iG9   with IMU tilt

iG9a   without IMU tilt

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

User Manual

Also see the *Getting Started Guide* for your selected Field Software.

This manual is for use with iG9 and iG9a 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. The download tool is not sold separately.

13 May 2021
iG9_UserManual_RevL_417.docx

Copyright, Control and Safety

Copyright © 2021 iGage Mapping Corporation. All rights reserved.

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 (<u>GLO</u>bal <u>NA</u>vigation <u>S</u>atellite <u>S</u>ystem), 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 use 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 and iG9a 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:

> This device may not cause harmful interference.
>
> 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 in transmit mode.

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.

iGage Mapping Corporation
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email: info@igage.com

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

Software updates and news are available from:

www.iG9.xyz

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, iG9a 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

All iGage iG9 receivers share the same electronic internals and GNSS Antenna. The iG9 has a precision IMU Tilt Sensor, the iG9a does not have a IMU Tilt sensor.

Specific naming conventions:

Model Name:	iG9, iG9a
Model Number:	i90
Part Number:	118029040501020105
NGS Antenna Model:	CHCI90 NONE

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

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 receivers for use as Base and Rover.

Typically, the Rover will be an iG9 with IMU Tilt and the Base will be an iG9a without tilt sensors.

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 (Blue)

LCD Screen

Fn / Next Button
Blinks Amber when recording data

Correction LED
Rover: FLOAT
Rover: Green FIXED

Power / Enter
Button

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 as 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
- 2 Batteries
- 5/8" 11 TPI Threaded Insert
- TNC radio antenna connector, recessed for impact resistance.
- Serial / Power
- Type-C USB
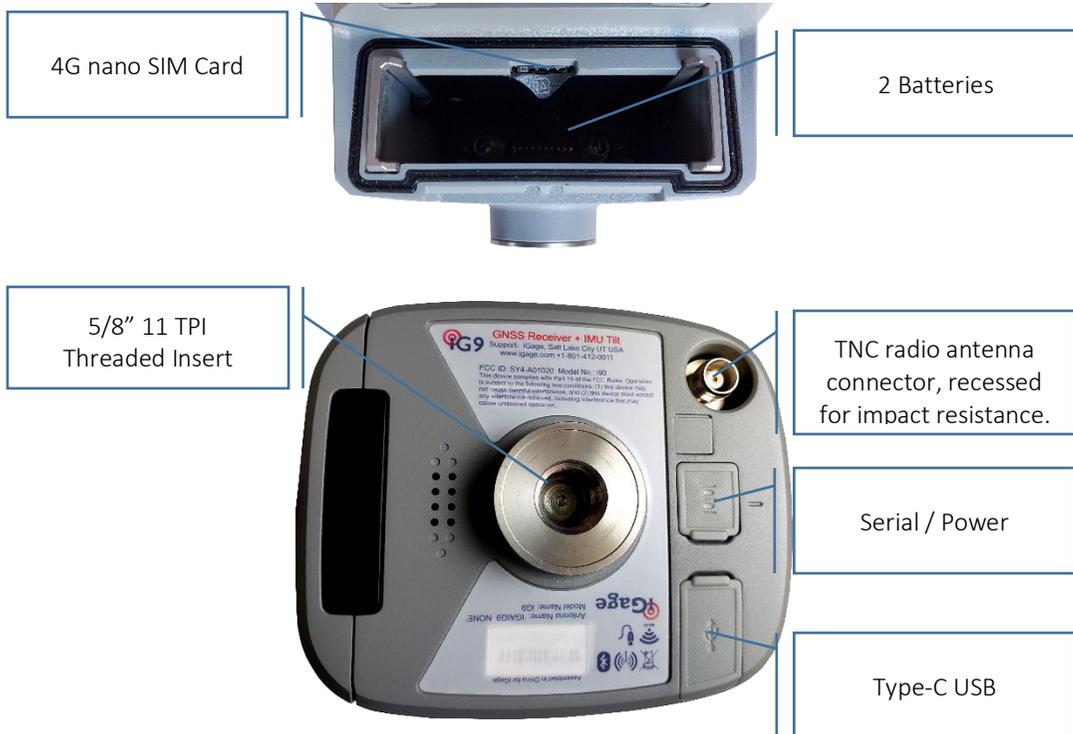
4G nano SIM Card	iG9 receivers have a NANO sized Sim Card slot. (NANO is the smallest sized sim card.) Insert cards with gold contacts facing up and the notch leading. The data modem is a 4G LTE modem and should work with all providers, however the modem is NOT Verizon certified.
Batteries	There are 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 77 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 device drivers are 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.

iG9 receivers include a high-precision IMU tilt compensator, iG9a receivers do not include tilt. A common kit includes an iG9 (with IMU Tilt) for the Rover and a iG9a (no IMU Tilt) for the Base.

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 / iG9a 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 except IMU Tilt is typically not purchased for the Base. 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]	
SIM CARD We optionally include a non-activated GSM SIM card withiG9 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]	

Optional Accessories

iGA, High Gain UHF Antenna

Extends UHF Radio range, excellent spare antenna in case the factory antenna is broken.

iGR, 35-Watt Repeater / Transceiver

Works as a remote repeater or cable connected high power radio.

Kit includes:

Radio, Power/Data Cable, 5-dBi Antenna, cable, 5/8" mount, USB-to-Serial adapter, User Manual

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 1 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

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. Remember that the receiver GNSS antennas were calibrated with two batteries inserted. The phase center may change if you remove the batteries.

Please keep at least one <u>charged</u> 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 2 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 condition.

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 'Preventing Illegal Radio Abuse Through Enforcement 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.

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

Main Menu

After the iG9 starts, the Status Overview Menu will be shown
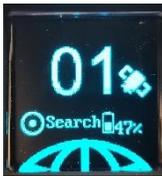
Clicking either button ![Fn] or ![Power] will display the Main Menu:

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:
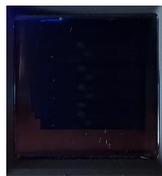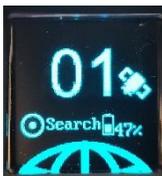
click the Fn button to display the Main Menu:

