WSRN – Frequently Asked Questions

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I can't connect, have my logins been turned off?

No, unless it is an expired test account period. WSRN otherwise never disables logins for any reason without contacting the user directly beforehand. A rare reason for disabling is an unpaid invoice, but even then, we do not disable without direct contact first. The exception is the free 90-day test accounts; those automatically disable after 90 days. If you attempt a login with and incorrect password 10 times, it may lock. In that case, contact us immediately and we can do a reset. If you cannot log in, it is likely for reasons discussed below.

I can't connect, is there something going on with the network today?

Very rare. Network outages are rare but can happen for various reasons. For such contingencies, we operate redundant systems that are identical without any differences in performance. The user can switch to another server and caster at any time. The quickest way to see if there is an issue with either system is to go to the respective web pages: www.wsrn.org or www.wsrn3.org and open the sensor map. You do not need to log in to the webpage to see the sensor map, but you could login in to test your logins. It is a good practice to instruct your crews on how to switch from one caster to another.

Are you doing maintenance on the system right now?

System maintenance and updates are done after hours, and typically on weekends (e.g., monthly security patches). If there is a major upgrade planned that could take one of the redundant servers offline for many hours, we send notices a month in advance via the user email list (for those who opt in to receive email notices). For whatever reason that a sever might be down (individual server uptime is over 98%) it is extremely unlikely that both would be down at the same time. Make sure your crews know how to switch casters when they need to (See the recommended presets section towards the end of this list).

My logins are OK, and the network looks OK, why can't I connect?

This is almost always related to cellular service. It can be frustrating as you may see bars on your phone, voice works OK, and it may have worked OK on a different day, but that does not necessarily mean that data is steaming well enough where you are at that time. One easy check is to open a browser on your field data collector and navigate to a website (choose one that changes a lot as you may see a cached page otherwise). Another tool is a cell status app, like

Network Cell Info Lite, that shows the signal strength in detail (for instance, a value of -100 dBm – 110 dBm often means spotty data streaming, and -110(+) dBm can mean no data streaming).

I forgot my username and/or password, can you give them to me again?

Please keep a copy of your credentials email handy and give one to your crews. And it's always a good practice to test your gear before going to the field. We can help if you are stuck I the field and forgot your password, but it might take some time. With many thousands of logins, we have to look them up, and now that there are new security protocols applied, we can't even see the passwords in the system. We look at secure copies of the original credential emails we sent you. If we are in the field or otherwise out of the office when you call or email, we may give you a temporary login (that automatically expires in a few days) in the interim until we can look up your credentials and re-email them to you.

What can I do in a poor cell environment?

You are at the mercy of the cellular coverage, and it might be poor in that area all the time, and somewhat usable on other days or different times of the day. The cell coverage maps from the main carriers are not always accurate but can give you general idea. The carriers have been rapidly upgrading their systems and coverage. There are apps that show cell tower locations and what carriers are on each tower. If you have a built-in modem, see if you have the option of connecting an external cell antenna. It is hard to keep up on which carrier works best in which region of the state; that continues to evolve over time. The WSRN has no map of cell coverage; the situation moves too fast, and it is impractical to try to comprehensively test across the state. We rely on feedback from users, and some note that they can now get cell service in areas they could not even a few years ago.

We do get asked if there are ways to improve the signals, like with boosters. From feedback from users: some carry phones/modem for two or more carriers if they work in multiple areas across the state. Some users who use their phone as a hotspot or have a portable WiFi hotspot will put those on a telescoping rod to get some elevation; it is surprising how an extra 10' can improve cell reception in some places. If you have a built-in modem, see if you have the option of connecting and external cell antenna. Some WiFi hotspots come with an external antenna jack (SMA coax connector). There are large dipole cell antennas, and directional (yagi-style,

that you can point at the nearest cell tower). Adding a booster to the mix may not help: if you have RF 'garbage' coming, the booster may just amplify the 'garbage'. In marginal cell areas, a booster can help, but it can be hit or miss. The in-line boosters work better than proximity-styler boosters. An effective booster can cost hundreds of dollars and needs its own power source. We use in-line boosters for many of the reference stations, but those are fixed locations where we test and set up the right antenna for the location.

We have tested a last resort option for spotty cell areas: switch to single-base (but there are trade-offs). The reason this might work is that single base does not require consistent bi-directional communications with our caster like VRS does; a single base solution is a request that starts the flow, and if there are gaps in the flow, your rover will simply wait until it has enough data. The one big caveat is that if you are in an area with poor cell, there is likely not a reference station nearby, and the long-baseline, single base solution may be poor quality and inconsistent.

A key recommendation from users who encounter poor/no cell areas: collect static and or PPK and post process or use one of the commercial precise point positioning (PPP) services that broadcast from L-Band satellites (lower precision, especially in the vertical, but good in a pinch). The WSRN has a post processing service for static observations (not PPK), for account holders; see more below.

