Activity B1: Locating GPS Satellites

Note: the procedures described below are for use with the yellow Garmin eTrex GPS receivers (the model supplied in the basic Virginia 4-H GPS Educational Kits). The instructions can easily be altered for use with other GPS receiver models.

Introduction:
Can you see the GPS satellites as they orbit above you? Well, not really. They are 11,000 miles above you, circling the earth every 12 hours, and too small to see with your eyes. However, you can "see" them electronically with your GPS receiver. In this activity, your students will determine satellite positions in the sky overhead and note which are providing active signals to their GPS receivers.

Time Involved: 30 minutes

Materials Needed: GPS receiver(s), magnetic compass(s). A receiver & compass for every one or two students is ideal, but the activity can be accomplished with larger groups and fewer receivers & compasses if necessary.

Getting Started:
- Location needed: open area away from large buildings and trees
- Note: if using a Garmin basic eTrex or Geko, be sure to use "advanced skyview" rather than "normal skyview".

  Also see *"Preparing GPS Receivers for Group Activities"*

Do the Activity:

Instructions to the students

- Turn on your GPS receivers and view the Satellite Page. Be sure that the page orientation is set to "orient sky northward" ("north up" on some models).

- Using your compass, determine which direction is north.

- Orient (aim) the top (nose) of the GPS receiver screen to north. You, your GPS receiver, and your compass should all be aiming the same direction!

- Current locations of GPS satellites in range are displayed in the concentric circles on the screen (up to a dozen satellites). Each satellite has a number. Satellite positions can now be determined relative to your position on the ground.

- Satellites along the outer ring are lowest on the horizon; those on the inner ring are at approximately a 45-degree position; those in the center of the inner ring are directly overhead.

- Each numbered satellite also has a corresponding “signal strength bar” at the bottom of the screen.

- Point to the locations of the satellites that you can “see” in the sky above you. Note which ones from which you are - and are not - receiving signals. Look about at your surroundings.

- Compare your results with others in your group.

Some questions for your students to ponder:

Q. Why are some of the satellites highlighted in gray?
(GPS receiver is in contact with the satellite & has started to retrieve data)

Q. Why are some of the satellites highlighted in black?"
(Satellite's data is now being used by receiver to pinpoint its location)

Q. What are the numbered bars on the screen's graph?
(Signal strength estimates for each satellite)

Q. Why are some satellites' signals not being used?
(Signals blocked - too low on horizon, buildings or hills, heavy tree cover, etc.)

Q. Why do the satellite connections and signal strength bars keep changing?
(Satellites are constantly moving in and out of range as they circle the earth twice per day. Also, your movements and surroundings affect the connections too.)

Q. Why does the accuracy estimate keep changing?
(Satellites are constantly moving in and out of range as they circle the earth twice per day. Also, your movements and surroundings affect the connections too.)

Background Information:

What is GPS? (from: http://www.navcen.uscg.gov/faq/gpsfaq.htm)

“GPS is a satellite-based radio-navigation system developed and operated by the U.S. Department of Defense (DOD). GPS permits land, sea, and airborne users to determine their three-dimensional position, velocity, and time 24 hours a day, in all weather, anywhere in the world with a precision and accuracy far better than other radio-navigation systems available today or in the foreseeable future.

GPS consists of three segments: space, control, and user.

- The Space Segment consists of a minimum of 24 operational satellites in six circular orbits 20,200 km (10,900 NM) above the earth at an inclination angle of

55 degrees with a 12 hour period. The satellites are spaced in orbit so that at any time a minimum of 6 satellites will be in view to users anywhere in the world. The satellites continuously broadcast position and time data to users throughout the world.

- The Control Segment consists of a master control station in Colorado Springs, with five monitor stations and three ground antennas located throughout the world. The monitor stations track all GPS satellites in view and collect ranging information from the satellite broadcasts. The monitor stations send the information they collect from each of the satellites back to the master control station, which computes extremely precise satellite orbits. The information is then formatted into updated navigation messages for each satellite. The updated information is transmitted to each satellite via the ground antennas, which also transmit and receive satellite control and monitoring signals.

- The User Segment consists of the receivers, processors, and antennas that allow land, sea, or airborne operators to receive the GPS satellite broadcasts and compute their precise position, velocity and time.

The GPS concept of operation is based upon satellite ranging. Users figure their position on the earth by measuring their distance from the group of satellites in space. The satellites act as precise reference points.

Each GPS satellite transmits an accurate position and time signal. The user's receiver measures the time delay for the signal to reach the receiver, which is the direct measure of the apparent range to the satellite. Measurements collected simultaneously from four satellites are processed to solve for the three dimensions of position, velocity and time."

Note: Comments and suggestions regarding this activity and other components of the Virginia 4-H GPS curriculum are appreciated. Please contact Mike Clifford at: mjc4h@vt.edu / 804-561-5411 / 11131 Amelia Springs Rd., Jetersville, VA 23083