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Definition:

Global positioning system is U.S. space-based global navigation satellite system, known as GPS. It is the most precise navigation system ever invented. It provides reliable location and time information in all weather and at all times and anywhere on or near the Earth there is an unobstructed line of sight to four or more GPS satellites. And it can be defined as under;

> ***"A navigational system, involving satellites and computers that can determine the latitude and longitude of a receiver on Earth by computing the time difference for signals from different satellites to reach the receiver."***

Introduction:

GPS was developed by the U. S. Department of Defense (DOD), Ivan Getting, and the Massachusetts Institute of Technology (MIT). Its official name is **NAVSTAR GPS (**Navigation Satellite timing and Ranging Global Positioning System**)**.

It is made up of a network of 24 satellites placed into orbit. That's why; it is based on a complex network of 24 satellites (with about 6 spares) orbiting the earth at a very high altitude approximately ***11,000 miles***. These satellites function 24 hours a day which are continuously sending signals to ground stations that monitor and control GPS operations and are designed to be resistant to jamming and interference.

GPS allows every square meter of the earth's surface to have a unique address, which offers limitless application possibilities when coupled with today's advanced micro-computer systems.

Nowadays, about ***30 active*** satellites orbit the earth in a distance of 20200 km. GPS satellites transmit signals which enable the exact location of a GPS receiver, if it is positioned on the surface of the earth, in the earth atmosphere or in a low orbit.

History:

Our ancestors had to go to pretty extreme measures to keep from getting lost. They erected monumental landmarks, laboriously drafted detailed maps and learned to read the stars in the night sky. "For centuries, navigators and explorers have searched the heavens for a system that would enable them to locate their position on the globe with the accuracy necessary to avoid tragedy and to reach their intended destinations.

And GPS is that gadget which was launched by DOD in 1978 strictly for military use. The idea for the system began much, much earlier. In fact the basic idea of GPS navigation can be traced back centuries to the first explorer who asked the question, "Where am I?" The technology of GPS history, however, first emerged in the 1950s. The technology of GPS history, however, first emerged in the 1950s.

The design of GPS is based partly on similar ground-based radio navigation systems, such as ***LORAN*** and ***the Decca Navigator*** developed in the early ***1940s***, and used during World War II.

1951- The seeds for the GPS technology were being planted. In 1951, Dr. Ivan Getting, a graduate of MIT student and a Rhodes Scholar from Oxford, put his Ph.D. in astrophysics to use at Raytheon. The Air Force requested a guidance system for a proposed ICBM traveling via railroad. In response to this request, Dr. Getting developed the first three-dimensional, position-finding system based on time difference of arrival. This system became the basis for the future GPS.

1957- Russia launched a satellite (Sputnik) into space which was developed by a team of U.S. scientists led by ***Dr. Richard B. Kershner*** were monitoring Sputnik's radio transmissions. It is thought to GPS came when the Soviet Union launched the first Sputnik in ***1957***.

After the launch, MIT researchers noticed that as Sputnik orbited the planet, its radio signal varied in strength. As it approached their position, the signal strength increased. When the satellite departed the MIT researchers' position, the signal strength decreased. From this increase and decrease of the radio signal, the MIT researchers could determine Sputnik's exact orbit. This recognition that radio signals from a satellite, or "artificial star" could determine distinct positions on the ground was truly the launching pad of the GPS system.

1960- The first satellite navigation system, Transit, used by the United States Navy, was first successfully tested in 1960. Using a constellation of five satellites, when The Aerospace Corporation was a principal participant in the conception and development of GPS, a technology that has significantly enhanced the capabilities of our nation’s military and continues to find new uses and applications in daily life. We’ve helped build GPS into one of history’s most exciting and revolutionary technologies and continue to participate in its ongoing operation and enhancement.

1973- The deployment portion of the GPS history began in 1973 with the decision to develop a satellite navigation system based on existing technology of the U. S. Air Force and the U. S. Navy. The system went through extensive testing during the next three years.

1977- The first transmitters were installed on the surface of the Earth and tested--even though no satellites have been launched yet. The transmitters were dubbed Pseudolites (pseudo satellites used to refer to something that is not a satellite which performs a function commonly in the domain of satellites. these are most often small transceivers that are used to create a local, ground-based GPS alternative.)

1978- 1985, eleven satellites were launched into space and put into position. In 1979, the decision was made to increase the number of satellites to 18. In 1980, the first Block I satellite was launched. This "bird' had sensors specifically designed to detect atomic explosions, and was placed in orbit as a means of monitoring the Soviet Union's compliance with the 1963 agreement with the United States to refrain from nuclear testing.

