

## **GSP330: Mobile Mapping & GIS Terminology**

GNSS = A satellite navigation or sat nav system is a system of satellites that provide autonomous geo-spatial positioning with global coverage. It allows small electronic receivers to determine their location (longitude, latitude, and altitude) to high precision (within a few metres) using time signals transmitted along a line of sight by radio from satellites. The signals also allow the electronic receivers to calculate the current local time to high precision, which allows time synchronisation. A satellite navigation system with global coverage may be termed a global navigation satellite system or GNSS

GPS = The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.[1] The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver.

CONTROL SEGMENT = The GPS control segment consists of a global network of ground facilities that track the GPS satellites, monitor their transmissions, perform analyses, and send commands and data to the constellation.

The current operational control segment includes a master control station, an alternate master control station, 12 command and control antennas, and 16 monitoring sites. The locations of these facilities are shown in the map above.

SPACE SEGMENT = The main functions of the Space Segment are to transmit radio-navigation signals, and to store and retransmit the navigation message sent by the Control Segment. These transmissions are controlled by highly stable atomic clocks on board the satellites.

The GPS Space Segment is formed by a satellite constellation with enough satellites to ensure that the users will have, at least, 4 simultaneous satellites in view from any point at the Earth surface at any time.

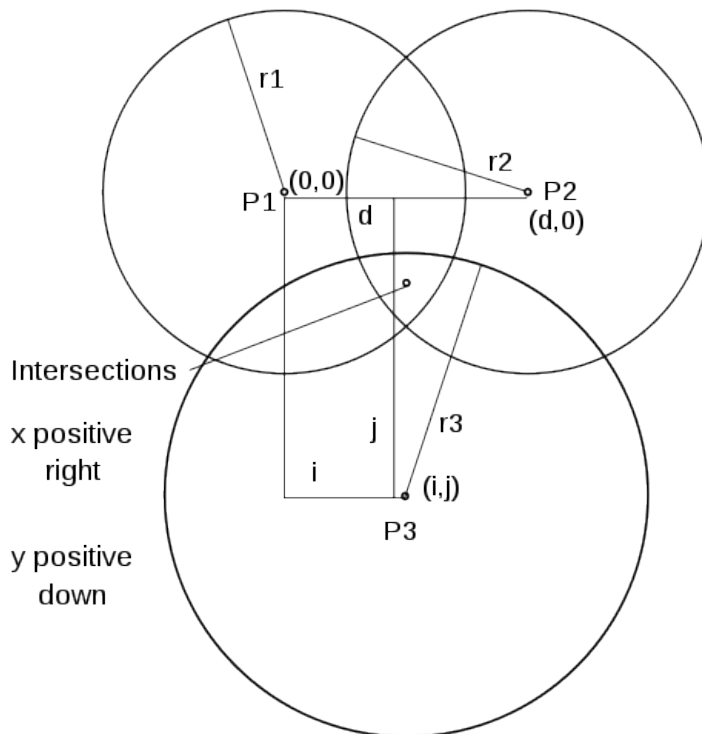
The space segment of an artificial satellite system is one of its three operational components (the others being the user and control segments). It is comprised by the satellite or satellite constellation and the uplink and downlink satellite links.

USER SEGMENT = The GPS User Segment consists on L-band radio receiver/processors and antennas which receive GPS signals, determine pseudoranges (and other observables), and solve the navigation equations in order to obtain their coordinates and provide a very accurate time.

This component consists of the GPS receivers and the user community. GPS receivers convert SV signal into position, velocity and time estimates. This process

requires four satellites to compute the four dimension of X, Y, Z (position) and time. With this ability, GPS has three main functions; navigation (for aircraft, ships, etc), precise positioning (for surveying, plate tectonics, etc,) and time and frequency dissemination (for astronomical observatories, telecommunications facilities, etc.)

TRILATERATION = In geometry, trilateration is the process of determining absolute or relative locations of points by measurement of distances, using the geometry of circles, spheres or triangles.[1][2][3][4] In addition to its interest as a geometric problem, trilateration does have practical applications in surveying and navigation, including global positioning systems (GPS). In contrast to triangulation, it does not involve the measurement of angles.



ATMOSPHERIC ERROR = A major error component is the atmospheric impact on the propagated GPS signal. Atmospheric errors are separated in two categories: the ionospheric effect and the tropospheric delay. The ionospheric effect is frequency dependent and it is caused by the region of the atmosphere between 50 and 1000 km above the surface of the Earth. The tropospheric delay is frequency independent, and it is caused by the lower part of the atmosphere, between the surface and 50 km.

EPHEMERIS ERROR = An "ephemeris error" is a difference between the expected and actual orbital position of a GPS satellite.

**CLOCK DRIFT** = Before looking at the effect of the receiver clock offset on performance, it helps to remind ourselves what the clock offset actually is. In brief, the offset represents the difference between what time the receiver thinks it is, and the true time, with the latter determined by the underlying GNSS atomic time scale.

As is well known, this difference is estimated as a nuisance parameter along with the receiver position. By analogy, the receiver clock drift (time derivative of the clock offset) is often also estimated as a nuisance parameter along with the receiver velocity.

**MEASUREMENT ERROR (NOISE)** = distortion of the signal caused by electrical interference or errors inherent in the GPS receiver itself.

**MULTIPATH** = the radio signals reflect off surrounding terrain; buildings, canyon walls, hard ground, etc.

**SELECTIVE AVAILABILITY** = Selective Availability (SA) was an intentional degradation of public GPS signals implemented for national security reasons.

In May 2000, at the direction of President Bill Clinton, the U.S government discontinued its use of Selective Availability in order to make GPS more responsive to civil and commercial users worldwide.

**GLONASS** = GLONASS (acronym for Globalnaya navigatsionnaya sputnikovaya sistema or Global Navigation Satellite System) is a space-based satellite navigation system operated by the Russian Aerospace Defence Forces. It provides an alternative to Global Positioning System (GPS) and is the only alternative navigational system in operation with global coverage and of comparable precision.

**GALILEO** = Galileo is a global navigation satellite system (GNSS) currently being built by the European Union (EU) and European Space Agency (ESA). The € 5 billion project[1] is named after the Italian astronomer Galileo Galilei. One of the aims of Galileo is to provide a high-precision positioning system upon which European nations can rely, independently from the Russian GLONASS, US GPS, and Chinese Compass systems, which can be disabled in times of war or conflict.[2] Tests in February 2014 found that for Galileo's search and rescue function, operating as part of the existing International Cospas-Sarsat Programme, 77% of simulated distress locations can be pinpointed within 2 km, and 95% within 5 km.

**BEIDOW/COMPASS** = The BeiDou Navigation Satellite System is a Chinese satellite navigation system. It consists of two separate satellite constellations – a limited test system that has been operating since 2000, and a full-scale global navigation system that is currently under construction.

**SBAS** = A satellite-based augmentation system (SBAS) is a system that supports wide-area or regional augmentation through the use of additional satellite-

broadcast messages. Such systems are commonly composed of multiple ground stations, located at accurately-surveyed points. The ground stations take measurements of one or more of the GNSS satellites, the satellite signals, or other environmental factors which may impact the signal received by the users. Using these measurements, information messages are created and sent to one or more satellites for broadcast to the end users. SBAS is sometimes synonymous with WADGPS, wide-area DGPS.

Satellite-based augmentation systems (SBAS), such as EGNOS, complement existing global navigation satellite systems (GNSS). SBAS compensate for certain disadvantages of GNSS in terms of accuracy, integrity, continuity and availability. For example, neither the USA's GPS nor Russia's GLONASS meet the operational requirements set by the International Civil Aviation Organisation (ICAO) for use during the most critical phases of aircraft flight, in particular landing. To solve it, ICAO decided to standardise several GNSS augmentation systems including SBAS. The SBAS concept is based on the transmission of differential corrections and integrity messages for navigation satellites that are within sight of a network of reference stations deployed across an entire continent. SBAS messages are broadcast via geostationary satellites able to cover vast areas.