My positions are off by several feet, what's up?

Another common support call is when the user sees values off by about 4 feet in horizontal. This is a datum transformation issue. GPS/GNSS is referenced to WGS/IGS/ITRF, and the values you typically want to work in are NAD-based (i.e., national reference framework). These are two different ellipsoids, separated by about 2m at the center of the earth, which means different separations around the globe. Your field software does a transformation on the fly (i.e., the Molodensky transformation). The issue is in your settings. The WSRN is constrained to NAD83-2011, and in some brands of field software you have to choose "No transformation" or you will be double transforming, which is about 4 feet in horizontal. For example, in some Topcon field software you choose "No Transformation", and in some Trimble software you choose "NAD83" and not "NAD83-2011". Consult with your equipment vendor on this. If your orthometric

elevation values are off between 60-80 feet, that indicates that a geoid model is not being applied in your field software. Again, consult with your equipment vendor.

My positions, compared to published control values are off by several tenths, what's up?

The Earth is dynamic. Differences may be due to the age of the published values, and/or the methods used to establish them. Due to plate velocities, for example, a position in the Seattle area may have changed by half a foot over 25 years. Published values may have been established with legacy methods, or legacy reference frameworks that do not have the same network accuracy as more recent ones. Plus, the marks may have been set 50 or 60 years ago, and there may be many reasons why they might be suspect. We suggest doing checks shots on recently published NGS or WSDOT marks that have NAD83-2011 values. You may wish to use a "localization" or "calibration" (it is called different things in different vendors field software) routine if you need to constrain your project to old, published values.

What datum, or reference frame does the WSRN work in?

The WSRN constrains all reference stations to the [National Spatial Reference Framework](#) (NSRS) of the National Geodetic Survey (NGS). Currently, this is NAD83-2011 Epoch 2010.00. Vertically, WSRN stations are also NSRS, expressed in ellipsoid heights. Orthometric elevations, like NGVD88 are derived in your field or office software by applying a [geoid separation model](#), For instance, [GEOID 2018 from the NGS](#). We recommend using whatever the latest geoid model is from the NGS. You can obtain the geoid files from the NGS or your GNSS rover vendor.

Does the WSRN provide me with State Plane Coordinates?

No, the WSRN works purely in geographic references. Any plane projections are done in your field or office software. Again, talk to your vendor about how to set that up in your field software.

Does the WSRN provide grid or ground?

No. Again, this is all handled in your field or office software.

Does the WSRN provide low-distortion projections (LDPs)?

Again, those are projections that would be handled in your field or office software. To date, Washington State has not developed or adopted LDPs, though an ad hoc datum committee in WA has requested a placeholder for LDPs with the NGS, but firm plans and funding to develop them have not been finalized. If and when LDPs for WA are developed, the NGS will provide the definitions to the manufacturers and then you would likely see them in you field or office software. In Oregon, the Department of Transportation (ODOT) developed LDPs covering the highway corridors, and ODOT also operates their state RTN, but the two functions are not directly related per se.

What hardware and software are needed to use the WSRN?

You need high-precision-grade GPS/GNSS receiver and antenna, either in the form of a standard "rover", or other receiver and antenna combinations. The receiver needs to be capable of using external corrections, and can track at least GPS satellites, or multiple constellations (e.g., combinations of GPS, GLN, GAL, BDS, etc.). To receive corrections from the WSRN you will need internet connectivity, typically via a cellular connection. You will need field software that supports your GPS/GNSS hardware, it will also need to support NTRIP connections (see the NTRIP section below).

You have to set that up with a cellular carrier directly (the WSRN does not do this) and use a modem or phone with a data plan. Some rovers have a modem built into the rover head, others have a modem in the field data controller, and other users work in an app on a phone. Some users prefer a portable WiFi "hotspot", and connect their controller to it via WiFi, while others use their phone as a hotspot. In any scenario, you need to have a data plan with a cell carrier. Nearly all field software or apps for surveying/mapping is set up for NTRIP protocols. If it does not, there are free apps that can receive corrections and pass them to a receiver, but you will still need a cellular data plan. See the NTRIP section below.

Can you recommend hardware and software?

No, we are prohibited from recommending or endorsing any products. Nearly all rovers made in the past 20 years can use services like the WSRN. There are some common protocols and formats offered by all RTN globally, and there is nothing inherent in what an RTN offers that

would be advantageous or disadvantageous for any brand or model. There are a few RTN (out of many hundreds) that only provide proprietary formats. The WSRN offers the common non-proprietary services. However, depending on the age of a rover, and what constellations of satellites and signals the rover supports, you would choose different corrections. For example: we broadcast multiple correction flavors (standard formats) for each station, and subnet (e.g., RTCM3.1, RTCM3.2_MSM, CMR+) because there are some users with older gear that cannot use newer formats. See the multi-constellation section below for those broadcast correction types and mount point naming convention. Contact us if you are unsure, though your equipment dealer should tell you the format your gear supports, as well as the equipment data sheet.

