The Principal of GPS and Their Application

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***Abstract* — We present the principal of GPS and their application. GPS is consists of 3 segments. A network of satellites that coded information, which makes it possible identify location by measuring distatce from the satellites. But GPS has errors which are combination of noise, bias, blunders. Nevertheless this errors, we can obtain accurate information about the place. In fact, GPS is used in everyday life.**

I. INTRODUCTION

GPS is Global Positioning System. A network of satellites that continuously transmit coded information, which makes it possible precisely identify location on earth by measuring distance from the satellites.

GPS is funded by and controlled by the U. S. Department of Defense (DOD). While there are many thousands of civil users of GPS world-wide, the system was designed for and is operated by the U. S. military. GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time. Four GPS satellite signals are used to compute positions in three dimensions and the time offset in the receiver clock.

Ⅱ. THE 3-SEGMENTS OF GPS

1. Space segment

The Space Segment of the system consists of the GPS satellites. These space vehicles (SVs) send radio signals from space. The nominal GPS Operational Constellation consists of 24 satellites that orbit the earth in 12 hours. There are often more than 24 operational satellites as new ones are launched to replace older satellites. The satellite orbits repeat almost the same ground track (as the earth turns beneath them) once each day. The orbit altitude is such that the satellites repeat the same track and configuration over any point approximately each 24 hours (4 minutes earlier each day). There are six orbital planes (with nominally four SVs in each), equally spaced (60 degrees apart), and inclined at about fifty-five degrees with respect to the equatorial plane. This constellation provides the user with between five and eight SVs visible from any point on the earth.

2. Control segment

The Control Segment consists of a system of tracking stations located around the world. The Master Control facility is located at Schriever Air Force Base (formerly Falcon AFB) in Colorado. These monitor stations measure signals from the SVs which are incorporated into orbital models for each satellites. The models compute precise orbital data (ephemeris) and SV clock corrections for each satellite. The Master Control station uploads ephemeris and clock data to the SVs. The SVs then send subsets of the orbital ephemeris data to GPS receivers over radio signals.

3. User segment

Navigation in three dimensions is the primary function of GPS. Navigation receivers are made for aircraft, ships, ground vehicles, and for hand carrying by individuals.Precise positioning is possible using GPS receivers at reference locations providing corrections and relative positioning data for remote receivers. Surveying, geodetic control, and plate tectonic studies are examples.

Time and frequency dissemination, based on the precise clocks on board the SVs and controlled by the monitor stations, is another use for GPS. Astronomical observatories, telecommunications facilities, and laboratory standards can be set to precise time signals or controlled to accurate frequencies by special purpose GPS receivers. Research projects have used GPS signals to measure atmospheric parameters.

Ⅲ. GPS DATA

The GPS Navigation Message consists of time-tagged data bits marking the time of transmission of each subframe at the time they are transmitted by the SV(space vehicle). A data bit frame consists of 1500 bits divided into five 300-bit subframes. A data frame is transmitted every thirty seconds. Three six-second subframes contain orbital and clock data. SV Clock corrections are sent in subframe one and precise SV orbital data sets (ephemeris data parameters) for the transmitting SV are sent in subframes two and three. Subframes four and five are used to transmit different pages of system data. An entire set of twenty-five frames (125 subframes) makes up the complete Navigation Message that is sent over a 12.5 minute period. Data frames (1500 bits) are sent every thirty seconds. Each frame consists of five subframes. Data bit subframes (300 bits transmitted over six seconds) contain parity bits that allow for data checking and limited error correction. Clock data parameters describe the SV clock and its relationship to GPS time. Ephemeris data parameters describe SV orbits for short sections of the satellite orbits. Normally, a receiver gathers new ephemeris data each hour, but can use old data for up to four hours without much error. The ephemeris parameters are used with an algorithm that computes the SV position for any time within the period of the orbit described by the ephemeris parameter set. Almanacs are approximate orbital data parameters for all SVs. The ten-parameter almanacs describe SV orbits over extended periods of time (useful for months in some cases) and a set for all SVs is sent by each SV over a period of 12.5 minutes (at least). Signal acquisition time on receiver start-up can be significantly aided by the availability of current almanacs. The approximate orbital data is used to preset the receiver with the approximate position and carrier Doppler frequency (the frequency shift caused by the rate of change in range to the moving SV) of each SV in the constellation. Each complete SV data set includes an ionospheric model that is used in the receiver to approximates the phase delay through the ionosphere at any location and time. Each SV sends the amount to which GPS Time is offset from Universal Coordinated Time. This correction can be used by the receiver to set UTC to within 100 ns.

