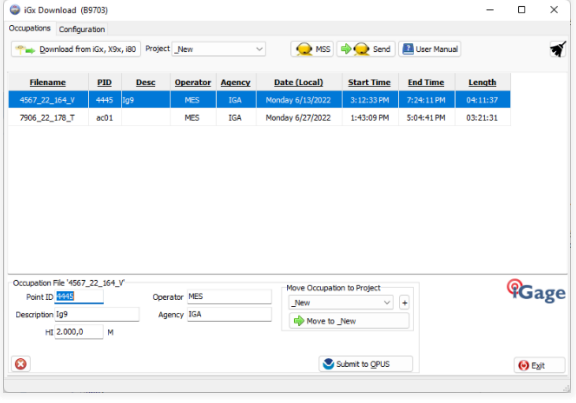
iGX Download

Static GNSS Receiver Download / RINEX Tool User Manual



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Copyright, Control and Safety

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Introduction

Thank you very much for choosing to purchase and use an iGage GNSS receiver!

This guide is designed to help you familiarize yourself with the iGx download tool that manages static occupations recorded on GNSS receivers.

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

iGage Mapping Corporation
1545 South 1100 East STE 1
Salt Lake City UT 84105 USA

+1-801-412-0011
email: support@igage.com

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

Software updates and news are available from:
www.iGGPS.com

Don't hesitate to call iGage for assistance deploying, using or updating your device. Remote assistance is available.

Technical Specifications

This tool works with these receivers sold by iGage:

X90 (X90D OPUS)
X91+
X900+
X900S
iG3, iG4, iG5, iG8, iG8a, iG9, iG9a
i90, i80

Partial support for: i50, i73, i83

The Really-Quick-Start Guide for Static Operation

Before First Use

Please read the "Best OPUS Practices for New and Experienced Users" section of this User Manual on page 42.

It will save you time and failed jobs.

In the Field

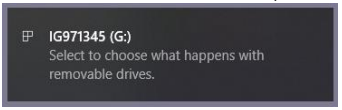
1. Fully charge the internal battery or attach an external power source.
2. Mount the receiver over the point you want to survey. Level and measure the Instrument Height (HI), use a fixed height tripod or range pole with Hold-a-Pole if available. For best results: align the button panel to face north, double-check your bubble and the instrument height (HI.)
   Record the HI, start time and point description in your field notes:
3. Push the ON/OFF button and hold it for 1-second until the lights flash. After 30 seconds the blue LED will flash once for every tracked Satellite.
4. Verify that the yellow 'Files' LED flashes once every 1-second as the receiver logs data.
5. Let the receiver record data for at least:
   OPUS-Rapid Static: 16-minutes
   OPUS-Static: 121-minutes
6. Turn the receiver off by pushing and holding the ON/OFF button for 1-second.

Office / Desktop

1. Install the download tool from the included thumbdrive or get the latest version from www.iGGPS.com.
2. Turn on the receiver, wait 10-seconds for the power LED to flash and then plug your receiver into a USB connector on your computer.

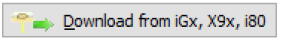
3. If you see the Windows AutoPlay screen:

click on the red 'X' button on the upper-right corner.
If you see the Windows 10 AutoPlay screen:



just ignore it.

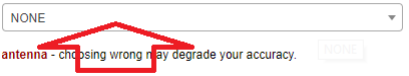
4. Start the iGx Download tool from your desktop, push the 'Download from GPS' button:



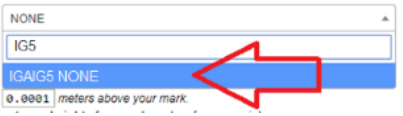
5. Highlight the occupation, set the Point ID, the Description and the HI; push the 'Submit to OPUS'

button.

6. When prompted press OK, then Control-V (to paste the file location and name,) then press the "Enter" key on your keyboard, or click on 'Open' to set the ZIP filename.
7. You will need to manually select the correct antenna type. Click anywhere in the 'antenna' selection box:



Then in the drop-down selection box:



Enter the correct antenna type, wait a moment for the list to populate and then click on the correct selection to choose the correct antenna model.

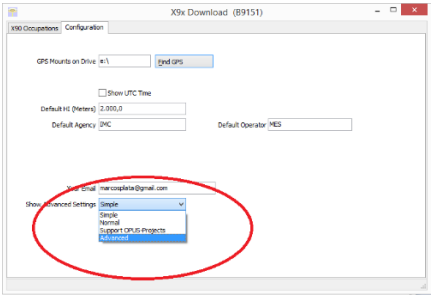
8. Finally press the ‘Upload to Rapid Static’ or ‘Upload to Static’ button as prompted at the bottom of the screen.

IMPORTANT! Exporting to other Programs (NOT OPUS)

The files that are submitted to OPUS by the iG download tool are decimated and may be stripped of all satellite information except for GPS.

> Again, Galileo, GLONASS and BeiDou are removed and the files are decimated to even 15-second intervals!

If you are using the occupation file in another application select the ‘Configuration’ tab, then choose 'Show Advanced Settings = Normal’ (or Advanced).



An ‘Export RINEX’ button will be shown on the main ‘Occupations’ tab:

Use this export button to write **full rate** (not decimated), **full constellation** RINEX files for use in external applications.

RINEX generated with this export function have the correct User, Agency, HI, Antenna Type loaded into the headers.

Technical Assistance

If you have questions or issues with your receiver, support is provided by iGage Mapping Corporation in Salt Lake City Utah:

iGage Mapping Corporation
www.iGage.com
1545 South 1100 East STE 1
Salt Lake City UTAH 84105
+1-801-412-0011 support@igage.com

Collecting Static Data

OPUS-Static, OPUS-RS and OPUS-Projects

> Additional information on OPUS-Static and OPUS-Rapid Static can be found in the 'OPUS' section of this manual.
>
> Please read the "***Best OPUS Practices for New and Experienced Users***" section of this User Manual on page 42. It will save you time and failed jobs.

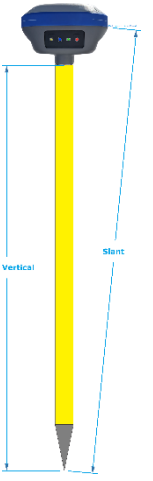
Prior to using the receiver, fully charge the battery to ensure that the static occupation is not interrupted by power failure.

When fully charged will run the receiver for about 12 hours at 60 degrees F.

When making occupations longer than 8-hours, or at low temperatures, you should provide external power to the receiver.

1. Place a freshly charged battery into the receiver.
2. Place the receiver above the point you want to survey.
3. Rotate the receiver so the pushbutton panel faces the North.
4. Level the receiver.
5. Record the 'Vertical Height' from the top of the survey mark to the bottom of the receiver; alternatively, you may measure a 'Slant Height' to the bottom of the blue rubber gasket at the minimum side radius.
6. At a minimum, make a careful note of the following items in your field book:

   Start Time and Date
   Instrument Height (HI)
   PID (Point ID, Mark Name)
   Description



7. Turn on the receiver. After 30 to 90-seconds, check that 5 or more satellites are tracked (the blue LED will blink 5 or more times.) The amber "Files" LED will begin to flash once every epoch (default 1-second) as the receiver records observables.
8. Wait an appropriate time period for data collection:

   OPUS-RS (Rapid Static)

   Minimum of 15-minutes
   Maximum of 2-hours

   OPUS-STATIC

   Minimum of 2-hours
   Maximum 48-hours
   4-hours suggested minimum

   Remember that for OPUS the data is going to be decimated to 30-second intervals. It is best to wait at least 1-minute longer than required to insure that the decimation process does not leave your file too short.

9. At the end of the occupation Press and hold the ON/OFF key for one-second until the receiver closes the current file and turns off.
10. Make a note of the end time in your field book.