### How it Works

A SBAS incorporates a modular architecture, similar to GPS, comprised of a Ground Segment, Space Segment, and User Segment:

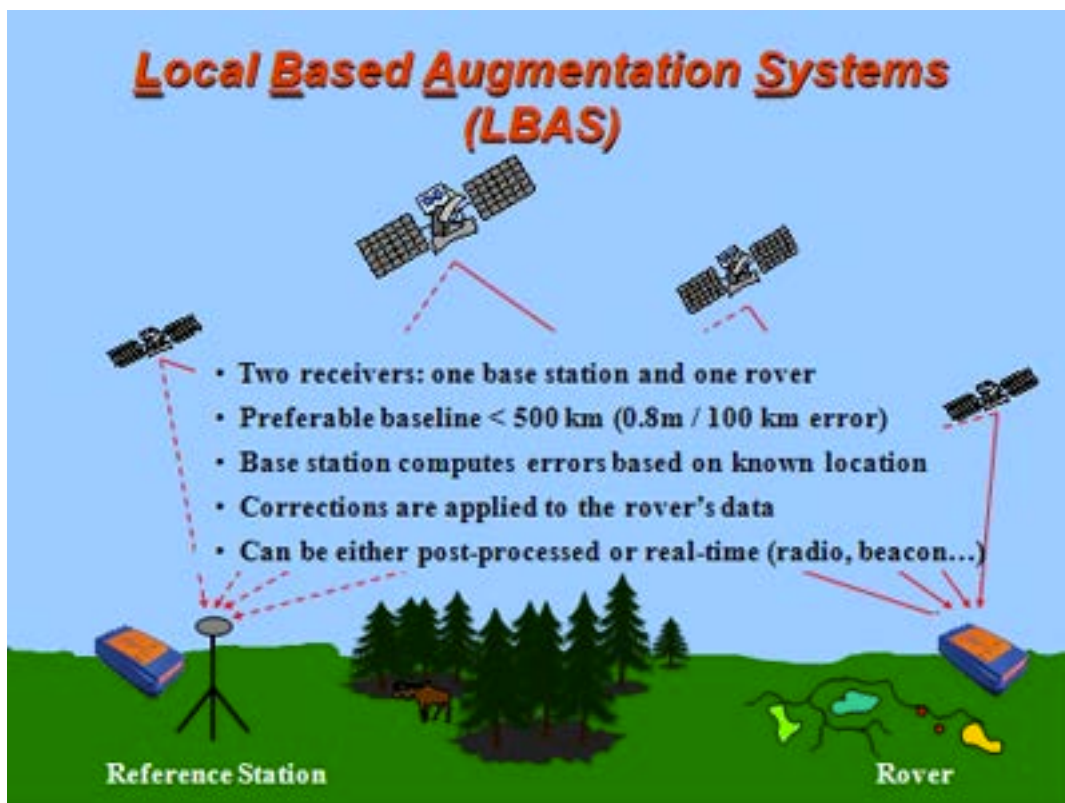
- The Ground Segment includes reference stations, processing centers, a communication network, and Navigation Land Earth Stations (NELS)
- The Space Segment includes geostationary satellites (For example, EGNOS uses Inmarsat transponders)
- The user segment consists of the user equipment, such as a SXBlue II GPS receiver and antenna

A SBAS uses a state-based approach in their software architecture. This means that a separate correction is made available for each error source rather than the sum effect of errors on the user equipment's range measurements. This more effectively manages the issue of spatial decorrelation than some other techniques, resulting in a more consistent system performance regardless of geographic location with respect to reference stations. Specifically, SBAS calculates separate errors for the following:

- The ionospheric error
- GPS satellite timing errors
- GPS satellite orbit errors

LBAS = Conventional DGPS involves setting up a reference GPS receiver with the antenna set at a point of known coordinates. This receiver makes distance measurements, in realtime, to each of the GPS satellites. The measured ranges include the errors present in the system. The base station receiver calculates what the true range is, without errors, knowing its coordinates and those of each satellite. The difference between the known and measured range for each satellite is the range error. This error is the amount that needs to be removed from each satellite distance measurement in order to correct for errors present in the system.

The base station transmits the range error corrections to remote receivers in real-time. The remote receiver corrects its satellite range measurements using these differential corrections, yielding a much more accurate position. This is the predominant DGPS strategy used for a majority of real-time applications. Positioning using corrections generated by DGPS radiobeacons for example, will provide a horizontal accuracy of less than 1m to 5 meters with a 95% confidence depending on the quality of the GPS receiver used. Under the same principle, more sophisticated, short-range DGPS systems (10 to 15 km) can achieve centimetre-level accuracy using carrier phase. In this case, we commonly refer to such a system as RTK instead of DGPS.



WAAS = The Wide Area Augmentation System (WAAS) is an air navigation aid developed by the Federal Aviation Administration (prime contractor Raytheon Company) to augment the Global Positioning System (GPS), with the goal of

improving its accuracy, integrity, and availability. Essentially, WAAS is intended to enable aircraft to rely on GPS for all phases of flight, including precision approaches to any airport within its coverage area.

WAAS uses a network of ground-based reference stations, in North America and Hawaii, to measure small variations in the GPS satellites' signals in the western hemisphere. Measurements from the reference stations are routed to master stations, which queue the received Deviation Correction (DC) and send the correction messages to geostationary WAAS satellites in a timely manner (every 5 seconds or better). Those satellites broadcast the correction messages back to Earth, where WAAS-enabled GPS receivers use the corrections while computing their positions to improve accuracy.

EGNOS = The European Geostationary Navigation Overlay Service (EGNOS) is a satellite based augmentation system (SBAS) developed by the European Space Agency, the European Commission and EUROCONTROL. It supplements the GPS, GLONASS and Galileo systems by reporting on the reliability and accuracy of the positioning data. The official start of operations was announced by the European Commission on 1 October 2009.

According to specifications, horizontal position accuracy should be better than seven metres. In practice, the horizontal position accuracy is at the metre level. The EGNOS system consists of four geostationary satellites and a network of ground stations.

MSAS = Multi-functional Satellite Augmentation System (MSAS) is a Japanese SBAS (Satellite Based Augmentation System), i.e. a satellite navigation system which supports differential GPS (DGPS) designed to supplement the GPS system by reporting (then improving) on the reliability and accuracy of those signals. Tests had been accomplished successfully, MSAS for aviation use was commissioned on September 27, 2007.

A similar service is provided in North America by Wide Area Augmentation System (WAAS), and in Europe by European Geostationary Navigation Overlay Service (EGNOS).

GAGAN = The GPS aided geo augmented navigation or GPS and geo-augmented navigation system (GAGAN) is an implementation of a regional satellite-based augmentation system (SBAS) by the Indian government. It is a system to improve the accuracy of a GNSS receiver by providing reference signals. The AAI's efforts towards implementation of operational SBAS can be viewed as the first step towards introduction of modern communication, navigation, surveillance/Air Traffic Management system over Indian airspace.

The project has established 15 Indian Reference Stations, 3 Indian Navigation Land Uplink Stations, 3 Indian Mission Control Centers, and installation of all associated

software and communication links. It will be able to help pilots to navigate in the Indian airspace by an accuracy of 3 m. This will be helpful for landing aircraft in tough weather and terrain like Mangalore and Leh airports.

RTK = Real Time Kinematic (RTK) satellite navigation is a technique used to enhance the precision of position data derived from satellite-based positioning systems, being usable in conjunction with GPS, GLONASS and/or Galileo. It uses measurements of the phase of the signal's carrier wave, rather than the information content of the signal, and relies on a single reference station to provide real-time corrections, providing up to centimetre-level accuracy. With reference to GPS in particular, the system is commonly referred to as Carrier-Phase Enhancement, or CPGPS.[citation needed] It has application in land survey and in hydrographic survey.

DGPS = Differential Global Positioning System (DGPS) is an enhancement to Global Positioning System that provides improved location accuracy, from the 15-meter nominal GPS accuracy to about 10 cm in case of the best implementations.

DGPS uses a network of fixed, ground-based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions. These stations broadcast the difference between the measured satellite pseudoranges and actual (internally computed) pseudoranges, and receiver stations may correct their pseudoranges by the same amount. The digital correction signal is typically broadcast locally over ground-based transmitters of shorter range.