The same applies to field software. We can discuss rovers and software generically. The feedback we receive from users and testing is that nearly all newer gear can achieve similar results. Shop around.

What do you mean by VRS and single-base?

VRS is a type of network RTK (NRTK) that uses data from multiple stations surrounding where you are working, and creates corrections modelled for your location to send corrections, as if you have a base right next to you with a near-zero baseline length. There are several types of NTRK, like MAC/MAX (master auxiliary approach), and FKP. Years ago, we offered the other formats but found that users did not use them and have settled on VRS. Differences in results were not significant, and we found that we could use better station spacing with VRS.

Single base is where differential-style corrections are from one individual station. One drawback of single base is that results degrade over distance, typically increasing greatly at distances of 10km or more. Real-time networks globally found that NRTK allowed for much greater station spacing; it would be impractical to be able to afford to build a network with 10km spacing. With NRTK they can be spaced at 30km-70km (depending on local conditions). That was the impetus for developing network corrections and RTN.

Can I receive WSRN corrections with my rover radio?

No. With the limited range of radios, it would be impractical to set up enough base radios to cover large areas (i.e., we'd have to put up over 1200 base radios to cover the state). Some

users though, use a modem to receive corrections from the WSRN and rebroadcast them via base radio, or various types RTK bridges. This approach is employed, for instance, for some construction sites.

Can you help me set up my rover?

In short, no. While we will try to help, we are not versed in every hardware/software combination, and that is more rightly the responsibility of the vendor that sold you the rover, through whatever support arrangement you have with them. When you receive login credentials from us via email when you first start working with the WSRN, it includes the key things you will need to put in the settings of your field data collector software, like caster address, and port. In general, you look for any screen in your software that has key words like 'NTRIP' or 'caster'.

Through years of support calls, we may have a general idea of what different manufacturers call different settings in their software, and will try to help if we can, but the best bet for settings help is to ask the vendor first. If the vendor gives you the new gear with the settings preset, we recommend you go over those (in detail) with them. Becoming familiar with the settings, and how to change them if needed, can help avoid getting stuck in the field trying to figure things out. Like if someone has changed your settings, or if you need to change them for other reasons.

Where do I find the current positions of the stations (e.g., for post processing)?

You can go to the sensor map and click on any station, then choose the info tab. That will list the live NAD83-2011 Epoch 2010.00 position and ellipsoid height of the antenna reference point (ARP) of the station. Users may need this if they are doing their own post-processing. We also provide links for IGS/NGS-style site logs (abbreviated), a PDF info sheet, KMZ, and CSV of all stations through the 'Reference Framework' page on our website.

What do the different color dots on the web map indicate?

On the sensor map, green indicates that the station is connected and in solution. Yellow indicates that we may have a connection, but that there may be an issue with data

completeness, spotty comms, or data quality and that it does not presently meet standards for inclusion in the solution. Red means we have lost connection altogether for the time being.

Why is that station down?

Stations might be down for various reasons, mostly weather in the winter. For instance, station SC03, on top of Mount Olympus can be down for weeks at a time in winter (deep snow over the solar panels). Often with often sites, an outage can be attributed be spotty comms that usually gets better in a matter of hours or a day. We can remotely fix many issues, but sometimes we have to plan a trip to the site to see what is up. Fortunately, even if individual stations are down, the network solution (VRS) is usually still fine—another reason why RTN were developed.

Is the WSRN multi-constellation?

Yes. All but two WSRN stations are four-constellation: GPS (U.S. Navstar), Glonass (GLN), Galileo (GAL), and Beidou (BDS). Plus, on the coast, some of the satellites from the QZSS constellation can be seen during different periods of the day. The exception is two of the stations built and operated by the scientific community that are GPS-only: P025 and P422. We will exclude these from VRS solutions until they are upgraded (and we have no idea when they will do that), but they are available for single base and static files.

While all but those few stations are multi-constellation, new signals on some of the constellations have only gone live in recent years, so we are in another phase of station upgrades to take advantage of newer signals. We studied logs of usage and started this latest phase of upgrades based on areas of high usage, like the Puget Sound Region, Spokane, Tri-Cities, Vancouver WA/SW region, and larger cities. We are on track for a full upgrade within the next 3 years.

What does 'MSM' mean?

This means 'multi-system message', a term used for RTCM corrections that support multiple constellations. We use MSM as a suffix for any of our mountpoints that are RTCM3.2-MSM corrections, a format that nearly all newer rovers can use. This is the format we recommend users of newer gear use so they can take advantage of as many satellites and signals as possible.

