Global positioning

How on earth does it work?

Dear Science Mine: OK, how does a GPS unit work?

Answer: Global Positioning System, or GPS, is a system designed to accurately determine positions on the earth's surface. It consists of three parts. The first is a series of satellites that transmit signals to earth. The second is the control, which makes adjustments to satellite position and clock signals by sending commands from ground stations. The third is the receiver system, which consists of base stations and handheld receivers.

Science Mine

KEN SANDAU

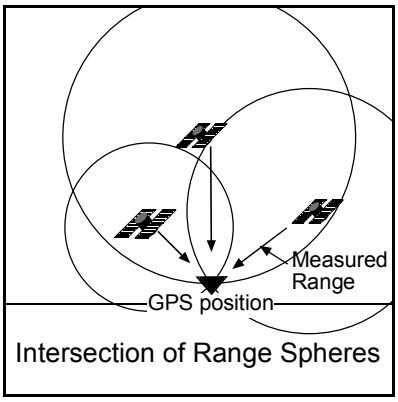
When you turn on your handheld GPS receiver, it scans the ether for signals from satellites, which continuously transmits a precise code (ones and zeroes) that is 267 days long. Once the receiver has determined the identity of a satellite, it identifies what part of the 267-day-long code it picked up and determines when that bit of code was sent.

The time difference between when the code was sent and when it was received tells your GPS unit how far you are from the satellite (time difference X speed of light = distance from satellite).

The receiver then knows that it lies within a sphere located X miles from the satellite. By repeating the same process with two or more additional satellites, the receiver can narrow the position down to the very small area in which the "spheres" intersect.

In practice it takes four satellite signals to get accurate positioning, the fourth acting as a reference for the other clock signals.

There are 24 GPS satellites in orbit around the earth. They have a 12-hour orbit time and are positioned so that nearly 100 percent of the earth's surface is able to receive signals from at least 6 satellites at any given time.



Each satellite contains an atomic clock that is accurate to billionths of a second per month, and continuously transmits information about its identity and position in binary code.

Your GPS receiver's internal clock is a quartz clock, which, although not as accurate as the satellite clocks, can be synchronized to calculate a position.

When satellite signals travel through different layers of the atmosphere, they can be slightly slowed or refracted, resulting in errors in distance measurement. The lower the angle of the satellite on the horizon, the more the signal is refracted.

Most receivers automatically select the most favorable signals and use them to calculate position. The most accurate GPS location readings come from satellites that are equally spaced and approximately 45 degrees above the horizon.

— Ken Sandau is a GIS specialist for the Montana Bureau of Mines and Geology in Butte and may be reached at ksandau@mtech.edu.

— How does a GPS work? Why is the sky blue? Need to know? You ask the questions and Montana Mind Expansion — a group of Butte-area professionals and lay people with expertise in all fields of science and engineering — will provide the answers. Send your most perplexing query to The Science Mine, care of The Montana Standard, Box 627, Butte 59703; or Colleen Elliott, geological engineering, Montana Tech, celliott@mtech.edu. The column runs Saturdays in The Standard.