

Appendix D – Brief GPS Overview



Global Positioning System (GPS)

Theory

What is GPS?

The Global Positioning System (GPS) is a satellite-based navigation system, providing position information, accurate to approximately 15m, anywhere on earth. Special methods can achieve position accuracy better than 1 mm. Satellites transmit radio signals, used by GPS receivers to compute positional information.

GPS System Configuration

24 Satellites orbit around the earth with a period of 12 hours. Because the orbits are inclined at 55 degrees to the equator, satellites are not seen to the North in Canada. Reception is difficult where the southern sky is obstructed (e.g., steep north-facing slopes, gullies, buildings in cities). Satellites operate on “sidereal time”, based on the earth’s rotation, so configurations repeat every 23h 56m (“solar time”). Certain times of the day are better or worse for GPS surveying; these times advance 4 minutes per day (~30 minutes per week).

Position Computation

How is it done?

GPS satellites broadcast a coded time signal;

GPS receiver computes a distance to the satellite, using the send-time, receive time, and the signal speed (speed of light):

GPS receivers calculate their position by intersecting ranges from four or more satellites (“triangulation”).

Sources of Error

Clock Errors

Receiver clocks have limited accuracy;

The observed “range” to the satellite (pseudorange) is biased by an unknown clock offset, translating to range errors of hundreds of kilometers.

Satellites have accurate atomic clocks (to a few trillionths of a second) but small errors cause range errors of a few meters.

Atmospheric

The signal is slowed down due to a magnetic effect as it travels through the atmosphere.

Common mode

Signal propagation and satellite errors are the same for receivers within the same general area.

Can be corrected using a reference receiver at a known location



Multipath

Signals reflect off nearby objects before reaching receiver antenna due to local site conditions

Increasing Accuracy of Position**Dilution of Precision (DOP) Mask**

DOP measures the geometry of the satellites relative to each other and to the receiver.

Low DOP = good geometry = more accurate (satellites are well spread in sky)

High DOP = poor geometry = less accurate (satellites are close together)

Obstructions (tree cover, buildings, etc.) cause higher DOPs.

GPS can be set to reject positions with DOPs too high (**PDOP limit=8 for SHIM**) to help ensure accuracy

Position Correction: Differential GPS

Position accuracy is increased by comparing the rover receiver (yours) with a reference receiver at a known location.

Without differential correction, the expected accuracy of GPS positions is about 20 metres.

Differential correction can be done either via post-processing or real-time (in the field).

Post-Processing Reference Data

After the survey is done, data from the field receiver and a reference receiver is downloaded to a computer and the positions are differentially corrected.

Real-Time GPS Surveying

Positions stored in the GPS receiver are corrected in the field, before downloading to the computer

Corrections are broadcast as soon as possible to users in a local area

Equipped GPS receivers can correct positions in real-time and store corrected positions in the field

GPS receivers can be configured to store uncorrected GPS data (for later post-processing) when real-time data is not available

Real-time corrections are slightly less accurate than post-corrected GPS, but the difference is not important for most mapping surveys (<1m).

Sound to Noise Ratio (SNR) Mask

Interference from trees, forest canopy, multipathing, and even GPS cable connections can cause signal attenuation. If the interfering components overwhelm the signal tracing can become difficult. The SNR is a comparison between the signal strength to the noise. **The SNR mask should be set to 3 for SHIM mapping however lowering the SNR mask to 0 allows for faster data collection with little difference to the accuracy of the collected data.**



From: RIC Standards Training using GPS Technology, September 1998.

Elevation Mask

Traveling through the atmosphere causes a great deal of noise to the GPS signal. The elevation mask allows GPS users to limit the length the signal travels through the atmosphere. **The elevation mask should be set to 15° according to RIC standards.**

From: RIC Standards Training using GPS Technology, September 1998.

Accuracy Requirements for SHIM

GPS-derived stream features must be within five metres of the true location, 95 percent of the time (to be compatible with 1:5000 scale municipal maps). Under typical conditions with local obstructions, forest cover, and other factors, five-metre accuracy is achievable only with the best GPS equipment and careful methods.

General Field Methods for Poor GPS Reception

Moving the antenna around within a meter can help re-acquire satellite signals, without affecting position accuracy.

Waiting for ten or twenty minutes (sometimes hours in extreme cases) can usually enable surveying.

Conventional methods can be used to supplement GPS methods during these reception “down” periods.

Adjusting the Receiver Configurations

Under forest canopy, configuring the receiver to accept weaker satellite signals will make GPS surveying possible in most situations.

Weaker signals (such as signals passing through foliage) may be less accurate than strong signals.

Using the manufacturer’s default configuration (e.g. SNR mask 6), the best GPS receivers are capable of accuracy better than 1 m in ideal conditions, but usually they work poorly in forest cover – if at all.

Reducing SNR to 0 allows collection of more data under forest canopy and does not degrade accuracy beyond acceptable limits (5 m, 95% confidence).

Using the Trimble Pathfinder

*Upload the Data Dictionary from Pathfinder Office
Configure GPS*

Field Mapping

Press on the power.

Select TerraSync Program

Select Data Collection from the main menu.



Select Create new file to create a new rover file. *Never re-open a rover file to add more information. You may lose your data or the file may become corrupted.*

Enter the file name. Decide on a file naming system and use it consistently (for example, Stream name / date: “FERG0601” for Fergus Creek, June 1st).

Select the Data Dictionary you will be using, which is generally the most recent Data Dictionary.

This opens the Start feature menu, from which you can choose to map point or line features.

Entering Shoreline Information

***Note:** Remember to pause logging before stopping to enter information into the data logger, and resume when you continue walking the stream centreline.*

Reference Information applies to the entire shoreline feature you are mapping. It is usually entered while standing at the start point, but the timing depends on crew preference. For example you may prefer to do it at the same time as entering characteristics for the first segment. In any case, the data logger will not let you end the stream feature until you have entered all the required information.