How can I try out the WSRN?

The WSRN recommends all new users use a (one-time) test account, that is free for 90 days, to make sure the service will work for their needs. The login provided automatically expires after 90 days. To request a test account simply send an email with your street address, company name (if applicable), primary contact name and email, and best phone number to get ahold of you. And tell us what day you would like the test to start. Please give us a day or two to set this up.

The login page for the WSRN asks for an 'Organization', what is my 'Organization'?

The organization is the group, or type of account you have. When you receive your WSRN credentials via email it will state your organization. For example, subscribers are in the org 'SUBS', partners in 'PARTNERS", schools and academia are in 'EDU', scientific entities are in 'SCIENCE', WSDOT is 'WSDOT', and test accounts are in 'TEST". Some other large entities have their own Org (we send that to them when they get issued credentials).

How do I get Rinex files for post-processing?

The WSRN logs 1Hz [hourly static files](#) from all stations locally (on both redundant systems), and also in a long-term archive. These are openly made available to anyone. If you are looking for static files within the past 60 days, you can use the 'Reference Data Shop'. Log in to the website (with your credentials or as a guest) and look for that option in the upper left. You create a request, choose one or more stations, a time period, type of static file you want, and sample rate. Orders must be specified in GPS time, which is (for ordering purposes) the same as Greenwich Mean Time (GMT). That is 7 or 8 hours different from local WA time depending on the time of year.

Note your order numbers. It may take a while to process the order (usually 5 min to an hour depending on how much you order), but you can log in later and see your order status. Never pick the email option (this is disabled due to potential file size issues)—choose the download option. When the order is ready you will see a download link; it will arrive in a single .zip file.

For static files older than 60 days, you need to go to the [archive at CWU/PANGA](), where the files are kept indefinitely, though they may decimate them after a few years to 15-sec or 30-sec to save file space. They may also compress them (using Hatanaka compression) and/or put them in 'gzip', 'bzip', or other formats. There are free utilities you can download online to decompress them.

What is Virtual Rinex?

Another option in the "Reference Data Shop' is Virtual Rinex. Using the same network (VRS) processing in our system, a static file is modeled from 6-9 stations around a location you specify in the order page. Other than picking a 'virtual' location it is the same steps as a regular static data order (see above). Once processed, it will send a download link of a .zip of the single Rinex file. It will post process just like any other Rinex.

Virtual Rinex was developed to be able to reduce the length of static sessions, though with as many satellites as there are now, it is not used as much. There has been a resurgence of use more recently, with UAS (drone) operators finding it can be a good option in some situations for PPK post-processing.

Please note: the storage of the specific data needed to create virtual Rinex is very storage intensive, therefore we only keep the source files for two days. If you plan to order Virtual Rinex, please do so within two days of your field work.

What is NTRIP?

You will likely see this term in the settings of your field data collector software. [NTRIP]() is 'Network Transport of RTCM over Internet Protocol'. It is an international standard for accessing real-time network (RTN) data. It was created decades ago by the BKG (German geodetic and mapping agency), when RTN were first developed, and adopted by the international Radio Technical Commission for Maritime Services (RTCM) 104 committee. The core code has been adopted by GPS/GNSS manufacturers. NTRIP consists of 'casters', like those the WSRN and all RTN hosts, that allow multiple users to access multiple 'sources', or 'mountpoints'. One analogy for NTRIP is that it is like an app that connects to a web service listing many steaming music or video channels: but with GNSS corrections instead.

The other component of NTRIP is the 'client'; the software in your field controller is the client. Required settings are a caster (typically an I.P. address of a caster), a port (e.g., '8080' for the WSRN), a user name and password, and you choose a mountpoint. See our mountpoint [naming convention guide](). Often, the field software builds list of mountpoints each time you access the caster, in some software you need to manually refresh the list. Depending on the software, if you choose single-base or network (e.g., VRS) you will see different lists. In some, you see all of the many hundreds of mountpoints.

Why are there so many different mountpoints on the list?

We need to offer different flavors 9standard formats) of corrections to serve a wide range of rovers, new and old. For instance, CMR+ (GPS+GLN) for some older rovers, RTCM3.1 (GPS+GLN) for other older rovers, and RTCM3.2-MSM (GPS+GLN+GAL+BDS+QZSS) for newer, multi-constellation rovers. We do not typically have CMRx mountpoints but can do those on request if needed (though 'MSM' mountpoints support the same sats and signals). You would not see any significant difference between results from any of the formats, except that some support more satellites. See our mountpoint [naming convention guide]().

So, for 145+ stations, and 6 VRS subnets, with 3-4 formats supported each, that adds up to a very long mountpoint list. One frustration is that the original core NTRIP code does not do alphabetical order. However, many of the field software manufacturers give you an option to list them in alphabetical order once the list is refreshed. Otherwise, keep scrolling and you'll find it eventually. Note that if you refresh when a particular station is down, it will exclude it, and you might need to refresh later when it is back up.

