GLOBAL POSITIONING SYSTEM (GPS)

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VERSION:

DATE: 12-06-2009

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# INTRODUCTION:

 Global Positioning System (GPS) may be used either as a positioning tool or as a survey tool. Global Positioning System -a shorted term for NAVSTAR GPS (Navigation Satellite Timing and Ranging) –a system for locating ourselves on earth. It is a satellite-based system created and controlled by the US Department of Defence, initially for military purposes but extended later for civilian usage. It consists of a constellation of 24 satellites (4 satellites in 6 orbital planes) orbiting at an approximate altitude of 20200 km every 12 hours.

 

**GPS WORKING PRINCIPLE:**

 Each satellite broadcasts two carrier waves in L-Band (used for radio) that travel to earth at the speed of light. The L1 channel produces a Carrier Phase signal at 575.42 MHz as well as a C/A and P Code. The L2 channel produces a Carrier Phase signal of 1227.6 MHz, but only P Code. These codes are binary data modulated on the carrier signal. The C/A or Coarse/Acquisition Code (also known as the civilian code), is modulated and repeated every millisecond; the P-Code, or Precise Code, is modulated is repeated every seven days.

 The GPS system works with a receiver (essentially a radio receiver) that acquires signal from satellites in order to locate its position geographically. The GPS receiver simply calculates the distance to the satellite by measuring the travel time of the signals transmitted from the satellite and multiplying it by the velocity.

 **Distance = velocity (speed of light) x Time**

GPS receivers calculate the position of objects in two dimensional or three dimensional space using a mathematical process called trilaterlation. Trilateration can be either two dimensional or three dimensional. Let us examine how 2-D and 3-D trilateration work.

**2-D Trilateration**

 The concept of trilateration is easy to understand through an example. Imagine that you are driving through an unfamiliar country and that you are lost. A road sign indicates that you are 500 km from city A. But this is not of much help, as you could be anywhere in a circle of 500 km radius from the city A. A person you stop by to ask for directions then volunteers that you are 450 km from city B. Now you are in a better position to locate yourself- you are at one of the two intersecting points of the two circles surrounding city A and city B. Now if you could also get your distance from another place say city C, you can locate yourself very precisely, as these three circles can intersect each other at just one point. This is the principle behind 2D trilateration.

**3-D Trilateration**

 The fundamental principles are the same for 2D and 3D trilateration, but in 3D trilateration we are dealing with spheres instead of circles. Here, we have to imagine the radii from the previous example going in all directions, that is in three dimensional space, thus forming spheres around the predefined points. Therefore the location of an object has to be defined with reference to the intersecting point of three spheres.

Thus if you learn that the object is at a distance of 100 km from [satellite](http://www.roseindia.net/technology/gps/what-is-trilateration.shtml) A, it simply says that the object could be on surface of a huge imaginary sphere of 100 km radius around satellite A. Now you are also informed that the object is 150 km from satellite B. The imaginary spheres of 100km and 150 km around satellites A and B respectively intersect in a perfect circle. The position of the object defined from a third satellite C intersects this circle at just two points. The Earth acts as the fourth sphere, making us able to eliminate one of the two intersection points of the first three spheres. This makes it possible to identify the exact location of the object.

 

**ACCURACY:**

There has been a misconception over the past years about the accuracy of GPS. It is true that fr many years the US Department of Defense maintained intentional degradation of accuracy called Select Availability (S/A), a system for randomly degrading the accuracy of the signals being transmitted to civilian GPS receivers. However, the S/A was removed in May 2000. Therefore, the accuracy of GPS should be a discussion based on the type of system (device) and its ability to eliminate error sources and not on the availability of reliable satellite signals.

Error sources are variable; here are some of the more commonly occurring:

1. IONOSPHERIC DELAYS:

 The ionosphere is the upper layer of the atmosphere ranging in altitude from 50 to 500 km. It consists largely of ionized particles which cause a disturbing effect on the GPS signals. Since the density of the ionosphere is affected by the sun there is less ionospheric influence during night time. The ionosphere has also a cyclical period of 11 years which reaches a maximum and a minimum of the magnitude of its effect. For the current cycle, it reached its maximum in 1998 and its minimum in 2004.

