Definitive Guide to GPS Auto Tracker

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All You Need To Know About GPS Tracking System

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Table of Contents

Introduction

Take a few moments if you will and think about how difficult it must have been for our ancestors to get from place to place. Back in the days before street signs could guide them and streets were pretty much not even there. Think back to the time when they couldn't call AAA for trip planning and they weren't even always sure which way to go in order to get to a destination.

How do you suppose they got from point A to point B? They learned in many ways. They used the stars to guide their way, they erected landmarks to keep track of where they had been, they drew maps and often just wandered about until they got where they thought they wanted to be.

Today, we have it much easier. Not only do we have the advantage of detailed maps, street names and such, but we also now have sophisticated navigation devices that can help us along our way in the form of GPS. Global Positioning Systems have revolutionized the way we travel.

At one time, the family vacation meant Dad driving the car and Mom reading a paper map all the while arguing about the best route to take. God forbid you get lost, too because Dad would rather take a beating than stop and ask for directions.

Technology has come a long way and GPS certainly has made a difference in how and even where we travel. It was originally developed by the United States Department of Defense for military purposes but soon, enterprising companies realized that this technology could have some truly great applications for the everyday person and they convinced the government to allow the technology to be released for distribution to the general public.

Now, ordinary people, with the aid of a GPS receiver, are able to do so much with a GPS system including navigating their way on trips and even tracking vehicles. The GPS technology can do so many things that it can be mind boggling and it can help to know how a GPS works and how it can help you.

The applications are changing almost on a daily basis as the technology evolves and grows. In this book, we will attempt to explain GPS to you, how it works and how it can work for you. Stick with us through the technical stuff and you may be surprised at what you find out! Let's start with the inception of GPS technology.

Chapter 1 - History Of GPS

(Return to Contents)

As we said before, Global Positioning Satellite technology was original developed by the United State Department of Defense and was meant for military use to keep track of enemies and know their position at all times. Tracking technology has been around for quite some time actually – since World War II to be exact.

GPS design is based partly on ground-based radio navigation systems developed in the early 1940's that were used in World War II. These systems were named LORAN and Decca Navigator and were focused on knowing where the enemy was so they could either attack or retreat depending on the size of the forces.

Additional inspiration for modern day GPS systems came when Sputnik was launched by the Soviet Union in 1957. A team of scientists monitored Sputnik's radio transmissions and discovered that because of the Doppler Effect, the frequency of the signal being transmitted was high as the satellite approached and lower as it moved away. The Doppler Effect is the change in frequency and wave length of a wave as it is perceived by an observer moving relative to the source of the waves.

This team of scientists that was observing Sputnik's radio transmissions soon realized that since they knew their exact location on the globe, they could pin point where the satellite was along its orbit by measuring the Doppler distortion. This was groundbreaking and very exciting for the military at the time.

The United States Navy used the first satellite navigation system called Transit. It was first successfully test in 1960 and was quite mind-boggling for everyone in the military. When the Navy tested Transit, they did so hoping for some quite specific results. Using a constellation of five satellites, they found that the system could provide a navigational fix approximately once per hour.

In 1967, the Navy developed the Timation satellite which proved the ability to place accurate clocks in space. This is a technology that the GPS system relies on. In the 1970's, the ground-based Omega Navigation System, based on signal phase comparison, became the first world-wide radio navigation system.

In February of 1978, the first experimental Block-I GPS satellite was launched into space and the development of modern-day GPS systems began. These original satellites were initially made by Rockwell International. Now, the satellites we use for GPS are manufactured by Lockheed Martin.

In 1983, Soviet interceptor aircraft shot down a civilian airliner flight KAL 007 as it flew in restricted Soviet airspace. This heinous act killed all 269 people on board – all of whom were civilians. Shortly thereafter, President Ronald Reagan announced that the GPS system would be made available for civilian use once it was completed. Because of this horrible act on the part of the Soviets, developed of the GPS system was stepped up more than it ever had been before and experimentations began in earnest.

By 1985, ten more experimental Block-I satellites had been launched into space to validate the concept of GPS and in 1989; the first modern Block-II satellite was launched. By December of 1993, the GPS system achieve initial operational capability and just a month later, a complete constellation of 24 satellites were in orbit with full operational capability declared by NAVSTAR in April of 1995.

A year after that, President Bill Clinton realized the importance of GPS to civilian users as well as military users which prompted him to issue a policy directive that declared GPS to be a dual-use system meaning civilian as well as military. He established an Interagency GPS Executive Board that was responsible for managing GPS as an asset of the United States.

Plans began in earnest to improve upon the system for the everyday user of the navigation system. An announcement was made that the government was going to upgrade the GPS system with two new civilian signals that would lead towards enhanced user accuracy and reliability particularly with respect to aviation safety.

Since those early years, the GPS technology has evolved into something that the everyday public uses and uses with amazing accuracy and reliability. What began as a way to keep track of our enemies is now used to help guide us along the way during trips and excursions.

In fact, the GPS system we have today has many applications including map making, land surveying, and commerce uses. Plus, because of the way a GPS can pinpoint times with amazing accuracy, scientists are able to use it in many applications including the study of earthquakes and the synchronization of telecommunications networks.

New uses for GPS systems are constantly being discovered and the way that technology is always evolving, we are sure that even more new uses will come about for the GPS systems. They will probably always be finding new uses too as the system is constantly improved upon.

So how does a Global Positioning Satellite system work? It can get a little complicated, but we'll try to simplify it as much as we can.

Chapter 2 - How GPS Works

(Return to Contents)

When people talk about "a GPS," they usually mean a GPS receiver. The Global Positioning System (GPS) is actually a constellation of 27 Earth-orbiting satellites (24 in operation and three extras in case one fails). As we said in the section above, the U.S. military developed and implemented this satellite network as a military navigation system, but soon opened it up to everybody else.

Each of these 3,000- to 4,000-pound solar-powered satellites circles the globe at about 12,000 miles (19,300 km), making two complete rotations every day. The orbits are arranged so that at any time, anywhere on Earth, there are at least four satellites "visible" in the sky.

A GPS receiver's job is to locate four or more of these satellites, figure out the distance to each, and use this information to deduce its own location. This operation is based on a simple mathematical principle called trilateration. Trilateration in three-dimensional space can be a little tricky, so we'll start with an explanation of simple two-dimensional trilateration.

Imagine you are somewhere in the United States and you are TOTALLY lost -- for whatever reason, you have absolutely no clue where you are. You find a friendly local and ask, "Where am I?" He says, "You are 625 miles from Boise, Idaho." This is a nice, hard fact, but it is not particularly useful by itself. You could be anywhere on a circle around Boise that has a radius of 625 miles.

You ask somebody else where you are, and she says, "You are 690 miles from Minneapolis, Minnesota." Now you're getting somewhere. If you combine this information with the Boise information, you have two circles that intersect. You now know that you must be at one of these two intersection points, if you are 625 miles from Boise and 690 miles from Minneapolis.

If a third person tells you that you are 615 miles from Tucson, Arizona, you can eliminate one of the possibilities, because the third circle will only intersect with one of these points. You now know exactly where you are – Denver, Colorado.

This same concept works in three-dimensional space, as well, but you're dealing with spheres instead of circles. Fundamentally, three-dimensional trilateration isn't much different from two-dimensional trilateration, but it's a little trickier to visualize. Imagine the radii from the previous examples going off in all directions. So instead of a series of circles, you get a series of spheres.

If you know you are 10 miles from satellite A in the sky, you could be anywhere on the surface of a huge, imaginary sphere with a 10-mile radius. If you also know you are 15 miles from satellite B, you can overlap the first sphere with another, larger sphere. The spheres intersect in a perfect circle. If you know the distance to a third satellite, you get a third sphere, which intersects with this circle at two points.

The Earth itself can act as a fourth sphere -- only one of the two possible points will actually be on the surface of the planet, so you can eliminate the one in space. Receivers generally look to four or more satellites, however, to improve accuracy and provide precise altitude information.

In order to make this simple calculation, then, the GPS receiver has to know two things:

- The location of at least three satellites above you
- The distance between you and each of those satellites

The GPS receiver figures both of these things out by analyzing high-frequency, low-power radio signals from the GPS satellites. Better units have multiple receivers, so they can pick up signals from several satellites simultaneously.

Radio waves are electromagnetic energy, which means they travel at the speed of light (about 186,000 miles per second, 300,000 km per second in a vacuum). The receiver can figure out how far the signal has traveled by timing how long it took the signal to arrive.

a GPS receiver calculates the distance to GPS satellites by timing a signal's journey from satellite to receiver. As it turns out, this is a fairly elaborate process.

