

Global Positioning System – The Future

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ABSTRACT

In the preceding year's people relied mostly on sun and stars to locate their position and direction on earth. Global Positioning System (GPS) was discovered with the development in electronic devices and accurate clock signals alongside satellite technology [1]. Mobile phones are not only for wireless communication, but now-a-days people use it for navigation purpose too. GPS provides the user with exact information regarding his position and direction. GPS has changed the life of man in the last 5 years. The basic principle of GPS is to make use of satellite data for calculating the precise position of a particular person or an object on the earth.

Keywords - Global Positioning System, Navigation, trilateration, Satellite.

1. INTRODUCTION

In this modern era, the most important technology in the day to day life of humans is Global Positioning System (GPS). It makes a human life easier by solving their problems. The principle component of the Global Navigation Satellite System (GNSS) is the GPS [2]. With the help of GPS one can find out "where I am on earth?". Initially man used to locate himself with the help of Sun and stars. But once when cloudy, one cannot figure out sun and stars. Hence after World War II, it is obvious to locate the exact position of a man under any circumstances. Thus in 1970s a satellite based system known as GPS was proposed. GPS uses a collection of 31 active satellites for providing the user with a perfect and an accurate position. These satellites make two orbits a day and are inclined 55 degrees to the equator. The meaning for accurate position is different for different person: For Ex: for a soldier, the accurate distance means 15m, for the captain of the ship, the meaning for accurate means 5m, and for a person in land, the word accurate means 1cm or even less [3]. Initially GPS was designed for the purpose of Military use. Once military people began using the GPS, it became obvious that GPS can also be used civilians. At present common man mostly use GPS for navigating his car while in travel.

GPS consists of three segments: the control segment, space segment and user segment [4]. All the three are distinct. Figure 1 shows the three segments of GPS. **The Control segment** – consists of 3 (three) ground antennas, monitor stations which are four in numbers and a master station. It is this master station controls the ground antennas remotely. The commands received from the Master station are being transmitted to GPS satellites by the ground antennas. Monitor stations function as radio receivers. The functions of master station are controlling the satellite and the entire operations of the system. **Space segment** – consist of 24 satellites and they circle the earth in six orbital planes. The angle of inclination for a satellite is 55 degrees considering the equator. The lifetime of each satellite is 10 years. **User segment** - consists of radio receiver and antennas for receiving GPS signals and decide their position and time.

2. HISTORY

In 1957, Russia launched the first satellite Sputnik – 1. It is the United States government initiative that leads to the findings of GPS [5]. In 1973 – It was decided to build up the first satellite navigation for military. From 1974 to 1979, various system tests were conducted by the US navy and the US Air Force. First satellite launched in 1978. And in 1979, it was decided to enlarge GPS in space with 18 satellites. From 1983, civilians were allowed to use GPS. The number of satellites increased

to 24 in the year 1988. In the consecutive year 1989 leads to the introduction of first hand held GPS receiver. In 1996, GPS was made free for civilians.

every satellite with great accuracy. Likewise GPS receiver is included with a clock. With these clocks we can decide how long it takes for the satellite's signal to arrive at the receiver [6]. GPS satellites transmit "pseudo random codes" which