Downloading, Processing and Archiving Data

Your GNSS receiver includes a download, preprocessing and archive tool called

iGx Download

for use with the NGS OPUS, RTX and exporting general files for external use. This tool runs on Windows PC's and distributed on a thumbdrive included with the receiver and is also available by web download.

Installing the Download Tool

Insert the thumbdrive in your computer and run the setup.exe file.

You can also download the latest version of the tool from:

www.iGGps.com

click on the 'iGx-Download' tool link to get the latest program version.

Follow the on-screen instructions to install the download tool and support tools on your computer.

Connecting the Receiver to your Computer

Summary: Turn on the GPS, wait for 60-seconds; plug in the USB Cable to your computer.

The receiver mounts just like a USB thumb drive (flash drive) on your Windows computer. No special drivers are required.

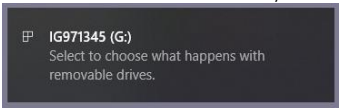
To download data from your receiver:

1. Turn on the GPS receiver
2. Wait 60 seconds for the receiver to fully boot.
3. Plug the USB-C connector into the USB hole on your receiver. The connector might be a Type-C, Type B or require a special cable:

and a USB port on your computer.

4. If you see the Windows AutoPlay screen:

click on the red 'X' button on the upper-right corner.
If you see the Windows 10 AutoPlay screen:



just ignore it.

The first time you attach a receiver, you may need to wait for a few minutes for standard device drivers to be downloaded / installed.

Since the drive connects as a standard USB thumbdrive the drivers are built into Windows XP, Windows Vista, Windows 7, Windows 8 and Windows 10.

If your receiver does not mount or an error message is displayed, you can usually unplug the receiver, wait a moment, then plug it back in.

If you continue to have problems check the 'Troubleshooting…' section at the end of this manual.

Starting the iGx Download Tool

You can start the iGx download tool by clicking on the iGx shortcut on your desktop:

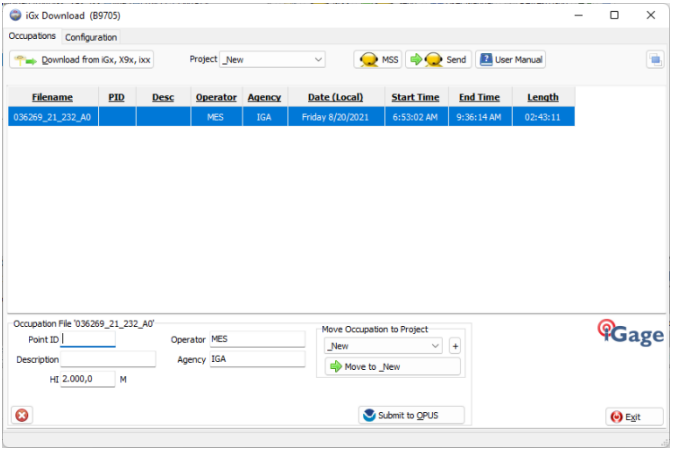
iGx

Downloading Data

Assuming the receiver is plugged in and has mounted (as a lettered drive) just press:

The program will automatically switch to the '_New' project and download every new file from your receiver. As files are downloaded, they are marked on the receiver as 'Downloaded' however they are not deleted from the receiver and may be manually downloaded again at a later time if needed.

As the .HCN binary files are downloaded from the receiver they are automatically converted to RINEX and added to the '_New' project and 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 header. Clicking twice on the header will reverse sort order the grid.

If you have any really short or unneeded occupations, you can select and delete them with:

 <- the 'Delete Occupation' button

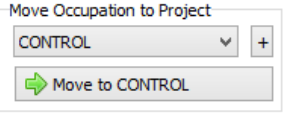
For each required observations, enter the values you recorded in your field book:

1. **PID** (Point ID) A unique short identifier for each marker (usually a 4 digit integer.) Only letters, numbers and the underscore are allowed in the PID. This number ends up as the first four characters of the filename submitted to OPUS and can be used to correlate occupations to OPUS solutions.
2. **Description** A longer description of the point. Note that quotes " and ' are not allowed in the description.
3. **HI** The Instrument Height which is the distance from the ground mark to the bottom of the receiver

add '**F**' to enter feet
add '**S**' to enter slant height
add '**SF**' or '**FS**' to enter slant feet height

4. **Operator** This value gets placed in exported RINEX files
5. **Agency** This value gets placed in exported RINEX files. By convention this is usually less than 6 characters. A current list of official contributors can be found with this online link: https://geodesy.noaa.gov/cgi-bin/get_contrib2.prl. If you plan to contribute to NGS or international projects follow this link: https://geodesy.noaa.gov/FGCS/BlueBook/annexc/annexc.index.shtml for information on obtaining an agency code.

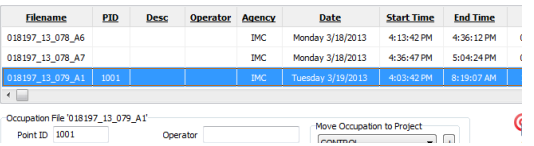
If the '_New' folder gets too full, you can make a new project folder (with the "+" button) and move some occupations to the new project:



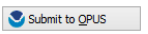
Submitting an Occupation to OPUS

Once all of the new occupations have downloaded you can submit an occupation to NGS OPUS, NGS OPUS-RS, RTX, AUSPOS. IBGE or post-process them using other software / services.

Click on an occupation to select it:



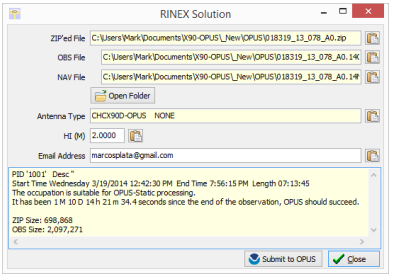
Click on the 'Submit to OPUS' button:



The currently selected occupation will be processed and prepared for upload to OPUS:

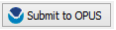
1. the file is decimated to 15-second epochs, header information is stuffed
2. the file is run through TEQC to insure it will be acceptable to OPUS
3. an Observation file and a Navigation file are generated
4. the Observation file is compressed into a ZIP file

If the 'Show Advanced Settings' is set to "Simple" then the program will skip directly to the '**Verify Filename to Upload**' screen (shown below.) If 'Show Advanced Settings' is set to "Normal", "Support OPUS-Projects" or "Advanced" then this 'RINEX Solution' helper screen is shown:



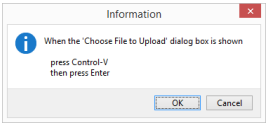
The program will suggest which service (OPUS-Static or OPUS-RS) and list the time since the end of the occupation with notes about the observation.

You can click the 'Submit to OPUS' button:

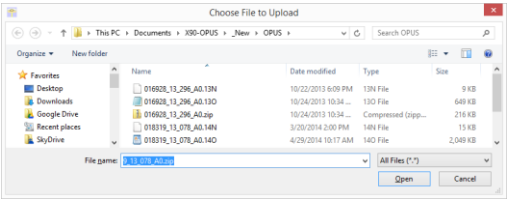


to automatically open an internet browser, which will load the NGS OPUS Submission form. After the web page has loaded, the program will automatically fill in the 'Antenna Type', the 'Antenna Height' and the 'Email address.'

Next the program will prompt you with instructions for automatically entering the Zipped observation file name into the browse dialog:

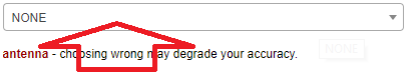


Click OK and then 'Choose File to Upload' will be displayed:



Press Control-V, then the 'Enter' key on your keyboard. You may also press Control-V, then click the 'Close' button with your mouse.

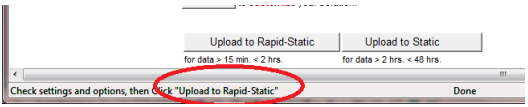
You will need to manually select the correct antenna type. Click anywhere in the 'antenna' selection box:



In the drop-down selection box:

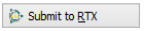
Enter the first few characters of the antenna name and then click on the correct selection to choose the antenna model.