L1, L2, L5:

- L1C = Civilian use signal, broadcast on the L1 frequency (1575.42 MHz), which contains the C/A signal used by all current GPS users. The L1C will be available with the first Block III launch, scheduled for 2015
- L2C = One of the first announcements was the addition of a new civilian-use signal, to be transmitted on a frequency other than the L1 frequency used for the coarse/acquisition (C/A) signal. Ultimately, this became the L2C signal, so called because it is broadcast on the L2 frequency. Because it requires new hardware on board the satellite, it is only transmitted by the so-called Block IIR-M and later design satellites. The L2C signal is tasked with improving accuracy of navigation, providing an easy to track signal, and acting as a redundant signal in case of localized interference.
- A civilian safety of life signal (broadcast in a frequency band protected by the ITU for aeronautical radionavigation service), first broadcast for demonstration purposes on satellite USA-203 (a Block IIR-M series satellite), and available on all GPS IIF satellites (and beyond).

Two PRN ranging codes are transmitted on L5: the in-phase code (denoted as the I5-code); and the quadrature-phase code (denoted as the Q5-code). Both

codes are 10,230 bits long and transmitted at 10.23 MHz (1 ms repetition). In addition, the I5 stream is modulated with a 10-bit Neuman-Hoffman code that is clocked at 1 kHz and the Q5-code is modulated with a 20-bit Neuman-Hoffman code that is also clocked at 1 kHz.

CARRIER PHASE = Utilizing the navigation message to measure pseudorange has been discussed. Another method that is used in GPS surveying applications is carrier phase tracking. The period of the carrier frequency times the speed of light gives the wavelength, which is about 0.19 meters for the L1 carrier. With a 1% of wavelength accuracy in detecting the leading edge, this component of pseudorange error might be as low as 2 millimeters. This compares to 3 meters for the C/A code and 0.3 meters for the P code.

C/A:

Legacy GPS signals

The original GPS design contains two ranging codes: the Coarse/Acquisition (C/A) code, which is freely available to the public, and the restricted Precision (P) code, usually reserved for military applications.

Coarse/Acquisition code

The C/A code is a 1,023 bit deterministic sequence called pseudorandom noise (also pseudorandom binary sequence) (PN or PRN code) which, when transmitted at 1.023 megabits per second (Mbit/s), repeats every millisecond. These sequences only match up, or strongly correlate, when they are exactly aligned. Each satellite transmits a unique PRN code, which does not correlate well with any other satellite's PRN code. In other words, the PRN codes are highly orthogonal to one another. This is a form of code division multiple access (CDMA), which allows the receiver to recognize multiple satellites on the same frequency.

POST-PROCESS = Real-time differential correction for GPS (real-time DGPS) has had a very positive effect on navigation and the verification of spatial data. But there are places in the world that don't have reliable real-time DGPS services, and many applications need better accuracy than is achievable from current real-time correction methods.

Depending on the technique used, postprocessed differential correction (postprocessing) can deliver GPS data accurate to a few meters in moving applications and to a few centimeters in stationary situations, and these levels of accuracy are now easier than ever to achieve.

CHANNELS = A receiver is often described by its number of channels: this signifies how many satellites it can monitor simultaneously. Originally limited to four or five,



this has progressively increased over the years so that, as of 2007, receivers typically have between 12 and 20 channels.

**URBAN CANYON** = An urban canyon is an artefact of an urban environment similar to a natural canyon. It is manifested by streets cutting through dense blocks of structures, especially skyscrapers that form a human-built canyon. Examples of urban canyons include the Magnificent Mile in Chicago, the Canyon of Heroes in Manhattan, and Hong Kong's Kowloon and Central districts. Urban canyons contribute to the urban heat island effect.

**BASE STATION/ROVER** = A commonly used technique for improving GNSS performance is differential GNSS, which is illustrated in Figure 32.

Using differential GNSS, the position of a fixed GNSS receiver, referred to as a “base station,” is determined to a high degree of accuracy using conventional surveying techniques. The base station determines ranges to GNSS satellites in view using two methods:

- Using the code-based positioning technique described in Chapter 2.
- Using the (precisely) known locations of the base station and the satellites, the location of satellites being determined from the precisely known orbit ephemerides and satellite time.

The base station compares the ranges. Differences between the ranges can be attributed to satellite ephemeris and clock errors, but mostly to errors associated with atmospheric delay. Base stations send these errors to other receivers (rovers), which incorporate the corrections into their position calculations.

Differential positioning requires a data link between base stations and rovers if corrections need to be applied in real-time, and at least four GNSS satellites in view at both the base station and the rovers. The absolute accuracy of the rover's computed position will depend on the absolute accuracy of the base station's position.

Since GNSS satellites orbit high above the earth, the propagation paths from the satellites to the base stations and rovers pass through similar atmospheric conditions, as long as the base station and rovers are not too far apart. Differential GNSS works very well with base-station-to-rover separations of up to tens of kilometres.

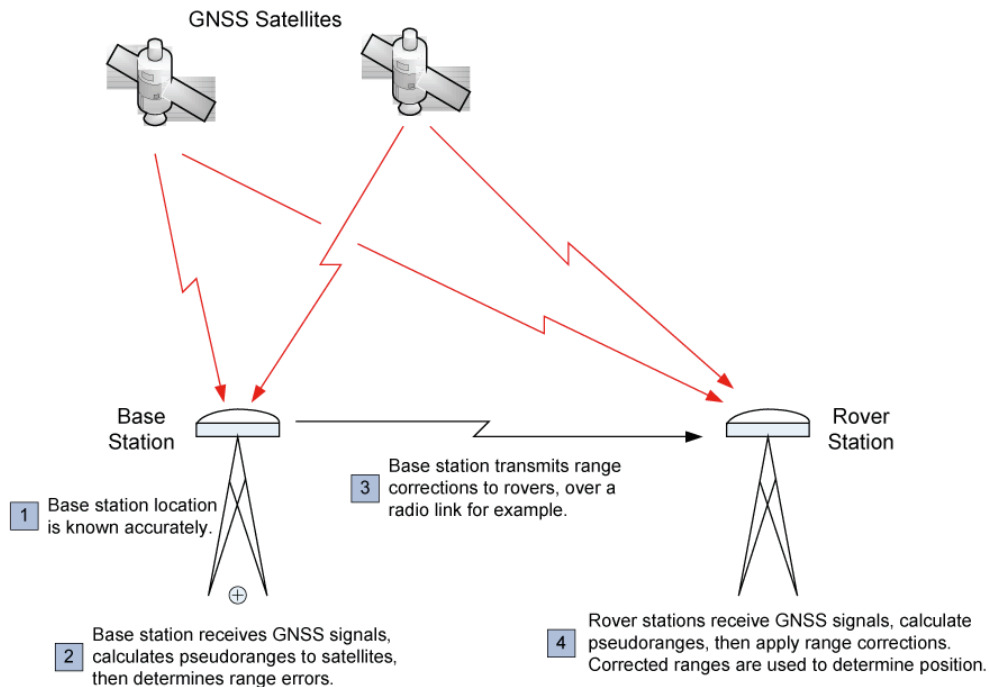
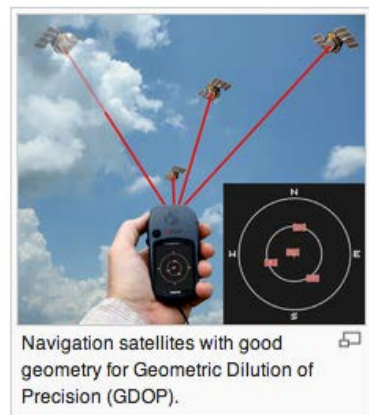
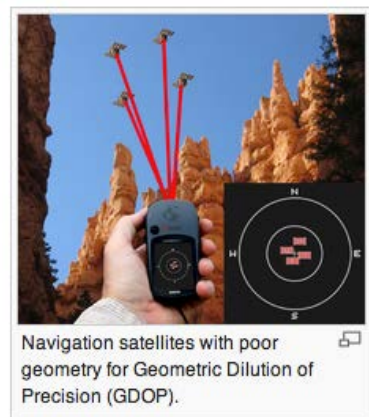


Figure 32 Differential GNSS

DOP = Dilution of precision (DOP), or geometric dilution of precision (GDOP), is a term used in satellite navigation and geomatics engineering to specify the additional multiplicative effect of navigation satellite geometry on positional measurement precision.

PDOP = PDOP stands for Positional Dilution of Precision. It indicates the accuracy of a 3D GPS position based on the number of satellites and the geometry of satellite positions. PDOP ranges from 0-99. The lower the number, the more accurate the data. Any position with a PDOP over 7 or 8 is probably not worth collecting.

