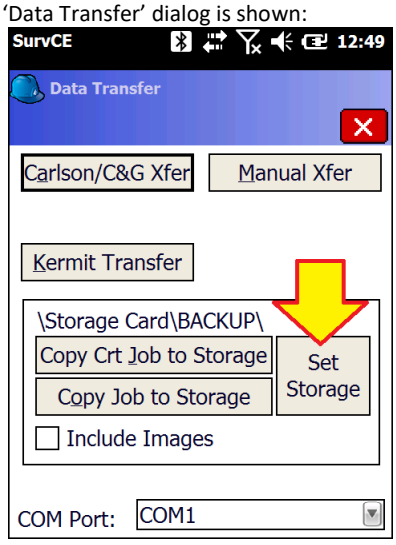
First make sure that your data collector has a SD or micro-SD card installed. These usually are placed in the battery compartment.

When you start a new job, store the job in the main memory. The default location in SurvCE is "/Device/Program Files/ SurvCE/Data/".

After you start a job, from the main menu go to 'Equip: 6: Data Transfer':



The 'Data Transfer' dialog is shown:



Click on the '**Set Storage'** button, navigate to the SD card (often called '**Storage Card**' or '**MMC Data Card**") and configure the destination to be a new folder.

Once the folder is named, click on the '**Copy Crt** (current) **Job to Storage**'. All of the current job's files will be copied to the backup location.

Throughout the day return to this menu and click the '**Copy Crt…**' button again to freshen your backup copy.

Data Collectors Should NEVER Standby & Manually Reconnecting

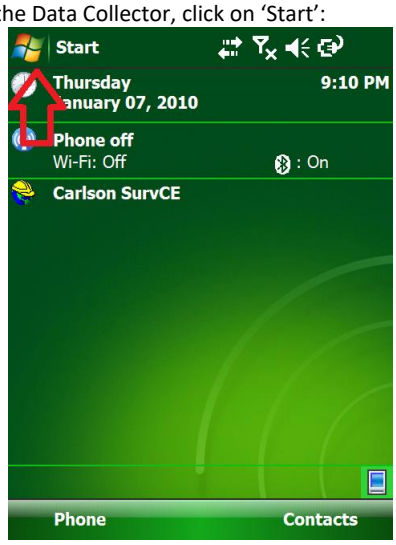
Your data collector is connected to the RTK head by Bluetooth. When/if the data collector goes into Standby, this communication link is shutdown.

When the data collector is brought out of Standby (typically by briefly pressing the power key,) it is supposed to automatically reconnect to the head. Depending on the state of communication before the data collector disconnects this reconnection procedure may be troublesome.

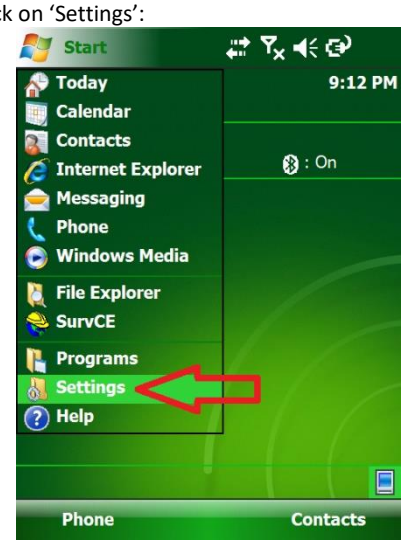
Never Standby

The best solution to this problem is to NOT ALLOW the data collector to enter standby. Turning off the backlight is okay, but you should configure the data collector to NEVER enter standby. Here is how:

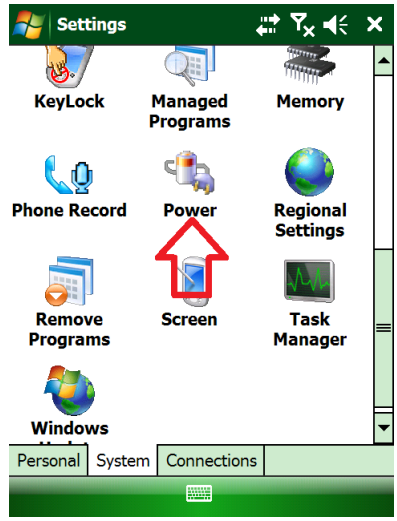
1. On the Data Collector, click on 'Start':



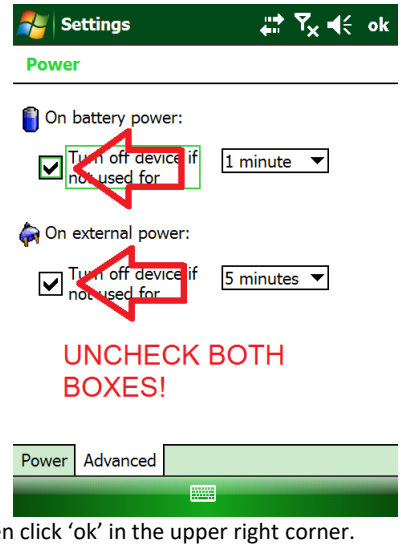
2. Click on 'Settings':



3. Select the 'System' tab, then drag down and click on 'Power':



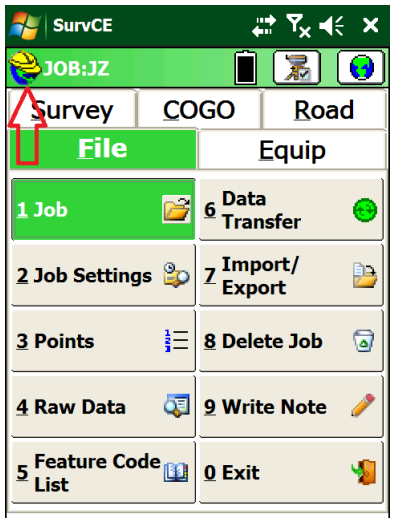
4. Uncheck both boxes:

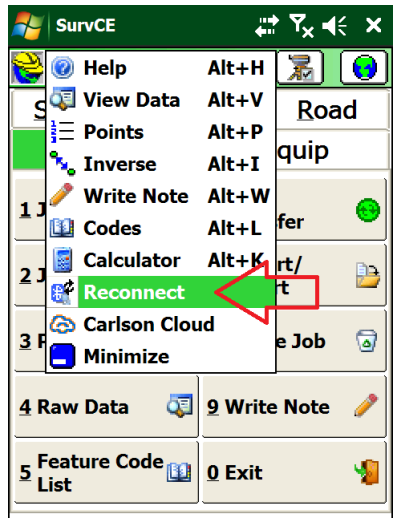


Then click 'ok' in the upper right corner.

Manually Reconnecting Bluetooth

If the automatic reconnect does not work (and this can happen often), you can manually ask SurvCE to reconnect to the RTK head. This is very useful after changing the battery mid-day. From the main SurvCE menu click on the '**Hard Hat**' in the upper left corner, then click on '**Reconnect'**:





SurvCE will re-initialize the Bluetooth communication link between the data collector and the RTK head. If the Reconnect selection fails to reestablish the connection, reconfigure the Rover from '**Equip: GPS Rover'**.

Downloading, Processing and Archiving Static Data

Your iG9 GNSS receiver works with a download, preprocessing and archive tool called

iGx Download

This tool works with the NGS OPUS, RTX, AUSPOS and IBGE online products.

iGx Download also automates the generation of RINEX for export to other programs.

Installing the Download Tool

Insert the provided disk in the DVD ROM drive of your computer and the installation tool should automatically run. Follow the on-screen instructions to install the download tool and the iGx-OPUS support tools on your computer.

You can always get the latest version of the iGx Downloader from the internet and install it directly:

https://iGGPS.com

Downloading Data from iG9 GNSS Receiver

Summary: Turn on the receiver, wait for it to boot; plug in the USB Cable to your computer.

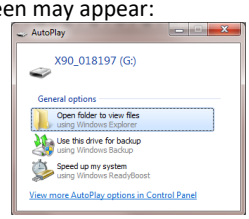
The iG9 receiver mounts as a USB thumb drive (flash drive) on your Windows computer. No special drivers are required.

To download data from your receiver:

1. Turn on the GNSS receiver.
2. Wait for the iG9 receiver to fully boot.
3. Plug the USB-C connector into the USB-C hole on your iG9 receiver:

and a USB port on your computer.

4. After a moment, for the Window's disk mount screen may appear:



If it does, close it by clicking on the red 'X' in the upper-right corner.

The first time you attach a receiver, you may need to wait up to 2-minutes for standard device drivers to be installed.

The correct drivers are built into Windows XP, Windows Vista, Windows 7, Windows 8 and Windows 10. The drivers are not distributed with the GNSS receiver.

If your receiver does not mount or an error message is displayed, you can unplug the receiver, wait a moment and plug it back in which usually results in a successful connection.

Starting the Download Tool

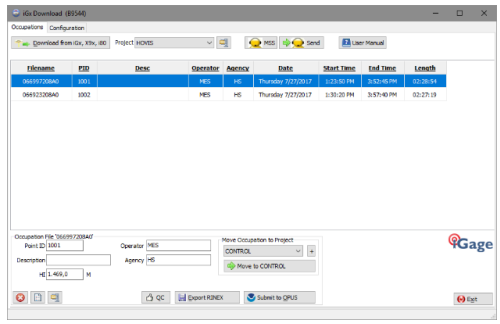
You can start the download tool by clicking on the Download shortcut on your desktop:

Using the Download Tool

Assuming the iG9 GNSS receiver is plugged in and has mounted as a drive letter, just press the '**Download from iGx, X9x, i80**' button:

The program will automatically switch to the '_New' project and download every new (not previously downloaded) file from your receiver.

As the .HCN binary files are downloaded from the receiver they are automatically converted to RINEX and added to the '_New' project and finally displayed in the occupation grid.



You can sort the grid by Filename, PID, Description, Operation, Agency, Start Date/Time, End Date/Time and Length by clicking on the column headers. Clicking twice on the header will reverse order the grid.

If you have any short or unneeded occupations, you can select and delete them:

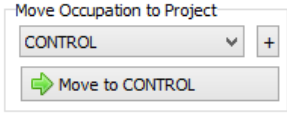
<- the 'Delete Occupation' button

For the remaining observations, enter the values you recorded in your field book:

1. **PID** (Point ID) A unique short identifier for each marker (usually a 4-digit integer.) Only letters, numbers and the underscore are allowed in the PID.
2. **Description** A longer description of the point. Note that quotes '"' and '"' are not allowed in the description.
3. **HI** The Instrument Height which is the distance from the ground mark to the bottom of the receiver:
   add '**F**' to enter feet
   add '**S**' to enter slant height
   add '**SF**' or '**FS**' to enter slant feet height

4. **Operator** This value gets placed in exported RINEX files. By convention this is usually less than 10 alphanumeric characters.
5. **Agency** This value gets placed in exported RINEX files. By convention this is usually less than 6 characters. A current list of official contributors can be found with this online link: https://geodesy.noaa.gov/cgi-bin/get_contrib2.prl. If you plan to contribute to NGS or international projects follow this link: https://geodesy.noaa.gov/FGCS/BlueBook/annexc/annexc.index.shtml for information on obtaining an agency code.

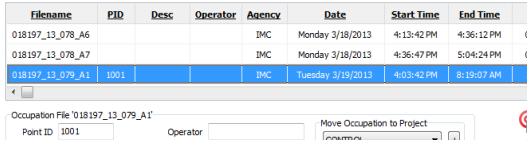
If the '_New' folder gets too full, you can make a new project folder (with the "+" button) and move older occupations to the new project:



Submitting an Occupation to OPUS

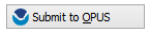
Once all of the new occupations have been deleted or assigned to a project you can submit an occupation to NGS OPUS, NGS OPUS-RS, RTX, and AUSPOS. IBGE or post-process them using other software / services.

Click on an occupation to select it:



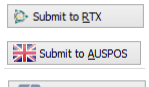
Double-check the PID and Instrument Height.

