



SESSION:
2012-2013

COMPUTER PROJECT WORK



GPS SYSTEM

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11th – 'D'

SESSION: 2012-2013

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CERTIFICATE

IT IS CERTIFIED THAT THE COMPUTER SCIENCE
PROJECT WORK HAS BEEN SUCCESSFULLY
PERFORMED BY :

ARUN KUMAR SINGH STUDENT OF CLASS XIth-D
(SCIENCE) AS REQUIRED FOR THE SESSION
ENDING PROJECT WORK DURING THE ACADEMIC
YEAR 2012-2013.

DATE:-

SUBJECT TEACHER:-

(MR. K.K KUMAWAT)

ACKNOWLEDGEMENT

I TAKE IMMENSE PLEASURE IN EXPRESSING MY GRATITUDE TO OUR PRINCIPAL MR.SHEKHAR JAKHORIA, KENDRIYA VIDYALAYA NO.1 , JAMNAGAR FOR HIS ENCOURAGEMENT AND CONSTANT SUPPORT IN UNDERTAKING THIS PROJECT.

I EXTEND MY HEARTY THANKS TO MR. K.K KUMAWAT, PGT.COMPUTER SCIENCE WHO GUIDED US TO MAKE THIS PROJECT SUCCESSFULLY.

I TAKE OPPORTUNITY TO EXPRESS MY GRATITUDE FOR HIS VALUABLE GUIDANCE, CONSTANT CONSTRUCTIVE COMMENTS, SYMPATHETIC ATTITUDE AND IMMENSE MOTIVATION WHICH HAS SUSTAINED MY EFFORT AT ALL STAGES OF THIS PROJECT.

TOPIC

**GPS SYSTEM
INCLUDING
CONCEPTS OF
COMPUTER APPLICATIONS**

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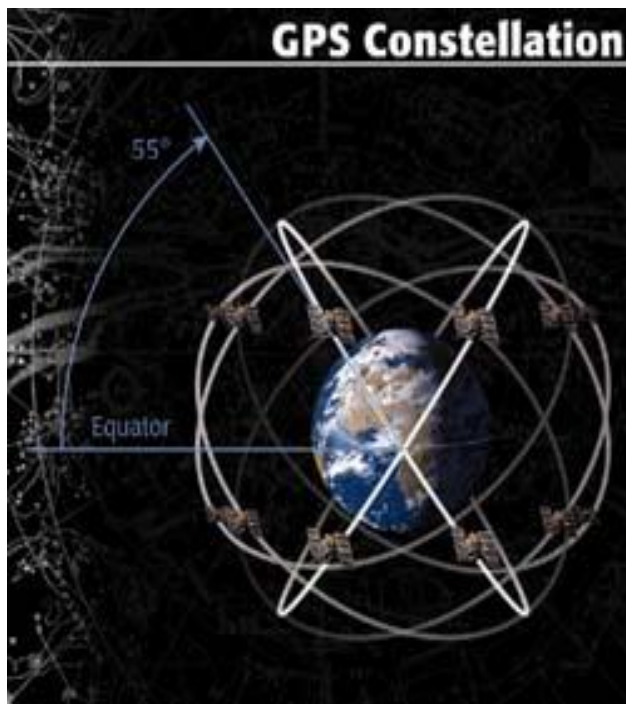
**OPERATING SYSTEM USED
IN GPS SYSTEM**

**COMPUTER SCIENCE
PROJECT**

INTRODUCTION TO GPS

How Does GPS Work?