Different GPS units require different PDOP limits. Recreational grade units (such as the Garmin or Magellans) do not have any limit, although a PDOP over 7 or 8 is not likely to produce results worth using. Mapping grade units (like our GeoXT) require a PDOP of 6.0 or less. Survey grade units (like our Hiper Pro) require a PDOP of 4.0 or less.



PDOP is typically shown on the GPS unit on the satellite page.

HDOP = Acronym for horizontal dilution of precision. A measure of the geometric quality of a GPS satellite configuration in the sky. HDOP is a factor in determining the relative accuracy of a horizontal position. The smaller the DOP number, the better the geometry.

VDOP = Vertical dilution of precision.

GDOP = geometric dilution of precision

$$GDOP = \frac{\Delta(\text{Output Location})}{\Delta(\text{Measured Data})}$$

CONSTELLATION = A satellite constellation is a group of artificial satellites working in concert. Such a constellation can be considered to be a number of satellites with coordinated ground coverage, operating together under shared control, synchronised so that they overlap well in coverage and complement rather than interfere with other satellites' important coverage.

ALMANAC = The almanac, provided in subframes 4 and 5 of the frames, consists of coarse orbit and status information for each satellite in the constellation, an ionospheric model, and information to relate GPS derived time to Coordinated Universal Time (UTC). Each frame contains a part of the almanac (in subframes 4 and 5) and the complete almanac is transmitted by each satellite in 25 frames total (requiring 12.5 minutes).[5] The almanac serves several purposes. The first is to assist in the acquisition of satellites at power-up by allowing the receiver to generate a list of visible satellites based on stored position and time, while an ephemeris from each satellite is needed to compute position fixes using that satellite. In older hardware, lack of an almanac in a new receiver would cause long delays before providing a valid position, because the search for each satellite was a slow process. Advances in hardware have made the acquisition process much faster, so not having an almanac is no longer an issue. The second purpose is for relating time derived from the GPS (called GPS time) to the international time standard of UTC. Finally, the almanac allows a single-frequency receiver to correct for ionospheric error by using a global ionospheric model. The corrections are not as accurate as augmentation systems like WAAS or dual-frequency receivers. However, it is often better than no correction, since ionospheric error is the largest error source for a single-frequency GPS receiver.

MULTIPATH = 1) Multipath results when the direct path to your receiver is blocked (by your body, your house, roof, trees, mountains, buildings, etc) and the signal from the satellite is REFLECTED by some object. The reflecting surface may be:

buildings, mountains, the ground, or any object that happens to be a radio reflector at 1.6Ghz.

2) Multipath are radio signals which have traveled FURTHER to get to your receiver than they should have. This can result in your GPS miscalculating its position because the signals may have traveled from feet to miles further to get to you than a direct line of sight signal path would have been.

3) Multipath can cause longer term "stable" errors or it can cause your position to wander at varying rates (even thousands of miles per hour if your GPS could follow such speeds). Sometimes GPS wanderings caused by multipath can cause your GPS to "jump" from one position to another as the multipath signal "comes and goes" and causes your GPS to jump from using one group of erroneous signals to another. These "jumps" can add substantial distances to the tracklog measurements in some GPS receivers.

CORS = A Continuously Operating Reference Station (CORS) network is a network of RTK base stations that broadcast corrections, usually over an Internet connection. Accuracy is increased in a CORS network, because more than one station helps ensure correct positioning and guards against a false initialization of a single base station.

RMSE = Root Mean Square Error (RMSE)

The RMSE is used to describe accuracy encompassing both random and systematic errors. RMSE is the square root of the square of the difference between a true test point and an interpolated test point divided by the total number of test points in the arithmetic mean.

CEP = When we quote GPS accuracy for GIS real time measurements, we usually quote CEP (Circular Error Probability). CEP is defined as the radius of a circle centered on the true value that contains 50% of the actual GPS measurements. So a receiver with 1 meter CEP accuracy will be within one meter of the true measurement 50% of the time. The other 50% of the time the measurement will be in error by more than one meter.

Note that it is probable that CEP measurements of the same point on the ground will differ by twice the probability. For example if a receiver has CEP of 1 meter, then it is probable that measurements of the same point will differ by 2 meters.

When you look at the accuracy specifications for a consumer GPS receiver, or the MobileMapper CX in real-time, WAAS corrected mode you will get an accuracy statement like "Real-Time Accuracy <1 Meter CEP".

This means that the MMCX with WAAS corrections, will be within 1 meter of the true ITRF 2000 (reference frame) coordinate, 50% (half) of the time. Assuming (of

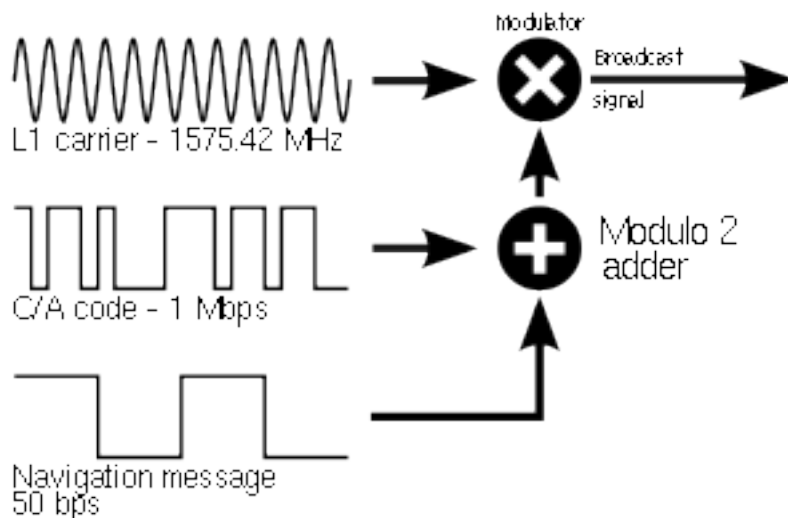
course) that the receiver has a clear view of the sky, there are 5 or more satellites visible and the PDOP is reasonable.

Remember that we are quoting horizontal accuracy; the vertical accuracy will be 2-3 times worse.

**DUAL FREQUENCY RECEIVERS** = For the ranging codes and navigation message to travel from the satellite to the receiver, they must be modulated onto a carrier frequency. In the case of the original GPS design, two frequencies are utilized; one at 1575.42 MHz ( $10.23 \text{ MHz} \times 154$ ) called L1; and a second at 1227.60 MHz ( $10.23 \text{ MHz} \times 120$ ), called L2.

The C/A code is transmitted on the L1 frequency as a 1.023 MHz signal using a bi-phase shift keying (BPSK) modulation technique. The P(Y)-code is transmitted on both the L1 and L2 frequencies as a 10.23 MHz signal using the same BPSK modulation, however the P(Y)-code carrier is in quadrature with the C/A carrier (meaning it is  $90^\circ$  out of phase).

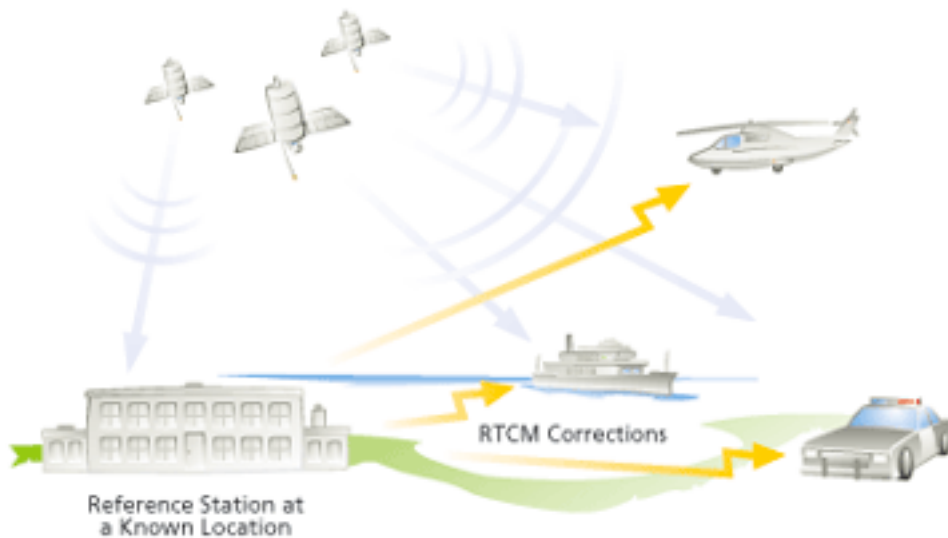
Besides redundancy and increased resistance to jamming, a critical benefit of having two frequencies transmitted from one satellite is the ability to measure directly, and therefore remove, the ionospheric delay error for that satellite. Without such a measurement, a GPS receiver must use a generic model or receive ionospheric corrections from another source (such as the Wide Area Augmentation System or EGNOS). Advances in the technology used on both the GPS satellites and the GPS receivers has made ionospheric delay the largest remaining source of error in the signal. A receiver capable of performing this measurement can be significantly more accurate and is typically referred to as a dual frequency receiver.