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)
```

Compatible Field Software

The following field software tools are compatible with the iG9 receiver:

GeoMax X-PAD Ultimate: fully compatible

MicroSurvey Field Genius: fully compatible

CHCNav LandStar7:   fully compatible

Carlson SurvCE version 5.09 through 6.08:   compatible without IMU Tilt Enabled

Carlson SurvPC version 6.07 through 6.08:   compatible with IMU Tilt Enabled

Note: Carlson has dropped all support for the iG9 receiver from Version 6.09 forward of both SurvCE and SurvPC.

Very detailed configuration and use instructions are available for X-PAD, LandStar7 and SurvPC. Contact iGage to receive either PDF or hardcopy versions of these Getting Started Guides.

Using IMU Tilt Compensation

The iG9 receiver has a accurate, fast, IMU based Tilt Compensation function built into the receiver.

Remember that the iG9a does not have Tilt Compensation.

The tilt compensation is fully supported by X-PAD, LandStar7, Field Genius and SurvPC (versions 6.05 through 6.08). SurvCE does not support Tilt Compensation.

Step-by-step Tilt compensation instructions follow for X-PAD, LandStar7 and SurvPC.

GeoMax X-PAD

To enable the IMU Tilted Pole corrections from the Survey or Staking screens, click on the Tools button at the bottom of the SURVY or STAKING screen:
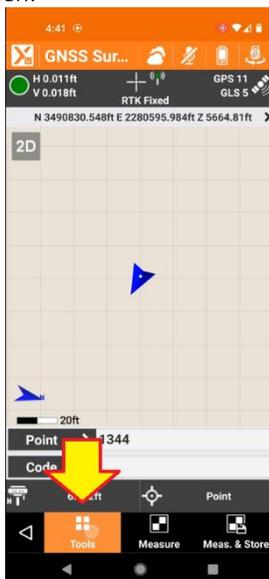
On the Tools menu:
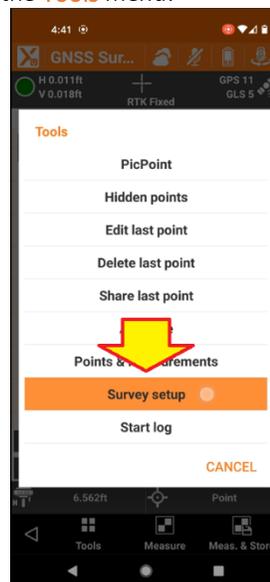
Click on Survey setup.

GNSS settings will be shown.
Drag the GNSS settings menu down to Sensors mode:
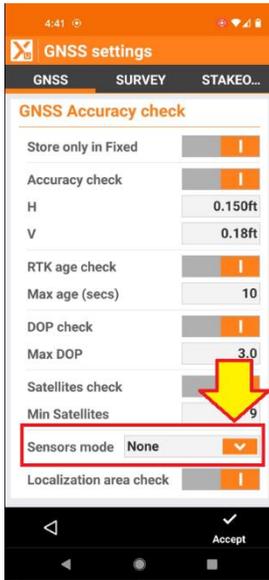
Click on the down button.

Change the Sensors mode to Tilted Pole (GNSS receiver):
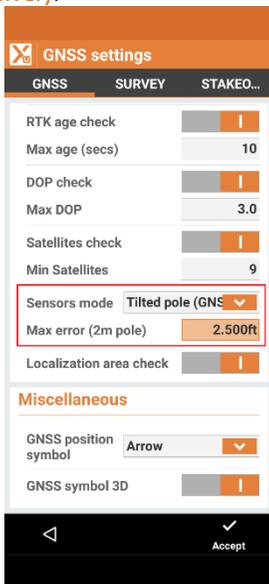
Set the Max error (2m pole) to the maximum horizontal offset of a receiver at the top of the pole from the point on the ground. (A 20° tilt on a 2-meter pole is 2.25' offset.) Tilts that result in a higher offset will pause measurements.

Finally click Accept.

The SURVEY or STAKING screen will be shown:

A translucent tilt indicator will be displayed on the map bottom. As the IMU initializes several prompts are shown. The symbol above requests that you need to rock the receiver back-and-forth on a point.

This icon:

requests that you hold the receiver nearly still and level.

Usually, the status goes back and forth between rocking and holding still.

The IMU will usually initialize in the process of moving between points if you ignore the initialization instructions.

Once the IMU has initialized the screen will display the tilt angle:

When this icon is shown, the tilt compensation is active and you can store a measurement.

If you hold the receiver perfectly still (on a prism pole bipod) for more than 30-seconds, the IMU will lose fine initialization. X-PAD will request that you rock the receiver again. Typically, you only need to shake the receiver 0.01' in one direction to immediately reinitialize the IMU.

When staking:

the tilt angle is shown.

Carlson SurvPC

Note: SurvCE running on Windows Mobile Devices will not work with IMU Tilt. (It appears that the program is too slow to process tilt compensation in real time.

To use the IMU, when configuring the iG9 Rover under 'Equip: GPS Rover' on the 'Receiver' tab, check the 'Use IMU' checkbox:
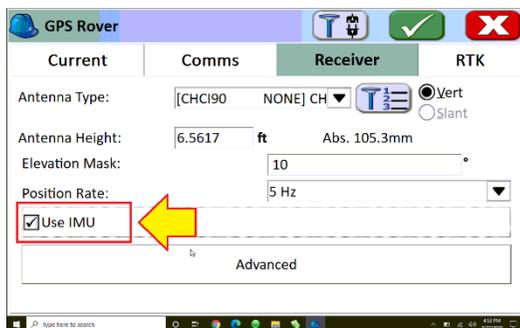
This will automatically set the 'Position Rate' to 5-Hz.
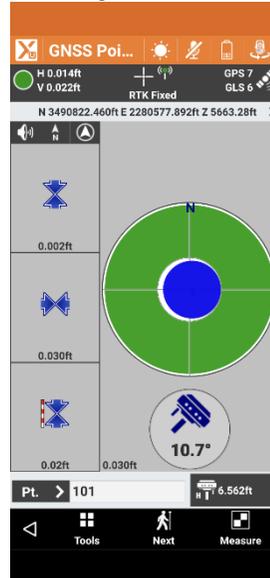
After configuring the iG9 as a Rover, you can enable/disable the tilted pole calibration:

1. from the 'Equip' tab, click on '5 Configure':