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.

Note, you may select an alternative PPP Service provider (on the configuration tab.) Some of the alternative providers are:



Trimble’s RTX Service

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 the receiver is connected on the ‘Configuration’ tab.

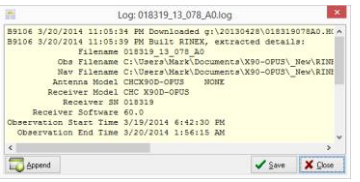
Viewing the Observation Log

(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

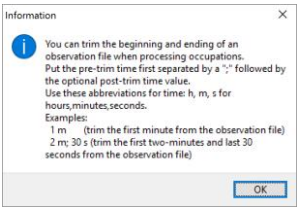
(Hidden when Simple)

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 helpful instructions:



Note: the trimmed length is not reflected in subsequent screens or on the occupation grid. Only the submitted file is

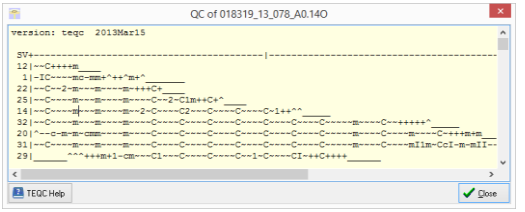
trimmed, all of the original data remains in the occupation. The trim settings must be reloaded after each submission.

Performing Quality Control

(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.

We use this QC function to verify receiver operation in our hardware validation process.

The MSS Factory Support Button

If you contact iGage for support, the technician may ask to view your computer screen remotely. Clicking the MSS button will download a support tool and provide a passcode that you can read to the technician who will then be able to view your screen and assist with issues.

The Send to Factory Support Button

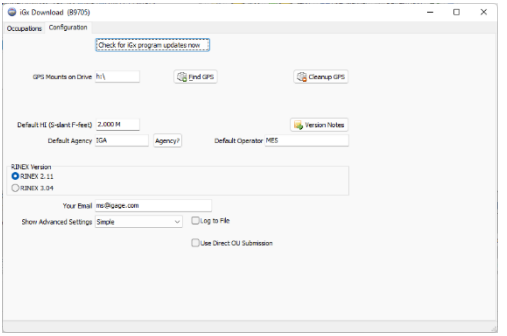
An iGage support technician may ask you to send a troublesome occupation to the factory for assistance. Simply highlight the occupation in the grid, click the 'Send' button and the occupation with all of the support files and settings will be bundled into a single ZIP file and pushed to the factory.

After you send a file, the resulting filename will be shown. You need to let the factory support person know what the filename is so they can find it on our servers.

Advanced Download Settings

Configuring the Download Tool

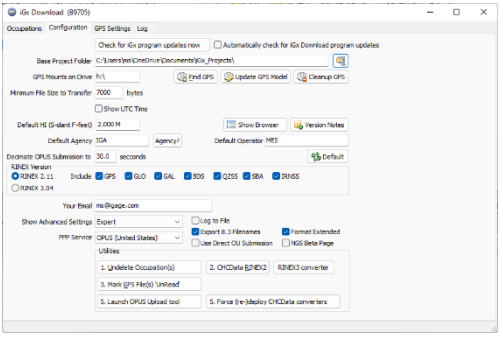
Click on the 'Configuration' tab:



At a minimum enter these values:

Agency	your company name
Operator	the name of the default operator
Email	your email address

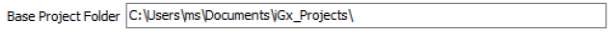
If you change 'Show Advanced Settings' from 'Simple' to 'Normal', 'Support OPUS Projects', 'Advanced' or 'Expert' additional setup values are shown:



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'. (If you have used early versions of the X9x download tool, the default location may be 'X90-OPUS'.)

Double-click over the current path to change the folder location.

In the Base Folder, 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	if you delete an occupation, it is not really deleted, just moved to the _Deleted folder. An undelete function is included in Utilities.
_Error	sometimes short occupations won't include navigation records, these short files end up here.

'Archive All Projects'

(Hidden when Simple)

Pressing the 'Archive' button to the right of the Base Project Folder entry will backup every occupation in every project to a single ZIP file.

This is handy if you want to move all of your data to another computer or make regular disaster recovery backups.

There are similar Archive buttons on the main page: one archives the current occupation and the other archives the entire current project.

The download tool does not provide a method to restore these backups, however they are standard ZIP files and the Windows operating system does include a tool to decompress them.

'GPS Mounts on Drive'

This is the drive letter that the GPS receiver was last found on. Don't worry if the drive letter changes when you plug in your receiver, the program will automatically find the receiver when you try to download data.

If you want to verify that the GPS receiver is connected and the receiver has successfully mounted as a drive, press 'Find GPS'.

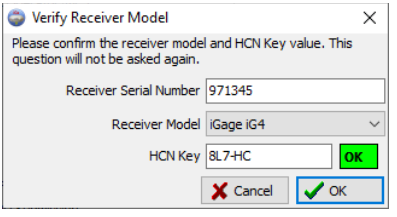
> Note: If you manually delete every single file and folder on the GPS receiver, the program won't be able to automatically find the receiver until after the GPS has recorded at least one file.

'Update GPS Model'

(Shown only when Advanced selected.)

The GPS Model is written into the receiver at the factory. If you delete ALL of the files on the receiver or format the receiver (it is a standard flash drive) it is possible that it will lose its receiver type.

With the receiver attached to your computer with the USB cable, click on the 'Update GPS Model' button to display this dialog:



Use the drop down 'Receiver Model' to change the receiver type.

If the HCN Key has been lost, you will find it on a white sticker inside the battery compartment.

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.

Click the 'OK' button to store the receiver type and HCN key on both the receiver and your computer.

'Cleanup GPS'

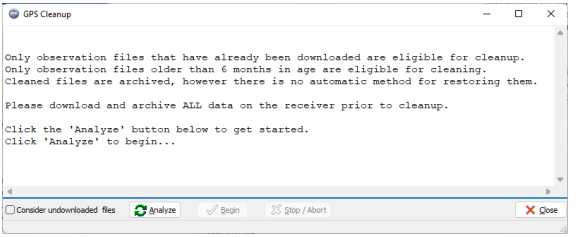
Receivers have different amounts of internal memory available to store observations in. Some receivers will automatically delete older files to make room for new observations. Other receivers like: X91+, X900+, X90, X900S, iG3, iG4 will eventually fill up.

Clicking the:

Will analyze the attached receiver and assist in cleaning up older files. Only files that have previously been downloaded (this can be overridden) and are older than 6-months are

eligible for deletion. All files are backed up to a special folder on your computer prior to deletion.

After clicking 'Cleanup GPS' this dialog will be shown:

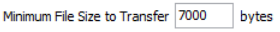


Click the 'Analyze' button. The cleanup tool will display a summary of the space used, space available and the space that will be recovered if cleaned.

Click the 'Begin' button to start the cleanup process. Each cleaned file will be copied to the '__GPSBackup' folder under the 'Base Project Folder'. After all files eligible for cleaning are copied and deleted from the receiver, all empty folders on the receiver will be removed.

'Minimum File Size to Transfer'

(Hidden when Simple)



Every time you turn on the GPS receiver, it will attempt to track satellites and open a new occupation file. Often several small junk files will be created that don't have any meaningful data and are of no value.

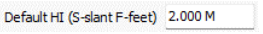
The download tool will automatically ignore files smaller than this minimum value. This keeps useless files from cluttering your computer.

'Show UTC Time'

When unchecked (the default,) the download tool will show the observation start and end times in your local time zone. If

you check 'Show UTC Time', then the times are displayed in UTC time.