At a particular time (let's say midnight), the satellite begins transmitting a long, digital pattern called a pseudo-random code. The receiver begins running the same digital pattern also exactly at midnight. When the satellite's signal reaches the receiver, its transmission of the pattern will lag a bit behind the receiver's playing of the pattern.

The length of the delay is equal to the signal's travel time. The receiver multiplies this time by the speed of light to determine how far the signal traveled. Assuming the signal traveled in a straight line, this is the distance from receiver to satellite.

In order to make this measurement, the receiver and satellite both need clocks that can be synchronized down to the nanosecond. To make a satellite positioning system using only synchronized clocks, you would need to have atomic clocks not only on all the satellites, but also in the receiver itself. But atomic clocks cost somewhere between $50,000 and $100,000, which makes them a just a bit too expensive for everyday consumer use.

The Global Positioning System has a clever, effective solution to this problem. Every satellite contains an expensive atomic clock, but the receiver itself uses an ordinary quartz clock, which it constantly resets.

In a nutshell, the receiver looks at incoming signals from four or more satellites and gauges its own inaccuracy. In other words, there is only one value for the "current time" that the receiver can use. The correct time value will cause all of the signals that the receiver is receiving to align at a single point in space.

That time value is the time value held by the atomic clocks in all of the satellites. So the receiver sets its clock to that time value, and it then has the same time value that all the atomic clocks in all of the satellites have. The GPS receiver gets atomic clock accuracy "for free."

When you measure the distance to four located satellites, you can draw four spheres that all intersect at one point. Three spheres will intersect even if your numbers are way off, but four spheres will not intersect at one point if you've measured incorrectly. Since the receiver makes all its distance measurements using its own built-in clock, the distances will all be proportionally incorrect.

The receiver can easily calculate the necessary adjustment that will cause the four spheres to intersect at one point. Based on this, it resets its clock to be in sync with the satellite's atomic clock. The receiver does this constantly whenever it's on, which means it is nearly as accurate as the expensive atomic clocks in the satellites.

In order for the distance information to be of any use, the receiver also has to know where the satellites actually are. This isn't particularly difficult because the satellites travel in very high and predictable orbits.

The GPS receiver simply stores an almanac that tells it where every satellite should be at any given time. Things like the pull of the moon and the sun do change the satellites' orbits very slightly, but the Department of Defense constantly monitors their exact positions and transmits any adjustments to all GPS receivers as part of the satellites' signals.

Of course, that is the simplified version – believe it or not. There is much more involved. Now is when we get into the technical part of the whole GPS system. The current GPS consists of three major segments. These are the space segment (SS), a control segment (CS), and a user segment (US).

The space segment is composed of the orbiting GPS satellites or space vehicles in GPS parlance. The GPS design calls for 24 space vehicles to be distributed equally among six circular orbital planes. These orbital planes are center on Earth and not rotating with respect to the distant stars. These six planes have a 55 degree tilt relative to the Earth's equator. They are separated by a 60 degree angle along the equator from a reference point to the orbit's intersection.

The satellites orbit at 12,600 miles above the Earth and each one makes two complete orbits each day so it passes over the same location on the Earth once each day. The orbits are arranged so that at least six satellites are always within a line of sight from almost everywhere on Earth's surface.

As of April, 2007, there are 30 actively broadcasting satellites in the GPS constellation. The additional satellites improve the precision of GPS receiver calculations by providing redundant measurements.

With the increased number of satellites, the constellation was changed to a non-uniform arrangement. This type of arrangement was shown to improve reliability and availability of the system. This has worked much better than a uniform system especially when multiple satellites fail.

Then there is the control segment. The flight paths of the satellites are tracked by US Air Force monitoring stations in Hawaii, Kwajalein, Ascension Island, Diego Garcia and Colorado Springs. There are also monitor stations operated by the National Geospatial-Intelligence Agency.

The tracking information is sent to the Air Force Space Command's master control station at Schriever Air Force Base in Colorado Springs which is operated by the 2d Space Operations Squadron of the United States air Force. The squadron contacts each satellite regularly with a navigational update using the ground antennas at Ascension Island, Diego Garcia, Kwajalein, and Colorado Springs.

These updates synchronize the atomic clocks on board the satellites to within one microsecond and adjust the ephemeris of each satellite's internal orbital model. These updates are created by a Kalman Filter which uses inputs from the ground monitoring stations, space weather information, and other various inputs.

Finally, there is the user segment of the GPS system. The user's GPS receiver is the user segment. In general, GPS receivers are composed of an antenna tuned to the frequencies transmitted by the satellites, receiver processors and a highly stable clock. They may also include a display for providing location and speed information to the user.

A receiver is often described by its number of channels that signifies how many satellites it can monitor simultaneously. Originally, this number was limited to four or five but it has progressively increased over the years so that now receivers typically have between twelve and twenty channels.

A typical GPS receiver module is based on the SiRF Star 3 chipset and measures 12 x 15 millimeters. The receivers are basically small, but they are powerful tools that are used on a daily basis by many people.

GPS receivers may include an input for differential corrections using the RTCM SC-104 format which is typically in the form of a RS-232 port at a speed of 4,800 bits per second.

Data is actually sent at a much lower rate which limits the accuracy of the signal sent using RTCM. Receivers with internal DGPS receivers can out perform those using external RTCM data. Even low-cost units commonly include Wide Area Augmentation System receivers.

Many GPS receivers can relay position data to a PC or other device using a NMEA 0183 protocol. There is a newer and less widely adopted protocol called the NMEA 2000 that has been developed as well. Both protocols are proprietary and are controlled by the US-based National Marine Electronics Association.

References to the NMEA protocols have been compiled from public records allowing open source tools like gpsd to read the protocol without violating intellectual property laws. Other proprietary protocols exist as well such as the u-blox, SiRF, and MTK protcols. Receivers can interface with other devices using methods including a serial connection, USB, or Bluetooth.

GPS receivers come in a variety of formats, from devices integrated into cars, phones, and watches, to dedicated devices from manufacturers Trimble, Garmin and Leica. The devices are portable handheld or are mounted onto a car’s dashboard or windshield using an easy suction grip mount.

The most essential function of a GPS receiver is to pick up the transmissions of at least four satellites and combine the information in those transmissions with information in an electronic almanac, all in order to figure out the receiver's position on Earth.

Once the receiver makes this calculation, it can tell you the latitude, longitude and altitude (or some similar measurement) of its current position. To make the navigation more user-friendly, most receivers plug this raw data into map files stored in memory.

Most people use GPS systems as a way to find their way from place to place. They are very handy navigational aids that can really help out when you are in an unfamiliar place and don't want to mess with paper maps. But how does the GPS receiver achieve this? How can it know where you are at and then help you get to where you need to go?

Each GPS satellite continuously broadcasts a navigation message at 50 bits per second giving the time, and almanac, and an ephemeris. The almanac consists of orbit and status information for each satellite in the constellation. A complete almanac transmission takes 12.5 minutes and is responsible for the long initial acquisition process when a new receiver is first turned on.

The ephemeris gives the satellite's own precise orbit and is transmitted every 30 seconds. The almanac assists in the acquisition of other satellites while an ephemeris from each satellite is needed to compute position fixes using that satellite.

The ephemeris is updated every two hours and is valid for four hours. The time needed to acquire is a significant element of the delay to first position fix when a receiver is switched on after having been off for several hours.

Each satellite transmits its navigation message with at least two distinct spread spectrum codes. The first is the Coarse Acquisition code which is freely available to the public. The second is the precise code which is usually encrypted and reserved for military applications.

The Coarse Acquisition code is a 1,023 chip pseudo-random PRN code at 1,023 million chips per second so that it repeats every millisecond. Each satellite has its own Coarse Acquisition code so that it can be uniquely identified and received separately from the other satellites transmitting on the same frequency.

The Precise code is a 10.23 mega-chip per second PRM code that repeats only every week. When the “anti-spoofing” mode is on as it is in normal operation, the Precise code is encrypted by the Y-code to produce a P(Y) code which can only be decrypted by units with a valid decryption key. Both the Coarse Acquisition code and the P(Y) codes impart the precise time of day to the user.

Once the GPS receiver is switched on, the signal is sent out from it and the satellites lock in its exact position. Then the user enters in the location they want to go to and it will calculate the best way to get there.

The coordinates are calculated according to the World Geodetic System. To calculate its position, a receiver needs to know the precise time. The satellites are equipped with extremely accurate atomic clocks, and the receiver uses an internal crystal oscillator-based clock that is continually updated using the signals from the satellites.

