

## 20. Dilution of Precision



The arrangement of satellites in the sky also affects the accuracy of GPS positioning. The ideal arrangement (of the minimum four satellites) is one satellite directly overhead, three others equally spaced near the horizon (above the mask angle). Imagine a vast umbrella that encompasses most of the sky, where the satellites form the tip and the ends of the umbrella spines.

GPS coordinates calculated when satellites are clustered close together in the sky suffer from **dilution of precision** (DOP), a factor that **multiplies the uncertainty associated with User Equivalent Range Errors** (UERE - errors associated with satellite and receiver clocks, the atmosphere, satellite orbits, and the environmental conditions that lead to multipath errors). The DOP associated with an ideal arrangement of the satellite constellation equals approximately 1, which does not magnify UERE. According to Van Sickle (2001), the lowest DOP encountered in practice is about 2, which doubles the uncertainty associated with UERE.

GPS receivers report several components of DOP, including Horizontal Dilution of Precision (HDOP) and Vertical Dilution of Precision (VDOP). The combination of these two components of the three-dimensional position is called PDOP - position dilution of precision. A key element of GPS mission planning is to identify the time of day when PDOP is minimized. Since satellite orbits are known, PDOP can be predicted for a given time and location. Various software products allow you to determine when conditions are best for GPS work.

MGIS student Jason Setzer (Winter 2006) offers the following illustrative anecdote:

*I have had a chance to use GPS survey technology for gathering ground control data in my region and the biggest challenge is often the PDOP (position dilution of precision) issue. The problem in my mountainous area is the way the terrain really occludes the receiver from accessing enough satellite signals.*

*During one survey in Colorado Springs I encountered a pretty extreme example of this. Geographically, Colorado Springs is nestled right against the Rocky Mountain front ranges, with 14,000 foot Pike's Peak just west of the city. My GPS unit was easily able to 'see' five, six or even seven satellites while I was on the eastern half of the city. However, the further west I traveled, I began to see progressively less of the constellation, to the point where my receiver was only able to find one or two satellites. If a 180 degree horizon-to-horizon view of the sky is ideal, then in certain places I could see maybe 110 degrees.*

*There was no real work around, other than patience. I was able to adjust my survey points enough to maximize my view of the sky. From there it was just a matter of time... Each GPS bird has an orbit time of around twelve hours, so in a couple of instances I had to wait up to two hours at a particular location for enough of them to become visible. My GPS unit automatically calculates PDOP and displays the number of available satellites. So the*

### The Nature of Geographic Information

 

### Chapters

- ▶ Chapter 1: Data and Information
- ▶ Chapter 2: Scales and Transformations
- ▶ Chapter 3: Census Data and Thematic Maps
- ▶ Chapter 4: TIGER, Topology and Geocoding
- ▼ Chapter 5: Land Surveying and GPS
  - 1. Overview
  - 2. Geospatial Data Quality
  - 3. Error and Uncertainty
  - 4. Systematic vs. Random Errors
  - 5. Survey Control
  - 6. Measuring Angles
  - 7. Measuring Distances
  - 8. Horizontal Positions
  - 9. Traverse
  - 10. Triangulation
  - 11. Trilateration
  - 12. Vertical Positions
  - 13. Global Positioning System
  - 14. Space Segment

*PDOP value was never as low as I would have liked, but it did drop enough to finally be within acceptable limits. Next time I might send a vendor out for such a project!*

## Try This!

Trimble, a leading manufacturer of GPS receivers, offers an online GPS mission planning interface. This activity will introduce you to the capabilities of the interface and will prepare you to answer questions about GPS mission planning later.

The online tool that you will use in this exercise requires that Microsoft Silverlight be installed on your machine. Silverlight does not run under all Web browsers. If you do not have Silverlight installed for the browser you are using you be prompted to install it.

1. Visit the [Trimble website](#).  
Hover your mouse cursor over *Support & Training*, and click on **Support A-Z**.
2. In the list of *Support Products A-Z*, find and click on the **Planning Software** link.
3. On the *Planning Software* page that you land on, follow the **Trimble GPS Data Resources** link.

In the next step, you may be prompted to install Microsoft Silverlight.  
If you are prompted to install Silverlight, go ahead and do so. There are Windows and Mac versions. The software will download, and then you will need to install it. Use the *Run as Administrator* option to do so. If the installation process comes back with a message that Silverlight is already installed, the implication is that you have more than one browser app installed on your machine and you just need to open the one that Silverlight is associated with. Chances are that it is Internet Explorer that you need to use.