Click on the 'Submit for OPUS' button:



U.S. National Geodetic Survey

Note, you may select an alternative PPP Service provider (on the configuration tab.) Some of the alternative providers are:



Trimble's RTX Service

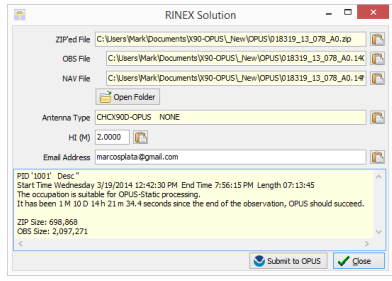
AUSPOS

Brazilian Institute of Geography and Statistics

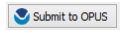
The currently selected occupation will be processed and prepared for upload to OPUS:

1. the file is decimated to 15-second epochs, header information is stuffed
2. the file is run through TEQC to insure it will be acceptable to OPUS
3. an Observation file and a Navigation file are generated
4. the Observation file is compressed into a ZIP file

If the '**Show Advanced Settings**' is set to "**Simple**" then the program will skip directly to the '**Verify Filename to Upload'** screen (shown below.) If 'Show Advanced Settings' is set to "Normal", "Support OPUS-Projects" or "Advanced" then this 'RINEX Solution' helper screen is shown:

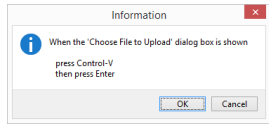


The program will suggest which service (OPUS-Static or OPUS-RS) and list the time since the end of the occupation. You can click the 'Submit to OPUS' button:

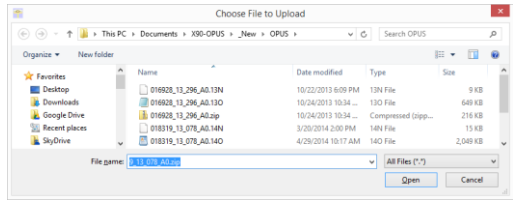


to automatically open an internet browser at the NGS OPUS Submission form. When the web page has loaded, the program will automatically fill in the 'Antenna Height' and the 'Email address.'

Verify Filename to Upload: The program will prompt you:



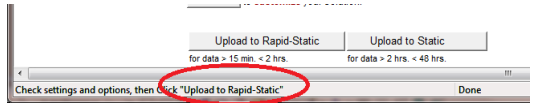
Click OK and then 'Choose File to Upload' will be displayed:



Press Control-V, then the 'Enter' key on your keyboard. You may also press Control-V, then click the 'Open' button with your mouse.

You will need to manually select the antenna type as prompted by the **iGx Download** tool. The download tool cannot automate the antenna selection.

The NGS OPUS Submission form will be ready to submit, check the entries and any extended options that you might want to use. The status bar will prompt you with the correct submission button:



Press either the 'Upload to Rapid-Static' or 'Upload to Static' button as directed, and your occupation will be uploaded to OPUS for processing.

Setting the Receiver Type

(Hidden when Simple)

When files are downloaded from the receiver, the receiver type is associated with the .HCN file. The 'Receiver Model' shows an occupation's associated hardware type:

If this is consistently incorrect, you can modify the device type while it is connected on the 'Configuration' tab.

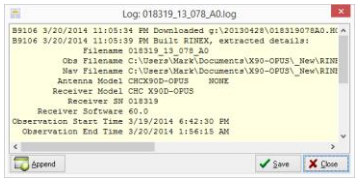
Viewing the Observation Log

(Hidden when Simple)

A detailed log is automatically kept for the files that you download and submit for processing.

Pressing the 'Log'

button shows the log file for the currently selected observation:



Pressing the 'Append'

button adds a date/time stamp and opens the log for user editing.

Press 'Save' to store your changes or 'Close' to close without saving.

Trimming Occupation Files

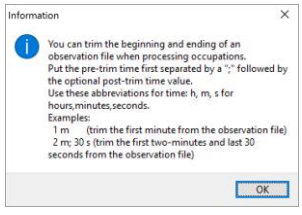
(Hidden when Simple)

Sometimes you may want to trim the start or end of an occupation file before you submit it to OPUS.

Common reasons for wanting to do this include:

- Receiver is turned on while sitting on your tailgate and then moved 20 feet and spun onto the tripod. The first 5-minutes of the observation are bogus.
- The operator forgets to turn off the receiver and observation data is collected while the receiver is transported back to the truck. The last 2 minutes of the observation file are bogus.
- The observation extends 5-minutes past midnight UTC, you don't want to wait an extra day to process. Trim 6 minutes from the end of the file.

Clicking the '?' button to the right of the trim dialog displays usage instructions:



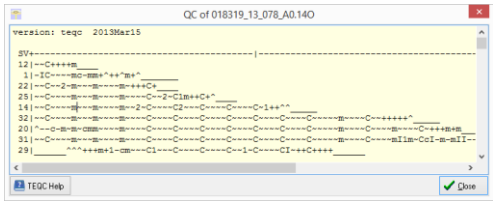
Note: the trimmed length is not reflected in subsequent screens or on the occupation grid. Only the submitted file is trimmed, all the original data remains in the stored occupation. The trim settings must be reloaded after each submission.

Performing Quality Control Checks

(Hidden when Simple)

Pressing the

button will launch the UNAVCO TEQC tool and run a standard RINEX QC run on the currently selected observation file. When the run is complete, the results will be shown in a window:



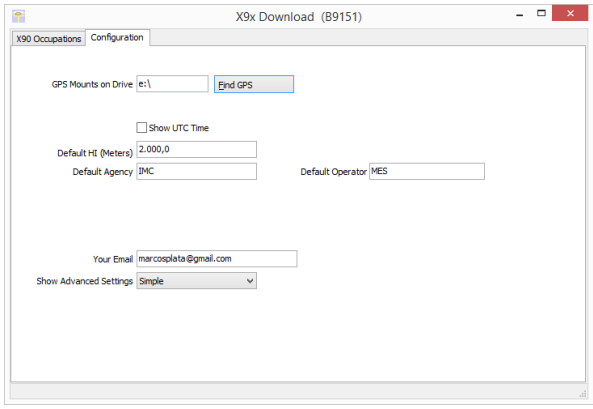
You can press the 'TEQC Help' button to download the User Guide for TEQC from the UNAVCO web site.

TEQC is a great tool for evaluating both the receiver's performance and the site suitability for collected data.

Advanced Download Settings

Configuring the Download Tool

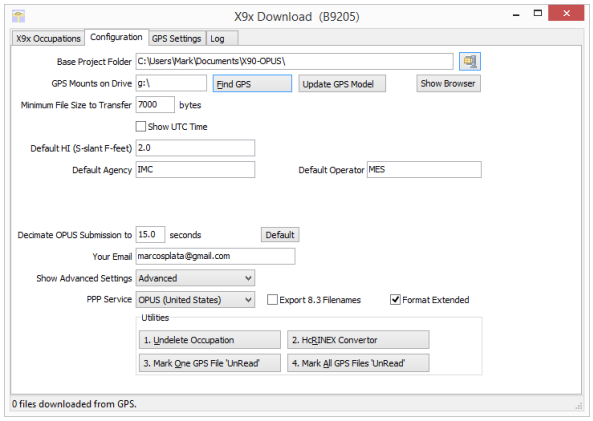
Click on the 'Configuration':



At a minimum enter these values:

Agency	your company name
Operator	the name of the default operator
Email	your email address

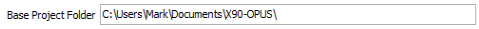
If you change 'Show Advanced Settings' from 'Simple' to 'Normal', 'Support OPUS Projects' or 'Advanced' additional setup values are shown:



You can change the rest of the configuration values as needed. Here are detailed descriptions for each of them:

'Base Project Folder'

(Hidden when Simple)



This is the full Window's path to the Base folder where all of the data is stored. The default location is in your 'Documents' folder in a folder named **iGx_Projects**.

Double-click over the current path to change the folder location.

The download tool will create a sub-folder for each Project that you add. In addition, there are always three special folders:

_New

New occupation files downloaded from the receiver are placed here first.

_Deleted

Deleted occupations are not really deleted, they are moved to the _Deleted folder. An undelete function is included in Utilities on the Settings tab.

_Error

Sometimes short occupations won't include navigation records, these short files end up in this folder.

'Archive All Projects'

(Hidden when Simple)

Pressing the 'Archive' button to the right of the Base Project Folder entry will back up every occupation in every project to a single ZIP file.

This is handy if you want to move all your data to another computer or make regular disaster backups.

There are similar Archive buttons on the main page: one archives the current occupation and the other archives the current project.

The download tool does not provide a method to restore these backups, however they are standard ZIP files and the Windows operating system does include a tool to decompress them.

'GPS Mounts on Drive'

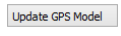
This is the drive letter that the GPS receiver was last found on. Don't worry if the drive letter changes each time you plug in a receiver, the program will automatically find the receiver as you download data.

If you want to verify that the GPS receiver is connected and has successfully mounted as a drive, press 'Find GPS'.

Note: If you manually delete every single file and folder from the GPS receiver, the program won't be able to automatically detect the receiver until the GPS has recorded at least one file.

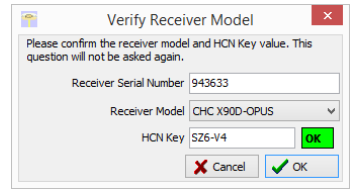
'Update GPS Model'

(Shown only when Advanced selected.)



The GPS Model is written into the receiver at the factory. If you delete ALL of the files on the receiver or format the receiver (it is a standard flash drive) it is possible that it will lose its receiver type.

With the receiver attached to your computer with the USB cable, click on the 'Update GPS Model' button to display this dialog:



Use the drop down 'Receiver Model' to change the receiver type. If the HCN Key has been lost, you can find it written on a white sticker inside the battery compartment. You cannot edit the 'Receiver Serial Number'.

If the HCN Key has been correctly entered, the 'OK' will be shown in a green box, otherwise it will display '????' in a red box.

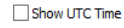
'Minimum File Size to Transfer'

(Hidden when Simple)

Every time you turn on the GPS receiver, it will attempt to track satellites and open a new occupation file. Often several small junk files will be created that don't have any meaningful data and are of no value.

The download tool will automatically ignore files smaller than this minimum value. This keeps useless files from being transferred to your computer.

'Show UTC Time'



When unchecked (the default,) the download tool will show the observation start and end times in your local time zone. If you check 'Show UTC Time', then the times are displayed in the UTC time zone.

'Default HI'

When you download an occupation from the receiver, this HI will be the default associated with every occupation. You can change the HI for each individual occupation later, this is just the default.

If you ALWAYS use a 2-meter range pole, then this value will always be 2.000 and you won't have to worry about HI blunders.

FEET: If you measure up in feet, you can enter the height in decimal feet and put an 'F' after the measurement. The program will automatically convert to Meters for you.

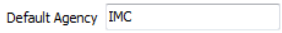
SLANT HEIGHT in Meters: If you measure a slant height, enter an 'S' after the measurement and the program will compute the vertical height for you.

SLANT HEIGHT in FEET: If you measure a slant height in feet, enter 'SF' or 'FS' after the measurement and the

program will compute the vertical height in Meters for you.

Note: if you use the 'PPP Service' = 'RTX (CenterPoint)' the submitted RINEX file spoofs an 'UNKNOWN EXT NONE' and adjusts your actual HI to reflect the generic antenna L1 offset.

'Default Agency'



Enter your company name here. This value is placed into every RINEX file that is exported. You can override this value on a file-by-file basis.

Typically, the Agency name is two to five characters with no spaces. While most strings up to 20 characters in length will be accepted, you may cause issues with other programs that consume generated RINEX. It is safest to keep this short with no special characters.

'Default Operator'

Enter the default name of the operator here. This value is placed into every RINEX file that is exported. You can override this value on a file-by-file basis.

Typically, the Operator name is two to five characters with no spaces. While most strings up to 20 characters in length will be accepted, you may cause issues with other programs that consume generated RINEX. It is safest to keep this short with no special characters.

'Decimate OPUS Submission to ...'

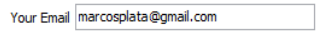
(Hidden when Simple)

When you submit a file to OPUS, it is always decimated at the NGS server to 30-second epochs (recording interval = 1 point every 15 seconds.) The default recording interval for most iGage receivers is 1 or 5-seconds.

By pre-decimating the RINEX file before upload, it is reduced to 1/6th to 1/30th the original size. This makes the upload process much faster while having no impact on the resulting solution.

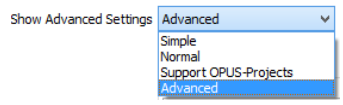
Observations submitted to RTX are not decimated, AUSPOS submissions are decimated to 15 seconds. Observations exported directly to RINEX using the '**Export RINEX**' button are never decimated.

'Your Email'



When you submit a file to OPUS, you need to provide your Email address so the OPUS processor can return a solution to you. The email address that you enter here will be used for all automatic submissions.

'Show Advanced Settings'



This setting determines the complexity of the **iGx Download** program.