The receiver identifies each satellite’s signal by its distinct Coarse Acquisition code pattern and then measures the time delay for each satellite. To do this, the receiver produces an identical Coarse Acquisition sequence using the same “seed number” as the satellite.

By lining up the two sequences, the receiver can measure the delay and calculate the distance to the satellite called the pseudorange. Overlapping pseudoranges are represented as curves and are modified to yield the probable position.

The orbital position data from the Navigation Message is then used to calculate the satellite’s precise position. Knowing the position and the distance of a satellite indicates that the receiver is located somewhere on the surface of an imaginary sphere centered on that satellite whose radius is the distance to it.

When four satellites are measured simultaneously, the intersection of the four imaginary spheres reveals the location of the receiver. Receivers known to be near sea level can substitute the sphere of the planet for one satellite using their altitude.

Often, these spheres will overlap slightly instead of meeting at one point, so the receiver will yield a mathematically most-probable position and often indicate the uncertainty.

Calculating a position with the P(Y) signal is generally similar in concept assuming a person can decrypt it. The encryption is essentially a safety mechanism. That means if a signal can be successfully decrypted, it is reasonable to assume it is a real signal being sent by a GPS satellite.

In comparison, civil receivers are highly vulnerable to spoofing since correctly formatted Coarse Acquisition signals can be generated using readily available signal generators. RAIM features do not protect against spoofing, since RAIM only checks the signals from a navigational perspective.

Of course, as with any piece of electronic equipment, there are bound to be glitches and problems arises from time to time. Nothing is exact, and although the GPS satellite system is accurate for the most part, there are times when things can interfere with the 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 the signal delay.

To measure the delay, the receiver compares the bit sequence received from the satellite with an internally generated version. By comparing the rising and trailing edges of the bit transitions, modern electronics can measure signal offset with within about one percent of a bit time or approximately ten nanoseconds for the Coarse Acquisition code.

Since GPS signals propagate nearly at the speed of light, this represents and error of about 3 miles. This is the minimum error possible using only the GPS Coarse Acquisition signal.

Of course, position accuracy can be improved by using the higher speed P(Y) signal. Assuming the same one percent bit time accuracy, the high frequency P(Y) signal results in an accuracy rate of about 30 inches.

Just as with any electronic device, there are bound to be some problems. With those problems, must come for fixes.

Chapter 3 - Problems And Solutions

(Return to Contents)

Electronics errors are one of several accuracy-degrading effects. They include ionospheric effects, ephemeris errors, satellite clock errors, multipath distortion, tropospheric effects, and numerical errors.

Inconsistencies of atmospheric conditions affect the speed of the GPS signals as they pass through the Earth's atmosphere and ionosphere. Correcting these errors is a significant challenge to improving GPS position accuracy.

These effects are smallest when the satellite is directly overhead and become greater for satellites nearer the horizon since the signal is affected for a longer time. Once the receiver's approximate location is known, a mathematical model can be used to estimate and compensate for these errors.

Because ionospheric delay affects the speed of microwave signals differently based on frequency – a characteristic known as dispersion – both frequency bands can be used to help reduce this error. Some military and expensive survey-grade civilian receivers compare the different delay in the frequencies to measure atmosphere dispersion and apply a more precise correction.

This can be done in civilian GPS receivers without decrypting the P(Y) signal carried on L2 by tracking the carrier wave instead of the modulated code. To do this on lower cost receivers, a new civilian code signal on L2 called L2C was added to the satellies. This new signal allows a direct comparison of the L1 and L2 signals using the coded signal instead of the carrier wave.

The effects of the ionosphere generally change slowly and can be averaged over time. The effects for any particular geographical area can be easily calculated by comparing the GPS-measured position to a known surveyed location. This correction is also valid for other receivers in the same general location.

Several systems send this information over radio or other links to allow L1 only receivers to make corrections. The date is transmitted via satellite system and transmits it on the GPS frequency using a special pseudo-random number so only one antenna and receiver is required.

Humidity also causes a variable delay resulting in errors similar to ionospheric delay but occuring in the troposphere. This effect is more localized and changes more quickly than ionospheric effects and is not frequency dependent. These traits make it much more difficult to make precise measurement and compensation for humidity errors than with the ionospheric effects.

Changes in altitude also change the amount of delay due to the signal passing through less of the atmosphere at higher elevations. Since the GPS receiver computes its approximate altitude, this error is relatively simple to correct.

GPS signals can also be affected by multi-path issues where the radio signals reflect off of surrounding terrain such as buildings, canyon walls, and hard ground. These delayed signals can cause inaccuracy as a well.

To correct these errors, many techniques have been developed, most notably one called narrow correlator spacing. For long delay multi-path, the receiver itself can recognize the wayward signal and get rid of it.

To address shorter delay multi-path from the signal reflecting off the ground, specialized antennas can be used. Short delay reflections are harder to filter out since they are only slightly delayed. The effects are almost indistinguishable from routine fluctuations in atmospheric delay.

Multi-path effects are much less severe in moving vehicles. When the GPS antenna is moving, the false solutions using reflected signals quickly fail to converge, and only the direct signals result in stable solutions.

Another problem we find with satellite signals has to do with clock and ephemeris errors. The navigation message from a satellite is sent out only every 12.5 minutes. In reality, the data contained in these messages tend to be out of date by an even larger amount.

When a GPS satellite is boosted back into a proper orbit, for some time following this movement, the receiver's calculation of the satellite's position will be incorrect until it receives another ephemeris update.

The onboard clocks are extremely accurate, but they do suffer from some clock drift. This problem tends to be very small but may add up to six feet of inaccuracy. This class of error is more stable than ionospheric problems and tends to change over days or weeks rather than minutes. This makes correction fairly simple by sending out a more accurate almanac on a separate channel.

The GPS system includes a feature called Selective Availability that introduces intentional, slowly changing random errors of up to 328 feet into the publicly available navigation signals to confound, for example, guiding long range missiles to precise targets. Additional accuracy was available in the signal, but in encrypted form that was only available to the United States military, its allies, and a few others government users.

Selective availability typically added signal errors of about 32 feet horizontally and 98 feet vertically. The inaccuracy of the civilian signal was deliberately encoded so as not to change very quickly.

As an example, the entire Eastern United States might read 98 feet off but 90 feet off everywhere else and in the same direction. To improve the usefulness of GPS for civilian navigation, differential GPS was used by many civilian GPS receivers to greatly improve accuracy.

During the Gulf War, the shortage of military GPS units and the wide availability of civilian units among personnel resulted in a decision to disable Selective Availability which was ironic as the concept had been introduced specifically for these situations allowing friendly troops to use the signal for accurate navigation while at the same time denying it to the enemy.

Since selective availability was also denying the same accuracy to thousands of friendly troops, turning it off or setting it to an error of zero – which is effectively the same thing – presented a clear benefit.

In the 1990's, the FAA started pressuring the military to turn off selective availability permanently. This would save the FAA millions of dollars every year in maintenance of their own radio navigation systems. The military resisted for most of the 1990's, but selective ability was eventually discontinued. This came after President Bill Clinton announced that users would have access to the error-free L1 signal.

Per the directive, the induced error of selective availability was changed to add no error to the public signals. Selective availability is still a system capability of GPS and error could, in theory, be reintroduced at any time.

In practice, in view of the hazards and costs this would induce for US and foreign shipping, it is unlikely to be reintroduced, however. Various government agencies, including the FAA have state that it is not intended to be reintroduced.

The US military has developed the ability to locally deny GPS and other navigation services to hostile forces in a specific area of crisis without affecting the rest of the world or its own military systems.

With the selective availability hardware, one of the side effects is the capability of it to correct the frequency of the GPS clocks to about one in five trillion. This is a significant improvement over the raw accuracy of the clocks.

According to the theory of relativity, due to their constant movement and height relative to the Earth-centered inertial reference of frame, the clocks on the satellites are affected by their speed (special relativity) as well as their gravitational potential (general relativity).

For the GPS satellites, general relativity predicts that the atomic clocks at GPS orbital altitudes will tick more repaidly because they are in a weaker gravitational field than the atomic clocks on the Earth’s surface. On the other hand, special relativity predicts that atomic clocks moving at GPS orbital speeds will tick more slowly than stationary ground clocks.

When combined, the discrepancy is 38 microseconds per day. To account for this, the frequency of the clock on board each satellite is given a rate offset prior to launch so that it will run slightly slower than the desired frequency on Earth.

