A

Seminar report

On

Global Positioning System

Submitted in partial fulfillment of the requirement for the award of degree
Of MCA

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SUBMITTED BY:

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Preface

I have made this report file on the topic **Global Positioning System;** I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

Acknowledgement

I would like to thank respected Mr…….. and Mr. ……..for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

Thirdly, I would like to thank my friends who helped me to make my work more organized and well-stacked till the end.

Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

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Introduction

(GPS) technology is a great boon to anyone who has the need to navigate either great or small distances. The Global Positioning System (GPS) is a burgeoning technology, which provides unequalled accuracy and flexibility of positioning for navigation, surveying and GIS data capture. This wonderful navigation technology was actually first available for government use back in the late 1970s.

The Global Positioning System (GPS) is a radio based **navigation system** that gives three dimensional coverage of the Earth, 24 hours a day in any weather conditions throughout the world. The technology seems to be beneficiary to the GPS user community in terms of obtaining accurate data upto about 100 meters for navigation, metre-level for mapping, and down to millimetre level for geodetic positioning. The GPS technology has tremendous amount of applications in Geographical Information System (GIS) data collection, surveying, and mapping.

The first GPS satellite was launched by the U.S. Air Force in early 1978. There are now at least 24 satellites orbiting the earth at an altitude of about 11,000 nautical miles. The high altitude insures that the satellite orbits are stable, precise and predictable, and that the satellites' motion through space is not affected by atmospheric drag. These 24 satellites make up a full GPS constellation. The satellites orbit the Earth every 12 hours at approximately 12,000 miles above the Earth. There are four satellites in each of 6 orbital planes. Each plane is inclined 55 degrees relative to the equator, which means that satellites cross the equator tilted at a 55 degree angle. The system is designed to maintain full operational capability even if two of the 24 satellites fail.

The GPS system consists of three segments: 1) The space segment: the GPS satellites themselves, 2) The control system, operated by the U.S. military, and 3) The user segment, which includes both military and civilian users and their GPS equipment.

The GPS system is passive, meaning that the satellites continuously transmit information towards the Earth. If someone has a GPS receiver they can receive the signal at no cost. The information is transmitted on two frequencies: L1 (1575.42 MHz), and L2 (1227.60 MHz). These frequencies are called carrier waves because they are used primarily to carry information to **GPS receivers**. The more information a receiver measures the more expensive the unit, and the more functions it will perform with greater accuracy.

When one receiver is tracking satellites and obtaining position data, the information received has traveled over 12,000 miles and has been distorted by numerous atmospheric factors. This results in accuracy of about 25 meters. Moreover, the department of Defense (the agency running the GPS) degrades receiver accuracy by telling the satellites to transmit slightly inaccurate information. This intentional distortion of the signal is called **Selective Availability** (SA). With SA turned on and one receiver is used, the greatest accuracy a user can expect is 100 meters.

To improve the accuracy of GPS, differential, or Relative Positioning can be employed. If two or more receivers are used to track the same satellites, and one is in a known position, many of the errors of SA can be reduced, and in some cases eliminated. Differential data can be accomplished using common code or carrier data (L1 or L2). The most accurate systems use differential data from a GPS **base station** that continually tracks twelve satellites and transmits the differential data to remote units using a radio link. With these systems centimeter accuracy and real-time navigation is possible.

All of these features make it a very desirable and useful technology for a mirid of activities including Search and Rescue, Aviation and Nautical navigation, hiking, hunting, camping, fishing, and many more. All of these various GPS users have unique needs which require different levels of understanding and skill in using this technology.

The Russian government has developed a system, similar to GPS, called GLONASS. The first GLONASS satellite launch was in October 1982. The full constellation consists of 24 satellites in 3 orbit planes, which have a 64.8 degree inclination to the earth's equator. The GLONASS system now consists of 12 healthy satellites. GLONASS uses the same code for each satellite and many frequencies, whereas GPS which uses two frequencies and a different code for each satellite.

Galileo is Europe's contribution to the next generation Global Navigation Satellite System (GNSS). Unlike GPS, which is funded by the public sector and operated by the U.S. Air Force, Galileo will be a civil-controlled system that draws on both public and private sectors for funding.

The service will be free at the point of use, but a range of chargeable services with additional features will also be offered. These additional features would include improved reception, accuracy and availability. Design of the Galileo system is being finalized and the delivery of initial services is targeted for 2008.