**DIFFERENTIAL CORRECTION** = Differential correction techniques are used to enhance the quality of location data gathered using global positioning system (GPS) receivers. Differential correction can be applied in real-time directly in the field or

when postprocessing data in the office. Although both methods are based on the same underlying principles, each accesses different data sources and achieves different levels of accuracy. Combining both methods provides flexibility during data collection and improves data integrity.

## Real-Time Differential GPS



The underlying premise of differential GPS (DGPS) requires that a GPS receiver, known as the base station, be set up on a precisely known location. The base station receiver calculates its position based on satellite signals and compares this location to the known location. The difference is applied to the GPS data recorded by the roving GPS receiver.

CODE PHASE = The words "Code-Phase" and "Carrier-Phase" may sound like electronic mumbo-jumbo but, in fact, they just refer to the particular signal that we use for timing measurements. Using the GPS carrier frequency can significantly improve the accuracy of GPS.

The concept is simple but to understand it let's review a few basic principles of GPS. Remember that a GPS receiver determines the travel time of a signal from a satellite by comparing the "pseudo random code" it's generating, with an identical code in the signal from the satellite.

The receiver slides its code later and later in time until it syncs up with the satellite's code. The amount it has to slide the code is equal to the signal's travel time.

The problem is that the bits (or cycles) of the pseudo random code are so wide that even if you do get synced up there's still plenty of slop.

Consider these two signals:

If you compared them logically you'd say they matched. When signal A is a one, signal B is a one. When signal A is a zero, signal B is a zero.

But you can see that while they match they're a little out of phase. Notice that signal A is a little ahead of signal B. In fact you could slide signal A almost a half a cycle ahead and the signals would still match logically.

That's the problem with code-phase GPS. It's comparing pseudo random codes that have a cycle width of almost a microsecond. And at the speed of light a microsecond is almost 300 meters of error!

Code-phase GPS isn't really that bad because receiver designers have come up with ways to make sure that the signals are almost perfectly in phase. Good machines get within a percent or two. But that's still at least 3-6 meters of error.

Take it to a higher (frequency) authority

Survey receivers beat the system by starting with the pseudo random code and then move on to measurements based on the carrier frequency for that code. This carrier frequency is much higher so its pulses are much closer together and therefore more accurate.

If you're rusty on the subject of carrier frequencies consider your car radio. When you tune to 94.7 on the dial you're locking on to a carrier frequency that's 94.7 MHz. Obviously we can't hear sounds at 94 million cycles a second. The music we hear is a modulation (or change) in this carrier frequency. So when you hear someone sing an "A" note on the radio you're actually hearing the 94.7 MHz carrier frequency being varied at a 440 cycle rate.

GPS works in the same way. The pseudo random code has a bit rate of about 1 MHz but its carrier frequency has a cycle rate of over a GHz (which is 1000 times faster!) At the speed of light the 1.57 GHz GPS signal has a wavelength of roughly twenty centimeters, so the carrier signal can act as a much more accurate reference than the pseudo random code by itself. And if we can get to within one percent of perfect phase like we do with code-phase receivers we'd have 3 or 4 millimeter accuracy! Yeeow!

Catching the Right Wave

In essence this method is counting the exact number of carrier cycles between the satellite and the receiver.

The problem is that the carrier frequency is hard to count because it's so uniform. Every cycle looks like every other. The pseudo random code on the other hand is intentionally complex to make it easier to know which cycle you're looking at.

So the trick with "carrier-phase GPS" is to use code-phase techniques to get close. If the code measurement can be made accurate to say, a meter, then we only have a few wavelengths of carrier to consider as we try to determine which cycle really marks the edge of our timing pulse.

Resolving this "carrier phase ambiguity" for just a few cycles is a much more tractable problem and as the computers inside the receivers get smarter and smarter it's becoming possible to make this kind of measurement without all the ritual that surveyors go through.

RTCM = The Radio Technical Commission for Maritime Services (RTCM) is an international standards organization.

The Radio Technical Commission for Maritime Services (RTCM) is an international non-profit scientific, professional and educational organization. RTCM members are organizations (not individuals) that are both non-government and government. Although started in 1947 as a U.S. government advisory committee, RTCM is now an independent organization supported by its members from all over the world.

In the United States, the Federal Communications Commission and U.S. Coast Guard use RTCM standards to specify radar systems, Emergency Position Indicating Radio Beacons, Differential GPS systems and the basic version of Digital Selective Calling radios.

nRTCM = ???

L-BAND = L band refers to four long different bands of the electromagnetic spectrum: 40 to 60 GHz (NATO), 1 to 2 GHz (IEEE), 1565 nm to 1625 nm (optical), and around 3.5 micrometres (infrared astronomy).

GIS DEFINITION = A geographic information system (GIS) is a computer system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. The acronym GIS is sometimes used for geographical information science or geospatial information studies to refer to the academic discipline or career of working with geographic information systems and is a large domain within the broader academic discipline of Geoinformatics.

SPATIAL DATA (ENTITIES) = Also known as geospatial data or geographic information it is the data or information that identifies the geographic location of features and boundaries on Earth, such as natural or constructed features, oceans, and more. Spatial data is usually stored as coordinates and topology, and is data that



can be mapped. Spatial data is often accessed, manipulated or analyzed through Geographic Information Systems (GIS).

**SPATIAL ANALYSIS** = Spatial analysis or spatial statistics includes any of the formal techniques which study entities using their topological, geometric, or geographic properties. Spatial analysis includes a variety of techniques, many still in their early development, using different analytic approaches and applied in fields as diverse as astronomy, with its studies of the placement of galaxies in the cosmos, to chip fabrication engineering, with its use of 'place and route' algorithms to build complex wiring structures. In a more restricted sense, spatial analysis is the techniques applied to structures at the human scale, most notably in the analysis of geographic data.

**TOPOLOGY** = In geodatabases, the arrangement that constrains how point, line, and polygon features share geometry. For example, street centerlines and census blocks share geometry, and adjacent soil polygons share geometry. Topology defines and enforces data integrity rules (for example, there should be no gaps between polygons). It supports topological relationship queries and navigation (for example, navigating feature adjacency or connectivity), supports sophisticated editing tools, and allows feature construction from unstructured geometry (for example, constructing polygons from lines).

## DATA ENTRY

- GIS Data Entry
  - Data entry can be very time consuming, but it is the most important task for the GIS process. This section discusses the basic organization of entering data, manual digitizing, georeferencing data, projections, and other important aspects.
- Data Entry Process
  - Data entry is a simple process that can take a great deal of time and effort, sometimes involving 75 percent of a project's lifespan. Because data entry is perhaps the most critical stage, patience and care are needed. The following points, depicted in figure 5-9, describe the basic data entry process.
    - Planning and organization: This is the most important part of the process, because without proper planning, subsequent steps will be inefficient or incorrect. The end product should be known and all steps in the procedure must lead to it effectively. Planning and organization must be given patience and focus, yet too often it is hurried and ignored.
    - Entering spatial data (digitizing): Entering spatial data can be time consuming. Manual digitizing is the most common process, and it can be tedious, although semiautomatic scanning is rapidly advancing. Other techniques are used, such as typing,

reading tape or CD-ROM data, downloading from the Internet, and using remote sensing imagery.