GPS observation processing must also compensate for another relativistic effect called the Sagnac effect. The GPS time scale is defined in an inertial system, but observations are processed in Earth centered and Earth fixed system which is co-rotating and simultaneity is not uniquely defined.

The Lorentz transformation between the two systems modifies the signal run time – a correction having opposite algebraic signs for satellites in the Eastern and

Western celestial hemispheres. Ignoring this effect will produce an east-west error on the order of hundreds of nanoseconds – or tens of meters in position.

The atomic clocks on board the GPS satellites are precisely tuned. This makes the system a practical engineering application of the scientific theory of relativity in a real-world system

Another possible problem for GPS systems has to do with interference and jamming. There are tons and tons of GPS receivers out there these days, so interference is probably going to come into play. Plus, jamming can be a problem in overloading the system as well.

Since GPS signals at terrestrial receivers tend to be relatively weak, it's easy for other sources of electromagnetic radiation to desensitize the receiver. This makes acquiring and tracking the satellite signals difficult or impossible.

One of the sources of interference is a naturally occurring emission is called solar flares and they have the potential to degrade GPS reception. Their impact can affect reception over the half of the Earth facing the sun. GPS signals can also be interfered with by naturally occurring geomagnetic store that are mostly found near the poles of the Earth's magnetic field.

Man-made interference can also disrupt or jam GPS signals. There was one documented case where an entire harbor was unable to receive GPS signals due to unintentional jamming caused by a malfunctioning television antenna. Intentional jamming is also possible.

Generally stronger signals can interfere with GPS receivers when they are within radio range or line of sight. Jamming a GPS signal can be done even by the layman. In fact, a 2002 article that appeared in the online magazine Phrack gave a detailed description on how to build a short range jammer.

The US government believes that jammers such as these were used occasionally during the war in Afghanistan. The US military also claimed to have destroyed a jammer with a GPS-guided bomb during the Iraq War. Such a jammer is relatively easy to detect and locate making it an attractive target for anti-radiation missiles.

Because of the potential for natural and man-made noise that interferes with GPS signals, there are many techniques being developed to deal with the interference. One obvious technique is to not rely on GPS as a sole source. There should be a fallback plan that should be in place in the event of a GPS malfunction.

In many receivers, there is a feature included called Receiver Autonomous Integrity Monitoring (RAIM). This is designed to provide a warning to the user if jamming or another problem is detected.

The US government has also deployed their Selective Availability Anti-Spoofing Module in their Defense Advanced GPS Receiver. This device is supposed to be able to detect jamming and maintains its lock on the encrypted GPS signals during interference which causes civilian receivers to lose a lock on the signal.

So what is being done to solve some of the problems that can occur with GPS signals both man-made and natural occurrences? Actually, there are a lot of things being done to help with problems like these.

GPS manufacturers are using augmentation methods to improve accuracy of GPS systems. These systems rely on external information being integrated into the calculation process. There are many such systems in place already and they are name or described based on how the GPS sensor receives the information.

Some systems transmit additional information about sources of error like clock drift, ephemeris, or ionospheric delay. Others give direct measurements of how much the signal was off in the past. A third group provides additional navigational or vehicle information that is integrated into the calculation process.

The accuracy of a calculation can also be improved through precise monitoring and measuring of the existing GPS signals in additional or alternate ways.

The first is called dual frequency monitoring. This method refers to systems that can compare two or more signals like the L1 frequency versus the L2 frequency. Since these are two different frequencies, they are affected in different yet predictable ways by the atmosphere and objects around the receiver. After monitoring these signals, it's possible to calculate and fix the error.

Receivers that have the correct decryption key can decode the P(Y) code relatively easily. This code is transmitted on both the L1 and L2 to measure the error. Receivers that do not possess the key can still use a processor called "codeless" to compare the encrypted information on L1 and L2 to gain much of the same error information.

The downside is that this technique is currently limited to specialized surveying equipment. Developers hope that in the future, additional civilian codes are expected to be transmitted on the L2 and L5 frequencies. When these become operational, all users will be able to make the same comparison and directly measure some of the errors.

Another form of precise monitoring is called Carrier Phase Enhancement. The error that this program fixes arises because the pulse transition of the PRN is not instantaneous which makes the satellite-receiver sequence matching operation imperfect.

This approach utilizes the L1 carrier wave which has a period a thousand times smaller than that of the C/A bit period to act as an additional clock signal and resolve the uncertainty

The phase difference error in the normal GPS amounts to between 6 and 10 feet of ambiguity. The Carrier Phase Enhancement monitoring works to within one percent of perfect transition reduces this error to one inch of ambiguity. By eliminating this source of error, Carrier Phase Enhancement coupled with DGPS normally realizes between 8 and 12 inches of absolute accuracy.

Finally, there is another approach for a precise GPS-based positioning system. This is called Relative Kinematic Positioning. In this approach, determination of range signal can be resolved to an accuracy of less than four inches. This is done by resolving the number of cycles in which the signal is transmitted and received by the receiver.

This can be accomplished by using a combination of differential GPS correction data, transmitting GPS signal information and ambiguity resolution techniques via statistical tests. This is actually possibly able to be conducted with processing in real-time as well.

As we've said, most people use their GPS system as a navigational aid. That means that, depending on where you are going, you will need to have a map of the place you are visiting. If you are a big traveler, you are going to need a lot of maps then, so let's take a look at the maps you can get for your GPS receiver.

Chapter 4 - Take A Left At The Red Barn

(Return to Contents)

Almost all GPS receivers come equipped with pre-loaded maps. However, these maps are not always what you need and/or want. That is why you will want to check out resources that will give you additional maps. And there are plenty of ways to get additional maps for your GPS.

The most essential function of a GPS receiver is to pick up the transmissions of at least four satellites and combine the information in those transmissions with information in an electronic almanac, all in order to figure out the receiver's position on Earth.

Once the receiver makes this calculation, it can tell you the latitude, longitude and altitude (or some similar measurement) of its current position. To make the navigation more user-friendly, most receivers plug this raw data into map files stored in memory.

You can use maps stored in the receiver's memory, connect the receiver to a computer that can hold more detailed maps in its memory, or simply buy a detailed map of your area and find your way using the receiver's latitude and longitude readouts. Some receivers let you download detailed maps into memory or supply detailed maps with plug-in map cartridges.

A standard GPS receiver will not only place you on a map at any particular location, but will also trace your path across a map as you move. If you leave your receiver on, it can stay in constant communication with GPS satellites to see how your location is changing. With this information and its built-in clock, the receiver can give you several pieces of valuable information:

- How far you've traveled (odometer)
- How long you've been traveling
- Your current speed (speedometer)
- Your average speed
- A "bread crumb" trail showing you exactly where you have traveled on the map
- The estimated time of arrival at your destination if you maintain your current speed

That's why having plenty of maps at your disposal is such an important tool of having your GPS receiver do what you are wanting it to do. When you have a GPS at your disposal, you can be assured that you will be able to get from point A to point B with little problem. Most of the modern GPS systems have voice capabilities that will provide you with verbal directions that allow you to concentrate on your driving.

So where do you go when you want to find maps for your GPS receiver? You actually have a lot of options when it comes to this question. You don't even have to buy anything if you don't want to as there are a lot of websites that offer you the option of downloading free maps for your GPS system.

To begin with, there are many different software programs available for purchase that contains complete maps of almost anyplace in the United States. These software programs are installed on the hard drive of your computer. Then you use a specific cord that is usually included with your receiver to connect to your computer and upload the maps to your GPS receiver.

One of the best selling software packages is made by – of course – Microsoft – and is called Streets and Trips 2007. The best part about this product is that it comes with a GPS receiver so you don't have to buy a separate unit from the software.

This GPS receiver isn't a cheap one either. It is stylish and compact with new and improved SiRF star III technology that is 10 times more sensitive than previous models. It allows you to find your location faster and holds a signal longer even in a building or a crowded city.

The Streets and Trips software combined with the GPS receiver gives you a tour guide who's ready to go virtually anywhere you want to go in the U.S. and Canada. It will monitor your progress from the sky and help you stay on course.

Another great software package for your GPS system is made by Delorme – a GPS manufacturer – and is called Street Atlas USA. Street Atlas USA gives you the most updated maps of the United States, Canada, and even Mexico with the most recent version. You get a powerful GPS navigation tool with spoken voice directions to guide you along the way, and it also has over four million points of interest.

We should talk a little bit here about points of interest. Good GPS software is always going to include points of interest (POI) for anyplace that you travel. POI includes restaurants, hotels, motels, gas stations, and other attractions for the places that you may be interested in visiting. If you are going to a place you have never been before, the POI will prompt you when you are nearing an attraction.

