3.1 Introduction

Global Positioning System (GPS) technology is a great boon to anyone who has the need to navigate either great or small distances. This wonderful navigation technology was actually first available for government use back in the late 1970s. In the past ten or so years, It has been made available to the general public in the form of handheld receivers that use this satellite technology provided by the U.S. government.

GPS formally known as the NAVSTAR (Navigation Satellite Timing and Ranging) Global Positioning System, originally was developed for the military. Because of its popular navigation capabilities and because you can access GPS technology using small inexpensive equipment, the government mad the system available for civilian use. The USA owns GPS technology and the Department of Defense maintains it. The first satellite was placed in orbit on 22nd February 1978, and there are currently 28 operational satellites orbiting the Earth at a height of 20,180 km on 6 different orbital planes. Their orbits are inclined at 55° to the equator, ensuring that at least 4 satellites are in radio communication with any point on the planet. Each satellite orbits the Earth in approximately 12 hours and has four atomic clocks on board. During the development of the GPS system, particular emphasis was placed on the following three aspects:

1. *It had to provide users with the capability of determining position, speed and time, whether in motion or at rest.*
2. *It had to have a continuous, global, 3-dimensional positioning capability with a high degree of accuracy, irrespective of the weather.*
3. *It had to offer potential for civilian use.*

GPS has also demonstrated a significant benefit to the civilian community who are applying GPS to a rapidly expanding number of applications. What attracts us to GPS is:

1. *The relatively high positioning accuracies, from tens of meters down to the millimeter level.*

2. *The capability of determining velocity and time, to an accuracy commensurate with position.*

3. *The signals are available to users anywhere on the globe: in the air, on the ground, or at sea.*

4. *Its is a positioning system with no user charges, that simply requires the use of relatively low cost hardware.*

5. *It is an all-weather system, available 24 hours a day.*

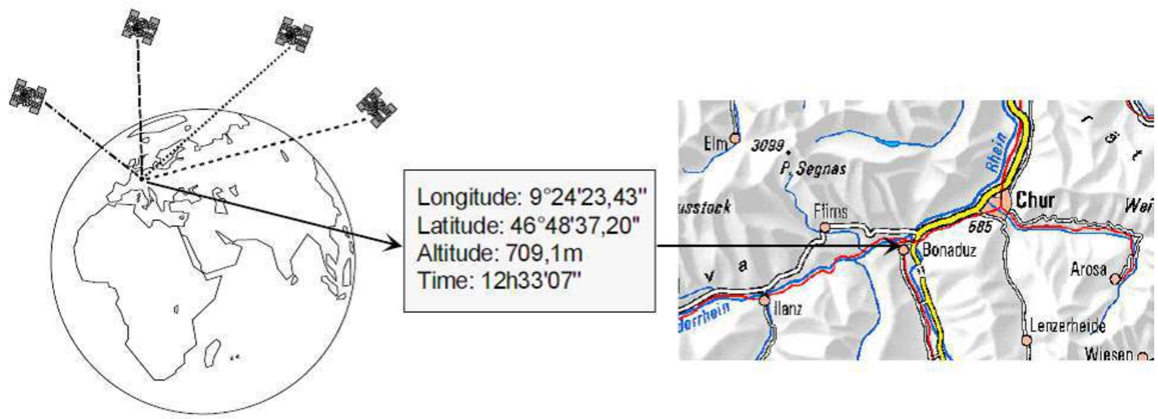
6. *The position information is in three dimensions, that is, vertical as well as horizontal information is provided*

Using the Global Positioning System (GPS, a process used to establish a position at any point on the globe) the following two values can be determined anywhere on Earth:

1. *One's exact location (longitude, latitude and height co-ordinates) accurate to within a range of 20 m to approx. 1 mm.*

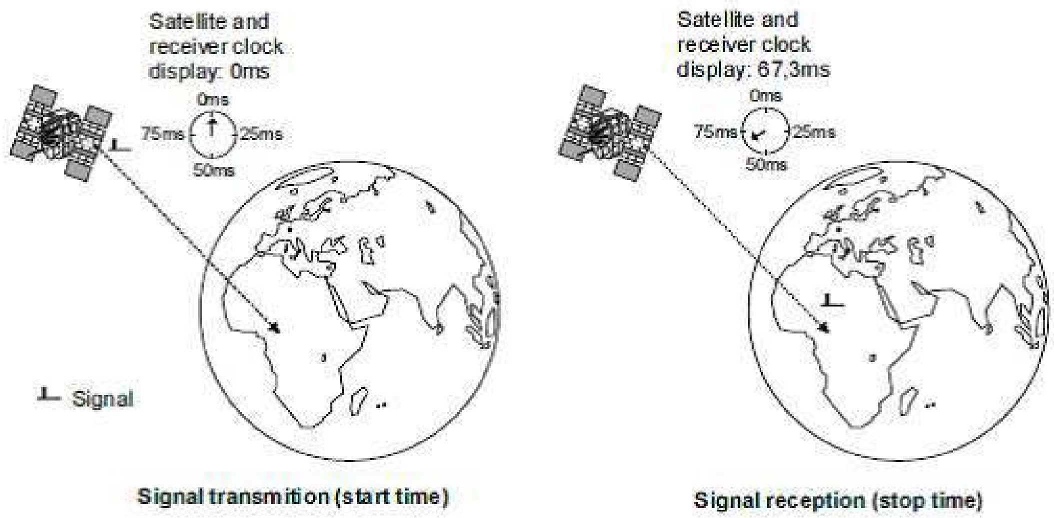
2. *The precise time (Universal Time Coordinated, UTC) accurate to within a range of 60ns to approx. 5ns.*

Speed and direction of travel (course) can be derived from these co-ordinates as well as the time. The coordinates and time values are determined by 28 satellites orbiting the Earth.