G. P. S. BASICS

GEOPOSITIONING -- BASIC CONCEPTS

By positioning we understand the determination of stationary or moving objects. These can be determined as follows:

1. In relation to a well-defined coordinate system, usually by three coordinate values and
2. In relation to other point, taking one point as the origin of a local coordinate system.

The first mode of positioning is known as point positioning, the second as relative positioning. If the object to be positioned is stationary, we term it as static positioning. When the object is moving, we call it kinematic positioning. Usually, the static positioning is used in surveying and the kinematic position in navigation.

GPS - COMPONENTS AND BASIC FACTS

The GPS uses satellites and computers to compute positions anywhere on earth. The GPS is based on satellite ranging. That means the position on the earth is determined by measuring the distance from a group of satellites in space. The basic principles behind GPS are really simple, even though the system employs some of the most high-tech equipment ever developed. In order to understand GPS basics, the system can be categorized into

FIVE logical Steps

- Triangulation from the satellite is the basis of the system.
- To triangulate, the GPS measures the distance using the travel time of the radio message.
- To measure travel time, the GPS need a very accurate clock.
- Once the distance to a satellite is known, then we need to know where the satellite is in space.
- As the GPS signal travels through the ionosphere and the earth's atmosphere, the signal is delayed.

- To compute a positions in three dimensions. We need to have four satellite measurements. The GPS uses a trigonometric approach to calculate the positions, The GPS satellites are so high up that their orbits are very predictable and each of the satellites is equipped with a very accurate atomic clock.

The Control Segment

The Control Segment consists of five monitoring stations (Colorado Springs, Ascesion Island, Diego Garcia, Hawaii, and Kwajalein Island). Three of the stations (Ascension, Diego Garcia, and Kwajalein) serve as uplink installations, capable of transmitting data to the satellites, including new ephemerides (satellite positions as a function of time), clock corrections, and other broadcast message data, while Colorado Springs serves as the master control station. The Control Segment is the sole responsibility of the DoD who undertakes construction, launching, maintenance, and virtually constant performance monitoring of the GPS satellites.

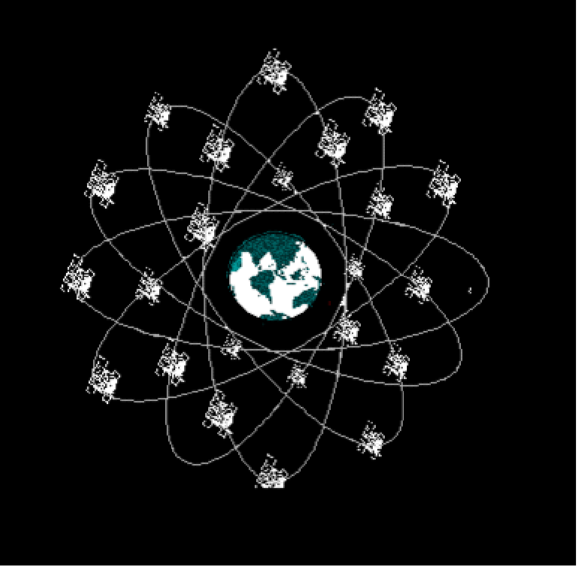
The DOD monitoring stations track all GPS signals for use in controlling the satellites and predicting their orbits. Meteorological data also are collected at the monitoring stations, permitting the most accurate evaluation of tropospheric delays of GPS signals. Satellite tracking data from the monitoring stations are transmitted to the master control station for processing. This processing involves the computation of satellite ephemerides and satellite clock corrections. The master station controls orbital corrections, when any satellite strays too far from its assigned position, and necessary repositioning to compensate for unhealthy (not fully functioning) satellites.

The Space Segment

The Space Segment consists of the Constellation of NAVASTAR earth orbiting satellites. The current Defense Department plan calls for a full constellation of 24 Block II satellites (21 operational and 3 in-orbit spares). Each satellite contains four precise atomic clocks (Rubidium and Cesium standards) and has a microprocessor on board for limited self-monitoring and data processing.

- Satellite orbits.

There are four satellites in each of 6 orbital planes. Each plane is inclined 55 degrees relative to the equator, which means that satellites cross the equator tilted at a 55 degree angle. The system is designed to maintain full operational capability even if two of the 24 satellites fail. They orbit at altitudes of about 12000, miles each, with orbital periods of 12 sidereal hours (i.e., determined by or from the stars), or approximately one half of the earth's periods, approximately 12 hours of 3-D position fixes. The satellites are equipped with thrusters which can be used to maintain or modify their orbits. The next block of satellites is called Block IIR, and they will provide improved reliability and have a capacity of ranging between satellites, which will increase the orbital accuracy.



- **Satellite Signals**

GPS satellites continuously broadcast satellite position and timing data via radio signals on two frequencies: L1 (1575.42 MHz), and L 2 (1227.60 MHz). These frequencies are called carrier waves because they are used primarily to carry information to GPS receivers. The radio signals travel at the speed of light (186,000 miles per second) and take approximately 6/100ths of a second to reach the earth.

The satellite signals require a direct line to GPS receivers and cannot penetrate water, soil, walls or other obstacles. For example, heavy forest canopy causes interference, making it difficult, if not impossible, to compute positions. In canyons (and "urban canyons" in cities) GPS signals are blocked by mountain ranges or buildings. If you place your hand over a GPS receiver antenna, it will stop computing positions.

Two kinds of code are broadcast on the L1 frequency (C/A code and P code). C/A (Coarse Acquisition) code is available to civilian GPS users and provides Standard Positioning Service (SPS). Using the Standard Positioning Service one can achieve 15 meter horizontal accuracy 95% of the time.

This means that 95% of the time, the coordinates you read from your GPS receiver display will be within 15 meters of your true position on the earth. P (Precise) code is broadcast on both the L1 and L2 frequencies. P code, used for the Precise Positioning Service (PPS) is available only to the military. Using P code on both frequencies, a military receiver can achieve better accuracy than civilian receivers. Additional techniques can increase the accuracy of both C/A code and P code GPS receivers.

The User Segment

The user segment is a total user and supplier community, both civilian and military. The User Segment consists of all earth-based GPS receivers. Receivers vary greatly in size and complexity, though the basic design is rather simple. The typical receiver is composed of an antenna and preamplifier, radio signal microprocessor, control and display device, data recording unit, and power supply.

The GPS receiver decodes the timing signals from the 'visible' satellites (four or more) and, having calculated their distances, computes its own latitude, longitude, elevation, and time. This is a continuous process and generally the position is updated on a second-by-second basis, output to the receiver display device and, if the receiver display device and, if the receiver provides data capture capabilities, stored by the receiver-logging unit.

GPS POSITIONING TYPES

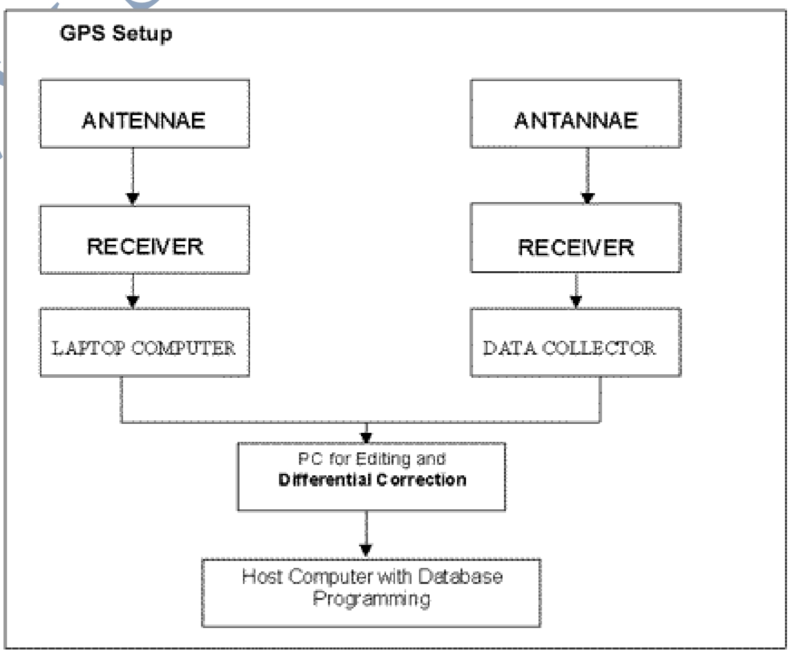
Absolute Positioning

The mode of positioning relies upon a single receiver station. It is also referred to as 'stand-alone' GPS, because, unlike differential positioning, ranging is carried out strictly between the satellite and the receiver station, not on a ground-based reference station that assists with the computation of error corrections. As a result, the positions derived in absolute mode are subject to the unmitigated errors inherent in satellite positioning. Overall accuracy of absolute positioning is considered to be no greater than 50 meters at best by Ackroyd and Lorimer and to be + 100 meter accuracy by the U.S. Army Corps of Engineers.

Differential Positioning

Relative or Differential GPS carries the triangulation principles one step further, with a second receiver at a known reference point. To further facilitate determination of a point's position, relative to the known earth surface point, this configuration demands collection of an error-correcting message from the reference receiver.
Differential-mode positioning relies upon an established control point. The reference station is placed on the control point, a triangulated position, the control point coordinate. This allows for a correction factor to be calculated and applied to other moving GPS units used in the same area and in the same time series. Inaccuracies in the control point's coordinate are directly additive to errors inherent in the satellite positioning process. Error corrections derived by the reference station vary rapidly, as the factors propagating position errors are not static over time. This error correction allows for a considerable amount of error of error to be negated, potentially as much as 90 percent.

GPS SETUP BLOCK DIAGRAM



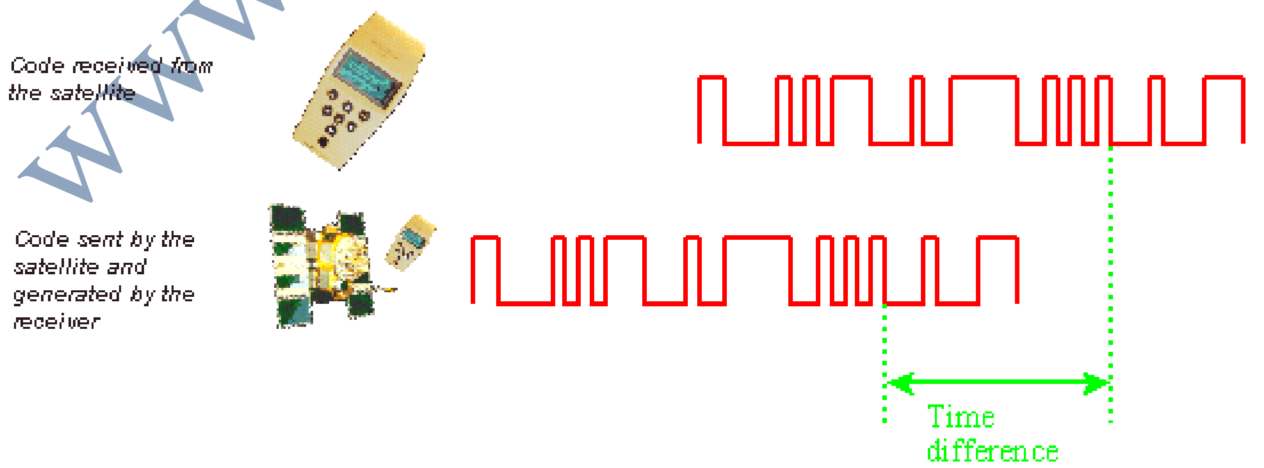
WORKING OF GPS

CALCULATING A POSITION

A GPS receiver calculates its position by a technique called satellite ranging, which involves measuring the distance between the GPS receiver and the GPS satellites it is tracking. The range (the range a receiver calculates is actually a pseudo range, or an estimate of range rather than a true range) or distance, is measured as elapsed transit time. The position of each satellite is known, and the satellites transmit their positions as part of the "messages" they send via radio waves. The GPS receiver on the ground is the unknown point, and must compute its position based on the information it receives from the satellites.

Measuring Distance to Satellites

The first step in measuring the distance between the GPS receiver and a satellite requires measuring the time it takes for the signal to travel from the satellite to the receiver. Once the receiver knows how much time has elapsed, it multiplies the travel time of the signal times the *speed of light* (because the satellite signals travel at the speed of light, approximately 186,000 miles per second) to compute the distance. Distance measurements to four satellites are required to compute a 3-dimensional (latitude, longitude and altitude) position.
In order to measure the travel time of the satellite signal, the receiver has to know when the signal left the satellite and when the signal reached the receiver. Knowing when the signal reaches the receiver is easy; the GPS receiver just "checks" its internal clock when the signal arrives to see what time it is. But how does it "know" when the signal left the satellite? All GPS receivers are synchronized with the satellites so they generate the same digital code at the same time. When the GPS receiver receives a code from a satellite, it can look back in its memory bank and "remember" when it emitted the same code. This little "trick" allows the GPS receiver to determine when the signal left the satellite.



