USGS
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Rocky Mountain Mapping Center

Questions and Answers Regarding GPS

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1. What do I need to know to get my GPS into correct operation?

We generally emphasize the following four points:

a) Select a coordinate system. We usually suggest using either the Universal Transverse Mercator System (UTM) or latitude/longitude. Using UTM results in easier plotting on the USGS 7.5' quadrangle maps. The coordinate system displayed by your GPS is usually just a position format selection on your unit's navigation set up page.

b) Select the correct horizontal datum. Most GPS units default to a datum called the World Geodetic System of 1984 (WGS84). However, most USGS maps are referenced to a different datum, the North American Datum of 1927 (NAD27). A few USGS maps are set to the North American Datum of 1983 (NAD83), which is virtually identical to WGS84. Check the map information at the lower left corner of the USGS 7.5' quadrangle to determine the correct datum used in the making of the map. Correct datum is especially important of you are using the UTM coordinate system. Your GPS setup menu may present several variations of NAD27 to select from; most users will select NAD27 **CONUS**, which is appropriate for the **continental US**.

c) Be aware that the vertical heights displayed by your recreational GPS receiver will not agree well with USGS map elevations. The main reasons for this discrepancy is the inherent poor fix geometry available for vertical determinations (the earth is always blocking some of the desired satellites) and the use of different reference surfaces for the vertical measurement. DO NOT USE GPS ELEVATIONS FOR CRITICAL NAVIGATION DECISIONS.

d) Select which "North" your GPS receiver will use as the zero degree reference. The default in your receiver is probably true north = 0 degrees. You can also select magnetic north = 0 degrees or grid north (north-south lines of the UTM grid) = 0 degrees. Many users select magnetic north as zero degrees to they can follow a compass bearing

without converting the azimuth to true north. Many GPS units automatically calculate the local magnetic variation (declination) for the fix time and date.

2. How do I locate a point in latitude and longitude on your 7.5' quadrangle?

To accurately plot a latitude/longitude position, the map reader must first connect the 2.5' ticks encompassing the area within which the point will be measured. Using a specially incremented scale, an engineers scale, or a variable scale template, the reader can accurately plot the latitude/longitude of a point.

3. What does the term UTM mean?

UTM is the acronym for Universal Transverse Mercator, a plane coordinate grid system named for the map projection on which it is based (Transverse Mercator). The UTM system consists of 60 zones, each 6-degrees of longitude in width. The zones are numbered 1-60, beginning at 180-degrees longitude and increasing to the east. The military uses their own implementation of the UTM system, called the Military Grid Reference System (MGRS).

4. Why don't your maps show the UTM grid?

Through time, policies have changed regarding whether or not a full UTM grid would appear on the 7.5' map series. Beginning in the mid 1950's, the grid was indicated by blue ticks around the projection at 1000 meter spacing. In 1979, the ticks were replaced with a full-line black UTM grid. Because so many complaints were received through a 1991 user survey, the full grid was removed in early 1992. Blue ticks returned to the maps. In 1994, another survey indicated that either a complete grid or internal 1000 meter ticks were the preferred treatment as opposed to the perimeter ticks alone. Once again, a full grid will appear on the 7.5' series with the exception of single edition quadrangles published cooperatively with the U. S. Forest Service.

5. How are UTM coordinates measured on the quadrangle?

UTM coordinates are measured on the map by subdividing the 1000 meter grid squares into tenths or hundredths. This will narrow down the coordinate to a 100 or 10 meter square. Usually the measurements are made using a simple mylar or paper scale or a coordinate reader. Note that the large numbers that are located adjacent to the tick marks around the perimeter of the map represent tens of thousand and thousands of meters. The millions and hundreds of thousands of meters are shown

with small numbers and are sometimes dropped when giving UTM coordinate positions. The military implementation of UTM (MGRS) drops the small digits and indicates the 100,000 meter square by a two letter identifier. Most UTM users and GPS units use the full value of the UTM coordinates.

6. What do the leading numbers and letters mean on my GPS UTM coordinate display (e.g. 13S)?

The number refers to the UTM zone as described above; the letter refers to an 8 degree band of latitude within the specific UTM zone. The southernmost band from 80 degrees South to 72 degrees South is letter "C". The letters increment to the North ending in "X" which is a 12 degree band from 72 degrees North to 84 degrees North. The system skips certain letters that may be confused with numbers, e.g. the letters “O” and “I” are not used.