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



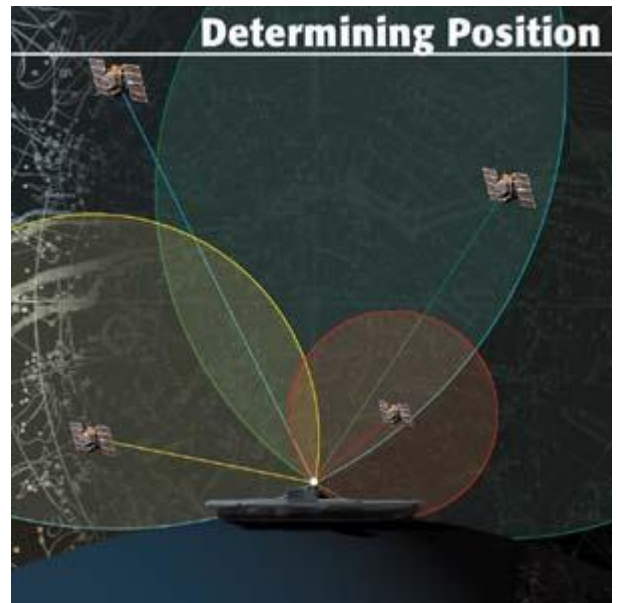
Each GPS satellite transmits data that indicates its location and the current time. All GPS satellites synchronize operations so that these repeating signals are transmitted at the same instant. The signals, moving at the speed of light, arrive at a GPS receiver at slightly different times because some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

When the receiver estimates the distance to at least four GPS satellites, it can calculate its position in three dimensions.

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

Determining Position

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



GPS Accuracy

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

When the system was created, timing errors were inserted into GPS transmissions to limit the accuracy of non-military GPS receivers to about 100 meters. This part of GPS operations, called Selective Availability, was eliminated in May 2000.

GLOBAL POSITIONING SYSTEM (GPS)

History

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

Predecessors

In 1956, the German-American physicist Friedwardt Winterberg proposed a test of general relativity (for time slowing in a strong gravitational field) using accurate atomic clocks placed in orbit inside artificial satellites. (To achieve accuracy requirements, GPS uses principles of general relativity to correct the satellites' atomic clocks.) Additional inspiration for GPS came when the Soviet Union launched the first man-made satellite, Sputnik in 1957. Two American physicists, William Guier and George Weiffenbach, at Johns Hopkins's Applied Physics Laboratory (APL), decided on their own to monitor Sputnik's radio transmissions. Within hours they realized that, because of the Doppler effect, they could pinpoint where the satellite was along its orbit from the Doppler shift. The Director of the APL gave them access to their UNIVAC to do the heavy calculations required. The following spring, Frank McClure, the deputy director of the APL, asked Guier and Weiffenbach to investigate the inverse problem - pinpointing the user's location given that of the satellite. (The Navy was developing the submarine-launched Polaris missile, which required them to know the submarine's location.) This led them and APL to develop the Transit system.

The first satellite navigation system, Transit, used by the United States Navy, was first successfully tested in 1960. It used a constellation of five satellites and could provide a navigational fix approximately once per hour.



Official logo for NAVSTAR GPS

In 1967, the U.S. Navy developed the Timation satellite that proved the ability to place accurate clocks in space, a technology required by GPS. In the 1970s, the ground-based Omega Navigation System, based on phase comparison of signal transmission from pairs of stations, became the first worldwide radio navigation system. Limitations of these systems drove the need for a more universal navigation solution with greater accuracy.

While there were wide needs for accurate navigation in military and civilian sectors, almost none of those were seen as justification for the billions of dollars it would cost in research, development, deployment, and operation for a constellation of navigation satellites. During the Cold War arms race, the nuclear threat to the existence of the United States was the one need that did justify this cost in the view of the United States Congress. This deterrent effect is why GPS was funded. It is also the reason for the ultra-secrecy at that time. The nuclear triad consisted of the United States Navy's submarine-launched ballistic missiles (SLBMs) along with United States Air Force (USAF) strategic bombers and intercontinental ballistic missiles (ICBMs). Considered vital to the nuclear deterrence posture, accurate determination of the SLBM launch position was a force multiplier.

Precise navigation would enable United States submarines to get an accurate fix of their positions prior to launching their SLBMs. The USAF with two-thirds of the nuclear triad also had requirements for a more accurate and reliable navigation system. The Navy and Air Force were developing their own technologies in parallel to solve what was essentially the same problem. To increase the survivability of ICBMs, there was a proposal to use mobile launch platforms (such as Russian SS-24 and SS-25) and so the need to fix the launch position had similarity to the SLBM situation. In 1960, the Air Force proposed a radio-navigation system called MOSAIC (Mobile System for Accurate ICBM Control) that was essentially a 3-D LORAN. A follow-on study called Project 57 was worked in 1963 and it was "in this study that the GPS concept was born." That same year the concept was pursued as Project 621B, which had "many of the attributes that you now see in GPS" and promised increased accuracy for Air Force bombers as well as ICBMs. Updates from the Navy Transit system were too slow for the high speeds of Air Force operation. The Navy Research

Laboratory continued advancements with their Imation (Time Navigation) satellites, first launched in 1967, and with the third one in 1974 carrying the first atomic clock into orbit.

Development

With these parallel developments in the 1960s, it was realized that a superior system could be developed by synthesizing the best technologies from 621B, Transit, Timation, and SECOR in a multi-service program.

During Labor Day weekend in 1973, a meeting of about 12 military officers at the Pentagon discussed the creation of a *Defense Navigation Satellite System (DNSS)*. It was at this meeting that "the real synthesis that became GPS was created." Later that year, the DNSS program was named *Navstar*. With the individual satellites being associated with the name Navstar (as with the predecessors Transit and Timation), a more fully encompassing name was used to identify the constellation of Navstar satellites, *Navstar-GPS*, which was later shortened simply to GPS.

Artist's conception of GPS Block II-F satellite in Earth orbit.



The DoD is required by law to "maintain a Standard Positioning Service (as defined in the federal radio navigation plan and the standard positioning service signal specification) that will be available on a continuous, worldwide basis," and "develop measures to prevent hostile use of GPS and its augmentations without unduly disrupting or degrading civilian

Awards

On February 10, 1993, the National Aeronautic Association selected the GPS Team as winners of the 1992 Robert J. Collier Trophy, the nation's most prestigious aviation award. This team combines researchers from the Naval Research Laboratory, the USAF, the Aerospace Corporation, Rockwell International Corporation, and IBM Federal Systems Company. The citation honors them "for the most significant development for safe and efficient navigation and surveillance of air and spacecraft since the introduction of radio navigation 50 years ago."

Two GPS developers received the National Academy of Engineering Charles Stark Draper Prize for 2003:

- Ivan Gettings, emeritus president of The Aerospace Corporation and an engineer at the Massachusetts Institute of Technology, established the basis for GPS, improving on the World War II land-based radio system called LORAN (*Long-range Radio Aid to Navigation*).
- Bradford Parkinson, professor of aeronautics and astronautics at Stanford University, conceived the present satellite-based system in the early 1960s and developed it in conjunction with the U.S. Air Force. Parkinson served twenty-one years in the Air Force, from 1957 to 1978, and retired with the rank of colonel.
- GPS developer Roger L. Easton received the National Medal of Technology on February 13, 2006.

In 1998, GPS technology was inducted into the Space Foundation Space Technology Hall of Fame.

Francis X. Kane (Col. USAF, ret.) was inducted into the U.S. Air Force Space and Missile Pioneers Hall of Fame at Lackland A.F.B., San Antonio, Texas, March 2, 2010 for his role in space technology development and the engineering design concept of GPS conducted as part of Project 621B.

On October 4, 2011, the International Astronautical Federation (IAF) awarded the Global Positioning System (GPS) its 60th Anniversary Award, nominated by IAF member, the American Institute for Aeronautics and Astronautics (AIAA). The IAF Honors and Awards Committee recognized the uniqueness of the GPS program and the exemplary role it has played in building international collaboration for the benefit of humanity.

Basic concept of GPS



Civilian GPS receiver system in

("GPS navigation device")

in a marine application.



Automotive navigation a taxicab.

A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the Earth. Each satellite continually transmits messages that include

- the time the message was transmitted
- satellite position at time of message transmission

The receiver uses the messages it receives to determine the transit time of each message and computes the distance to each satellite using the speed of light. Each of these distances and satellites' locations define a sphere. The receiver is on the surface of each of these spheres when the distances and the satellites' locations are correct. These distances and satellites' locations are used to compute the location of the receiver using the navigation equations. This location is then displayed, perhaps with a moving map display or latitude and longitude; elevation information may be included. Many GPS units show derived information such as direction and speed, calculated from position changes.