'Default HI'



When you download an occupation from the receiver, this HI will be the default associated with every occupation. You can change the HI for each individual occupation later, this is just the default.

If you ALWAYS use a 2-meter range pole, then this value will always be 2.000 M 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 a 'UNKNOWN EXT NONE' and adjusts your actual HI to reflect the generic antenna L1 offset.

'Default Agency'

Enter your company code here. This value is placed into every RINEX file that is exported. You can override this value on a file-by-file basis.

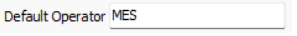
Typically, the Agency is 2 to 6 characters in length however the RINEX definition allows values up to 40 characters in length.

Clicking the 'Agency?' button will launch your web browser to the NGS site:

https://geodesy.noaa.gov/FGCS/BlueBook/annexc/annexc.index.shtml

Where you can read about how to apply for a unique code recognized by the NGS.

'Default Operator'

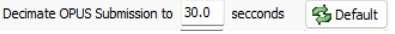


Enter the default name of the operator / observer here. This value is placed into every RINEX file that is exported. You can override this value on a file-by-file basis.

Typically, the observer is 2 to 10 characters or the operator's initials, however the RINEX definition allows values up to 20 characters in length.

'Decimate OPUS Submission to ...'

(Hidden when Simple)



When you submit a file to OPUS, it is always decimated at the NGS server to 30-second epochs (recording interval = 1-observation every 30-seconds.)

Clicking the 'Default' button sets the decimate value to 30-seconds and selects RINEX 3 format.

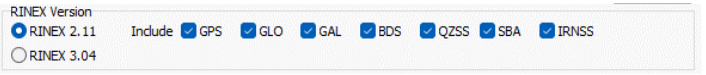
The default recording interval your receiver is probably 5 or 1-second.

By pre-decimating the RINEX file before uploading, the file size is greatly reduced speeding transfer to the NGS. This makes the upload process much faster while having no impact on the resulting solution.

Observations exported with the 'Export' button, submitted to RTX are not decimated.

RINEX Version

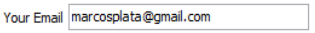
(Partially hidden when in Simple mode)



You can select RINEX2 or RINEX3 files for use with OPUS and RTX. As of 2022, RINEX3 is suitable for all online services and is preferred.

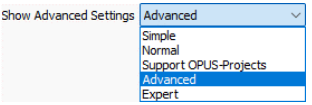
If you select RINEX2 then you can individually remove observations from GNSS constellations.

'Your Email'



When you submit a file to OPUS, you need to provide your Email address so the OPUS processor can return a solution to you. The email address that you enter here will be automatically entered for all submissions performed by the program.

'Show Advanced Settings'



This setting determines the complexity of the iGx-Download program.

Simple: *(the Default setting)*

Hides archive functions, Minimum File size, Receiver Model, Antenna Name Decimate setting, QC function, Export to RINEX button, OPUS-Projects, the GPS Settings tab and the Log tab.

Normal:

Shows everything except for OPUS-Projects, the GPS Settings and Log tab.

OPUS-Projects:

Displays the OPUS-Projects checkbox which allows automatic submission to a NGS registered project.

Advanced:

Displays the GPS Settings and Log tabs.

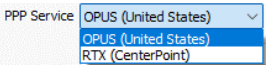
Expert:

Displays the ‘View HCN Header’, ‘View RINEX Header’, ‘Force Agency-Operator’ buttons and the trimming tool debug screen.

Typically, you will never need to use the 'Advanced' or ‘Expert’ functions.

‘PPP Service’

(Hidden when Simple)

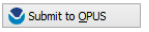


The iGx download tool supports the OPUS and RTX services directly.

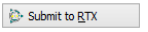
Support for AUSPOS and IBGE has been removed, use the ‘Export’ button to build compatible files for these services.

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: 

http://geodesy.noaa.gov/OPUS/

RTX: 

http://trimblertx.com

Export 8.3 Filenames

(Hidden when Simple)

If this box is unchecked then the iGx download program submits files using filenames like this:

917226_14_072_A0.OBS

The device serial number, the year, the Julian day of year and the observation number are included in the filename.

Checking this box results in exported filenames like:

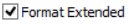
10050720.14O

Where 1005 is the Point ID, 072 is the Julian date, 0 is the observation number, 14 is the year and O indicates an observation file.

Because OPUS includes the filename in the generated report, we recommend that you check the 'Export 8.3 Filenames' option.

Format Extended

(Only shown when PPP Service = OPUS)



The NGS returns three styles of reports:

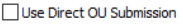
Standard: Single Page Report
Extended: Standard + baseline details + State Plane in (s)Ft
Standard + XML: Single Page + XML

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. We recommend keeping 'Extended' checked by default for this reason.

Prior to submitting an OPUS report, you can modify any of the Option settings, checking this box results in the extended output initially being checked.

We recommend that you check the 'Format Extended' box.

Use Direct OU Submission



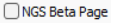
Checking this box allows the program to skip displaying the NGS submission web page. All information is uploaded automatically without operation assistance.

If you use direct submission, then you will not be able to specify CORS stations to include and exclude. OPUS Projects and extended outputs are supported.

We recommend that you enable the 'Use Direct OU Submission' checkbox if you are not an expert user. It greatly simplifies the submission process.

‘NGS Beta Page’

(Hidden when Simple)



When checked the NGS OPUS Beta submission is used:

```
https://beta.ngs.noaa.gov/OPUS/
```

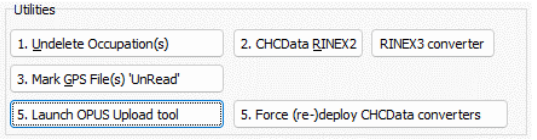
when unchecked:

```
https://www.ngs.noaa.gov/OPUS/
```

This checkbox is not honored when ‘Use Direct OU Submission’ is checked.

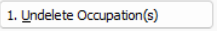
Utilities

(Hidden when Simple)



Additional utilities for working with observations are included.

“1. Undelete Occupations”



When you delete an observation, it is 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 folder.

“2. CHCData RINEX2/3 Convertor”

Files are stored on the receiver in a .HCN binary file. When the iGx download tool downloads a file, it is automatically

converted to standard RINEX2 or RINEX3 using the CHCData tool.

'CHCData RINEX2' launches the CHCData tool in RINEX2 manual mode. The 'RINEX3 Converter' button launches the converter in RINEX3 mode.

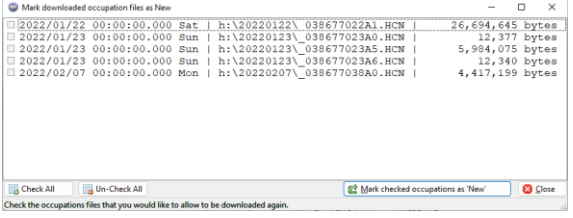
Clicking this button runs the CHCData tool in manual mode. You can browse for HCN files and manually convert them to standard RINEX files. Results are always placed in a subfolder named 'RINEX' under the file to be converted.

"3. Mark GPS File(s) UnRead"

When files are downloaded from the receiver, they are not deleted from the receiver, but the filename on the receiver is modified to begin with an underscore '_'.

This function allows you to specify a single or multiple files to mark as 'unread' or 'New'. Once a file is unread the next download action will re-download and convert the file.

When you click the 'Mark GPS File(s) UnRead' button, the tool will search the currently attached receiver for occupations which have already been downloaded. The occupations will be listed by observation date (the latest occupations will be at the bottom of the list):



Check the occupations that you would like to redownload.

Click the 'Mark checked occupations as 'New'' button.

Return to the 'Occupations' tab in the download tool and click the 'Download' button.

