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:

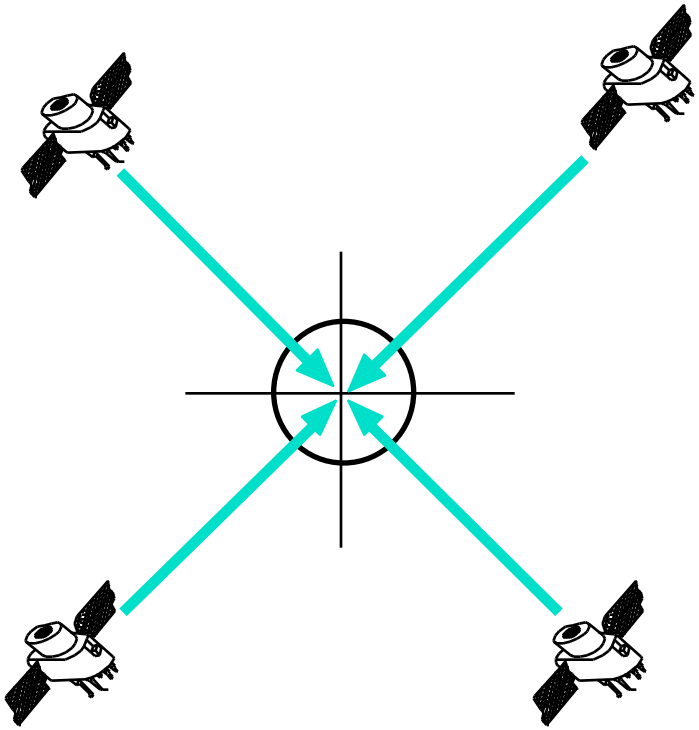
- Number of visible satellites
- Satellite Geometry
- Multipath
- Satellite Clock Errors
- Ephemeris Errors
- Atmospheric Effects
- Receiver Errors
- Operator knowledge and awareness

Number of Visible Satellites

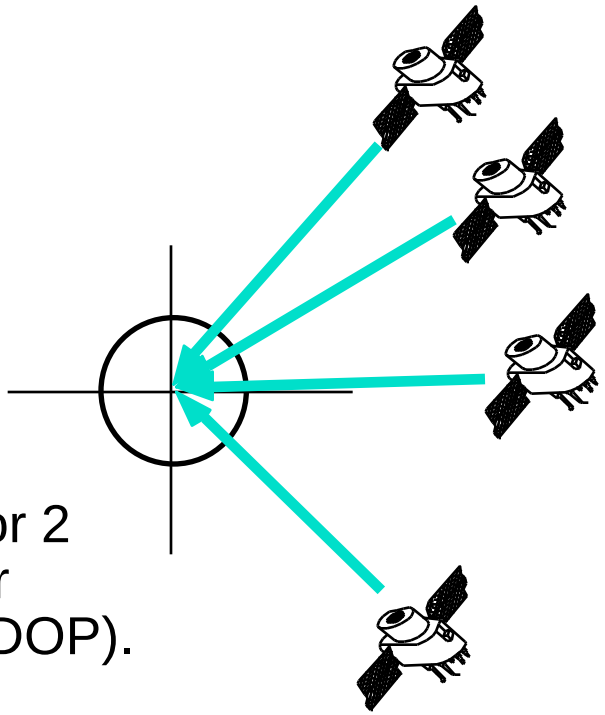
- At least 4 satellites are required
- Typically more than7 satellites are preferred for accuracy
- Due to arrangement in the sky

Satellite Geometry

HDOP (Horizontal Dilution Of Precision)