3.2 Concepts of GPS

Generating GPS signal transit time 28 satellites inclined at 55° to the equator orbit the Earth every 11 hours and 58 minutes at a height of 20,180 km on 6 different orbital planes (Figure 3). Each one of these satellites has up to four atomic clocks on board. Atomic clocks are currently the most precise instruments known, losing a maximum of one second every 30,000 to 1,000,000 years. In order to make them even more accurate, they are regularly adjusted or synchronised from various control points on Earth. Each satellite transmits its exact position and its precise on board clock time to Earth at a frequency of 1575.42 MHz. These signals are transmitted at the speed of light (300,000 km/s) and therefore require approx. 67.3 ms to reach a position on the Earth's surface located directly below the satellite. The signals require a further 3.33 us for each excess kilometer of travel. If you wish to establish your position on land (or at sea or in the air), all you require is an accurate clock. By comparing the arrival time of the satellite signal with the on board clock time the moment the signal was emitted, it is possible to determine the transit time of that signal (Figure 4).



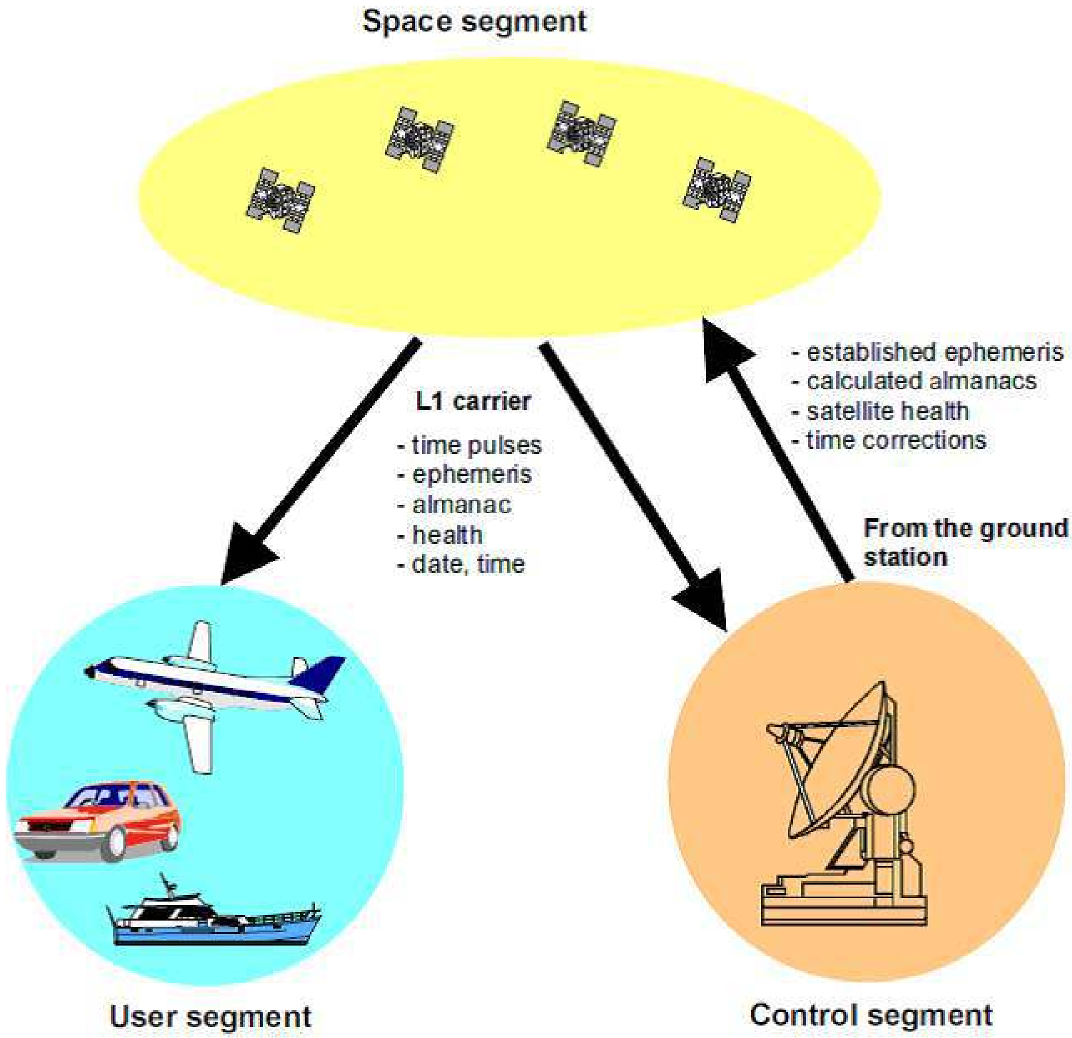
The distance S to the satellite can be determined by using the known transit time τ:

distance travel time x the speed of light

S =τ x c

Measuring signal transit time and knowing the distance to a satellite is still not enough to calculate one's own position in 3-D space. To achieve this, four independent transit time measurements are required. It is for this reason that signal communication with four different satellites is needed to calculate one's exact position. Why this should be so, can best be explained by initially determining one's position on a plane.

3.2.1 GPS system elements



The GPS system consists of three segments. (Good general references on the GPS system are) :

*• The **Space Segment**: comprising the satellites and the transmitted signals.*

*• The **Control Segment**: the ground facilities carrying out the task of satellite tracking, orbit computations, telemetry and supervision necessary for the daily control of the space segment.*

• The ***User Segment****: the entire spectrum of applications equipment and computational techniques that are available to the users.*

The Space Segment consists of the constellation of spacecraft and the signals broadcast by them

