Virtual Meeting Report
National Geospatial Advisory Committee (NGAC)
October 11 and 12, 2023
Earl F. Burkholder, PS, PE, F.ASCE
Global COGO, Inc. – Las Cruces, NM 88003

Web link to FGDC/NGAC – home page https://www.fgdc.gov/ngac

Web link to Agenda – October 2023

https://www.fgdc.gov/ngac/meetings/october-2023/final-agenda-ngac-oct-2023.pdf

Web link to Committee Members https://www.fgdc.gov/ngac/ngac-membership.pdf

I, Earl F. Burkholder, requested permission to attend the NGAC meeting virtually. Noting that the agenda included a 15 minute slot for public comment, I asked to be able to give an "elevator pitch" on *Promoting a 3-D Model for 3-D Data* and agreed to a 3-minute time limit. As it turns out, no one else signed up to provide comments and I was permitted to use the entire 15 time allotment.

Before the meeting, I had provided an outline of proposed comments – annotated herein with additional comments (*in italics)* made due to permitted use of entire 15 minute allotment. As my recall isn't perfect, I accept responsibility for any discrepancy between what I remember and what was actually recorded.

****

Promoting a 3-D Model for 3-D Data

Earl F. Burkholder, PS, PE, F.ASCE
Las Cruces, NM 88003
October 12, 2023

I started by expressing appreciation for the opportunity to provide comments and noting that I've known Gray Thompson (NGAC Chair) for some time. I applauded the work he does and the contributions he has made to the surveying profession.

I also noted that I wrote an Editorial for the August 1995 issue of the ASCE Journal of Surveying (JSE) supporting development of the National Spatial Data Infrastructure.

I. Retired Surveyor/Engineer/Educator/Consultant/Researcher

A. Advocate for geometry - rigor, simplicity, and end user applications.
B. A single voice carries little weight unless credible and persistent.

One guiding principle for my interests in spatial data is to focus on the convergence of abstraction/technology/policy/practice. In listening to the NGAC discussions yesterday and this morning, it seems that the NGAC is pursuing abstraction on steroids.

II. Digital Revolution Drives Innovation – Analog to Digital

A. AT&T (and internet) – digital communications.
B. Kodak (and others) – digital imaging.

C. Google Earth (and others) – digital spatial/geospatial data.

I've observed the importance of language in effective communication. For example, I was oblivious to the difference in meaning between the adjectives "national" and "federal" when discussing spatial data programs – I'm working on that.
I have little (or no) experience with nautical charts. I am now fully sympathetic with the enhanced characteristics of a "chart" over those of a "map."
What about spatial data? Are spatial data a sub-category of geospatial data or are geospatial data a sub-category of spatial data. I suggested context makes a difference.

- *Mathematically, geospatial data are a sub-category of spatial data.*
- *Geographically, spatial data are a sub-category of geospatial data.*

III. Mathematical Characteristics of Spatial Data

A. Geometry is ultimately based on WGS 84 or ITRF
   1. Rectangular Coordinates - Cartesian X/Y/Z, time is 4th dimension.
      a. Rules of solid geometry – universal and long standing.
      b. Within scope of practicing professionals
   2. Geodesy and ellipsoidal coordinates.
      a. Computations referenced to ellipsoid.
      b. Horizontal and vertical have disparate origins.

B. Spatial data contain errors – standard deviation describes uncertainty.
   1. No measurement is perfect, but quality is mathematically definable.
   2. Error propagation tracks uncertainty, with respect to what (wrt)?
   3. Evaluating the consequences of uncertainty is enormously important.

I glossed over this "math" section by noting the diversity of talent associated with the use of spatial data. My focus is, and has been, on geometry. Presumptuously, I stand toe-to-toe with others on geometry. Even so, there is much more I need to learn.

IV. Analog to Digital Transition Supports Both True 3-D and Pseudo 3-D

A. Two "physical" references for spatial data computations are:
   1. Earth's center of mass (CM) is the basis for a 3-D datum and **true 3-D**.
   2. The geoid (approx. by sea level) is the basis for elevation. In this case, horizontal and vertical have different origins resulting in **pseudo 3-D**.

B. Earth's (CM) is a better vertical reference than the geoid because:
   1. The location of the Earth's CM is easier to find – satellites orbit the CM.
   2. The geoid is an arbitrary equipotential surface which moves wrt the CM.

C. Computational efficiency and standardization are enhanced with true 3-D.
   1. True 3-D is achieved by using a single origin for 3-D data.
   2. Pseudo 3-D is a consequence of using separate 2-D/1-D datums.
   3. True 3-D is a better fit for computing spatial data accuracy.

