GPS (GNSS) REPORTING

LEARNING OBJECTIVES

On completion of this module you will be able to:

> describe what GPS is (herein after called GNSS) and how it is applied in cadastral surveying (basic level only)

WHAT YOU WILL COVER

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In this module you will cover:

> Definition of Global Navigation Satellite Systems and how they operate
> Explanation of how GNSS is used in cadastral surveying

INTRODUCTION

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BACKGROUND

You will have learned in the previous module how survey equipment has evolved to accomodate modern technology. Whilst the Total Station still plays a significant role in most present day surveys it can be greatly assisted with the addition of GPS equipment.

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Over recent years a number of satellites have been established and are now constantly orbiting earth. A network of these satellites are used to support the Global Positioning System (GPS). With GPS equipment the surveyor can accurately determine a survey position without the need for clear line of sight between survey marks. The prerequisite for GPS surveying is that there must be no overhead cover or canopy which obstruct the signal between the satelites and the GPS receiver. To obtain a effective number of signal connections with several satellites there must be a clear view to the surrounding horizon. For this reason it is not practical to use GPS under bush cover or amongst buildings.

This modern day equipment is compact and easy to use and hence only small survey teams are needed to conduct a survey.

DEFINITION

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The Global Positioning System (GPS) now referred to as Global Navigation Satellite Systems (GNSS) is a worldwide radio navigation system formed from a constellation of satellites and their ground stations (These stations monitor the GNSS satellites as to their orbit and giving their exact positions).

Advanced forms of GNSS use these satellites (man-made stars) as reference points to calculate positions to centimetre accuracy.

For further information about this subject in relation to cadastral surveying visit the following websites;

> http://www.trimble.com/index.aspx

> http://www.en.wikipedia.org/wiki/Real_Time_Kinematic

> http://www.sli.unimelb.edu.au/fig7/Brighton98/Comm7Papers/TS65-Hansen.html

BASIC CONCEPTS OF GNSS

This part of the training covers the basic elements of GNSS used in surveying. For further information on the basic principles behind GPS (GNSS) visit the Tutorial on the Trimble website www.trimble.com/gps/index.shtml.

THE SATELLITES

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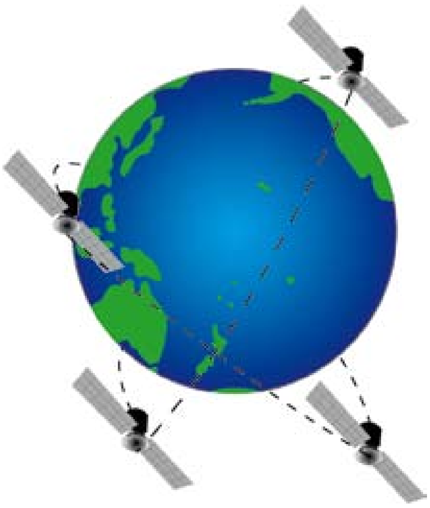

GNSS (Global Navigation Satellite Systems) essentially make use of numerous (a constellation) navigational satellites circling the earth to derive positions or navigate on the earth's surface.

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The main satellite constellation to date is GPS (GNSS) which is that, initiated and maintained by the US Defence Dept. It currently consists of thirty satellites orbiting at an altitude of about 20,000Km and has been fully operational since 1994. The Russians also have satellite navigation system (Glonass) currently consisting of ten satellites. All these satellites travel in precise orbits around the earth. With this knowledge and the monitoring of any changes to the satellite orbits from stations on earth an ephemeris (ephemeris - a set of parameters from which an accurate position for the satellite can be computed for any point in time) is available for each satellite.

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The satellites have on board atomic clocks which keep very accurate time. They transmit radio signals with this timing information. The radio signal, as well as carrying information, carries a code known as a pseudo random code. Each satellite has a unique pseudo random code. Also of importance is the carrier frequency of the radio signal. This constitutes the main part of the signal; the pseudo code being a modulation of this signal. It is this signal and its modulations that are received and utilised by GNSS receivers.

GNSS RECEIVERS AND OBTAINING A POSITION

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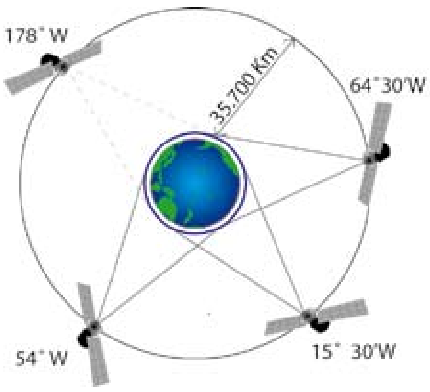
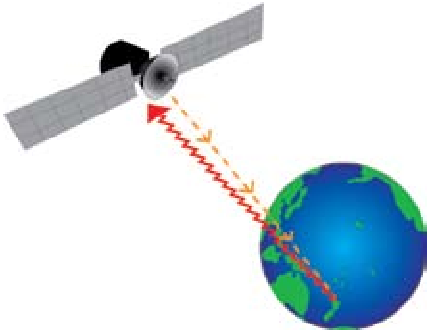
Essentially, resolving the position of the GNSS receiver requires measuring the distance from the receiver to at least four satellites. The positions of the satellites at any point in time are known as the ephemeris, information for each satellite is stored in the receiver and utilised to compute the positions at any point in time. Knowing the speed at which the radio signal travels, the speed of light, and the time taken for the signal to travel from the satellite to the receiver, then the distances from satellite to receiver can be computed.