GPS ERROR

There are many sources of possible errors that will degrade the accuracy of positions computed by a GPS receiver. The travel time of GPS satellite signals can be altered by atmospheric effects; when a GPS signal passes through the ionosphere and troposphere it is refracted, causing the speed of the signal to be different from the speed of a GPS signal in space. Sunspot activity also causes interference with GPS signals. Another source of error is measurement noise, or distortion of the signal caused by electrical interference or errors inherent in the GPS receiver itself.

Errors in the ephemeris data (the information about satellite orbits) will also cause errors in computed positions, because the satellites weren't really where the GPS receiver "thought" they were (based on the information it received) when it computed the positions.

Small variations in the atomic clocks (clock drift) on board the satellites can translate to large position errors; a clock error of 1 nanosecond translates to 1 foot or 0.3 meters user error on the ground. Multipath effects arise when signals transmitted from the satellites bounce off a reflective surface before getting to the receiver antenna. When this happens, the receiver gets the signal in straight line path as well as delayed path (multiple paths). The effect is similar to a ghost or double image on a TV set.

Geometric Dilution of Precision (GDOP)

Satellite geometry can also affect the accuracy of GPS positioning. This effect is called Geometric Dilution of Precision (GDOP). GDOP refers to where the satellites are in relation to one another, and is a measure of the quality of the satellite configuration. It can magnify or lessen other GPS errors. In general, the wider the angle between satellites, the better the measurement. Most GPS receivers select the satellite constellation that will give the least uncertainty, the best satellite geometry.
GPS receivers usually report the quality of satellite geometry in terms of Position Dilution of Precision, or PDOP. PDOP refers to horizontal (HDOP) and vertical (VDOP) measurements (latitude, longitude and altitude).A low DOP indicates a higher probability of accuracy, and a high DOP indicates a lower probability of accuracy. A PDOP of 4 or less is excellent, a PDOP between 5 AND 8 is acceptable, and a PDOP of 9 or greater is poor. TDOP or Time Dilution of Precision refers to satellite clock offset.

Selective Availability (SA)

Selective Availability, or SA, occurred when the DoD intentionally degraded the accuracy of GPS signals by introducing artificial clock and ephemeris errors. When SA was implemented, it was the largest component of GPS error, causing error of up to 100 meters. SA is a component of the Standard Positioning Service (SPS), which was formally implemented on March 25, 1990, and was intended to protect national defense. SA was turned off on May 1, 2000.

Factors that affect GPS

There are a number of potential error sources that affect either the GPS signal directly or your ability to produce optimal results:

- **Number of satellites - minimum number required**:

You must track at least four common satellites - the same four satellites - at both the reference receiver and rover for either DGPS or RTK solutions. Also to achieve centimeter -level accuracy, remember you must have a fifth satellite for on-the fly RTK initialization. This extra satellite adds a check on the internal calculation. Any additional satellites beyond five provide even more checks, which is always useful.

- Multipath - reflection of GPS signals near the antennae:

Multipath is simply reflection of signals similar to the phenomenon of ghosting on our television screen. GPS signals may be reflected by surfaces near the antennae, causing error in the travel time and therefore error in the GPS positions.

- Ionosphere - change in the travel time of the signal:

Before GPS signals reach your antenna on the earth, they pass through a zone of charged particles called the ionosphere, which changes the speed of the signal. If your reference and rover receivers are relatively close together, the effect of ionosphere tends to be minimal. And if you are working with the lower range of GPS precisions, the ionosphere is not a major consideration. However if your rover is working too far from the reference station, you may experience problems, particularly with initializing your RTK fixed solution.

- **Troposphere - change in the travel time of the signal:**
  Troposphere is essentially the weather zone of our atmosphere, and droplets of water vapors in it can affect the speed of the signals. The vertical component of your GPS answer (your elevation) is particularly sensitive to the troposphere.

- **Satellite Geometry - general distribution of the satellites:**
  Satellite Geometry or the distribution of satellites in the sky effects the computation of your position. This is often referred to as Position Dilution of Precision (PDOP).
  PDOP is expressed as a number, where lower numbers are preferable to higher numbers. The best results are obtained when PDOP is less than about 7.PDOP is determined by your geographic location, the time of day you are working, and any site obstruction, which might block satellites. You can use planning software to help you determine when you'll have the most satellites in a particular area.

