Specific Assumptions for the Global Spatial Data Model (GSDM)

Earl F. Burkholder, PS, PE, F.ASCE – September 2015

The global spatial data model (GSDM) is built on:

1. The assumption of a single origin – earths' center of mass – for 3-D spatial data.
2. Use of the earth-center earth-fixed (ECEF) rectangular geocentric coordinate system as defined and implemented by the U.S. DoD for the GPS.
3. Descartes' long-standing rules of solid geometry including matrices and vector algebra.
4. Fundamental rules for error propagation given as $\Sigma_{yy} = J_{yx}\,\Sigma_{xx}\,J_{xy}^{t}$.

In addition to local flat-earth rectangular coordinate systems used extensively in engineering practice, geospatial data models that preserve geometrical integrity beyond flat-earth assumptions include:

1. Geodetic equations on the ellipsoid.
2. Cartographic equations on a mapping surface.
3. GSDM equations in 3-D space.

Conceptual consequences include:

1. The GSDM includes both a functional model of geometrical equations for position and a stochastic model that describes spatial data accuracy point by point.
2. The globally unique position of any point (in the "cloud" within and out to the satellite orbits) is defined by a triplet of X/Y/Z metric coordinates.
3. Although computers can handle many significant digits, most applications are based on coordinate differences and involve many fewer significant digits.
   (Comment – in general, coordinates are treated as absolute values while differences are relative.)
4. The spatial data accuracy of each point is described by the standard deviation of each of the three X/Y/Z components. Numerical filters obviate the need for many, but not all, meta data.
5. The correlation between each pair of points is uniquely defined by covariance matrix elements.
6. Issues of network accuracy and local accuracy are supported by using the full covariance matrix associated with a pair of points. Reliance on the "permanence" of local accuracy will become increasingly important for future datum definitions and recognition that, on a global scale, everything moves. Local accuracy correctly describes local relative relationships.
7. Geospatial data are those spatial data specifically referenced to the earth. Are geospatial data a subcategory of spatial data or are spatial data a subcategory of geospatial data? I don't know. The difference is in the way the data are used. Mathematically, it makes no difference.

Operational implications include:

8. Spatial positioning computations are performed in 3-D space using one set of equations that are equally applicable worldwide.
9. While map projections will still be valuable for graphical display; property surveys, engineering design, and rigorous geometrical applications are not encumbered with state plane zones, projection parameters, grid scale factors, elevation factors, or combined factors.
10. The user selects any point as the "standpoint" or more commonly called, the P.O.B. Differencing from the P.O.B. to any other point in the project (or even the cloud) will efficiently provide the local tangent plane horizontal distance and the true azimuth with respect to the local meridian.
11. Geospatial data users worldwide stand to benefit from using a common reference system (the GSDM) from which local systems can be related with geometrical integrity.
12. Quality of absolute position and quality of relative location are defined by network/local accuracies. Both are simultaneously supported by the GSDM.

References and Resources

It is not expected that anyone will read all the items listed. There are many others, but the following items illustrate the huge challenge and opportunities facing geospatial data users worldwide. By default, if not otherwise, many ASCE members will rise to the challenge of efficient use of 3-D digital geospatial data.

1. Noted geodesist, Helmut Moritz, noted the simplicity of using a basic global rectangular reference system in a 1978 paper, "Definition of a geodetic datum" as published in the Proceedings of the Second International Symposium on Problems Related to Re-definition of the North American Geodetic Networks.

2. Writing in support of a specific program (but applicable to all spatial data applications), the following link points to an Award-Wining paper "Viewing Spatial Data from the 3-D Perspective."

   http://www.globalcogo.com/setepaper.pdf

3. The defining document for the Global Spatial Data Model is filed with the U.S. Copyright Office

   http://www.globalcogo.com/gsdmdefn.pdf

4. A "big picture" paper containing all the fundamental equations and describing the GSDM for the Institute of Navigation is posted at:

   http://www.globalcogo.com/ionpaper.pdf

5. A concise item written for the AGU and printed in EOS describes some implications of the GSDM.

   http://www.globalcogo.com/gsdm-eos.pdf This is a high-level item!

6. A 1-page view of the challenges worldwide for implementing the GSDM contains related links.

   http://www.globalcogo.com/challenge.pdf

7. A case is made for ASCE to include high-level geomatics topic in their educational curricula:

   http://www.globalcogo.com/ASCE3D2012.pdf

8. Operationally and from a regulatory perspective, ASCE is heavily involved in the energy industry and modern underground mapping:

   http://globalcogo.com/underground-mapping.pdf

9. A link to the status of the 2nd edition effort (updated from time to time) is:

   http://www.globalcogo.com/SecEd.html