# How GPS Works

## The GPS System

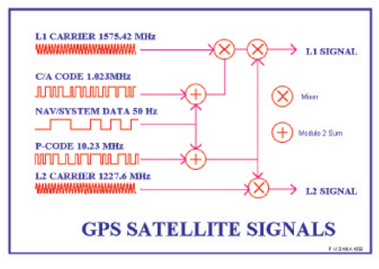
*In space:*
24 or more satellites orbit the earth twice a day at an altitude of 12000 miles. The 1st was launched in 1978, the 24th in 1994.

*On earth:*
(1) The US Air Force operates several control stations around the world.
(2) Users receive signals broadcast by the satellites. The GPS receiver calculates the user's position.

## Technical Details *(skip if you like!)*

*Carriers* are 2 sinusoids onto which the GPS codes and navigation messages (see below) are modulated:
L1 carrier: 1575.42 MHz
L2 carrier: 1227.60 MHz

*"Selective Availability", or SA,* the deliberate degradation of the signal, was turned off in May 2000.




*GPS Block II satellites :*

| | |
|---|---|
| weight | 930 kg in orbit |
| size | 5.1 m |
| speed | 4 km/sec |
| clocks | 2 cesium, 2 rubidium |
| design life | 7.5 years |
| launched | Delta rocket |

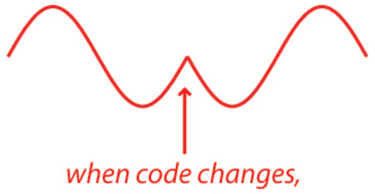
*Codes* (sequences of 0s and 1s, phase-modulated onto carriers)

C/A code, available to all, modulated onto L1 only.

Y code, encrypted and available to military users, modulated onto L1 and L2.

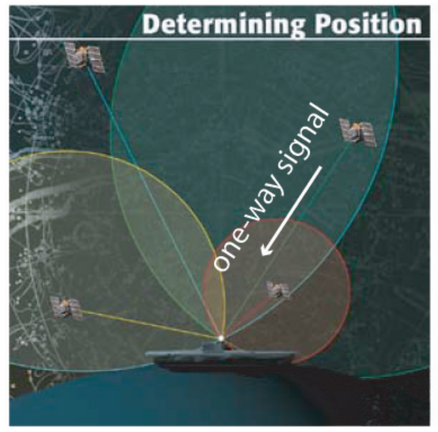
*Navigation message*: satellite positions, clock corrections, other information.

How phase modulation works:



*when code changes, multiply carrier by -1*

## How Does Your GPS Receiver Know Where You Are?



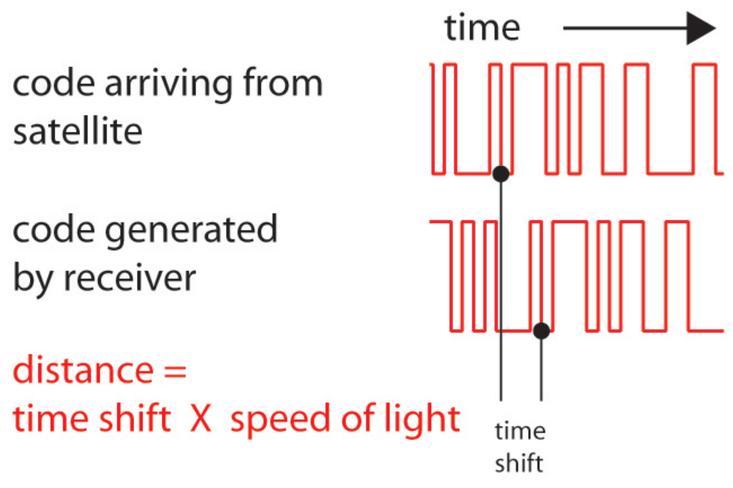

If you know where the satellites are ...

And you know how far you are from the satellites ...

**Then you know where YOU are.**

You know where the satellites are because they broadcast their positions.

