Module 8

Modern Navigation Systems

Sextant Navigation

Module 8B
Dilution of Precision

Summary of Module 8

- Students will use simulated and/or actual measurements of the angles of three or more stars above the horizon to determine their position on the surface of the earth at a known instant in time. (8A)
- The Equation of Time will be Introduced (8B)
- **The concept of dilution of precision will be introduced and linked to the least squares algorithms developed earlier. (8C)**

Reading/viewing

- Read the primary text by Kayton & Fried, in particular section 2.8.2 and all of the pages cited in the index under the topic of GDOP

Amplification of measurement error

- There is a “lever arm” effect when a measurement of angle, distance, time delay, etc. is converted into an estimate of a different parameter.
- For example, measurement of the north star gives good information about one’s latitude, but even a tiny measurement error causes an estimate of longitude inferred from this to be greatly in error
- Likewise, measurements of the sun provide good, but not “great” estimates of latitude.

Dilution of precision

- This effect is called “dilution of precision”
- It comes in several flavors, particularly for GPS:
  - Horizontal dilution of precision (HDOP)
  - Vertical dilution of precision (VDOP)
  - Position dilution of precision (PDOP)
  - Time dilution of precision (TDOP)

DOP is characterized by standard deviations and variances

coordinates, then, by definition, the position dilution of precision is

$$(\text{PDOP})^2 = \frac{\sigma_x^2 + \sigma_y^2 + \sigma_z^2}{\sigma_R^2} \tag{2.33}$$

and the horizontal dilution of precision (HDOP) is

$$(\text{HDOP})^2 = \frac{\sigma_x^2 + \sigma_y^2}{\sigma_R^2} \tag{2.34}$$

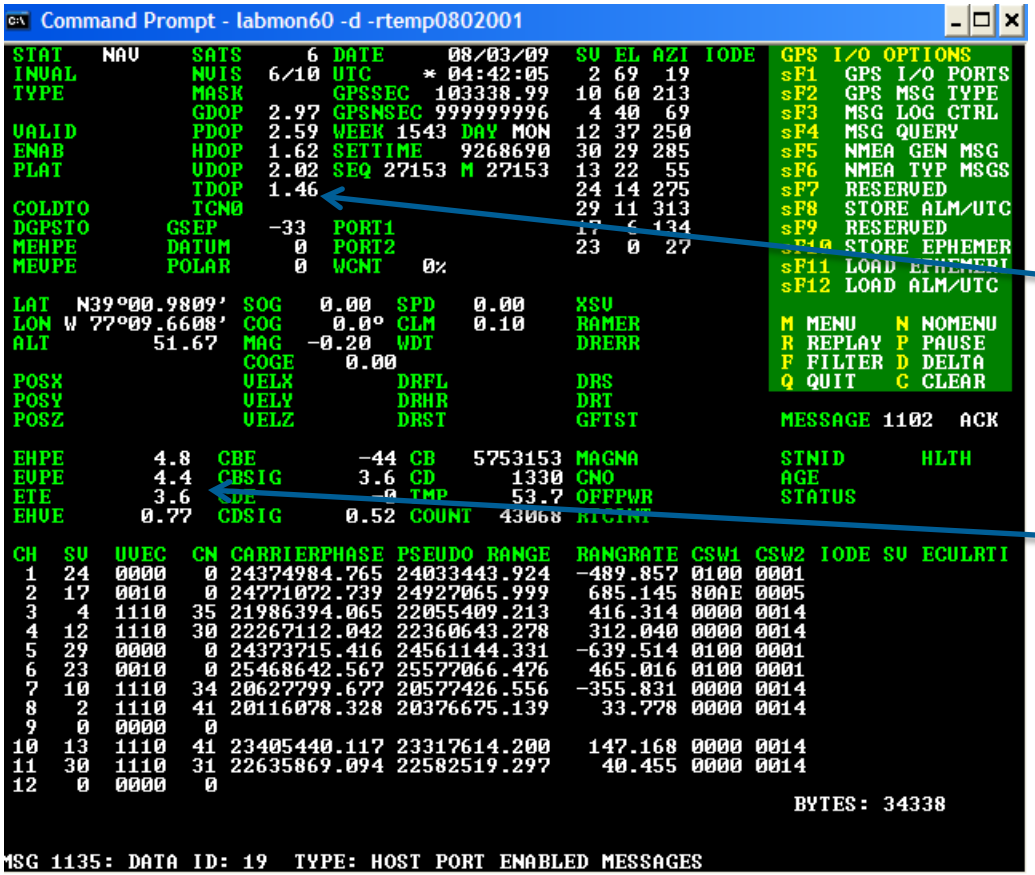
In pseudoranging systems, the GDOP is

$$(\text{GDOP})^2 = (\text{PDOP})^2 + (\text{TDOP})^2$$

where TDOP is the time dilution of precision, the contribution of clock error to the error in pseudorange. Equations for GDOP, PDOP, and HDOP, when the standard deviations in range to each station are different, are provided in [12].

From the text. Note that the variances for independent measurements add according to the Pythagorean theorem.

As will be seen in a future module, GPS receivers "report" DOP



The various DOPs estimated by GPS

The corresponding position errors.

Assignment 8.3

1. In navigation problems, it is common to divide by the sine or cosine of an angle. For a 1% measurement error in the measurement of θ, plot the corresponding estimation error in the function $f(\theta) = 1/\cos(\theta)$ for $0 < \theta < 90$ degrees.

End of Mod 8C