Ⅳ. POSITION, TIME FROM GPS

The GPS receiver produces replicas of the C/A and/or P (Y)-Code. Each PRN code is a noise-like, but pre-determined, unique series of bits. The receiver produces the C/A code sequence for a specific SV with some form of a C/A code generator. Modern receivers usually store a complete set of precomputed C/A code chips in memory, but a hardware, shift register, implementation can also be used. The C/A code generator produces a different 1023 chip sequence for each phase tap setting. In a shift register implementation the code chips are shifted in time by slewing the clock that controls the shift registers. In a memory lookup scheme the required code chips are retrieved from memory.

If the receiver applies a different PRN code to an SV signal there is no correlation. When the receiver uses the same code as the SV and the codes begin to line up, some signal power is detected. As the SV and receiver codes line up completely, the spread-spectrum carrier signal is de-spread and full signal power is detected.

The receiver PRN code start position at the time of full correlation is the time of arrival (TOA) of the SV PRN at receiver. This TOA is a measure of the range to SV offset by the amount to which the receiver clock is offset from GPS time. This TOA is called the pseudo-range

Ⅴ. GPS ERROR SOURCE

GPS errors are a combination of noise, bias, blunders. Noise errors are the combined effect of PRN code noise (around 1 meter) and noise within the receiver noise (around 1 meter). Bias errors result from Selective Availability and other factors

Selective Availability (SA). SA is the intentional degradation of the SPS signals by a time varying bias. SA is controlled by the DOD to limit accuracy for non-U. S. military and government users. The potential accuracy of the C/A code of around 30 meters is reduced to 100 meters (two standard deviations). The SA bias on each satellite signal is different, and so the resulting position solution is a function of the combined SA bias from each SV used in the navigation solution. Because SA is a changing bias with low frequency terms in excess of a few hours, position solutions or individual SV pseudo-ranges cannot be effectively averaged over periods shorter than a few hours. Differential corrections must be updated at a rate less than the correlation time of SA (and other bias errors).

* Other Bias Error sources;
-SV clock errors:1 meter.
-Ephemeris data errors: 1 meter
-Tropospheric delays: 1 meter.
-Unmodeled ionosphere delays: 10 meters.
-Multipath: 0.5 meters
-Blunders can result in errors of hundred of kilometers

Ⅵ. MILITARY USES FOR GPS

The system made its public debut to rave reviews in the 1991 Gulf War. U.S. troops used it for navigation on land, sea, and in the air, for targeting of bombs, and for on-board missile guidance. GPS allowed U.S. ground troops to move swiftly and accurately through the vast, featureless desert of the Arabian Peninsula.

GPS receivers were used in several aircraft, including F-16 fighters, KC-135 aerial refuelers, and B-2 bombers

Navy ships used them for rendezvous, minesweeping, and aircraft operations.

GPS has become important for nearly all military operations and weapons systems. In addition, it is used on satellites to obtain highly accurate orbit data and to control spacecraft orientation.

Ⅶ. GPS USES IN EVERYDAY LIFE

The GPS system was developed to meet military needs of the Department of Defense, but new ways to use its capabilities are continually being found. Today, GPS is saving lives, helping society in many other ways.

