Differential correction with NA2011 and the newest epoch of NAD83

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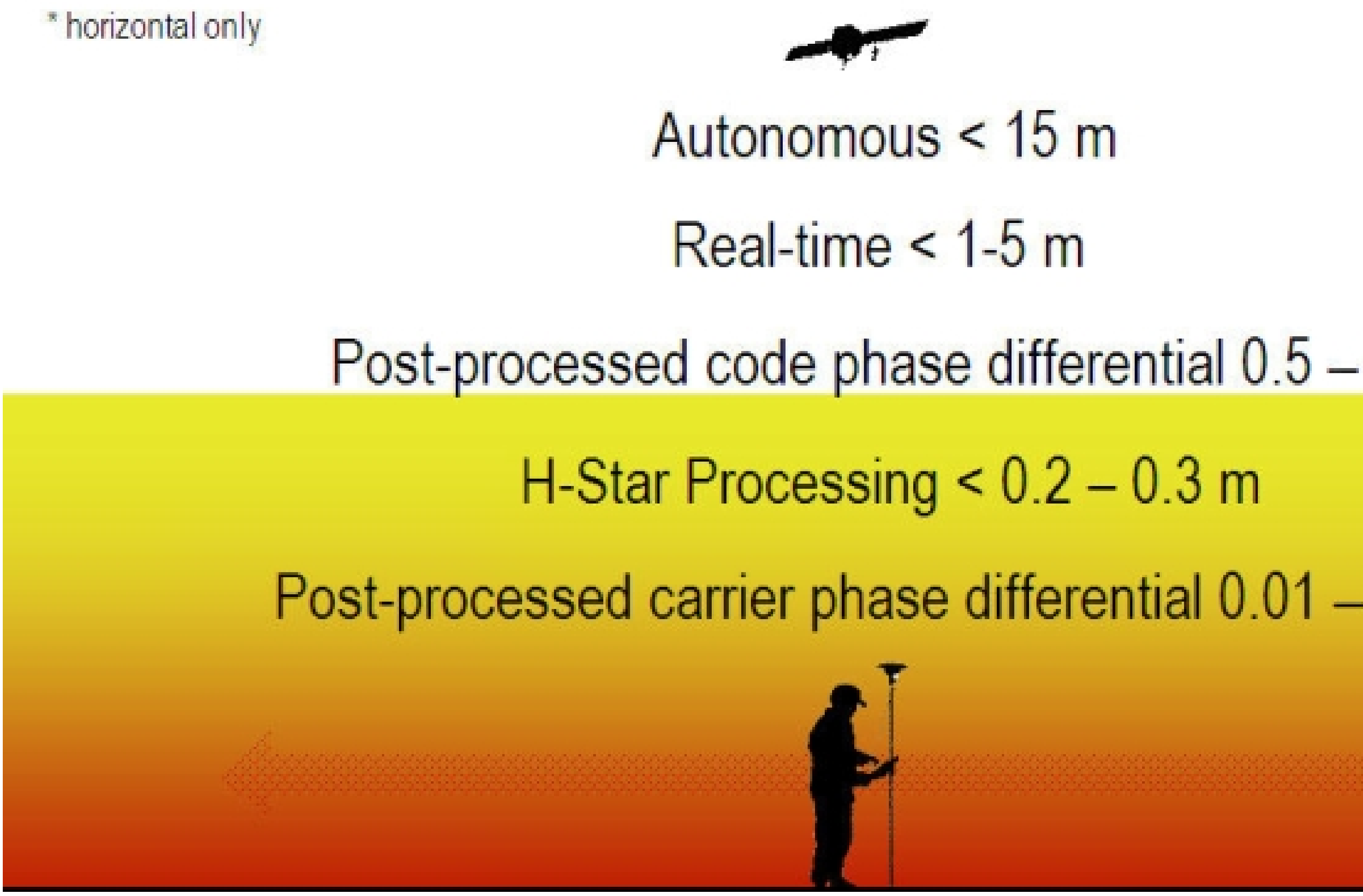
the long-awaited results of months of rigorous testing and peer review



1. Autonomous

Autonomous means uncorrected data. An autonomous, or uncorrected, position has no correction applied. It is subject mostly to atmospheric delay. These errors can be removed, however, when the positions are corrected with either the GPS Analyst extension for ArcGIS, GPS Pathfinder Office utilities or a real-time source.