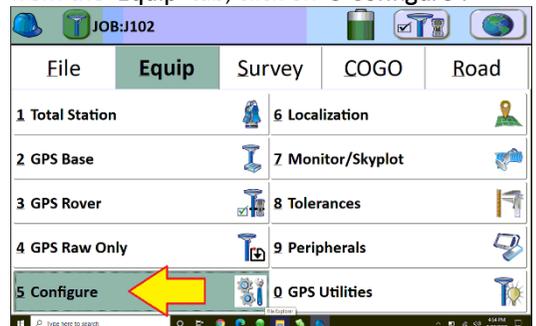
2. from the 'C' (Configure) button on the Store and Stake screens:

Select the IMU tab (1):
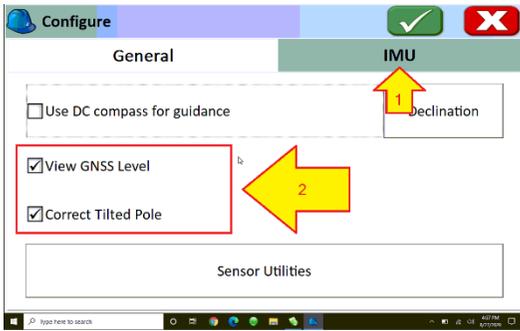
Check both the 'View GNSS Level' and 'Correct Tilted Pole' check boxes.

When in the Store or Stake screens, the top line of the display will display an icon with the current IMU initialization state.
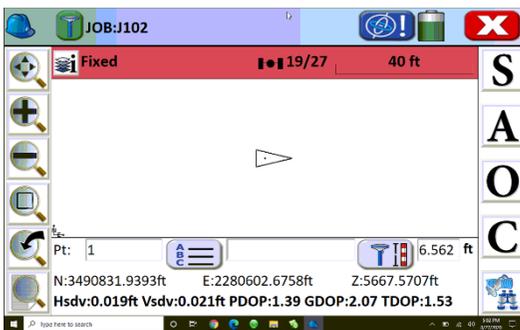
If this icon is shown on the top line:

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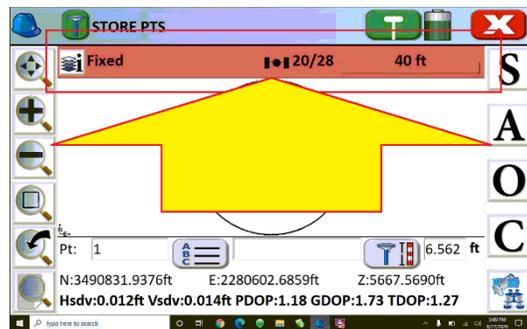
When the top line is red, any one or multiple tolerance conditions will prevent you from storing a shot, without overriding the action.

To configure the Tolerance settings, from the main menu 'Equip: 8 Tolerances':
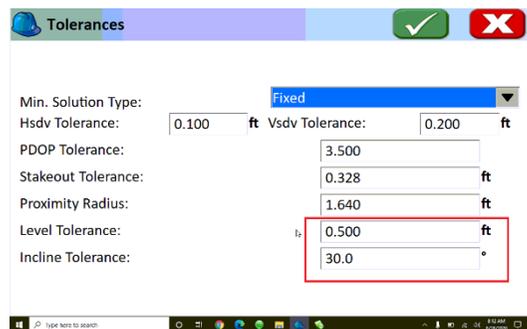
The 'Level Tolerance' is the maximum allowable linear ground distance error allowable.

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

Verifying the Tilt Function

SurvPC has a 'One Point Sensor Test' accessible from 'Equip: GPS Utilities: Sensor Utilities: One Point Sensor Test':
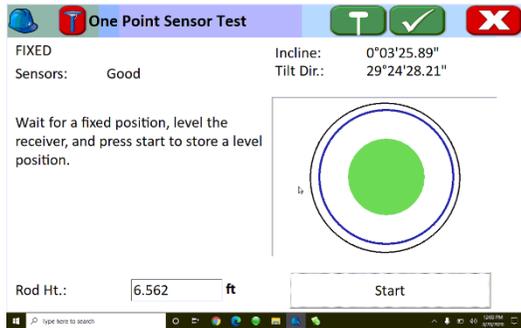
Enter the correct rod height, ensure that the receiver is FIXED and the IMU is initialized, then click 'Start'. A short average position will be computed.

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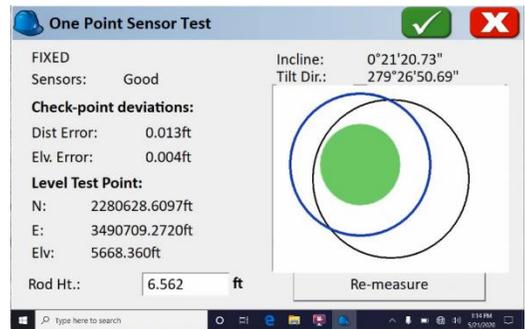
The reported 'Incline' is the pole tilt angle. The 'Tilt Dir' is the direction the pole is leaning assuming the display is pointing towards the operator.

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)

LandStar7

CHC LandStar7 directly supports the iGage iG9 receivers, with or without built-in IMU heading + level indicators that allow the position of the rod point to be accurately computed.

You can activate the IMU in any of the Survey Store or Stake screens:
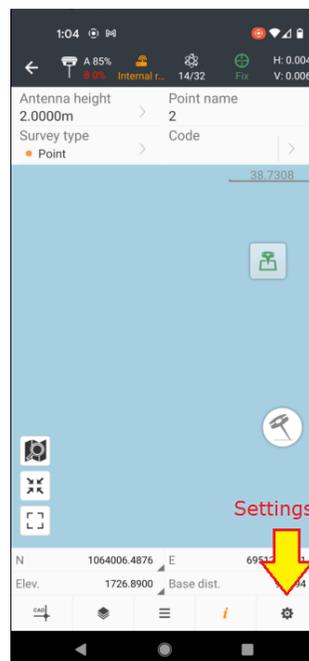
Click on Settings.

Set the Use tilt slider ON (Right).

LandStar7 will immediately ask you to initialize the IMU.

And will ask you to alternate between asking you to hold the pole upright:
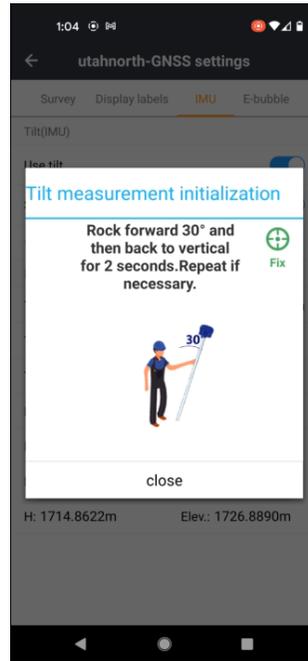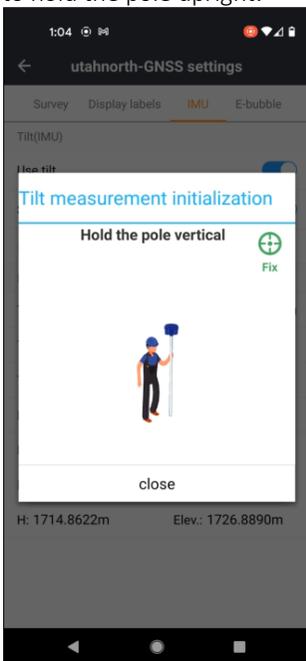
And rocking the pole forward then back to vertical (or left/right and back to upright again).

After a few moments the IMU initialize and detailed pole-tilt information will be shown:
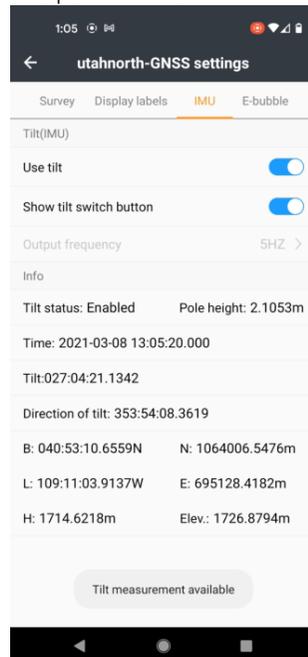
Click the back arrow to return to the survey screen.

The IMU status is shown as a green tilt. Clicking on this moveable button allows toggling tilt

compensation on and off.

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.

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 antennas 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:
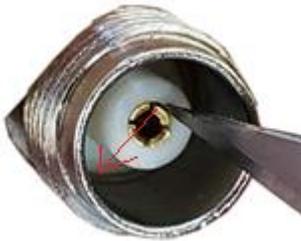
Bending the center contacts 'in' towards the center.

Configuring the iG9 Internal Cellular Modem

Internal GSM Method:

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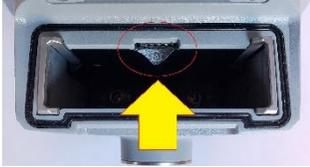
While the modem is compatible with the Verizon system, it is not Verizon certified and it is probably not possible to activate in the Verizon network.

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 your Field Software 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'
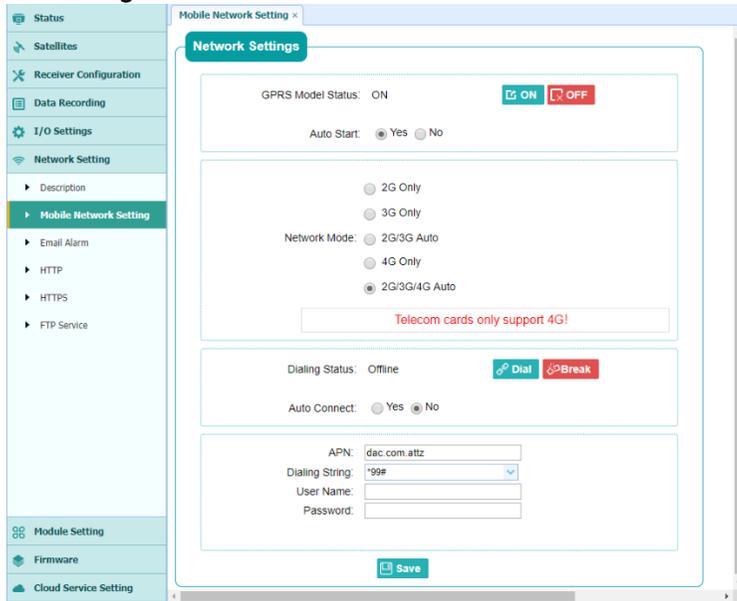
Click ON to turn on the cellular modem. Set **Auto Start** to Yes, set **Auto Connect** to Yes.

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.