For example, say you are traveling South in the area of Louisiana. You have just passed Baton Rouge and your GPS system tells you that you are approaching a POI called The Myrtle's Plantation. This is one of the most haunted houses in the country and is a bed and breakfast with some of the most deep Southern history you will ever find in the country.

Now if you had not done any research prior to your trip, you might not have known about The Myrtle's. Since you are a history buff and you have a little time to kill, you decide that you may just want to stop by and see what this place is all about. Without your GPS system and the POI included with the software, you wouldn't have known what the Myrtle's was or what it could offer you in the way of entertainment.

With POI, you can also find out information about the specific places if they are attractions. The GPS system will also tell you about upcoming hotels – which is good if you are ready to stop for the night – restaurants – good if you're hungry – and gas stations – good if you're running out of fuel!

Of course, when you go onto a long trip, you probably should do a little research before you leave so that you know where you want to go and plan your route. What the GPS system will do is guide you along the way, help you from getting lost, and direct you toward your destination with a minimum of problems and troubles.

Now, let's get back to those maps. There are a lot of places on the Internet that allow you to download maps for free from websites that offer them. We'll give you a few places you might want to try out, but there is something you should know about free maps from the Internet.

Free maps are often just like shareware products. That means they are "watered down" versions of full products that are available for sale. You will get some features, but not all of them. In order to get what you need, you may have to buy the full version in order to get the features that you need.

On the upside, though, you will have access to maps for free that you might not be able to find anywhere else. That includes maps of foreign countries like

England or Ireland. Plus, with a lot of the free software programs, you can make your own maps with your own points of interest according to your specifications.

Here are some places you may want to try first:

- Track Maker (www.gpstm.com) – Here you can download GPS Track Maker software completely free. Their website touts this program as the most complete free program for GPS devices. It is compatible with more than 160 GPS models including Garmin, Magellan, and others. You can easily create your own maps with support for vector maps and images. This software is multi-language and provides free vehicle tracking – another great use of a GPS system which we will address later on.

- GPSS (www.gpss.tripoduk.com) – On this British website, there are many, many things that you can download for free that will work with your GPS. That includes free maps, software utilities, and tracking software. This site, like many others that have free software, is a personal website that everyday people use to share the maps they have created.

- Topo Fusion (www.topofusion.com) - TopoFusion is GPS Mapping software for Windows. It downloads maps (Topo, Aerial Photo and Satellite) automatically from Microsoft's TerraServer and NASA's OnEarth server, storing them on the hard drive for offline use. Topo Fusion's maps are the latest and up to date and the site looks like it is the most technologically advanced website we have found yet with the most comprehensive information.

Of course, your GPS system can be used for much more than just navigation. There are a variety of uses for your GPS system.

Chapter 5 - Look At What I Can Do!

(Return to Contents)

As we've said before, the GPS system was originally developed by the United States Department of Defense intended for military use. It was intended to allow troops keep track of the enemy and be able to succeed with military operations, so of course, one function of a GPS system is for military applications.

Military Use

With concern to military applications, GPS allows accurate targeting of various military weapons including ICBMs, cruise missiles, and precision-guided munitions. It is used to navigate and coordinate the movement of troops and supplies. The GPS satellites also carry nuclear detonation detectors which form a major portion of the United States Nuclear Detonation Detection System.

Accurate and to-date information on the location of the enemy as well as our own forces is one of the most critical information a military commander seeks. In today's fast paced electronic battlefield such information, if disseminated timely, can act as a major force multiplier. The dawn of the space age has led to the development of several dual use technologies, which find extensive application both in military and civilian fields.

Global Positioning System (GPS) is one such technology. Military forces the world over are using GPS for diverse applications both during wartime and peacetime. These include navigation, targeting, rescue, guidance and facility management. With war clouds looming all over the world, the US led forces are likely to showcase weapon systems, which rely heavily upon GPS for their accuracy and lethality.

Human beings have always looked towards the skies for navigation. Till today celestial bodies like sun and stars are used for finding out the directions. This assumes more importance if you are a soldier moving in unknown enemy territory. The significance of locating one's position in the world cannot be more important than for a soldier, as this could mean the difference between life and death, defeat and victory.

With the coming in of the space age, mankind has tried to replace these celestial bodies with artificial satellites so that navigation is possible both during day and night. Global Positioning System (GPS) is one such dual use technology, which has found extensive application both for military and civilian purposes in area of navigation and others.

GPS has given military forces the lethal combination of precision strike with adverse weather performance, standoff range, and operational flexibility - all at a low marginal cost.

There are really four things that are extremely important in a GPS system that the military needs it to be: accuracy, all-weather, easy-to-use, and portable. The GPS system currently in service meets these requirements fully except for the fact that ultimately it is a system run for the US military and if you happen to be their adversary then you may be in some problem as the power to introduce intentional error in the signal rests with them.

Although the US Department of Defense's policy of "Selective Availability" (under which intentional noise was added to GPS signals to make them less accurate) has been removed last year, its reintroduction is still in their hands.

Accuracy of GPS may vary from few meters to few tens of meters, which meets the military needs for navigational purposes. However, for precise location of targets for aerial bombings, missile strike etc accuracy to a level of mm is required.

This can be achieved through Differential GPS (DGPS). Nevertheless to achieve this level of accuracy, proper error modeling is necessary. A detailed discussion on GPS related errors and accuracy may be found in Tiwari et al. (2000).

Further, the GPS satellite signals are also not affected to that extent due to bad weather as conventional terrestrial radio signals. This is an important requirement, as military forces need all weather navigation systems.

Most of today's GPS receivers are quite easy to use and give the position in both the geographical latitude and longitude and the local map projection system coordinates besides providing data in WGS-84 coordinate system. Moreover over the years, the GPS receivers have also drastically reduced in size and weight, and thus become more portable.

For example, today wristwatches commercially available off the shelf have GPS receivers built in them. Even cell phones and PDA's come with built-in GPS technology.

The role of the military in any country can be very varied and every system for it must meet these requirements fully. In general, there are two major tasks of the military regarding the Barrack and the Battlefield.

Barrack encompasses all the peacetime activities in which the military personnel are involved. This may include training, disaster relief, peacekeeping and management of large bases / installations. Battlefield includes all wartime activities. The military applications of GPS revolve around these activities.

Some of these can be enumerated as:

- Navigation
- Tracking
- Bomb and Missile guidance
- Rescue
- Facility Management
- Map updation

These are only some of the applications as more and more uses may be derived from GPS, but let's take a look at each of these applications just a little more closely.

Navigation

For a soldier operating under cover of darkness in enemy territory the biggest challenge is navigation due to unfamiliar territory and lack of easily identifiable landmarks on ground. Soldiers have been using night skies for ages to find out direction but their location on ground cannot be determined.

The necessity of knowing their own position by troops during war was very clearly highlighted during the Gulf War (1990) and the Kargil conflict (1999). This can be judged from the fact that initially about 1000 GPS receivers were issued for use during the Gulf war but by the end nearly 9000 handheld devices were in use.

Similarly, during the Kargil conflict, Indian patrols operating in rugged terrain along the line of control, initially strayed into enemy held areas with disastrous consequences but later on the availability of handheld GPS receivers proved to be invaluable to them.

In fact, these GPS receivers are fast replacing the conventional compasses in a soldier's rug sack. Special Forces and crack teams also use these to reach and destroy vital enemy installations. Such teams can draw air and artillery fire accurately by providing the accurate positional data.

Further, gun positions can be occupied quickly using GPS, as in modern warfare, artillery batteries must move often to keep pace with assault troops and to avoid being hit by counter fire. Convoy movements can also be tracked and planned effectively using GPS devices.

Tracking

In a military scenario, potential targets need to be constantly tracked before they are declared hostile and engaged by various weapon systems. This tracking data is fed as input to modern weapon systems such as missiles and smart bombs etc. Just to site an example, the US Army has developed a GPS Truth Data Acquisition, Recording, and Display System (TDARDS).

It is a compact, lightweight, low-cost, and easily transportable or mobile GPS-based tracking system that uses up-to-date GPS data, radio data link, and computer technology to provide highly accurate, real-time time-space position information (TSPI) on up to ten test objects, such as ground vehicles, helicopters, and fixed-wing aircraft.

The system is highly modular, built with commercial off-the-shelf hardware, and easily modifiable to meet any special needs of individual testing and tracking applications.

Bomb Tracking and Missile Guidance

Modern day weapon systems are designed to use GPS data as input for targeting and guidance. Cruise missiles commonly used by US to accurately hit targets from large standoff distances use multi-channel GPS receivers to accurately determine their location constantly while in flight.

