Global Positioning System

(GPS) Lectures

References

1- L.F.Wiederholt, ”GPS SYSTEM SEGMENTS “ lecturer. 2012

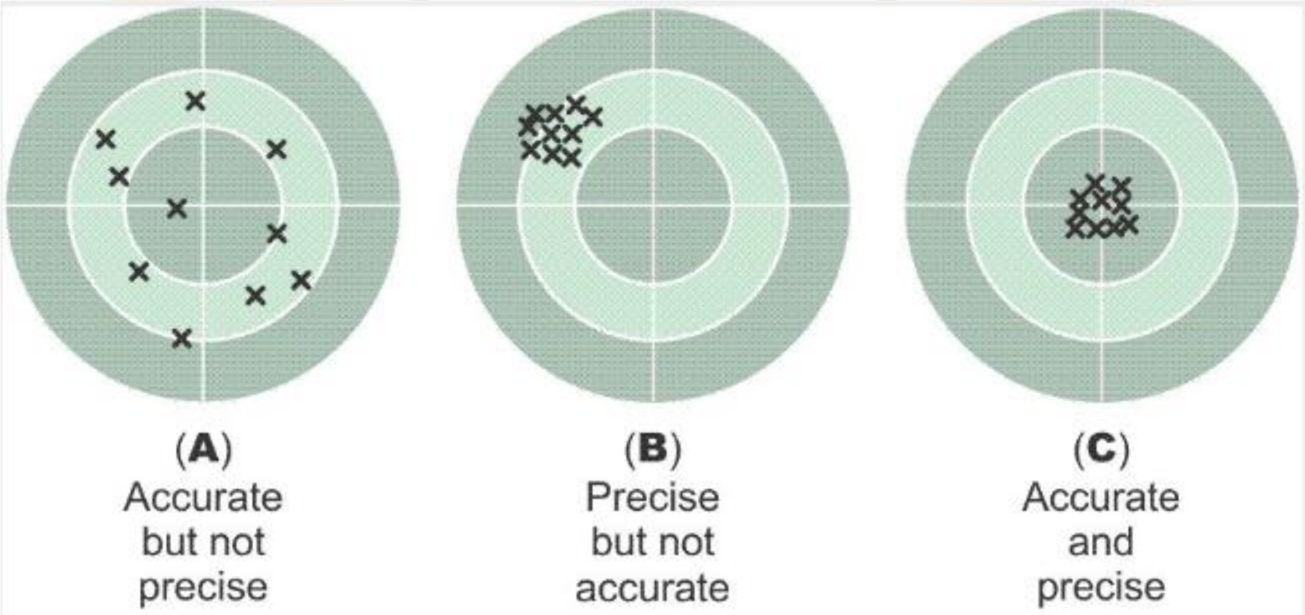
2- E. Calais,” The Global Positioning System” Purdue University - EAS Department, Civil 3273 – ecalais@purdue.edu

3- Elliott D. Kaplan,” Understanding GPS Principles and Applications” © 2006 ARTECH HOUSE, INC. 685 Canton Street, Norwood, MA