Set the **Dial String** to '***99#**', leave the **User Name** and **Password** empty. Click **Save**.

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.

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 X-PAD, Field Genius or SurvCE/SurvPC when setting the iG9 as a network Rover.

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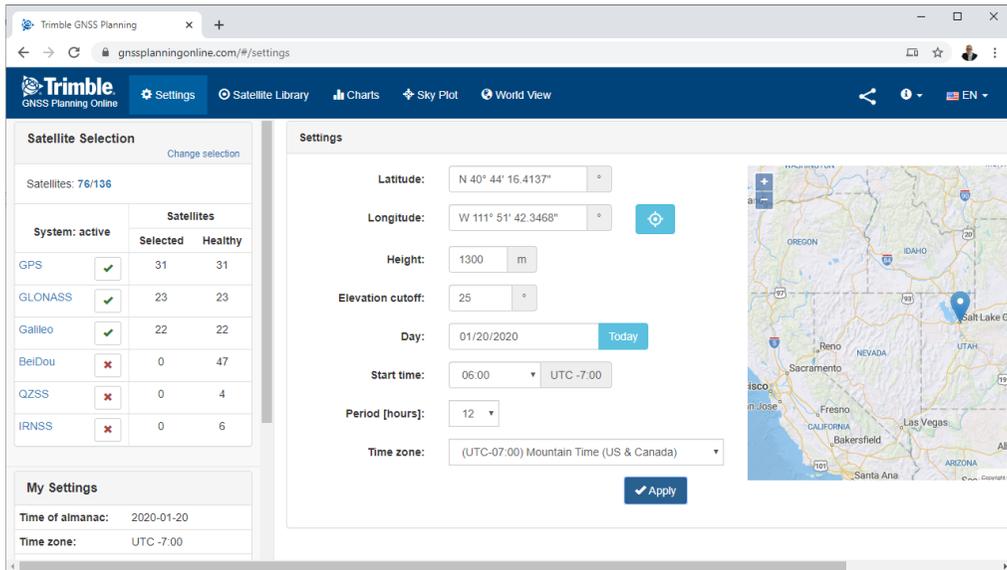
First configure the settings: pay attention to the 'Time Zone' and approximate job elevation. Set the 'Elevation Cutoff' to a high value like 25 - 30 degrees to simulate heavy canopy. Check GPS, GLONASS and Galileo leaving BeiDou unchecked (as it probably will have minimal contribution.) Click 'Apply'.

Click on 'Charts' and roll down to the PDOP chart:
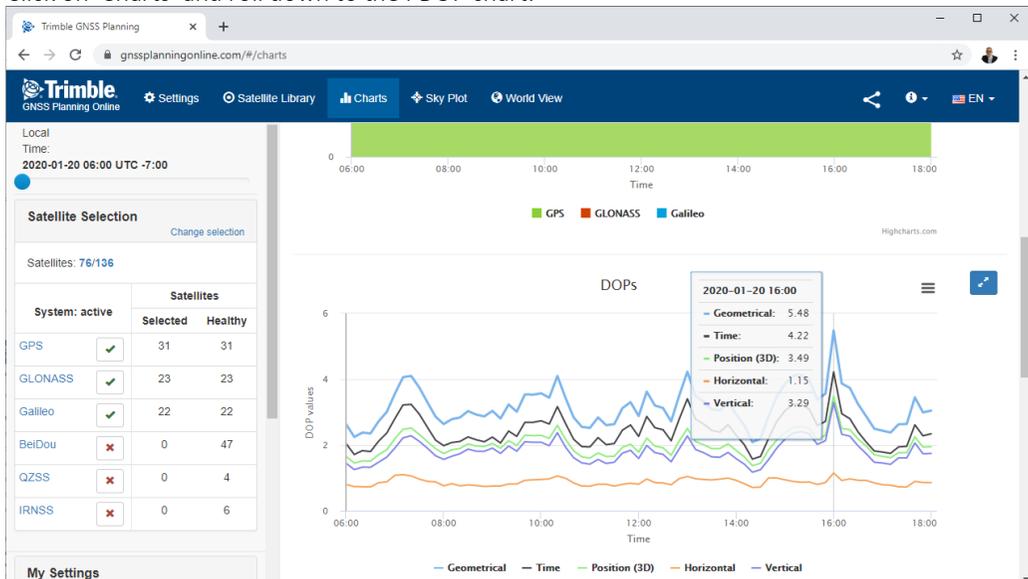
GDOPs higher than 3 will present difficult operation, GDOPs higher than 5 may not fix under canopy. Usually waiting 20-minutes for the constellation to improve will make a huge difference.

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.

Make sure Wi-Fi is Enabled

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.

Wi-Fi turns off after 15-minutes to Save Power

To save power, if the Wi-Fi modem is not in use for 15-minutes it is powered down, even when enabled. Clicking either front panel button will enable it again.

Connecting a Computer or Mobile Device

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

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

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

Enter the Wi-Fi password "**12345678**"
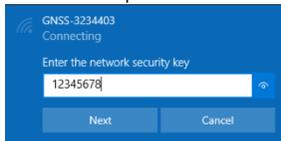
Click on '**Next**' to connect by Wi-Fi to the GPS head.

Open a browser window on your PC and type in the GPS IP address:

http://192.168.1.1
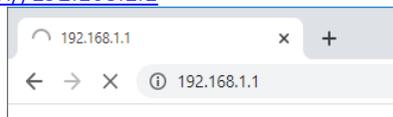
A Login screen will be shown:

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

Click the '**Login**' button, you will be at the '**Home Screen**' of the GPS receiver:
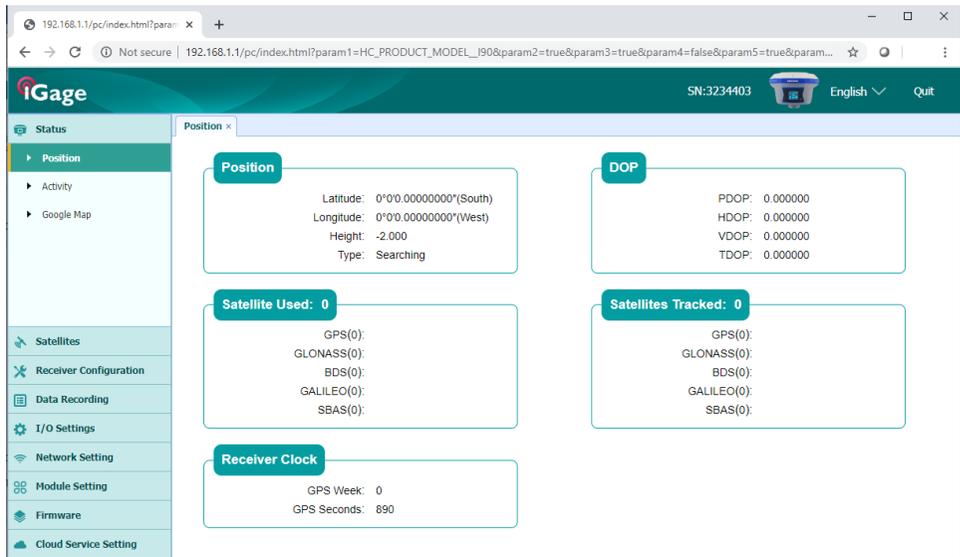
From the Wi-Fi interface, you can configure nearly every aspect of the receiver's operation using the left-hand section tabs and sub-items.

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 iG9.xyz website, click on Tools, then Radio. The programming tool will run on any PC:
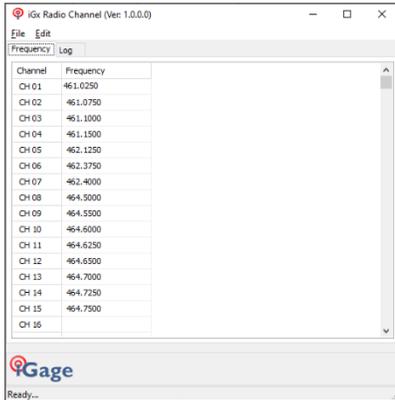
With this tool you can create a standard list, modify frequencies, and reorder the frequency list. When the frequency list matches your FCC License, then you can save a .CFG file for uploading to the iG9 receiver.

You must login to the GPS receiver using the instructions 'Connecting the iG9 to a PC or Smartphone via Wi-Fi' found on Page 37.

Open a browser and go to this address http://192.168.1.1/set_en.html :
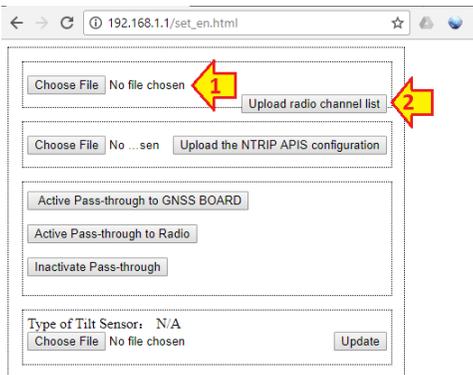
(1) Click on 'Choose File' and browse to the settings file, then (2) click on 'Upload radio channel list' the new radio table list will be installed in the head.

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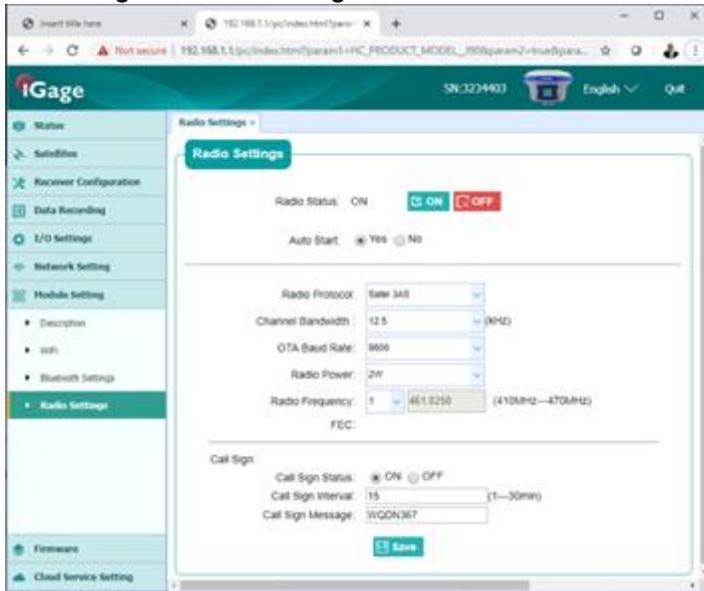
If the '**Radio Status**' is **Off**, click **On** to turn on the radio power.

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.

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:

> Turn on the GNSS receiver.
>
> <u>Wait for the iG9 receiver to fully boot.</u>
>
> Plug the USB-C connector into the USB-C hole on your iG9 receiver:

> and a USB port on your computer.
>
> 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:
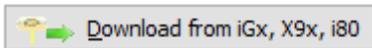
The program will automatically switch to the '_New' project and download every new (not previously downloaded) file from your receiver.

