HISTORY OF THE GLOBAL SPATIAL DATA MODEL (GSDM)

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The concept of an integrated 3-D database for spatial data grew out of discussions with Dr. Alfred Leick during the author's 1990/91 sabbatical at the University of Maine. Leick's description of the 3-D Geodetic Model (Leick 1990) is all-inclusive and presented at a high level. The challenge, against a backdrop of surveying engineering applications and anticipating increasing use of GNSS for positioning, appeared to be capturing the benefits of modern technology for 2-D and flat-Earth users without destroying the inherent rigor of 3-D measurements. As it turns out, GNSS technology has been embraced by the geomatics community since the 1980s and many spatial data applications are competently accomplished using flat-Earth concepts. But, in part because map projections are strictly two-dimensional and because using state plane coordinates is an obvious application for GNSS, the third dimension did not get the attention it deserved in those early years. Instead, the concern of many focused on the difference between grid distance as defined by state plane coordinates and the ground distance as used in construction activities and on survey plats. In an attempt to understand and to address the grid/ground distance issues, a questionnaire was sent to all 50 state DOTs in 1990 requesting feedback. Those thoughtful responses are reported in Appendix III of a paper presented at the 1991 ASCE Transportation Specialty Conference (Burkholder 1993). That paper also lays the ground-work for what became known as the 3-D global spatial data model (GSDM).

A model is successful to the extent that it is both appropriate and simple. The 3-D Geodetic Model proposed by Alfred Leick (1990) is very comprehensive and includes concepts of both geometrical geodesy and physical geodesy. Without faulting the 3-D Geodetic Model, the question must be asked whether or not that model is appropriate for addressing the grid/ground distance issue. Concepts of physical geodesy and gravity are important as scientific inquiries and readily handled by a comparatively small number of professionals. At the high end, the demand for appropriateness overrides the need for simplicity and the formal 3-D model should be used. But, that model is viewed as overkill for many surveying and engineering applications. The GSDM incorporates the geometrical concepts of the comprehensive 3-D Geodetic Model but the GSDM presumes that issues related to gravity are accommodated before spatial data are brought into the GSDM.

It has been said that GNSS (and other) technologies have solved the location problem. Many in the spatial data community need and use location data productively. The GSDM is both appropriate and simple for those applications. It is readily acknowledged that understanding why a point is where it is or understanding how or why a point moves as it does involves more complicated concepts of gravity and physical geodesy. In those cases, the appropriateness of the 3-D Geodetic Model becomes the overriding criterion.

Although the conceptual foundation for the GSDM was developed during the 1990/91 sabbatical experience, recommendations for practical application emerged in work performed for the Southeastern Wisconsin Regional Planning Commission (SEWRPC) in the 1990s. Beginning in 1964 the SEWRPC embarked on an ambitious project to establish reliable state plane coordinates and elevations on all section and quarter section corners within the seven-county region. The networks were built on the NAD 27 horizontal datum and the NGVD 29 vertical datum and have provided reliable survey control to support land and engineering surveys within the seven-county region for over fifty years. Additionally, the SEWRPC control system has provided an invaluable basis for development of computerized land information and public works management systems. The new (1980s) horizontal and vertical datums – NAD 83 and NAVD 88 – developed by NGS

offered little benefit to SEWRPC constituents because reliable networks were already serving the user community.

None-the-less, some state and federal agencies, utilities, and private sector users did make the transition to using the new datums and brought varying forms of pressure on SEWRPC to make the transition as well. SEWRPC was not convinced of the benefits of making the transition to the NAD 83 and NAVD 88 and was resolute in continuing use of the two proven networks. But, recognizing their obligation to their constituents, SEWRPC commissioned preparation of local transformations that could be used by others to make reliable datum transformations. Two separate technical reports were prepared for and published by the Commission (SEWRPC 1994 and SEWRPC 1995) – one for horizontal and one for vertical.

While discussing the scope of those reports, the suggestion was made that an integrated 3-D database populated with transformed data from the existing control networks would be an efficient way to capture the value of the existing networks while supporting the user community in uses of 3-D digital spatial data. That suggestion was deemed impractical and two separate reports were prepared and implemented (Bauer 2005). However, following completion of those two reports, the author was asked to prepare a follow-up report outlining the 3-D concepts and procedures by which the value of 3-D digital spatial data could be captured and preserved. That report, "Definition of a Three-Dimensional Spatial Data Model for Southeastern Wisconsin," (Burkholder 1997b) builds on the concepts described in Burkholder (1993) and references a formal definition and description of the 3-D global spatial data model (GSDM) filed with the U.S. Copyright Office (Burkholder 1997a). A book devoted to the GSDM was published by CRC Press in 2008 (Burkholder 2008).The 2nd Edition of that book is scheduled for release in July 2017.

References

Bauer, K.W. 2005. A control survey and mapping project for an urbanizing region (A study in persistence). *Surveying and Land Information Science*, 65 (2): 75-83.

Burkholder, E.F. 2008. *The 3-D Global Spatial Data Model: Foundation of the Spatial Data Infrastructure*, Boca Raton: CRC Press.

Burkholder, E.F. 1997a. *Definition and description of a global spatial data model (GSDM*. Washington, DC: U.S. Copyright Office. www.globalcogo.com/gsdmdefn.pdf.

Burkholder, E.F. 1997b. *Definition of a three-dimensional spatial data model for southeastern Wisconsin*. Waukesha, WI: Southeastern Wisconsin Regional Planning Commission

Burkholder, E.F. 1993. Using GPS results in true 3-D coordinate system," *Journal of Surveying Engineering*, 119 (1): 1-21.

Leick, Alfred, 1990. *GPS Satellite Surveying.* New York: John Wiley

Southeastern Wisconsin Regional Planning Commission (SEWRPC). 1994. Technical Report No. 34, *A Mathematical relationship between NAD 27 and NAD 83 (91) state plane coordinates in southeastern Wisconsin.* Waukesha, WI: Southeastern Wisconsin Regional Planning Commission

Southeastern Wisconsin Regional Planning Commission (SEWRPC). 1995. Technical Report No. 35, *Vertical Datum Differences in Southeastern Wisconsin*. Waukesha, WI: