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*

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> *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 on 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.

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.

PENNSTATE

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 ›

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