The best accuracy you can expect to attain with any GPS receiver without a correction method applied is within 15 meters (2D RMS) for the horizontal measurement. Vertical accuracy is within 25 meters. This is typically true for any commercial GPS receiver from any vendor.

2. Real-time methods

Real-time correction is recommended for navigation with any receiver while in the field. The base station is broadcasting signals for corrections of rover data while in the field and is ideal for navigation purposes where corrections are needed on the spot. The disadvantages of real-time correction include less accuracy due to latency in both the correction and rover signals, different ephemeris at the base and at the rover and datum transformation issues.
For the best accuracy available, always re-correct positions with a more accurate, post-processing method upon return to the office.

Real-time data is also referred to as DGPS (Differential GPS) or RTCM (Radio Technical Commission for Maritime Services). This actually refers to the data protocol often used to deliver the corrections. Real-time base station signals can come from many possible sources: a) integrated SBAS receiver, b) internal or external beacon receiver, c) satellite differential receiver like Omnistar, d) your own base station broadcasting corrections via a DGPS radio or over the Internet or e) VRS corrections over the Internet.

a. SBAS (Satellite-based Augmentation System)

SBAS provides correction data for visible satellites. Corrections are computed from ground station observations and then uploaded to geostationary satellites. This data is then broadcast on the L1 frequency, and is tracked using a channel on the GPS receiver, exactly like a GPS satellite. WAAS, EGNOS, and MSAS are examples of satellite-based augmentation systems (SBAS).
WAAS (Wide Area Augmentation System) was established by the Federal Aviation Administration (FAA) for flight and approach navigation for civil aviation. WAAS improves the accuracy and availability of the basic GPS signals over its coverage area, which includes the continental United States and outlying parts of Canada and Mexico.

EGNOS (European Geostationary Navigation Overlay Service) is the European equivalent of WAAS.

MSAS (Multi-function Transport Satellite-based Augmentation System) is the Japanelse equivalent of WAAS and is currently under development.

b. Beacon

The US Coast Guard has an existing network of radio beacons, which broadcast data for marine and land users. Many other countries have a similar system. Piggybacking on existing hardware, GPS corrections are broadcast from the beacons at no cost to the user. To use the corrections requires a beacon differential GPS receiver. This may either be integrated into the GPS receiver such as is the case with the Pro XR/XRS receiver, or a separate beacon receiver such as the GeoBeacon receiver connected to the GPS receiver.
Real-time corrections supplied by beacons are in terms of the NAD 1983 (CONUS) CORS 96 datum rather than WGS 1984 and often require a datum transformation for their use.

c. Satellite Differential (Omnistar)

This is a subscription-based service, which transmits corrections from a network of reference stations to the service's satellites, which then broadcasts corrections to subscribers. To use the corrections requires a satellite differential receiver (either integrated into the GPS receiver such as is the case with the Pro XRS receiver, or a separate satellite differential receiver may be connected to the GPS receiver). Coverage is worldwide.
Real-time corrections supplied by the Omnistar VBS service are in terms of the NAD 1983(CORS 96) datum rather than WGS 1984 and often require a datum transformation for their use. Omnistar XP and HP services are in terms of ITRF00 (basically the same as WGS84).