1. Aircraft, Shipping and Automobile navigation

Airlines have saved millions of dollars by using GPS to hone their flight plans. GPS can be used for instrument landing at small, as well as large, airports and is making new air-avoidance systems possible. GPS not only makes flying safer, but also more efficient. And GPS saves fuel and extends an aircraft`s range by ensuring pilots don`t stray from the most direct routes to their destinations. GPS accuracy will also allow closer aircraft separations on more direct routes, which in turn means more planes can occupy our limited airspace.

Shipping companies equip their tankers and freighters with GPS for navigation and to record and control the movement of their-vessels.

Automobile manufacturers are offering moving-map displays guided by GPS receivers as an option on new vehicles so that drivers not only can find out where they are but also can be given directions on display screens. In Japan, 500,000 automobiles have already been equipped with a GPS-based navigation system.

2. Transportation and Emergency

Vehicle tracking is one of the fastest-growing GPS applications. GPS-equipped fleet vehicles, public transportation systems, delivery trucks, and courier services use receivers to monitor their locations at all times and to speed deliveries.

GPS is also helping to save lives. any police, fire, and emergency medical service units are using GPS receivers to determine the police car, fire truck, or ambulance nearest to an emergency, enabling the quickest possible response in life-or-death situations. And they use GPS to pinpoint destinations and map their routes.

3. Mapping

Mapping is the art and science of using GPS to locate items, then create maps and models of everything in the world. Because it is not affected by force of gravity, GPS can be used to draw map accurately. And GPS is applied to many kinds of measurement. because it can grasp a wide region quickly and exactly.

4. Surveying

In the field of wildlife management, threatened species such as the Mojave Desert tortoise are being fitted with

GPS receivers and tiny transmitters to help determine population patterns and possible sources of disease.
GPS-equipped balloons are monitoring goles in the ozone layer over the polar regions, and air quality is being monitored using GPS receivers. Buoys tracking major oil spills transmit data using GPS.
Also, earth scientists use GPS to monitor earthquakes and the shifting of the earth`s tectonic plates. And GPS can help recoverer from the effects of the earthquake. And Satellite builders use GPS receivers to track the positions of their satellites.

5. Clocks for computer time synchronization
GPS is also used to disseminate precise time, time intervals, and frequency. Knowing that a group of timed events is perfectly synchronized is very important. GPS makes the job of "synchronizing our watches" easy and reliable. Telecommunications companies increasingly rely on GPS to synchronize their land-based digital networks, comparing their reference clocks directly with GPS time.

6. Construction
During construction of the tunnel under the English Channel, British and French crews started digging from opposite ends: one from Dover, England, one from Calais, France. They relied on GPS receivers outside the tunnel to check their positions along the way and to make sure they met exactly in the middle. Otherwise, the tunnel might have been crooked.
Using GPS, construction workers can accurately measure and align. It is now possible to accurately measure any point in three dimensions anywhere on the site. So GPS allow surveyors to easily stakeout designs of roads, bridges and tunnels.

7. Agriculture
GPS farming systems provide precise guidance for field operations, or collection of map data on tillage, applications, planting, weeds, insect and disease infestations, cultivation and irrigation. Machine Control systems automate equipment to save time and costs associated with field operators.
Field data can be used to analyze management practices and determine optimal strategies for infield operations. For example, a farming GIS database might include layers on field topograpy, soil types, surface drainage, subsurface drainage, soil testing results, rainfall, irrigation, chemical application rates, and corp yield.

8. And so forth - general leisure (mountaineering, fishing), management of forest

Ⅷ. CONCLUSION

The future of GPS appears to be virtually unlimited.
Technological fantasies abound. The system provides a novel, unique, and instantly available address for every square yard on the surface of the planet--a new international standard for locations and distances. To the computers of the world, at least, our locations may be defined not by a street address, a city, and a state, but by a longitude and a latitude. With the GPS location of services stored with phone numbers in computerized "yellow pages," the search for a local restaurant of the nearest gas station in any city, town, or suburb will be completed in an instant. With GPS, the world has been given a technology of unbounded promise, born in the laboratories of scientists who were motivated by their own curiosity to probe the nature of the universe and our world, and built on the fruits of publicly supported basic research.

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