- Edit and correct: regardless of entry procedures, the data must be checked for accuracy. Mistakes are normal, and must be corrected. This process can require much work, but it is necessary.
- Georeference and projection: The digitized data usually need to be referenced to the real world, typically using some established coordinate system, such as Latitude-Longitude. This step can occur before or after digitizing (depending on the GIS). In addition, a projection must be specified for translating world sphere data to a flat, 2D view.
- Convert: Digitized data must be given a specific data structure – either vector or raster. If vector is selected, topology may be assigned for those GIS programs that use it. These steps are fairly simple, often automatic, typically involving a few commands to select the desired operation. Some GIS work only with one data format type, but many are now able to accept either vector or raster, and selection may not be necessary. For example, many vector systems save in vector format automatically, but raster gridding option is available. Perhaps this step may soon disappear from most GISs.
- Database construction and entering attributes: Once the geographic data set has been secured, the database must be developed. The first step is to create the database; that is, to construct fields (columns). Some databases require considerable work to develop, whereas others are very easy and flexible to produce. Many GIS establish initial databases at the digitizing stage, and records are entered as they are digitized, often along with some automatic data, such as item number, area, and perimeter where appropriate. There are various ways of entering attributes, from typing to loading tables. Data derived from outside sources usually have attached databases, although they can be modified or expanded as needed.

**EDITING =**

**RECORD =**

**FIELD = Information about a feature should be documented in the feature class' attribute table. Information about an attribute can be documented in the Fields section in the feature class' metadata.**

**DATA TYPES:**

- **NOMINAL** = Data divided into classes within which all elements are assumed to be equal to each other, and in which no class comes before another in sequence or importance; for example, a group of polygons colored to represent different soil types.

A set of data is said to be nominal if the values / observations belonging to it can be assigned a code in the form of a number where the numbers are simply labels. You can count but not order or measure nominal data. For example, in a data set males could be coded as 0, females as 1; marital status of an individual could be coded as Y if married, N if single.

- **ORDINAL** = Data classified by comparative value; for example, a group of polygons colored lighter to darker to represent less to more densely populated areas.

A set of data is said to be ordinal if the values / observations belonging to it can be ranked (put in order) or have a rating scale attached. You can count and order, but not measure, ordinal data.

The categories for an ordinal set of data have a natural order, for example, suppose a group of people were asked to taste varieties of biscuit and classify each biscuit on a rating scale of 1 to 5, representing strongly dislike, dislike, neutral, like, strongly like. A rating of 5 indicates more enjoyment than a rating of 4, for example, so such data are ordinal.

However, the distinction between neighbouring points on the scale is not necessarily always the same. For instance, the difference in enjoyment expressed by giving a rating of 2 rather than 1 might be much less than the difference in enjoyment expressed by giving a rating of 4 rather than 3.

- **INTERVAL** = Data classified on a linear calibrated scale, but not relative to a true zero point in time or space. Because there is no true zero point, relative comparisons can be made between the measurements, but ratio and proportion determinations are not as useful. Time of day, calendar years, the Fahrenheit temperature scale, and pH values are all examples of interval measurements.

An interval scale is a scale of measurement where the distance between any two adjacent units of measurement (or 'intervals') is the same but the zero point is arbitrary. Scores on an interval scale can be added and subtracted but can not be meaningfully multiplied or divided. For example, the time interval between the starts of years 1981 and 1982 is the same as that between 1983 and 1984, namely 365 days. The zero point, year 1 AD, is arbitrary; time did not begin then. Other examples of interval scales include the heights of tides, and the measurement of longitude.

- **RATIO** = Data classified relative to a fixed zero point on a linear scale. Mathematical operations can be used on these values with predictable and meaningful results. Examples of ratio measurements are age, distance, weight, and volume.
- **CYCLICAL** = Data consisting of directions or times in which the measurement scale is cyclic (after 23.59 comes 00.00, after 359° comes 0°, after 31 December comes 1 January). Special techniques are required for summarizing and modelling all types of cyclic data. For example, the histogram is replaced by the circular histogram or the rose diagram, and the principal distribution used to model the data is not the normal distribution but the von Mises distribution.

## VECTOR DATA MODEL

- **POINT** = A point feature is described by its X, Y and optionally Z coordinate. The point attributes describe the point e.g. if it is a tree or a lamp post.
- **LINE** = A polyline is a sequence of joined vertices. Each vertex has an X, Y (and optionally Z) coordinate. Attributes describe the polyline.
- **POLYGON** = A polygon, like a polyline, is a sequence of vertices. However in a polygon, the first and last vertices are always at the same position.

## NODE

- [ESRI software] In a geodatabase, the point representing the beginning or ending point of an edge, topologically linked to all the edges that meet there.
- [ESRI software] In a coverage, the beginning or ending point of an arc, topologically linked to all the arcs that meet there.
- [data structures] In a TIN, one of the three corner points of a triangle, topologically linked to all triangles that meet there. Each sample point in a TIN becomes a node in the triangulation that may store elevation z-values and tag values.

**VERTEX** = One of a set of ordered x,y coordinate pairs that defines the shape of a line or polygon feature.

**SHAPEFILE** = A vector data storage format for storing the location, shape, and attributes of geographic features. A shapefile is stored in a set of related files and contains one feature class.

**COVERAGE** = A data model for storing geographic features. A coverage stores a set of thematically associated data considered to be a unit. It usually represents a single layer, such as soils, streams, roads, or land use. In a coverage, features are stored as both primary features (points, arcs, polygons) and secondary features (tics, links,

annotation). Feature attributes are described and stored independently in feature attribute tables.

**RASTER DATA MODEL** = A representation of the world as a surface divided into a regular grid of cells. Raster models are useful for storing data that varies continuously, as in an aerial photograph, a satellite image, a surface of chemical concentrations, or an elevation surface.

**.GRID** = An Esri grid is a raster GIS file format developed by Esri, which has two formats:

1. A proprietary binary format, also known as an ARC/INFO GRID, ARC GRID and many other variations
2. A non-proprietary ASCII format, also known as an ARC/INFO ASCII GRID

The formats were introduced for ARC/INFO. The binary format is widely used within Esri programs, such as ArcGIS, while the ASCII format is used as an exchange, or export format, due to the simple and portable ASCII file structure.

The grid defines geographic space as an array of equally sized square grid points arranged in rows and columns. Each grid point stores a numeric value that represents a geographic attribute (such as elevation or surface slope) for that unit of space. Each grid cell is referenced by its x,y coordinate location.

**.TIF** = TIF is lossless (including LZW compression option), which is considered the highest quality format for commercial work. The TIF format is not necessarily any "higher quality" per se (the image pixels are what they are), and most formats other than JPG are lossless too. This simply means there are no additional losses or JPG artifacts to degrade and detract from the original. And TIF is the most versatile, except that web pages don't show TIF files. For other purposes however, TIF does most of anything you might want, from 1-bit to 48-bit color, RGB, CMYK, LAB, or Indexed color. Most any of the "special" file types (for example, camera RAW files, fax files, or multipage documents) are based on TIF format, but with unique proprietary data tags - making these incompatible unless expected by their special software.

**.IMG** = Files with the .img file extension are normally bitmap files that contain image data. The image that is contained in the IMG file can be a graphic bitmap or an image of a disc.

**.JPW (WORLD FILES (XX.XXW))** = A world file is a plain text computer data file used by geographic information systems (GIS) to georeference raster map images. The file specification was introduced by Esri.

Small-scale rectangular raster image maps can have an associated world file for GIS map software which describes the location, scale and rotation of the map. These world files are six-line files with decimal numbers on each line.

World files do not specify a coordinate system; this information is generally stored somewhere else in the raster file itself or in another companion file, e.g. Esri's .prj file. The generic meaning of world file parameters are:

- Line 1: A: pixel size in the x-direction in map units/pixel
- Line 2: D: rotation about y-axis
- Line 3: B: rotation about x-axis
- Line 4: E: pixel size in the y-direction in map units, almost always negative[3]
- Line 5: C: x-coordinate of the center of the upper left pixel
- Line 6: F: y-coordinate of the center of the upper left pixel

CELLS/PIXELS = Pixels are analogous to grid cells. To display gridded data as a picture, define a transformation from grid coordinates to pixel coordinates and then sample the gridded data at the whole integer pixel coordinate points. The most common technique is to map grid cells onto pixels one for one. More sophisticated techniques, often referred to as "resampling", allow for scrolling, zooming, and rotating.

#### CELL

The smallest unit of information in raster data, usually square in shape. In a map or GIS dataset, each cell represents a portion of the earth, such as a square meter or square mile, and usually has an attribute value associated with it, such as soil type or vegetation class.