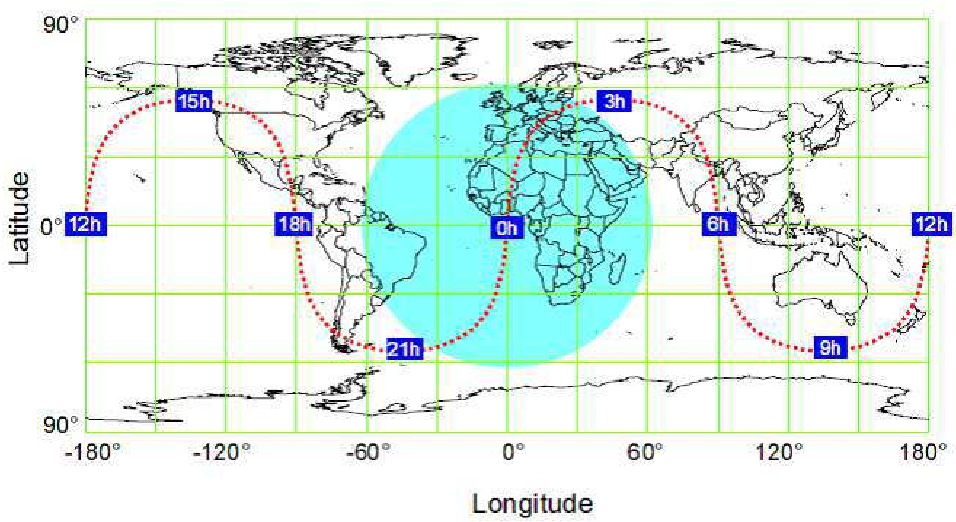
which allow users to determine position, velocity and time. The basic functions of the satellites are to:

• Receive and store data transmitted by the Control Segment stations.

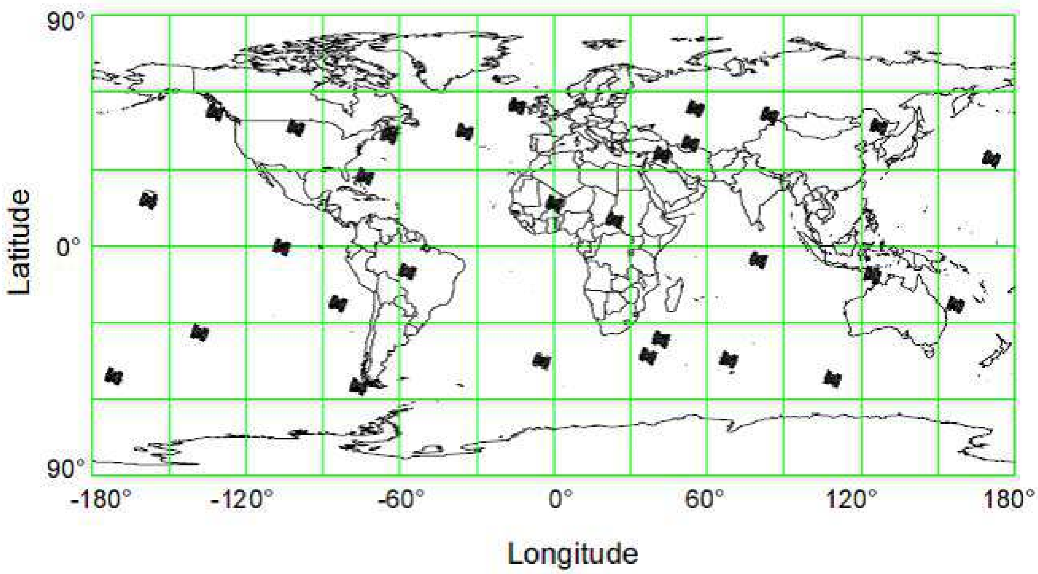
• Maintain accurate time by means of several onboard atomic clocks.

• Transmit information and signals to users on two L-band frequencies.

• Provide a stable platform and orbit for the L-band transmitters.



Satellite signals can be received anywhere within a satellite's effective range. The effective range (shaded area) of a satellite located directly above the equator/zero meridian intersection. The distribution of the 28 satellites at any given time can be seen. It is due to this ingenious pattern of distribution and to the great height at which they orbit that communication with at least 4 satellites is ensured at all times anywhere in the world.



ure 10: Position of the 28 GPS satellites at 12.00 hrs UTC on 14th April 2001

3.2.2 Control segment

The control segment (Operational Control System OCS) consists of a Master Control Station located in the state of Colorado, five monitor stations equipped with atomic clocks that are spread around the globe in the vicinity of the equator, and three ground control stations that transmit information to the satellites.

The most important tasks of the control segment are:

- *Observing the movement of the satellites and computing orbital data (ephemeris)*

- *Monitoring the satellite clocks and predicting their behaviour*

- *Synchronising on board satellite time*

- *Relaying precise orbital data received from satellites in communication*

- *Relaying the approximate orbital data of all satellites (almanac)*

- *Relaying further information, including satellite health, clock errors etc.*

The control segment also oversees the artificial distortion of signals (SA, Selective Availability), in order to degrade the system's positional accuracy for civil use. System accuracy had been intentionally degraded up until May 2000 for political and tactical reasons by the U.S. Department of Defense (DoD), the satellite operators. It was shut down in May 2000, but it can be started up again, if necessary, either on a global or regional basis.

3.2.3 User segment

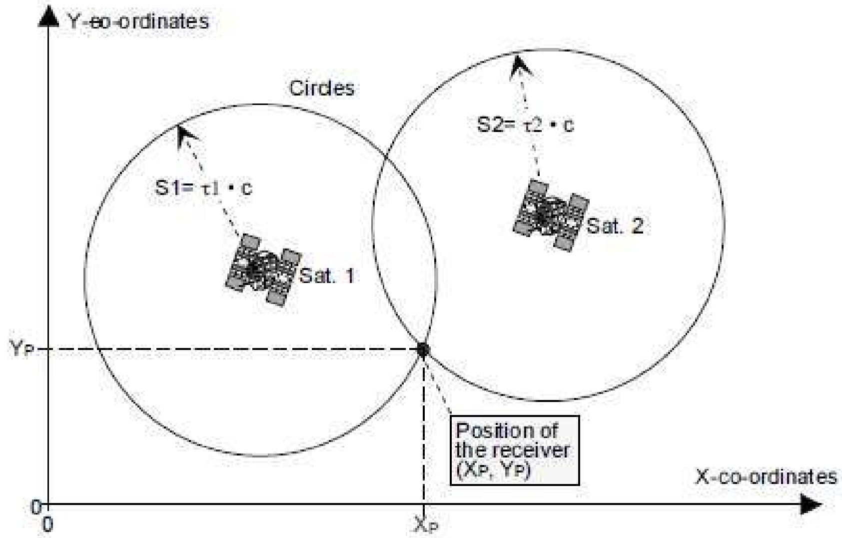
The signals transmitted by the satellites take approx. 67 milliseconds to reach a receiver. As the signals travel at the speed of light, their transit time depends on the distance between the satellites and the user.