When satellites are spread out, PDOP is Low (good).
When satellites are closer together, PDOP is High (weak).

- **Satellite Health - Availability of Signal:**
  While the satellite system is robust and dependable, it is possible for the satellites to occasionally be unhealthy. A satellite broadcasts its health status, based on information from the U.S. Department of Defense. Your receivers have safeguards to protect against using data from unhealthy satellites.

- **Signal Strength - Quality of Signal :**
  The strength of the satellite signal depends on obstructions and the elevation of the satellites above the horizon. To the extent it is possible, obstructions between your GPS antennae and the sky should be avoided. Also watch out for satellites which are close to the horizon, because the signals are weaker.

- **Distance from the Reference Receiver :**
  The effective range of a rover from a reference station depends primarily on the type of accuracy you are trying to achieve. For the highest real time accuracy (RTK fixed), rovers should be within about 10-15 Km (about 6-9 miles) of the reference station. As the range exceeds this recommended limit, you may fail to initialize and be restricted to RTK float solutions (decimeter accuracy).

- **Radio Frequency (RF) Interference:**
  RF interference may sometimes be a problem both for your GPS reception and your radio system. Some sources of RF interference include:
  - Radio towers
  - Transmitters
  - Satellite dishes
  - Generators

One should be particularly careful of sources which transmit either near the GPS frequencies (1227 and 1575 MHz) or near harmonics (multiples) of these frequencies. One should also be aware of the RF generated by his own machines.

- **Loss of Radio Transmission from Base:**

If, for any reason, there is an interruption in the radio link between a reference receiver and a rover, then your rover is left with an autonomous position. It is very important to set up a network of radios and repeaters, which can provide the uninterrupted radio link needed for the best GPS results.

Following is the list of possible sources of GPS error and their general impact on positioning accuracy.

Error source	Potential error	Typical error
Ionosphere	5.0 meters	0.4 meters
Troposphere	0.5 meters	0.2 meters
Ephemeris data	2.5 meters	0 meters
Satellite clock drift	1.5 meters	0 meters
Multipath	0.6 meters	0.6 meters
Measurement noise	0.3 meters	0.3 meters
Total	~ 15 meters	~ 10 meters

REDUCING GPS ERROR

Is there a way to cancel out the errors and get better than 15 meter accuracy? The answer is yes, but the level of accuracy depends on the type of equipment used.

Differential Correction

Differential correction is a method used to reduce the effects of atmospheric error and other sources of GPS positioning error (differential correction cannot correct for multipath or receiver error; it counteracts only the errors that are common to both reference and moving receivers). It requires, in addition to "roving" GPS receiver, a GPS receiver on the ground in a known location to act as a static reference point. This type of setup is often called a **GPS base station or reference station**. Since the base station "knows" where it is, it can compute the errors in its position calculations (in reality, it computes timing errors) and apply them to any number of moving receivers in the same general area. This requires that the base and rover receivers "see" the same set of satellites at the same time. The base station, depending upon how it is configured, can correct moving GPS receiver data in one (or both) of two ways.

1) In the first method, called real-time differential correction or real-time differential GPS (DGPS), the base station transmits (usually via radio link) error correction messages to other GPS receivers in the local area. In this case, the positions read on GPS receiver while collecting data, are the corrected positions.

2) The second method, called post-processed differential correction, is performed on a computer *after* the moving receiver data are collected. While one is out in the field collecting data, the positions he/she read on his/her moving GPS receivers are uncorrected. It is not until he/she takes his/her rover files back to the office and process them using differential correction software and data from the base station file, that he/she get corrected positions. The base station file contains information about the timing errors. This information allows the differential correction software to apply error corrections to the moving receiver file during processing. Since the base and rover receivers have to "see" the same set of satellites at the same time, the base file has to start before the rover file starts, and end after the rover file ends (a base station is normally set up to track all satellites in view, insuring that it will "see" at least the four satellites that the moving receiver is using to compute positions).

ACCURACY OF GPS

The accuracy that can be achieved using GPS depends on the type of equipment used, the time of observation, and the positions of the satellites being used to compute positions. In general, recreational and mapping grade receivers using C/A code without differential correction are accurate to between 5 and 15 meters. Most mapping and recreational grade receivers with differential correction can provide from about 1 to 5 meter accuracy. Some receivers use what is called "carrier-smoothed code" to increase the accuracy of the C/A code. This involves measuring the distance from the receiver to the satellites by counting the number of waves that carry the C/A code signal. These receivers can achieve 10 cm to 1 meter accuracy with differential correction. Dual frequency survey grade receivers using more advanced network survey techniques can achieve centimeter to millimeter accuracy.