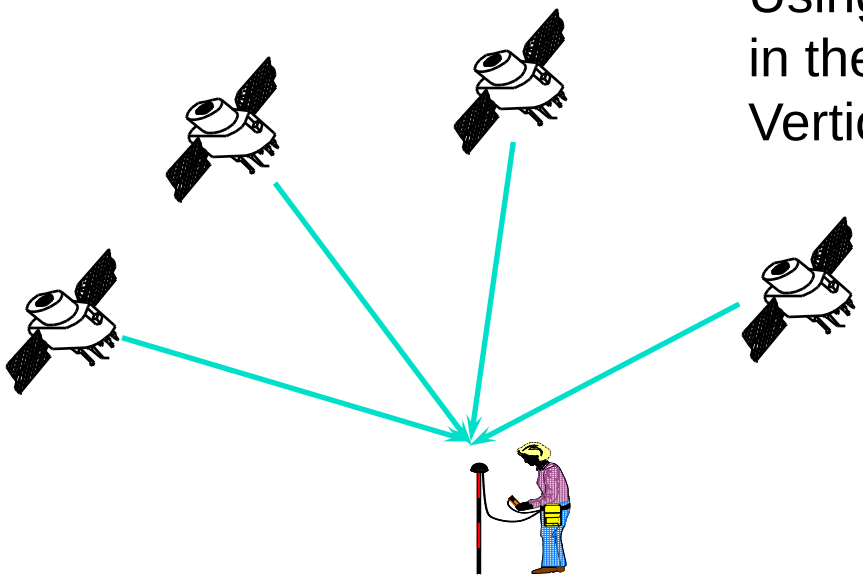
Using satellites from the 4 compass quadrants will provide a good Horizontal solution (Low HDOP)



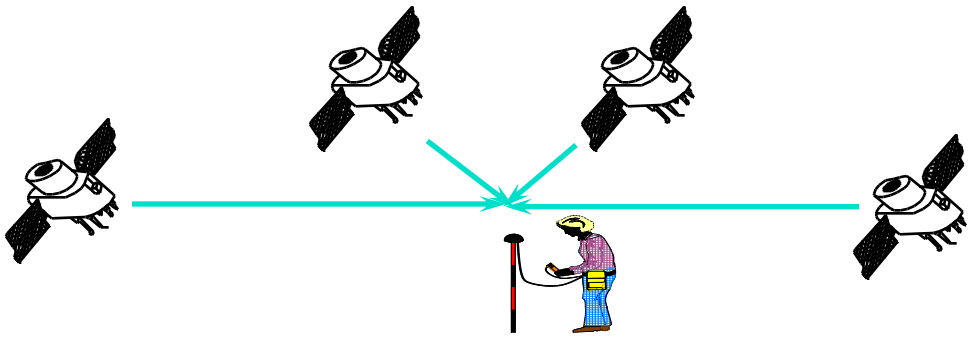
Using satellites from only 1 or 2 quadrants will provide a poor Horizontal solution (HIGH HDOP).

Satellite Geometry

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).