I can't connect, am I being jammed?

The short answer is no. Things like jamming, interference, and spoofing are extremely rare in our state. We have only verified a handful of instances in the 20 years the WSRN has been operating. Examples are mostly related to altimeter radar at the end of large runways; it only happens when that is turned on for a plane to land, it is brief, and it simply blanks out any GPS/GNSS reception. Another was near a large a naval facility on the peninsula, though that

was brief, and over a decade ago. Working under high power transmission lines is usually OK, but there have been some rare occasions where it messed up the cell and GPS/GNSS signals. Deliberate jamming is rare, and usually occurs only in combat zones. Even in those instances it is very localized, focused, and mostly brief.

Other RF interference is rare, and there are no persistent areas of interference in our state that we have been able to verify. Interference, when it is present, would mostly result in a denial of service, and not a false position. A map of persistent interference/jamming zones is: gpsjam.org. Incidents of suspected GPS issues should be, and are reported to the U.S. Coast Guard Navigation Center: NAVCEN and investigated by multiple federal agencies. Spoofing is when a party deliberately overrides signals to create false positions. It is rare, difficult to do, and would result in values being many miles off, and not just a few tenths.

There are signal jammers like the cheap "trucker jammers" that some people have used to jam their on-board GPS to block being tracked. This is very rare, highly illegal, and only a few cases have been confirmed (nationwide). Plus, the vehicle with the jammer is moving and you might not even notice the few epochs of outage as it passes by.

We have spectrum analyzers on many of our reference stations (and have never seen any persistent interference). Plus we have some portable devices, so we can investigate areas of suspected interference if need be.

Can solar storms mess up my results?

Yes, but they are very rare. There are many news alerts about various solar storms or other space weather events. However, in the 20 years we've been operating, there have only been a handful of days when we would recommend not using GPS/GNSS. Our network tracks the effects of ionospheric activity with data from our own sensors, and to see the status, log into the website and choose the 'I95 Ionosphere' option in the upper left. Only when it goes into the red would you see enough degradation to consider using non-GNSS methods.

One caveat though about single base operations: if you do single base on one day with calm ionospheric conditions, you may get different results than on a day of high ionospheric activity. Network corrections, like VRS, can model out most high iono, but neither will have much luck if

in the red. There are hazards to mixing solutions: If you start a project with one method, you may get different results when switching baseline lengths or on different iono status days.

Is single base better than VRS?

It can be, but only under very specific conditions. Single base degrades over distance. If you have a site base (that you can see from the rover, or under a km), or a station within a few km, that may yield better results than VRS on good iono days but may vary from day to day. One rule of thumb is to not use single base if you are more than 10km from a station or base. For single base to work best, the base has to be set up in as good, or better, sky conditions than the rover, with low multipath conditions, and it has to support the same constellations as the rover—and it does not get stolen.

It is possible (yet not recommended) to get fixed results from single base at very long baseline lengths, 20km, 30km, and more. We have experimented (just for fun) with getting fixes from Spokane to Seattle (but would never, ever recommend this). The problem is that you will not get consistent results at long baseline lengths as the conditions could vary from day to day, even hour to hour.

Contrary to some marketing-driven rumors from the early days of RTN, VRS does include a physical base station (PBS or PRS); a PBS code is in all VRS corrections. The model of the corrections is virtual, but there is still a tie to a fixed station. Nearly every rover that can export vectors can export the rover-PBS vector.

When I connect to VRS, sometimes I see less satellites, why is this?

It depends on the age of your rover. There are new sats and signals that were only implemented in the past few years. An older rover may not be able to utilize all of the sats and signals it "sees". In legacy VRS/MAC/FKP solutions, it would cull out some satellites that were not fixing, to create the corrections. Your rover would likely not use bypassed sats for the same reason. And your rover needs to use satellites that are in common with 6-9 surrounding stations.

However, in April 2023 we implemented a new feature that includes more satellites for ranging, even if they are not among the fixed ones used in modelling the corrections. While this does not degrade results, it may not necessarily improve results. However some tests and user feedback

have shown it can improve quality and completeness, in certain situations that may have been challenging in the past, with limited satellites. Like in some sky-view challenged locations. In short, you now use more of the sats you see in your solutions (for newer rovers).

How will the deprecation of the U.S. Survey Foot affect the WSRN?

No. Any projection to plane coordinates, and feet units is performed in your field and/or office software. There will be no changes to the WSRN related to measurement units. The WSRN operates with geographical references, constrained to the National Spatial Reference System of the National Geodetic Survey (i.e., NAD83-2011 Epoch 2010.00) and applies geographic values (i.e., Lat/Long) and an ellipsoid height in meters.