Simple: *(the Default setting)*

Hides archive functions, Minimum File size,

Receiver Model, Antenna Name Decimate setting, QC function, Export to RINEX button, OPUS-Projects, the GPS Settings tab and the Log tab.

Normal:

Shows everything except for OPUS-Projects, the GPS Settings and Log tab.

OPUS-Projects:

Displays the OPUS-Projects checkbox which allows automatic submission to an NGS registered project.

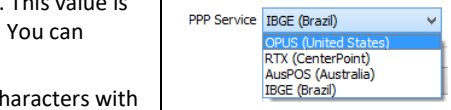
Advanced:

Displays the GPS Settings and Log tabs.

Typically, you will never need to use the 'Advanced' setting and functions.

'PPP Service'

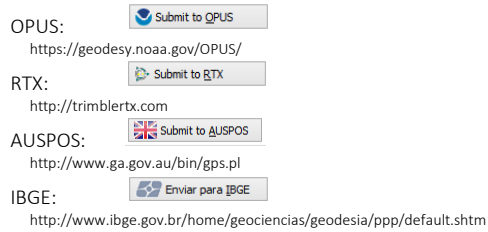
(Hidden when Simple)



The Download tool supports several PPP (Precise Point Positioning) services.

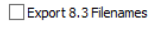
The submit button on the main page tracks this setting and the upload strategy is adjusted to each available service.

Additional Information is available on each service on the web:



Export 8.3 Filename

(Hidden when Simple)



When unchecked, the Download program submits files using filenames like this:

917226_20_072_A0.OBS

The device serial number, the year, the Julian day of year and the observation number. Some services and programs (like NGS OPUS) prefer names in an 8.3 (xxxxxxxx.xxx) format.

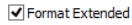
Checking this box results in exported filenames like:

10050720.20O

Where 1005 is the first four characters of the Point ID, 072 is the Julian date, 0 is the observation number, 20 is the year and O indicates an observation file.

Format Extended

(Only shown when PPP Service = OPUS)



The NGS returns three styles of reports:

Standard:
Single Page Report
Extended:
Standard + Baseline details + State Plane in US Survey Feet or International Feet as appropriate Standard XML: Single Page XML

For new OPUS users, the 'Format Extended' includes one important addition: State Plane coordinates are shown in both Meters and US Survey Feet (or International Feet) at the bottom of the report. The download tool defaults to 'Extended' checked for this reason.

Prior to submitting an OPUS report, you can modify any of the Option settings, however checking this box results in the extended output always initially being checked.

Utilities

(Hidden when Simple)

Additional utilities for working with observations are included.

"1. Undelete Occupations"

When you delete an observation, it is actually moved to a special "_Deleted" folder.

Clicking the **Undelete Occupation** button allows you to specify a deleted observation to restore. When an occupation is undeleted, it is always returned to the _New project.

"2. CHCData RINEX Convertor"

Files are stored on the receiver in an '.HCN' binary file. When the tool downloads a file, it is automatically converted to standard RINEX using the CHCData RINEX tool.

Clicking this button runs the CHCData RINEX tool in manual mode. You can browse for HCN files and manually convert them to standard RINEX files. Results are always placed in a subfolder named 'RINEX' under the file to be converted.

"3. Mark One File Unread"

When files are downloaded from the receiver, they are not deleted from the receiver. The filename on the receiver is modified to begin with an underscore '_'.

This function allows you to specify a single file to mark as 'unread.' Once a file is unread the next download action will re-download and convert the file.

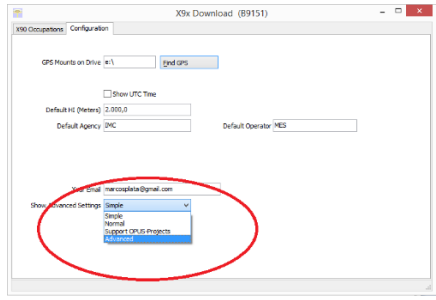
"4. Mark All GPS Files Unread"

This function marks EVERY observation file on the receiver as unread. The next download will read every single file on the receiver. (This will take quite a bit of time if your receiver has hundreds of files.)

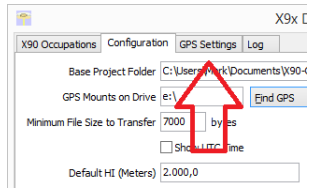
GPS Settings

(Hidden when Simple)

To modify the 'GPS Settings' or view the log, select the 'Configuration' tab, then choose 'Show Advanced Settings = Advanced.'



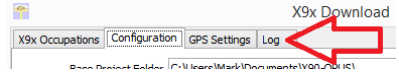
When 'Advanced' is selected, two additional tabs will be displayed:



GPS 'Settings' Tab

The GPS Settings options on the download tool are not compatible with the iG9. You can use the front panel controls or the Wi-Fi connection to make recording interval changes to the iG9.

The 'Log' Tab



The 'Log' tab shows detailed results of the current program operation. It may be useful to debug some aspect of file processing.

OPUS: What is it?

OPUS (Online Positioning User Service) is a free service provided by the NGS (National Geodetic Survey.)

From the NGS Website:

> "This Online Positioning User Service (OPUS) provides simplified access to high-accuracy National Spatial Reference System (NSRS) coordinates. Upload a GPS data file collected with a survey-grade receiver and obtain an NSRS position via email.
> OPUS requires minimal user input and uses software which computes coordinates for NGS' Continuously Operating Reference Station (CORS) network. The resulting positions are accurate and consistent with other National Spatial Reference System users."

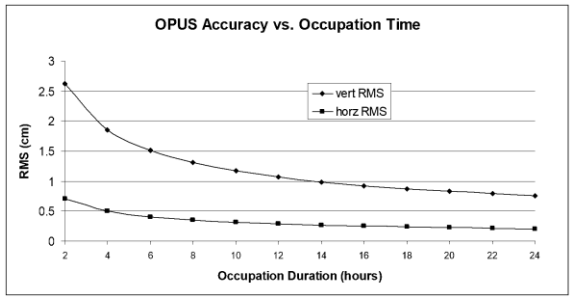
Here are direct links to more detailed information:

http://geodesy.noaa.gov/INFO/OnePagers/OPUSOnePager.pdf
http://geodesy.noaa.gov/OPUS/about.jsp

One of the most important contributors to vertical accuracy computed by OPUS-Static is the length of occupation: longer times are better.

If you are concerned about elevation, please remember that a 2-hour OPUS static observation has an expected height accuracy of 2.5 cm. A 6-hour occupation has an expected accuracy of 1.5 cm.

Again, longer times are better. Your expectations should be tempered by this NGS graph:



OPUS-RS (Rapid Static)

Standard OPUS-Static sessions require 2-hour observations. OPUS-RS sessions can be as short as 15-minutes.

However, OPUS-RS solutions are not available universally. In general, OPUS-RS requires:

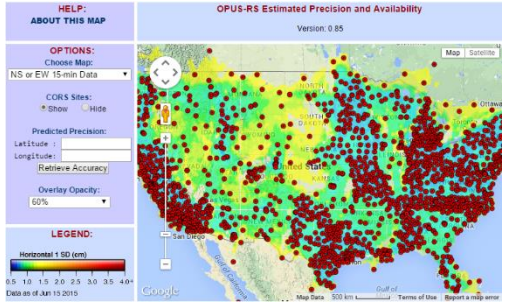
> 3 (or more) CORS within 250 km of your site your site must be within 50 km of the polygon formed by the CORS sites

If you are working in Southwest Nevada, along the highline of Montana or in North or South Dakota, OPUS-RS probably will not work and you will have to collect more than 2 hours of data for submission to OPUS-STATIC!

Prior to collecting data for OPUS-RS check the latest status map to ensure that OPUS-RS will work. The online OPUS-RS resource

http://geodesy.noaa.gov/OPUSI/Plots/Gmap/OPUSRS_sigmap.shtml

is updated routinely and reflects the probability that an occupation at a given location will be successful and the expected accuracy for a 15-minute and 1-hour occupation.



In some areas there is a risk that if a single CORS site is unavailable, your OPUS-RS job will not be processed. Caution and planning are suggested for OPUS-RS jobs.

OPUS-Projects

OPUS Projects is a relatively new online tool. Its use requires taking a NGS training class, but the invested time is well worth it as OPUS-Projects will allow you to combine the observation files from multiple receivers and multiple sessions.

There is an excellent article and video describing OPUS Projects in the October 2013 'American Surveyor' magazine. Search for "OPUS-Projects: The Next Revolution in GPS" to find a full resolution PDF.

OPUS Error Messages and Failures

There are lots of possible error messages when processing OPUS solutions. It is our experience that almost all errors fall into a single category:

> "There is not enough nearby CORS data to effectively process your occupation…**yet**."

In general, the solution is nearly always the same:

> "Wait until more data becomes available and resubmit your job."

If you are processing OPUS-RS jobs in an area with very few CORS stations, and one CORS station was offline, waiting will not help. OPUS-Static is the solution for locations where OPUS-RS is not dependable.

CORS stations can report observations hourly or daily. In some areas (typically UNAVCO PBO sites) most of the sites report once at the end of each day (GMT.) So, data that is needed to process your job is not available until 4:00 am GMT on the day after you collect data.

The Download tool allows you to submit jobs to alternative services like AUSPOS and RTX. Typically, these alternative services closely match OPUS.

If you submit an observation to OPUS and nothing comes back, check your SPAM folder. OPUS solutions are regularly misidentified as spam.

OPUS is sometimes unavailable or takes longer than other times.

Interpreting OPUS Results

When you receive an OPUS solution by email from the NGS, it will look something like this:

```
       USER: ms@igage.com                        DATE: May 06, 2014
  RINEX FILE: p4490900.14o                       TIME: 16:08:35 UTC

    SOFTWARE: page5  1209.04 master93.pl 022814   START: 2014/03/31 00:00:00
   EPHEMERIS: igs17861.eph [precise]              STOP: 2014/03/31 23:59:00
    NAV FILE: brdc0900.14n                    OBS USED: 45735 / 47174   :97%
    ANT NAME: TRM29659.00     SCIT          # FIXED AMB:   162 /   171   :95%
  ARP HEIGHT: 0.0083                        OVERALL RMS: 0.011(m)

   REF FRAME: NAD_83(2011)(EPOCH:2010.0000)            IGS08(EPOCH:2014.2452)

            X:     -2184137.494(m)    0.003(m)          -2184138.362(m) 0.003(m)
            Y:     -3839941.381(m)    0.001(m)          -3839940.177(m) 0.001(m)
            Z:      4585410.516(m)    0.005(m)           4585410.529(m) 0.005(m)

          LAT:   46 15 35.23578      0.005(m)            46 15 35.25052 0.005(m)
        E LON:  240 22  8.47069      0.002(m)           240 22  8.40767 0.002(m)
        W LON:  119 37 51.52931      0.002(m)           119 37 51.59233 0.002(m)
       EL HGT:          208.861(m)    0.003(m)                208.444(m) 0.003(m)
    ORTHO HGT:          230.163(m)    0.018(m) [NAVD88 (Computed using GEOID12A)]

                          UTM COORDINATES    STATE PLANE COORDINATES
                           UTM (Zone 11)         SPC (4602 WA S)
  Northing (Y) [meters]     5126276.950           103343.987
  Easting (X)  [meters]      297235.684           566995.383
  Convergence  [degrees]    -1.90148112           0.63125220
  Point Scale                1.00010542           0.99993063
  Combined Factor            1.00007268           0.99989789
```

Here are some general rules to help judge the quality of a solution:

> The orbit [precise] should be precise or rapid (not-ultra rapid.)
> > 90% observations used or > 80% # Fixed Ambiguities
> > 50% Fixed Ambiguities or > 95% observations used
> Overall RMS < 0.030(m)
> Lat / Lon RMS < 0.030(m)

If you collect data under canopy or in an area where there are buildings or trees that obstruct the view above 10° elevation, the number of observations used will be lower.

Make sure you use the left-hand column (NAD_83) results, not the right-hand column (IGS08.)

Be careful with heights. Both ellipsoid and orthometric heights are listed. The orthometric height is NAVD88 GPS derived and typically is the elevation you need.

The RMS error estimate for the orthometric height includes an error estimate for the GEOID in addition to the RMS value for the ellipsoid height.

US Survey Feet vs. International Feet, Scale Factors

The state plane coordinates are listed at the bottom in the right-hand column. They are in Meters. If you need Feet, you can convert them, however be careful to convert to International Feet or U.S. Survey Feet as required by your State and application:

> US Survey Feet = Meters * (3937/1200)
> International Feet = Meters / 0.3048

The misapplication of Ft/M scale factor can result in a 30-foot coordinate blunder! If you request an 'Extended Format' OPUS results, the state plane coordinates are computed and returned at the bottom of the report.