Four different signals are generated in the receiver having the same structure as those received from the 4 satellites. By synchronising the signals generated in the receiver with those from the satellites, the four satellite signal time shifts Δt are measured as a timing mark.

3.2.4 Determining a position on a plane

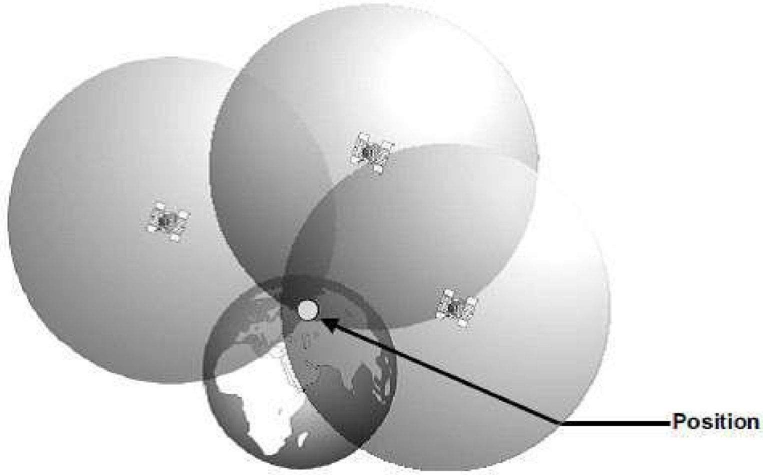
Imagine that you are wandering across a vast plateau and would like to know where you are. Two satellites are orbiting far above you transmitting their own on board clock times and positions. By using the signal transit time to both satellites you can draw two circles with the radii S1 and S2 around the satellites. Each radius corresponds to the distance calculated to the satellite. All possible distances to the satellite are located on the circumference of the circle. If the position above the satellites is excluded, the location of the receiver is at the exact point where the two circles intersect beneath the satellites.

Two satellites are sufficient to determine a position on the X/Y plane.



In reality, a position has to be determined in three-dimensional space, rather than on a plane. As the difference between a plane and three-dimensional space consists of an extra dimension (height Z), an additional third satellite must be available to determine the true position. If the distance to the three satellites is known, all possible positions are located on the surface of three spheres whose radii correspond to the distance calculated.

The position sought is at the point where all three surfaces of the spheres intersect.



All statements made so far will only be valid, if the terrestrial clock and the atomic clocks on board the satellites are synchronised, i.e. signal transit time can be correctly determined.

3.3 Types of GPS

Google Earth and Google Maps are made to work with GPS data

Many services allow you to upload your GPS tracks and waypoints to Google Earth. Others also let you upload your photos and even geo-reference them for you, so they are projected exactly on the spots where they have been taken.

Hybrid GeoTools *make custom and standard software to extend the functionality of popular geographic tools such as Google Earth.*

Hybrid GeoTools' **Active GPX Route Player** *for Google Earth. The "Media Player" of GPS playback. Simple to use yet endlessly customizable, up to 50 routes can be played back at the same time. Adjust time, speed scale, viewing behavior, track and icon appearance and watch progress against an altitude profile. Every turn, acceleration and stop is faithfully recreated.*

New in Version 1.1 - Virtual Cyclist - Set the power, weight, aerodynamics and see how you'd perform on the climbs of the Tour de France.

Hybrid GeoTools' **3D Route Builder** *is a GPS Editor for Google Earth. It offers fine grain control of routes directly in Google Earth not only in terms of positioning and altitude but also in time. Easily shift and scale time, correct barometric drift, synch to video files and build accurate GPS (GPX), KML/KMZ and Garmin TCX files from scratch or from existing files. Playback routes in real-time and optionally with absolute altitude - that means tunnels, bridges, cable car rides and flights take on new levels of realism.*

3dtracking *Ltd has just launched a new range of completely free GPS services through their website http://www.3dtracking.net. Simply put, through using your mobile phone or PDA, along with your GPS receiver, you can record and view your movements in detail on Google Earth or Google Maps. You can even use the free service for live tracking using Google Earth or Google Maps. Download of the required 3dtracking GPS software application, as well as use of the website, is completely free (and there are no future* *plans to charge for this either. Ever). The web server also retains all the data you've ever recorded and submitted, so you can always go back and view your older recorded data at any time.*

Adam Schneider has added Google Maps as an output format in **GPS Visualizer***. You can upload your GPS data file (in a supported format) and instantly view it in Google Maps. It is also available as an output choice in the other input forms, including the address form.*

Phone2GEarth *is an easy Nokia Series 80 GPS software application that allows to log tracks which are directly saved as Google Earth KML files. New and useful features like: - English, Spanish, German and French languages. - Place marks supported with timestamps in the track. - bluetooth autostart, for easy use. - Complete Series 80: 9300, 9500 - Color and phone name configurable. It allows deferent phones, tracks etc. Requirements: * Series 80 (Symbian) Smartphone (9500, 9300). * GPS Bluetooth (NMEA protocol). * Google Earth (Windows).*

Earth Bridge *is designed to bridge the gap between Google Earth and your GPS receiver. See your location on Google Earth in real-time and easily control your view. Record your track as you move. Earth Bridge GPS software requires an NMEA 0183 compatible GPS device connected via a serial interface.*

GEtrax *is a Windows GPS software application that can.*

Plot various format track files in Google Earth.