“5. Force (re-)deploy of CHCData converters”

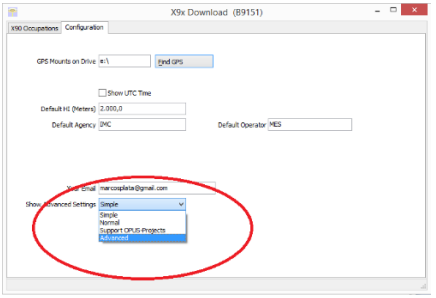
(Visible when in Expert mode)

If you use CHCData in manual mode (either RINEX2 or RINEX3) it is possible to damage the CHCData conversion defaults. This button will delete the existing deployment and redeploy both the RINEX2 and RINEX3 tools with the recommended settings.

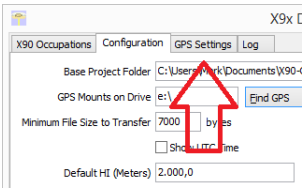
GPS Settings

(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:



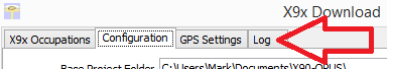
GPS 'Settings' Tab

The GPS Settings options on the download tool are not compatible only with these receivers:

X90, X91+, X900+, X900S, iG3, iG4

For other receivers use the Wi-Fi connection to make recording interval changes. Check the hardware manual that came with your receiver.

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.)

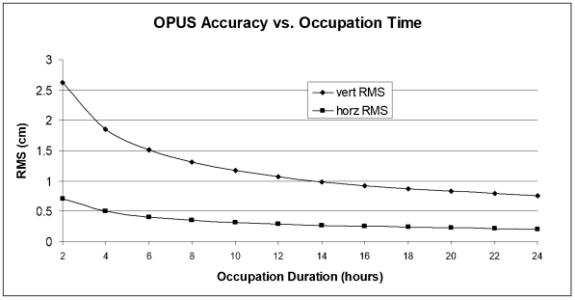
From the NGS Website:

> "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 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 contributions to vertical accuracy computed by OPUS 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.



OPUS-RS (Rapid Static)

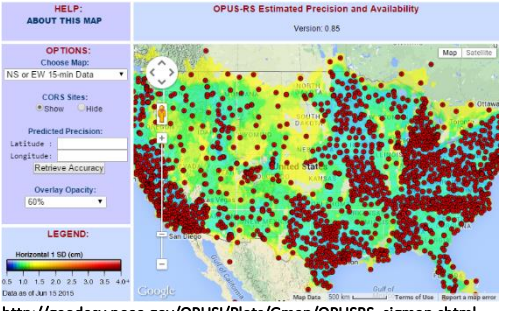
Standard OPUS-Static sessions require 2-hour observations. OPUS-RS sessions can be as short as 15-minutes.

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 high line of Montana or in North or South Dakota, OPUS-RS probably will not work and you will have to collect at least 2-hours of data for submission to OPUS-STATIC.

Prior to collecting data for OPUS-RS you can check the latest status map to insure 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 predicts a best case accuracy for a 15-minute or 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.

25% of all submitted OPUS-RS occupations fail. Please read the "Best OPUS Practices for New and Experienced Users" section of this User Manual on page 42. It will save you time and failed jobs.

OPUS-Projects

OPUS Projects is a relatively new online tool. Its use requires taking a NGS training class. 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 resolution 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 may not help as more data may never become available. OPUS-Static is the solution for locations where OPUS-RS is not dependable.

Interpreting OPUS Results

When you receive an OPUS solution by email from the NGS if formatted using a fixed space font it will look like this:

```
      USER: testbench@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
```

The most important indicators of the quality of an OPUS solution are highlighted in yellow.

Here are some general rules to help judge the quality of a solution:

> 90% observations used or > 80% # Fixed Ambiguities
> 50% Fixed Ambiguities or > 95% observations used
Overall RMS < 0.030(m)
Both Lat and Lon Peak-to-Peak < 0.030(m)
Ellipsoid Height Peak-to-Peak < 0.040(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) unless you know you want IGS framed results.

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 Peak-to-Peak error estimate for the orthometric height includes the error estimate for the GEOID in addition to the Peak-to-Peak error estimate value for the ellipsoid height.

US Survey Feet vs. International Feet, Scale Factors

IMPORTANT: 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 in the nominal foot type for the area .

If your survey is at a significant elevation (> 100 feet) you may need to apply the Combined Factor (listed on the OPUS report for both UTM and State Plane Coordinates) to inversed distances to match optical shots made at ground level.

Getting ready to use OPUS

OPUS is a great tool for grounding your survey. But OPUS is part of a larger toolset. Before you begin a project take a moment to think about the 'Big Picture':

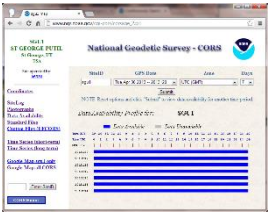
A. What are your GOALS?
    a. Required accuracy
    b. Horizontal and Vertical Datum; Geoid model choice
    c. Survey style: OPUS-Static, OPUS-Rapid Static, OPUS-Projects
    d. Consider FGDC Standards:

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

B. Are there passive marks available for control?
    a. Will CORS, passive or a combination control the survey?
    b. Are local passive marks recoverable, undisturbed, sufficient quality, stable and GPS friendly?
    c. Where are the nearby NGS CORS stations? This will determine 'Rapid Static' or 'Static' availability.

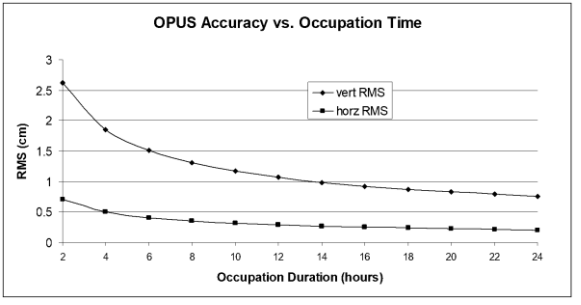
C. OPUS-Rapid Static Requirements
    a. Find the closest 9 CORS sites with available observations
    b. A minimum of 3 CORS stations within 250 KM are required.
    c. Your site must be within 50 km of a polygon created by the remaining available CORS.
    d. If the eligible CORS count is low, check the past reliability of recent observations to insure that there is a high probability of sufficient sites for OPUS-RS to compute a solution. Use the CORS 'Data Availability' to

check for recent observations:



D. Mission Planning: Satellite Availability and Network Planning
    a. How many receivers will you use for simultaneous observations? If you are using OPUS-Projects then More = Better.
    b. Checkout online 'Mission Planning' tools for U.S. satellite availability using reasonable masks (>15 degrees) during collection periods. If there are any periods with fewer than 6 SV's or PDOPS higher than 3, plan on occupying points longer.

E. How long will you observe a site? Again:

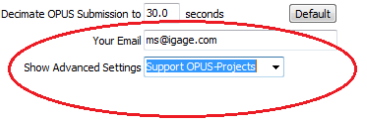


F. Are your sites GPS compatible? Are there obstructions higher than 10 degrees?

Using OPUS-Projects

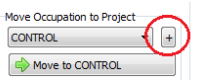
If you are contributing occupations to a registered OPUS-Project, the iGx tool can assist you when uploading files into your project by automatically entering the NGS project ID:

1. Turn ON OPUS-Projects support. On the 'Configuration' tab, set 'Show Advanced Settings' to "Support OPUS-Projects" or "Advanced":

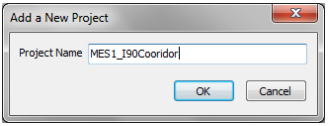


2. Add the NGS registered OPUS-Projects 'Project Identifier' supplied by your project administrator:

Click the "+" button

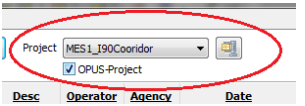


Enter the exact identifier



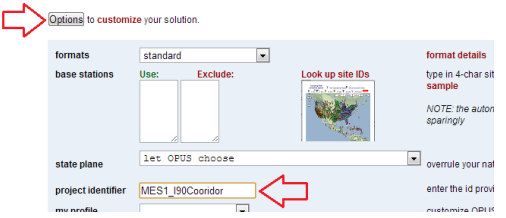
as the new project name.