In typical GPS operation, four or more satellites must be visible to obtain an accurate result. Four sphere surfaces typically do not intersect. Because of this we can say with confidence that when we solve the navigation equations to find an intersection, this solution gives us the position of the receiver along with accurate time thereby eliminating the need for a very

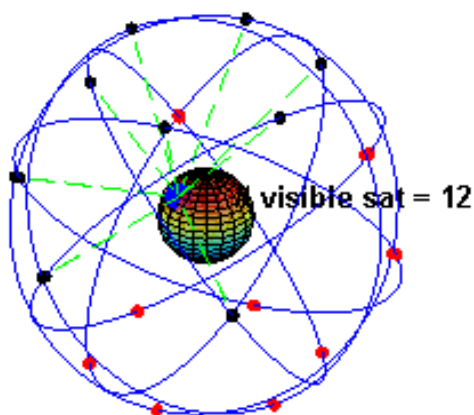
large, expensive, and power hungry clock. The very accurately computed time is used only for display or not at all in many GPS applications, which use only the location. A number of applications for GPS do make use of this cheap and highly accurate timing. These include time transfer, traffic signal timing, and synchronization of cell phone base stations.

Although four satellites are required for normal operation, fewer apply in special cases. If one variable is already known, a receiver can determine its position using only three satellites. For example, a ship or aircraft may have known elevation. Some GPS receivers may use additional clues or assumptions such as reusing the last known altitude, dead reckoning, inertial navigation, or including information from the vehicle computer, to give a (possibly degraded) position when fewer than four satellites are visible.

Space Segment



Unlaunched GPS block II-A satellite on display at the San Diego Air & Space Museum.



A visual example of the GPS constellation in motion with the Earth rotating. Notice how the number of *satellites in view* from a given point on the Earth's surface, in this example at 45°N, changes with time.

The space segment (SS) is composed of the orbiting GPS satellites, or Space Vehicles (SV) in GPS parlance. The GPS

design originally called for 24 SVs, eight each in three approximately circular orbits, but this was modified to six orbital planes with four satellites each. The orbits are centered on the Earth, not rotating with the Earth, but instead fixed with respect to the distant stars. The six orbit planes have approximately 55° inclination (tilt relative to Earth's equator) and are separated by 60° right ascension of the ascending node (angle along the equator from a reference point to the orbit's intersection). The orbital period is one-half a sidereal day, i.e., 11 hours and 58 minutes. The orbits are arranged so that at least six satellites are always within line of sight from almost everywhere on Earth's surface. The result of this objective is that the four satellites are not evenly spaced (90 degrees) apart within each orbit. In general terms, the angular difference between satellites in each orbit is 30, 105, 120, and 105 degrees apart which, of course, sum to 360 degrees.

Orbiting at an altitude of approximately 20,200 km (12,600 mi); orbital radius of approximately 26,600 km (16,500 mi), each SV makes two complete orbits each sidereal day, repeating the same ground track each day. This was very helpful during development because even with only four satellites, correct alignment means all four are visible from one spot for a few hours each day. For military operations, the ground track repeat can be used to ensure good coverage in combat zones.

As of December 2012, there are 32 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 nonuniform arrangement. Such an arrangement was shown to improve reliability and availability of the system, relative to a uniform system, when multiple satellites fail. About nine satellites are visible from any point on the ground at any one time (see animation at right), ensuring considerable redundancy over the minimum four satellites needed for a position.

Control Segment



Ground monitor station used from 1984 to 2007, on display at the Air Force Space & Missile Museum.

The control segment is composed of

1. a master control station (MCS),
2. an alternate master control station,
3. four dedicated ground antennas and
4. six dedicated monitor stations

The MCS can also access U.S. Air Force Satellite Control Network (AFSCN) ground antennas (for additional command and control capability) and NGA (National Geospatial-Intelligence Agency) monitor stations. The flight paths of the satellites are tracked by dedicated U.S. Air

Force monitoring stations in Hawaii, Kwajalein, Ascension Island, Diego Garcia, Colorado Springs, Colorado and Cape Canaveral, along with shared NGA monitor stations operated in England, Argentina, Ecuador, Bahrain, Australia and Washington DC. The tracking information is sent to the Air Force Space Command MCS at Schriever Air Force Base 25 km (16 mi) ESE of Colorado Springs, which is operated by the 2nd Space Operations Squadron (2 SOPS) of the U.S. Air Force. Then 2 SOPS contacts each GPS satellite regularly with a navigational update using dedicated or shared (AFSCN) ground antennas (GPS dedicated ground antennas are located at Kwajalein, Ascension Island, Diego Garcia, and Cape Canaveral). These updates synchronize the atomic clocks on board the satellites to within a few nanoseconds of each other, and adjust the ephemeris of each satellite's

internal orbital model. The updates are created by a Kalman filter that uses inputs from the ground monitoring stations, space weather information, and various other inputs.

The Operation Control Segment (OCS) currently serves as the control segment of record. It provides the operational capability that supports global GPS users and keeps the GPS system operational and performing within specification.

OCS successfully replaced the legacy 1970's-era mainframe computer at Schriever Air Force Base in September 2007. After installation, the system helped enable upgrades and provide a foundation for a new security architecture that supported the U.S. armed forces. OCS will continue to be the ground control system of record until the new segment, Next Generation GPS Operation Control System (OCX), is fully developed and functional.

The new capabilities provided by OCX will be the cornerstone for revolutionizing GPS's mission capabilities, and enabling Air Force Space Command to greatly enhance GPS operational services to U.S. combat forces, civil partners and myriad of domestic and international users.

The GPS OCX program also will reduce cost, schedule and technical risk. It is designed to provide 50% sustainment cost savings through efficient software architecture and Performance-Based Logistics. In addition, GPS OCX expected to cost millions less than the cost to upgrade OCS while providing four times the capability.

The GPS OCX program represents a critical part of GPS modernization and provides significant information assurance improvements over the current GPS OCS program.

- OCX will have the ability to control and manage GPS legacy satellites as well as the next generation of GPS III satellites, while enabling the full array of military signals.
- Built on a flexible architecture that can rapidly adapt to the changing needs of today's and future GPS users allowing immediate access to GPS data and constellations status through secure, accurate and reliable information.

Message Format

Each GPS satellite continuously broadcasts a *navigation message* on L1 C/A and L2 P/Y frequencies at a rate of 50 bits per second (see bitrate). Each complete message takes 750 seconds (12 1/2 minutes) to complete. The message structure has a basic format of a 1500-bit-long frame made up of five subframes, each subframe being 300 bits (6 seconds) long. Subframes 4 and 5 are subcommutated 25 times each, so that a complete data message requires the transmission of 25 full frames. Each subframe consists of ten words, each 30 bits long. Thus, with 300 bits in a subframe times 5 subframes in a frame times 25 frames in a message, each message is 37,500 bits long. At a transmission rate of 50 bps, this gives 750 seconds to transmit an entire almanac message. Each 30-second frame begins precisely on the minute or half-minute as indicated by the atomic clock on each satellite



The first subframe of each frame encodes the week number and the time within the week, as well as the data about the health of the satellite. The second and the third subframes contain the *ephemeris* - the precise orbit for the satellite.



GPS message format

Subframes	Description
1	Satellite clock, GPS time relationship
2-3	Ephemeris (precise satellite orbit)
4-5	Almanac component (satellite network synopsis, error correction)

The fourth and fifth subframes contain the *almanac*, which contains coarse orbit and status information for up to 32 satellites in the constellation as well as data related to error correction. Thus, in order to obtain an accurate satellite location from this transmitted message the receiver must demodulate the message from each satellite it includes in its solution for 18 to 30 seconds. In order to collect all the transmitted almanacs the receiver must demodulate the message for 732 to 750 seconds or 12 1/2 minutes.

All satellites broadcast at the same frequencies. Signals are encoded using code division multiple access (CDMA) allowing messages from individual satellites to be distinguished from each other based on unique encodings for each satellite (that the receiver must be aware of). Two distinct types of CDMA encodings are used: the coarse/acquisition (C/A) code, which is accessible by the general public, and the precise P(Y) code, which is encrypted so that only the U.S. military can access it.

The ephemeris is updated every 2 hours and is generally valid for 4 hours, with provisions for updates every 6 hours or longer in non-nominal conditions. The almanac is updated typically every 24 hours. Additionally data for a few weeks following is uploaded in case of transmission updates that delay data upload.

