

GPS Operation FUNDamentals



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14 April 2011

Tonight's Timely Topics:



- ▶ What is the Global Positioning System (GPS)?
- ▶ How does GPS work?
- ▶ Types of GPS Receivers (GPSr)
- ▶ GPS Settings, Coordinate Systems & Map Datums
- ▶ GPS Maps: Base – Topo – Street – NW Trails
- ▶ Loading geocaches to a GPSr
- ▶ Navigation using a GPSr
- ▶ Marking Accurate Waypoints
- ▶ Getting the most out of Batteries

Global Positioning System



- ❖ GPS is owned by the US Department of Defense.
- ❖ The system consists of three parts:
 - Space Segment
 - Control Segment
 - User Segment
- ❖ The GPS system design started in 1973. There were 11 "Block I" experimental satellites deployed from 1978 to 1985 for development and testing of the system.
- ❖ The first operational "Block II" satellite was launched in 1989 and the 24th satellite was launched in 1994 bringing the system fully online.
- ❖ The Air Force Space Command certified the system for general navigation on April 27, 1995.



The Space Segment



- The Space Segment consists of at least 24 satellites in 6 orbital planes at an altitude of 12,550 miles from the Earth's surface. Each plane has at least 4 satellites.
- These planes have an inclination of about 55° relative to the Earth's equator and each satellite makes one orbit around the Earth every 12 hours (semi-synchronous).
- Since 1989, there have been a total of 48 Block II series GPS satellites launched into orbit.
- There are currently 31 healthy satellites in use in the active constellation with 11 more being built.
- The next generation of GPS satellites (Block III) has another 26 satellites planned to eventually replace the current Block II series of satellites.

The Control Segment



- The Control Segment includes all of the ground-based systems that track and control the GPS satellite constellation.
- The exact position of each satellite is monitored for accuracy of the orbit and the ground track.
- The health and orbit data for the constellation is uploaded to each satellite every couple hours.
- When there is a discrepancy in orbit position, the satellite is marked "unhealthy" until the data is corrected or it's orbital position is changed.
- When "unhealthy", it is not used for positioning.

The User Segment



- This includes everyone on or near the Earth with a receiver who is using the GPS signals.
- The original intended user was the Military, but in 1983 President Reagan ordered that the system would be made available to civilians.
- To prevent an enemy from using GPS as a weapon guidance system, the "civilian" signal was intentionally degraded under a program called "Selective Availability".
- This caused civilian users to have a random horizontal error of about 100 meters (328 feet).

Selective Availability



- To allow civilian access for general navigation without giving everyone high-precision, the GPS signals were intentionally degraded.
- A DOD-approved user with the right GPSr could enter the day's code to remove the error.
- In 1996, President Clinton ordered that SA would be shut off as GPS had become a dual-use system with significant civilian value.
- On May 2, 2000 the SA degradation was shut off, though it can be turned back on at any time.

What the satellite does



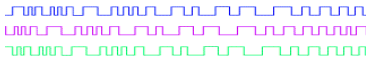
- Each satellite transmits exact time and the precise orbit data on the same two frequencies
- One consists of the Course Acquisition "C/A" code and the encrypted Precision "P(Y)" code
- The other has the military's Precision "P" code which can only be used when decrypted by special receivers with the proper key code
- In order to tell the difference between satellites, each signal has a different encoding called a pseudo-random sequence or PRN code

The GPS Radio Signal



- This is a very low power transmission using a carrier wave that is modulated like an FM radio.
- The signal travels at the speed of light in space, though it slows slightly in the atmosphere.
- The GPSr basically compares the time the signal was received to the time it was sent to find out how long it took to get to you.
- The distance to the satellite can then be computed. With the distance to at least 3 satellites, your relative position can be triangulated. More satellites = more accuracy.