Select the new Project



and check the 'OPUS-Project' checkbox under the Project selector.

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:


Options to customize your solution.
formats
standard
format details
base stations
Use:
Exclude:
Look up site IDs
type in 4-char sit
sample
NOTE: the autor
sparingly
state plane
let OPUS choose
overrule your nat
project identifier
MES1_I90Cooridor
enter the id provi

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 failures.

The 'OPUS Error Message' Joke

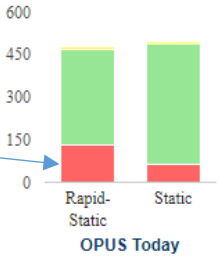
> "The NGS processing engine has a big fishbowl with 500 possible error messages printed on little slips of paper. If a job fails, the OPUS processor removes the five best error messages from the fishbowl. Next the fishbowl is shaken and three to five slips are randomly pulled from the fishbowl and returned to the user."

OPUS error reporting is getting better. Someday this joke won't be funny anymore.

But you should remember this: 'you are not alone.' Every-Single-Day a substantial portion of all OPUS submissions fail and most fail with a confusing error message.

#1 OPUS-RS is Dicey

When you submit OPUS occupations, there is a graphic that shows the daily number of jobs and the daily success rate. **On most days over 25% of all submitted OPUS-RS (Rapid Static) jobs fail!**



Relatively few OPUS-Static jobs fail, and most of the Static jobs that fail initially will successfully process when resubmitted the following day.

When using OPUS RS or Static longer occupations are **always** better. OPUS-Static is always more reliable than OPUS-Rapid Static.

Please remember if you are submitting 15 to 30-minute OPUS-RS occupations **they WILL fail regularly**. Don't be surprised and don't blame your receiver.

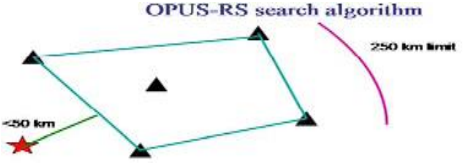
#2 Only Some Submissions are being returned by OPUS

OPUS always returns an email. **Always**. But missing solutions is a VERY common issue.

If you are not getting solutions or an error messages back, the missing solutions have been trapped in your email SPAM filter or you have entered your email address incorrectly on the submission form.

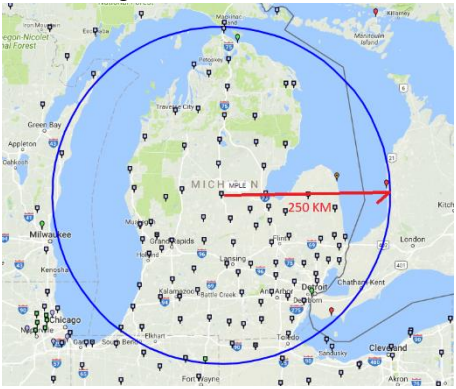
#3 OPUS-RS is Very dependent on the Number, Availability, Proximity, Distribution and Quality of nearby CORS Stations

The initial stage of OPUS-RS processing determines if a network of three to nine CORS stations within 250 KM of the user location can be built.



The user location is allowed to 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 a lot 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.

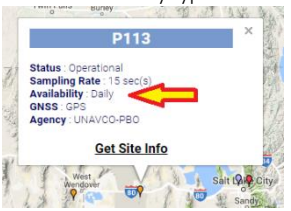
If you are in the middle of Utah there are very few CORS sites available on a good day:

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 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.

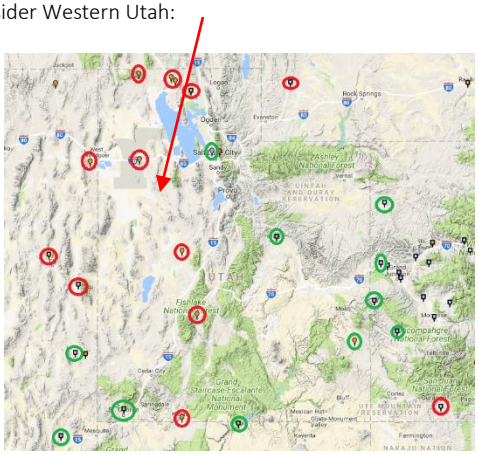
If your OPUS submission has sufficient nearby hourly stations, then you can probably wait 45 minutes after the top of the hour following your file collection and an OPUS submission will be successful.

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 of 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.

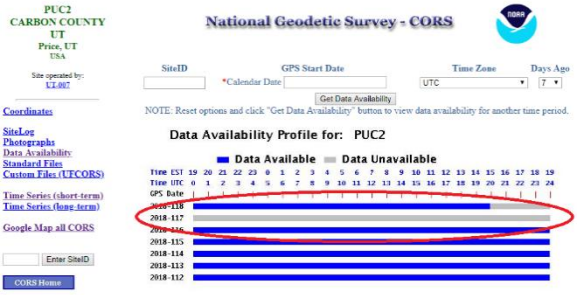
Because no other nearby CORS data is available, OPUS has used hourly files from CORS sites over 250 KM away to process the second file. These long baselines have much higher uncertainty and result in higher peak-to-peak error estimates. If we resubmit the 2nd occupation on Wednesday, it will have excellent results, similar to 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 has to 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, so if a baseline solution appears to be noisy, then (obviously) your rover data must be at fault.

In other words, any 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.

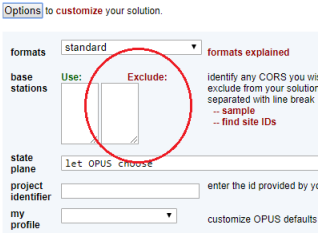
OPUS error messages are structured based on this assumption of highest quality CORS data and low expectations of your user data quality.

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

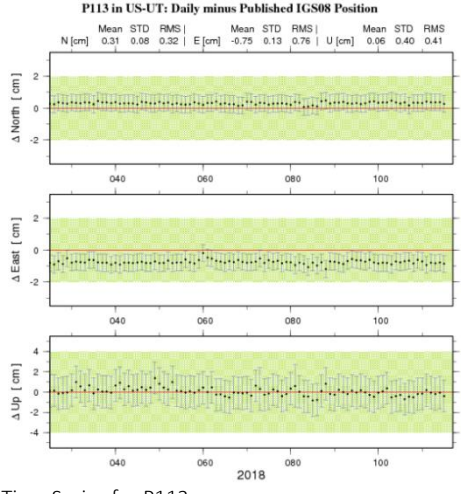
Stuff happens and some of the CORS stations are unreliable and a few are horrible. No matter how bad a station might be, NGS CORS will collect the bad data and the OPUS engine will use the bad data and then blame your occupation for all issues.

The only effective control that a user has is the ‘Exclude’ box under ‘Options’:



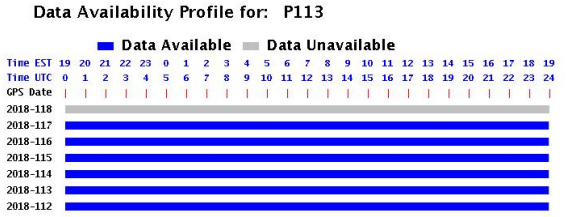
But how can you determine if a CORS station should be excluded?