GPX

XML

OziExplorer

Raw NMEA data (text)

CSV data (text - one type only)

Plot GPX or OziExplorer format waypoint files in Google Earth (as placemarks).

Read live (NMEA) data from any gps (COM port) and plot location and track in Google Earth.

Read a track file directly from a Garmin gps and plot it in Google Earth.

Put tracks (including live data) on a server and email a recipient for remote viewing.

Save tracks in GoogleMap and OziExplorer format.

Save track and waypoint files as GPX format for archiving.

Read track data from existing KML files.

Read Ham radio tracking data from Findu.com or from a receiver and plot the location and track in Google Earth.

GPS Radar *GPS software from JGUI allows you to use your Windows Mobile*) device for the following reasons:*

- *monitor your localization by GPS receiver.*
- *save the track and points of moving.*
- *generate various XML reports.*
- *upload points to dedicated Internet server.*
- *review your moving on designed web pages with Google Maps streets or satellites images.*
- *generate GoogleEarth current location.*
- *generate GoogleEarth track files.*
- *review your moving directly on GoogleEarth interface screen with all its features.*

This GPS software version works well with any Windows Mobile device with GSM network connection built-in. So called: Phone Edition devices. Any GPS receiver is required.

GPS Track *GPS software connects to a GPS and records the path that you travel. Tracks can be uploaded to a web site, sent by email, transferred via Bluetooth, or written to a flash memory card. Google Maps and Google Earth are used to view the tracks. File formats such as GPX and CSV are also supported. Compatibility: This GPS software requires a cell phone or other mobile device with:*

J2ME (Java 2 mobile edition).

Java API for Bluetooth (JSR-82).

A GPS with Bluetooth is also required.

EveryTrail *is an online platform that enables you to visualize your travel and outdoor activities and share these with like minded people from all over the world. With EveryTrail you can easily upload GPS data you recorded while out on the trail and add your photos and notes, to create a visual record of your outdoor activity. EveryTrail was created by a small group of passionate travel and outdoor enthusiasts, out of dissatisfaction with current solutions to share trips with friends and like minded people.*

3.3.1 Components of a GPS Instrumentation

The following components of a generic GPS receiver can be identified (figure 1.9):

Antenna and Preamplifier: Antennas used for GPS receivers have broadbeam characteristics, thus they do not have to be pointed to the signal source like satellite TV receiving dishes. The antennas are compact and a variety of designs are possible. There is a trend to integrating the antenna assembly with the receiver electronics.

Radio Frequency Section and Computer Processor: The RF section contains the signal processing electronics. Different receiver types use somewhat different techniques to process the signal. There is a powerful processor onboard not only to carry out computations such as extracting the ephemerides and determining the elevation/azimuth of the satellites, etc., but also to control the tracking and measurement function within modern digital circuits, and in some cases to carry out digital signal processing.

Control Unit Interface: The control unit enables the operator to interact with the microprocessor. Its size and type varies greatly for different receivers, ranging from a handheld unit to soft keys surrounding an LCD screen fixed to the receiver "box".

Recording Device: in the case of GPS receivers intended for specialised uses such as the surveying the measured data must be stored in some way for later data processing. In the case of ITS applications such as the logging of vehicle movement, only the GPS-derived coordinates and velocity may be recorded. A variety of storage devices were utilised in the past, including cassette and tape recorders, floppy disks and computer tapes, etc., but these days almost all receivers utilise solid state (RAM) memory or removable memory "cards".

Power Supply: Transportable GPS receivers these days need low voltage DC power. The trend towards more energy efficient instrumentation is a strong one and most GPS receivers operate from a number of power sources, including internal NiCad or Lithium batteries, external batteries such as wet cell car batteries, or from mains power.

3.3.2 Primary GPS terms

TRACK: *This indicates the direction in which you move. Sometimes this is called HEADING. For navigation on land this is OK, but a boat or a plane can travel in another direction, than the direction in which it is headed, due to wind or current.*

TRACKLOG: *This is the electronic equivalent of the famous bread crumb trail. If you turned (automatic) tracklog on, your receiver will, at fixed intervals or at special occasions, save the position, together with the time, to its memory. This can be invaluable if at any moment during your trip you (have to) decide to go back exactly along the route that brought you to your actual position.*

TRACBACK: *Among the best known GPS terms, it is the navigation method that will bring you back to your point of departure along the same trail that you traveled to your actual position. In order to be able to use this method, you may need to copy the tracklog to one of the free track channels. (This is where you need your manual for). Often a saved track can only contain 250 points, but be assured that your GPS receiver will do a wonderful job in choosing the points which best represent your traveled track.*

WAYPOINT: *Probably one of the most used general GPS terms. A waypoint is nothing more or less than a saved set of co-ordinates. It does not have to represent a physical point on land. Even at sea or in the air, one can mark a waypoint. Once saved in your GPS receiver, you can turn back to exactly that set of co-ordinates. You can give waypoints meaningful names. They can be created 'on the fly', which means that you can register them at 130 km/h on the road or even at 800 km/h in a plane. Your GPS will attribute it a number, which you can change to any name you want, once you have the time. You can also manually enter a set of co-ordinates, that you found on a map. This way you can plan ahead a trip or a walk with as much detail as you like.*

Waypoints are very powerful navigation aids and for really critical operations it should be considered to not only store their co-ordinates in your GPS receiver, but also in your paper notebook. After all a highly sophisticated device as a GPS receiver could stop functioning correctly for a lot of reasons.

ROUTE: *A route is a series of two or more waypoints. To create a route, you have to tell your GPS to reserve some place in its memory for a new route and then you indicate which waypoints will form the route. You enter them in the* *order in which you want to travel them, but you can easily navigate them in reverse order. You can add waypoints and delete others, but once saved, the order in which your GPS will guide you along the waypoints is fixed.*

This is a great way to plan ahead a walk. You can even create waypoints and routes on your desktop PC and transfer them to your GPS receiver. All you need for this is a cable which links your GPS to a RS232-port(COM) on your computer and a piece of software, that enables you to mark points on a map at your screen. We will treat this in more detail elsewhere on the site. You will see that this is absolutely not rocket-science.