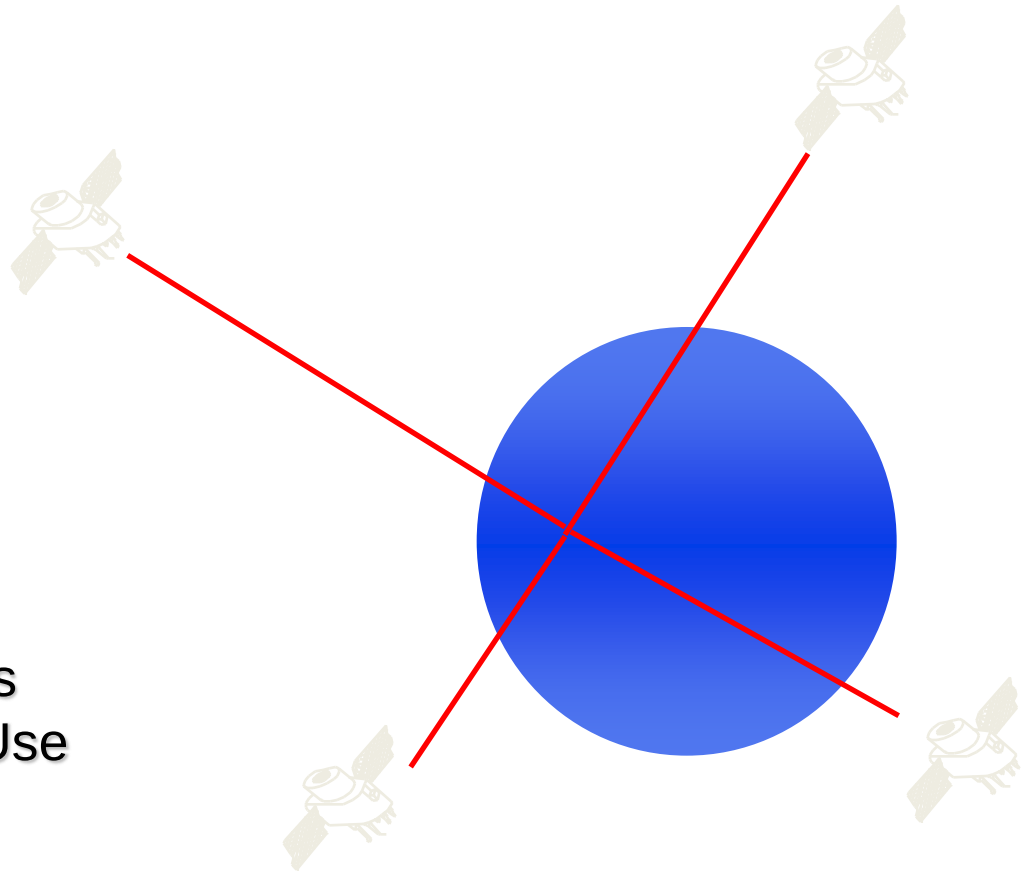
Satellite Geometry

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



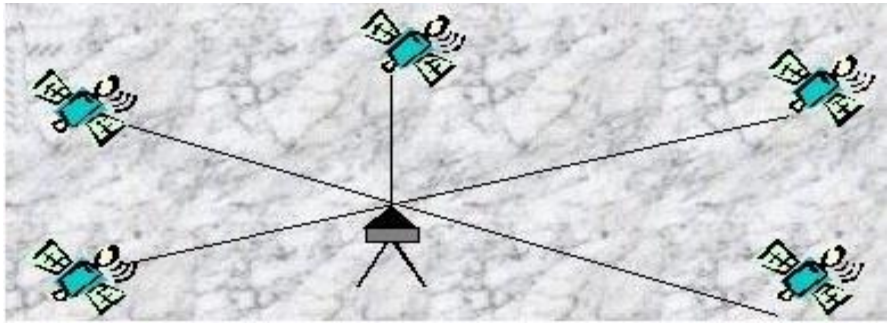
Satellite Geometry

GDOP = *Geometric* Dilution of Precision

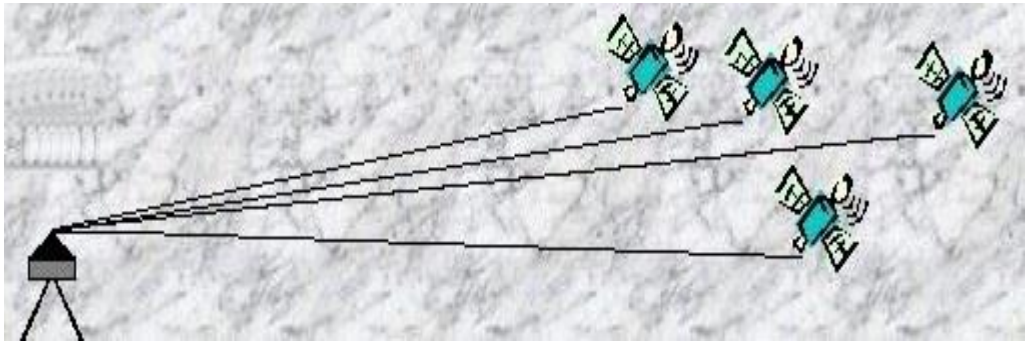
Estimate of satellite conditions *for a given location* <u>*& time*</u>

Given in *distance units* (meters or feet)