Users should consult their respective local jurisdictions and applicable state agencies for any requirements to work in international feet and consult vendors for any questions about how to apply this (if applicable) in their field and/or office software. Read more about the deprecation of the US Survey Foot here.

What are the WSRN plans for the upcoming national datum shift?

The National Geodetic Survey (NGS) is planning on a new reference framework, NATREF 2022 (but will likely be in 2025 or 2026). This is a significant shift, much like the change from NAD27 to NAD83, by as much as 4 feet in WA. The state is putting wording in the RCW/WAC to reflect this change. As we did with the shift from NAD83-CORS96 to NAD83-2011 (in 2012), our network and primary caster will be in NATREF, and we will provide an alternate caster in NAD83-2011 for a transition period of about a year.

What kind of results should I expect using the WSRN?

Just like with a base-rover RTK setup or static, there are many factors and sources of error that can affect precision and accuracy: sky view, capabilities of the rover, age and quality of the rover and what constellations it supports, multipath, user errors, space weather conditions, and (to a much lesser degree) weather conditions.

In general, you should be able to get reliable and repeatable results under 3cm 3D with newer survey-grade gear. Note that there are many 'resource grade' receivers that are only designed

to get sub-meter, sub-foot, or decimeter results; these are often used, and work well for asset or resource mapping.

What field procedures should I use to gain confidence in my results?

This is a subject that would take volumes to cover and is a much discussed among surveyors and mappers. Using the WSRN or any other RTN is not really different from RTK fundamentals for base-rover, the baseline length considerations we discussed earlier aside. All of the WSRN operations team are surveyors, and we are keenly aware that surveyors must do whatever steps and analysis may be needed to have confidence in their data—confidence enough to stand behind their data. How each surveyor approaches this process is their call based on their own knowledge and experience. Therefore, we do not weigh in on what the "best" approach would be. Instead, we can relate some of the best practices our users have developed, and what we hear from peer RTN.

As with any use of GPS/GNSS, it is a rather mind-blowing proposition that using satellites 20,000km out can deliver what is needed to get centimeter results, but there are multiple sources of error than can affect quality and repeatability. When taking a field 'shot', an amazing convergence of physics gets applied, and in short, a best practice is to see if it can do that magic repeatedly under the same conditions and in slightly different conditions. To do this, multiple observations are a best practice, doing things like reinitializing, and checking in on test marks, etc. There are tools in the many different field software packages that can help you do this in the field.

Some manufacturers accommodate multiple shots on the same point for a statistical analysis. Some users will reobserve at a different time of day, to affect a different satellite geometry (though there is less of a need for that with so many satellites up there now). There are even options in some field software to have it choose different geometries from the many satellites for you. Some may also offer an option for long observations, say minutes, and it does a kind of convergence, reducing outliers. Your vendor would be the best resource for what approaches might work best with your specific gear.

The Washington State Department of Natural Resources (WADNR) is in the process of updating their GPS guidelines document (2004). The new GNSS guidelines (available in 2023 or 2024)

will also include elements of new NGS guidelines (also being developed at this time). Once both are published, we will link them on the WSRN website.

What are the different zones on the printable map?

You should have received a PDF map of the WSRN with your login credentials email. And you can get updated versions from the 'printable map' link in the lower left of the webpage. It is a schematic, and not to scale. It indicates what stations are NGS CORS and which have been Bluebooked with the NGS. You will also see 6 zones, or subnets. To effectively operate the WSRN, manage stations in areas of different velocity, and model factors like tropospheric scaling, we run 6 operational subnets with overlaps.

You will see designators like 'PRSN' for the Puget Sound subnet, PACWA for the coast, EWA for northeast WA, etc. There are respective VRS solutions for each subnet. The subnet is the prefix for VRS solutions in the mountpoint lists. For example: SEWAVRS_MSM is the SE region, VRS type solution. And the suffix is the corrections format i.e., MSM is RTCM3.2-MSM; multiple constellations. See the Mountpoint Name Guide. It is very important that your crews know how to change mountpoints, especially if working a different parts of the state.

Are there some recommended presets for the using the WSRN?

To take advantage of our redundant services, we recommend creating two of any presets. In some survey software they call presets "survey styles". To avoid your crews getting stuck in the field, in the unlikely scenario that one of our servers/casters is down, having the presets means they can switch back and forth easily. We gave the two systems nicknames of "108" and "121" (this is from the last 3 numbers in the respective caster IP addresses). We recommend 4 presets: one each for VRS for each caster, and one each for single-base for each caster. A naming convention for the presets adopted by a lot of our users is: "108_WSRN_VRS", "121_WRSN_VRS", 108_WSRN_SB", and "121_WSRN_SB".

How far outside of the network can I use it?