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.
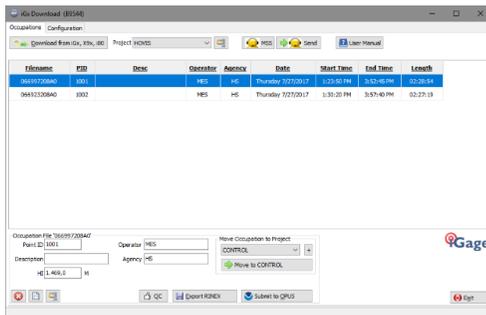
You can sort the grid by Filename, PID, Description, Operation, Agency, Start Date/Time, End Date/Time and Length by clicking on the column headers. Clicking twice on the header will reverse order the grid.

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:

> **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.

> **Description** A longer description of the point. Note that quotes '"' and '"' are not allowed in the description.

> **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

> **Operator** This value gets placed in exported RINEX files. By convention this is usually less than 10 alphanumeric characters.

> **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:
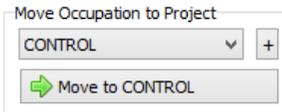
Submitting an Occupation to OPUS

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:

the file is decimated to 15-second epochs, header information is stuffed

the file is run through TEQC to insure it will be acceptable to OPUS

an Observation file and a Navigation file are generated

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:
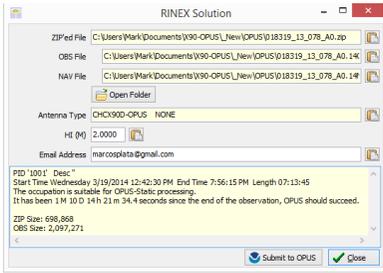
The program will suggest which service (OPUS-Static or OPUS-RS) and list the time since the end of the occupation. You can click the 'Submit to OPUS' button:

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:
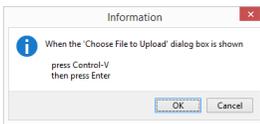
Click OK and then 'Choose File to Upload' will be displayed:
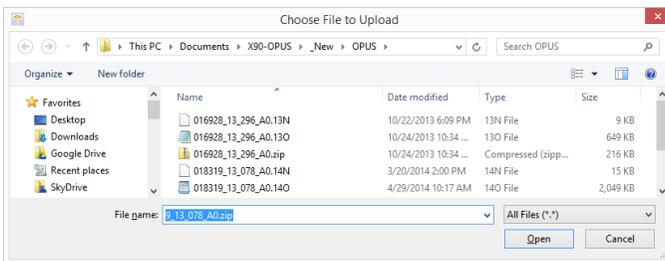
Press Control-V, then the 'Enter' key on your keyboard. You may also press Control-V, then click the 'Open' button with your mouse.

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:
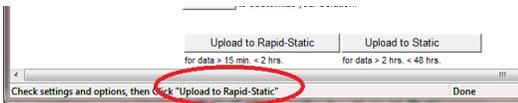
Press either the 'Upload to Rapid-Static' or 'Upload to Static' button as directed, and your occupation will be uploaded to OPUS for processing.

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:
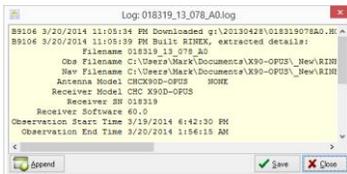
Pressing the 'Append'

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:
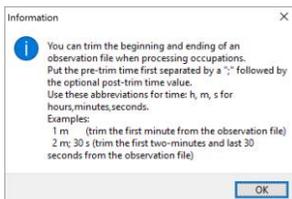
Note: the trimmed length is not reflected in subsequent screens or on the occupation grid. Only the submitted file is trimmed, all the original data remains in the stored occupation. The trim settings must be reloaded after each submission.

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'

GPS Mounts on Drive e:\ [Find GPS]

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.)

[Update GPS Model]

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:

Verify Receiver Model

Please confirm the receiver model and HCN Key value. This question will not be asked again.

Receiver Serial Number: 943633
Receiver Model: CHC X90D-OPUS
HCN Key: SZ6-V4 [OK]

[X Cancel] [✓ OK]
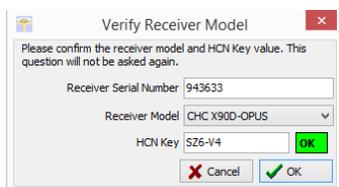
Use the drop down 'Receiver Model' to change the receiver type. If the HCN Key has been lost, you can find it written on a white sticker inside the battery compartment. You cannot edit the 'Receiver Serial Number'.

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)

Minimum File Size to Transfer 7000 bytes

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'

☐ 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'

Default HI (S-slant F-feet) 2.0

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'

Default Agency IMC

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'