Also in 1980, the onboard atomic clocks, the most accurate timepieces in the world, were activated. Developed by physicists, atomic clocks measure time by the change in energy levels of electrons. These clocks are stable, continuous, and accurate to a nanosecond, or one-billionth of a second.

In 1983, the GPS ceased being solely a military system and was made available for public use.

Though the GPS system was available for public use, the first Gulf War in 1990 saw temporary deactivation of use by the public, because the military needed more receivers. Public use returned in 1993 along with the decision that the GPS system would be available free of charge to the entire world. Full Operational Capacity (FOC) was achieved in July of 1995 with the placement and activation of the last of the 24 satellites.

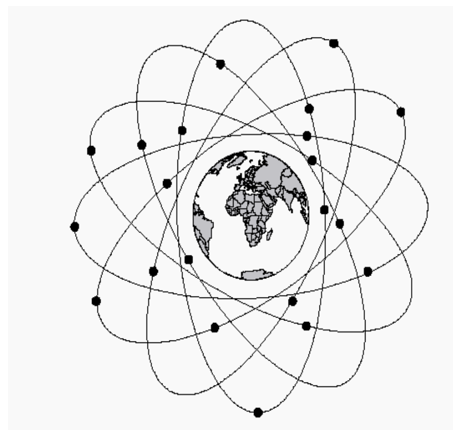
Since 1995, GPS history has seen considerable technological advancement. More satellites have been put into orbit, increasing both availability and accuracy. Previously GPS could locate a subject within 100 meters. That accuracy improved to finding subjects within 10-15 meters, and at present can be measured within centimeters in some cases.

Parts of GPS:

GPS consists of three main segments:

- Space
- Control
- user

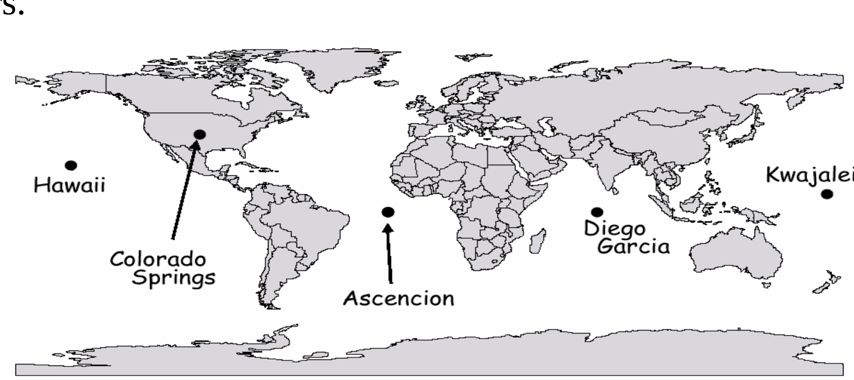
The Space Segment:



This part consists of 24 satellites, manufactured by Rockwell International, which are launched into space by rockets, from Cape Canaveral, Florida. They are about the size of a car, and weigh about 19,000lbs. Each satellite is in orbit above the earth at an altitude of 11,000 nautical miles (12,660 miles), and takes 12 hours to orbit one time. There are 6 orbital planes each having 4 satellites. The orbits are tilted to the equator of the earth by 55° so that there is coverage of the polar regions. The satellites continuously orient themselves to ensure that theirsolar panels stay pointed towards the sun, and their antennas point toward the earth. Each satellite carries 4 atomic clocks.

The Control Segment:

