National Park Service

National Park Service
U.S. Department of the Interior

Northeast Temperate Network
Standard Operating Procedures

Global Position System:
Field Collection Standards

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Global Positioning Systems (GPS): Data Collection Standard Operating Procedures and Guidelines

This section addresses instrument settings, field operation, data processing for GPS data collection.

Definition of the Global Positioning System

GPS is currently a network of 25 Department of Defense satellites that orbit the earth approximately every 12 hours, emitting signals to Earth at precisely the same time. The position and time information transmitted by these satellites is used by a GPS receiver to determine a location coordinate on the earth using three or more satellites.

The satellites broadcast on two carrier frequencies in the L-band of the electromagnetic spectrum. One is the "L1" or 1575.42MHz and the other is "L2" or 1227.6MHz. Codes are broadcast on these carrier frequencies in much the same way as a radio or television station broadcasts information on its channels (or frequencies). The satellites broadcast two codes–a military-only encrypted Precise Position Service (PPS) code and a civil-access or Standard Position Service (SPS) code. All commercially available consumer GPS receivers are SPS receivers, of which there are two basic types: Code-phase and carrier-phase. Code-phase receivers use the "lower frequency" code to determine position, while carrier-phase receivers lock into the "higher frequency" carrier signal to determine location. The carrier signal receivers provide higher accuracy than the code-phase devices because of the higher signal frequency associated with the carrier signal. Refer to the following web site for details on the GPS technology:

http://www.palowireless.com/gps/tutorial3.asp

Positional Data

The National Map Accuracy Standard (NMAS) published by the USGS establishes the NPS *minimum* standard for map data accuracy. Typically a GPS will provide much better accuracy than required by NMAS if it is used carefully and with full attention to the parameters that the user can set or track. The parameters listed below will make it easier to achieve a reasonable and reliable level of accuracy. Please note that different GPS units use different names and/or definitions for some of these parameters. If you have questions regarding NPS requirements contact Tim Smith at Tim_Smith@nps.gov or your regional GIS coordinator.

GPS Positional Accuracy

Positional accuracy for autonomous, code-phase, resource grade, or C/A-code receivers range from 100 meters to less than 2 meters. Under ideal circumstances, accuracy for carrier-phase units (often referred to as geodetic receivers) can be measured in millimeters. Accuracy depends on a number of factors, several of which may be monitored in the field:

- Number of satellite vehicles - Optimally, at least 4 satellites should be used to obtain a 3-dimensional position. More satellites will increase accuracy;
- Positional Dilution of Precision (PDOP) - PDOP should be as low as possible, ideally 4 or less when collecting mapping data.;
- Signal-to-noise ratio (SNR) – This is the ratio of incoming signal strength to the amount of interfering noise as measured in decibels on a logarithmic scale. Lower is better; and,
- Estimated Horizontal Error - A measurement of horizontal position error in feet or meters based upon a variety of factors including Dilution of Precision (DOP) and satellite signal quality.

Positional accuracy for both code-phase and carrier-phase receivers depends largely on a process called differential correction. Differential correction is an adjustment that accounts for errors or interference that affect the accuracy of GPS signals. The correction is determined by comparing data from a base station – a precisely known location, or reference position – that is obtained at precisely the same time as the rover (receiver) files are collected. Because the reference location doesn't change, the difference between the accurate location of the reference and where the signal from the satellite network says the station is located can be used to generate a correction. Optimally, the base files must contain data from the same satellites as the rover files - in effect this means that the rover files must be collected within 300 miles of the base station so that the rover receiver and the base station receiver are "seeing" the same set of satellites.

Differential corrections should be used whenever possible to remove the greatest source of GPS error. Real-time differential corrections, the preferred differential correction alternative are available through the NDGPS/Coast Guard Beacon System; the WAAS (FAA) satellite based differential system; OmniStar; or a variety of paid private differential services. Post-process differential GPS can be obtained from the NGS base stations available from the web or local community base stations.