7. Why doesn't Grid North correspond to True North?

Grid North pertains to the north for a specific plane coordinate system. All north-south lines run parallel to one another in the UTM projections. True North refers to geodetic or geographic north pole, and the lines of longitude converge in the Lambert Conformal Conic projection used on the 7.5’ maps. Because the 7.5’ maps mix the UTM and conic projections occasionally the UTM grid will appear at a small angle to the neat lines of the map. This is not a cause for concern so long as the UTM grid has been drawn in correctly by the user.

8. How do I report a position?

If coordinates are to be passed on to another person it is technically necessary to report the horizontal datum and the latitude/longitude of the point (e.g. NAD 27 CONUS, 44 degrees, 7 minutes, 30 seconds north/ 104 degrees, 15 minutes, 10 seconds west). If using UTM, include datum, grid zone number, row indicator, easting and then the northing value (e.g. NAD 83/13 S/ 0404524E/ 4239242N). UTM coordinates are always read to the right and up. Different needs may dictate different reporting schemes.

9. Which is the best or more accurate system, the UTM or the latitude/longitude coordinate system?

One system is no more or less accurate than the other. They are just two different ways of positioning a point. Many experienced users prefer UTM

over latitude/longitude when using 7.5' topographic quadrangle maps. Ocean going sailors and other marine users almost always use latitude/longitude because navigation charts are optimized for this method.

10. How can I get more information on any of these coordinate systems and GPS in general?

Many excellent references can be found in standard textbooks. More and more information is being posted on the internet. Refer to the attached lists for specific web sites.

11. How much distance does a degree, minute and second cover on your maps?

The distances vary. A degree, minute or second of latitude remains fairly constant from the equator to the poles; however a degree, minute, or second of longitude can vary greatly as one approaches the poles (because of the convergence of the meridians). At 38 degrees North latitude, one degree of latitude equals approximately 364,000 ft (69 miles), one minute equals 6068 ft (1.15 miles), one-second equals 101 ft; one-degree of longitude equals 288,200 ft (54.6 miles), one minute equals 4800 ft (0.91 mile), and one second equals 80 ft.

12. How do I convert UTM coordinates to latitude/longitude values or vice versa?

Of course, your GPS unit will convert coordinates for you. The USGS uses computer programs to easily convert between UTM and latitude/longitude. One program that is available is Tri_con (Windows 95) or Geocon (DOS) which can be downloaded for free at http://rockyweb.cr.usgs.gov/software

13. Why don't your map coordinates agree with those I obtain with my GPS receiver?

There are two main reasons why this may occur. First, be sure your GPS receiver is set to the correct horizontal datum. Experience has shown that

the position differences between NAD27 and NAD83 (WGS84) can vary by as much as 100 meters in easting and several hundred meters in northing. In latitude/longitude the maximum error may approach 200 meters.

14. Why don't the elevations on your maps agree with those provided by my GPS system? Which ones are correct?

GPS heights are based on an ellipsoid (a mathematical representation the earth's shape), while USGS map elevations are based on a vertical datum tied to the geoid (or what we commonly call mean sea level). Basically they are two different systems, although they have a relationship that has been modeled. The main source of error has to do with the arrangement of the satellite configurations during fix determinations. The earth blocks out satellites needed to get a good quality vertical measurement. Once the vertical datum is taken into account, the accuracy permitted by geometry considerations remains less than that of horizontal positions. It is not uncommon for satellite heights to be off from map elevations by +/- 400 ft. Use these values with caution when navigating. ***GPS units do not replace basic map and compass skills!***

15. Why are the NAD 83 position values so far from the NAD 27 values? Were the old coordinates wrong?

The old coordinates were not wrong, just different. They are based on different earth shapes or ellipsoids. They were based on the best technology at the time. Mathematically, NAD83 is a stronger datum because all previously existing horizontal stations and newer GPS surveyed stations were adjusted simultaneously. The positions within NAD27 were adjusted in arcs, as the networks progressed across the country. Errors between stations adjusted in different arcs could have been substantial.