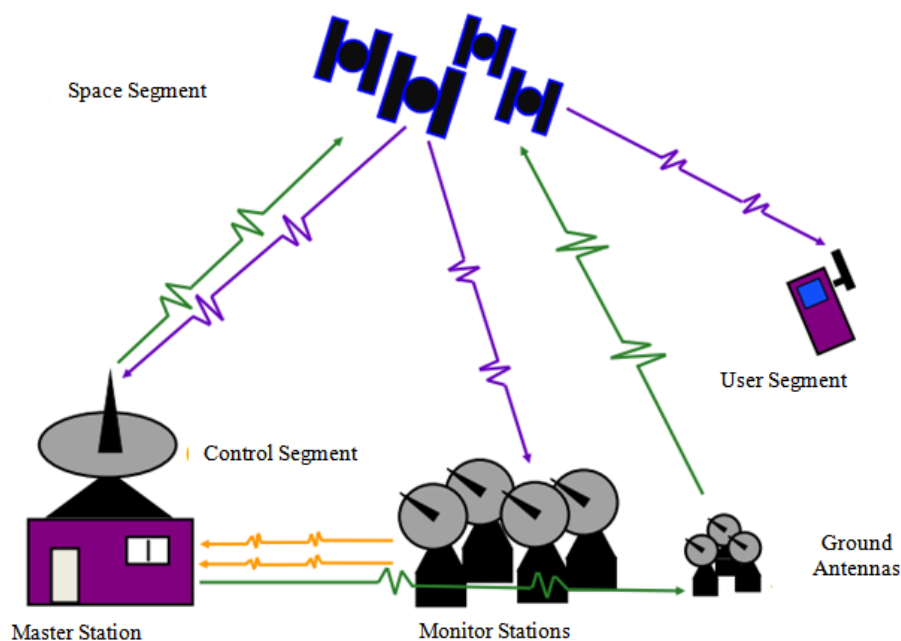


Fig 1 Three Segments of GPS

3. WORKING OF GPS

Now-a-day people have started using location based technologies to an unprecedented level. Lot of location enabled devices like mobile phones, digital cameras, in vehicle navigation are in the market and are providing a wide advantage to access GPS. Basically GPS refer to in vehicle navigation mainly for finding one's location. But these are called as GPS receivers [6]. To decide the position on the surface of the earth, a GPS receiver uses a complex version called trilateration. Trilateration engages in working with distances. The timing signals are received from the three satellites present in the Global Positioning system. GPS receivers receives signal from the satellites, thus providing the receiver with the accurate details of the location of receiver, days time, and the device speed. Every satellite in the GPS collection will be sending signals periodically beside time signal [7]. Once the GPS device receives these, it begins to compute the distance between the satellite and the device. The distance involving the satellite and the receiver is calculated by getting the disparity between the time the radio signal was send from GPS satellite and the time the GPS receiver received the signal [8]. An atomic clock is equipped with

hold the information regarding the time and the satellite's orbital path. The receiver in turn interprets these pseudo random codes for calculating the variation between its clock and the transmitted signal time. The formula for calculating the distance to the satellite (d) is given as below in Eq. (1):

$$d = \text{speed} \times (t_{rv} - t_{origin}) \quad (1)$$

where:

speed = the speed of light,

t_{origin} = time at the origin and

t_{rv} = time at the receiver.

Figure 2 shows the calculating distances between satellites and receivers. As soon as the receiver accepts the signals from a minimum of three satellites, it then spots its position using the process of trilateration. For calculating a 2-D position, a GPS must need a minimum of 3 satellites data. For 2-D latitude and longitude position on a map is enough. But for finding a 3-D position, it must need at least 4 satellites. In 3-D calculation we need to get the details of latitude, longitude and altitude. Trilateration is a procedure of deciding your location based on of the meeting point of spheres. As soon as the receiver obtain a signal from any one of the three satellite, the receiver starts

to calculate the distance between the receiver and the satellite taking into consideration a 3-D sphere thinking the satellite is at the middle of the sphere. The receiver performs the same calculation for the rest of the satellites and then continues to locate the intersection point of the 3 spheres for calculating its location. Figure 3 shows the image for 2D-trilateration and 3D-trilateration. The red dot in figure 3a shows the exact position of an object and the red sphere tells the location of an object in figure 3b.

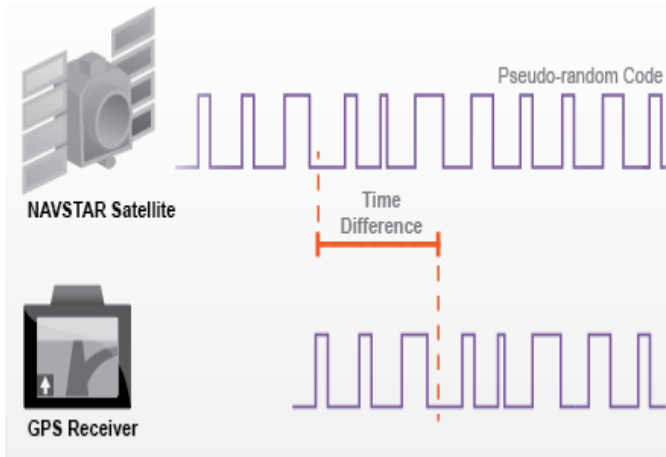


Fig 2. Calculating distances between satellites and receivers
Courtesy: [6]

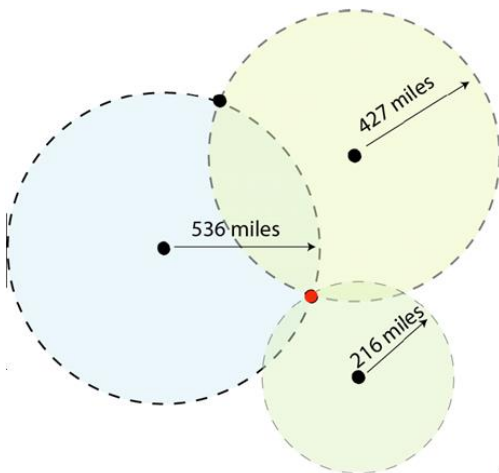
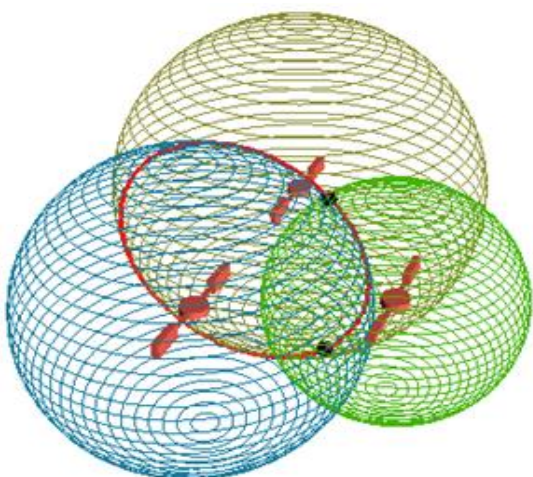


