The Case for Network Accuracy and Local Accuracy as Supported by the Global Spatial Data Model and a BURKORD™ Database for Storing Point X/Y/Z Coordinates, the Covariance Matrix of Each Station, and the Between-Station Correlation Covariance Matrices.

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December 2016

This article contains a concise summary that shows discrimination and computation of network accuracy and local accuracy as obtained by using the global spatial data model (GSDM).

The GSDM was developed to accommodate use of 3-D digital spatial data - a consequence of the digital revolution. The GSDM is built on the assumption of a single origin for 3-D spatial data (Earth's center of mass) and builds a computational model on the concepts of solid geometry as formalized by René Descartes in the 1600s. The GSDM is viewed as compatible with and subordinate to the rectangular geocentric Earth-centered Earth-fixed (ECEF) coordinate system as defined and adopted by the US Department of Defense. Two primary components of the GSDM are the functional model devoted to geometry (location) and the stochastic model which is devoted to describing the uncertainty (accuracy) of spatial data.

The defining document for the GSDM was filed with the US Copyright Office in 1997. Since then, numerous technical papers have been published describing various aspects of the GSDM. A book, "The 3-D Global Spatial Data Model: Foundation of the Spatial Data Infrastructure" was published by CRC Press in 2008 and a 2nd Edition, "The 3-D Global Spatial Data Model: Principles and Applications," is schedule for publication by CRC Press in 2017. The 2nd Edition, contains additional material on least squares adjustment and provides examples of innovative applications.

Spatial data accuracy is a seminal application of the GSDM in that various kinds of accuracy are readily available to answer the all-important question, "accuracy with respect to what?" The stochastic model portion of the GSDM can be used efficiently to discriminate between the accuracy of a point with respect to the coordinate system (or underlying datum) as well as the accuracy of a point with respect to other points in the survey or database. The example that follows appears in the 2nd Edition of the 3-D book.

RINEX GPS data were downloaded from nine continuously operating reference stations (CORS) operated by the Wisconsin Department of Transportation (WisDOT) in such a way that 16 non-trivial baselines connecting the nine CORS could be computed. Once processed, each baseline consisted of the ΔX/ΔY/ΔZ components and the associated baseline covariance matrix. The ECEF values for two stations, FOLA and KEHA, as obtained from WisDOT were used to control adjustment of network. The following pages are exhibits showing various parts of the computations supporting the conclusions as presented in the 2nd Edition of the 3-D book.

Notes include:

1. The least squares adjustment was controlled by “holding” the WisDOT values at stations FOLA and KEHA. Although the computed X/Y/Z coordinates for the remaining stations were very close to the values as determined by WisDOT, the purpose of the network adjustment was not to determine the adjusted ECEF coordinates of the stations but to determine the covariance matrix for the network.

2. Although the WisDOT values for X/Y/Z coordinates were held at stations FOLA and KEHA, each of the three components at each station was assigned a standard deviation of 0.002 meters. That tolerance is quite close to holding the control values “fixed” at each station. A subsequent adjustment was computed based upon standard deviations of 0.020 meters for each component at each station. The resulting difference is quite enlightening when investigating issues of network accuracy and local accuracy.

3. Exhibit A shows the WISCORS Network Status for the entire state.

4. Exhibit B shows the nine stations and the vectors used in the adjustment. Point numbers were assigned to each of the nine stations and arrows show the direction of each vector.

5. Exhibit C is an 8-page printout of the least squares adjustment. The printout includes:

    a. The inverse of the matrix of normal equations. This matrix is used to compute the covariance matrix of the adjustment.
    b. The computed ECEF values for each of the nine stations.
    c. The residuals associated with each of the 16 vectors used in the adjustment.
    d. The reference variance.
    e. The covariance matrix for the entire adjustment. The covariances are underlined for each of the stations within the overall covariance matrix.
    f. Not a part of the adjustment, but the last part shows examples (and format) for the covariance matrix for each station and the station-to-station correlation submatrices.

6. Exhibit D is a 2-page printout of the BURKORD™ file that lists the adjusted coordinates for each of the nine stations and the related covariance matrices.

    a. The first nine records are “point” records. Each record includes both the X/Y/Z values of each station and the covariance matrix values for each station. Because the station covariance matrix is symmetrical, only six values are stored.

    b. The remaining records are “correlation” records. Each record applies to one station-pair and includes all nine values needed to define the interaction.

7. Exhibit E is a 4-page comparison of accuracies (network and local) between all station pairs. The printout is twice as large as needed because the accuracies (“here” to “there” and “there” to “here”) are essentially the same, but not identical. Several lessons are available to be learned from this printout.

8. Exhibit F is a 1-page listing of several point-pair accuracies computed by holding a “relaxed” tolerance at control stations FOLA and KEHA – that is 0.020 instead of 0.002 m. The important observation is that network accuracy reflects the degradation of control while the local accuracies (reflecting the internal quality of observations) changed little.