 In addition, low elevation satellite signals (anywhere between the horizon and up to 15 degrees above it) will be affected by a longer ionospheric delay as the distance the signal has to travel further and generally “noisier”. In the more sophisticated GPS receivers an “elevation mask” can be set so that satellites below the mask are not used in computing position.

2. SATELITTE ND RECEIVER CLOCK ERRORS:

 Each satellite is equipped with a very accurate clock which is continuously monitored by ground stations (US Department of Defense). Despite this, errors of precision can be up to one metre.

3. MULTIPATH ERROR:

 This is where more than one signal is received due to a reflection on other objects nearby (tall buildings or lakes) causing erroneous measurements.

4. SATELLITE GEOMETRY:

 This means the relative position of the satellites at a specific moment. When satellites are located at wide angles relative to each other, the possible error margin is small. On the contrary, when satellites are grouped together or located in a line the geometry will be poor. The effect of

the geometry of the satellites on the position error is called Geometric Dilution of Precision (GDOP).

 

 **TYPES OF GPS:**

There are three types of Gps, depending on the level of acquired accuracy.

1. Hand-held GPS or Navigational (> c. 10m)
2. Differential Code-Phase GPS (DGPS) (< 1m)
3. Carrier-Phase GPS (< cm)

**HAND-HELD GPS:**

 The Navigational or hand-held GPS consists of a single receiver, as easy to use as a mobile phone and around the same cost. It is the simpler technique of GPS but also the least accurate. The position calculated from the satellites’ signal is frequently distorted by sources of error, which can degrade its accuracy by several metres (about 15 to 100 m).

 

**DIFFERENTIAL CODE-PHASE GPS:**

 This differential measurement technique eliminates most of source errors, achieving results of sub-metre accuracy. It is obviously a more complex system than hand-held GPS - which is reflected in its substantially higher cost. It consists of a base station and a rover receiver connected by a radio link. The base station or reference receiver when located at a known point can estimate what the ranges to

the satellites should be and work out the differences between the computed and calculated range values. These differences are known as corrections. The base station transmits these real time differential corrections to the rover receiver (through the radio) so they can be used to correct its measurements. The DGPS corrections are transmitted in a standard format specified by the Radio Technical Commission Marine (RTCM).

 

**CARRIER PHASE GPS:**

This differential system achieves accuracy ranging from centimetre to millimetre, depending on the measuring technique. The Carrier-Phase GPS uses a minimum of two receivers simultaneously.

 After an autonomous position is calculated using differential code methods, clock errors can be annulled by observing two satellites from two receivers by a method known as double differencing. Once the better approximation of the position is known, a statistical calculation of phase intersections from multiple satellites can be used to resolve ambiguous results.

 

**USES OF GPS:**

GPS-equipped aircraft can quickly plot the perimeter of a forest fire so fire supervisors can produce updated maps in the field and send firefighters safely to key hot spots.

 During construction of the tunnel under the English Channel, British and French crews started digging from opposite ends: one from Dover, England, and one from Calais, France. They relied on GPS receivers outside the tunnel to check their positions along the way and to make sure they met exactly in the middle. Otherwise, the tunnel might have been crooked

 GPS-equipped fleet vehicles, public transportation systems, delivery trucks, and courier services use receivers to monitor their locations at all times for both efficiency and driver safety.

 GPS has become important for nearly all military operations and weapons systems. It is also used on satellites to obtain highly accurate orbit data and to control spacecraft orientation.

 Automobile manufacturers are offering moving-map displays guided by GPS receivers as an option on new vehicles. The displays can be removed and taken into a home to plan a trip. Several major rental car companies have GPS-equipped vehicles that give directions to drivers on display screens and through synthesized voice instructions

 GPS-equipped balloons monitor holes in the ozone layer over the polar regions as well as air quality across the nation. Buoys tracking major oil spills transmit data using GPS to guide cleanup operations. Archaeologists, biologists, and explorers are using the system to locate ancient ruins, migrating animal herds, and endangered species such as manatees, snow leopards, and giant pandas.