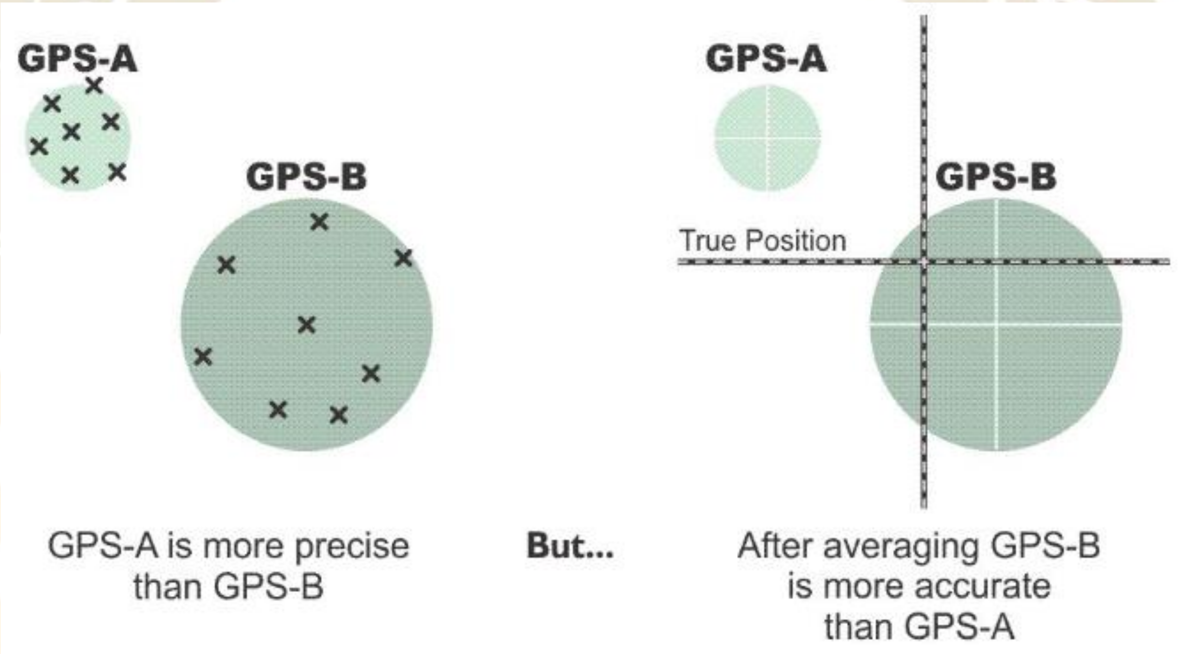
Lecture (6) GPS

Accuracy and Precision in GPS

- When planning a GPS/GNSS survey, one of the most important parameters is the ***accuracy*** specification.
- A clear accuracy goal avoids ambiguity both during and after the work is done.
- It is important to remember that there is a difference between **precision** and **accuracy**.
- The efficiency of a GNSS receiver is evaluated by the precision and accuracy it provides.
  - **Accuracy** refers to degree of closeness to **true position**, while
  - **precision** refers to closeness towards the **mean or true position**
- One aspect of **precision** can be visualized as the tightness of the clustering of measurements; the closer the grouping, the more precise the measurement.
- **Accuracy**, on the other hand, requires one more element. It has to have a *truth set.* For example, the *truth* in illustration for A, B and C is the center of the target - without that accuracy is indefinable.
- In other words, accuracy is not determined by measurement alone. There must also be a standard value or values involved is through the comparison of the measurements with such standard values that the outcome of the work can be found to be sufficiently near the ideal or *true* value, or not.



- For example, on the left in the illustration it may seem at first that the average of the measurements in the GPS-A group are more accurate than the average of those in GPS-B because the GPS-A group is more precise.
- However, when the true position is introduced on the right it is revealed that the GPS-B group's average is the more accurate of the two, because accuracy and precision are not the same. When it comes to accuracy, there are other important details too.



- Local accuracy and network accuracy are not the same.
- **Local accuracy**, also known as *relative accuracy*, represents the uncertainty in the positions relative to the other adjacent points to which they are directly connected.
- **Network accuracy**, also known as *absolute accuracy*, requires that a position's accuracy be specified with respect to an appropriate *truth* set such as a national geodetic datum.

Dilution of Precision (DOP)

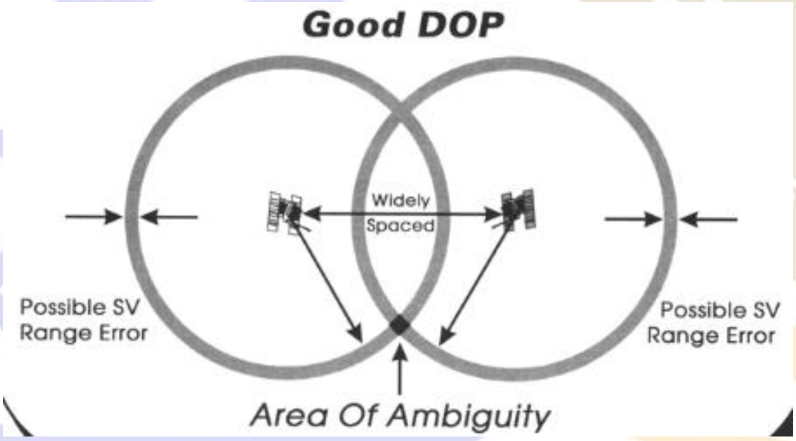
- The Dilution of Precision (DOP) is, in turn, a measure of the geometry of the visible satellite constellation.
- Dilution of Precision (DOP) reflects each satellite's position relative to the other satellites being accessed by a receiver.
- It describes sensitivity of receiver to changes in the geometric positioning of the SVs. The higher the DOP value, the poorer the measurement.
- The cumulative UERE (User Equivalent Range Error) totals are multiplied by a factor of usually 1 to 6, which represents a value of the *Dilution of Precision*, or DOP.
- A low numeric Dilution of Precision value represents a good satellite configuration, whereas a higher value represents a poor satellite configuration.