ROUTE LEG *is the straight line between two adjacent waypoints in a route.*

GOTO *is also among the best known GPS terms and probably the most used navigation method with a GPS receiver, because it is easily understood and executed. If you tell your companion that you will GOTO waypoint X, it will calculate the direction and distance from your actual location to the set of co-ordinates, represented by the indicated waypoint. Your GPS receiver is unable to know what obstacles, hazards or whatever, if any, there are between you and waypoint X, so it will guide you in a straight line to the indicated point. This is great on open water or in the air, but on land it is often not the best method.*

BEARING: *Once you told to which point you want to travel, your GPS will continuously calculate in which direction that point is situated, seen from your actual position. That direction is the bearing. If you navigate along a route, the bearing will be the direction to the NEXT waypoint in the route. If you do or can not travel in a straight line to the waypoint, the bearing will fluctuate all the time.*

TURN: *This GPS term indicates the difference between the direction you should travel in (BEARING) and the direction in which you are actually traveling (TRACK). An indication of '28L' means that you should modify your actual direction of travel with 28° to the Left, if you wish to ever reach your point. In principle, when you have the reading of TURN on your navigation page, you* *don't need the readings of those other two GPS terms BEARING and TRACK, but most people prefer reading these two.*

3.4 GPS Errors and Correction

3.4.1 The effect and correction of time error

We have been assuming up until now that it has been possible to measure signal transit time precisely. However, this is not the case. For the receiver to measure time precisely a highly accurate, synchronised clock is needed. If the transit time is out by just 1 μs this produces a positional error of 300m. As the clocks on board all three satellites are synchronised, the transit time in the case of all three measurements is inaccurate by the same amount. Mathematics is the only thing that can help us now. We are reminded when producing calculations that if N variables are unknown, we need N independent equations.

If the time measurement is accompanied by a constant unknown error, we will have four unknown variables in

3-D space:

- *longitude (X)*
- *latitude (Y)*
- *height (Z)*
- *time error (Δt)*

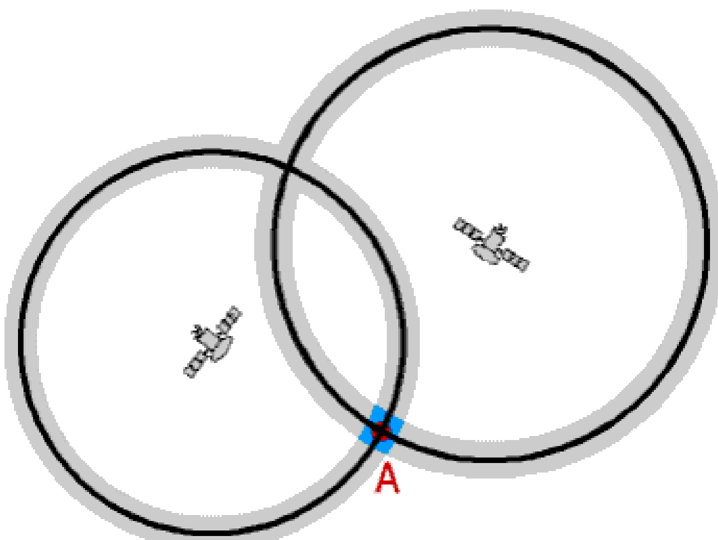
It therefore follows that in three-dimensional space four satellites are needed to determine a position.

3.4.2 Satellite geometry

Another factor influencing the accuracy of the position determination is the "satellite geometry". Simplified, satellite geometry describes the position of the satellites to each other from the view of the receiver.

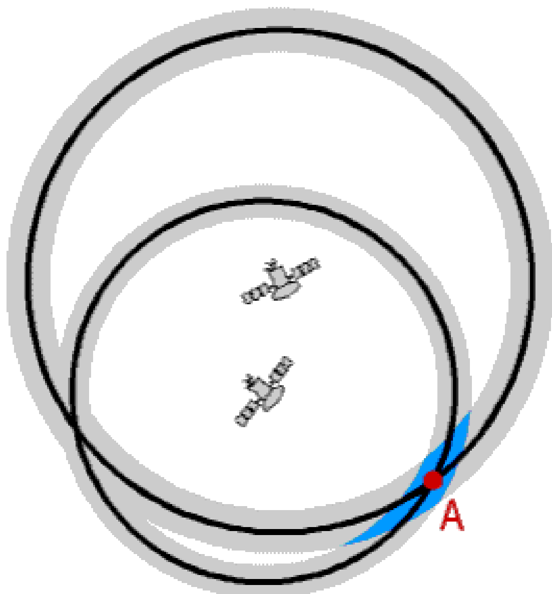
If a receiver sees 4 satellites and all are arranged for example in the north-west, this leads to a "bad" geometry. In the worst case, no position determination is possible at all, when all distance determinations point to the same direction. Even if a position is determined, the error of the positions may be up to 100 – 150 m. If, on the other hand, the 4 satellites are well distributed over the whole firmament the determined position will be much more accurate. Let's assume the satellites are positioned in the north, east, south and west in 90° steps. Distances can then be measured in four different directions, reflecting a „good" satellite geometry.

The following graph shows this for the two-dimensional case.



Good geometrical alignment of two satellites

If the two satellites are in an advantageous position, from the view of the receiver they can be seen in an angle of approximately 90° to each other. The signal runtime can not be determined absolutely precise as explained earlier. The *possible positions are therefore marked by the grey circles. The point of intersection A of the two circles is a rather small, more or less quadratic field (blue), the determined position will be rather accurate.*



Bad geometrical alignment of two satellites

If the satellites are more or less positioned in one line from the view of the receiver, the plane of intersection of possible positions is considerably larger and elongated- The determination of the position is less accurate.