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

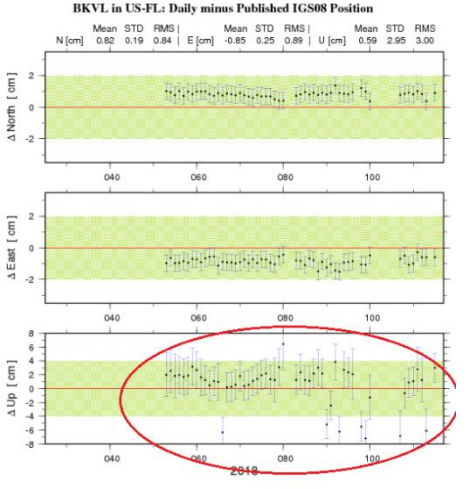
You also want to look at the recent ‘Data Availability’:



Availability for P113

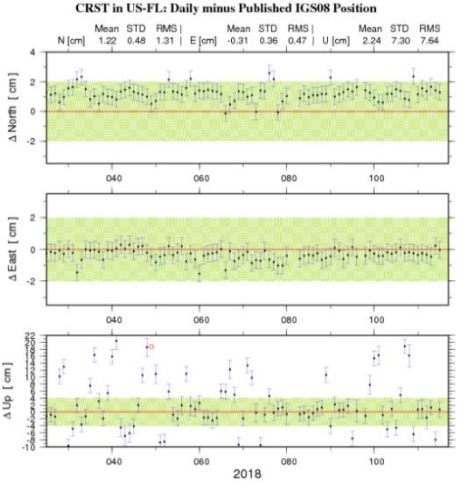
The position trends are very stable and are within 1 cm horizontal and vertical of the published IGS08 positions. The average locations and all of the error bars are fully contained in the green error bands. Coupled with continuous recent Data Availability this station appears be a great CORS resource.

However, if you look at a station's Time Series and it looks similar to this:



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

Even worse sites abound in the NGS array:



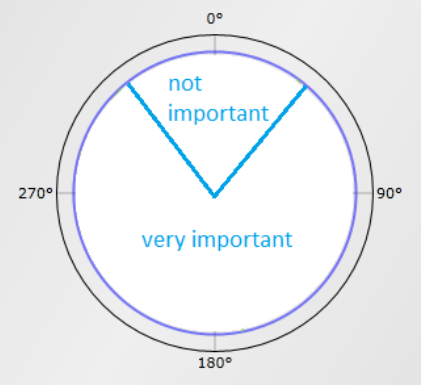
These stations and all the others like them are unsuitable for any processing use. It is your responsibility to exclude them from your solutions.

#8 GPS Suitable Locations

The NGS recommends that you submit GPS occupations collected in **GPS suitable locations**. However, very little NGS guidance is provided for what is 'GPS suitable' in the context of OPUS submissions. Let's compare good and bad locations.

Best Case Scenario

The best possible site would have a totally clear view of the sky above 10° at all azimuths where there is a possibility of a GPS satellite being in the sky:



Obstructions to the North not important in North America

Note: OPUS will process observations down to 10° elevation so you should set your receiver to start tracking a few degrees below 10°, or just allow it to track all the way to the horizon (0 degrees Elevation Mask.)

Attributes of a great GPS location for collection OPUS ready occupations:

- No overhead power lines
- No trees: leaves on or leaves off
- No power poles (wood or metal)
- No radar or radio paths that cross over the top of the receiver
- No chain link fences nearby
- Locations under busy landing paths are undesirable
- No large 'GPS reflective' surfaces (metal roofs) nearby: avoid multipath
- Receiver facing correct direction: usually MMI (Man-Machine-Interface AKA the push buttons), antenna connector or North fiduciary pointing to the North.
- Receiver mounted very securely on well braced, fixed-height tripod

- No chance of giant birds sitting on your antenna during occupations:

This picture is an actual GIANT crow sitting on an actual CORS antenna!

- No chance of trucks higher than your antenna passing nearby during occupation

Yes, users get great results in challenging locations all the time. And you may be lucky, but these are real rules and you should consider respecting them.

Worst Case Scenarios

All of the sites presented below are actual customer sites (or in some cases slightly obfuscated locations to save embarrassment.)

Remember that during times of low DOP (see the mission planning section of this document) you may get reasonable OPUS-Static and OPUS-RS solutions at these challenging locations. Longer (3-hour) and very long occupations (over 8-hours) may be dependable because the high-DOP conditions are bridged with times of good coverage. However, in general, you should avoid the following scenarios.

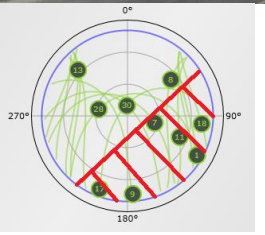
Semi-Trucks and Trains

This bench mark is 3 feet north of the eastbound edge-of-pavement of I80 near Green River Wyoming:

It has fantastic views in all directions, unfortunately a semi-truck drives by every 20-seconds and completely obscures a receiver's view of the southern sky. This forces the receiver (and OPUS) to lose lock. This is a **BAD** location and will greatly increase the RMS error estimates and drop the percentage of observations used.

Large Structures to the South

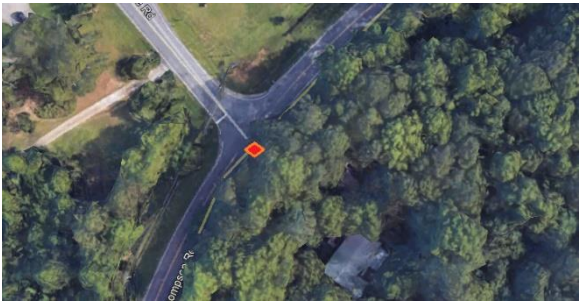
This 8-story parking garage is 40 feet to the southeast of the brass rivet in the street. The red arrow points South.



This is a **bad** location because the structure completely blocks the antenna's view to the South and East.

Huge Trees to the South

BAD: This site is not suitable for GPS observation because of large trees to the south:



Southern sky is fully blocked and trees obscure view directly overhead.

We can debate:

- leaves on, leaves off
- pine needles vs. broad leaves
- length of pine needles
- size of tree-trunks
- size of branches

But trees above 10° to the East, South or West are bad and 100% canopy is really bad.

Huge Trees Overhead

Trees (with or without leaves) directly above the antenna prevent the receiver from having a clear view of the sky. Even though this location has open water to the South, it is directly underneath large trees. Water can also be a source of significant multipath (see the next section). This is a **BAD** location:

Large Reflective Surfaces Nearby

Your receiver trusts that the signals that it receives have traveled directly from the satellite to your antenna. Large nearby surfaces present opportunities for the receiver to have signals arrive having taken multiple paths (multipath) or entirely the wrong path.

Not only do these tanks block the view to the South, but they also have metal-reflective surfaces that provide a multiple length signal path for every signal from every satellite to the observation area:

(this image is looking South)

Flat metal surfaces are bad. Corrugated metal surfaces (like corrugated roofing) are even worse. Some mirrored glass windowing used on building exteriors is reflective at microwave frequencies. Box truck bodies, metal buildings, metal roofs and open water are all potential sources of multipath.

Deep Canyons

Locations at the bottom of deep canyons, especially East-West trending canyons will present full, 100% obstruction below the ridge line to the South. Most of the GPS satellites are to the South. This is BAD.

RBUT (below) is a NGS CORS site, and is the closest CORS site to the iGage office in Salt Lake City Utah. This site is hindered by a solid mountain 30° mask to the South. This could be a challenging location for GPS observations and is not a great location for a CORS site.

Moving further North would gain elevation, effectively lowering the southern mask.

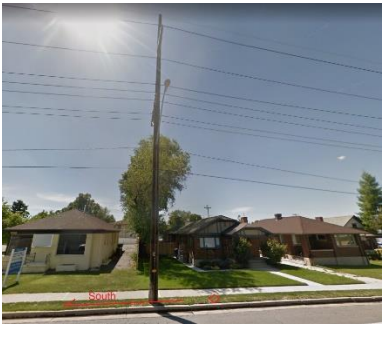
Power Poles

< 500 KV DC Transmission Lines and Tower

This class-1 elevation bench mark with measured gravity is unfortunately in a location that is no longer suitable for GPS observations. It was set prior to the construction of the powerline. This is a BAD location.