d. Your own base station

If there are no base data providers in your area, you can set up your own GPS reference station.
The main requirement for a reference station is that it be situated over a very accurately surveyed reference position. Any error in the reported reference position will contribute to errors in the corrected rover data. There are many methods for transmitting and receiving corrections for example -
* • A reference receiver connected to a radio modem or data radio that transmits corrections by radio to a rover receiver connected to a radio modem that receives the corrections.
* • A reference receiver connected to the Internet that broadcasts corrections so that a rover receiver can connect to and use these corrections via an Internet link from the field.

e. VRS (Virtual Reference Stations)

A VRS system consists of GPS hardware, software, and communication links. It uses data from a network of base stations to provide corrections to rovers that are more accurate than corrections from a single base station.
To start using VRS corrections, the rover sends its position to the VRS server (a computer running VRS software such as Trimble's GPSNet(tm) software). The VRS server uses the base station data to model systematic ephemeris, troposphere, and ionosphere errors at the rover position. It then sends interpolated RTCM correction messages back to the rover.
Depending on the VRS software, the VRS server may also use the data from the base station network to simulate a base station (or VRS) at the rover's location.

3. Post-processing methods

Post-processing methods take place upon return to the office rather than in the field to take advantage of base station data available on the Internet. Base station files are posted on the Internet daily or hourly for GPS users. They are less immediate but offer greater accuracy than real-time corrections. It is recommended that real-time corrected data be re-corrected by post-processing methods when the greatest accuracy possible is required. Discussed here are a) **code phase differential correction** which is recommended method for Trimble Juno, XM, XT receivers and b)
H-Star processing
which is recommended method for GeoXH and ProXH users.