QUALITY	DOP
Very Good	1-3
Good	4-5
Fair	6
Suspect	>6

- A DOP value of less than 2 is considered excellent-about as good as it gets, but it doesn't happen often, usually requiring a clear view of the sky all the way to the horizon.
- DOP values of 2 to 3 are considered very good.
- DOP values of 4 or below are frequently specified when equipment accuracy capabilities are given.
- DOP values of 4 to 5 are considered fairly good and would normally be acceptable for all but the highest levels of survey precision requirements.
- A DOP value of 6 would be acceptable only in low precision conditions, such as in coarse positioning and navigation. Position data generally should not be recorded when the DOP value exceeds 6.

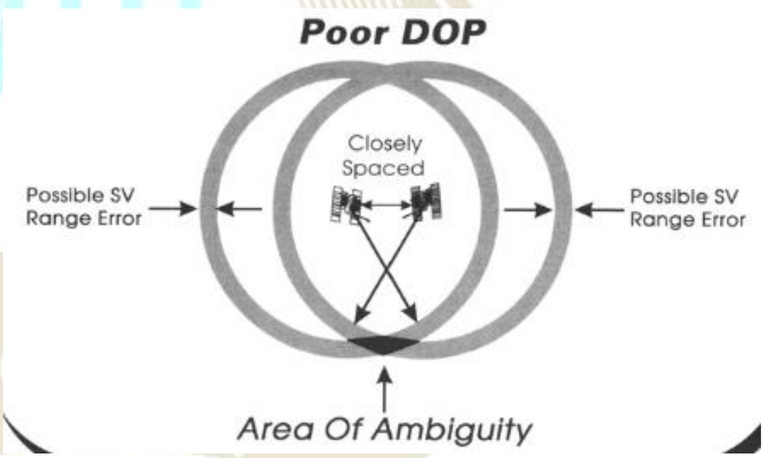
- The ideal orientation of four or more satellites would be to have them equally spaced all around the receiver, then the fix should be highly accurate. But if all four are observed in close proximity to each other within a single quadrant, then the fix will be less accurate.
- The lower diagram illustrates the best orientation. That is, to have one satellite directly above and the other three evenly spaced around the receiver and elevated to about 25 to 30 degrees (to help minimize atmospheric refraction). This would result in a very good DOP value.
- Also, when the satellites are widely spaced, the overlap area of the two zones of possible satellite range error is relatively small, called the *"area of positional ambiguity."*

Navigation satellites with good geometry for geometric dilution of precision (GDOP).



- The lower diagram illustrates poor satellite geometry. In this case, all of the satellites are clustered together. This would result in a poor or high DOP value.
- The true position is somewhere in the area where the two "fuzzy position" range zones overlap (indicated in the diagram as a small diamond). However, in this case, the area of ambiguity is large.