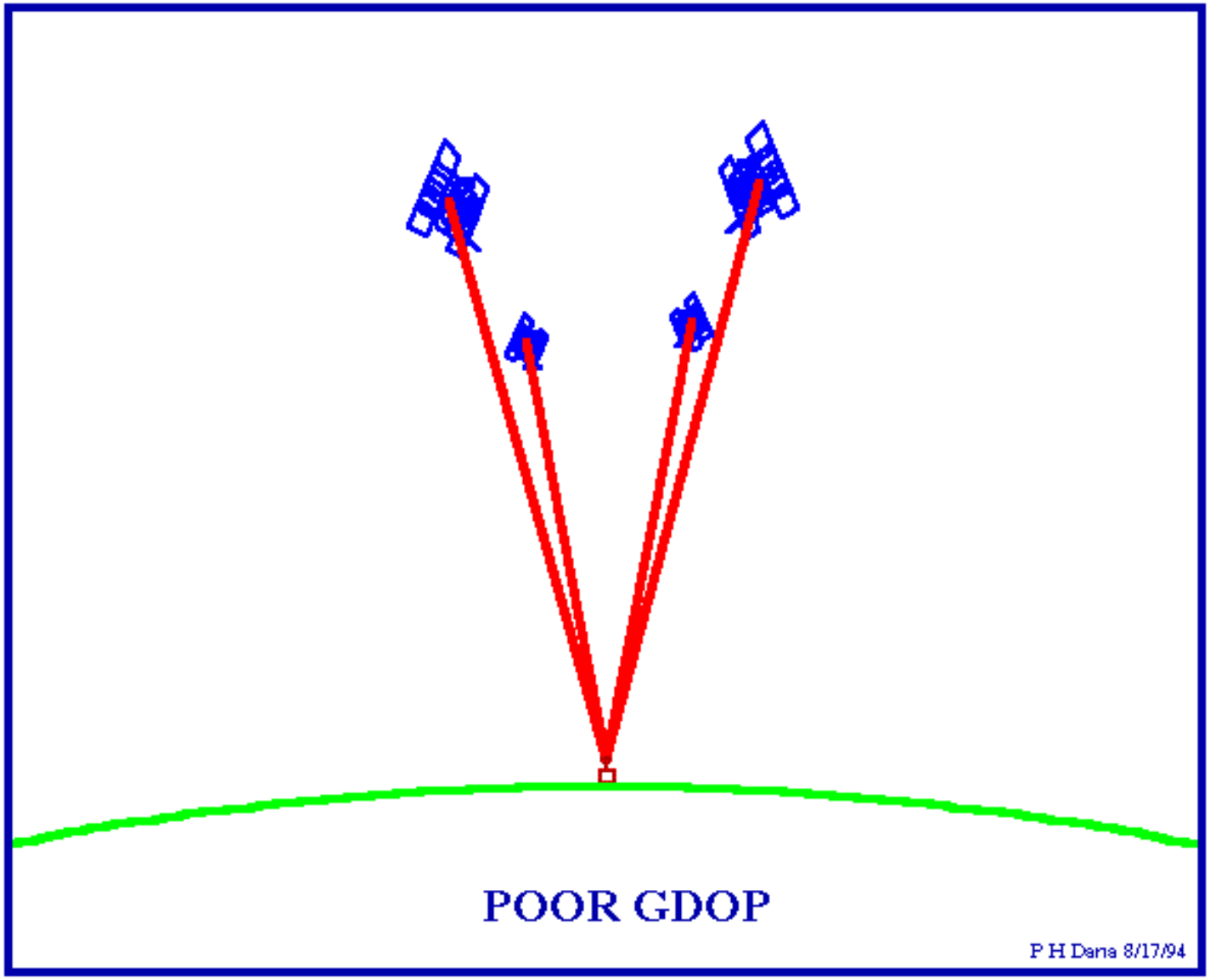
Satellite Position relative to other satellites.