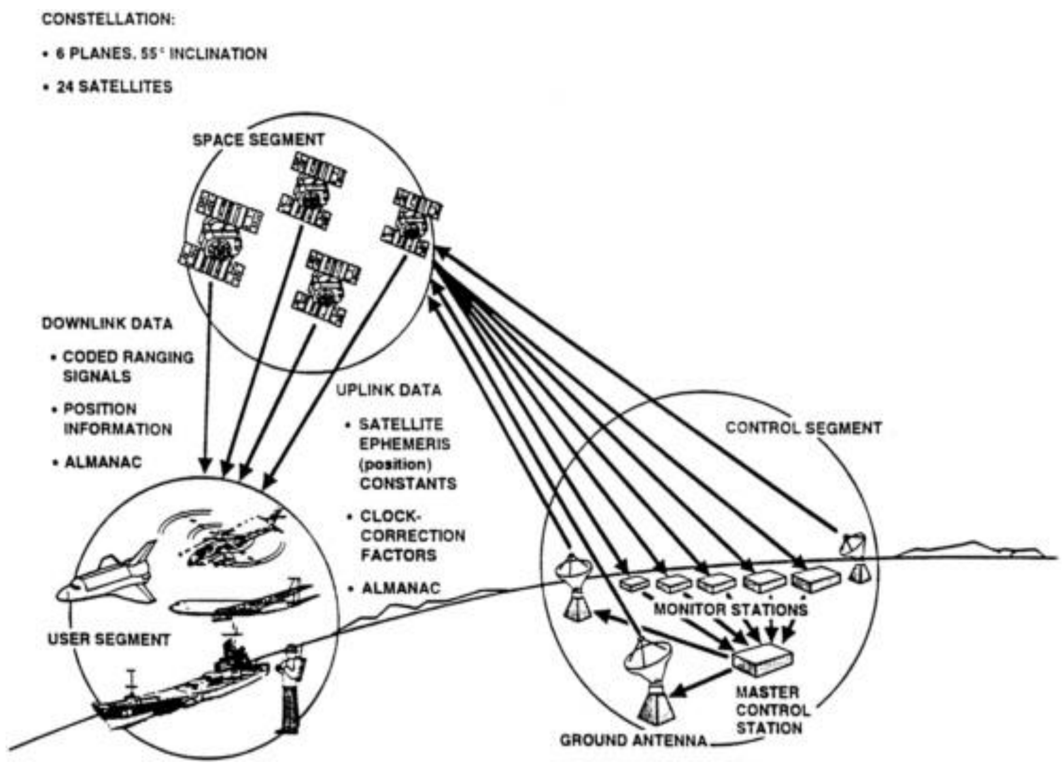
This part consists of 5 worldwide unmanned base-stations that monitor the satellites to track their exact position in space, and to make sure that they are operating correctly. The stations constantly monitor the orbits of the satellites and use very precise radar to check altitude, position and speed. Transmitted to the satellites are ephemeris constants and clock adjustments. The satellites in turn, use these updates in the signals that they send to GPS receivers.



STATIONS IN GPS CONTROL SEGMENTS

The User Segment:

This part consists of user receivers which are hand-held or, can be placed in a vehicle. All GPS receivers have a manual programmed into their computer, which tells them where each satellite is at any given moment. The GPS receivers detect, decode and process the signals received from the satellites. The receiver is usually used in conjunction with computer software to output the information to the user in the form of a map. As the user does not have to communicate with the satellite there can be unlimited users at one time.



SEGMENTS OF GPS

Work of GPS:

The basis of GPS is triangulation from satellites. GPS operates using trilateration, which can be defined as under;

> ***"Trilateration is the process of determining the position of an unknown point by measuring the lengths of the sides of an imaginary triangle between the unknown point and two or more known points."***

Procedure:

Gps works in the following scenario:

1. Sending if the signals
2. Receiving of signals
3. Determination of position
4. Accuracy of positioning

Sending the signals:

Global Positioning System satellites transmit signals to equipment on the ground. GPS receivers passively receive satellite signals; they do not transmit. GPS receivers require an unobstructed view of the sky, so they are used only outdoors and they often do not perform well within forested areas or near tall buildings. GPS operations depend on a very accurate time reference, which is provided by atomic clocks at the U.S. Naval Observatory. Each GPS satellite has atomic clocks on board.

Receiving the signals:

Each GPS satellite transmits data that indicates its location and the current time. All GPS satellites synchronize operations so that these repeating signals are transmitted at the same instant. The signals, moving at the speed of light, arrive at a GPS receiver at slightly different times because some satellites are farther away than others. The distance to the GPS satellites can be determined by estimating the amount of time it takes for their signals to reach the receiver. When the receiver estimates the distance to at least four GPS satellites, it can calculate its position in three dimensions.

As we know, there are at least 24 operational GPS satellites at all times. The satellites, operated by the U.S. Air Force, orbit with a period of 12 hours. Ground stations are used to precisely track each satellite's orbit.

Determining Position:

A GPS receiver "knows" the location of the satellites, because that information is included in satellite transmissions. By estimating how far away a satellite is, the receiver also "knows" it is located somewhere on the surface of an imaginary sphere centered at the satellite. It then determines the sizes of several spheres, one for each satellite. The receiver is located where these spheres intersect.

GPS Accuracy:

The accuracy of a position determined with GPS depends on the type of receiver. Most hand-held GPS units have about 10-20 meter accuracy. Other types of receivers use a method called Differential GPS (DGPS) to obtain much higher accuracy. DGPS requires an additional receiver fixed at a known location nearby. Observations made by the stationary receiver are used to correct positions recorded by the roving units, producing an accuracy greater than 1 meter.