16. How will the change in Selective Availability (SA) degradation affect the accuracy of the positions I obtain with my stand alone GPS receiver?

On May 2, 2000, Selective Availability (SA) was turned off. This allows the stand alone GPS receiver to obtain real time accuracies in the range of 10-20 meters rather than the 100 meters available when SA is operating. Further accuracies will be obtained with the addition of a second and third civilian frequency. However, this will not occur until a sufficient number of new BLOCK IIR satellites have been launched. This may not occur until 2006.

17. What happens if a satellite goes bad or new satellites are placed in orbit? Will I have to get a new receiver or have my present device recalibrated?

A satellite could temporarily be bad (the military could be adjusting its orbit or updating the transmitted information). Sometimes the user must be able to look at the screen and determine if the information looks reasonable. The GPS receiver can detect if a satellite is unhealthy and reject the signal from position computations. If a satellite has gone bad, the military will shut it down until the problem has been fixed. If the damage is irreparable, the satellite will be turned off and withdrawn from use. If new satellites are placed in orbit, the receiver will be able to pick them up once the satellites have been declared operational and have transmitted their unique identifying almanac and ephemeris information.

18. Which makers/systems do you recommend?

We cannot recommend individual makers/systems. Some of the major manufacturers are Trimble Navigation, Magellan, Ashtech, Garmin, and Rockwell. Other electronic firms are continually entering the GPS market. Some comparisons of GPS receivers are offered on: http://gpsinformation.net. Most manufacturers offer comparisons of their own models. Garmin, for example, offers a comparison worksheet on: http://www.garmin.com/outdoor/compare.jsp

19. How is the State Plane Coordinate system set up? Can GPS provide coordinates in these values? What about Public Land Survey System (PLSS) readouts?

The State Plane Coordinate System (SPCS) is a plane coordinate system (N-S and E-W lines are perpendicular) in which each individual state has

from one to six zones, depending on the state's size and shape. The grid system in some states is based on the Lambert Conformal Conic Projection, while the system for other states is based on the Transverse Mercator Projection. As a general rule-of-thumb, states that are longer E-W than N-S use Lambert, while states that are longer N-S use Transverse Mercator. The most notable exception to this is California, which is based on Lambert.

For NAD27, all coordinates were based on U. S. Survey Feet. USGS 7.5' maps show 10,000 foot black grid ticks along the perimeter of the map. The appropriate zone is listed in the margin data at the lower left-hand corner of the map.

For NAD83, coordinates may be in meters, U. S. Survey Feet, or International Feet depending on the State. Each State was allowed to choose which unit of measure they wanted for surveys within their boundaries. Some states changed origins fro their State Plane Coordinate System when switching from NAD27 to NAD83. For these reasons, using this grid system has become less popular than in the past.

Some Trimble professional grade GPS receivers are capable of providing positions in the State Plane Coordinate System. Of course, latitude/longitude or UTM positions recorded in the field or post processed in a computer, can be transformed to SPCS through the computer software mentioned above in question 12.

GPS cannot provide readouts in the Public Land Survey System (PLSS). Points can be plotted onto a map in lat/long or UTM. From that position a user can determine the Section that encompasses the point.

20. How do I get my coordinates off the GPS units and onto my computer for further analysis?

A popular free downloadable extension that turns Garmin GPS data into ESRI GIS-compatible files:

http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html

An inexpensive GPS download software product: http://www.oziexplorer.com/

A freeware GPS download software product, Waypoints +:
http://www.tapr.org/~kh2z/Waypoint/

GPS RELATED WEB SITES

This is an informal collection of websites we have found to be interesting or useful. Commercial sites are shown on this list for information purposes only. No endorsement is expressed or implied. All URLs are http:// sites unless otherwise specified.