Timing is Everything



- All the PRN codes are known by the GPSr
- The GPSr uses a timing trick to align the PRN code shift pattern of the signal by comparing it to the same internally generated signal
- The difference in timing between the two signals is how long it took the signal to reach the GPSr
- That difference times the speed of light is the distance to the satellite from the GPSr

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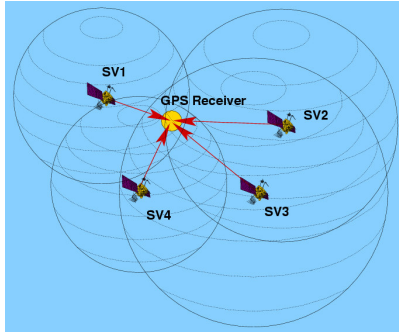
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Triangulation



The distance to at least 3 satellites is computed from the PRN signal shift and then GPSr uses triangulation to compute your position based on the known locations of the satellites



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Signal Errors



- A timing error of only 1/1000 of a second translates to as much as a 200 mile ground error!
- Radio signals going through the atmosphere slow down with great variations, this introduces errors when calculating the PRN timing shift
- In certain geographic settings, the signals can bounce off objects, adding time to their travel and creating errors in the calculations
- These errors are countered by atmospheric modeling and the use of ground-based corrections through Differential GPS and Wide Area Augmentation System
- Using fixed GPSr with known locations, the exact error can be calculated and sent out for correction use

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Types of GPSr



- ✦ Military P(Y) Code precision receivers
- ✦ Surveyor Grade DGPS precision receivers
- ✦ Fixed-position science stations
- ✦ Atomic timing services
- ✦ Marine Chart Plotter GPSr
- ✦ Aviation GPSr
- ✦ Handheld recreational GPSr
- ✦ Vehicle navigation and tracking systems



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Brands of Handhelds



- ➔ Garmin - www.garmin.com
- ➔ Magellan - www.magellangps.com
- ➔ DeLorme - www.delorme.com
- ➔ Lowrance - www.lowrance.com
- ➔ Trimble - www.trimbleoutdoors.com



Just a sample of the popular brands of handheld GPSr

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Garmin Handhelds



- ➔ Basic non-mapping Handhelds:
 - ➔ eTrex H, GPS 60, & GPS 72
- ➔ Mapping Handhelds:
 - ➔ eTrex Venture, Summit, Legend, & Vista
 - ➔ GPSMAP 60, 62, 76, & 78 series
 - ➔ Oregon & Dakota series



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The "Other" Guys



- **Magellan** eXplorist GC, 310, 510, 610, and 710, all are capable of "paperless" caching
- **DeLorme** Earthmate PN 40, 60, & 60w, some use satellite images and the "w" pairs to a [SPOT](#)
- **Lowrance** Endura Out&Back, Safari, & Sierra use a combination of touch screen & physical buttons
- **Trimble's** focus is on Smartphone GPS applications including [Geocache Navigator](#)

GPSr Settings



- Most GPSr can be used right out of the box without changing anything
- At a minimum, ensure that you have the coordinate system and map datum set to the right units for Geocaching use
- Other settings include standard or metric units, time formats, and battery types

Coordinate Systems



This is the same spot, written different ways:

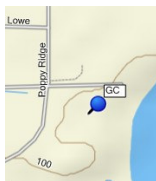
DMM: N 60° 29.190' W 151° 07.715'

DMS: N 60° 29' 11.4" W 151° 7' 42.9"

Decimal: 60.48650 -151.12858

UTM: 5V E 602838 N 6707055

MGRS: 5VPH0283807055



Map Datums



- Map Datums are the survey “baseline” coordinates used when drawing a map
- The most current Datum is **WGS 84** which stands for “World Geodetic System 1984”
- Most of the USGS topographical maps for Alaska were originally done under **NAD 27** which is “North American Datum 1927”
- If using waypoints from a paper map in the field there are times when you might need something else, but for Geocaching you should always have your GPSr set to the **WGS 84** Map Datum

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Electronic Compass



- Some GPSr have a separate electronic compass built in, the rest rely on your changes in position to figure out which way you are going. If you are standing still, only an electronic compass will point you the right direction!
- Most GPSr use an automatic declination for any compass heading features
- Some can be set to switch between the electronic compass and your heading calculation at a certain speed of travel
- Electronic compasses must be **calibrated**
- A 2-axis compass must be held level

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GPSr Maps



- ✘ A non-mapping GPS will show you a blank “map” with relative waypoint positions and show your “breadcrumb” track log
- ✘ The basemap included with many mapping units is a very simplistic street and feature map with marginal accuracy
- ✘ More accurate and complete maps come with high-end units or can be purchased

