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Research Article

GPS- Where are We?

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ABSTRACT

The purpose of this paper is to showcase the experiences that incurred the designing and discerning of a position in space 'where we are'. GPS Global Positioning System (GPS) is part of satellites orbiting around the universe. It sends the details of their position in space back to earth. GPS has many applications in diverse areas. It is available to any user with a GPS receiver. It has its usefulness in military, weather conditions, vehicle location, farms, mapping and many other areas. This paper reviewed the types of GPS receivers, Data Engineering applications and the future of how more precise GPS can be.

Keywords: GPS Global Positioning System, Applications of GPS, How GPS Works, where we are, GPS Devices, GPS Analysis of Velocities, GPS Velocity Analysis, Triangulation to Determine

1. Introduction

In this section of the paper, a brief overview of GPS Technology is provided. The Global Positioning System (GPS) is a constellation of satellites (24 satellites) that orbit the earth twice a day, transmitting precise time and position (latitude, longitude and altitude) information. They are arranged in such a way that one can track and receive signals anywhere on earth. With a GPS Receiver, users can determine their location anywhere on the Earth. The complete system consists of 24 satellites orbiting about 12,000 miles above the Earth, and five ground stations to monitor and manage the satellite constellation. These satellites provide 24-hour-a-day coverage for both two-and three-dimensional positioning anywhere on Earth.

A GPS satellite navigation system was designed by the US Department of Defense, which continues to manage the system, to provide continuous, worldwide positioning and navigation data to US military forces around the globe. To be specific, GPS was designed by the US military in the late 1960's and its first satellite was launched in February, 1978. And the first handheld receiver was introduced in 1989. GPS basically offers two levels of service namely SPS (Standard Positioning Service) for civilian access and PPS (Precise Positioning Service) for exclusive military use with higher level of encryption[1].

There are various GPS satellite systems now. NAVSTAR - the one used by the United States of America which was designed by the US military and is shared even to civilians around the world. Others are Galileo -developed and used in Europe, the GLONASS- developed and used in Russia, IRNSS-developed and used in India, and the Bei-Dou-2 (BDS) - developed and used in China. We also have many different receiver devices that work with the GPS satellites systems in locating where we are. They are but not limited to Wi-Fi, Beacon, Carrier data or Cell towers, Meta data, bid stream, identifiers, cell phones, and internet protocols.

Knowing where we are is accomplished through atomic clocks and location data. Basically the satellites broadcast the time and their position. The GPS receiver receives these signals, listening to three or more satellites at once (called tracking), to determine the user's position on earth[2].

2.1. How GPS works

A GPS working principle is that it measures the time interval between the transmission and the reception of a satellite signal.

GPS Technology works in devices called receivers- (e.g Wi-Fi, Beacon, Carrier data or Cell towers, meta data, bid stream, identifiers, cell phones, internet protocols) - by receiving signals from satellites which are in orbit around the earth.

Figure 1: Types of GPS devices-receivers.

The GPS is made up of 24 satellites. They calculate the position by measuring the relative time it takes for the signal to arrive from about three or four satellites close to where we are or the location of the receivers.

A broadcast signal, travelling at the speed of light from a GPS satellite takes 65 and 85 milliseconds to reach a receiver on the earth surface. This time variation depends on the distance between the receiver on the earth surface and the satellite in orbit. The farther a GPS receiver from the satellite, the longer it takes for the signal to arrive.

Each GPs signal contains the satellite position and current time and is synchronized with all GPS signals (altogether 3 or 4 satellites) so that the repeating broadcast occurs at the same instant of time. GPS receivers passively monitor the signals from all GPS satellites as they move across the earth's orbits in space.

The receiver is closer to a satellite when it receives signals from that satellite earlier than other satellites. A receiver's location is calculated from the time it takes for it to receive signals from four satellites simultaneously[3].