There are four basic levels of accuracy - or types of solutions - that can be obtain with real-time GPS mining system:

Autonomous	Accuracy	15 - 100 meters
Differential GPS (DGPS)	Accuracy	0.5 - 5 meters
Real-Time Kinematic Float (RTK Float)	Accuracy	20cm - 1 meter
Real-Time Kinematic Fixed (RTK Fixed)	Accuracy	1cm - 5 cm

GPS satellites broadcast on three different frequencies, and each frequency (or career wave) has some information or codes on it.

L1 Career	L2 Career
19 cm wavelength	24 cm wavelength
1575.42 M Hz	1227.6 M Hz
C/A Code	P Code
Navigation	Navigation Message

- *P Code :* Reserved for direct use only by the military
- *C/A Code :* Used for rougher positioning

- For Single frequency use only L1 career is used
- For Double frequency, L1/L2/L3 career is used
- The navigation message (usually referred to as the ephemeris) tells us where the satellites are located, in a special coordinate system called WGS-84. If you know where the satellites are at any given time, then you can compute your location here on earth.

- ## Why Reference Station?

As is different levels of accuracy in GPS positions, one must have a reference receiver, which is stationary, and a rover, which can be mobile or stationary.
The GPS reference station normally operates continuously, 24 hours a day. The coordinates of this station must be known before we can begin using GPS on any of our machines. First a proper site for the reference station is to be selected, and then a GPS survey is performed to obtain the known coordinates. This is usually done as part of the installation, either by the installation team or other qualified personal.
Once it is installed, the GPS reference station can perform two functions simultaneously:

- Receive data from the satellites
- Broadcast GPS data to the rovers in the mine

One reference station can support unlimited rovers. The primary constraint may be distance, because accuracy may suffer if one is working too far from the reference station. This maximum distance will vary with the accuracy requirements and environment.

Selecting the Reference Station

Some of the features of a good reference site are:

- Clear View to the Sky
- Proximity to your Working Areas: This is both a GPS issue and a radio issue. Remember, R TX is generally limited to about 10-15 Km (6-9 miles) for reliable initializations, due primarily of potential errors from the ionosphere. Therefore, one should select a reference site that is within about 10-15 Km of where rovers is expect to work.
- Absence of RF Interference: Try to place the reference station away from sources of radio interference, which arise from radio towers, transmitters, television or other satellite dishes, high-voltage power lines, and any other obvious source of interference.
- Minimal Sources of Multipath: Multipath at the reference site can cause inaccurate answers or interfere with the rover's ability to initialize.
- Continuous AC / DC Power Source
- Stable Antennae Mount: Not only the monument should be stable, but also the GPS antennae itself should be secure and stable to minimize the movement.
- Accessibility of the station

Reference Station Equipment:

- GPS receiver
- GPS antenna
- Radio and antenna, Power supply, & Cables

Radios

We have seen that each GPS rover must receive information from the reference station to achieve accurate positions. To maintain constant communication between your reference station and rover, you need these items at the reference station and at each rover:

- Radio
- Radio Antenna
- Cables

The radios are cabled directly into the GPS receiver. Power may be provided to the radio through the GPS receiver. At the reference site, GPS data is broadcast through the radio. At the rover site, the reference GPS data is received by the radio and routed into the rover receiver, where it is processed together with rover's GPS data the rover radio can also draw power from the GPS receiver.

Repeater Radios: If, for any reason, the reference station transmission cannot reach the rovers, then we must use one or more repeaters. A repeater relays the data from reference or another repeater. The maximum number of repeaters that can be used depends on type of radio. Repeaters differ from reference and rover radios in two important ways: they must have their own source of power, and they can be moved as the needs change. The radios draw very low power, but they require uninterrupted power. Because repeaters may need to be moved to accommodate needs, batteries or compact solar power units are normally used. Frequency and Bandwidth: Most radios used in GPS fall within one of the following frequency ranges:

- 150-174 MHz (VHF)
- 406-512 MHz (UHF)
- 902-928 MHz (spread spectrum)

The lower-frequency radios (150-174 MHZ) tend to have more power, due to design and legal issues (not Physics), However, the bandwidth, which determines the amount of data can be transmit, is narrower in these lower ranges (also due to design, not physics).