You should avoid locations that are under high voltage transmission lines and have large steel towers directly to the south.

Smaller power poles and lines are also unacceptable, especially if they are south of the occupation site:



#9 Optimizing Occupations in the Real-World

Receiver Placement

In North America, the most important sky is to the East, South and West (because there are never any GPS satellites directly north.) So, if you are setting up in a field that is surrounded by large trees, locations in the middle of the North side of the open area are preferable because the southern sky effectively opens up:

Longer Observations

OPUS-RS is especially vulnerable to bad sites. If you think a site may have problems, try to collect over two hours of data so that you will have the option of using OPUS-Static. You can always trim the 2-hour observation file and also submit it as a Rapid Static job in addition to the Static job.

A six-hour occupation may return great results at a site where 2-hour occupations fail. More-time in adverse locations is always better.

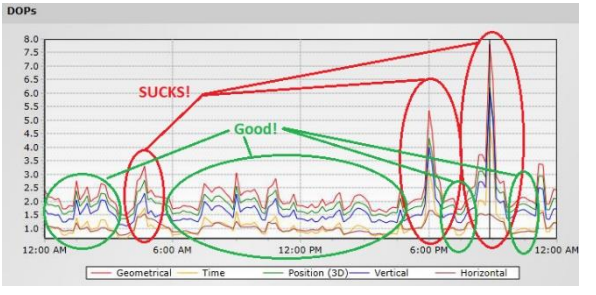
#10 Mission Planning

With modern GNSS RTK receivers that track lots of satellite constellations and lots of signals, mission planning is no

longer required. A full GNSS receiver tracks so many satellites that there are no bad times..

However, OPUS is **GPS only** and mission planning should be used to select better times to occupy sketchy locations. Especially if you are using OPUS-RS.

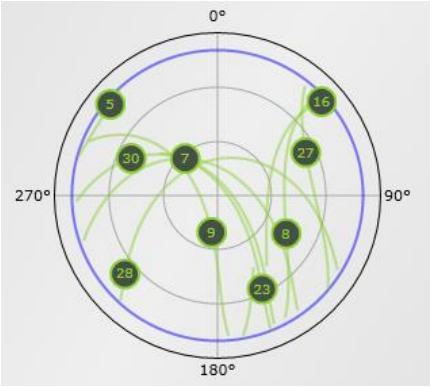
Here is a typical GPS Only Mission Planning example:



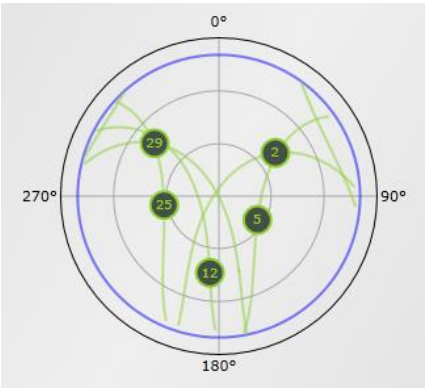
Lower DOP is better than higher DOP. You can see that most of the day, DOP is excellent. Most OPUS submissions will be successful. However starting at 5:30 pm there are large DOP spikes.

At this location, on this day, any one-hour OPUS-RS occupation from 5:30 pm to 9:30 pm will certainly fail. However 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.

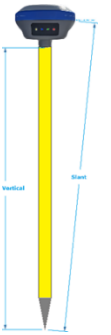
The change in satellite constellation, which determines PDOP is why a receiver will work one day and then not work in a nearby location at a different time.

#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 on page **Error! Bookmark not defined.** in the **Error! Reference source not found.** section of this User Manual.

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 of these errors are eliminated if you use a fixed height 2.0 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

Check the User Manual for your receiver for details.

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.

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 / 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.

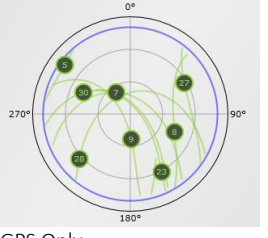
#12 Why does Modern RTK work where OPUS fails?

Yes, OPUS is substantially more finicky than modern GNSS RTK. OPUS jobs routinely fail in places and at times that RTK works flawlessly. There are two primary reasons: number of satellites and baseline length.

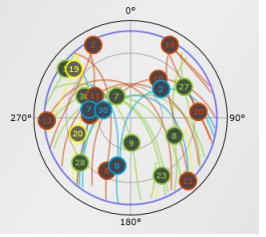
Number of Satellites and Signals

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 receiver tracks GPS, GLONASS, Galileo and BeiDou satellites, OPUS currently only uses the GPS observations. So a great constellation like the one on the right is reduced to the minimal constellation on the left.

A modern GNSS RTK receiver has and **uses** more signals at all times than the OPUS processing tools.

Baseline Distance

OPUS processes GPS baselines from your receiver all the way back to each individual CORS station. Typically these will be 45 KM (28 miles) to 150 KM (93 miles) baselines. In some areas the nearest CORS station might be 250 KM distant!

RTK processes the baseline from your RTK Base to your RTK Rover which typically will be less than 10 KM (6 miles.)

Short baselines 'Fix' more easily and have substantially less noise.

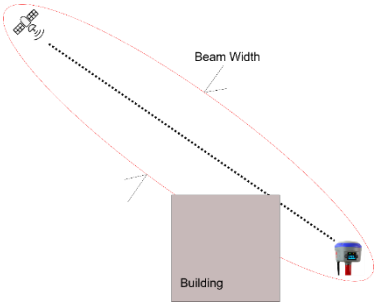
#13 Fresnel Zone Considerations

Most GPS users think of the radio path from their receiver to each of the satellites is like a small laser beam. This is incorrect.

The GPS beam width is spread out in a cigar shaped area known as the 'Fresnel Zone'.

Fresnel is pronounced with a silent-s: Frenel), named after French physicist Monsieur Fresnel.

Wikipedia has an excellent article on the Fresnel effect: https://en.wikipedia.org/wiki/Fresnel_zone; be sure to check out the section on 'Fresnel Zone Clearance' mid-article.



The Fresnel effect explains for why your GPS receiver will track a satellite which is fully behind a building or ridgetop. The beam width is wide enough that a portion of the signal reaches the GPS receiver, even though the beam's center is fully blocked by the building.

Tracking a satellite means that the satellite is 'visible' to your receiver, however just tracking is not sufficient to accurately evaluate a carrier-phase position.

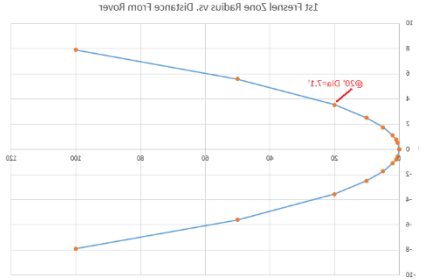
To compute an accurate position, your receiver needs a very clean signal with few reflections, obstructions or delays. Any object blocking a part of the beam can be a source of reflection, attenuation or delay.

Clear path means that you don't just need a small opening in the trees for a laser beam to shoot through. You need an opening in the trees large enough that *most* of the energy which is spread out over the Fresnel beam width reaches the receiver with no obstructions.

How wide is the Fresnel beam along the path? Much wider than you think!

Here is a beam-width chart for GPS L1 (1.575 GHz):

Distance	1st Fresnel Dia
0.0	0.0
0.5	1.1
1.0	1.6
2.0	2.2
5.0	3.5
10.0	5.0
20.0	7.1
50.0	11.2
100.0	15.8
33000000.0	6414.3



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

At the midpoint between your receiver and the satellite, the Fresnel beam is over 6,000 feet in diameter! And that is for the signal for a single satellite, multiply this by the number of tracked satellites and there is signal energy everywhere.

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!