The Multiple Launched Rocket System (MLRS) vehicle uses GPS based inertial guidance to position itself and aim the launch box at the target in a very short time (Fig 3). This reduces the chances of detection and counter bombardment.

The Exploitation of DGPS for Guidance Enhancement (EDGE) program of the US army has developed a 2000 lb glide bomb, which uses a GPS seeker rather than a Laser for guidance. This bomb could accurately hit its target 11 miles from its drop point guided by four DGPS base stations about 1000 nautical miles away.

Rescue

Rescue and emergency response is another area where GPS can prove invaluable to the military. Determining the location of a casualty during operations, emergency response teams can use the GPS to reduce response time.

For example, the US Air Force is already taking advantage of GPS based technology and is developing a Combat Survivor Evader Locator (CSEL) system. The new system integrates the GPS receiver with a communications radio so that search and rescue teams can locate downed aircrew members faster and more accurately than before.

Map Updation

To carry out planning at various military headquarter levels, the defense forces need accurate and updated maps at various scales depending upon the level of the commander for planning operations, administrative planning and training. The availability of GPS shall augment the collection of precise data necessary for quick and accurate map updation.

The GPS can also be used effectively for the establishment of grid control locations for the placement of various weapons and other assets, location of targets etc. For example, the modern mapping techniques such as remote sensing and GIS will now constantly use the DGPS technology to register the images into absolute geo-coordinates.

This would enable the military personnel to utilize modern map products to accurately determine the locations of target points for use by the new generation of weapons.

Facility Management

In almost all countries of the world, the military manages and operates large bases which cover extensive areas. To manage these facilities effectively, it is essential to prepare an accurate base map.

Here GPS/DGPS can be of immense help, as existing maps are not updated regularly. GPS co-opted with Geographic Information System (GIS) can effectively tackle this task.

For example, at Yokosuka US Naval Base in Japan, Arc View GIS software was used to evaluate three different components for the GPS implementation. First, for modeling the optimum location for a GPS base station, secondly for selecting benchmark locations to fix the base station location and thirdly evaluating accuracy of survey by GPS.

With wars raging these days, the world is likely to witness the state of the art weaponry being used by the US led forces. Most of these, either directly or indirectly shall be using GPS to accurately target and achieve the desired results.

Depending upon the nature of military activity (i.e., navigation or precise target location), a particular kind of GPS may be used. It may thus be summarized that the GPS based weapon systems are here to stay and will form the backbone for the future development of better, more accurate and lethal munitions.

Civilian Use

(Return to Contents)

Of course, the most prominent use for the GPS system in the civilian world is for navigation purposes. The truth is that there are actually many more uses for a GPS than just keep you from getting lost on a trip.

An almost unlimited number of civilian applications benefit from GPS signals – all of which utilize one or more of three basic components of the GPS; absolute location, relative movement, and time transfer.

The ability to determine the receiver's absolute location allows GPS receivers to perform as a surveying tool or as an aid in navigation. The capacity to determine relative movement enables a receiver to calculate local velocity and orientation which is useful in vessels or observations of the Earth. Being able to synchronize clocks to exacting standards enables time transfer which is critical in large communication and observation systems.

Finally, measurements of all these components enable researchers to understand the Earth's environment better. That includes assessing the atmosphere and the planet's gravity by observing how those environmental components alter the propagation of GPS signals.

To help prevent civilian GPS guidance from being used in an enemy's military or improvised weaponry, the US government controls the export of civilian receivers. A US-based manufacturer cannot generally export a GPS receiver unless the receiver contains limits restricting it from functioning when it is simultaneously at an altitude above 60,000 feet and traveling at over 1,000 knots or 515 miles per second.

Of course, the GPS system is great for boaters and sailors. Because of the accuracy of the system, the satellites can pinpoint almost exactly where you are on the water and then guide you along the way when there are no street signs or even landmarks to help guide you on your way. Today, almost all boats are equipped with GPS systems.

If you are a hiker, having a GPS system can also be a great tool to bring along with you on your trip. Being lost in the woods is a nightmare for many hikers. Of course, you do have landmarks to help you along, but you can also get disoriented quite easily as well. With a portable hand held GPS locator, you can get back on track with the push of a button.

Because the GPS receivers use technology that includes points of interest, some manufacturers are gearing their systems toward business as well. Some museums are using them to guide visitors through the museum and allowing the GPS receiver provides the visitor with information about displays.

In what sounds like a scene out of a James Bond movie, GPS systems can also be used to track people in many different ways. There are a lot of applications that GPS tracking would be useful in doing and keeping track of people as well as vehicles.

To start with, many trucking companies are beginning to install GPS auto tracking devices into their trucks. This allows them to know exactly where their trucks are at all times. They can keep their trucks on time and even improve on delivery times being able to pinpoint those delivery times with even better accuracy.

The GPS technology can also pick out better routes for the trucks to use to get the best gas mileage and make the shortest trip. This improves on efficiency in a big way.

Car rental companies also use these devices to keep track of their rental cars, and car lots will have portable devices that they move from car to car to prevent theft during test drives. In fact, this is a great way to prevent car theft when vehicles have these devices installed.

Law enforcement loves it when they have a stolen car equipped with a GPS device. They are easier to track as all they have to have is the GPS device's number and software with tracking capabilities.

Insurance companies are starting to like this idea as well because they are now offering discounts on customer policies when that customer has a GPS device in their vehicle.

Private investigators think that GPS auto tracker is a great invention. When they are hired to track a person – for whatever reason – they like having this type of tool at their disposal.

One private investigator we spoke with personally gave his own testimony to this author about how GPS auto tracker has changed his business. These are his words:

“There was a time when I would have to sit for hours waiting for a vehicle to move if I was tracking the possibility of a cheating spouse. I had a paying job and I was determined to do it right. But sometimes, I would lose the car and have to start all over again.

Then I found a GPS auto tracker receiver that I could put into a magnetic box and sneak up behind a vehicle placing it somewhere on the bottom of the car without being seen. I would then be able to track that car from my laptop in my car and see where that car was going.

The GPS auto tracker system has made such a huge difference in my business as I have irrefutable proof of where a vehicle has been, plus, I don’t lose them anymore! It has been, in my opinion, one of the most valuable tools in the private investigation business in years!”

Again, an almost space-age application that is currently being explored is the possibility of being able to keep track of Alzheimer’s patients using GPS technology. What this requires is the insertion of a small tracking device (smaller than a piece of rice) underneath the skin of the patient. This is essentially a miniaturized version of a GPS receiver.

Then, with software that goes with the device, you can know where your loved one is at all times. We hear about stories on the news all the time regarding Alzheimer’s patients who have wandered off and become lost. If this technology comes into being, no more lost patients!

A similar technology like this has been used for awhile with pets, so there really is no reason not to explore using it with humans.

Going back to law enforcement, prisoners who are out on home confinement such as Martha Stewart was last year, GPS technology was used to keep a pinpoint on her location at all times. In fact, this type of technology has been used with home confinement bracelets for quite some time.

With GPS Auto Tracker technology, even nervous parents of new drivers can find piece of mind when their children are out on the road. Many parents like these place a GPS auto tracker under the seat or on the under-carriage of their teen's vehicle. Then they can almost instantly track where their teen is, where they have been and even how they have been driving.

Now, the GPS auto tracker won't be able to keep your kid from doing things they shouldn't be doing, but at least you'll be able to track their movements. Plus, when you get a reading on how they are driving, you may find some things that concern you which can prompt a good talk of safe and responsible driving habits.

Enterprising young people have even made a game out of using their handheld GPS devices. This game is called geocaching and is growing in popularity. Essentially, geocaching is a huge worldwide treasure hunt.

Members of the organization will hide usually small things like toys or trinkets. Most often, however, there is a log book that is hidden where people who find it can sign that they have been there and leave a little message.

Some geocachers have taken the game to another level and hidden things like money and valuable jewelry. In fact, one man had even written a book about treasure hunting. It was a fictional story in which the story line revolves around some very expensive and very unique jewelry.

An investor in his project commissioned to have the jewelry made and then the pieces were hidden for geocachers to find. It started a worldwide frenzy since many of these pieces were worth in the hundreds of thousands of dollars.

Some people will leave small tokens in their hidden spots for geocachers to find. They may also include instructions as to what they want you to do with the trinket or where they want you to move it to.

One geocacher found a Darth Vadar figure. He was an airline pilot for the Air Force and was instructed to take it with him wherever he went. He followed the request and together they logged over 27,000 airline miles together.

