Virginia Community College Geospatial Institute

Chapter 2:
Introduction to GPS

Prepared by the Virginia Geospatial Extension Program, Tidewater Community College and Virginia Western Community College for the

Geospatial Technician Education Through Virginia's Community Colleges (GTEVCC)

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  - GPS World (Free, online magazine) http://www.gpsworld.com
  - Online Articles and Websites http://www.extension.org/pages/GPS_Publications
- Software
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  - DNR Garmin (free) http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html
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Introduction to Global Positioning Systems (GPS)

1. Introduction

GPS (Global Positioning System) is a powerful tool especially when coupled with GIS. If you collect data in the field, GPS enables you to know "precisely" the location of the collected data. With this information, you can import the data into a GIS where it can be properly queried, analyzed, and viewed in a larger context. Many GPS units on the market today are both cheap and easy to use, making them a viable tool in today's workforce. There are far too many GPS units out there to discuss each of their features and interfaces. For this exercise, we are going to focus on one readily available, functional, cost-effective unit, Garmin eTrex Venture HC. Using this GPS receiver, you will gain proficiency in collecting, downloading, and manipulating an array of GPS data using a variety of software packages.

2. GPS Basics

2.1 What is the Global Positioning System

The GPS is a space-based radio-navigation system consisting of a constellation of satellites, a network of ground stations, and receivers. A minimum of 24 GPS satellites orbit the earth providing users with accurate information on position, velocity, and time anywhere in the world. There are at least five control stations monitoring the satellites. These control stations continuously track satellites and update the positions of each satellite. Without them, the accuracy of the system would degrade in a matter of days. The GPS is operated and maintained by the Department of Defense. In order to access this system, you are required to have a GPS receiver.

Want to learn more about GPS? Then check out these online resources!
The official Government GPS Website - http://www.gps.gov
How stuff works - http://electronics.howstuffworks.com/gadgets/travel/gps1.htm
Practice and Fun with GPS - http://www.gps-practice-and-fun.com/GPS-navigation-blog.html
Trimble (GPS receiver company) - http://www.trimble.com/gps/index.shtml
Garmin (GPS receiver company) - http://www8.garmin.com/aboutGPS
Geocaching - http://www.geocaching.com

2.2 What are GPS Receivers?

GPS units like the ones you will be working with today are referred to as "GPS Receivers". They receive the radio signals transmitted from GPS satellites. These radio signals contain important information that enables a given receiver to determine the distance between the receiver, and the satellite that is emitting a signal. If the GPS receiver receives this information simultaneously from three satellites, then it can calculate the X,Y position of the receiver. If the unit is able to receive a radio signal from a fourth satellite, it can use the extra information to calculate the GPS unit's elevation. Note that the elevation information often is considered to have at least twice as much error as the X,Y location.

2.3 What is Selective Availability and Differential Correction?

The accuracy of a calculated GPS position is a function of many different variables (i.e., receiver

strength, battery strength, robustness of internal algorithms, local topography, etc.). The government can further degrade the signal if they have deemed it necessary (e.g. war). This particular source of error is called Selective Availability (SA) and can generate errors in position of 300 feet or more. Differential Correction was developed to eliminate errors in GPS locations generated by SA and other sources. As of May 1, 2000, SA has been turned off, so other sources of GPS errors are corrected by Differential Correction. There are base stations around Virginia (and elsewhere) with accurately surveyed locations that support Differential Correction in GPS receivers. Each base station has a GPS receiver, which collects incoming signals. The true (surveyed) location is then compared to the received GPS coordinates. The calculated correction factors are compiled and can be used to obtain a very high degree of accuracy with your data. Most commercially available GPS receivers will not do this correction in the field. It is done on your computer in your office.

Note: You will not apply any Differential Correction factors to the data you collect today.

2.4 What is Averaging?

Another technique used to improve the accuracy of a calculated GPS location is called Averaging. Geographic coordinates acquired through averaging are not as precise as coordinates acquired through Differential Correction. Averaging is conducted by the GPS receiver in the field, though not all units are equipped with the averaging capability. With this feature, a GPS unit will collect data continuously and calculate many positions over a small time period (e.g. 30 seconds). The receiver will then average these positions together to get the final result. The GPS receiver must be stationary for Averaging to work.

3. GPS Data Overview

Waypoints

Virtual coordinate locations collected and stored in your GPS unit are called Waypoints. Waypoints are manually saved, on a GPS receiver. Information associated with GPS Waypoint data includes: locational information (latitude and longitude or other coordinates), time, date, elevation, and a unique ID#.