Satellite Frequencies

All satellites broadcast at the same two frequencies, 1.57542 GHz (L1 signal) and 1.2276 GHz (L2 signal). The satellite network uses a CDMA spread-spectrum technique where the low-bitrate message data is encoded with a high-rate pseudo-random (PRN) sequence that is different for each satellite. The receiver must be aware of the PRN codes for each satellite to reconstruct the actual message data. The C/A code, for civilian use, transmits data at 1.023 million chips per second, whereas the P code, for U.S. military use, transmits at 10.23 million chips per second. The actual internal reference of the satellites is 10.22999999543 MHz to compensate for relativistic effects that make observers on Earth perceive a different time reference with respect to the transmitters in orbit.

The L1 carrier is modulated by both the C/A and P codes, while the L2 carrier is only modulated by the P code. The P code can be encrypted as a so-called P(Y) code that is only available to military equipment with a proper decryption key. Both the C/A and P(Y) codes impart the precise time-of-day to the user.

The L3 signal at a frequency of 1.38105 GHz is used to transmit data from the satellites to ground stations. This data is used by the United States Nuclear Detonation (NUDET) Detection System (USNDS) to detect, locate, and report nuclear detonations (NUDETs) in the Earth's atmosphere and near space. One usage is the enforcement of nuclear test ban treaties.

The L4 band at 1.379913 GHz is being studied for additional ionospheric correction.

GPS frequency overview

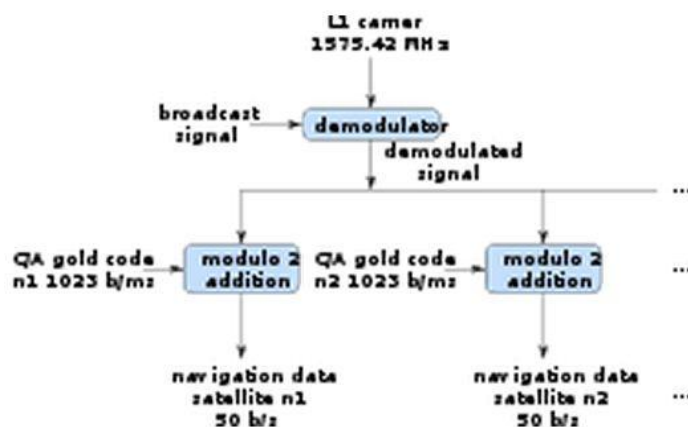
Band	Frequency	Description
L1	1575.42 MHz	Coarse-acquisition (C/A) and encrypted precision P(Y) codes, plus the L1 civilian (L1C) and military (M) codes on future Block III satellites.
L2	1227.60 MHz	P(Y) code, plus the L2C and military codes on the Block IIR-M and newer satellites.
L3	1381.05 MHz	Used for nuclear detonation (NUDET) detection.
L4	1379.913 MHz	Being studied for additional ionospheric correction. [citation needed]
L5	1176.45 MHz	Proposed for use as a civilian safety-of-life (SoL) signal.

The L5 frequency band at 1.17645 GHz was added in the process of GPS modernization. This frequency falls into an internationally protected range for aeronautical navigation, promising little or no interference under all circumstances. The first Block IIF satellite that would provide this signal is set to be launched in 2009. The L5 consists of two carrier components that are in phase quadrature with each other. Each carrier component is bi-phase shift key (BPSK) modulated by a separate bit train. "L5, the third civil GPS signal, will eventually support safety-of-life applications for aviation and provide improved availability and accuracy."

A conditional waiver has recently been granted to LightSquared to operate a terrestrial broadband service near the L1 band. Although LightSquared had applied for a license to operate in the 1525 to 1559 band as early as

2003 and it was put out for public comment, the FCC asked LightSquared to form a study group with the GPS community to test GPS receivers and identify issue that might arise due to the larger signal power from the LightSquared terrestrial network. The GPS community had not objected to the LightSquared (formerly MSV and SkyTerra) applications until November 2010, when LightSquared applied for a modification to its Ancillary Terrestrial Component (ATC) authorization. This filing (SAT-MOD-20101118-00239) amounted to a request to run several orders of magnitude more power in the same frequency band for terrestrial base stations, essentially repurposing what was supposed to be a "quiet neighborhood" for signals from space as the equivalent of a cellular network. Testing in the first half of 2011 has demonstrated that the impact of the lower 10 MHz of spectrum is minimal to GPS devices (less than 1% of the total GPS devices are affected). The upper 10 MHz intended for use by LightSquared may have some impact on GPS devices. There is some concern that this will seriously degrade the GPS signal for many consumer uses. Aviation Week magazine reports that the latest testing (June 2011) confirms "significant jamming" of GPS by LightSquared's system.