If your survey is at a significant elevation (> 100 feet) you may need to apply the Combined Factor (listed on the OPUS report for both UTM and State Plane Coordinates) to inversed distances to match optical shots made at ground level.

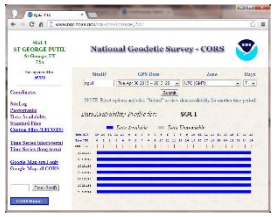
Getting ready to use OPUS

OPUS is a great tool for grounding your survey. But OPUS is part of a larger toolset. Before you begin a project take a moment to think about the 'Big Picture':

A. What are your GOALS?
   a. Required accuracy
   b. Horizontal and Vertical Datum; Geoid model choice
   c. Survey style: OPUS-Static, OPUS-Rapid Static, OPUS-Projects
   d. Consider FGDC Standards:
      http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy

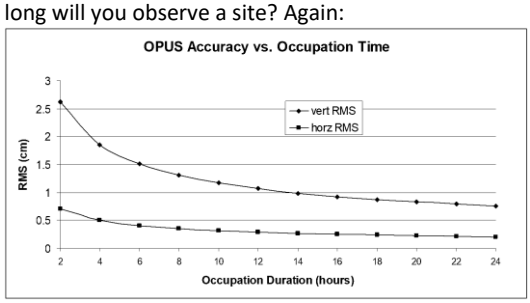
B. Are there passive marks available for control?
   a. Will CORS, passive or a combination control the survey?
   b. Are local passive marks recoverable, undisturbed, sufficient quality, stable and GPS friendly?
   c. Where are the nearby NGS CORS (active) marks? This will determine 'Rapid Static' or 'Static' availability.

C. OPUS-Rapid Static Requirements
   a. Find the closest 9 CORS sites with available observations
   b. A minimum of 3 CORS stations within 250 KM are required.
   c. Your site must be within 50 km of a polygon created by the remaining available CORS.
   d. If the eligible CORS count is low, check the past reliability of recent observations to ensure that there is a high probability of sufficient sites for OPUS-RS to compute a solution. Use the CORS 'Data Availability' to check for recent observations:



D. Mission Planning: Satellite Availability and Network Planning
   a. How many receivers will you use for simultaneous observations? If you are using OPUS-Projects then More = More-Better.
   b. Checkout online 'Mission Planning' tools for U.S. satellite availability using reasonable masks (>15 degrees) during collection periods. If there are any periods with fewer than 6 SV's or PDOPS higher than 3, plan on occupying points longer.

E. How long will you observe a site? Again:

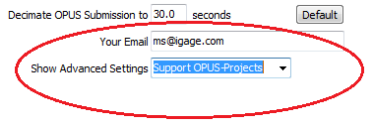


F. Are your sites GPS compatible? Are there obstructions higher than 10 degrees?

Using OPUS-Projects

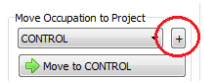
If you are contributing occupations to a registered OPUS-Project (note that NGS Training and authorization is required to use 'OPUS-Projects'), the Download tool can assist you when uploading files:

1. Turn ON OPUS-Projects support. On the '**Configuration'** tab, set '**Show Advanced Settings'** to "**Support OPUS-Projects"**:

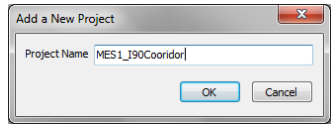


2. Add the NGS registered OPUS-Projects '**Project Identifier**' supplied by your project administrator:

Click the "+" button

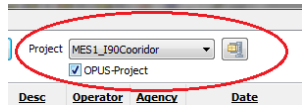


Enter the exact identifier



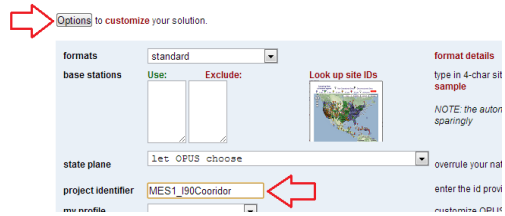
as the new project name.

Select the new Project



and check the newly displayed '**OPUS-Project'** checkbox.

3. Now, when you submit an occupation that has been moved to the project, the upload tool will automatically press the 'OPTIONS' button on the OPUS submission form and fill in the project identifier:



Best OPUS Practices for New and Experienced Users

After supplying OPUS targeted receivers for many years, we know that most users experience the same reoccurring problems.

The suggestions in this chapter will save you time and OPUS related static job failures.

The 'OPUS Error Message' Joke

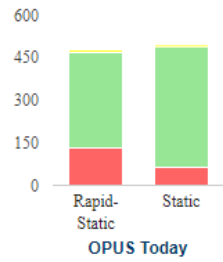
> "The NGS processing engine has a big fishbowl with 500 possible error messages printed on little slips of paper. If a job fails, the OPUS processor removes the five best error messages from the fishbowl. Next the fishbowl is shaken, and three to five slips are randomly pulled from the fishbowl and returned to the user."

OPUS error reporting is getting better. Someday this joke won't be funny anymore.

But you should remember this: 'you are not alone.' Every-Single-Day a substantial portion of all OPUS submissions fail and most fail with a confusing error message.

#1 OPUS-RS is Dicey

When you submit OPUS occupations, there is a graphic that shows the daily number of jobs and the daily success rate. **On most days over 25% of all submitted OPUS-RS (Rapid Static) jobs fail!**



Relatively few OPUS-Static jobs fail, and most of the Static jobs that fail initially will successfully process when resubmitted the following day.

When using OPUS RS or Static longer occupations are **always** better. OPUS-Static is always more reliable than OPUS-Rapid Static.

Please remember if you are submitting 15 to 30-minute OPUS-RS occupations **they WILL fail regularly**. Don't be surprised and don't blame your receiver.

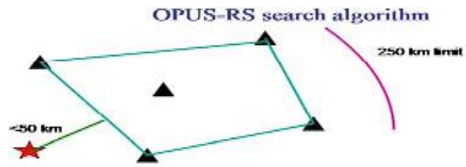
#2 Only Some Submissions are being returned by OPUS

OPUS always returns an email. **Always**. But missing solutions is a VERY common issue.

If you are not getting solutions or an error messages back, the missing solutions have been trapped in your email SPAM filter or you have entered your email address incorrectly on the submission form.

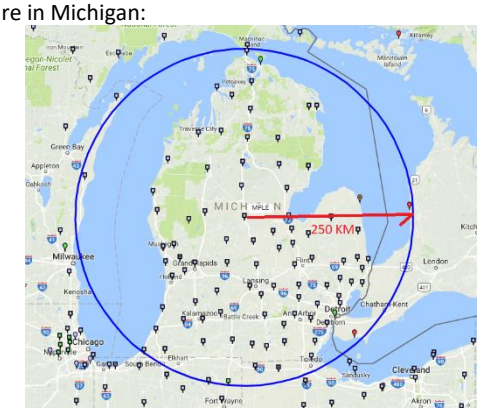
#3 OPUS-RS is Very dependent on the Number, Availability, Proximity, Distribution and Quality of nearby CORS Stations

The initial stage of OPUS-RS processing determines if a network of three to nine CORS stations within 250 KM of the user location can be built.



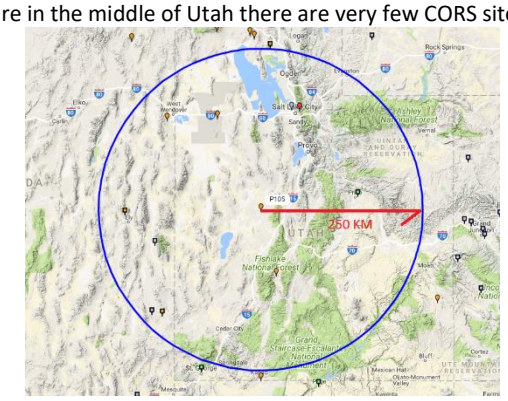
The user location can be up to 50 KM from the polygon surrounding the selected sites which allows OPUS-RS to succeed in coastal areas where there are no CORS sites offshore. However, every CORS site that is used must be within 250 KM of the user site.

If you are in Michigan:



There are plenty of CORS stations within 250 KM of everywhere. OPUS-RS is likely to always succeed, even if a few of the stations are offline, are missing data or are very noisy and must be discarded. It is likely that OPUS-RS will work all the time in Michigan.

If you are in the middle of Utah there are very few CORS sites available on the best of days:



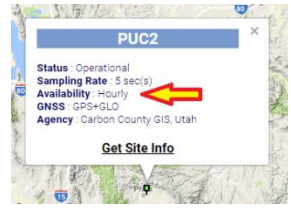
On a bad day, if a few stations are offline or have not yet archived data then your OPUS-RS solution will fail because there are not enough stations close to your occupation.

In many areas a single offline CORS station without data will make OPUS-RS use impossible.

#4 Daily vs. Hourly CORS Availability

If you click a CORS station pin on the NGS CORS map, you will get a station summary which includes an 'Availability' note. There are two availably types:

Daily



Hourly

Daily means that a full day's CORS station data is collected and then sometime after midnight UTC the data is archived and becomes available for use as CORS data. Collection is ONCE PER DAY.

Hourly means that the previous hour's data is collected and available immediately after the top of each hour. Collection is EVERY HOUR.

Hourly data is much more desirable.

For the two sites above:

P113 data is typically available at 09:03 am (UTC) on the following day.

PUC2 data is typically available 35 minutes after the top of each hour.

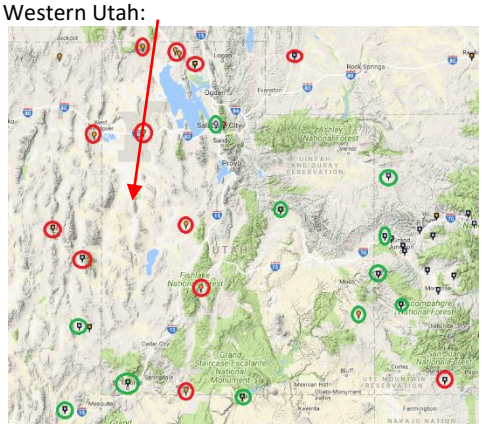
If your OPUS submission has sufficient nearby hourly stations, then you can probably wait 45 minutes after the top of the hour following your file collection and an OPUS submission will be successful.

However, if you are collecting data in an area where most of the stations have only daily availability you will have to wait a longer time before the nearby stations will be available for use.

This is especially troublesome if you acquire observation data in two separate UTC days. (In other words, your observation spans midnight UTC.)

#5 Some areas of the United States effectively ONLY have Daily Data

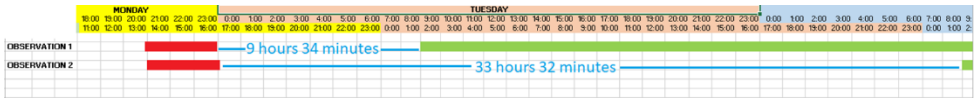
Consider Western Utah:



Daily Stations Red; Hourly Stations Green

If your observation is in the western part of the state, there are only daily stations available.

Let's look at an example with two observations collected on the Northwest side of Utah near Wendover Nevada:



The two observations were performed Monday afternoon (the red bars.) One is a section corner, the other is vertical bench mark which is only 400 feet northeast of the section corner. Both locations enjoy completely open sky – no canopy. Both observations are **exactly** three hours in length.

The first observation starts at 1:59 pm Mountain Time (20:59 UTC) and ends at 4:59 pm Mountain Time (23:59 UTC.)

The second observation starts two minutes after the first at 2:01 pm Mountain Time (21:01 UTC) and ends two minutes after the first observation ends at 5:01 pm Mountain Time.

We submit both occupations to OPUS Tuesday morning, the day after we collect the observations.

OPUS returns the first solution and it looks fantastic with 98% observations used and an ellipsoid height RMS error estimate of 0.011 meters.

OPUS returns the second solution with an ominous warning 'the observation data is noisy', only 62% of the observations were used and the ellipsoid height RMS error estimate is 0.219 meters!

Q: Is the second receiver defective?

The first OPUS solution was able to use all the nearby UNAVCO PBO CORS sites which surround Wendover Utah. Data from these sites were available in the archive at 2:35 am Mountain (09:35 UTM) on Tuesday; in this case 9 hours and 34 minutes after the end of the first occupation.