You know how far you are from the satellites because the GPS code is tied to time. The receiver uses the code to measure how long it took the satellite signal to travel to the receiver.




The satellite and receiver codes are time-shifted because it takes several hundredths of a second for the signal to travel to the receiver. The receiver shifts the codes until they match.

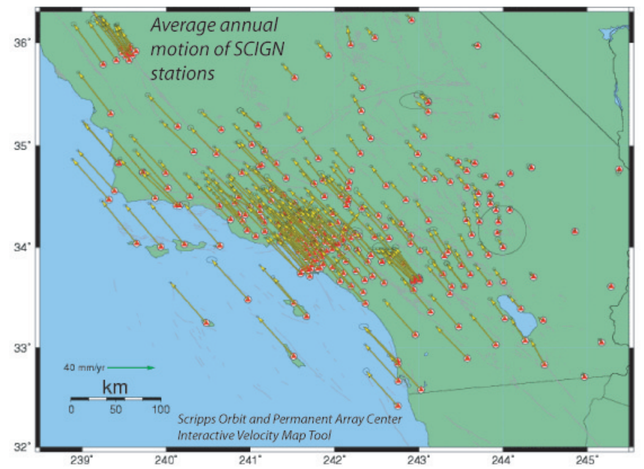
Your position is usually good to within 20 feet ...

and almost always good to within 50 feet.

## How Do Scientists Get Positions To Within a Fraction of an Inch?

SCIGN
Southern California Integrated GPS Network
www.scign.org

SCIGN is operated by: SCEC JPL USGS
Major funding for SCIGN provided by: USGS

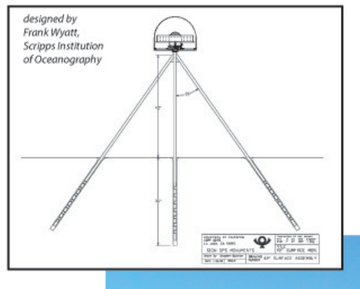



Standard GPS use gives you your position to within 50 feet or better. To measure the small motions of the earth's crust due to fault slip, scientists need much better precision. The scientists of the Southern California Integrated GPS Network (SCIGN) get precision of a few millimeters (1 mm is 1/25 inch). SCIGN achieves this by:

**More data:** SCIGN uses 24 hours of data from many stations.

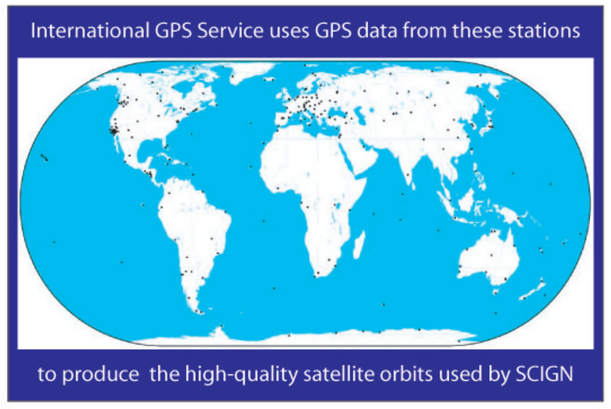
**Using more of the signal:** SCIGN uses the the wavelengths of both carriers as a ruler.

**Better monuments:** SCIGN developed an especially stable monument,




designed to minimize local motions.

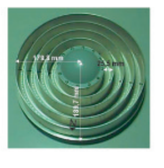
**Better methods:** Instead of using the position calculated inside the receiver, SCIGN uses software developed at MIT and JPL. This software corrects for the effects of the atmosphere, satellite and receiver clock errors, and other sources of error.



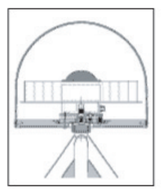

**Better orbits:** Instead of using the satellite positions broadcast by the satellites themselves, SCIGN uses high-quality orbits produced by the International GPS Service using stations all over the world.

**Better equipment:** SCIGN uses the best receivers and antennas available.

Choke-ring antenna...



...goes under dome



Geodetic-quality GPS receiver, with communication and power equipment