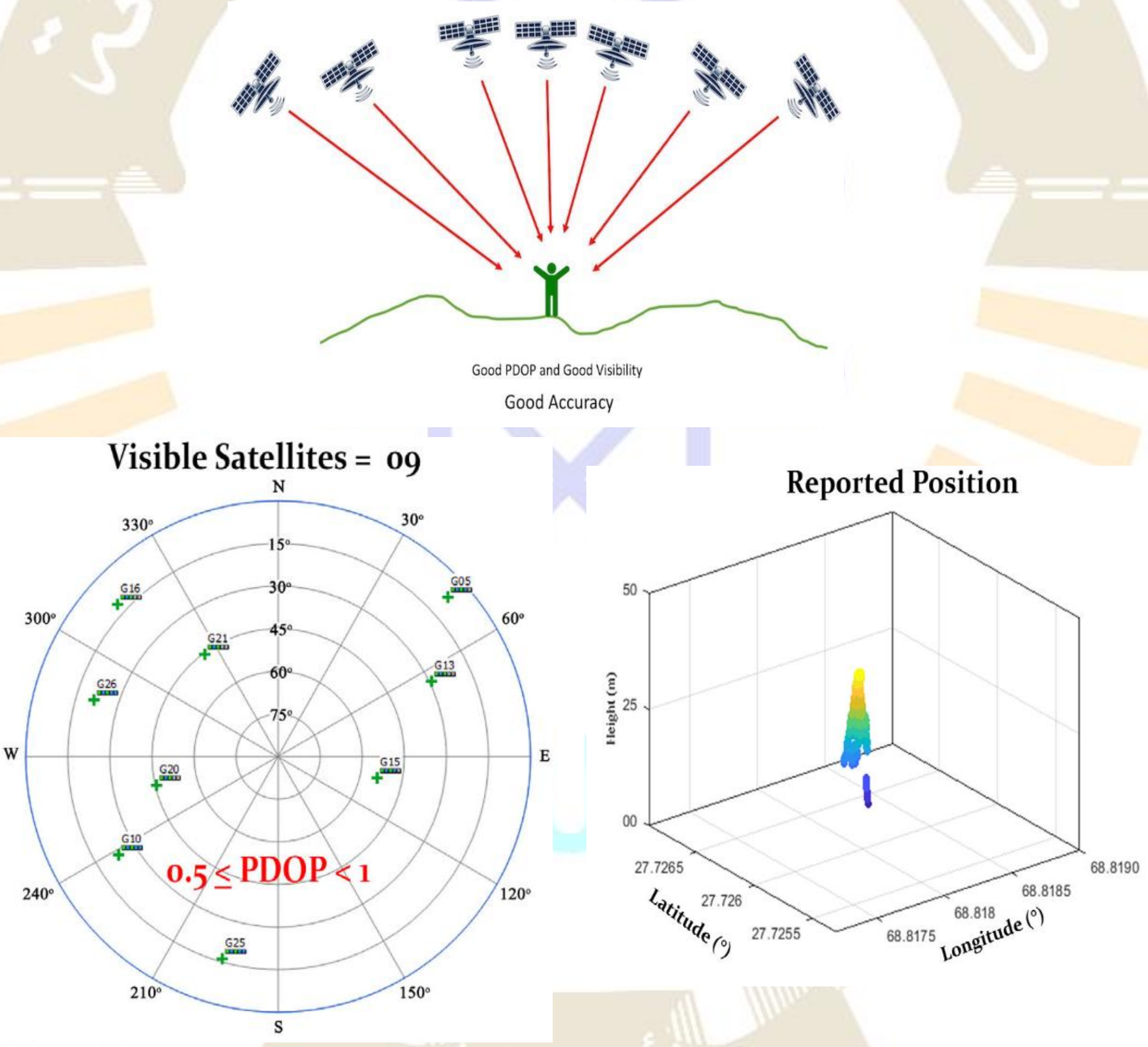
Navigation satellites with poor geometry for geometric dilution of precision (GDOP).