While the VRS corrections will work outside of the network, the rule of thumb for base rover RTK should be followed: no more than 10km beyond the outermost stations.

How much does the WSRN cost?

For partners that invest in WSRN infrastructure or host sites, there is no additional cost. For non-partners, there is an annual contribution, or "subscription". This $1,900 per year for single login. A bundle of 5 is $5,700, 10 is $10,000, 20 for $15,000, and combinations thereof. This is invoiced annually until the subscriber fills out a cancellation form.

Can I pay by the day, week, or month, and can I use a credit card?

The WSRN is only set up for yearly accounts. This is a relatively small operation, without the resources to manage complex accounting. Often for one-off projects, a test account works. Or, if a firm only uses it on rare occasions, we look at partnership opportunities that would reflect this. There is no mechanism for accepting credit cards (which also entail high fees). Never send a check until invoiced and only then to the accounts group specified. See the process below.

My invoice has late fees, how can we avoid this?

There are always unforeseen circumstances, like a change of contact email, company name, or billing address. Sometimes an invoice might sit on someone's desk, or in an inbox once sent, or gets sent to someone no longer there. Contact us if this happens and we can work on a resolution. But the best thing you can do to avoid this is please keep the WSRN apprised of any new billing contact name, email address, and mailing address (this is a requirement specified in any new agreements).

How do I apply for a subscription?

If you have not used a test account, we recommend you do so before you formally apply for a paid account. To apply for a subscriber account, fill out, sign, and email us the combined 'Agreement and Application From'. The last page of the form is the application and is mainly just contact info. Be sure to provide a billing email and mailing address. Unless you want specific login names, we would prefer to assign those and/or simply use the same as you had with your test account (we have a preferred naming convention that helps streamline operations).

On the agreement part of the form, leave the 'Anniversary Date' blank (we fill that out when signed on this end). Be sure to indicate the number of logins requested and initial next to that. Once signed on this end, an invoice will be sent after the next 15th of the month. Never send a

check with your application, you do that once invoiced and only to the address specified on the invoice. A note about invoices: they look a little confusing, you will see odd amounts on different line items. This is an internal accounting thing, but they add up to your total for the subscription. You will be invoiced each year on the anniversary date.

How do WSRN partnerships work?

The infrastructure of the WSRN was funded and built primarily through partnerships: site hosts, contributions and loans of base receivers and antennas, power, communications, mount hardware, and software upgrades. To maintain, update, and improve the WSRN, new hardware and software is added on a continuous basis. Partners are given logins in exchange for the contribution or loan of hardware/software.

The needs of the WSRN change as we work through various upgrade phases, and especially as the technology changes and constellations modernize. For example, we may need antennas for a while, and new receivers at another time. Depending on the type/amount of hardware or software, a partner would receive 'x' number of logins for 'x' number of years. Contact us by email or phone if you'd like to hear current partnership opportunities.

We're a school or scientific institution, how can we gain access?

Most public schools are eligible for academic accounts, as do most scientific entities. There are multiple federal and state agencies partnered with the WSRN, so contact us and we can look up if you are eligible under those partnerships for accounts.

We no longer need the WSRN, how can I suspend or cancel?

If you wish to suspend or cancel, please fill out, sign, and email us an 'Intent to Cancel Form'. If you have already received an annual invoice but then realize you'd like to cancel, we can check usage logs and cancel or prorate the invoiced amount accordingly. If you wish to sign up again in the future, we can reactivate with a new agreement.

Is the WSRN run by a state agency?

No, it is a public/private cooperative, with over 150 partners. Partners include cities, counties, utilities, academic and scientific institutions, and private firms. Individual Washington State Department of Transportation (WSDOT) regions are partners, hosting many of the reference station sites, as does other state agencies. One of the founding partners, Seattle Public Utilities (a department of the City of Seattle) operates the data center of the WSRN and manages the subscriptions. This cooperative model is a bit unique among real-time networks (RTN) in the U.S. and has been operating since 2002.

If the WSRN is run by the government, why isn't it free?

The WSRN is not a government entity, it is a public/private cooperative, fully self-supporting. There is no direct state or federal funding, though we have applied for and received minor grants in the past. Subscription income is applied directly to operational costs, and together with partnerships, for infrastructure construction, upgrades, and maintenance. Every dime gets invested in the network.

Does the WSRN have an automated post-processing service?

Yes, we offer one, using the data from our stations (which includes some NGS CORS), which is nicknamed 'WAPUS". This is similar to the NGS OPUS service and can be a good supplement for various field operations.

NGS OPUS is an amazing public amenity that enables users to submit static files of 2 hours or more for post-processing, constrained to NGS CORS. There is also OPUS-RS, that can process observations for shorter periods. These can provide high-precision positions, with high confidence and fidelity to the national reference framework (datum). However, OPUS only works (presently) with the GPS constellation. And there are some challenges for OPUS in WA: there are no constraining CORS past the coast, and few in Canada. Users should look at the peak-to-peak values in the results; they may be higher than desired. Plus, the published positions for constraining NGS CORS may not be updated until they are as much as 5cm 3D out of tolerance (mainly due to plate tectonic velocities).