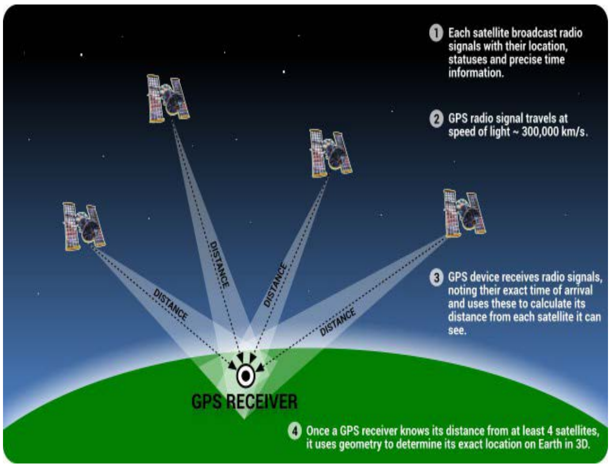

Figure 2: How GPS works[4].

3.2. Where are we?

Figure 3: Where are we? (Location).

Basically there are four (4) satellites in each orbit around the earth. The earth radius is about 6,000km and Satellites travel with a speed of 14,000km/hr. Data or Information is transmitted through electromagnetic waves which move at the speed of light c= 300000 km/sec.

as we know

$v = s/t$

Where:

V = velocity/ speed for this we take v as speed of light, c

S = the distance or position of object in space (where we are)

t = the relative time taken for Data signal to reach the receiver from each satellite

Each satellites have a radius of distance S1, S2 and S3 respectively this distance is calculated as the distance of the receiver to the satellite and by this formula.

Then the position or distance of where we are will be:

$S = c.\ t$

$S = c.\ (ts - tR)$

Where ts is the atomic clock time of satellite in space tR is the time of the Receiver at position[5].

t is the relative time difference for signal to get to the receiver - this is calculated as (ts - tR) and S is the position of an object in space or where we are from each satellite.

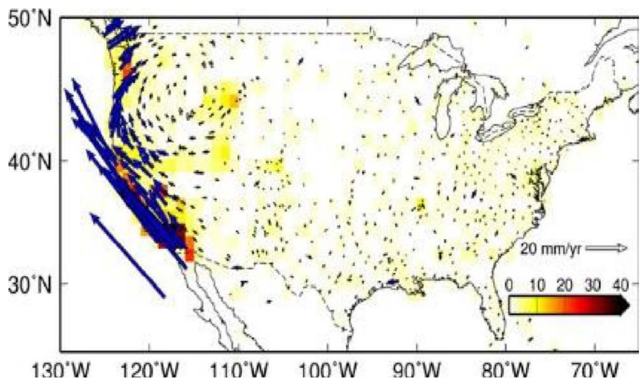

Figure 4: GPS Analysis of Velocities for the United States[6].

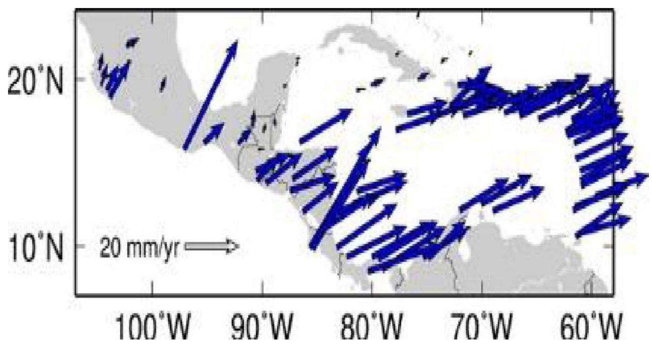

Figure 5: GPS velocity Analysis for the Caribbean[7].

By triangulation we are able to determine the exact location X, of 'where we are'- the receiver on the earth. This is reliable up to 5- 10 meters' radius under open sky[8,9]

2.3. Applications of GPS

GPS Technologies are found in virtually every industry sector from mining, aviation, surveying, agriculture, marine, recreation and of course the military where it all started. Its application falls into five[10,11] (5) major categories:

1. Location- Determining a position
2. Navigation- Getting from one location to another
3. Tracking- Monitoring object or personal movement
4. Mapping- Creating maps of the world
5. Timing- Bringing timing to the world

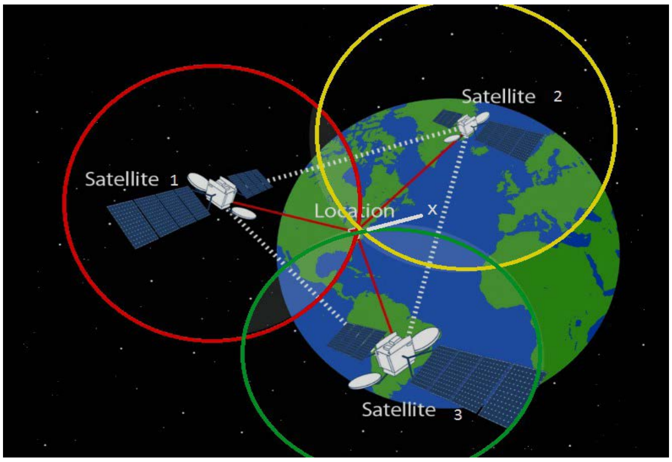

Figure 6: Triangulation to determine our location- where we are.

