GPS SURVEYING FIELD PROCEDURES

By

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Abstract

With the GPS constellation now complete surveying by GPS is fast becoming a practical and cost effective alternative to traditional surveying methods on many standard surveying and engineering tasks.In order to decide on whether to use GPS or conventional methods,or indeed a combination of both,an understanding of the methods available,the capabilities and limitations of each is essential.

This paper will outline tasks suitable for GPS and explain the various and increasing operational modes which are available.

1.0 Introduction

GPS was conceived and designed to be a navigational tool for the US military forces.That is a single receiver determining its position in real time,this is termed point positioning or pseudoranging.Its design has meant that the general public can receive the transmissions from the satellites provided they have a suitable receiver.In order to make sense of the transmission the receiver must have a decoder,in the same way that Satellite television viewers have,however unlike satellite TV viewers there is currently no charge for being able to receive the signal.This analogy with satellite TV can be taken further,although the civil population can make use of the GPS signals they will be restricted to the Coarse Acquisition (C/A) Code and only those who have an "extra chip" will be able to make use of the Precise (P) Code,a bit like having to pay extra for the movie channels on satellite TV.

For surveying purposes we need the decoder to obtain the satellite coordinates and corrective terms to the satellite clocks.Ideally we could do with access to the second frequency to remove the effects of the ionosphere on the transit time of the satellite signal.Other errors that plague the system can largely be removed,or at least reduced to acceptable levels,by the use of two receivers at two locations,one of which is known,the **Reference** or **Master** receiver,and one which can be moved to the stations to be surveyed,the **Remote** or **Rover.**

It is important to realise at this stage that both receivers must observe at least four common satellites at the same time in order to obtain results,it is equally important to realise that for surveying accuracies you must be able to receive and record the carrier phase measurements as well as the code.

Although most software makes use of all the observables,the code on both the L_1 and L_2 frequencies,the carrier phase on both frequencies and combinations of the foregoing the bottom line for the surveyor is that we use the code to get the coordinates of the satellites,the carrier phase to get the distance to the satellites and a second frequency to correct the distance for ionospheric refraction,everything else is best left to the experts!

So what are the operating modes and for what surveying tasks can they be used?

2.0 Static Differential

Static Differential is defined as the relative positioning of a remote receiver using the carrier phase,with both receivers remaining static during the observations.That is we use two receivers and determine the coordinate differences,or more usually the baseline vectors,between the receivers whilst both remain static.The length of time they must remain static primarily depends on the length of the baseline between the receivers and the accuracy required.
For baselines over 20km and for accuracies in the order of 5ppm we need to be collecting in excess of an hours worth of data with dual frequency receivers because we need to be able to correct for the possible different effects of the ionosphere at either ends of the line.

With these observing criteria it is not surprising that this method is restricted to primary control schemes,trig ties and in some instances monitoring surveys e.g offshore structures.

3.0 Rapid Static

This method is identical to Static Differential but as the name implies less time is spent static by the rover.It is possible to obtain similar accuracies to static differential with as little as 5 minutes of common data.Again the amount of data required depends on the quality of data,the geometry of the satellites and the length of the baseline.Our experience shows that upto 20km the length of time would vary between 5 and 30 minutes,after which you would probably resort to static differential.

This method is suitable for the densification of control for road surveys or large detail surveys for example where control is required every 100-200 metres,in this scenario provided that baselines are kept below 5km and at least 5 satellites are observed with near optimal geometry,one could fix a point,with 5 minutes of data,to around the +/-10mm level.
Other applications would be control for photogrammetry.Depending on the scale of photography and redundancy it might be possible to extend the baselines upto 20km with the observation period being extended on a sliding scale.Experience shows that 2mins/km seems to work reasonbly well.

It should be noted that when using **Rapid Static**,sometimes referred to as **Fast Static**,the significant points are that the mobile receiver can be **Switched Off** between stations and that the so called "integer ambiguity" is determined anew at each mobile setup.

4.0 Stop and Go

This is a form of Rapid Static except in this mode the roving receiver must remain switched on and tracking at least four satellites whilst moving from point to point as well as during the on station observations.The integer ambiguity is determined at the first roving station and providing continuous lock is maintained on the satellites by both the reference and mobile receivers the same integer value is used for subsequent setups.This reduces the amount of time required at each setup to a few seconds,typically 10-15 secs.In this mode it is not dissimilar to bearing and distances using a total station.

The rover can be mounted on a plumbing rod instead of a tripod and each point can be visited in turn.If lock is lossed on the satellites it is necessary for the roving receiver to remain static so that a new value for the integer ambiguity can be determined.This value can then be used till another loss of lock occurs.

This method lends itself to fixing large numbers of points in a localised area that is relatively free of obstructions.This could be for standard detailing surveys,contouring or volumetric surveys or borehole locations and the like.It could also be used for as built surveys for pipelines or asset inventories for such things as street furniture or utility resources.