In the nominal 450 MHz and 900 MHz ranges, the bandwidth is wider.

Radio Range

To guarantee steady, uninterrupted transmission over the radio, one should be aware of some of the factors that affect the radio's effective range.

- Antenna Height: raising the radio antenna is the easiest and most effective way to increase range.
- Antenna design: radiating patterns vary, depending on the antenna design.
- Cable length and type: radio signals suffer loss in cables, so keep the length to a minimum.
- Output power: doubling output power does not double your effective range.

- Obstructions: Buildings, walls and even the machines can block or interrupt radio transmission. The repeaters should be carefully used to help minimize the effect of obstructions.

What should be known before acquiring a GPS Receiver?

Before acquiring GPS equipment, it is important to clearly define the needs in terms of accuracy level required and end results expected.

Do one simply want to be able to navigate in the woods, or want to map out points, lines and areas that can be differentially corrected and imported into a GIS (a computer mapping system)?, Do real-time differential GPS is needed for any reason?

Is 15 meter accuracy good enough? If so, one doesn’t have to worry about differential correction. If one want to make a map from the data, is 1-5 meter accuracy sufficient, or sub-meter accuracy is required for the application? Remember that more accurate equipment is more expensive. In addition, consider the needs for durability and weather resistance, and details such as whether or not an external antenna can be connected to the receiver, and its size, weight and suitability for the method of survey (e.g., will it be used in a backpack, mounted on a vehicle, or carried in ?).

GPS APPLICATIONS

Global Positioning Systems is in fact is available to users at any position worldwide at any time. With a fully operational GPS system, it can be generated to a large community of likely to grow as there are multiple applications, ranging from surveying, mapping, and navigation to GIS data capture.

There are countless GPS applications, a few important ones are covered in the following passage.

- Surveying and Mapping

The high precisions of GPS carrier phase measurements, together with appropriate adjustment algorithms, provide an adequate tool for a variety of tasks for surveying and mapping. Using DGPS methods, accurate and timely mapping of almost anything can be carried out. The GPS is used to map cut blocks, road alignments, and environmental hazards such as landslides, forest fires, and oil spills. Applications, such as cadastral mapping, needing a high degree of accuracy also can be carried out using high grade GPS receivers. Continuous kinematic techniques can be used for topographic surveys and accurate linear mapping.

- Navigation

Navigation using GPS can save countless hours in the field. Any feature, even if it is under water, can be located up to one hundred meters simply by scaling coordinates from a map, entering waypoints, and going directly to the site. Examples include road intersections, corner posts, plot canters, accident sites, geological formations, and so on. GPS navigation in helicopters, in vehicles, or in a ship can provide an easy means of navigation with substantial savings.

- Remote Sensing and GIS

It is also possible to integrate GPS positioning into remote-sensing methods such as photogrammetry and aerial scanning, magnetometry, and video technology. Using DGPS or kinematic techniques, depending upon the accuracy required, real time or post-processing will provide positions for the sensor which can be projected to the ground, instead of having ground control projected to an image. GPS are becoming very effective tools for GIS data capture. The GIS user community benefits from the use of GPS for location data capture in various GIS applications. The GPS can easily be linked to a laptop computer in the field, and, with appropriate software, users can also have all their data on a common base with every little distortion. Thus GPS can help in several aspects of construction of accurate and timely GIS databases.

- Geodesy

Geodetic mapping and other control surveys can be carried out effectively using high-grade GPs equipment. Especially when helicopters were used or when the line of sight is not possible, GPS can set new standards of accuracy and productivity.

- Military

The GPS was primarily developed for real time military positioning. Military applications include airborne, marine, and navigation.

Conclusion

Barring significant new complications due to S/A (Selective Availability) from DOD, the GPS industry is likely to continue to develop in the civilian community. There are currently more than 50 manufacturers of GPS receivers, with the trend continuing to be towards smaller, less expensive, and more easily operated devices.

While highly accurate, portable (hand-held) receivers are already available, current speculation envisions inexpensive and equally accurate 'wristwatch locators' and navigational guidance systems for automobiles. However, there is one future trend that will be very relevant to the GIS user community, namely, community base stations and regional receive networks, as GPS management and technological innovations that will make GPS surveying easier and more accurate.

Also **INDIA** in the future will do use this technology, not only in the field of Defense, but also in civilian community as this is not a scientific luxury but is the need of future.

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