Trackpoints

Every GPS receiver collects tracks, or "track points", which are stored in the receiver's "Tracklog". The trackpoints are often considered as digital bread-crumbs, as they are collected at a specified distance (or time) as the GPS receiver is carried across the landscape. Trackpoint data includes, coordinate information (latitude and longitude), time, date, and elevation. In addition, other information is often stored as well.

Track points are collected automatically and continuously by the GPS receiver, as opposed to Waypoints, which are manually stored by user input.

Trackpoints are often used by the GPS's "Trackback" function. Car navigation systems, for example, rely on tracklog data to navigate you back exactly the same way that you arrived at your destination. Hunters and recreational users often use the Trackback function to route themselves back to their car or their tent... The trackback function will navigate these individuals back through the same route that they took when they left.

Routes
A route is a sequence of waypoints that is set up on the GPS receiver using previously stored waypoints. Using a route you can navigate to a sequence of waypoints.

While GPS receivers have internal memory to store data, it is often necessary to download the data to an external source (hard drive) to keep it from being deleted.

4. Collecting Data

We will be collecting several types of GPS data, including: Waypoints, Trackpoints (or tracks) and Routes. In addition, we will also learn how to calculate area and perimeter measurements (on the fly). For this exercise, we will use the document: "Garmin eTrex Venture HC: A Introductory Handbook for Natural Resource Professionals". This document is also available from the Virginia Geospatial Extension Program's Website (http://www.cnr.vt.edu/gep under "Cool Tools").

5. Downloading and Uploading Data

Downloading data from your GPS receiver to your computer requires a USB cable (older GPS receivers may have a serial cable). Cables are often provided when you purchase your GPS receiver (and if it is not included with your GPS receiver, you can purchase a cable separately). You also need to acquire a software program that enables your GPS receiver to communication with your desktop or laptop computer. Often, GPS receivers come with some communication software.

In addition to proprietary software that often comes with a GPS receiver, there are several GPS software products that are available for free off the Internet. Examples of free GPS software can be downloaded from the Virginia Geospatial Extension Program Website (http://www.cnr.vt.edu/gep under the "Cool Tools" section of the Website). In this exercise, you will work with a free software program called DNR Garmin. DNR Garmin is used by users across the globe to download data (waypoints, tracks, etc.) from their GPS receivers to their computers. In addition, this software can also be used to upload data from a computer to a GPS receiver.

5.1 DNR Garmin

DNR Garmin was developed by the Minnesota Department of Natural Resources. MN DNR provides upgrades to the software periodically, so be sure to check for upgrades every year or so... Note that the option to download the DNR Garmin software is towards the bottom of the webpage (Figure 1).

Figure 1: DNRGarmin download page.

We will reference a separate handout "DNR Garmin: A User Guide for Educators" when downloading and uploading data.

6. Geocaching

Geocaching is a high tech treasure hunting game. Participants look for hidden containers (caches) with the assistance of their GPS receivers. Once a container is found, the general rule is to take an item from the container, and leave an item in the container for someone else to find. Most containers also have a log book, where you can record your find. Geocaching.com (http://www.geocaching.com) provides geocachers with a clearinghouse of information associated with Geocaching.

The Virginia Geospatial Extension Program has developed several initiatives to support geocaching across the Commonwealth. The VGEP, for example, has supported or funded a number of trackable items, including geocoins. Information associated with these geocoins can be accessed through the Virginia Geospatial Extension Program Website (http://www.cnr.vt.edu/gep under "Cool Tools") or the Map@syst Website (http://www.extension.org/pages/Map@Syst_Community_Page).

We will be conducting a navigation exercise and a geocaching exercise using a geocoin. For this exercise, we will reference the following documents:

- The Virginia Geocoin Adventure
- 4-H Geocoin Adventure: Reflections in Learning Land Use and Land Cover

7. Review

In this section, you were exposed to the following:

- What is the Global Positioning System and how does it work?
- Recreational, mapping and survey grade GPS receivers
- Error and accuracy
- DATUM's
- Averaging
- Differential Correction
- The Wide Area Augmentation System (WAAS)
- Collecting GPS Data: Waypoints, and trackpoints (or Tracks)
- Downloading, Saving and Uploading GPS data
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In addition, you were exposed to some freely available software packages and other resources (Websites and Power Point materials) that can support your classroom instruction.

!!!IMPORTANT!!!
Just remember, that knowing how to operate a GPS does not make you a surveyor!

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