#### PIXEL

- [data models] The smallest unit of information in an image or raster map, usually square or rectangular. Pixel is often used synonymously with cell.
- [remote sensing] In remote sensing, the fundamental unit of data collection. A pixel is represented in a remotely sensed image as a cell in an array of data values.
- [graphics (computing)] The smallest element of a display device, such as a video monitor, that can be independently assigned attributes, such as color and intensity. Pixel is an abbreviation for picture element.

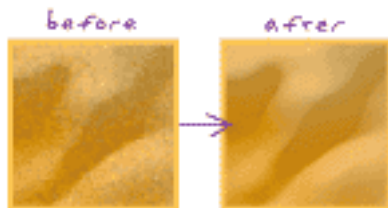
GEODESY = The science of measuring and representing the shape and size of the earth, and the study of its gravitational and magnetic fields.

DATUM = The reference specifications of a measurement system, usually a system of coordinate positions on a surface (a horizontal datum) or heights above or below a surface (a vertical datum).

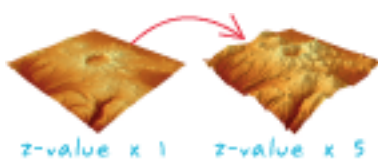
PROJECTIONS = A method by which the curved surface of the earth is portrayed on a flat surface. This generally requires a systematic mathematical transformation of the earth's graticule of lines of longitude and latitude onto a plane. Some projections can be visualized as a transparent globe with a light bulb at its center (though not all projections emanate from the globe's center) casting lines of latitude and longitude onto a sheet of paper. Generally, the paper is either flat and placed tangent to the globe (a planar or azimuthal projection) or formed into a cone or cylinder and placed over the globe (cylindrical and conical projections). Every map projection distorts distance, area, shape, direction, or some combination thereof.

### MAP GENERALIZATIONS

- SIMPLIFICATION = A type of cartographic generalization in which the important characteristics of features are determined and unwanted detail is eliminated to retain clarity on a map whose scale has been reduced.
- SMOOTHING = In image processing, reducing or removing small variations in an image to reveal the global pattern or trend, either through interpolation or by passing a filter over the image.



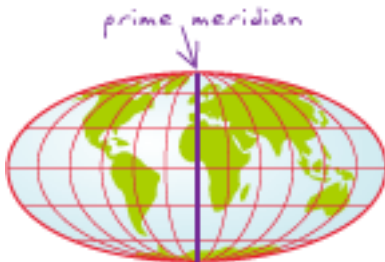
- COLLAPSE =
- AGGREGATION = The process of collecting a set of similar, usually adjacent, polygons (with their associated attributes) to form a single, larger entity.
- AMALGAMATION =
- MERGING = Combining features from multiple data sources of the same data type into a single, new dataset.
- REFINEMENT =
- EXAGGERATION = A multiplier applied uniformly to the z-values of a three-dimensional model to enhance the natural variations of its surface. Scenes may appear too flat when the range of x- and y-values is much larger than the z-values. Setting vertical exaggeration can compensate for this apparent flattening by increasing relief.



- ENHANCEMENT = In remote sensing, applying operations to raster data to improve appearance or usability by making specific features more detectable. Such operations can include contrast stretching, edge enhancement, filtering, smoothing, and sharpening.
- DISPLACEMENT =

## COORDINATE SYSTEMS

- SPHERICAL (GEOGRAPHIC LATITUDE, LONGITUDE) = A reference system using positions of latitude and longitude to define the locations of points on the surface of a sphere or spheroid.



- PROJECTED: CARTESIAN (UTM, STATE PLANE) = A reference system used to locate x, y, and z positions of point, line, and area features in two or three dimensions. A projected coordinate system is defined by a geographic coordinate system, a map projection, any parameters needed by the map projection, and a linear unit of measure.

## DEFINE PROJECTION VS. PROJECT TOOL

- Projection
  - A method by which the curved surface of the earth is portrayed on a flat surface. This generally requires a systematic mathematical transformation of the earth's graticule of lines of longitude and latitude onto a plane. Some projections can be visualized as a transparent globe with a light bulb at its center (though not all projections emanate from the globe's center) casting lines of latitude and longitude onto a sheet of paper. Generally, the paper is either flat and placed tangent to the globe (a planar or azimuthal projection) or formed into a cone or cylinder and placed over the globe (cylindrical and conical projections). Every map projection distorts distance, area, shape, direction, or some combination thereof.





equiarectangular projection

- Other possible matches:
  - azimuthal projection
  - compromise projection
  - conformal projection
  - conic projection
  - cylindrical projection
  - display projection
  - equal-area projection
  - equidistant projection
  - Gauss-Krüger projection
  - gnomonic projection
  - interrupted projection
  - oblique projection
  - orthographic projection
  - planar projection
  - projection transformation
  - secant projection
  - stereographic projection
  - tangent projection
- Projection transformation
  - The mathematical conversion of a map from one projected coordinate system to another, generally used to integrate maps from two or more projected coordinate systems into a GIS.
- Projection Tool
  - The tool used in a gis to perform a projection transformation

## MAP COMPONENTS

1. Title
2. Compass Rose
3. Coordinate system information
4. Scale
5. Legend
6. Author
7. Data Source
8. Figure caption

## MAP SCALES > LARGE VS. SMALL

- Map scale = The ratio or relationship between a distance or area on a map and the corresponding distance or area on the ground, commonly expressed as a fraction or ratio. A map scale of 1/100,000 or 1:100,000 means that one unit of measure on the map equals 100,000 of the same unit on the earth.
- Large scale = Generally, a map scale that shows a small area on the ground at a high level of detail.
- Small scale = Generally, a map scale that shows a relatively large area on the ground with a low level of detail.

DIGITIZING TABLE AND PUCK = A way of using a digitizing tablet in which locations on the tablet are mapped to specific locations on the screen. Moving the digitizer puck on the tablet surface causes the screen pointer to move to precisely the same position on the screen.

- Puck = The handheld device used with a digitizer to record positions from the tablet surface.

SCAN DIGITIZING = The process of converting the geographic features on an analog map into digital format using a digitizing tablet, or digitizer, which is connected to a computer. Features on a paper map are traced with a digitizer puck, a device similar to a mouse, and the x,y coordinates of these features are automatically recorded and stored as spatial data.

ON-SCREEN / HEAD'S-UP DIGITIZING = Manual digitization by tracing a mouse over features displayed on a computer monitor, used as a method of vectorizing raster data.

## COORDINATE GEOMETRY (COGO)

- [coordinate geometry (COGO)] Acronym for coordinate geometry. A method for calculating coordinate points from surveyed bearings, distances, and angles.
- [coordinate geometry (COGO)] Automated mapping software used in land surveying that calculates locations using distances and bearings from known reference points.

GEOREFERENCING = Aligning geographic data to a known coordinate system so it can be viewed, queried, and analyzed with other geographic data. Georeferencing may involve shifting, rotating, scaling, skewing, and in some cases warping, rubber sheeting, or orthorectifying the data.

ORTHORECTIFY = The process of correcting the geometry of an image so that it appears as though each pixel were acquired from directly overhead.

Orthorectification uses elevation data to correct terrain distortion in aerial or satellite imagery.

## CONTROL POINTS

- [surveying] An accurately surveyed coordinate location for a physical feature that can be identified on the ground. Control points are used in least-squares adjustments as the basis for improving the spatial accuracy of all other points to which they are connected.
- [coordinate systems] One of various locations on a paper or digital map that has known coordinates and is used to transform another dataset—spatially coincident but in a different coordinate system—into the coordinate system of the control point. Control points are used in digitizing data from paper maps, in georeferencing both raster and vector data, and in performing spatial adjustment operations such as rubber sheeting.

RMSE / SPATIAL ERROR (IN GENERAL) = Acronym for root mean square error. A measure of the difference between locations that are known and locations that have been interpolated or digitized. RMS error is derived by squaring the differences between known and unknown points, adding those together, dividing that by the number of test points, and then taking the square root of that result.

COORDINATE TRANSFORMATION = The process of converting the coordinates in a map or image from one coordinate system to another, typically through rotation and scaling.

TABULAR DATA (NON-GIS INFO) = Descriptive information, usually alphanumeric, that is stored in rows and columns in a database and can be linked to spatial data.

GEOCODING = A GIS operation for converting street addresses into spatial data that can be displayed as features on a map, usually by referencing address information from a street segment data layer.