It has the advantages that firstly there is no need to traverse in control for your total station and multiple rovers can be used in conjunction with a single master and of course there is no need for line of sight between master and rover.

Despite the costs of the receivers it can be cost effective in certain types of survey and where line of site to the satellites is restricted additional control could be established quickly for use by total stations.

5.0 Reoccupation

This method is a variation on the above static methods but allows two data sets taken at different times,at the same roving station,to be combined in the postprocessing to provide a solution at sites where visibility is restricted and the minimum four satellites are not visible at a single occupation.This occurs when the survey station is located close to structures or trees.The two observation periods should be separated by a couple of hours to allow a change in the satellite geometry.

This is a scenario similar to the restricted areas in detail surveying where a combination of GPS and conventional might prove the most economic solution.

Note:
For all the above methods,**Two** receivers,tracking and **Recording** code and **Carrier Phase** are required,the receivers must remain static during the on station observation period and **Both** receivers must track at least **Four common** satellites.The data must be **Postprocessed** to give survey accuracies,the only results available in real time are the point positioned navigation solution.

6.0 Kinematic

Kinematic positioning can best be defined as the relative positioning of a continuously moving receiver using the carrier phase measurements.That is the position of the roving receiver is continuously changing whilst the reference receiver remains static.This method requires determining the integer ambiguity before starting to move the roving receiver and maintaining lock on four common satellites throughout the observation period,it is similar to Stop and Go except there is no need to stop.The antenna can be vehicle mounted and the sample rate can be such that the software will determine a position every three seconds,for example.In other words if you drive along a road or track at 20 mph and set the sample rate to 3 seconds you will produce a longitudinal section of the road with fixes at approximately every 25 metres.

This method is obviously rapid and can be used for volumetric surveys over large drivable stockpiles,it can be used for reconnaissance surveys for drivable route location surveys and for updating small scale mapping etc.
The problem with this method is that if you lose lock on the satellites you must remain static to reinitialise the kinematic loop.

7.0 AROF

Ambiguity **R**esolution **O**n the **F**ly (AROF) allows you to determine the integer ambiguity whilst moving so theoretically if you lose lock on the satellites there is no need to stop,you can continue moving and after an uninterrupted period of observations the software will determine the integer ambiguity and backcompute the value at the start of the run.

This is a relatively new technique and its sole purpose is to avoid the necessity to remain static after loss of lock or at the start of your observations.Such a system fitted in an aircraft and synchronised to the aerial camera shutter would fix the principal point of photographs possibly reducing the need for ground control or premark.

Note:

Two receivers tracking and recording code and carrier phase data are required,one remains static throughout the observation period whilst the other can move continuously and the trajectory or position at discrete points can be determined.The data must be **postprocessed**.

8.0 Real Time Kinematic (RTK)

The obvious progression from the above methods is to avoid the necessity to postprocess the data before you get a result.
This is required if the system is to be used for setting out for civil engineering projects and if you need to be able to validate the data before evacuating a site.
These situations might arise in the offshore industry for rig location or pipelaying exercises or might arise in remote inhospitable areas of land surveys where the equipment might be carried in a helicopter and a return trip would be expensive.

In order to be able to carry out such surveys there must be a telemetric link between the reference and roving receiver and the roving receiver firmware must be capable of making use of the corrections received from the master.

For some time now,in the offshore industry,it has been possible to carry out such surveys.Corrections to the pseudoranges from the reference receiver to the satellites are calculated from the known positions of both,these corrections are then transmitted to the roving receiver to be used in the calculation of its position.Accuracies are in the order of metres rather than the submetre accuracy required for survey.
For surveying we need to be able to transmit carrier phase information.

It is now possible to determine centimetre positions in real time using this technique and of course it is still possible to record data for postprocessing once the survey stake has been positioned.

The applications of this method are obvious.it will allow setting out and checking of survey points in real time.

Note:

With this method what you see in the display of the roving receiver is the accurate position of the receiver relative to a reference station,this can be expressed in any local system and if setting out is required it is possible to display the deviation from the required position.

Note:

For many years the offshore industry has referred to navigation using GPS satellites and corrections received from a shore station as **DGPS**,Differential GPS.In this context the roving receiver is always moving along with the vessel which is what we on land would call kinematic or real time kinematic.The difference between surveying and navigating is that in surveying we use the carrier phase observable where generally speaking in navigation they use the code observable.

As with most survey techniques there are areas of overlap and for GIS data acquisition DGPS using code only has been extended to land based surveys.Omnistar and Landstar are two such systems available in PNG.

There are many derivatives of the above methods pseudostatic pseudokinematic,semi-kinematic etc the above should help you to classify the modes.