If you are interested in geocaching, go to the website www.geocaching.com and check out all the quests that have been posted. There are tons and tons of options out there for enterprising young geocachers. It's fun and interesting and can introduce you to not only new people, but open up your world to new experiences as well.

Well, there's no doubt that GPS systems are good for both the military as well as the everyday person. You have a lot of choices when it comes to choosing your GPS receiver, so let's take a look at which ones you might be able to pick.

Chapter 6 - How Much Is That GPS In The Window?

(Return to Contents)

There are so many companies that have gotten onto the "GPS Train" that it might be overwhelming to try and figure out which one you want to buy for yourself. Of course, one of the biggest considerations you will want to think about is what you plan to use your GPS system for.

We'll attempt to go over a few of the most popular products from some of the most popular manufacturers. Please keep in mind that we don't condone one particular product over the other and we will attempt to remain un-biased in our descriptions taking them from some of the places that have done reviews of these products.

One of the most well-known names in the GPS business is Garmin. Garmin has been producing GPS systems for years, and they are staying on top of technology to continually turn out new systems that remain the top choices of reviewers everywhere.

Reviewers say that the Garmin GPS 60CSx handheld device is the best all-around handheld GPS and it gets great scores in reviews for fast map rendering and speedy satellite lock even from a cold start. This is due to its SiRF Star III chipset which is one of the most advanced technologies around today.

This handheld GPS is rubberized and water-resistant and comes with a 64MB memory card so you can add additional maps. It comes pre-loaded with North American base maps but reviewers say this unit really shines when used with the optional Garmin MapSource software.

The Garmin GPS 60CSx has a 2.6 inch color screen, an electronic compass, a barometric altimeter, along with a special geocaching menu (which we have already talked about before!) It weighs a light 7 ½ ounces and runs for about 18 hours on two AA batteries.

While the Garmin GPS 60CSx is certainly one of the best handheld devices around according to reviewers, this type of technology does not come cheap. An estimated cost for a unit like this runs in the $400 range, but remember, you are paying for quality that you will definitely get!

Another company that is in the forefront of the GPS producing industry is Magellan. The good thing about Magellan is that they realize that there are some people out there who just cannot spend a lot of money on a GPS system. That is why their eXplorist 500 LE is one of the most popular handheld device on the market today: mainly because the price stays below $200.

Just because it is inexpensive doesn't mean that you get a cruddy product. You actually will have a great handheld device that will do a lot of things – and all in a user-friendly way!

The Magellan eXplorist 500 LE does not use the latest SiRF star III GPS chipset – which gets much better reception – it does have a nice big screen measuring 2 ¼ inches which is unusual in its price range. The 5.4 ounce handheld GPS unit is compact and water resistant.

Sometimes reception can be spotty, reviewers do find that the unit is very easy to use. On-board memory is limited, but it can be expanded by adding an SD memory card so you can store additional maps.

Another amazing unit you can look at the purchase comes from the Delorme Company and is called the Earthmate. This lightweight GPS system comes with satellite imagery that is very appealing to many people.

It, too, does not use the most advanced GPS chipset, the Earthmate does have some unique display qualities. Most notably, the Earthmate has the ability to display satellite imagery of terrain which many receivers cannot do. In fact, many reviewers liken it to the online website Google Earth.

The Magellan Earthmate is small and waterproof and comes in a bright yellow color so it’s hard to lose! It is lightweight with a 2.2 inch color display.

Most reviews say that this GPS system’s performance is very good – even without the latest chipset technology. Although Garmin has the best accuracy and reception, this unit has the best display and they cost about the same. Again, it comes down to what is most important for you.

Those are the top units by expert reviewers, and, as we’ve said, which one you choose really depends on what you are going to use the system for. But what if you have no idea what you are looking for?

Chapter 7 - Deciding On The Right One

(Return to Contents)

With all of the different choices you have in GPS receivers that are on the market these days, you may feel a little overwhelmed in deciding which one you want. While you will want something that will meet your needs, you may want some features that you never even knew existed, so we'll help guide you along the way when it comes to knowing what to look for in a GPS receiver.

These suggestions come in no particular order, but they are things that you will have to think about when choosing a GPS. Each component of your GPS system will work together to give you the choices that you are looking for and the performance that you need.

First, look at the display. Look for color displays that are easy to see in all lighting conditions, such as the one found on the Lowrance iWay 500c. Select a GPS model with a good color screen that can be read in all lighting conditions.

The larger the screen, the more expensive the unit will be, but even big screens can be difficult to read in direct sunlight. Also, check the viewing performance of the display to make sure you can read it from any angle.

Look for a model that includes street-level maps. Some manufacturers charge extra to unlock maps from their Web sites or CDs, while others include only partial regions. This can get expensive if you're planning a cross-country trip. Make sure you can update the unit's firmware and mapping data.

On most portable models, a USB or serial port lets you connect the system to a PC, where you can upload the latest maps and system software as it becomes available. On in-dash models, maps are typically read from an integrated DVD or CD player and require only the latest discs to be brought up-to-date.

Choose a GPS unit to fit your traveling habits. If you do a lot of long-distance driving, consider a model with a dedicated hard drive that stores maps of the entire country. Otherwise, a model that uses an SD card to store maps is a good bet, and you can buy additional cards to load more maps when necessary.

If you want to share one unit between many vehicles, look for a model that is lightweight and easy to install and remove from your vehicle. Stay away from permanent mounting devices unless you plan on using the unit in just one vehicle.

If you decide on an in-dash model, pay the extra money to have it professionally installed. Unlike car stereo systems, which can be fairly easy to install, a GPS system requires careful placement of the antenna, and some systems require a special cable hookup to your vehicle's speedometer mechanism.
Like anything else, the more bells and whistles included in your GPS system, the more you'll end up paying, but there are certain features that are more or less standard equipment these days.

Street-level maps with voice- and text-prompted driving directions are the foundation of any in-car GPS system worth its salt, and we're starting to see systems that use text-to-speech technology to deliver specific street names rather than more generic instructions, such as "Turn right in 0.5 miles."

A comprehensive points of interest (POI) database containing airports, hospitals, dining options, shopping, service stations, and more, is a must if you're traveling in unfamiliar territory, as is automatic routing from a POI, an address book, or your present location.

Look for a device with touch-screen controls, automatic rerouting when you veer off course and variable map perspectives, such as 3D and bird's-eye views. As you get into the high-end models, look for big daylight-readable screens and real-time traffic and weather alerts, which usually require an annual subscription fee.

Most companies include the basic accessories such as vehicle mounts and car chargers in the box. Most in-car navigation systems are ready to use right out of the box and come with everything you need to get up and running in a matter of minutes.

Still, there are accessories available that will help you get the most out of your investment, including auxiliary antennas that can be mounted at the base of your windshield to improve signal reception and carry cases to protect your GPS unit when not in use.

You can also pick up various mounting devices, including motorcycle-mounting kits and low-profile external antenna mounts that adhere to the trunk of your car. Additionally, you can purchase more maps on CD media or flash memory cards, as well as AC adapters that let you use your GPS unit at home.

If you are looking for a car mounted unit, you will want one that is installed easily so that you can move it from car to car. That usually means that you will need a suction mount that will attach directly to your windshield. But it is strong, so it will hold and you will be able to use your GPS unit in any car you have.

While all GPS systems come with pre-loaded maps, you will also probably want to have the capability to load your own maps depending on where you are traveling to. That means you will want to have a GPS system with enough memory to hold those extra maps. Usually 64MB memory is enough, but you can also buy add-on memory cards for use with your GPS system.

As we've said, virtually all vehicle GPS systems come with maps, although not all of them are detailed street-level maps. Most in-dash models use optical media, such as CD-ROM or DVD-ROM discs that come directly from the manufacturer with maps preloaded.

In some cases, these discs are part of the package, but some vendors require that you purchase them separately or subscribe to a plan that provides updated discs on an annual basis. DVD media containing detailed maps of the entire United States are typically priced in the $300 range.

As we've addressed in a previous section, you can also download many maps for free from the internet, but they are likely to be less detailed than you would like.

Top-of-the-line portable models provide comprehensive street-level maps on a hard drive, so you never have to worry about losing detailed coverage when you travel outside of a map region. This seamless coverage is what makes this type of GPS system so popular.

Units that use removable media, such as flash memory cards, can hold as much detail as the memory card allows. For example, the Mio 136, a PDA/GPS device designed for use in a car and on foot, doesn't come with preloaded maps. Instead, it has 32MB of internal memory and comes with a 256MB SD (Secure Digital) card to hold detailed map regions.

