A Cost/Benefit Analysis of Spatially Processed GNSS Signals under Different Conditions of Geometrical Dilution of Precision (GDOP)

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One way to increase positional accuracy is to reduce multipath error that comes from low elevation satellites that are more prone to consist of multipath signals as a result of reflection and/or diffraction. These signals from low elevation satellites can be ignored by spatial processing antennas that are designed to mitigate or cut off signals that are not from higher elevations. However satellites that are clustered together at high elevations will add to Geometrical Dilution of Precision (GDOP). In this paper, the cost/benefit analysis of using overhead satellites is being studied using a simple model.

From literature (Richard Langely, GPS World, May 1999) when four satellites when one satellite at the zenith, and three others are equally spaced azimuthally forming a tetrahedron (Fig. 1), then the volume of this tetrahedron is highly correlated with the geometric dilution of precision (GDOP). Larger volumes make for smaller GDOP. Assuming θ is the angle that the azimuthally placed satellites make with the receiver located at the center of the sphere, one can correlate GDOP values with this angle. From simple analysis it can be shown for this case that $GDOP = \frac{1.732}{\left(\cos(\theta)\right)^3}$ (1.732 is the minimum GDOP value when the 3 satellites are sitting on the horizon). The $GNSS$ position error = UERE $\times$ GDOP where UERE is the user equivalent range error that combines receiver noise, satellite clock and ephemeris error, and multipath error. UERE is dominated by multipath error if ionospheric affects are removed by systems such as dual-frequency precise positioning systems. Using an intuitive approach, where the multipath error at an angle close to the horizon is most severe, then we can write, $UERE = (a + b \times (\frac{\pi}{2} - \theta))$ meters, where the θ dependent part is the multipath component leaving ‘a’ as the non-multipath component. Therefore the GNSS position error $= (a + b \times (\frac{\pi}{2} - \theta)) \times \frac{1.732}{(\cos(\theta))^3}$. It has been shown that with careful control of multipath, using reasonable weights for ‘a’ and ‘b’, that overhead satellites do not pose an unacceptable tradeoff with GDOP increases.

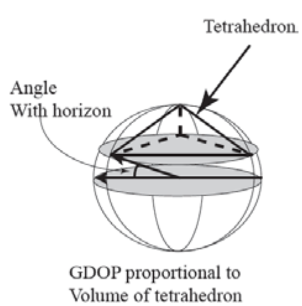

Figure 1. Tetrahedron formed by one satellite at zenith three others equally spaced azimuthally..