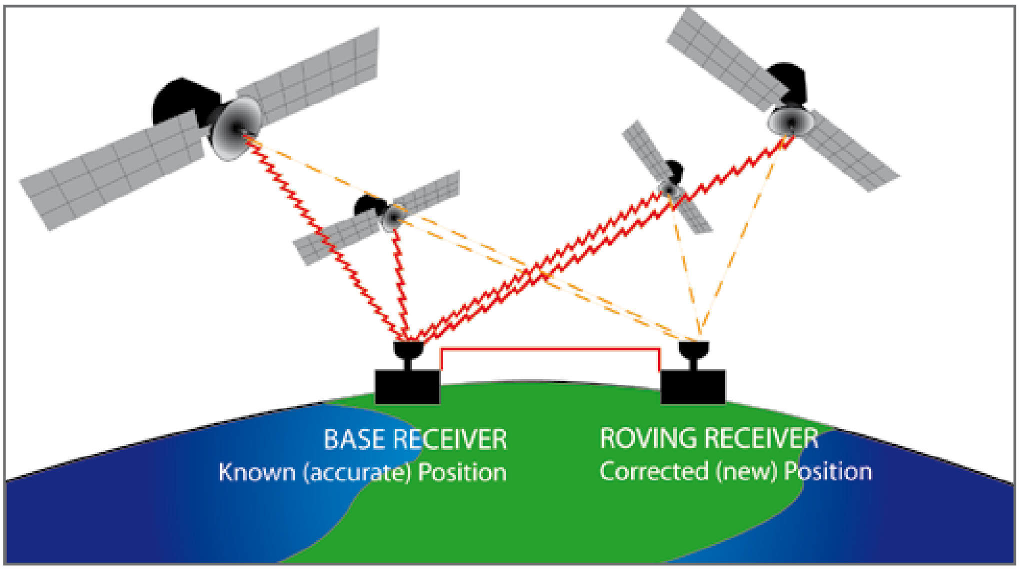
While the clock in the satellite is very accurate (atomic), that in the receiver is less accurate. This keeps the cost of equipment to a reasonable level.

To derive the elapsed time for the signal to travel between satellite and receiver the following method is used. The receiver broadcasts a radio signal of the same frequency and with the same pseudo random code as that broadcast by the satellite.

The assumption is made that satellite and receiver are generating the same pseudo random code at the same time. By comparing how late the satellites pseudo random code appears compared to the receivers code, a determination of how long it took the signal to travel between satellite and receiver can be derived. This answer is further refined in GNSS survey equipment by making the same comparison with the carrier signal which has a much higher frequency and shorter wave length than that of the pseudo random code.



A further refinement to the answer is obtained by deriving a correction to the receiver's clock. This is done by deriving simultaneous measurements to at least four satellites. This means the receiver must have at least four channels. To get all the ranges (distances) from the satellites to meet at the one point the receiver will derive a correction which is applied as a correction to the receiver's clock.



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To obtain results to a sufficient accuracy required for cadastral and control surveys, a differential system is also used. One receiver, the base, is set up on a point for which an accurate position is known. This known position is then used to calculate an error correction factor for each satellite observation. These corrections can then be applied to the roving receiver which is establishing new positions and receiving signals from the same satellites at the same time as the base receiver.

REAL TIME KINEMATIC (RTK)

11 This method of obtaining a position is used in RTK (Real Time Kinematic) survey systems where the base receiver and the roving receiver are linked by radio. The base station broadcasts the error corrections to the rover which then applies the corrections to derive a position for the new point in real time. The term "kinematic" refers to operating the roving receiver in motion. The rover is in constant contact (lock) with the satellites, giving it the ability to track movement and also derive a position when stationary.

12 While these progressive forms of refinement might seem cumbersome they are required to reduce the effect of various error sources. The GNSS satellite signals must pass through the ionosphere, a layer of charged particles surrounding the earth at an altitude from 50 to 500 km and then the troposphere, the lower part of the earth's atmosphere that encompasses our weather, before reaching earth. These mediums can distort the signal. There may also be errors in the position of the satellite, although corrections to the ephemeris are broadcast to and then from the satellites. There may also be tiny errors in the satellites' atomic clocks.

Another source of error is multipath errors. This error occurs when GNSS receivers receive satellite signals which have been reflected from surrounding objects before arriving at the receiver. This form of error can be reduced by selecting sites where there are few reflective surfaces but this is not always an option. Increasing occupation times can also reduce the risk of errors. Repeating the observation at a different time of the day when the satellites are in a different orientation can also be an effective check for this form of error.

NOTE: For details on GNSS requirements within a cadastral dataset refer to Survey Technical Module 6

LEARNER'S WORKSHEET ANSWERS

ASSESSMENT

Answer the following questions when viewing the listed websites.

Using www.trimble.com/index.aspx - Trimble GPS tutorial

1. In reference to GPS, what is triangulation?
   Using at least 3 satellites to pinpoint where you are in space (mathematically you need 4 to determine an exact position)
2. What is the secret to getting perfect timing?
   Make an extra satellite measurement
3. What is a multi-path error?
   Where a signal may bounce of several obstructions before reaching the receiver
4. What are the 5 main "real world" applications of GPS put to work?
   Location, Navigation, Tracking, Mapping & Timing

Using www.en.wikipedia.org/wiki/Real_Time_Kinematic

5. Satellite navigation is a technique used in land and what other type of survey?
   Hydrographic
6. What does the CP in CPGPS stand for?
   Carrier-Phase Enhancement
7. In RTK (Real Time Kinematic) how many base stations are used?
   One

Using www.sli.unimelb.edu.au/fig7/Brighton98/Comm7Papers/TS65-Hansen.html

8. To avoid problems with the RTK method, what distance is it best used up to? 5 kms
9. Complete this statement - "GPS is a 3 dimensional co-ordinate system"

NOTES