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TO: Spatial Data Community

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RE: Use of 3-D digital spatial data

From a background of surveying and engineering, my professional focus has been serving the end user with adoption of "better" methods for using 3-D digital spatial data.

I have witnessed an impressive evolution in how spatial data are used – from rigorous geometry-based engineering to adoption by the geographic information system (GIS) community to management of spatial data by computer scientists with input from the spatial reasoning community. Solid geometry relationships are long-standing and unambiguous but practical applications must address the impact of gravity – meaning that flat-Earth concepts (spatial data) must come under the umbrella of global relationships traditionally defined with latitude/longitude/ellipsoid height (geospatial data). Applications of artificial intelligence (AI) require unambiguous definitions and use of proven geospatial data relationships. The 3-D global spatial data model (GSDM) provides an efficient bridge between disciplines and applications worldwide.

Surveying/engineering/mapping/remote sensing:
In the past, geospatial data were the "bread & butter" for these disciplines. In that environment, horizontal and vertical are referenced separately. This "traditional" market is very much geometry based, is huge, and must not be abandoned. In time, this market will evolve to use of an integrated 3-D model for 3-D data.

Geographic information systems (GISs):
The National Spatial Data Infrastructure (NSDI), administered by the Federal Geographic Data Committee (FGDC), was established in 1994. With the advent of GPS and computers, geographic information systems (GISs) came to the fore as many users relied more and more on collecting, storing, displaying, analyzing, and using spatial data. Although this market also could be called "traditional," the underlying principles are more abstract than geometry. The commercial investment in associated policies and procedures is huge and vendors – both hardware and software - have done very well supporting this new digital economy.

Workflow optimization:
Expanding beyond rote data processes, spatial reasoning has contributed to many advances related to optimizing spatial data workflow in many applications. Emphasis is on efficiency (measure once use often), standardization, and accuracy. Several affected areas include land records (cadastral), tax records, resource inventory, environmental impact assessments, transportation, utilities, voting demographics, smart cities, building information management (BIM), fleet management, and others. The observation here is that traditional separation of horizontal and vertical continues to be accommodated, howbeit, awkwardly.

Herein lies the challenge. Gravity is associated with a curved Earth and drives the mandate for separate horizontal and vertical datums. Flat-earth computations are less complicated but geometrical integrity and computational efficiency can suffer if separate horizontal and vertical datums are used. Currently the National Geodetic Survey (NGS) is pursuing a multi-million-dollar effort to develop a geoid model that can be incorporated into spatial data computations. At best, that is a stop gap measure with a limited life span.

A better solution is to use an integrated 3-D spatial data model for spatial data. To do that, accommodations for the impact of gravity need to be made before Earth-centered Earth-fixed (ECEF) X/Y/Z coordinates are entered into the data base. Making that transition looms as a big challenge for the spatial data user community but there are numerous benefits to be realized in making such a change.

Artificial intelligence (AI):
Coordinating use of datums, coordinate systems, sensors, and project specifications often involves human judgement — sometimes even for innocuous details. A forward-looking statement is that artificial intelligence that relies on spatial data will be successful only to the extent that human intervention can be removed. As the use of spatial data continues to evolve and artificial intelligence (AI) is implemented into more applications, adoption and use of a "standard" 3-D model is absolutely essential. The 3-D global spatial data model (GSDM) has been defined, is already in place, and can be implemented immediately by anyone. All equations of the GSDM are in the public domain and programming the geometrical relationships for performing computations in 3-D space is much less complicated than performing computations on the ellipsoid or using map projection equations.

Convergence:
Given the previous four areas of focus, the following are offered for consideration.

1. The GSDM was first defined in 1997 and includes equations for both functional model geometrical relationships and a stochastic model for tracking error propagation (providing a measure of uncertainty for any computed position or subsequent geometrical element – distances, directions, etc.).
2. Two editions of "The 3-D Global Spatial Data Model" have been published by CRC Press, 2008 & 2018.
3. Details of the GSDM have been challenged in the technical press and successfully rebutted. Additional information can be provided – see www.globalcogo.com/validation.pdf.
4. NGS is modernizing the National Spatial Reference System (NSRS) with completion originally scheduled for December 31, 2022. The completion date has been pushed back due to the COVID-19 pandemic and for other reasons. New horizontal and vertical datums will be published as part of the project. The "science" portion of that project is above reproach.
5. As part of the modernization project, NGS plans to offer two separate (but related) products that fail to keep step with evolving concepts regarding use of 3-D digital spatial data. They are:
    a. Developing a comprehensive geoid model for continued use of separate horizontal and vertical datums. There will be scientific benefits associated with publication of the geoid models but promoting use of geoid modeling within the spatial data user community is a disservice to evolving professional practice – especially AI.
    b. Promoting the use of low-distortion projections (LDPs) to be used in place of state plane coordinate systems. It will be far better to adopt a 3-D model for 3-D data!
6. The 3-D GSDM provides better processes for using modern 3-D spatial data. Items supporting that assertion include:
    a. Definition of accuracy terms — www.globalcogo.com/appendixE.pdf.
    b. Rebuttal of NGS criticism of local accuracy – www.globalcogo.com/validation.pdf.
    c. Description of the role of a model – www.globalcogo.com/rolemodel.pdf.
    d. Technical paper by Burkholder "Reconciling Gravity and the Geometry of 3-D Digital Geospatial Data," peer-reviewed, but not accepted for publication www.globalcogo.com/ImpactOfGravity.pdf
    e. Paper by Burkholder, By Comparison, the GSDM is "Simple," www.globalcogo.com/simple.pdf.
    f. Publication of the FGDC Strategic Plan for implementing the NSDI 2021-2024.
    g. GIM paper, "Quantum Physics to Disrupt Geospatial Industry over the Coming Decade."
7. A formal presentation on this material can be arranged.