## ADDING XYZ DATA =

JOINS AND RELATES TO SPATIAL DATABASES = ArcMap provides two methods to associate data stored in tables with geographic features: joins and relates. When you join two tables, you append the attributes from one onto the other based on a field common to both. Relating tables defines a relationship between two tables—also based on a common field—but doesn't append the attributes of one to the other; instead, you can access the related data when necessary.

- Joining based on attributes from table
  - Typically, you'll join a table of data to a layer based on the value of a field that can be found in both tables. The name of the field does not

have to be the same, but the data type has to be the same; you join numbers to numbers, strings to strings, and so on.

- Suppose you obtain daily weather forecasts by county and generate weather maps based on this information. As long as the weather data is stored in a table in your database and shares a common field with your layer, you can join it to your geographic features and use any of the additional fields to symbolize, label, query, or analyze the layer's features.
- Joining by locations
  - When the layers on your map don't share a common attribute field, you can join them using a spatial join, which joins the attributes of two layers based on the location of the features in the layers. With a spatial join, you can find:
    - The closest feature to another feature.
    - What's inside a feature.
    - What intersects a feature.
    - How many points fall inside each polygon.
- Relates
  - Unlike joining tables, relating tables simply defines a relationship between two tables. The associated data isn't appended to the layer's attribute table like it is with a join. Instead, you can access the related data when you work with the layer's attributes.
  - For example, if you select a building, you can find all the tenants that occupy that building. Similarly, if you select a tenant, you can find what building it resides in (or several buildings, in the case of a chain of stores in multiple shopping centers—a many-to-many relationship). However, if you performed a join on such data, ArcMap will only find the first tenant belonging to each building, ignoring additional tenants.

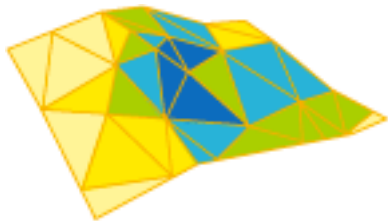
FORMAT REQUIREMENTS (E.G. DELIMITED TEXT) =

#### ATTRIBUTE DATA AND TABLES

- [data models] Nonspatial information about a geographic feature in a GIS, usually stored in a table and linked to the feature by a unique identifier. For example, attributes of a river might include its name, length, and sediment load at a gauging station.
- [data models] In raster datasets, information associated with each unique value of a raster cell.
- [graphics (map display)] Information that specifies how features are displayed and labeled on a map; for example, the graphic attributes of a river might include line thickness, line length, color, and font for labeling.

## TINS, TERRAINS, AND DEMS =

- Tins = Acronym for triangulated irregular network. A vector data structure that partitions geographic space into contiguous, nonoverlapping triangles. The vertices of each triangle are sample data points with x-, y-, and z-values. These sample points are connected by lines to form Delaunay triangles. TINs are used to store and display surface models.



- Terrains = An area of land having a particular characteristic, such as sandy terrain or mountainous terrain.
  - Terrain datasets = A multiresolution, TIN-based surface built from measurements stored as features in a geodatabase. Associated and supporting rules help organize the data and control how features are used to define the surface. Terrain datasets are typically derived from sources such as lidar, sonar, and photogrammetric data.
- DEMs = Acronym for digital elevation model. The representation of continuous elevation values over a topographic surface by a regular array of z-values, referenced to a common datum. DEMs are typically used to represent terrain relief.

SPATIAL DATABASE = A structured collection of spatial data and its related attribute data, organized for efficient storage and retrieval.

## DATABASE QUERIES BASED ON ATTRIBUTES =

### SIMPLE SELECTION =

### COMPOUND SELECTIONS (AND, OR, NOT) =

BOOLEAN EXPRESSIONS = An expression, named for the English mathematician George Boole (1815-1864), that results in a true or false (logical) condition. For example, in the Boolean expression "HEIGHT > 70 AND DIAMETER = 100," all locations where the height is greater than 70 and the diameter is equal to 100 would be given a value of 1, or true, and all locations where this criteria is not met would be given a value of 0, or false.

BOOLEAN OPERATORS = A logical operator used in the formulation of a Boolean expression. Common Boolean operators include AND, which specifies a combination of conditions (A and B must be true); OR, which specifies a list of alternative

conditions (A or B must be true); NOT, which negates a condition (A but not B must be true); and XOR (exclusive or), which makes conditions mutually exclusive (A or B may be true but not both A and B).

### SELECTION OPERATIONS =

ON-SCREEN QUERY (IDENTIFY TOOL) = In ArcGIS, a tool that, when applied to a feature (by clicking it), opens a window showing that feature's attributes.

### SPATIAL SELECTION (CONTAINMENT AND ADJACENCY)

- Containment = A spatial relationship in which a point, line, or polygon feature or set of features is enclosed completely within a polygon.
  - Adjacency = [geography] A type of spatial relationship in which two or more polygons share a side or boundary.
  - [Euclidean geometry] The state or quality of lying close or contiguous.



- CLASSIFICATION = The process of sorting or arranging entities into groups or categories; on a map, the process of representing members of a group by the same symbol, usually defined in a legend.
  - BINARY = a data classification method that seeks to partition data into two states, such as yes or no, on or off, true or false, or 0 or 1.
  - EQUAL INTERVAL = A data classification method that divides a set of attribute values into groups that contain an equal range of values.
  - EQUAL-AREA = A data classification method that divides polygon features into groups so that the total area of the polygons in each group is approximately the same.
  - NATURAL BREAKS = A method of manual data classification that seeks to partition data into classes based on natural groups in the data distribution. Natural breaks occur in the histogram at the low points of valleys. Breaks are assigned in the order of the size of the valleys, with the largest valley being assigned the first natural break.
  - QUANTILE = A data classification method that distributes a set of values into groups that contain an equal number of values.

MAP ALGEBRA = A language that defines a syntax for combining map themes by applying mathematical operations and analytical functions to create new map themes. In a map algebra expression, the operators are a combination of mathematical, logical, or Boolean operators (+, >, AND, tan, and so on), and spatial analysis functions (slope, shortest path, spline, and so on), and the operands are spatial data and numbers.

RECLASSIFICATION = The process of taking input cell values and replacing them with new output cell values. Reclassification is often used to simplify or change the interpretation of raster data by changing a single value to a new value, or grouping ranges of values into single values—for example, assigning a value of 1 to cells that have values of 1 to 50, 2 to cells that range from 51 to 100, and so on.

PROXIMITY FUNCTIONS (BUFFERS) = A type of analysis in which geographic features (points, lines, polygons, or raster cells) are selected based on their distance from other features or cells.

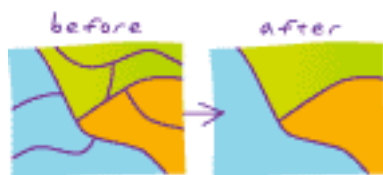
- [spatial analysis] A zone around a map feature measured in units of distance or time. A buffer is useful for proximity analysis.



- [spatial analysis] A polygon enclosing a point, line, or polygon at a specified distance.

DISSOLVE FUNCTIONS

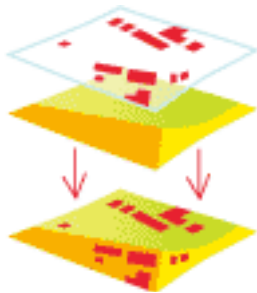
- [ESRI software] A geoprocessing command that removes boundaries between adjacent polygons that have the same value for a specified attribute.



- [data editing] The process of removing unnecessary boundaries between features, such as the edges of adjacent map sheets, after data has been captured

## OVERLAY OPERATIONS

- CLIP (COOKIE-CUTTER) = A command that extracts features from one feature class that reside entirely within a boundary defined by features in another feature class.
- INTERSECT (SPATIAL "AND") = A geometric integration of spatial datasets that preserves features or portions of features that fall within areas common to all input datasets.
- UNION (SPATIAL "OR") = A topological overlay of two or more polygon spatial datasets that preserves the features that fall within the spatial extent of either input dataset; that is, all features from both datasets are retained and extracted into a new polygon dataset.



- ERASE (SPATIAL "NOR") = In ArcInfo, a command that removes or deletes features from one coverage that overlap features in another coverage.

GAP AND SILVER POLYGONS = A small, narrow, polygon feature that appears along the borders of polygons following the overlay of two or more geographic datasets. Sliver polygons may indicate topology problems with the source polygon features, or they may be a legitimate result of the overlay.