DeLorme homepage	www.delorme.com
DGPS- Omnistar	www.omnistar.com
FAA-GPS page	gps.faa.gov
Forest Service GPS page	www.fs.fed.us/database/gps
Fish & Wildlife Service GPS	www.fws.gov/data/gps.html
Fugawi Moving Map Software	www.fugawi.com
GPS World Magazine	www.gpsworld.com
GPS Outfitters	www.gpsoutfitters.com
Garmin homepage	www.garmin.com
Joe Mehaffey and Jack Yeazel GPS Info	joe.mehaffey.com
Localized GPS Service Interrupt Notices	www.navcen.uscg.gov/gpsnotices
Map Tools	www.maptools.com
Magellan GPS	www.magellangps.com
National Geodetic Survey	www.ngs.noaa.gov

National Geographic Maps- Trails Illustrated maps.nationalgeographic.com/trails

National Park Service GPS4GIS Resource www.nps.gov/gis/gps/gps4gis/

Navtech GPS Supply www.navtechgps.com

NAVSTAR GPS homepage (military) tyco.usno.navy.mil/gpsinfo.html

Navtech GPS Supply-GPS Websites www.navtechgps.com/links.asp

OzieExplorer www.oziexplorer.com

Russian Space Forces (GLONASS) rssi.ru/SFCSIC/english.html

Space Environ Ctr-homepage www.sec.noaa.gov

Trimble Navigation-GPS homepage www.trimble.com

UTexas & UColorado GPS Overview http://www.colorado.edu/geography/gcraft/notes/gps/gps_f.html

US Coast Guard www.navcen.uscg.gov

USCG-GPS status www.navcen.uscg/ADO/GpsActiveNanu.asp

USCG-DGPS status www.navcen.uscg.gov/ADO/DgpsSelectStatus.asp

USCG-Civil GPS Service Interface Committee www.navcen.uscg.gov/cgsic/default.htm

USGS homepage www.usgs.gov

Waypoint Enterprises www.waypoint-ent.com

Wormley Educational Observatory Institute www.edu-observatory.org/gps/gps.html

COMMERCIAL SOURCES FOR GPS RELATED PRODUCTS

BOOKS AND MAGAZINES

GPS Land Navigation; Michael Ferguson, 255 pages, $19.95 plus shipping
GPS Waypoints: Colorado; Michael Ferguson, 256 pages, $15.95, also available for Arizona, Idaho, Oregon, Utah and Washington.
Published by Glassford Publishing, PO Box 2895, Boise, ID 83701-2895
1 888 477-6379, www.gps-books.com

GPS Made Easy, Using Global Positioning Systems in the Outdoors; Lawrence Lethan, 208 pages, 2nd edition, paperback, $14.95 plus shipping
Published by The Mountaineers, 300 3rd Ave West, Seattle, WA 98119
1 800 284-8554 or 206 284-8484
Also available at Tattered Cover Bookstore, Denver, CO 303 322-7727 and Recreational Equipment Inc. (REI) 303 932-0600.

GPS World Magazine; www.gpsworld.com,
1 800 346-0085 x 477 or 218 723-9477

Map and Compass; Cliff Johnson, 67 pages, 2nd edition, paperback
Published by The Globe Pequot Press, PO Box 833, Old Saybrook, CT 06475
1 800 243-0495, www.globe-pequot.com

VIDEOS

USING GPS WITH MAPS (GPS-VHS), $19.95 (plus $5.00 handling), a privately produced product distributed by the USGS.

COORDINATE READERS

To accurately scale positions on a topographic map, a graduated Mylar scale is useful. The sources below can supply coordinate readers:

'The Coordinator, USA' 1 800 275-7526

'Map Tools'; 1755 La Honda Rd #95, Woodside, CA 94069
750 851-9341 (fax), www.maptools.com

'Waypoint Enterprises'; PO Box 3368, Show Low, AZ 85902-9163
520 367-2600 (v) 520 537-9163 (f), www.waypoint-ent.com

In addition, the USGS can supply a basic UTM reader for 7.5' 1:24, 000/1:25, 000 maps (CR-2) and another for 1:50,000 scale maps (CR-1). These readers are priced at $2.50 each. In addition, all orders for delivery within the United States will have a $5.00 handling charge assessed.

Phone orders are accepted with credit cards at 1 888 275-8747. You may also order free indexes to topographic map coverage or place orders for maps or the USING GPS WITH MAPS video at the same number.

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U.S. Geological Survey
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URL:http://rockyweb.cr.usgs.gov /outreach/gps/gps_questions_and_answers.html
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