The satellite geometry is also relevant when the receiver is used in vehicles or close to high buildings. If some of the signals are blocked off, the remaining satellites determine the quality of the position determination and if a position fix is possible at all. This can be observed in buildings close to the windows. If a position determination is possible, mostly it is not very accurate. The larger the obscured part of the sky, the more difficult the position determination gets.

Most GPS receivers do not only indicate the number of received satellites, but also their position on the firmament. This enables the user to judge, if a relevant satellite is obscured by an obstacle and if changing the position for a couple of meters might improve the accuracy. Many instruments provide a statement of the *accuracy of the measured values, mostly based on a combination of different factors (which manufacturer do not willingly reveal).*

To indicate the quality of the satellite geometry, the DOP values (dilution of precision) are commonly used. Based on which factors are used for the calculation of the DOP values, different variants are distinguished:

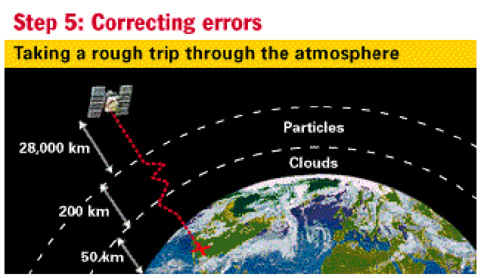
GDOP (Geometric Dilution Of Precision); Overall-accuracy; 3D-coordinates and time

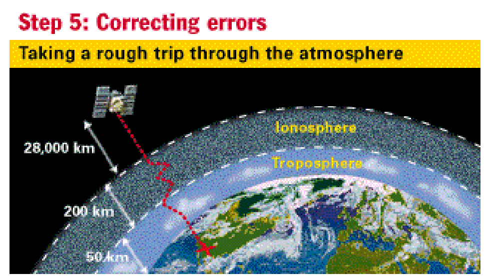
PDOP (Positional Dilution Of Precision) ; Position accuracy; 3D-coordinates

HDOP (Horizontal Dilution Of Precision); horizontal accuracy; 2D-coordinates

VDOP (Vertical Dilution Of Precision); vertical accuracy; height

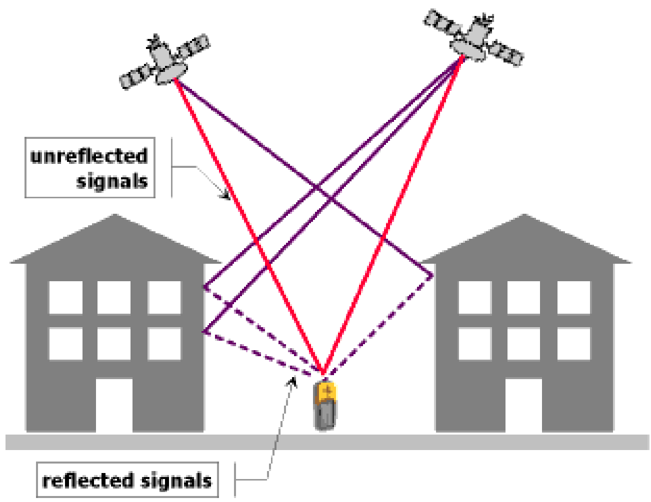
TDOP (Time Dilution Of Precision); time accuracy; time





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.

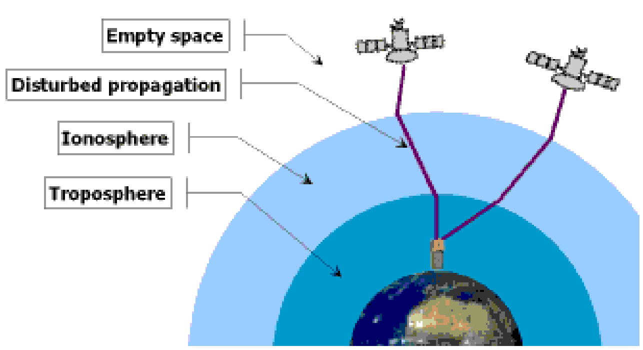
3.4.3 Multipath effect



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.

3.3.4 Atmospheric effects



Another source of inaccuracy is the reduced speed of propagation in the troposphere and ionosphere. While radio signals travel with the velocity of light in the outer space, their propagation in the ionosphere and troposphere is slower.

In the ionosphere in a height of 80 – 400 km a large number of electrons and positive charged ions are formed by the ionizing force of the sun. The electrons and ions are concentrated in four conductive layers in the ionosphere (D-, E-, F1-, and F2-layer). These layers refract the electromagnetic waves from the satellites, resulting in an elongated runtime of the signals.

These errors are mostly corrected by the receiver by calculations. The typical variations of the velocity while passing the ionosphere for low and high frequencies are well known for standard conditions. Theses variations are taken into account for all calculations of positions. However civil receivers are not capable of correcting unforeseen runtime changes, for example by strong solar winds.

3.3.5 Clock inaccuracies and rounding errors

Despite the synchronization of the receiver clock with the satellite time during the position determination, the remaining inaccuracy of the time still leads to an error of about 2 m in the position determination. Rounding and calculation errors of the receiver sum up approximately to 1 m.

3.3.6 Relativistic effects

The following section shall not provide a comprehensive explanation of the theory of relativity. In the normal life we are quite unaware of the omnipresence of the theory of relativity. However it has an influence on many processes, among them is the proper functioning of the GPS system. This influence will be explained shortly in the following.

As we already learned, the time is a relevant factor in GPS navigation and must be accurate to 20 - 30 nanoseconds to ensure the necessary accuracy. Therefore *the fast movement of the satellites themselves (nearly 12000 km/h) must be considered.*

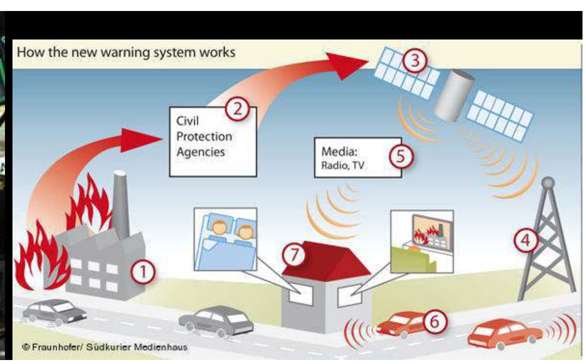
Whoever already dealt with the theory of relativity knows that time runs slower during very fast movements. For satellites moving with a speed of 3874 m/s, clocks run slower when viewed from earth. This relativistic time dilation leads to an inaccuracy of time of approximately 7,2 microseconds per day (1 microsecond = 10-6 seconds).