4. On the *GPS Data Resources* page, follow the **GNSS Planning Tool** link.  
The **GNSS Planning Online** interface will open. You will land on the *Settings* page.
5. Go ahead and enter at least longitude and latitude information for a location you are interested in.  
You can also use the **Pick** button to interactively select a location. After you pick a location from the map, click the **Apply** button.
6. Change or take note of the other setting in the *Settings* dialog window.
7. Click the *Settings* window **Apply** button.  
Your settings will be processed. Then you can click on any of the other buttons along the left side of the interface.

For example, the **Satellite Library** button gives you access to the satellites in the various GPS systems that exist. You can choose the satellites you want to use. Clicking on a satellite entry from one of the system lists will bring up its almanac information.

8. Click the **DOPs** button. This allows you to see how the various sources of Dilution of Precision vary throughout the time period that was specified on the *Settings* page.  
Can you determine the best and worst times of day for GPS work?
9. Spend some time investigating what the other buttons allow you to investigate.

- 15. Control Segment
- 16. User Segment
- 17. Satellite Ranging
- 18. GPS Error Sources
- 19. User Equivalent Range Errors
- **20. Dilution of Precision**
- 21. GPS Error Correction
- 22. Differential Correction
- 23. Real-Time Differential Correction
- 24. Post-Processed Differential Correction
- 25. Summary
- 26. Bibliography

► [Chapter 6: National Spatial Data Infrastructure I](#)

► [Chapter 7: National Spatial Data Infrastructure II](#)

► [Chapter 8: Remotely Sensed Image Data](#)

► [Chapter 9: Integrating Geographic Data](#)

---

## Navigation

- [login](#)
- [Search](#)

Trimble's GNSS Planning Online tool is not a teaching tool; you will not find a Help button that links to explanations of the functionality. The planning tool is aimed at users already versed in the terminology and technology.



This textbook is used as a resource in Penn State's Online Geospatial Education online degree and certificate programs. If this topic is interesting to you and you want to learn more about online GIS and GEOINT education at Penn State, check out our [Geospatial Education Program Office](#).

◀ 19. User Equivalent Range Errors

up

21. GPS Error Correction ▶

Author: David DiBiase, Senior Lecturer, John A. Dutton e-Education Institute, and Director of Education, Industry Solutions, Esri. Instructors and contributors: Jim Sloan, Senior Lecturer, John A. Dutton e-Education Institute; Ryan Baxter, Senior Research Assistant, John A. Dutton e-Education Institute, Beth King, Senior Lecturer, John A. Dutton e-Education Institute and Assistant Program Manager for Online Geospatial Education, and Adrienne Goldsberry, Senior Lecturer, John A. Dutton e-Education Institute; College of Earth and Mineral Sciences, The Pennsylvania State University.

Penn State Professional Masters Degree in GIS: Winner of the 2009 Sloan Consortium award for Most Outstanding Online Program

This courseware module is offered as part of the Repository of Open and Affordable Materials at Penn State.

Except where otherwise noted, content on this site is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

The College of Earth and Mineral Sciences is committed to making its websites accessible to all users, and welcomes comments or suggestions on access improvements. Please send comments or suggestions on accessibility to the site editor. The site editor may also be contacted with questions or comments about this Open Educational Resource.



The John A. Dutton Institute for Teaching and Learning Excellence is the learning design unit of the College of Earth and Mineral Sciences at The Pennsylvania State University.

#### Navigation

- Home
- News
- About
- Contact Us
- People
- Resources
- Services
- Login

#### EMS

- College of Earth and Mineral Sciences
- Department of Energy and Mineral Engineering
- Department of Geography
- Department of Geosciences
- Department of Materials Science and Engineering
- Department of Meteorology and Atmospheric Science
- Earth and Environmental Systems Institute
- Earth and Mineral Sciences Energy Institute

#### Programs

- Online Geospatial Education Programs
- iMPS in Renewable Energy and Sustainability Policy Program Office
- BA in Energy and Sustainability Policy Program Office

#### Related Links

- Penn State Digital Learning Cooperative
- Penn State World Campus
- Web Learning @ Penn State



2217 Earth and Engineering Sciences Building, University Park, Pennsylvania, 16802  
Contact Us

Privacy & Legal Statements | Copyright Information  
The Pennsylvania State University ©  
2023