Error sources:

All GPS positions are not 100% accurate and thus must have some error in them. Before we turn our attention to just how accurate our GPS positions are, we should have a quick look at some of the errors that affect the positions we get from the GPS. Each of the following errors has an impact on the accuracy of our GPS positions.

1. Satellite Orbits
2. Time of arrival of signal:
3. Receiver clock error:
4. Orbital error:
5. Atmospheric effect:
6. Multipath effect

Satellite Orbits:

Although the satellites are positioned in very precise orbits, slight shifts of the orbits are possible due to gravitation forces. Sun and moon have a weak influence on the orbits. The orbit data are controlled and corrected regularly and are sent to the receivers in the package of ephemeris data. Therefore the influence on the correctness of the position determination is rather low, the resulting error being not more than 2 m.

Time of arrival of signal:

The position calculated by a GPS receiver requires the current time, the position of the satellite and the measured delay of the received signal. The position accuracy is primarily dependent on the satellite position and signal delay.

Receiver clock error:

The receiver enabled with a clock that is not as accurate as the atomic clock in satellite and so produce a little timing error.

Orbital error:

This occurs when the satellite's orbital location is calculated wrongly. As the right location of the satellites position in the orbit is essential, even a small error can leave a large difference as far as accuracy is concerned.

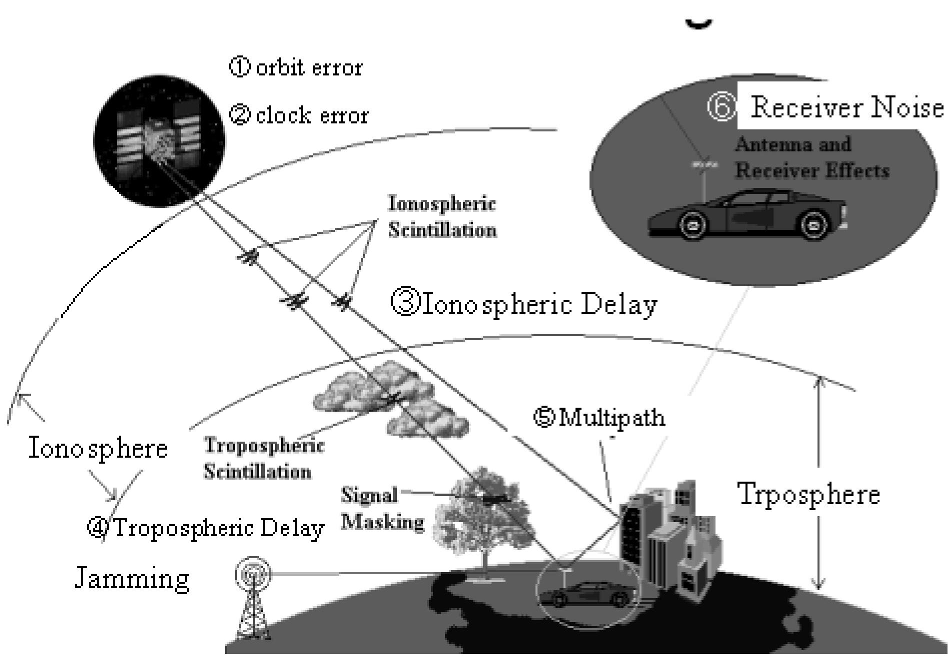
Atmospheric effect:

Any change in atmospheric condition can affect GPS radio signals as signals travel through the thick layer of the atmosphere. Both ionosphere and troposphere can leave little or more impact on the speed of the radio signals. Dual frequency measurement or comparing the two frequencies L1 and L2 can reduce the error and also define a precise location of the receiver.

Multipath effect

The multipath effect is caused by reflection of satellite signals (radio waves) on objects. It was the same effect that caused ghost images on television when antennae on the roof were still more common instead of todays satellite dishes.

For GPS signals this effect mainly appears in the neighbourhood of large buildings or other elevations. The reflected signal takes more time to reach the receiver than the direct signal. The resulting error typically lies in the range of a few meters.



ERRORS OF GPS

Applications of GPS:

GPS technology has matured into a resource that goes far beyond its original design goals. These days scientists, sportsmen, farmers, soldiers, pilots, surveyors, hikers, delivery drivers, sailors, dispatchers, lumberjacks, fire-fighters, and people from many other walks of life are using GPS in ways that make their work more productive, safer, and sometimes even easier.

Here are a few examples of real-world applications of GPS. These applications fall into five broad categories.