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GPSr Street Maps



- ❖ Street Maps show details of roads and street addresses without much terrain
- ❖ Used for vehicle navigation, the accuracy and detail drops as you get further away from large cities



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GPSr Marine Charts



- ❖ Charts are used in Marine applications and show navigation details for waterways
- ❖ Charts are often sold on SD cards and plug into special Marine GPSr “plotters”



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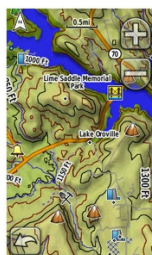
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Topographic Maps



- ❖ USGS type topographic maps are the most common for outdoor users
- ❖ They show all terrain features just like a paper map as well as most roads
- ❖ Many varieties are available



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NW Trails Maps

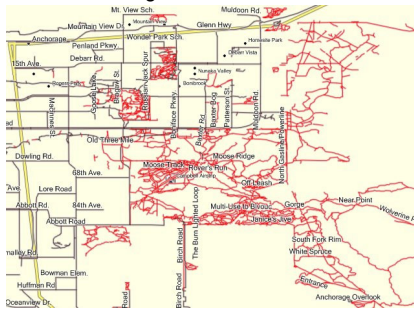


- ❖ These are a set of user-created map overlays that can be put “on top” of your existing maps
- ❖ The “trails” are track log files submitted by individuals which are then compiled into the map
- ❖ [Download](#) and install into Garmin’s Mapsource program and then you can upload it along with your chosen maps into your GPSr for field use
- ❖ If you know of trails that are not in the NW Trail set, consider capturing a tracklog of the trail and submitting it for inclusion in future releases

NW Trails Maps



Sample of the Anchorage area NW Trails:



Loading Caches



- Using the “Mark” button, you can manually type in the coordinates to the GPSr
- From a cache listing, you can upload the current cache using plugins from Garmin, Magellan, & DeLorme
- From a list of caches, you can download all the caches via the checkboxes using the LOC download button at the bottom

PQ's & GSAK



- Premium Members at geocaching.com can filter and download GPX files containing up to 1000 cache listings
- These can be loaded into EasyGPS, MapSource, and the GSAK program
- From GSAK, you can directly load a batch of caches to your GPSr or even create a custom POI (points of interest) file to replace the POI file in your Garmin

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Navigating to a Cache



- There are two basic methods of using a GPSr for navigation to a waypoint
- You can select the destination point and enter the GPSr's Navigation Mode which uses a compass-like directional arrow to point you in the right direction
- Or you can use the GPSr just like a map where you can see your location relative to the waypoint and figure the best route

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Directional Navigation



- Select a waypoint from the waypoint list using the "find" button or scroll around the map page and select a waypoint on the screen. Some GPSr have special geocaching features that make this easier.
- From the waypoint details screen, select "go to" and it will enter navigation mode
- You get a compass image with an arrow pointing toward the waypoint

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Directional Navigation



- Remember that the arrow only works if you are moving or have an electronic compass that is calibrated and you are holding the unit level
- This method doesn't tell you how to get there as it's just a straight line



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Map Navigation



- To navigate using the map, use the zoom buttons to adjust the map in or out until you can see the intended waypoint
- Look at the terrain, trails, or roads to figure out the best way to get to the cache
- As you move, your position indicator will move and you can check your progress
- When you get closer to the cache, keep zooming in until you are within 20-30 feet

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Map Navigation



Using the map screen, as you get closer to the cache, look at the best route to get there from your current location just as if you were reading a paper map. Keep zooming in as you get closer to the cache until the screen is at the maximum zoom level.



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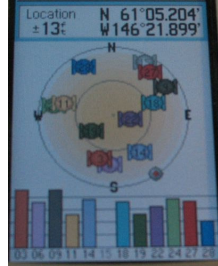
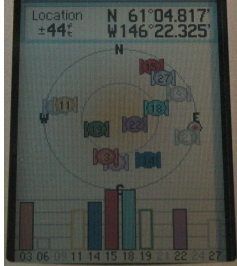
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Accurate Waypoints



Run the GPSr with clear sky view for at least 10 minutes to allow it to download the current satellite almanac data:



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Accurate Waypoints



- Once at the spot you want to record, let the GPSr “settle” for a few minutes and then press the “mark” button to bring up a waypoint details screen where you can name it, enter a comment field, and select a map icon.
- If your GPSr has Averaging capability, start the averaging process and allow the unit to sit still for about a minute or so. It may tell you the accuracy as it goes.
- Save the averaged point and it will return to the waypoint details screen. Look at the distance to the waypoint to see how far away it is. If it is within about 6-10 feet, then you have a good waypoint. If it is more than that, press the average button again to repeat the process.