2.4. Accuracy and problems of GPS

GPS accuracy is about 5mm (16ft) under open sky. The number of jamming and RFI is increasing every year.

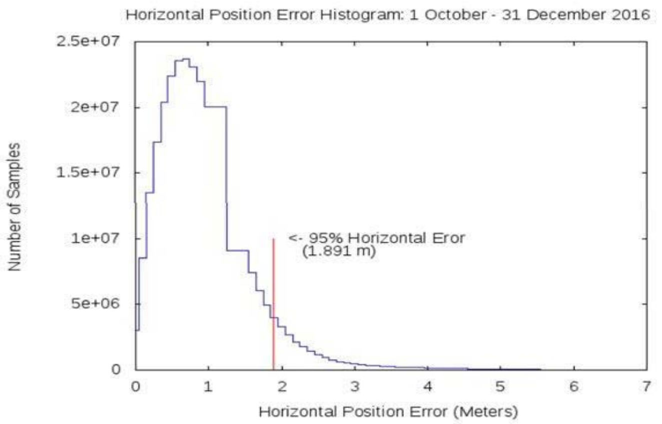

Figure 7: Accuracy of GPS Data in December 31, 2016.

From the information provided by GPS.Gov (2015), the accuracy of the GPS signal in space is actually the same for both the civilian GPS service (SPS) and the military GPS service (PPS). However, SPS broadcasts on one frequency, while PPS uses two. These means military users can perform ionospheres' correction, a technique that reduces radio degradation caused by the Earth's atmosphere. With less degradation, PPS provides better accuracy than the basic SPS.

Radio frequency Interference RFI causes threats to GPS receivers around the world due to their very low power signals. The Modulations and regulations to protect reserved frequency bands are not enough to solve problems related to the jamming of RFI[12].

2.5. Future of GPS

The future of GPS is bright, as the US modernization program is ongoing, lots of effort are being put in place to upgrade the GPS space and control segments with new features to improve its performance (Fig 8).

The modernization is introducing modern technologies throughout the space and control segments that will enhance overall performance. Legacy computers and communications systems are being replaced with a network-centric architecture to allow more frequent and precise satellite commands that will improve accuracy for everyone.

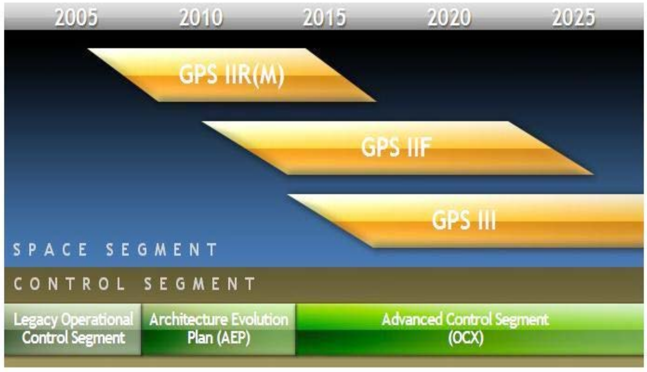

Figure 8: GPS Future in the US[13].

The GPS modernization program involves a series of consecutive satellite acquisitions, including GPS IIR (M), GPS IIF, and GPS III. It also involves improvements to the GPS control segment, including the Architecture Evolution Plan (AEP) and the Next Generation Operational Control System (OCX). The schedule for the parallel space and control segment upgrades is shown above in Figure 8

There are a couple of things that will emerge over the next few years. All mobile devices will be able to use GPS cost-efficiently. Cell phones will be the most important driver.

In the near future GPS data and Web services from receivers will be enhanced to allow greater access even to deep sea locations- where it is limited, effective discovery, 100% accuracy and better integration of different datasets at satellite stations[14].

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