1. Location
2. Navigation
3. Tracking
4. Mapping
5. Timing
6. Agriculture

Location:

The first and most obvious application of GPS is the simple determination of a "position" or location. GPS is the first positioning system to offer highly precise location data for any point on the planet, in any weather. That alone would be enough to qualify it as a major utility, but the accuracy of GPS and the creativity of its users are pushing it into some surprising realms.

Knowing the precise location of something, or someone, is especially critical when the consequences of inaccurate data are measured in human terms.

Navigation:

GPS helps you determine exactly where you are, but sometimes important to know how to get somewhere else. GPS was originally designed to provide navigation information for ships and planes. So it's no surprise that while this technology is appropriate for navigating on water, it's also very useful in the air and on the land.

It's interesting that the sea, one of our oldest channels of transportation, has been revolutionized by GPS, the newest navigation technology. Trimble introduced the world's first GPS receiver for marine navigation in 1985. And as you would expect, navigating the world's oceans and waterways is more precise than ever.

Communication:

If navigation is the process of getting something from one location to another, then tracking is the process of monitoring it as it moves along.

Commerce relies on fleets of vehicles to deliver goods and services either across a crowded city or through nationwide corridors. So, effective fleet management has direct bottom-line implications, such as telling a customer when a package will arrive, spacing buses for the best scheduled service, directing the nearest ambulance to an accident, or helping tankers avoid hazards.

GPS used in conjunction with communication links and computers can provide the backbone for systems tailored to applications in agriculture, mass transit, urban delivery, public safety, and vessel and vehicle tracking. So it's no surprise that police, ambulance, and fire departments are adopting systems like GPS-based AVL (Automatic Vehicle Location) Manager to pinpoint both the location of the emergency and the location of the nearest response vehicle on a computer map. With this kind of clear visual picture of the situation, dispatchers can react immediately and confidently.

Aviators throughout the world use the Global Positioning System (GPS) to increase the safety and efficiency of flight. With its accurate, continuous, and global capabilities, GPS offers seamless satellite navigation services that satisfy many of the requirements for aviation users. Space-based position and navigation enables three-dimensional position determination for all phases of flight from departure, en route, and arrival, to airport surface navigation.

Mapping:

Surveying and mapping community is steadily redefining the tools required to increase productivity and obtain highly accurate data.

Using the near pinpoint accuracy provided by the Global Positioning System (GPS) with ground augmentations, highly accurate surveying and mapping results can be rapidly obtained, thereby significantly reducing the amount of equipment and labor hours that are normally required of other conventional surveying and mapping techniques. Today it is possible for a single surveyor to accomplish in one day what used to take weeks with an entire team. GPS is unaffected by rain, wind, or reduced sunlight, and is rapidly being adopted by professional surveyors and mapping personnel throughout the world.

It's a big world out there, and using GPS to survey and map it precisely saves time and money in this most stringent of all applications. Today, GPS makes it possible for a single surveyor to accomplish in a day what used to take weeks with an entire team. And they can do their work with a higher level of accuracy than ever before.

The technology which is now the method of choice for performing control surveys, and the effect on surveying in general has been considerable. Mapping is the art and science of using GPS to locate items, and then create maps and models of everything in the world. And we do mean everything. Mountains, rivers, forests and other landforms. Roads, routes, and city streets. Endangered animals, precious minerals and all sorts of resources. Damage and disasters, trash and archeological treasures. GPS is mapping the world.

Agriculture:

"We started using more digital technology in the last 10 years. We have gone to GPS (Global Positioning System) for a handful of different operations from cultivating to planting. By using GPS on the tractors, the entire process from leveling the field to planting the seed to irrigating the crop has been much more efficient than in the past. GPS is used in a lot of applications throughout most aspects of agriculture."

Timing:

Although GPS is well-known for navigation, tracking, and mapping, it's also used to disseminate precise time, time intervals, and frequency. Time is a powerful commodity, and exact time is more powerful still. Knowing that a group of timed events is perfectly synchronized is often very important. GPS makes the job of "synchronizing our watches" easy and reliable.

There are three fundamental ways we use time. As a universal marker, time tells us when things happened or when they will. As a way to synchronize people, events, even other types of signals, time helps keep the world on schedule. As a way to tell how long things last, time provides and accurate, unambiguous sense of duration.

GPS satellites carry highly accurate atomic clocks. And in order for the system to work, our GPS receivers here on the ground synchronize themselves to these clocks. That means that every GPS receiver is, in essence, an atomic accuracy clock.

Astronomers, power companies, computer networks, communications systems, banks, and radio and television stations can benefit from this precise timing.