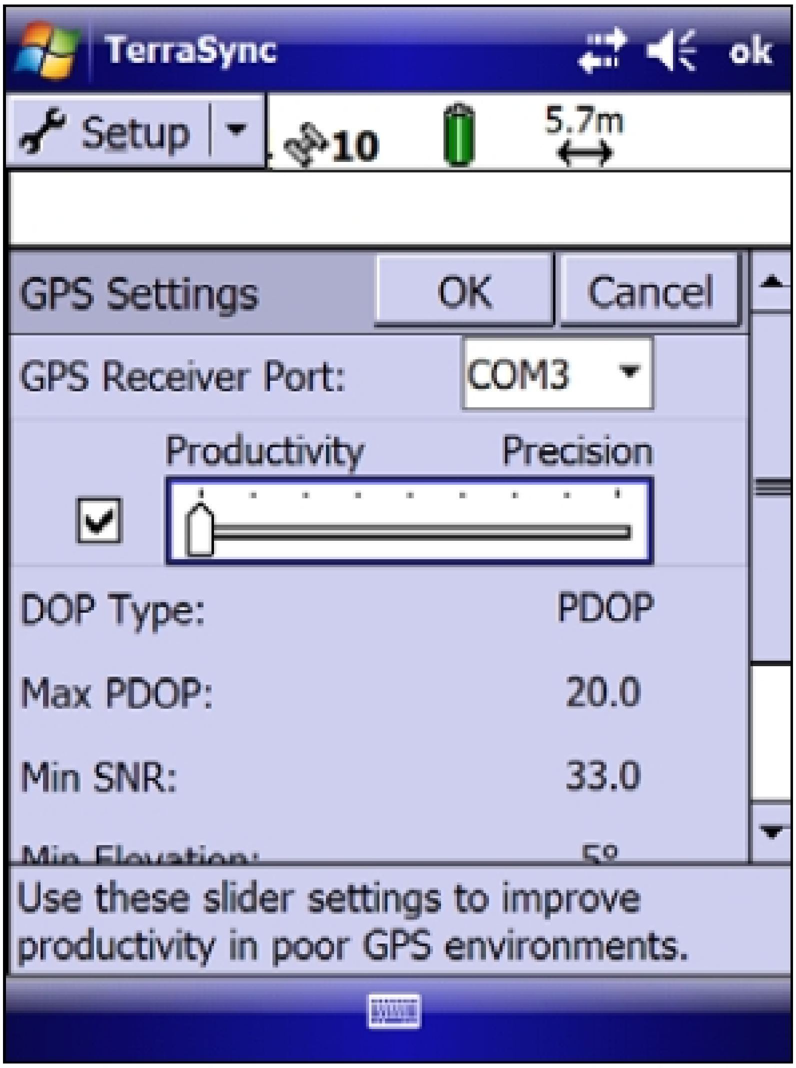
a. Code phase differential

Code phase differential correction post-processing uses code phase observations. Post-processed code phase differential correction data collected with ArcPad and GPScorrect can yield up to 50 cm + 1 ppm differential accuracy in the horizontal on a second-by-second basis (RMS), when optimal conditions, such as those listed below -.
• PDOP < 6 or HDOP < 4
• SNR > 39
• Elevation mask 15 ° or greater
• Baseline ≤ 250 km (155 miles)
• 4 or more satellites
• Reasonably low multipath environment
• Trimble base station collecting synchronized measurements over

surveyed-in coordinates

NOTE: the above settings have CHANGED with [Trimble's introduction of DELTA-PHASE POST-PROCESSING]

As of Dec 2010, users should change from the above to settings to the those marked PRODUCTIVITY whcih allow for data collection at "looser" standards during field collection. The new DeltaPhase post-processing engine uses this larger sum of data for better correction.



b. H-Star processing for GeoXH and ProXH/XRT receivers only

H-star processing uses dual-frequency carrier phase observations. Carrier phase signals contain more detailed information than code phase signals and allow for more accuracy. However, carrier phase collection relies on data being collected for a continuous time block with a minimum number of satellites. This is referred to as "carrier lock".
For the collection of a point feature, the receiver must track 4 or more satellites without interruption for a 2-minute block. For a line or polygon feature, 5 satellites are required. Accuracy depends on the duration of the carrier lock with measurements logged before and after the current position. If feature logging begins within less than 2 minutes of the initiation of the carrier phase signal, but the signal persists for an uninterrupted 2-minute block, that feature will have carrier level accuracy. If the uninterrupted 2-minute block is not achieved, that feature will have code level accuracy.
The processing steps are similar to code phase processing, but base stations must be dual-frequency, survey-grade base statons. Furthermore, it is recommended that multiple reference stations be used to reduce errors caused by reference station bias and distance. Data must be processed with either GPS Analyst extension v1.20 or greater or GPS Pathfinder Office software v3.10 or greater
With H-Star processing, ArcPad + GPScorrect can yield 30 cm (sub-foot) accuracy with a GeoXH or ProXH, and 20 cm (sub-8") accuracy in the horizontal (RMS) when using the external Zephyr antennae in optimal conditions, such as the following -

- PDOP < 6
- SNR > 39
- Elevation mask 15 ° or greater
- 4 or more satellites for static, point data
- 5 or more satellites for dynamic line or polygon data
- Reasonably low multipath environment
- Sufficient blocks (minimum 2 minutes) of data with carrier lock
- 1 dual-frequency reference station within 80 km (recommended), or
- Minimum of 3 dual-frequency reference stations within 200 km

NOTE: the above settings have CHANGED with Trimble's introduction of DELTA-PHASE POST-PROCESSING as in image above.

As of Dec 2010, users should change from the above to settings to the those marked PRODUCTIVITY whcih allow for data collection at "looser" standards during field collection. The new DeltaPhase post-processing engine uses this larger sum of data for better correction

c. Carrier phase differential

This method is outside the scope of this site and is not discussed here.

Software for differential correction

Once back in the office, there are 2 options for processing field-collected ArcPad data.

Trimble GPS Analyst Extension (GA)

A Trimble extension to ESRI ArcGIS Desktop used for the differential correction and validation of your GPS data within a personal geodatabase.

Trimble Pathfinder Office (PFO)

A desktop suite that can be used to process ArcPad data, as well as many other GPS-related utilities. The differential correction and ShapeCorrect utilities in PFO.