# Principles of GPS

# Principles of GPS..

- How the Global Positioning System works is, conceptually, really very simple
- The GPS system is based on a distance measuring (satellite ranging) system
- That means that we find 'our position' on earth by measuring our distance from a group of satellites in space

# Principles of GPS..

- Lets start with a simple example of triangulation:
- Assume that Sam's boat travels at a speed of 6 miles per hour. Sam has determined that his favorite fishing spot in the Lake is:
  - > 10 minutes from dock A
  - > 7.5 minutes from dock B, and
  - > 15 minutes from dock C

## Principles of GPS...

- The first step is to calculate how far the fishing spot is from each of the docks
- Speed of 6 miles/ hr = 0.1 miles/minute

#### • DISTANCE = SPEED X TIME

- ✓ Distance to dock A:
- 0.1miles/minute X 10 minutes = 1 mile
   ✓ Distance to dock B:
- 0.1miles/minute X 7.5 minutes = 0.75 miles
- ✓ Distance to dock C:



• 0.1miles/minute X 15 minutes = 1.5 miles





#### Principles of GPS.

From this example, we can define the steps required to locate the fishing spot as follows:

- 1. <u>Determine the time</u> required to reach the fishing spot from each of 3 boating docks on the lake
- 2. <u>Assume that the speed</u> of the boat is constant at 6 miles per hour
- 3. <u>Calculate the distance</u> in miles, from each of the three docks
- 4. <u>Locate each of the boating docks</u> already marked on the map
- 5. <u>Determine the fishing spot</u> location by drawing circles on the map around the three docks, which were equivalent to calculated distances



#### Principles of GPS.

- ✓ These are essentially the same steps a GPS receiver uses to determine its position
- In the example above, the ranging method was used to determine the location of the fishing spot in <u>2-dimensions</u> based on distances from <u>3- reference points</u>, by intersecting 3-circles at a single point
- Likewise, GPS provides positions information in three dimensions by using signals from four (or more reference points) satellites

## Principles of GPS..

- Lets have a look how GPS works
- Lets assume we are lost on the planet earth and we are trying to locate ourselves using GPS
- If we know that we are a certain distance from satellite A, say 11,000 miles, that really narrows it down where in the whole universe we can be
- It tells us we must be somewhere on an imaginary sphere that is centered on the satellite and that has a radius of 11,000 miles





#### Principles of GPS...

- By ranging from three satellites we can narrow down where we are to just two points in space
- But how do we decide which one of those two points is our true location?
- We do that by making a fourth measurement from another satellite

### Principles of GPS.

- There are other ways of deciding our true location:
- We can make an intelligent assumption, because one of the two points is a ridiculous answer. Reason: the incorrect point may not be close to the earth
- Or if you're sure of your altitude, like mariners are
- However, the computers in the GPS receivers have various mathematical techniques for distinguishing the correct point from the incorrect one

#### Principles of GPS.

In simple terms, the steps required in finding position on earth is as follows:

- 1. Determine the time required for satellite signal to reach the GPS unit/receiver
- 2. Assume that the <u>speed of light is constant</u> at 186,000 miles per second
- 3. Receiver <u>calculates the distance</u> from each of the four or more satellites
- 4. Locate each of the satellites on specified orbits
- 5. Make <u>corrections about the position</u> and read out the coordinates

#### Summary: How does GPS work?

- GPS is a Distance/Ranging system
- Operates on the <u>Principle of Trilateration</u>
- Satellites transmit unique Radio waves
- Receivers passively receive SV signal
- Receivers measure time for signal to reach it
- Distance computed by  $D = V \times T_{\Delta}$
- V = C = 300,000 Km/Sec (186,000Mi/Sec)





#### Why 4 satellites?

- Accurate positioning requires very precise measurement
- Only takes 6/100 sec. for SV signal to reach ground
  - At 300,000 Km/s
    - 1/1,000,000 sec error => 300 M Pos. error
- Satellites have very precise Atomic Clocks
- Receivers have only 'Inexpensive' Quartz clocks
- What if clock is off by just tiny fraction of a second



























Two GPS Services

SPS: Standard Positioning Services Use of only L1 Band

PPS: Precise Positioning Services
Use of both L1 and L2 Band

#### Basic GPS Signal Structure

Each Satellite Transmits On Two Frequencies

#### L1 Carrier 1575.42 MHz and L2 Carrier 1227.60 MHz

Superimposed on these carriers are Pseudo-Random, Binary, Bi-Phase Modulation Codes called PRN (*Pseudo-Random Noise*) Codes unique to each satellite

Coarse Acquisition Code (C/A-Code): Standard Positioning Precise, or Protected Code (P-Code) Precise Positioning