The second occupation extended one minute into Tuesday. Data from the UNAVCO PBO sites will not be available until after 2:35 am on **Wednesday**; 33 hours and 32 minutes after the end of the second occupation.

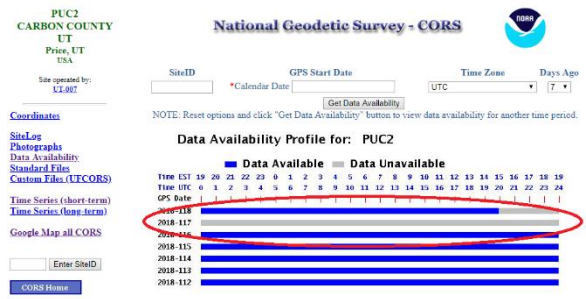
Because no other nearby CORS data is available, OPUS has used hourly files from CORS sites over 250 KM away to process the second file. These long baselines have much higher uncertainty and result in higher peak-to-peak error estimates. If we resubmit the 2nd occupation on Wednesday, it will have excellent results, like the first observation.

A: The receivers are identical and neither is defective.

A smart rule-of-thumb is to try to never collect observation data that spans midnight UTC. It causes additional problems a few days after collection when OPUS is forced to splice ultra-rapid and rapid orbits. It causes additional problems in a few weeks if precise orbits become available for only the 1st portion of an occupation and OPUS must splice precise orbits for the first portion and rapid orbits for the second portion.

#6 Offline CORS Stations

Often when you look at the 'Data Availability' plot from a CORS station's information page:



You will sometimes find that several hours or an entire day's observation data is unavailable, shown as gray instead of blue.

For a station to be used in a solution, overlapping data for the ENTIRE user occupation must exist. So, if you performed an observation on Julian day 117 near the station PUC2 (shown above) and were planning on having PUC2 data available, then you are out of luck.

#7 NGS CORS Station Quality

When you submit an occupation from your receiver, your receiver's recorded data is compared with the recorded data from nearby surrounding CORS stations.

OPUS assumes that all CORS data is perfect, if a baseline solution appears to be noisy, then (obviously) your rover data must be at fault.

In other words: high residuals in the baseline processing are the fault of the user data and are never a result of bad CORS station data. Even when the CORS station data is bad.

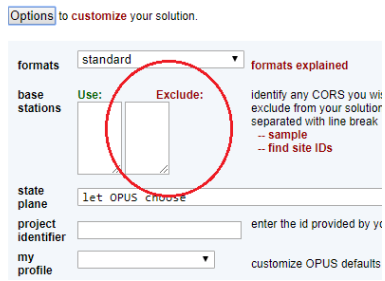
OPUS error messages are structured based on this assumption of highest quality CORS data and low expectations of your user data quality.

While most CORS stations are:

- sited at excellent stable locations
- have 100% open sky view above 10-degree elevation in all directions
- have top quality leveling mounts
- are bolted to stable masonry structures or well-engineered ground monuments
- have booked coordinates that are within 2 cm of their apparent actual location
- have state of the art choke ring antenna
- have short, high-quality low-loss coaxial antenna cables with dielectric filled connectors
- enjoy top of the line GNSS receivers with the latest firmware

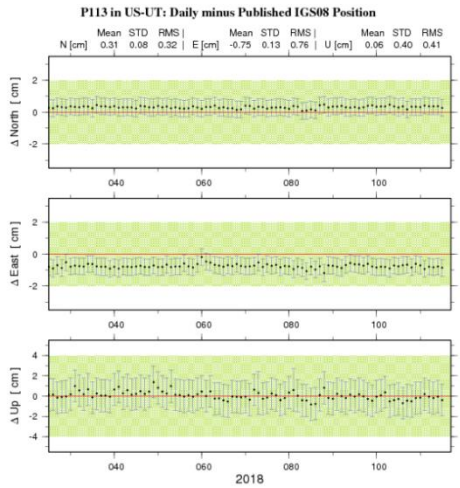
Stuff happens and some of the CORS stations are unreliable and a few are horrible. No matter how bad a station might be, NGS CORS will collect the bad data and the OPUS engine will use the bad data and then blame your occupation for all issues.

The only effective control that a user has is the 'Exclude' box under 'Options':



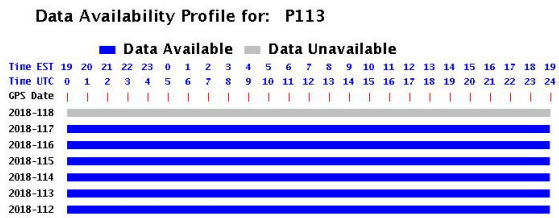
But how can you determine if a CORS station should be excluded?

This is a great question. The best way is to click on the 'Time Series (short term)' button. Here is an example of a great station:



Time Series for P113

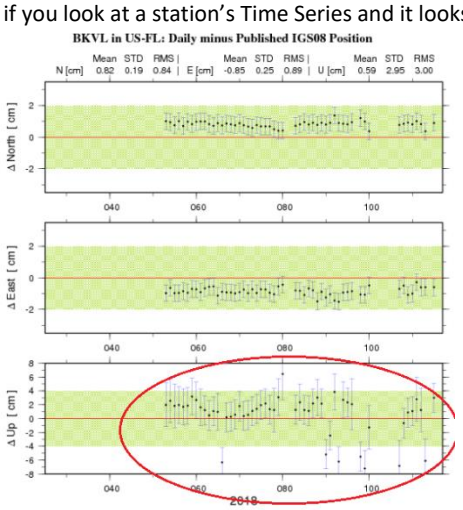
You also want to look at the recent 'Data Availability':



Availability for P113

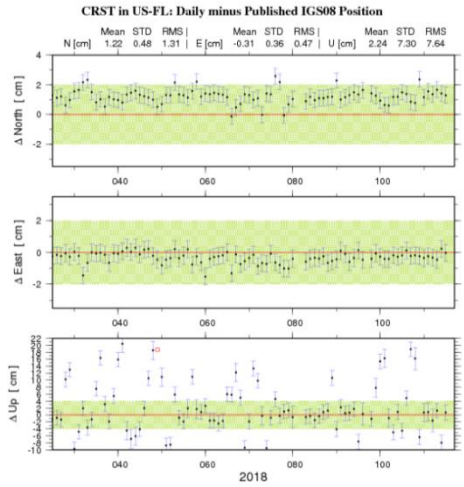
The position trends are very stable and are within 1 cm horizontal and vertical of the published IGS08 positions. The average locations and all the error bars are fully contained in the green error bands. Coupled with continuous recent Data Availability this station appears be a great CORS resource.

However, if you look at a station's Time Series and it looks like this:



You will want to ALWAYS exclude the station from your solutions. If you catch this site on a bad day (and it has a lot of them) you can expect significant elevation and horizontal errors.

Even worse sites abound in the NGS array:



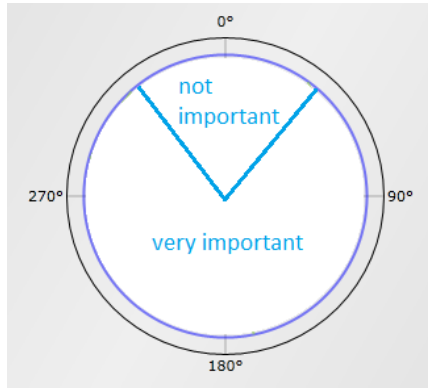
These stations and all the others like them are unsuitable for any processing use. It is your responsibility to exclude them from your solutions.

#8 GPS Suitable Locations

The NGS recommends that you submit GPS occupations collected in **GPS suitable locations**. However, very little NGS guidance is provided for what is 'GPS suitable' in the context of OPUS submissions. Let's compare good and bad locations.

Best Case Scenario

The best possible site would have a totally clear view of the sky above 10° at all azimuths where there is a possibility of a GPS satellite being in the sky:



Obstructions to the North not important in North America

Note: OPUS will process observations down to 10° elevation so you should set your receiver to start tracking a few degrees below 10°, or just allow it to track all the way to the horizon (0 degrees Elevation Mask.)

Attributes of a great GPS location for collection OPUS ready occupations:

- No overhead power lines
- No trees: leaves on or leaves off
- No power poles (wood or metal)
- No radar or radio paths that cross over the top of the receiver
- No chain link fences nearby
- Locations under busy landing paths are undesirable
- No large 'GPS reflective' surfaces (metal roofs) nearby: avoid multipath
- Receiver facing correct direction: usually MMI (Man-Machine-Interface AKA the push buttons), antenna connector or North fiduciary pointing to the North.
- Receiver mounted very securely on well braced, fixed-height tripod

- No chance of giant birds sitting on your antenna during occupations:

This picture is an actual GIANT crow sitting on an actual CORS antenna!

- No chance of trucks higher than your antenna passing nearby during occupation

Yes, users get great results in challenging locations all the time. And you may be lucky, but these are real rules and you should consider respecting them.

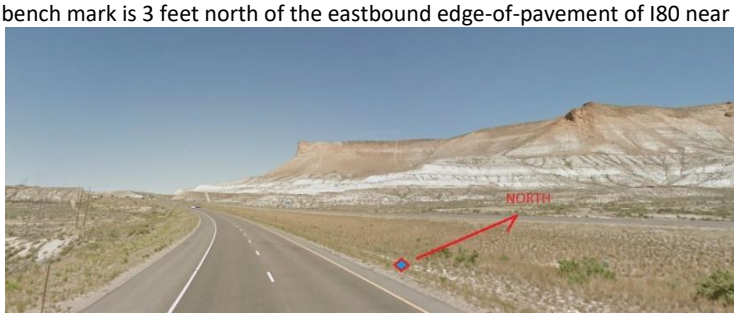
Worst Case Scenarios

All of the sites presented below are actual customer sites (or in some cases slightly obfuscated locations to save embarrassment.)

Remember that during times of low DOP (see the mission planning section of this document) you may get reasonable OPUS-Static and OPUS-RS solutions at these challenging locations. Longer (3-hour) and very long occupations (over 8-hours) may be dependable because the high-DOP conditions are bridged with times of good coverage. However, in general, you should avoid the following scenarios.

Semi-Trucks and Trains

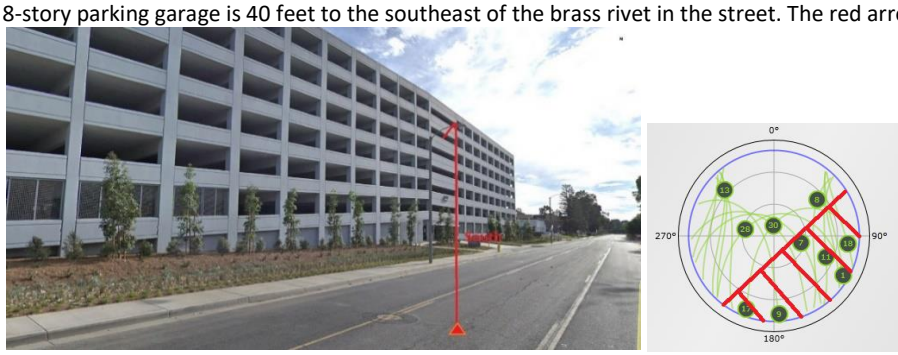
This bench mark is 3 feet north of the eastbound edge-of-pavement of I80 near Green River Wyoming:



It has fantastic views in all directions, unfortunately a semi-truck drives by every 20-seconds and completely obscures a receiver's view of the southern sky. This forces the receiver (and OPUS) to lose lock. This is a **BAD** location and will greatly increase the RMS error estimates and drop the percentage of observations used.

Large Structures to the South

This 8-story parking garage is 40 feet to the southeast of the brass rivet in the street. The red arrow points South.



This is a **bad** location because the structure completely blocks the antenna's view to the South and East.

Huge Trees to the South

BAD: This site is not suitable for GPS observation because of large trees to the south:

Southern sky is fully blocked and trees obscure view directly overhead.

We can debate:

- leaves on, leaves off
- pine needles vs. broad leaves
- length of pine needles
- size of tree-trunks
- size of branches

But trees above 10° to the East, South or West are bad and 100% canopy is really bad.

Huge Trees Overhead

Trees (with or without leaves) directly above the antenna prevent the receiver from having a clear view of the sky. Even though this location has open water to the South, it is directly underneath large trees. Water can also be a source of significant multipath (see the next section.) This is a **BAD** location:

Large Reflective Surfaces Nearby

Your receiver trusts that the signals that it receives have traveled directly from the satellite to your antenna. Large nearby surfaces present opportunities for the receiver to have signals arrive having taken multiple paths (multipath) or entirely the wrong path.

