Proper Weighting of Your GPS Data is Important

GPS observation equations are (sufficiently) known and well-docurnented. However, the same can not yet be said of the variance-covariance (VC-) matrix of GPS observations. In the many available GPS-textbooks are to be found only few comments, if any, on the VC-matrix of GPS observations. Advertisement or data sheets for GPS receivers are also usually vague in their specifications concerning precision characteristics of the data output by the receiver.

The Weight Matrix

Due to this lack of information in the public domain, one is inclined as user to begin with the simplest weight matrix possible. Such a choice may, however, represent an oversimplification that fails to do justice to the more complicated noise characteristics of the data. The choice of weights is optimal when the weight matrix equals the inverse of the VC-matrix of the observations. In this case, the balance between the relative weights is such that the best possible precision is obtained in the computed solution. A proper choice of the VC-matrix is of importance for other stages of data processing as well. For instance, the detection power of statistical tests, employed for model validation and quality control, will be reduced when noise characteristics are not properly taken into account. Also the *a posteriori* quality description of the computed results will be affected when misspecified or oversimplified VC-matrices are used.

What Are the Issues?

Experience has shown that the main effects one has to reckon with when constructing a GPS VC-matrix are: frequency dependence (data of the same type, but of different frequency may have significantly different noise levels), satellite elevation dependence (for a large part caused by the gain-pattem of the receiver antenna), cross-correlation (dependent upon the receiver mechanisation of the measurement process) and time-correlation (dependent upon the configuration of the receiver firmware). Exaggeration of the information content of data will occur as a result of the neglecting of significant cross-correlation or time-correlation. For instance, a receiver is not a truly dual-frequency receiver when its data shows significant cross-correlation between the frequencies. Also, the very high rates at which some receivers are capable of outputting their data is no guarantee that the data is free from time-correlation.

A Plea

Research into the stochastic modelof GPS observables is at present still in its infancy. Only a few studies have been reported in the literature. Of course, a systematic study of the stochastic model is far from trivial. Not only do the noise characteristics depend upon the mechanisation of the measurement process, and therefore on the make and type of the receiver used, but residual terms not captured by the observation equations, such as environmental effects, will also have their influence. However, despite these difficulties we believe that the time has come to put more effort into the stochastic model and to try to come up with a-more qualitative description of noise characteristics. Any such study should represent a joint effort on the part of users, researchers and manufacturers.
Users should be aware of the pitfalls involved and manufacturers should be more forthcoming in the quality description concerning their data, while researchers should develop independent methods for bench-marking the quality of such data. By directing attention to noise characteristics and sharing the knowledge so obtained it should hopefully become possible more firmly to establish links between the stochastic model and individual user data.

Prof.dr.ir. P.J.G. Teunissen, Department of Mathematica] Geodesy and Positioning Delft University of Technology, Delft, The Netherlands, E-mail: p.j.g.teunissen@geo. tudelft .nl