Principles of GPS Operation
Recap

- GNSS – Global Navigation Satellite System

- NAVSTARGPS

- 3 Segments of GPS
  - Space Segment
  - Control Segment
  - User Segment

- How Does GPS work? – Triangulation
  - Need at least 4 Satellites
  - Calculate Distance to 3 Satellites to pinpoint your location
GPS Receivers vs Mobile Devices

- GPS uses satellites
- Mobile Devices use Cell towers for triangulation
GPS Position Accuracy

- Many factors can affect the accuracy of GPS data

Significant Parameters:

- Number of visible satellites
- Satellite Geometry
- Multipath
- Satellite Clock Errors
- Ephemeris Errors
- Atmospheric Effects
- Receiver Errors
- Operator knowledge and awareness
Number of Visible Satellites

• At least 4 satellites are required

• Typically more than 7 satellites are preferred for accuracy

• Due to arrangement in the sky
HDOP (Horizontal Dilution Of Precision)

Using satellites from the 4 compass quadrants will provide a good Horizontal solution (Low HDOP).

Using satellites from only 1 or 2 quadrants will provide a poor Horizontal solution (HIGH HDOP).
VDOP (Vertical Dilution Of Precision)

Using satellites well spread out in the sky will provide a good Vertical Solution (Low VDOP).

Using only satellites which are located low on the horizon will result in a poor Vertical Solution (HIGH VDOP).
PDOP (Position Dilution Of Precision)

PDOP is the combination of both the Horizontal and Vertical components of position error caused by satellite geometry.

**PDOP Values**
- 2-4 = Excellent
- 4-6 = Good
- 6-8 = Fair
- 8-10 = Poor
- 10-12 = Marginal
- Above 12 PDOP is too high do not use
Satellite Geometry

GDOP = Geometric Dilution of Precision
Estimate of satellite conditions for a given location & time
Given in distance units (meters or feet)

Satellite Position relative to other satellites.

Ideal GDOP: One Satellite directly overhead
w/an abundance of additional satellites
spaced evenly around the sky

Poor GDOP: Satellites clustered
GOOD GDOP

15°
GOOD GDOP - BAD VISIBILITY
PDOP vs. GDOP

PDOP = *Position* Dilution of Precision (amount of *error*)
   “Good” is from 4 – 6 (< 4 is excellent, > 8 poor)
   Can be used as a tolerance setting for acceptability of signal quality (a “PDOP mask” or filter)

GDOP = *Geometric* Dilution of Precision
   Estimate of satellite conditions *for a given location & time*
   Sometimes given in *distance units* (meters or feet)

PDOP * GDOP = *Overall estimate of accuracy (distance)*
   (PDOP of 4) * (GDOP of 30’) = (Accuracy of +/- 120’)

PDOP & GDOP often used interchangeably
   Also: HDOP, VDOP, TDOP, RDOP...
      (horizontal, vertical, time, relative)
   *In all cases, smaller is better*
<table>
<thead>
<tr>
<th>DOP Value</th>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>Ideal</td>
<td>This is the highest possible confidence level to be used for applications demanding the highest possible precision at all times.</td>
</tr>
<tr>
<td>1-2</td>
<td>Excellent</td>
<td>At this confidence level, positional measurements are considered accurate enough to meet all but the most sensitive applications.</td>
</tr>
<tr>
<td>2-5</td>
<td>Good</td>
<td>Represents a level that marks the minimum appropriate for making business decisions. Positional measurements could be used to make reliable in-route navigation suggestions to the user.</td>
</tr>
<tr>
<td>5-10</td>
<td>Moderate</td>
<td>Positional measurements could be used for calculations, but the fix quality could still be improved. A more open view of the sky is recommended.</td>
</tr>
<tr>
<td>10-20</td>
<td>Fair</td>
<td>Represents a low confidence level. Positional measurements should be discarded or used only to indicate a very rough estimate of the current location.</td>
</tr>
<tr>
<td>&gt;20</td>
<td>Poor</td>
<td>At this level, measurements are inaccurate by as much as 300 meters with a 6 meter accurate device (50 DOP × 6 meters) and should be discarded.</td>
</tr>
</tbody>
</table>
GPS Position Accuracy

General Statement of Accuracy:

• Taking all of the error sources into account, GPS accuracy will be approximately 10 meters for most GPS units. However, any given position may result in accuracy as low as 5 meters or up to 40 meters.
Demo

• http://www.navcen.uscg.gov/?pageName=gps Almanacs

• http://www.trimble.com/GNSSPlanningOnline /