True 3-D versus Pseudo 3-D

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An Expanded Version of This Discussion is Posted at
http://www.globalcogo.com/ComprehensiveDiscussionOf3D.pdf

I presented "Digital Twins and the Elephant in the Room" to the Surveying Educators Conference on August 3, 2022 – see www.globalcogo.com/sages2022.pdf. This *Benchmarks* article adds background details to that presentation and asks, "why does it matter?"

1. The Surveying and Geomatics Educators Society (SaGES) holds a "get-together" conference for surveying educators every other summer. Due to the pandemic, the conference was postponed in 2021 and held virtually in 2022 – see http://www.geosages.org/.

2. "Digital Twins" is defined as an electronic representation of the physical world. Although applicable in various disciplines, a geospatial digital twin is important to surveyors and others who use spatial data – see www.globalcogo.com/GSDM-and-DT.pdf.

3. The "elephant in the room" comes from a reluctance of some to acknowledge the difference between true 3-D and pseudo 3-D. "Digital Twins" accommodates either one. Briefly, true 3-D has a single origin for 3-D data but pseudo 3-D has two origins – one origin for horizontal and a separate origin for vertical. The difference between true 3-D and pseudo 3-D is described in more detail at www.globalcogo.com/true-versus-pseudo.html.

4. GPS emerged as a measuring tool in the 1980s and the grid/ground distance difference became a hot topic of discussion among surveyors. While on sabbatical leave from the Oregon Institute of Technology in 1990/91, I sent an inquiry to all 50 state DOTs asking how they handled the grid/ground distance difference and how the difference should be handled. I received replies from 46 out of 50 DOTs. Those replies are summarized in an appendix to a technical paper, "Using GPS Results in True 3-D Coordinate System," presented at the ASCE GPS '91 Specialty Conference in Sacramento, CA. Figure 6 in that paper is a schematic of coordinate systems, www.globalcogo.com/Tru3d.pdf, and shows the relationship between "true 3-D" and "pseudo 3-D." The formal definition of the global spatial data model (GSDM) grew out of that initial paper.

5. Gravity and Earth curvature are the underlying reason for the difference between true 3-D and pseudo 3-D. A comprehensive paper, "Reconciling Gravity and the Geometry of 3-D Digital Geospatial Data," www.globalcogo.com/ImpactOfGravity.pdf, makes a case for mitigating the impact of the difference by using ellipsoid height (true 3-D) rather than orthometric height for the third dimension.

6. Judging by patents filed, the digital revolution has spawned unparalleled human creativity. Associated innovations include an amazing array of “high tech” gadgets, products, and services. On the marketing side, entrepreneurs use social media to influence many consumer choices. In the professional arena, sorting through myriad choices can be exhausting and time-consuming. “Digital Twins” can be used to gain a better understanding of spatial/geospatial data concepts. Transparency is a caveat for the informed user. As it turns out, the difference between true and pseudo 3-D has significant professional and economic implications. The “elephant” needs to be discussed openly.

7. For a starter, legitimate questions when evaluating characteristics of point cloud data are:
    a. Are the reported results based on true 3-D or pseudo 3-D?
    b. What is the basis of accuracy statements? Accuracy “with respect to what?”

8. The follow list is not complete. Each item needs more study and documentation.

    a. Historical practice relies on pseudo 3-D coordinates:
        - Topographic maps with contours.
        - Construction plans with elevations.
        - Flood plain maps.
        - Many other. . .

    b. True 3-D is used in existing and evolving applications:
        - NGA uses ECEF as a matter of policy – see CJCSI 3900.01D 14 May 2015.
        - Land subsidence studies.
        - Earthquake prediction.
        - Navigating autonomous vehicles – absolute/relative accuracy both needed.
        - LiDAR point cloud data – X/Y/Zs are primary GNSS data.
        - Other. . .