Default Operator MSilver

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)

Decimate OPUS Submission to 15.0 seconds [Default]

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'

Your Email | marcosplata@gmail.com

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'

Show Advanced Settings | Advanced
Simple
Normal
Support OPUS-Projects
Advanced
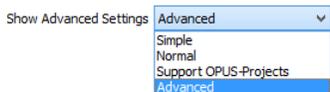
This setting determines the complexity of the **iGx Download** program.

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)

PPP Service | IBGE (Brazil)
OPUS (United States)
RTX (CenterPoint)
AusPOS (Australia)
IBGE (Brazil)

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:

OPUS: [Submit to OPUS]
https://geodesy.noaa.gov/OPUS/

RTX: [Submit to RTX]
http://trimblertx.com

AUSPOS: [Submit to AUSPOS]
http://www.ga.gov.au/bin/gps.pl

IBGE: [Enviar para IBGE]
http://www.ibge.gov.br/home/geociencias/geodesia/ppp/default.shtm
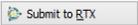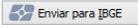
Export 8.3 Filename

(Hidden when Simple)

☐ Export 8.3 Filenames

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)

☑ Format Extended

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)

Utilities	
1. Undelete Occupation	2. HcRINEX Convertor
3. Mark One GPS File 'UnRead'	4. Mark All GPS Files 'UnRead'

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.'
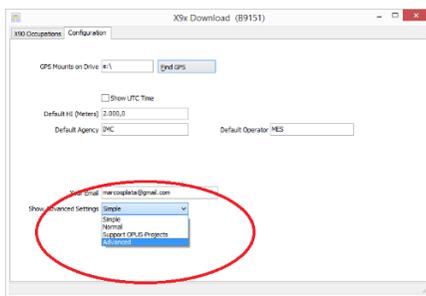
When 'Advanced' is selected, two additional tabs will be displayed:
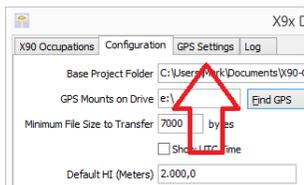
GPS 'Settings' Tab

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
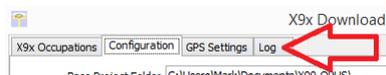
The 'Log' tab shows detailed results of the current program operation. It may be useful to debug some aspect of file processing.

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:
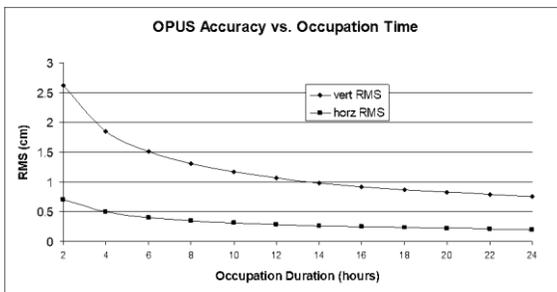
OPUS-RS (Rapid Static)

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.
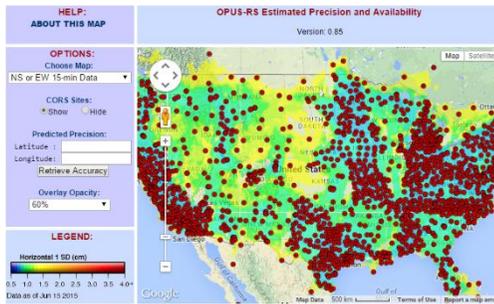
In some areas there is a risk that if a single CORS site is unavailable, your OPUS-RS job will not be processed. Caution and planning are suggested for OPUS-RS jobs.

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':

> What are your GOALS?
> Required accuracy

Horizontal and Vertical Datum; Geoid model choice

Survey style: OPUS-Static, OPUS-Rapid Static, OPUS-Projects

Consider FGDC Standards:

http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy

Are there passive marks available for control?

Will CORS, passive or a combination control the survey?

Are local passive marks recoverable, undisturbed, sufficient quality, stable and GPS friendly?

Where are the nearby NGS CORS (active) marks? This will determine 'Rapid Static' or 'Static' availability.

OPUS-Rapid Static Requirements

Find the closest 9 CORS sites with available observations

A minimum of 3 CORS stations within 250 KM are required.

Your site must be within 50 km of a polygon created by the remaining available CORS.

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:
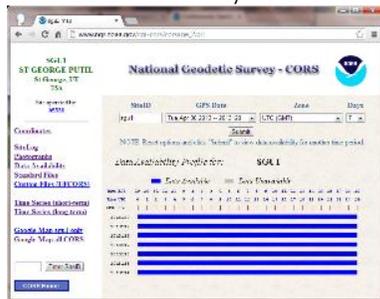
Mission Planning: Satellite Availability and Network Planning

How many receivers will you use for simultaneous observations? If you are using OPUS-Projects then More = More-Better.

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.

How long will you observe a site? Again:
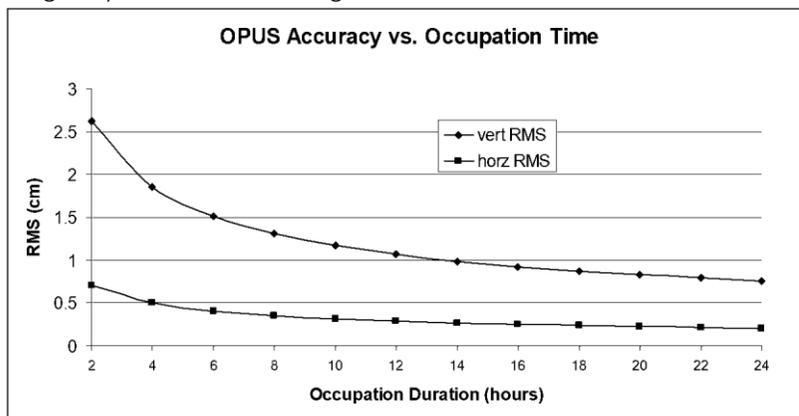
Are your sites GPS compatible? Are there obstructions higher than 10 degrees?

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**":