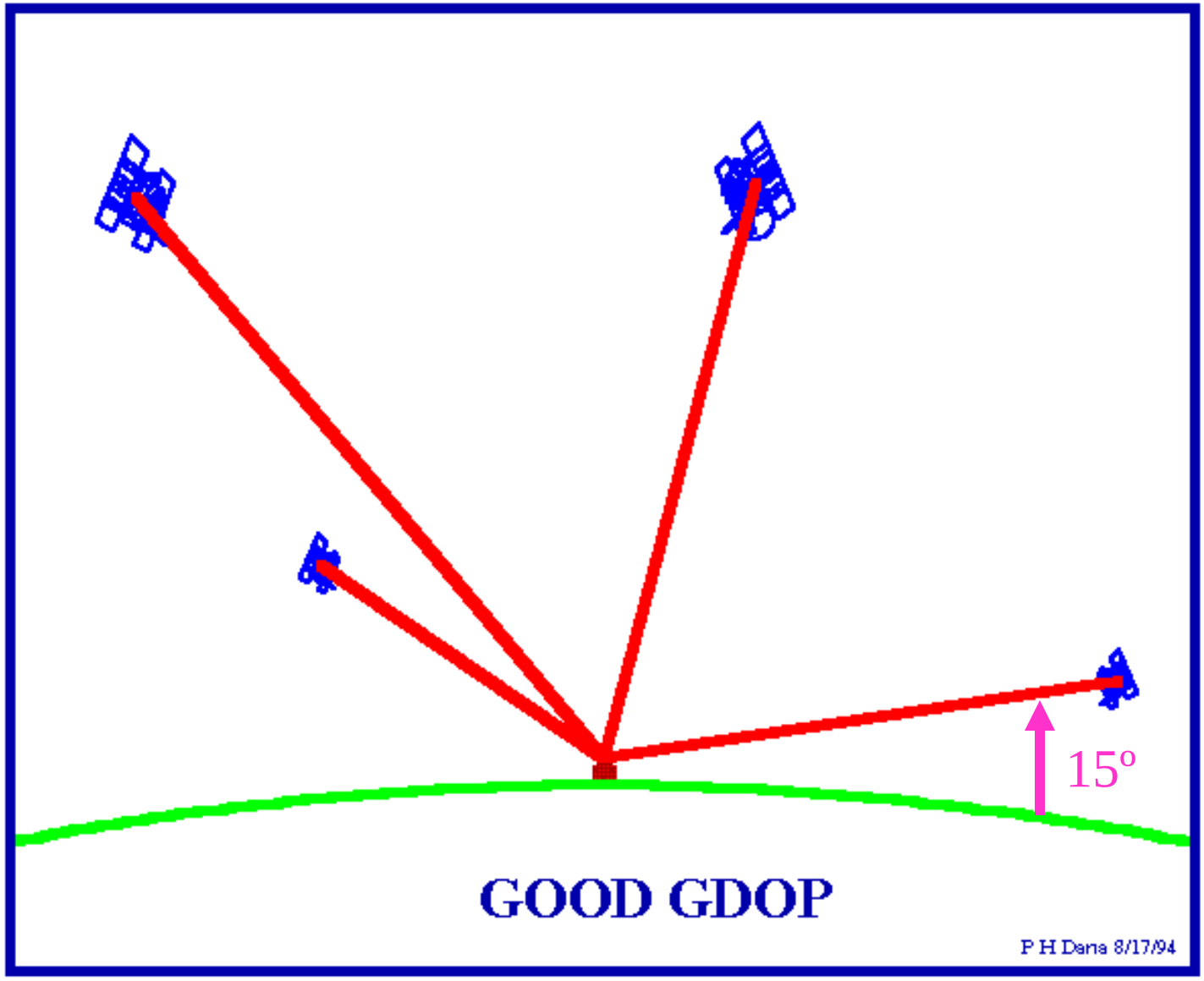


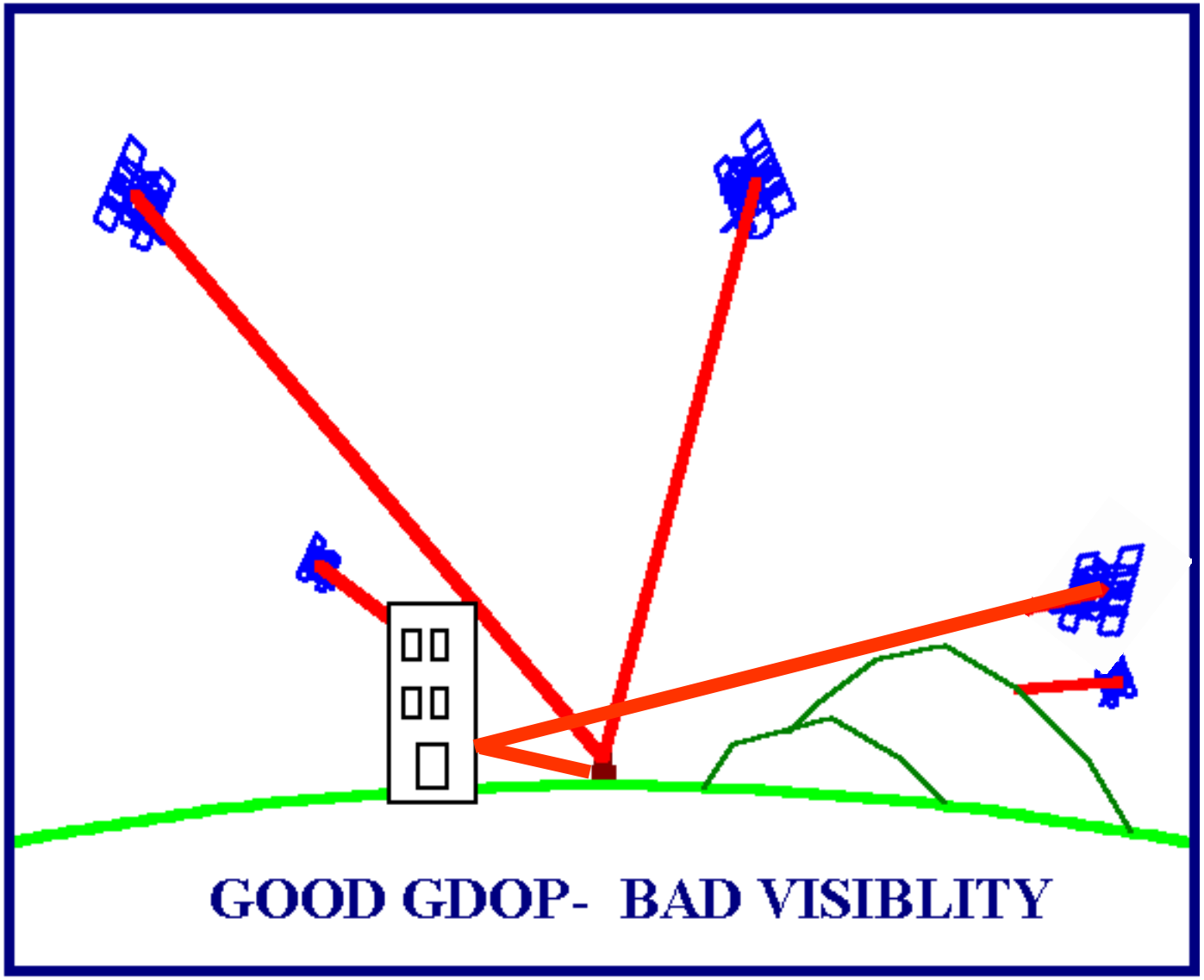
Ideal GDOP: One Satellite directly overhead w/an abundance of additional satellites spaced evenly around the sky



Poor GDOP: Satellites clustered


POOR GDOP
P H Dana 8/17/94


15°
GOOD GDOP
P H Dana 8/17/94


GOOD GDOP- BAD VISIBLITY

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* <u>*& time*</u>

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

DOP Value	Rating	Description
<1	Ideal	This is the highest possible confidence level to be used for applications demanding the highest possible precision at all times.
1-2	Excellent	At this confidence level, positional measurements are considered accurate enough to meet all but the most sensitive applications.
2-5	Good	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.
5-10	Moderate	Positional measurements could be used for calculations, but the fix quality could still be improved. A more open view of the sky is recommended.
10-20	Fair	Represents a low confidence level. Positional measurements should be discarded or used only to indicate a very rough estimate of the current location.
>20	Poor	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.

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=gpsAlmanacs
- http://www.trimble.com/GNSSPlanningOnline/