1. BENEFITS OF GPS OVER OTHER FORMS OF EQUIPMENT FOR MEASURING

* Relatively high positioning accuracies, from tens of meters to millimeter level.
* Capability of determining velocity and time, to an accuracy commensurate with position.
* Signal availability to users anywhere on the globe; in air, on the ground, or at sea.
* It is a positional system with no user charges and uses relatively low cost hardware.
* It is an all-weather system, available 24 hours a day.
* The position information is in three dimensions, that is, vertical as well as horizontal information is provided.

1. GPS ERRORS

The following errors can arise in the use of GPS:

1. **EPHEMERIS ERRORS AND ORBIT PERTURBATIONS**

Satellite ephemeris errors in the prediction of satellite position which may then be transmitted to the user in the satellite data message. Ephemeris errors are satellite dependent and are very difficult to correct and compensate while modelling the orbit of a satellite because many forces acting on the predicted orbit of a satellite are difficult to measure directly. Ephemeris errors produce equal error shifts in the calculated absolute point positions.

1. **CLOCK STABILITY**

GPS depends on accurate time measurements, GPS satellites carry rubidium and cesium time standards that are usually accurate to 1 part in 1012 and 1 part in 1013, respectively, while most receiver clocks are accurate by quarts’ standard accuracy of 1 part in 108. A time offset is the difference between the time recorded by the satellite clock and that recorded by the receiver range errors observed the user as a result of the time offset between the satellite and receiver clock have a linear relationship and can be approximated by the following relation:

Where, *RE =* user equivalent range e (UERE)

*TO* = Time offset

*C* = Speed of light

1. **IONOSPHERIC DELAY**

GPS signals are electromagnetic signals and as such are non-linearly dispersed and refracted when transmitted through a highly charged environment like the ionosphere. Dispersion and refraction of the GPS signal is referred to as the ionospheric effect because it results in an error in the GPS range calculation as the velocity of the radio signals from the satellite is affected, the ionospheric range effects are frequency dependent and are not constant

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1. **TROPOSPHERIC DELAYS**

The troposphere is a part of the atmosphere which is closest to the earth. It extends from the surface of the earth to about 9km above the poles and 16km above the equator. But as far as GPS signal is concerned, the troposphere is combined with the stratosphere and taken to be a height of 50km above the surface of the earth. The tropospheric delay adds a slight distance to the range the receiver measures between itself and the satellite. The troposphere is an electrically neutral layer of the earth’s atmosphere. Hence, it is neither ionized or dispersive.

The tropospheric conditions causing the refractions of the GPS signal can be modelled by measuring the dry and wet components. The dry component is best approximated by the following equation:

Where, *DC* = Dry term range contribution in zenith direction in meters

*PO =* Surface pressure in millimeters

1. **SIGNAL MULTIPATH**

Multipath describes an error affecting positioning that occurs when the signal arrives at the receiver from more than one path. This occurs when the GPS receiver is positioned close to a large reflective surface such as a lake, a big rock or a building. In this case the satellites signal does not travel directly to the antenna but hits the nearby object first and is reflected to the receiver’s antenna creating a false measurement. This increases the travel time of the signal, thereby causing errors. This is called multipath error and is similar to the ghost effect of a TV receiver.

1. **SATELLITE AND RECIEVER CLOCK ERRORS**

Even though clocks in a satellite are very accurate to about 3 nanoseconds, they do drift slightly causing small errors, affecting the accuracy of the position. The satellite clocks are independent of each other. The clocks are made up of rubidium and cesium oscillators. The oscillators are stable unless frequent taking does not disturb them and adjustment required is minimum. While the GPS time drift is to be kept between one millisecond, the satellite clocks can be allowed to drift up to a millisecond from GPS time.

1. **SELECTIVE AVAILABILITY (S/A)**

Selective availability is a process applied by the U.S. department of defense to the GPS signal. This is intended to deny civilian and hostile foreign powers from getting full accuracy of GP by subjecting the satellite clocks to a process known as *dithering*, which alters their time slightly. Additionally, the ephemeris is broadcasted as being slightly different from what is in reality. Together these factors make selective availability the biggest single source of inaccuracy in the system. Military receivers use a decryption key to remove the selective availability errors and so they are much more accurate.

1. **ANTI-SPOOFING (A/S)**

Anti-spoofing is similar to S/A and is intended to deny civilians access to the P-code part of the GPS signal, thereby forcing the user to use the C/A code which has selective availability applied to it. Anti-spoofing encrypts the P-code into a signal called the Y-code. Only users with military GPS receivers can decrypt the Y-code. Military receivers are more accurate because the do not use the course/acquisition code to calculate the time taken by the signal to reach the receiver.

1. **RECEIVER NOISE**

Receiver noise includes a variety of errors associated with the ability of the GPS receiver to measure a finite time difference. These include signal processing, clock/signal synchronization and correlation methods, receiver resolution, signal to noise ratio, etc.