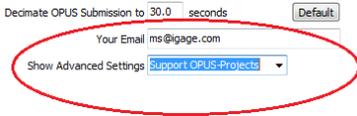
2. Add the NGS registered OPUS-Projects '**Project Identifier**' supplied by your project administrator:

Click the "+" button
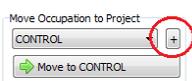
Enter the exact identifier
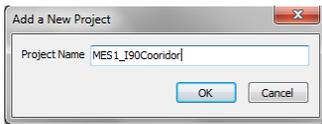
as the new project name.

Select the new Project
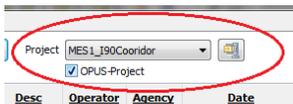
and check the newly displayed '**OPUS-Project**' checkbox.

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:
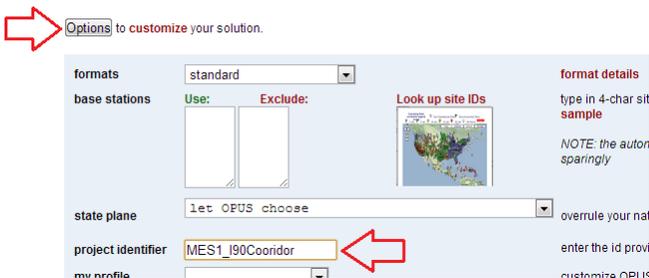
Best OPUS Practices for New and Experienced Users

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.
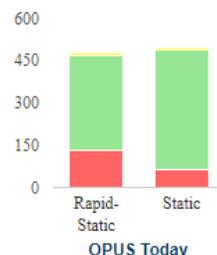
#2 Only Some Submissions are being returned by OPUS

OPUS always returns an email. <u>Always</u>. 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.
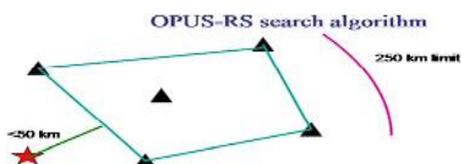
The user location can be up to 50 KM from the polygon surrounding the selected sites which allows OPUS-RS to succeed in coastal areas where there are no CORS sites offshore. However, every CORS site that is used must be within 250 KM of the user site.

If you are in Michigan:
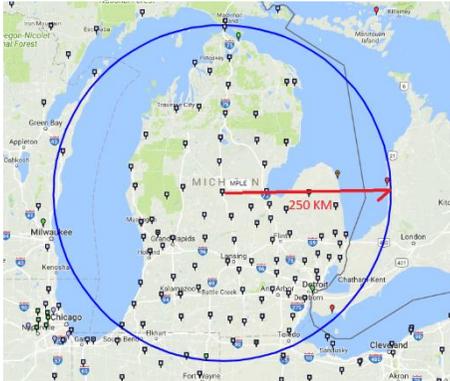
There are plenty of CORS stations within 250 KM of everywhere. OPUS-RS is likely to always succeed, even if a few of the stations are offline, are missing data or are very noisy and must be discarded. It is likely that OPUS-RS will work all the time in Michigan.

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:
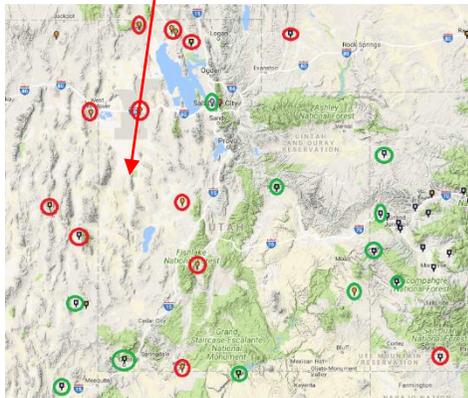
Daily Stations Red; Hourly Stations Green

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:
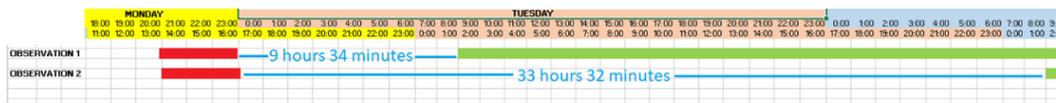
The two observations were performed Monday afternoon (the red bars.) One is a section corner, the other is vertical bench mark which is only 400 feet northeast of the section corner. Both locations enjoy completely open sky – no canopy. Both observations are **exactly** three hours in length.

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:
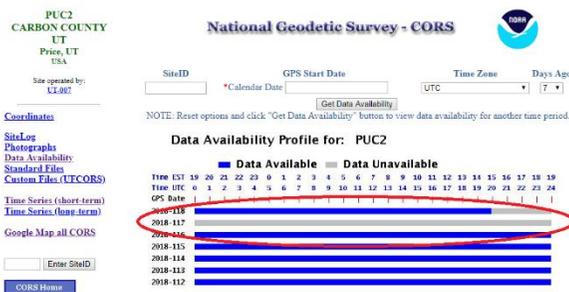
You will sometimes find that several hours or an entire day's observation data is unavailable, shown as gray instead of blue.

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:
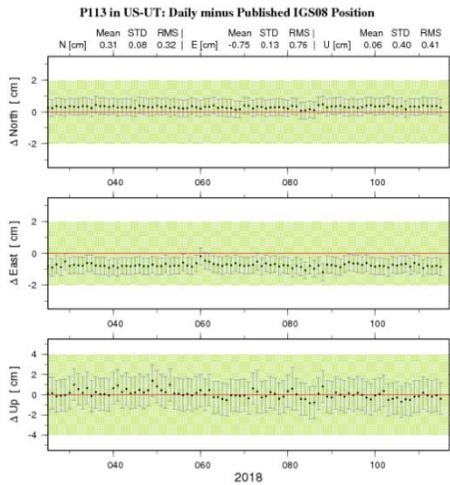
Time Series for P113

You also want to look at the recent 'Data Availability':
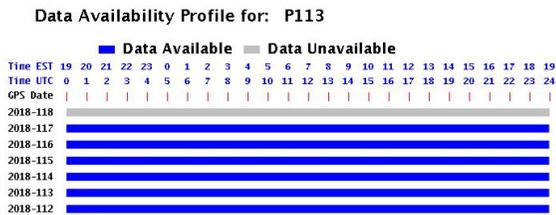
Availability for P113

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:
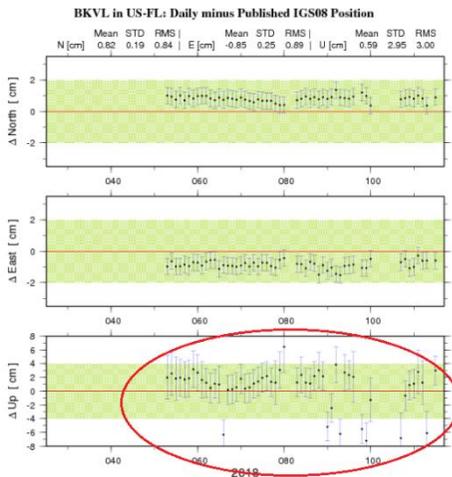
You will want to ALWAYS exclude the station from your solutions. If you catch this site on a bad day (and it has a lot of them) you can expect significant elevation and horizontal errors.

Even worse sites abound in the NGS array:

CRST in US-FL: Daily minus Published IGS08 Position
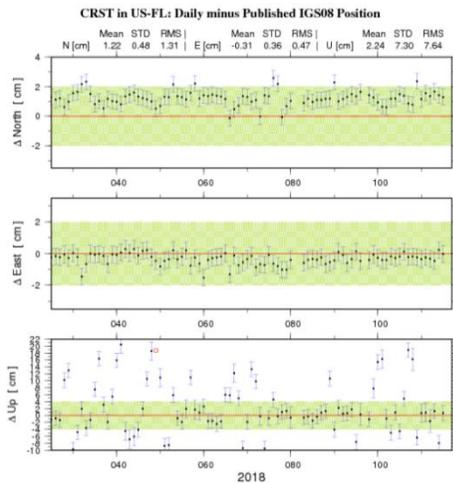
These stations and all the others like them are unsuitable for any processing use. It is your responsibility to exclude them from your solutions.

#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:
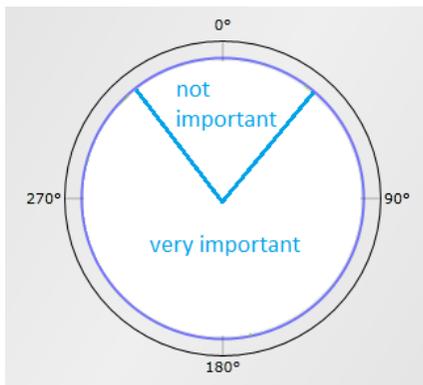
Obstructions to the North not important in North America

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.

iGage iG9 User Manual
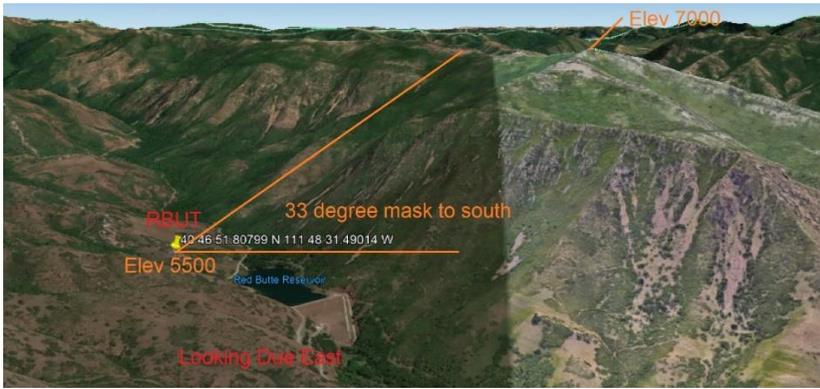
Power Poles

< 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:
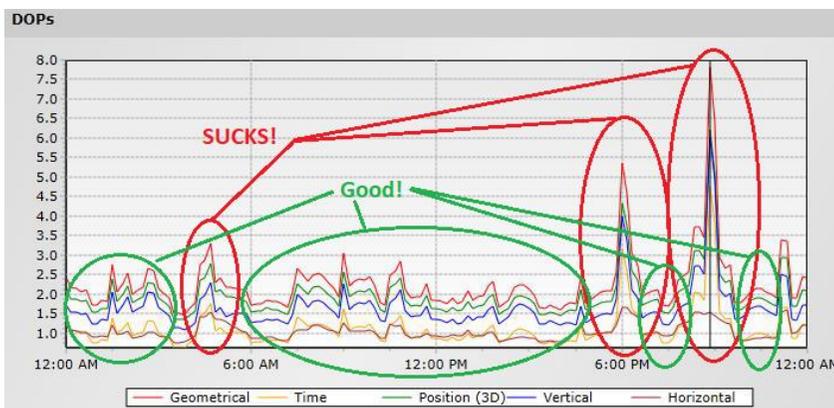
Lower DOP is better than higher DOP. You can see that most of the day, DOP is excellent. Most OPUS submissions will be successful. However, starting at 5:30 pm there are large DOP spikes.