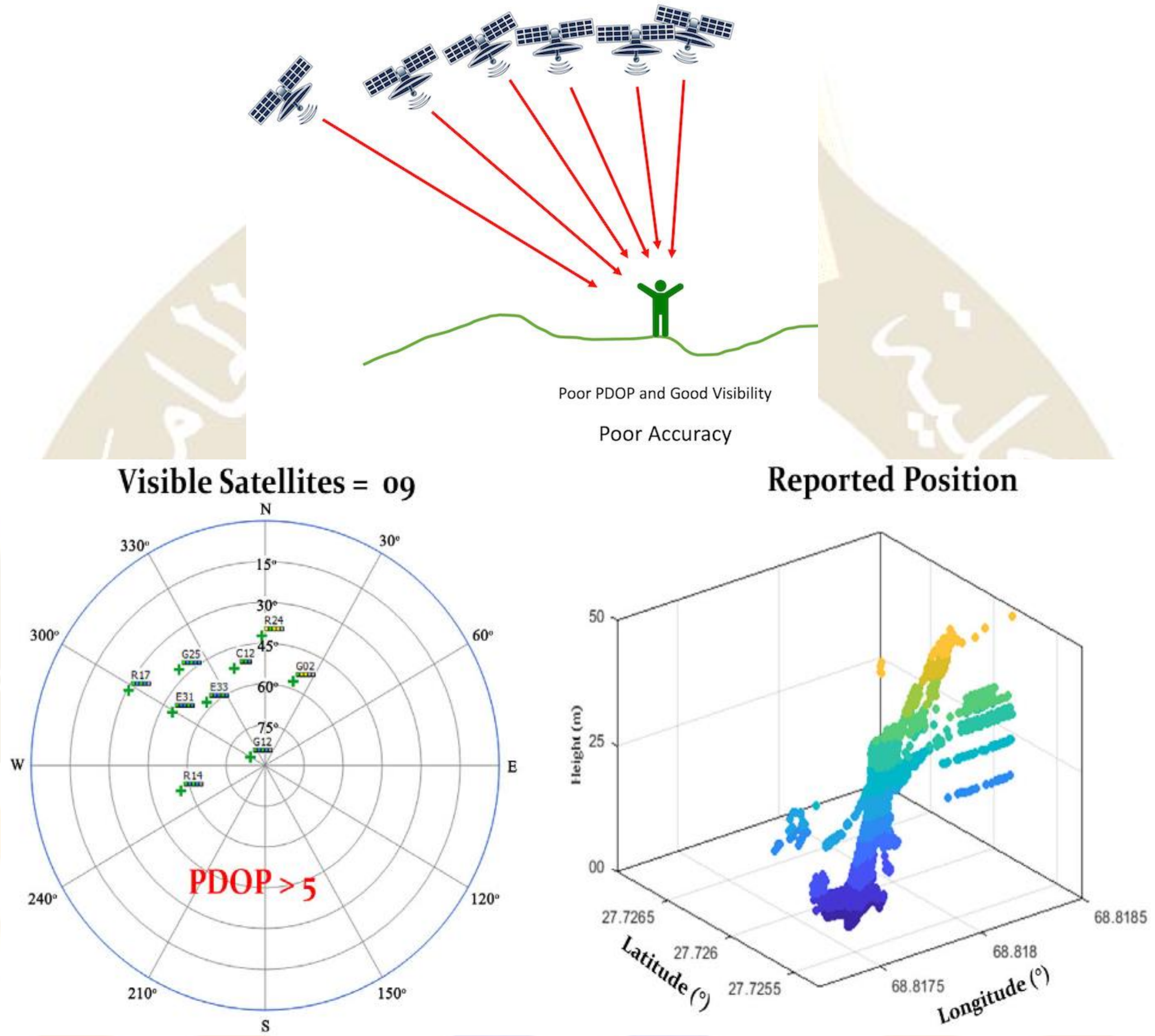
Types of Dilution of Precision (DOP)

There are five different types of dilution of precision that effects differently on the accuracy of a receiver:

1. Geometric Dilution of Precision (GDOP).
2. Positional Dilution of Precision (PDOP) is the DOP value used most commonly in GPS to determine the quality of a receiver's position. PDOP**,** or *Precision Dilution of Precision*, probably the most commonly used, which is the dilution of precision in three dimensions. Sometimes called the *Spherical DOP*.



(a) Satellites spread apart in the sky, enclosing more volume resulting in Good Satellite Geometry.



(b) Satellites spread apart in the sky, enclosing less volume resulting in Poor Satellite Geometry

Figure. Effect of satellite geometry on accuracy of position estimation.

3. Horizontal Dilution of Precision (HDOP) is the dilution of precision in two dimensions horizontally. This value is often lower (meaning “better”) than the PDOP because it ignores the vertical dimension.
4. Vertical Dilution of Precision (VDOP) is the dilution of precision in one dimension, the vertical.
5. Time Dilution of Precision (TDOP) is the dilution of precision with respect to time. The DOP at any given moment will change with time as the satellites move along their orbits.

Example:

At the offset location, you acquired the GPS reading of

N 38.8760 and W 94.7990.

You took the reading 77 meters north of the Study Site.

Solution:

1) 77 meters / (11m/.0001degrees) = .0007 degrees

2) Your corrected latitude is N 38.8760 - .0007 = N 38.8753 degrees

3) Your GPS measurement of the Study Site would then be recorded as

N 38.8753 and W 94.7990.

(Remember to reverse the addition or subtraction if you are in the southern hemisphere.)

At this point give the participants the field guides and data collection sheets, go outside, and let them practice the measurements.

If your receiver records to five decimal places, please record the degrees to the nearest 0.00001.