Demodulation And Decoding



Demodulating and Decoding GPS Satellite Signals using the Coarse/Acquisition Gold code.

Because all of the satellite signals are modulated onto the same L1 carrier frequency, the signals must be separated after demodulation. This is done by assigning each satellite a unique binary sequence known as a Gold code.

The signals are decoded after demodulation using addition of the Gold codes corresponding to the satellites monitored by the receiver.

If the almanac information has previously been acquired, the receiver picks the satellites to listen for by their PRNs, unique numbers in the range 1 through 32. If the almanac information is not in memory, the receiver enters a search mode until a lock is obtained on one of the satellites. To obtain a lock, it is necessary that there be an unobstructed line of sight from the receiver to the satellite. The receiver can then acquire the almanac and determine the satellites it should listen for. As it detects each satellite's signal, it identifies it by its distinct C/A code pattern. There can be a delay of up to 30 seconds before the first estimate of position because of the need to read the ephemeris data.

Processing of the navigation message enables the determination of the time of transmission and the satellite position at this time. For more information see Demodulation and Decoding, Advanced.

Accuracy

GPS time is theoretically accurate to about 14 nanoseconds. However, most receivers lose accuracy in the interpretation of the signals and are only accurate to 100 nanoseconds.

GPS receiver manufacturers design GPS receivers to use spectrum beyond the GPS-allocated band. In some cases, GPS receivers are designed to use up to 400 MHz of spectrum in either direction of the L1 frequency of 1575.42 MHz. However, as regulated under the FCC's Part 15 rules, GPS receivers are not warranted protection from signals outside GPS-allocated spectrum. The FCC and LightSquared have each made public commitments to solve the GPS interference issue before the network is allowed to operate. However, according to Chris Dancy of the Aircraft Owners and Pilots Association, airline pilots with the type of systems that would be affected "may go off course and not even realize it." The problems could also affect the Federal Aviation Administration upgrade to the air traffic control system, United States Defense Department guidance, and local emergency services including 911.

Military And Communication

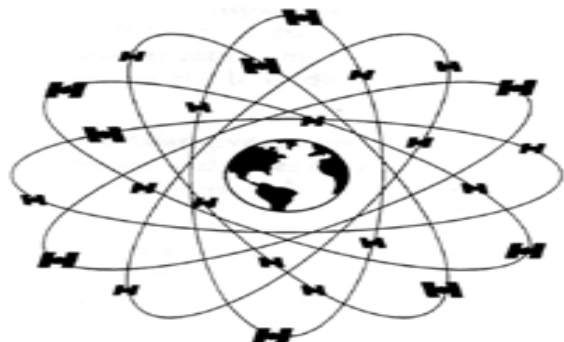
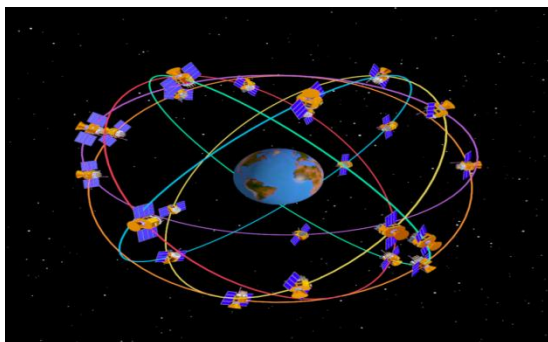


Attaching a GPS guidance kit to a 'dumb' bomb, March 2003.



GPS receivers are now integrated in many mobile phones.

The navigational signals transmitted by GPS satellites encode a variety of information including satellite positions, the state of the internal clocks, and the health of the network. These signals are transmitted on two separate carrier frequencies that are common to all satellites in the network. Two different encodings are used: a public encoding that enables lower resolution navigation, and an encrypted encoding used by the U.S. military.



**THANK
YOU !**

• • •

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