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
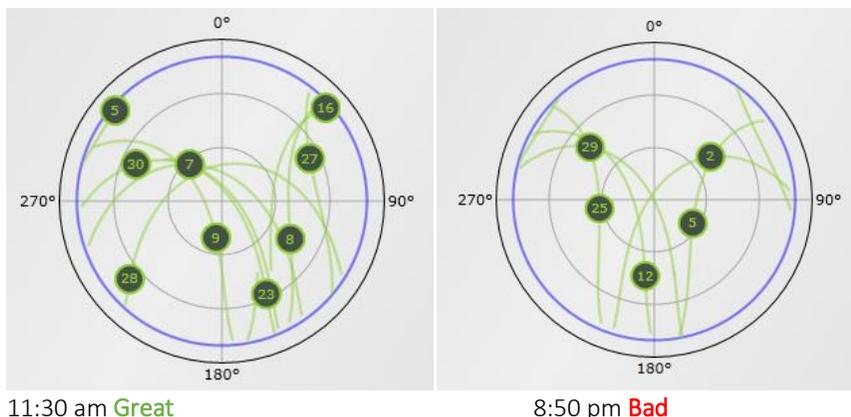
One pitfall of OPUS-RS is very short occupations may entirely fall into a very high-DOP period. As you can see from the DOP plot above, high DOPs rarely last for more than an hour and longer OPUS-Static occupations will usually have some periods of low DOP and excellent coverage.

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 83.

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:
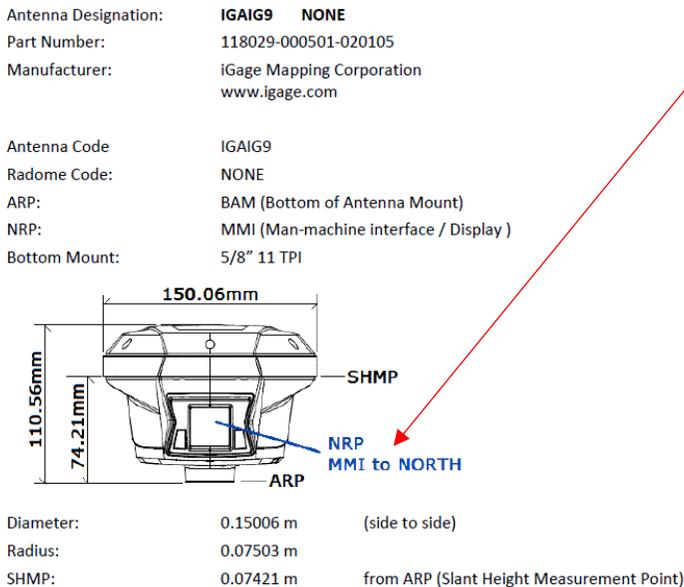
The iG9 should have the MMI (the button/LED panel) turned to face the North.

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):
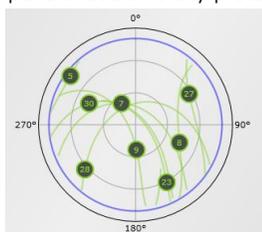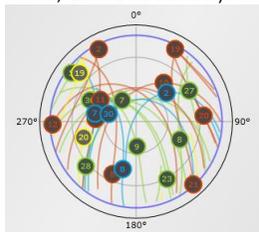
GPS Only   GPS + GLONASS + Galileo + BeiDou

More satellites are better. More signals are better. Even though the iG9 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.
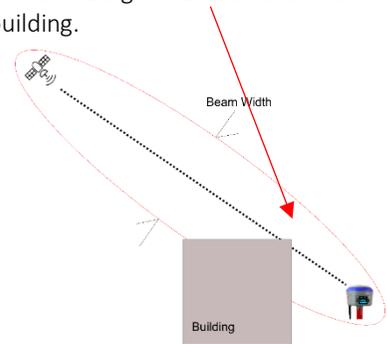
How wide is the Fresnel beam along the path? Much wider than you think!

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

1st Fresnel Zone Radius vs. Distance From Rover
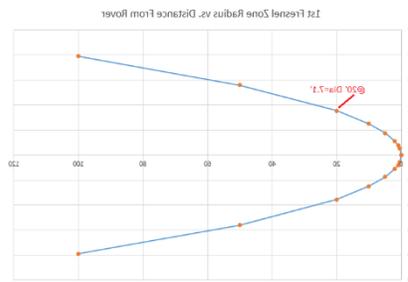
1 foot above your GNSS antenna, the beam width is 1.6' in diameter. 20 feet above the Rover antenna (perhaps the midpoint of tree canopy), the 1st Fresnel beam diameter is 7 feet! A clearing in the treetops 100' above your antenna needs to be 16' in diameter.

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 80.

5. The receiver won't mount as a Disk Drive.

Before plugging GPS cable into your PC, did you wait for the power LED to blink 3 times?

Unplug, wait 15-seconds, try again

Try another USB port, try another USB cable

Use an external USB Hub (this fixes intermittent disk mounts.)

Try other computers.

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
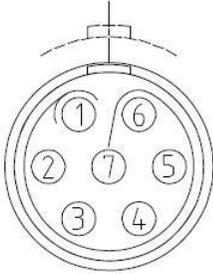
PIN	FUNCTION
1	Ground (-)
2	Ground (-)
3	RS232-TX (Output)
4	PPS (Pulse Output)
5	Not Used
6	VIN
7	RS232-RX (Input)

Figure 3 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 37 to get your PC connected to the receiver by Wi-Fi and logged into the web interface.
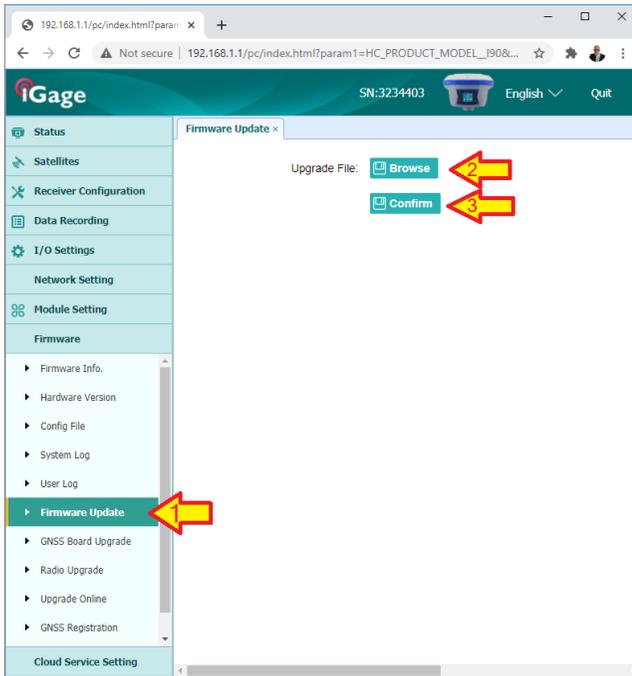
Click on Firmware, then 'Firmware Upgrade' (1), then 'Browse' (2), find and select the firmware, finally click on 'Confirm' (3) to begin the upgrade process. The receiver will reboot twice during the upgrade process.

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 37 to get your PC connected to the receiver by Wi-Fi and logged into the web interface.
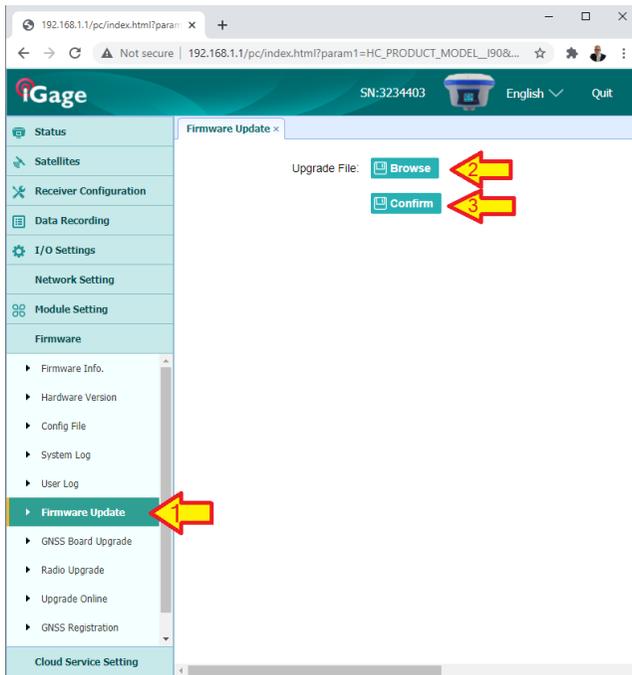
Click on Firmware, then 'Upgrade', then 'Browse' and find the firmware finally click on 'Confirm'.
The receiver will reboot twice during the upgrade process.

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 37.

Once connected, from the Main Menu,
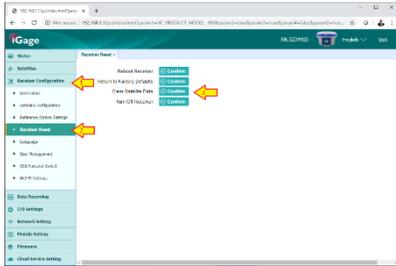
Click on **Receiver Configuration**: **Receiver Reset** then '**Clear Satellite Data**' '**Confirm**'.

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 and iG9a receivers have an NGS calibration "`CHCI90          NONE`"

The .atx and .gra files for the iG9 can be found on the website https://iG9.xyz ; click on **Tools**, then **Antenna**

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`"
            `12345678901234567890`

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 United States. The purchaser shall always pay any associated duty associated with warranty repairs.