Recommended Receiver-Specific Settings

Garmin and PLGR units:

- EHE: less then or equal to 12 meters. This will keep you just within the NMAS for a 1:24,000 map, which is the maximum acceptable.
- Minimum of 4 satellites (3D) for every position.
- Position Type: If possible and practical, real-time differentially corrected positions should be collected.

Trimble Pathfinder Systems (PRO XR's, XRS's, and GeoExplorers):

- PDOP: less then or equal to 6 (we recommend starting with a PDOP maximum of 4 and shifting to 5 if data collection is not successful at 4; this will keep you around the NMAS for a 1:5,000 map).
- Minimum of 4 satellites (3D) for every position.
- SNR: less then or equal to 5.
- Elevation Mask: 15.
- Antenna height: be sure to check for correct antenna height setting. This setting should be the usual height at which the antenna will be carried. If the antenna is attached to a pole, it must be located above the user's head and the antenna height setting should be the height of the top of the pole. Wherever possible, the antenna should be clear of any obstructions.
- Position Type: Must be post-processed or real-time differentially corrected.

All GPS units.

- Check the graphics data collection screen regularly to see if you are getting multi-path or other apparent distortions to the data. Garmin and PLGR's require the user to monitor the screen and stop data collection during poor PDOP or SNR windows. Trimble receiver's set to the appropriate mask will stop collecting automatically.
- Be aware of the possibility of multi-path interference and use offsets or other methods to keep the antenna away from building overhangs, tall fences or walls, and heavy canopy wherever possible.
- ALWAYS use differential correction, either real-time or post processed.
- Feature settings.

  Point:

  - Trimble: minimum of 30 positions, collected at 1 second interval and averaged.
  - All Others: 90 to 120 positions, collected at 1-2 second interval and averaged.

  Line/Polygon:

  - use a 2-5 second interval for walking and for road driving, depending on the road type and speed of the vehicle, wait for a position at each corner, and use a minimum of 3 positions to define any curve/change in direction.

Note: If maximum accuracy is required, synchronize the collection rate with the base station logging rate (Stations log anywhere from 1 to 30 second data). Logging rates should be in multiples of 1 or 5 for best differential corrections. Logging rates in multiples other than 1 and 5 may reduce the number of positions that are synchronized with base data and may reduce accuracy. Try to map all features in a single area in a single day or on consecutive days.

Attribute Data

Data dictionaries (e.g., Trimble) or data collection forms (e.g., ArcPAD) are designed to describe features (landscape, biological, cultural, or historical) simply, efficiently, and without redundancy. A data dictionary or form organizes data into types or themes and reduces user error when entering values. This type of data collection is an efficient use of time and energy. Set up a menu and pick-lists in a database and load them into the GPS unit or data collection device prior to going out into the field. Create and use a data dictionary or data collection form whenever possible to collected attribute data.

Coordinate Metadata

Complete all applicable elements identified on the Northeast Region GPS Metadata Form.

Projection and Coordinate System

All digital geospatial data should reference the appropriate coordinate system, and this reference should be noted in the metadata. All spatial data collected or submitted for national, regional, or network NPS programs shall be geo-referenced and provided in a standard projection. Digital geospatial data should be referenced to two coordinate systems–the current standard system used by the individual park (generally UTM, NAD83) and a regional-scale system (Geographic, NAD83). The steps used to get the data into the proper projection must be documented in the metadata. The project manager must specify, approve, and document any deviation from these projection standards.

Horizontal / Vertical Accuracy and Precision

All spatial data collected shall be analyzed for their spatial accuracy and shall meet or exceed the National Mapping Program Standards for the particular scale intended. Longitude and Latitude coordinates for geographic data should be recorded to a minimum of 5 significant digits to the right of the decimal point and stored as a double precision attribute or database field. Any calculations done with location data should be done at double precision with the results rounded or truncated to the appropriate propagated error limits. All calculations and processes completed on the spatial data shall be reported in the metadata.