Not only do these tanks block the view to the South, but they also have metal-reflective surfaces that provide a multiple length signal path for every signal from every satellite to the observation area:

(this image is looking South)

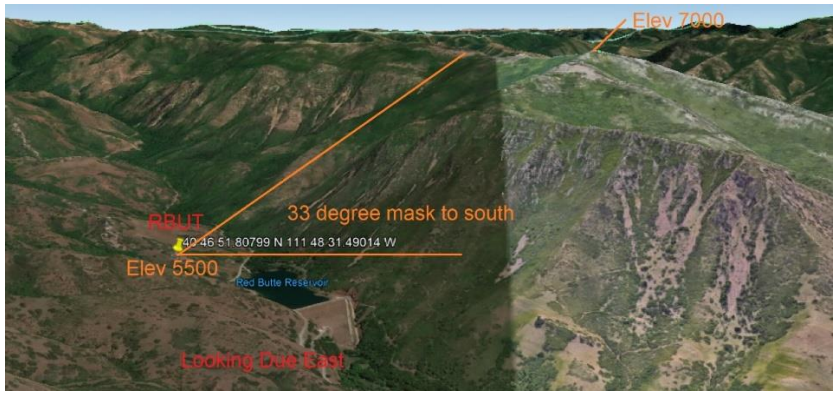
Flat metal surfaces are bad. Corrugated metal surfaces (like corrugated roofing) are even worse. Some mirrored glass windowing used on building exteriors is reflective at microwave frequencies. Box truck bodies, metal buildings, metal roofs and open water are all potential sources of multipath.

Deep Canyons

Locations at the bottom of deep canyons, especially East-West trending canyons will present full, 100% obstruction below the ridge line to the South. Most of the GPS satellites are to the South. This is BAD.

RBUT (below) is an NGS CORS site and is the closest CORS site to the iGage office in Salt Lake City Utah. This site is hindered by a solid mountain 30° mask to the South. This could be a challenging location for GPS observations and is not a great location for a CORS site.

Moving further North would gain elevation, effectively lowering the southern mask.



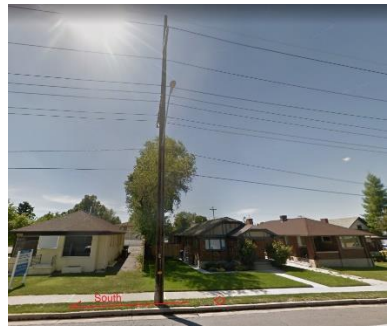
Power Poles

< 500 KV DC Transmission Lines and Tower

This class-1 elevation bench mark with measured gravity is unfortunately in a location that is no longer suitable for GPS observations. It was set prior to the construction of the powerline. This is a BAD location.

You should avoid locations that are under high voltage transmission lines and have large steel towers directly to the south.

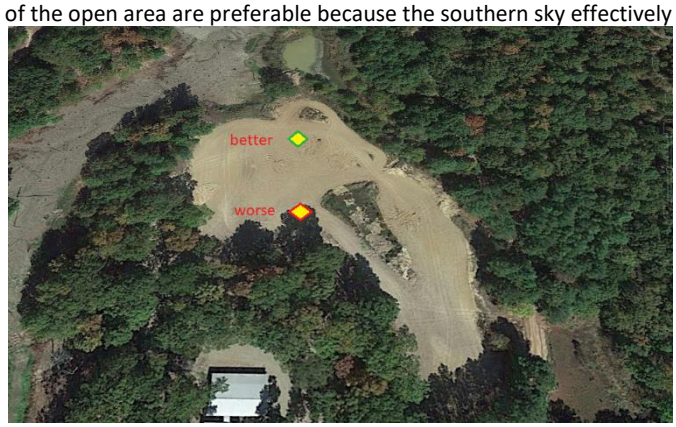
Smaller power poles and lines are also unacceptable, especially if they are south of the occupation site:



#9 Optimizing Occupations in the Real-World

Receiver Placement

In North America, the most important sky is to the East, South and West (because there are never any GPS satellites directly north.) So, if you are setting up in a field that is surrounded by large trees, locations in the middle of the North side of the open area are preferable because the southern sky effectively opens up:



Longer Observations

OPUS-RS is especially vulnerable to bad sites. If you think a site may have problems, try to collect over two hours of data so that you will have the option of using OPUS-Static. You can always trim the 2-hour observation file and also submit it as a Rapid Static job in addition to the Static job.

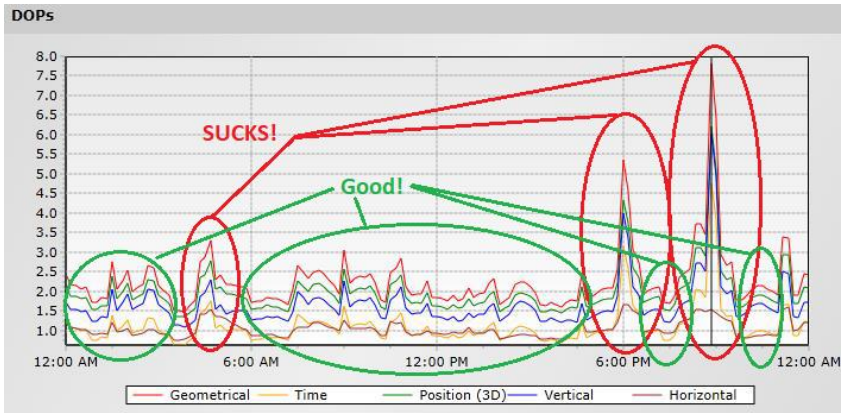
A six-hour occupation may return great results at a site where 2-hour occupations fail. More-time in adverse locations is always better.

#10 Mission Planning

With modern GNSS RTK receivers that track lots of satellite constellations and lots of signals, mission planning is no longer required. A full GNSS receiver tracks so many satellites that there are no bad times...

However, OPUS is **GPS only** and mission planning should be used to select better times to occupy sketchy locations. Especially if you are using OPUS-RS.

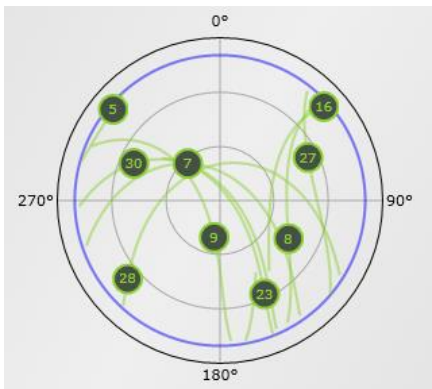
Here is a typical GPS Only Mission Planning example:



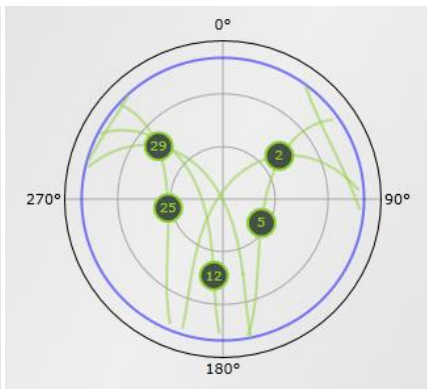
Lower DOP is better than higher DOP. You can see that most of the day, DOP is excellent. Most OPUS submissions will be successful. However, starting at 5:30 pm there are large DOP spikes.

At this location, on this day, any one-hour OPUS-RS occupation from 5:30 pm to 9:30 pm will certainly **fail**. But a one-hour OPUS-RS occupation from 11:30 am to 12:30 pm (or most of the rest of the day) will probably be **successful**.

DOP is a function of how many and where the satellites are in the sky. We prefer more satellites, spread over a larger portion of the sky, with one or more satellites in every quadrant:



11:30 am **Great**



8:50 pm **Bad**

One pitfall of OPUS-RS is very short occupations may entirely fall into a very high-DOP period. As you can see from the DOP plot above, high DOPs rarely last for more than an hour and longer OPUS-Static occupations will usually have some periods of low DOP and excellent coverage.

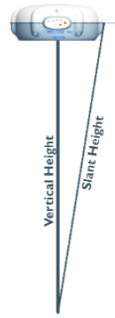
The change in satellite constellation, which determines PDOP is why a receiver will work one day and then not work in a nearby location at a different time.

#11 Be Procedure Smart: avoid Blunders

Assuming that your receiver is in a location that is suitable for GPS observations, at a suitable time, there are several procedural blunders that you can do to force a bad result:

- Mounting system is not level and receiver is not centered over the ground mark.
- Antenna height (HI) is wrong.
- Antenna is mis-rotated, doubling antenna compensation errors.
- Wrong antenna type is selected.
- No battery in head with external power

Use a Fixed Height Tripod, Get the HI Correct!



The #1 OPUS procedure failure is a blundered instrument height. The ONLY HI that OPUS will accept is the vertical height above ground to the ARP (Antenna Reference Point) in meters.

If you use a tribrach, you are going to have to make a slant measurement and then reduce the slant distance and SHMP (Slant Height Measurement Point) vertical offset to a metric vertical height. The process is described in the "**'Slant Height' to 'Vertical Height':**" section on page 133.

Slant reduction error is also very common source of blundered instrument height. The iGx_Download tool makes this computation automatically for you; however, you must keep track of Slant vs. Vertical and Feet vs. Meters.

Transposition of digits in random heights that occur with tribrachs on tripods is a common source of error. Measurement to the wrong place on the antenna is a common source of error. Mixing slant measurements in feet with metric SHMT and radius constants is a common source of error. Confusing slant heights between multiple occupations is a common source of errors. Using 'inch' tapes instead of 'tenths' tapes is a common source of errors.

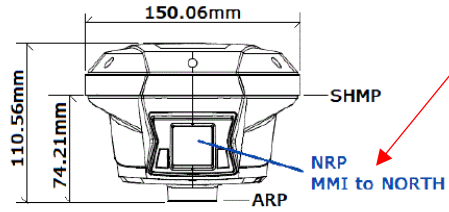
All these errors are eliminated if you use a fixed height 2-meter tripod or a 2-meter pole with a Hold-a-Pole for every static occupation. The answer is always just "2.0" meters. Which is very easy to remember.

Rotate your Receiver Correctly

Every antenna has a 'correct' rotation. It is VERY important to spin the antenna so that it faces the correct direction.

You can determine the correct rotation for any modeled antenna by looking up the antenna definition on the NGS Antenna Calibration website. Here is the information from the NGS site for the iG9 receiver:

Antenna Designation:	**IGAIG9 NONE**
Part Number:	118029-000501-020105
Manufacturer:	iGage Mapping Corporation www.igage.com
Antenna Code	IGAIG9
Radome Code:	NONE
ARP:	BAM (Bottom of Antenna Mount)
NRP:	MMI (Man-machine interface / Display)
Bottom Mount:	5/8" 11 TPI



Diameter:	0.15006 m	(side to side)
Radius:	0.07503 m	
SHMP:	0.07421 m	from ARP (Slant Height Measurement Point)

The iG9 should have the MMI (the button/LED panel) turned to face the North.

What happens if you don't rotate the antenna correctly? OPUS has a calibration file for every antenna that relates a change in L1 height offset by the position of the satellite in the sky and the XY offset of the center of the antenna from the center of the mounting nut.

OPUS compensates for the northing, easting offset assuming the antenna is facing North. If you rotate the antenna 180° so that the MMI is pointing to the South, then the offset error is doubled, and your final solution will be in error by double the centering offset!

Bad rotation alignment can also be responsible for making an occupation appear noisy. OPUS compensates for the antenna vertical offset changes depending where satellites are in the sky. If you mis-rotate the antenna then the compensation will be applied incorrectly, perhaps doubling the receiver's centering error.

Use the Correct Antenna Model

Make sure that you have the correct antenna model selected. Some antenna have multiple radomes and revisions listed.

For example: the Ashtech version of the Dorne Margolin chokering (which is a replacement of ASH700936 which has even more models and revisions) has 10 revision and dome combinations:

ASH701945B_M	NONE	ASH701945B_M	SCIT
ASH701945B_M	SCIS	ASH701945B_M	SNOW
ASH701945C_M	OLGA	ASH701945C_M	SCIS
ASH701945C_M	SNOW	ASH701945C_M	SCIT
ASH701945C_M	PFAN	ASH701945C_M	NONE

Each revision has a different calibration, you must select the correct model, or you will introduce substantial height uncertainty to your solution.

Batteries In or Batteries Out?