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Accurate Waypoints



- If you want to ensure that you have a great set of coordinates, leave the cache site and come back several hours later.
- You will have a different batch of satellites overhead and you can check to see if your first recorded waypoint brings you to the same spot.
- If it doesn't, go through the averaging process again and return to check it a few hours later.
- Some locations with poor coverage may make perfect coordinates very difficult to record.

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Batteries



- Most GPSr run on “AA” batteries
- Alkaline
 - Shortest run time
 - Cost more over the long-term due to single use
- NiMH Rechargeable
 - Longer run time, if properly maintained
 - Reusable for hundreds of charges
- Lithium
 - Longest run time, especially in cold weather
 - Expensive investment and they are single use

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NiMH Batteries



- Keep them in pairs and never mix old and new NiMH batteries
- Recharge them in matched pairs as most chargers put 2 batteries in series during charging
- They do not have a long shelf life, so charge them just prior to use
- Run them down to a “low battery” warning at least every other month

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Proximity Waypoints



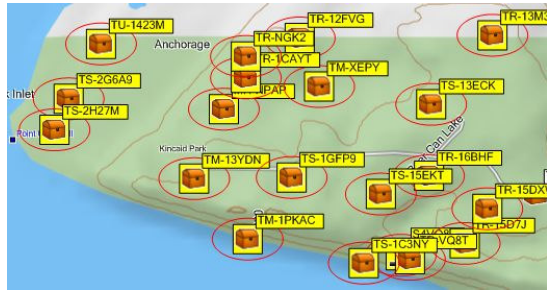
- ✓ A neat trick you can do with Garmin’s MapSource is to select a group of waypoints and assign a Proximity distance to all of them.
- ✓ This is helpful when planting a cache in a popular area.
- ✓ Select all the caches in the area around your intended hiding spot, right click one to open the Waypoint(s) Properties box, set the Proximity distance to 0.1 mile, and then upload them to your GPSr.
- ✓ When you get to the field, look at your map page and you will see a circle drawn around each of these caches on the screen. You can easily visualize if you are more than 0.1 mile from every cache on the screen this way.

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Proximity Waypoints



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Resources



- GS Knowledge Books: support.groundspeak.com
- GeocacheAlaska! Forums: geocachealaska.proboards.com
- Trimble GPS Tutorial: www.trimble.com/gps
- Switchback's NW Trails: www.switchbacks.com/nwtrails/
- USNO GPS Info: www.usno.navy.mil/USNO/time/gps/gps-info
- Garmin GPS Info: www8.garmin.com/aboutGPS/
- US Gov't GPS Info: www.gps.gov

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GEOCACHE ALASKA! Inc.

Exploring the Last Frontier • www.geocachealaska.org



GeocacheAlaska! Is a nonprofit Alaskan organization which:
Promotes geocaching as an exciting, family - oriented activity that increases awareness of parks and trails
Represents geocaching interests in public forums and to recreation land managers
Increases awareness of geocaching issues through interaction with other outdoor activity groups and public
Educates geocachers about low impact geocaching and promotes stewardship of our natural resources
Promotes the "Cache In Trash Out" program to help with the maintenance of parks and trail systems
Encourages individuals and families to get outside and enjoy Alaska's outdoor recreational opportunities
Provides opportunities for the geocaching community to meet and socialize with like-minded geocachers
Maintains an extensive website with local caching information, as well as a lively forum for idea exchange
Provides premium members access to extra benefits such as reduced prices on GeocacheAlaska! products and special events, and a free email address, while supporting costs of the website, forums and education
Premium Membership is \$20 annually or you can sign up as an Associate Member for free
Every Membership helps us towards achieving our goals!
Membership applications are available [online](#) and from the hosts of this Event



2010 GeocacheAlaska! custom [GeoCoins](#) are still available for purchase!