Fig 3a. 2D – trilateration



Sr. No	Pros	Cons
1	We can get GPS free of cost with any device that supports GPS	Since people focus more on GPS, which may lead to accidents
2	It is easy to use	Rarely it gets failed, at that time need to carry backup map and directions
3	GPS can operate in any weather conditions	Battery life is poor, since these systems rely on Battery. Once the battery gets drained, then it will not work [9]
4	GPS is updated frequently	Inaccuracy, since building and trees act as an obstacle which lead in the deflection of signal
5	One can know his exact location on earth at any point of time.	Price is a key concern, since GPS system cost high with additional features.
6	It can be accessed at any time (24 x 7)	A stolen object cannot be traced if the Receiver is in off state [10]

Fig 3b. 3D - trilateration

4. PROS AND CONS OF GPS

GPS plays a vital role now in our day to day life. It has become a part and parcel of our life. The advantage and disadvantage of GPS are given in table - I.

5. APPLICATIONS OF GPS

Till now we have seen how GPS receivers are used to navigate and locate a person or an object. GPS is not only used by civilians, but also used by Navy, farmers in agriculture, in aircraft aviation, railways and highways. The author explains in detail about how GPS can be used in the above mentioned field. Figure 4 shows some sample images showing GPS involvement in various fields.

5.1. Navy

GPS is very useful in search and also for rescue operations [11]. More accurate information is provided for the Navy for navigation and also to establish their location thereby facilitating search and rescue. GPS is used by a naval ship's officer to be familiar with the vessel's position in the middle of sea. The ship's position is vital both for the departure and arrival of the vessel from and to the port. Even for underwater

surveying GPS is used by the Navy. To find the location for fishing GPS is used. With the help of Automatic Identification System (AIS), vessel traffic is controlled in the sea.

5.2. Agriculture

The progress of precision agriculture is enabled by the dawn of GPS in combination with Geographic Information System (GIS). Farmers can now work even their field has low visibility due to rain or mist. Many GPS equipments are available for farmers, which helps them in increasing their production in an efficient way. To enhance their farm business, farmers are now using GPS based products. With the help of the collected information by GPS receivers, the farmers can do farm mapping identify the areas where few crops are affected by disease, etc. For spraying chemicals where needed, farmers use crop dusters which are operational with GPS.

5.3. Aircraft Aviation

For increase in flight safety and competence, aviators use GPS, since it provides with flawless satellite navigation. Huge amount of money, fuel, and time are saved with the help of GPS in the field of Aviation, since more efficient new air routes are discovered using GPS. To get higher accuracy, GPS is continuously getting modernized. Another component of GPS is Enhanced Ground Proximity Warning System (EGPWS). This EGPWS will diminish the hazard of aircraft accidents in Terrain.

5.4. Railways

Locomotive movement, rail cars, vehicle maintenance are tracked in rail systems using GPS. The safety of rail, its security, and operational efficiency are improved to great extent when GPS is combined with computers, and some sensors. Using this technology, rail accidents are reduced, cost of operating the rails are diminished, and there is an increase in customer satisfaction and cost efficient. For preventing rail collisions, we use an automatic system called Positive Train Control (PTC).

5.5. Highways

Safety of the vehicles using highways or streets is now increased efficiently with the help of GPS. People who are travelling on highways can predict the traffic they wish to travel in few hours using GPS. Companies used to track the delivery of their goods at the promised time using GPS. One

can identify the location of fuel stations, hotels, etc using GPS. In-vehicle navigation is another milestone of GPS.

6. CONCLUSIONS

GPS has made a technological revolution in numerous fields and has opened many research fronts in many fields [12]. GPS technology is now available in mobile phones, containers, wrist watches, etc. GPS receivers cost is coming down drastically, but the accuracy of the receivers is improving. With the extraordinary development in the hardware of the present GPS receiver, researchers are widening the development of the GPS receiver so that the accuracy and the speed can still be improved in the coming years. Researchers are planning to use GPS for predicting the occurrence of earth quake. Thus with its widening scope, GPS is set to develop into a new revolutionary technique of this century.

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