To provide our users with an option to post-process (e.g., when they work out of cell range, or wish to check control values) we have an automated service that constrains to our stations, and the NGS CORS (that are within tolerance). Registered users (e.g., partners and subscribers) can log in, choose 'Online Post Processing in the upper left of the page, submit static files from 6 minutes to 6 hours (please convert them to Rinex first) and our system does the baseline processing. It will return a PDF and/or an XML report of the results as NAD83-2011 geographic coordinates (not state plane; you will need to convert that yourself. Do not choose the email option (disabled), simply wait or log in again later to see a list of your orders.

We recommend that new users of this service contact us so we can set up a live walk though of the process.

Can I use the WSRN for my drone operations?

Certainly, but there can be a lot of nuance to this answer, as there are many different approaches that drone (UAS) operators take to meet their desired relative/absolute precision and accuracy goals. You can use the WSRN services, real-time and static, as part of such varied approaches—when appropriate.

For many drone operations, setting up a base on the site can be the best choice. Be that for real-time (RTK), or post-processing (baseline and PPK). This is because a very short baseline length can yield the best results. However, if your site is only a short distance from a WSRN station (e.g., under 10km on a good iono day), this could work well for RTK and/or static post-processing. Some users use VRS for their real-time data, and/or for establishing ground control points (GCP). Some users will use Virtual Rinex, requested for a virtual location on the site. Generally, working without GCP is not a preferred choice, unless you are only interested in relative precision, and even for that, including at least some GCP can be a best practice.

One aspect of processing drone data is the inertial (IMU) data, that when processed together with the observations from the on-board GNSS, in a PPK workflow, has grown in popularity. It is not as if PPK is much different than RTK (it is simply delayed RTK so to speak) but the addition of the IMU, and precise orbit data, that can make a difference. Your drone vendor can recommend software to do this PPK/IMU step. This is essentially the same as many mobile mapping workflows.

General Geodesy, Surveying, and Technology Questions?

If a question is directly related to access to your account, and/or the status of, the WSRN, we are more than happy to answer emails and calls as rapidly as we can get to them. However, there have been many instances where folks get the impression that we offer more services and support than we are chartered to. Some misconceptions:

Is the WSRN the state geodetic entity? No, even though we do operate valuable geodetic infrastructure, constrained to the NGS reference framework. If there are matters of geodetic control, then you should contact the entity that established the control, like the NGS, WSDOT, cities counties, etc. For anything NGS related, contact your NGS regional advisor.

Does the WSRN publish surveying standards? No. Surveying standards (and recommendations) are published by federal, state, local, and private entities (e.g., ALTA), and professional associations/societies. There are updated GNSS guidelines currently in development by WADNR, and we will link those when published. The WSRN offers infrastructure and corrections and does not otherwise publish any procedures or standards.

Does the WSRN support user hardware and software? No. As explained in a prior section, there are too many combinations of make and model; your dealer or vendor is a better source for this type of support. Plus, we are prohibited from doing that: we cannot be doing the work that your service/support vendor should be doing.

Is the WSRN is a great 24/7 resource for anything tech related? No. Our operations may be pretty much on call all the time, and some folks will call at all hours. But note that in user/partner agreements our core hours for support are 9:00am-3:00pm M-F. While we try to be as helpful as we can, and try to make the service work for everyone, sometimes folks take advantage of our availability—please do not do that.

Do not send your crews out there without any training on how to use the WSRN and expect us to do it. We have had calls for help with setting up total stations, and even how to put gaming apps on phones (no kidding). We are not a 24/7 tech line; we are just part of a cooperative. And

with the help of all partners and users, we have been able to keep this amenity running for 20 years, and with some of the best performance stats among RTN globally.

Some of the terminology in the FAQ is unfamiliar, can you explain those?

We aimed the FAQs at the core user groups, like surveyors, mappers, construction, etc. But there are new user segments and if there are answers in the FAQ that you'd like further explanation on, contact us by email. Then we can set up a call or online meeting (or group training) to explain; we might be delayed but will get to those as soon as we can.

Do You Send out Regular Bulletins Via Email?

If you sign up for any WSRN services, the email you provided is added to the email list for when we send out update bulletins. Your contact info is shared with no one. We usually only send to 2-3 bulletins per year, or if we are planning any major maintenance (though we typically do those after hours and users do not even notice).

If you receive a bulletin email and would like to stop receiving them, use the unsubscribe link in the bulletin. If you'd like to add a colleague to the email list, use the subscribe link in the bulletin.