A typical map region, such as the I-95 corridor from Boston to Washington, D.C., uses more than 200MB of storage. If you want to cover more ground, you'll have to purchase extra SD cards and preload the necessary regions before hitting the highway. Changing SD cards on the fly is no big deal, but it can get expensive if you want nationwide coverage at your fingertips.

The least expensive units will come with base maps of the United States, which include major interstate roadways and highways. For some travelers, this is sufficient, especially if they simply want to track their progress on long-range trips.

If the unit has enough memory or a slot that accepts flash media, you can add detailed maps as you go. It's rare to find an automotive GPS system that relies on internal memory to store maps since flash memory offers more flexibility.

Loading maps onto your GPS unit can be a time-consuming process, but it can be well worth the time. First, you'll have to load the mapping software on a PC and connect the GPS device to your computer. Depending on the software, you can select predetermined regions to upload, or you may have to pan the map and create your own regions, which requires constant adjustments to create a region that will fit on your memory card.

In some cases, you have to visit the vendor's Web site to download maps to your PC, and then upload them to the GPS unit. Both methods may require an unlock code to access the maps, which usually carries an additional fee and can cost hundreds of dollars, depending on the vendor.

The biggest advantage that in-car GPS devices have over paper maps is the ability to create electronic routes, complete with turn-by-turn directions and, in most cases, voice-guided directions. Depending on your GPS unit's feature set, it may be necessary to plot a route on your PC before heading out on the highway, although most current models contain enough memory and map storage for on-the-fly routing.

Creating a route involves entering a destination and letting the system determine a route from your current location. You will often have the opportunity to choose which way the GPS selects your route depending on if you want the shortest route, the most economical, or the most scenic.

Almost all the of the high-end vehicle navigations systems utilize touch-screen technology to make entering destinations and addresses as easy as possible, and a few select models let you access the onscreen keyboard via a wireless remote control.

Some of the newer (and more expensive) in-dash models now feature voice-activated input, such as the 2006 Honda Civic Hybrid, where you train the system to accept spoken commands. How cool is that?

Like we said, routes can be calculated any number of ways, depending on your preference. You can ask for the fastest or the shortest route and tell the system to avoid certain routes, such as toll roads and interstate highways. This is particularly helpful if you know that a stretch of road is under construction or is closed for some reason.

Once the system has your starting point and your destination, it calculates the best route according to your specifications, and then displays it on a map, highlighting each segment of road along the way.

The map view is typically a 2D view, although most of the latest systems are capable of displaying 3D and aerial map views. You can also view the directions in text with details such as distance between turns and estimated time of arrival based on your current traveling speed.

Ideally, the system is capable of giving voice-guided directions, which lets the driver concentrate on driving without having to glance at the screen. With voice directions, it's almost impossible to get lost or miss a turn because you are alerted of your next maneuver well before you actually have to make it.

The voice prompt typically warns you of your next turn immediately after you've completed a maneuver, again as you're heading toward the turn to give you enough time to safely change lanes, then one more time as you approach the actual turn or exit ramp.

Newer system feature text-to-speech functionality, which actually tells you the name of upcoming streets. If you still manage to miss the turn or deviate from the original route, the system will calculate a new route based on your present location.

Of course, an in-car navigator is only as good as its receiver, and since all GPS systems are not created equal, some are more accurate than others. The same goes for mapping data and directions; a good system will have up-to-date maps that can differentiate between one-way streets, dead ends, and so on. As a rule of thumb, GPS systems that use NavTeq or TeleAtlas digital maps are among the most accurate for mapping detail.

This may seem like a lot of information to take in, but with constantly changing technology, you will definitely want to explore all your options. This is especially true when you are going to be spending a lot of money on a GPS navigational system.

Believe it or not, you may not actually have to buy a separate GPS receiver in order to get navigational technology. These days, many cell phones and PDA's come equipped with GPS technology. And with the advent of Blue Tooth – which allows you to seamlessly connect various devices without cables – you will find that your cell phone or PDA can actually do a lot of different things if you take time to explore those things!

Essentially, how this technology works is that you have a GPS enabled device – such as a PDA or a cell phone – and you then upload maps to this device via the internet. Then you tell your device – cell phone or PDA – that they are going to act like a GPS receiver (whether they like it or not)!

After that, you can use either device as a GPS receiver by entering in your desired location information and be well on your way. You are, of course, limited by the memory capabilities of this device and may not get all of the bells and whistles that a regular GPS device can offer, but it'll do the job – and without extra expense!

This is truly space-age technology, but you might be wondering whether or not there are any advances in the works for the GPS system. Well, of course, technology is always evolving.

Today, they are working on making GPS receivers able to receive the generally weak signals that are coming down from the satellite constellations. That means that high sensitivity GPS receivers must be invented. But rest assured, they are already in the works!

High sensitivity GPS receivers use large banks of correlators and digital signal processing to search for GPS signals very quickly. What happens with this is that the results are very fast time from first fixes when the signals are at their normal levels – such as in the great outdoors.

When GPS signals are weak – as they generally are indoors – the extra processing power can be used to integrate weak signals to the point where they can be used to provide a position or timing solution.

You see, GPS signals are already weak when they arrive at the Earth's surface. The GPS satellites have transmitters that only deliver 27 watts from a distance of about 20,000 miles in orbit above the Earth. By the time the signals arrive at the user's receiver, they are just weak.

Conventional GPS receivers integrate the received signals for the same amount of time as the duration of a complete C/A code cycle. This results in the ability to acquire and track signals down and make them receivable.

Essentially, high sensitivity GPS receivers are able to integrate the incoming signals for up to one thousand times longer than normal. This means they can acquire signals that are one thousand times weaker which really improves performance!

High sensitivity GPS receivers can provide positioning in many but not all indoor locations. Signals are either heavily attenuated by the building materials or reflected as multi-path. Given that these high sensitivity receivers may be so much more sensitive than regular ones, they can actually be sufficient enough to track through three layers of dry bricks or up to 20 cm of steel reinforced concrete.

Conclusion

Sometimes it can be amazing and overwhelming to consider the way that technology has changed our lives. Before that, we would have to rely on paper maps to guide us along our journeys, now we have a little electronic device that will talk to us as we drive.

For years and years, the family vacation has often been filled with stress and strife as Dad tried to find the right route toward the amusement park with Mom in the passenger seat asking him to “Just stop and ask for directions!”

Now, all you have to do is look at your GPS and you will not only know exactly where you are, but exactly where you need to go! No more fighting, no more fuss – well, we can’t be responsible for the kids in the back seat, but you get the idea!

The technology of the GPS system has come so far in such a small amount of time, the thought of it can be mind-boggling. We went from a system that would tell us where the enemy was on the battlefield to showing us where the next Starbucks is. Incredible!

Even if you think that technology has no place in your vehicle, you may want to think again. GPS can make life much easier on the road – especially if you travel a lot. You can enjoy a whole huge piece of mind as you travel life on the highway.

Plus, consider the ways that you can keep track of where your vehicles are at almost any time! As we said before, it can give parents of new drivers a kind of comfort that none of us have ever known the first time our “babies” got behind the wheel of a car alone!

In short, GPS technology can be complicated, but it can also be very helpful. If you haven't already, be sure that you know what is out there and then do some research. Reading this book is a great start, but plays around with different systems and then makes a choice that is right for you.

You know how the song goes……"Life is a highway, I wanna ride it all night long…." Just be sure you don't get lost on the highway of life. Get a GPS system and stay right on track!

Recommended Resources

Free HTML Editor – NVU allow you to create your own web pages the simple and easy way without any HTML or PHP programming knowledge.

Free FTP Program – FileZilla is FTP (File Transfer Protocol) software that allows you to upload files to your website and also it is built-in and strong and easy to use web interface, besides using for uploading of files to your website, you can also use this software to perform files downloading from your website for backup purpose.

Domain Names – Hosting4Wealth domain Names for your new website are a bargain here.

Web Hosting – Hosting4Wealth Hosting offers unlimited domain hosted in one account with reasonable monthly hosting fee of less than $10 per month.

Merchant Account – Paypal.com offers you to accept credit card payment from your customers all around the world with various currency options.

Autoresponder Choice 1 - Aweber offers the most reliable autoresponders on the net! If email deliverability is important to you signup today!

Niche Contents PLR & MRR Membership – Niche4Wealth is a membership site that delivers 4 brand new niche private labels resell rights products on monthly basis and also offers more than hundreds resell rights products in the libraries. If you are looking for a way to make more income profits on each day selling info products, why not pay a visit to this site to see how you can make money with the products and contents in the membership.

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