Everything inside an integrated receiver's body changes the effective antenna calibration. **Everything**.

Slight changes in the PCB's, UHF radios being installed / omitted, the cellular modem model: they all result in a change in antenna calibration. Sometimes the change is very small and other times a seemingly innocuous change will result in a substantial phase center change.

iG9 receivers are calibrated with two batteries inserted into the battery compartment. If you power an iG9 with external power, you should still include batteries in the head to match the original antenna calibration conditions

#12 Why does Modern RTK work where OPUS fails?

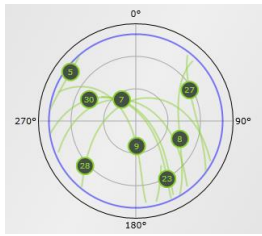
Yes, OPUS is substantially more finicky than modern GNSS RTK. OPUS jobs routinely fail in places and at times that iG9 RTK works flawlessly.

There are two primary reasons: number of satellites and baseline length.

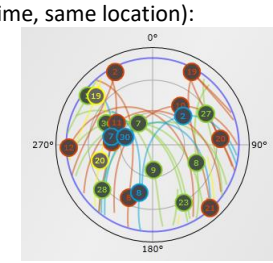
Number of Satellites and Signals

OPUS is GPS only. Modern GNSS RTK uses additional satellites (GLONASS, Galileo, BeiDou) and additional signals like GPS L2C, GPS L5 and GLONASS L3.

Compare these two sky plots (same time, same location):



GPS Only



GPS + GLONASS + Galileo + BeiDou

More satellites are better. More signals are better. Even though the iG4 tracks GPS, GLONASS, Galileo and BeiDou satellites, OPUS currently only uses the GPS observations. So, a great constellation like the one on the right is reduced to the minimal constellation on the left.

A modern GNSS RTK receiver has and **uses** more signals at all times than the OPUS processing tools.

Baseline Distance

OPUS processes GPS baselines from your receiver all the way back to each individual CORS station. Typically, these will be 45 KM (28 miles) to 150 KM (93 miles) baselines. In some areas the nearest CORS station might be 250 KM distant!

RTK processes the baseline from your RTK Base to your RTK Rover which typically will be less than 10 KM (6 miles.)

Short baselines 'Fix' more easily and have substantially less noise.

#13 Fresnel Zone Considerations

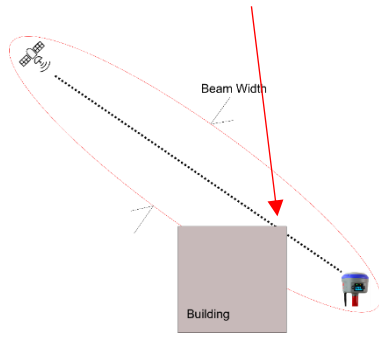
Most GPS users think of the radio path from their receiver to each of the satellites is like a small laser beam. This is incorrect.

The GPS beam width is spread out in a cigar shaped area known as the 'Fresnel Zone'.

Fresnel is pronounced with a silent-s: "Frenel", named after French physicist Monsieur Fresnel.

Wikipedia has an excellent article on the Fresnel effect: https://en.wikipedia.org/wiki/Fresnel_zone; be sure to check out the section on 'Fresnel Zone Clearance' mid-article.

The Fresnel effect explains for why your GPS receiver will track a satellite which is fully behind a building or ridgetop. The beam width is wide enough that a portion of the signal reaches the GPS receiver, even though the beam's center is fully blocked by the building.



Tracking a satellite means that the satellite is 'visible' to your receiver, however just tracking is not sufficient to accurately evaluate a carrier-phase position.

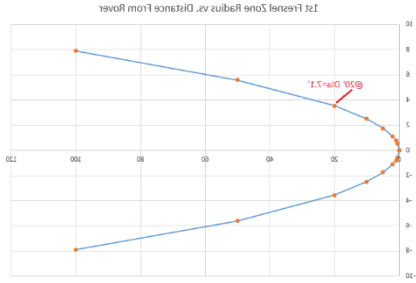
To compute an accurate position, your receiver needs a very clean signal with few reflections, obstructions, or delays. Any object blocking a part of the beam can be a source of reflection, attenuation, or delay.

Clear path means that you don't just need a small opening in the trees for a laser beam to shoot through. You need an opening in the trees large enough that *most* of the energy which is spread out over the Fresnel beam width reaches the receiver with no obstructions.

How wide is the Fresnel beam along the path? Much wider than you think!

Here is a beam-width chart for GPS L1 (1.575 GHz):

Distance	1st Fresnel Dia
0.0	0.0
0.5	1.1
1.0	1.6
2.0	2.2
5.0	3.5
10.0	5.0
20.0	7.1
50.0	11.2
100.0	15.8
33000000.0	6414.3



1 foot above your GNSS antenna, the beam width is 1.6' in diameter. 20 feet above the rover antenna (perhaps the midpoint of tree canopy), the 1st Fresnel beam diameter is 7 feet! A clearing in the treetops 100' above your antenna needs to be 16' in diameter.

At the midpoint between your receiver and the satellite, the Fresnel beam is over 6,000 feet in diameter! And that is for the signal for a single satellite, multiply this by the number of tracked satellites and there is signal energy everywhere.

OPUS Best Practices Conclusion

There are lots of things that can go wrong with OPUS occupations. Some you can control, some you can't.

If you stack multiple problems:

Bad Constellation + Short Occupation + Moderate Canopy + Bad HI => FAILURE

Your OPUS solutions will fail or have high RMS estimates and the time you spent collecting the observation will be wasted.

The OPUS family of online tools: OPUS-Static, OPUS-RS, OPUS-Projects are amazing. They allow users to generate reliable X, Y and Height coordinates for GPS suitable locations, anywhere in the world. Hopefully by utilizing the simple rules presented in this chapter, all your jobs will be

OPUS-Successful!

Troubleshooting the iG9 Receiver

1. Receiver won't turn on:

Batteries are fully discharged: Charge batteries or use external power.

Contacts on battery are dirty: Clean battery and receiver contacts with a soft cloth or soft eraser.

Battery is bad: Try another battery.

2. Is the receiver tracking satellites?

The BLUE LED flashes once for each SV (satellite vehicle) that is currently tracked.

If you are indoors, the LED will flash **once** every 5-seconds. However, no SV's will be tracked.

The receiver should begin tracking within 30-seconds after a warm start. After a cold start (off for more than 1 week) it may take 90-seconds for the receiver to begin tracking.

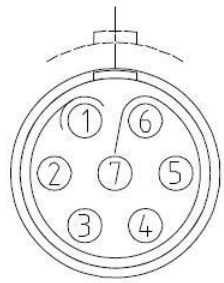
If the receiver will not track satellites outside after waiting 5-minutes do an OEM engine reset using one of the methods outlined in "**GNSS OEM Reset**" on page 130.

5. The receiver won't mount as a Disk Drive.

1. Before plugging GPS cable into your PC, did you wait for the power LED to blink 3 times?
2. Unplug, wait 15-seconds, try again
3. Try another USB port, try another USB cable
4. Use an external USB Hub (this fixes intermittent disk mounts.)
5. Try other computers.
6. Try turning off your PC, wait a minute and then turn on again. Reinsert the USB cable.

iG9 Serial and USB IO Port Definitions

Serial IO Port Definition

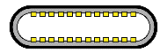


PIN	FUNCTION
1	Ground (-)
2	Ground (-)
3	RS232-TX (Output)
4	PPS (Pulse Output)
5	Not Used
6	VIN
7	RS232-RX (Input)

Figure 14 iG9 7-Pin Serial IO Lemo Connection Information

USB Port Definition

The iG9 has a standard USB Type-C connector.



When connected to a computer with a USB cable, the receiver mounts as a lettered disk drive.

Upgrading Firmware

The iG9 has three sets of upgradable firmware:

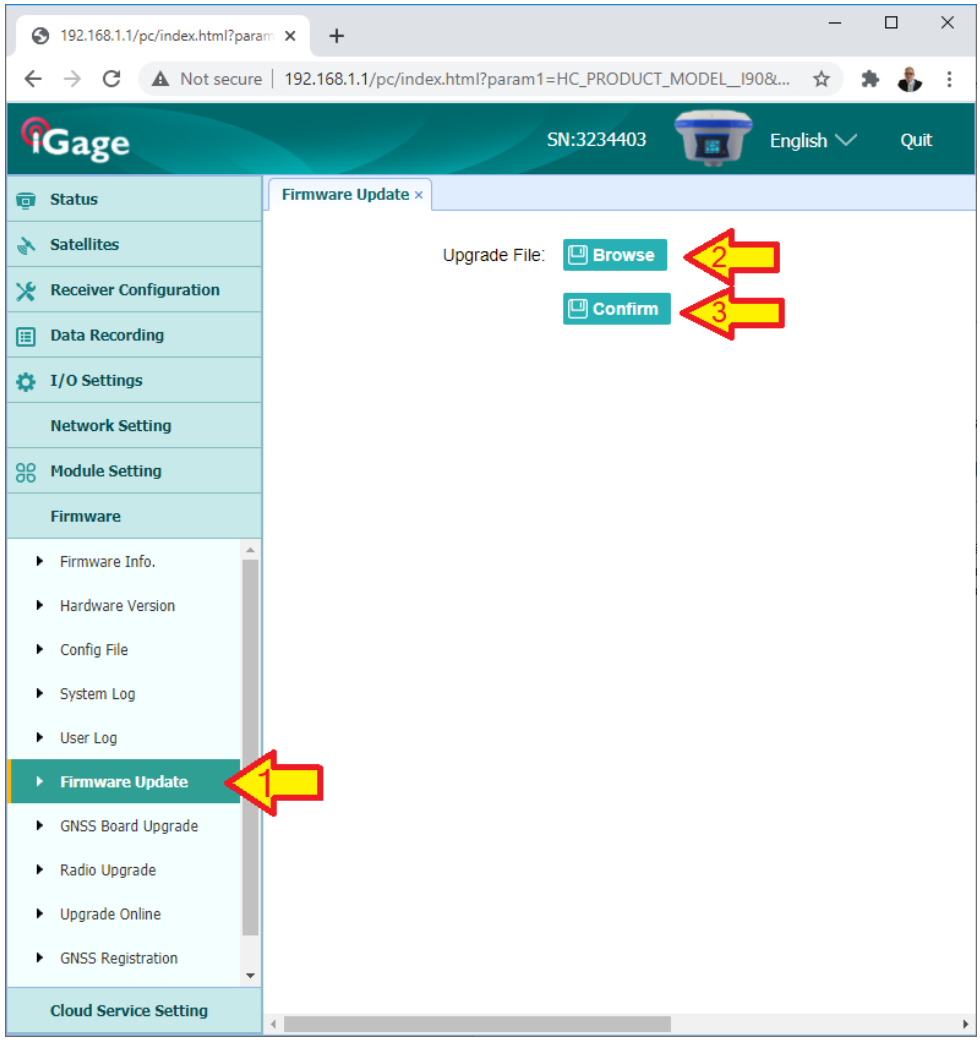
- Main Board
- OEM Board (the GNSS Engine)
- UHF Radio Board

All three are updated using a similar process via the Wi-Fi interface.

Updating Main Board Firmware

Download the Main Board firmware from the iG9 website: https://iG9.xyz/out/firmware/index.htm

Follow the instructions in section "**Connecting the iG9 to a PC or Smartphone via Wi-Fi**" on page 87 to get your PC connected to the receiver by Wi-Fi and logged into the web interface.