The theory of relativity also says that time moves the slower the stronger the field of gravitation is. For an observer on the earth surface the clock on board of a satellite is running faster (as the satellite in 20000 km height is exposed to a much weaker field of gravitation than the observer). And this second effect is six times stronger than the time dilation explained above.

3.5 Application of GPS

That's right - we are the 'Users'. All kinds of people use GPS for all kinds of purposes. While the GPS was designed for the Military, the number of civilian users is greater than Military users. Some of the more common uses of the GPS are:

Emergency Services - *Fire, ambulance or other 911 services to locate people in distress.*



Aviation *- pilots use it to guide their aircraft.*

Agriculture *- farmers use it manage their farms better*

Ground Transportation

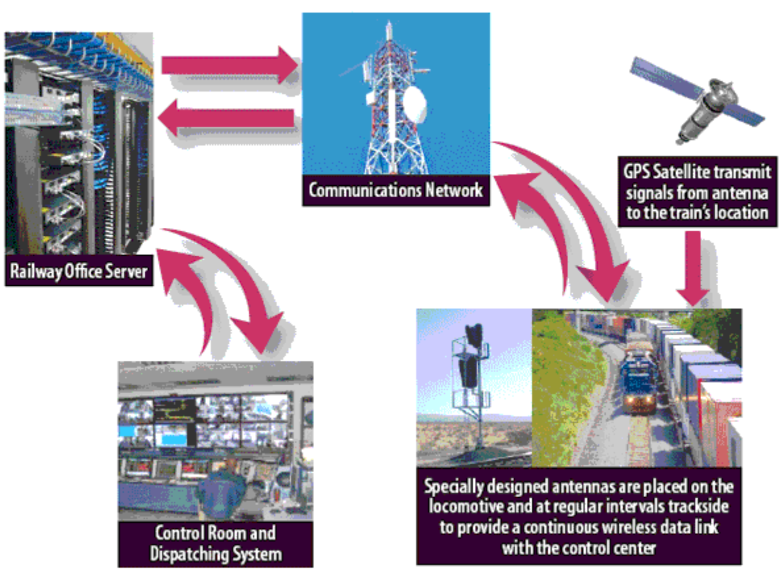
GPS technology helps with automatic vehicle location and in-vehicle navigation systems. Many navigation systems show the vehicle's location on an electronic street map, allowing drivers to keep track of where they are and to look up other destinations. Some systems atutomatically create a route and give turn-by-turn directions. GPS technology also helps monitor and plan routes for delivery vans and emergency vehicles.

GIS (Geographic Information System) Data Collection *- cities use it to locate their services such as power lines and water hydrants even streets*

Marine *- fishermen and vessels at sea use it as a guide to steer their boats or to identify a location on the sea*

Rail

Precise knowledge of train location is essential to prevent collisions, maintain smooth traffic flow, and minimize costly delays. Digital maps and onboard inertial units allow fully-automated train control.



Vehicle Navigation *- so you don't need maps to get to Grandma's house*

Recreation *- hikers and campers use it to keep from getting lost*

There will be many more users to follow in the future...

3.6 Summary

In this unit we have discussed the technology of global positioning system. The key components essential for a global positioning system to function has also been discussed. We also learned about the errors that can be present in a GPS data and therefore what are the most suitable methods of collecting data with a GPS. The types of GPS enables us to understand the various functionality of the GPS, and thus its applications have also been enclosed.

3.7 Glossary

Signal- *Information conveyed via an electric current or electromagnetic wave.*

Synchronization- *The process of automatically updating certain elements of a metadata file.*

Google Earth/Maps- *Software or an interphase where online maps and satellite data can be viewed. This was launched by the network chain Google.*

GPS position- *A satellite based device that records x,y,z coordinates and other data. Ground locations are calculated by signals from satellites orbiting the Earth.*

Navigation- *The combined mental and physical activities involved in traveling to a destination, often a distant or unfamiliar one. The activity of guiding a ship, plane, or other vehicle to a destination, along a planned or improvised route, according to reliable methods.*

Orbital Plane- *All of the planets, comets, and asteroids in the solar system are in orbit around the Sun. All of those orbits line up with each other making a semi-flat disk called the orbital plane. The orbital plane of an object orbiting another is the geometrical plane in which the orbit is embedded.*

3.8 References

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2. *http://www8.garmin.com/manuals/GPSGuideforBeginners_Manual.pdf*
3. *http://www.inovatrack.com/gps/GPS_basics_u_blox_en.pdf*
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12. *http://www.vehicle-tracking-gps.com/buyhere-payhere.htm*

13. *http://www.vosizneias.com/60544/2010/07/21/goshen-ny-orange-county-emergency-services-to-receive-automatic-vehicle-locator-dispatching-system*

14. *http://www.dw-world.de/dw/article/0,,4543691,00.html*

3.9 Suggested Readings

1. *http://www.gmat.unsw.edu.au/snap/gps/gps_notes1.pdf*
2. *http://www.kowoma.de/en/gps/errors.htm*
3. *http://www.geod.nrcan.gc.ca/edu/geod/gps/gps09_e.php*
4. *Fundamentals of Remote Sensing .pdf*

3.10 Terminal Questions

1. *Why do we need a GPS?*
2. *How many satellites are needed by a GPS in a 3D space?*
3. *Name 3 different types of GPS and cite their uses.*
4. *Name any 4 errors in acquiring GPS data. Explain geometric error and its corrections.*
5. *Give 5 examples of application of GPS.*

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