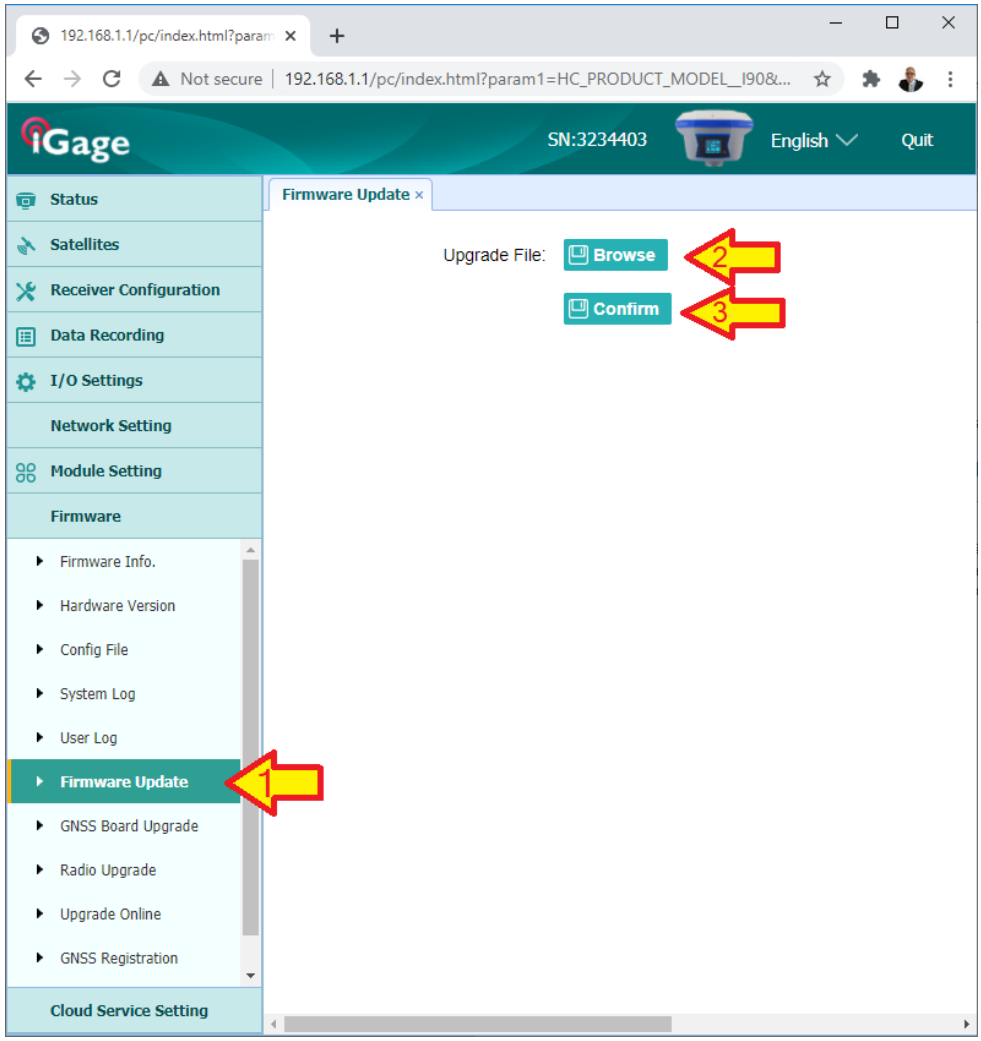


Click on Firmware, then 'Firmware Upgrade' (1), then 'Browse' (2), find and select the firmware, finally click on 'Confirm' (3) to begin the upgrade process. The receiver will reboot twice during the upgrade process.

Updating OEM Firmware

Download the OEM firmware from the iG9 website: https://iG9.xyz/out/firmware/index.htm

Follow the instructions in section "**Connecting the iG9 to a PC or Smartphone via Wi-Fi**" on page 87 to get your PC connected to the receiver by Wi-Fi and logged into the web interface.



Click on Firmware, then 'Upgrade', then 'Browse' and find the firmware finally click on 'Confirm'. The receiver will reboot twice during the upgrade process.

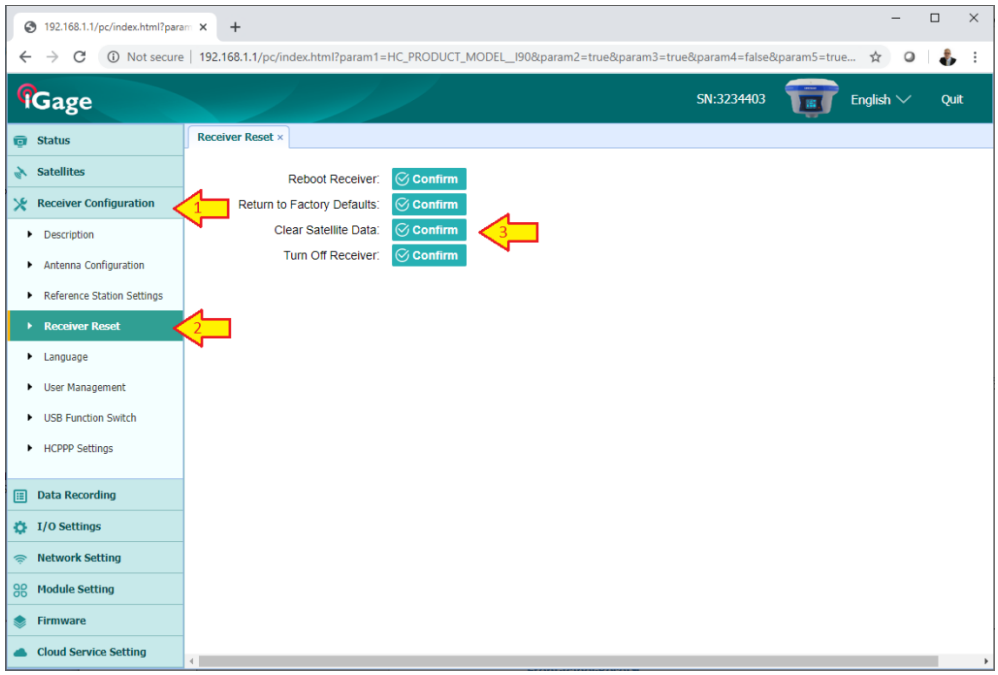
GNSS OEM Reset

It is possible to reset the iG9 from the Front Panel and from the web interface. This procedure should not be required for normal operation.

Web Interface Reset

Connect a PC, tablet or smartphone to the WiFi web interface of the iG9 as shown in '**Connecting the iG9 to a PC or Smartphone via Wi-Fi**' on page 87.

Once connected, from the Main Menu,



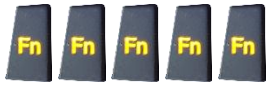
Click on **Receiver Configuration**: **Receiver Reset** then '**Clear Satellite Data**' '**Confirm**'.

You can also reboot the entire receiver, clear the satellite ephemeris data, and reset the iG9 head back to factory defaults or turn off the receiver.

Front Panel Reset

From the front panel Main Menu:

Click **Fn** 5 times to move to the 'Set' menu option



Click the **Enter** key to enter the Set menu:

Click the **Fn** key 6 times to move down to 'OEM Board Reset', then click **Enter**:

Click the **Fn** key once to OK:

The receiver will display '**Reset OEM Board, Resetting…**' then after 15-seconds the receiver will reboot. Resetting the engine erases the OEM Engine memory, erases all satellite data and reboots the OEM engine.

iG9 Antenna Model

The iG9 receiver has an NGS calibration "CHCI90 NONE"

The .atx and .gra files for the iG9 can be found on the website https://iG9.xyz

Summary

L1	114.0 mm
L2	91.07 mm
Radius	55.3 mm
SHMP	74.2 mm
ARP	Bottom of Antenna Mount (BAM)
North Reference	Turn Display to North

The antenna designator is "CHCI90 NONE"
1234567890123456789 0

A summary of the .atx file:

```
G01                                                     START OF FREQUENCY
   1.56       2.17     105.34                          NORTH / EAST / UP
G02                                                     START OF FREQUENCY
   1.51       2.74     106.45                          NORTH / EAST / UP
```

Filename: igaig9.gra; Antenna reference points and dimensions:

```
IGAIG9

     .. ---==+=---- ..            <--  0.1106
   /                  \
   ====================          <--  0.0742  Bottom of band
   \   +============+   /
   |   \ *|     |* /   |
   |   /[]|_____|[]\   |
    \=__ ============ __=/
         \________/
          +--x--+                 <--  0.0000  BAM=ARP
                                               MMI=NRP
   <--     0.1501    -->
```

‘Slant Height’ to ‘Vertical Height’:

Slant Heights are measured from the Ground Mark (GM) to the bottom of the blue band that separates the white cap and the gray bottom of the receiver.

Vertical Heights are measured from the Ground Mark (GM) to the bottom of the receiver’s 5/8” 11 TPI nut, the ARP (Antenna Reference Point.)

Manually Converting Heights

Receiver	Radius r (meters)	SHMP h (meters)
iG9	0.07505	0.0742

$$v = \sqrt{s^2 - r^2} - h$$

v: vertical height

s: slant height

r: receiver diameter at measurement point

h: Slant Height Measurement Point (SHMP) offset from receiver bottom

Examples

Measured Slant s (feet)	Slant s (m)	iG9 Vertical v (m)
6.965	2.123	2.0474
5.148	1.569	1.4931

Warranty

Before you get hung-up with hardware and software problems, please give us (iGage Mapping Corporation) a call:

+1-801-412-0011

Our goal is to take great care of our customers and be reasonable with everyone. Our response to issues may exceed your expectations and our written warranty.

IMC is “iGage Mapping Corporation” of Salt Lake City Utah USA.

IMC warrants the iG9 receivers, which we sell, to be free of defects in material and workmanship and will conform to our published specifications for these periods:

GPS receivers:	2-years
Cables and accessories:	1-year
Batteries:	90-days

This warranty applies only to the original purchaser of the product.

Hardware: Purchaser's exclusive remedy under this warranty shall be limited to the repair or replacement, at IMC's option, of any defective part of the receiver or accessories which are covered by this warranty. Repairs under this warranty shall only be made by IMC at an IMC service center. Any repairs by a service center not authorized by IMC will void this warranty.

In the event of a defect, IMC will at its option, repair or replace the hardware product with no charge to the purchaser for parts or labor. The repaired or replaced product will be warranted for 30-days from the date of return shipment, or for the balance of the original warranty, whichever is longer.

Software: IMC warrants that software products included with hardware products will be free from media defects for a period of 30-days from the date of shipment and will substantially conform to the then-current user documentation provided with the software. IMC's sole obligation shall be the correction or replacement of the media so that it will substantially conform to the then-current user documentation. IMC does not warrant the software will meet purchaser's requirements or that its operation will be uninterrupted, error-free, or virus-free. Purchaser assumes the entire risk of using the software.

Exclusions

The following are excluded from the warranty coverage:

Periodic maintenance and repair or replacement of parts due to normal wear and tear.

Display windows.

Product Finishes.

Batteries exposed to heat, cold; or batteries opened or physically damaged.

Installations or defects resulting from installation.

Any damage caused by (i) shipping, misuse, abuse, negligence, tampering, or improper use; (ii) disasters such as fire, flood, wind, and lightning; (iii) unauthorized attachments or modification.

Service performed or attempted by anyone other than an authorized IMC service center.

That the receiver will be free from any claim for infringement of any patent, trademark, copyright, or other proprietary right, including trade secrets.

Any damage due to accident, resulting from inaccurate satellite transmissions. Inaccurate transmissions can occur due to changes in the position, health or geometry of a satellite or modifications to the receiver that may be required due to any change in the GPS. IMC GPS receivers use GPS satellites to obtain position, velocity, and time information. GPS is operated by the US government, which is solely responsible for the accuracy and maintenance of the GPS system. OPUS and OPUS-RS is a service of the NGS and IMC shall not be responsible for issues with NGS provided services.

Except as set forth in this limited warranty, all other expressed or implied fitness for any particular purpose, merchantability, or non-infringement, are hereby disclaimed.

IMC shall not be liable to the purchaser or any other person for any incidental or consequential damages whatsoever, including but not limited to lost profits, damages resulting from delay or loss of use, loss of or damages arising out of breach of this warranty or any implied warranty even though caused by negligence or other fault of IMC or negligent usage of the product.

In no event will IMC be responsible for such damages, even if IMC has been advised of the possibility of such damages.

This written warranty is the complete, final, and exclusive agreement between IMC and the Purchaser.

RMA

To obtain warranty service from iGage Mapping Corporation the purchaser must obtain a return materials authorization (RMA) number prior to shipping by calling

+1-801-412-0011

Or by email:

info@igage.com

Purchaser's return address and the RMA number must be clearly printed on the outside of the package. IMC reserves the right to refuse to provide free-of-charge service if the date of sale cannot be determined or if the serial number is altered or removed. IMC will not be responsible for any losses or damage to the product incurred while the product is in transit or is being shipped for repair. Insurance is recommended. IMC suggests using a traceable shipping method such as UPS, FedEx or USPS with signature tracking when returning a product for service.

Do NOT send batteries with equipment for repair. If you do, they will not be returned as we are unable to ship used batteries.

The Purchaser shall always pay shipping to IMC, **IMC will return warranty repairs by UPS ground**, unless the Purchaser agrees to prepay expedited service costs. IMC will not pay for warranty returns to destination outside of the contiguous 48-states. The purchaser shall always pay any associated duty associated with warranty repairs.