I found it "easier" to discuss this section by noting three different issues – all being a consequence of gravity – (Covered differently above).

- *Geometry of spatial data includes two origins – Earth's CM & the geoid.*
- *Using separate horizontal/vertical datums as opposed to a 3-D datum.*
- *Pseudo 3-D continues to be used by some while others evolve to true 3-D.*

V. User Communities Have Vested Interests in Alternatives

A. **Pseudo 3-D** uses horizontal/vertical datums – "if it isn't broke, don't fix it!"
   1. Topographic maps, site maps, civil infrastructure, and construction.
   2. Water related infrastructure – rivers, cannels, sewers, FEMA maps.

B. **True 3-D** embodies rules of solid geometry within an Integrated 3-D datum.
   1. Monitoring land subsidence and vertical movements.
   2. Robotics for driverless vehicles, drones, manufacturing.

C. Subjective observations include:
   1. Military (and other users) select policies which serve selfish needs.
   2. Civilian/professional users are reluctant to modify 2-D/1-D practices.
   3. Researchers and academics have developed pseudo 3-D practices.
      a. Geoid modeling provides a way to continue using elevation.
      b. Low-distortion projections support flat-Earth computations.

While not possible to identify all impacted user communities, examples include:
- *Pseudo 3-D: NGS and USGS*
- *True 3-D: Military (NGA), DOT, and NASA*

VI. Many benefits are possible if spatial data users are on the "same geometry page" and using a standard spatial data model - an integrated 3-D datum.

A. The global spatial data model (GSDM) is an integrated 3-D datum worldwide.
B. The GSDM includes both a functional model and a stochastic model.
C. The GSDM is well defined, and all equations are all in the public domain.
D. Proliferation of (disparate) coordinate systems can be mitigated.
E. Standardized computational methods can be applied across disciplines.

I "skipped" Section VI until the end where I asked if the GSDM is a solution in search of a problem. Then I turned it around by suggesting that the GSDM and associated database is compatible with what I learned about the characteristics of a High-Definition Map (Chart).

VII. Looking Ahead – Consider abstraction/technology/policy/practice!

A. True 3-D users are not adversely impacted but can enjoy added benefits.
B. Modernization of the NSRS is key:
   1. NSRS coordinate values (ECEF) will be different/better.
      a. X/Y/Z values primary, other geometrical values are derived.
      b. Error propagation provides uncertainty of derived values.
      c. Use meters exclusively – all derived values responsibility of user.
   2. Ellipsoid height should be used instead of orthometric heights.
   3. Orthometric heights are rarely essential.
      a. Corrections (similar to equation-of-time) are available if needed.

b. Hydraulic gradients are defined by dynamic heights.

C. Someone (NIST or other reliable independent organization) to study issues.

D. Benefits to practicing professionals in surveying/engineering/GIS

1. Geoid modeling rarely needed.
2. Distortion inherent in low-distortion projections can be avoided.
3. Stochastic model can be used to track uncertainty.

(Use a 3-D model for 3-D data!)

Given a 2-minute warning, I attempted to summarize by noting:

- *A credible study is needed to identify issues and to make recommendations.*
- *As a practicing surveyor/engineer, I don't need geoid modeling or LDPs.*
- *That the GSDM can be a solution to many challenges in "going digital."*

VIII. Resources

A. Generic Global COGO, Inc. website http://www.globalcogo.com

B. Website promoting true 3-D http://tru3d.xyz

C. Specific link to NIST proposal http://www.globalcogo.com/NIST-memo.pdf

********** COMMENTS ********** 10/31/2023

Upon reflection following the meeting, my aspiration is that readers realize that the solution can be quite simple – use ellipsoid height in place of orthometric height for the third dimension – and that the GSDM:

1. Is compatible with Digital Twins concepts and details.
2. Can provide a common rigorous foundation for the content of high-definition maps.
3. Will be an integral component of AI reliance on spatial/geospatial data.

Earl F. Burkholder, PS, PE, F.ASCE
Global COGO, Inc.
Las Cruces, NM 88003
www.globalcogo.com

********** POSTCRIPT ********** 11/10/2023

In my comments to the NGAC on October 12, 2023, I made the point that the convergence of abstraction/technology/policy/practice justifies discussions of True 3-D and Pseudo 3-D. I observed that the NGAC discussions pursued abstraction aggressively. I called it "abstraction on steroids."

Writing this follow-up report, I learned that NGS planned to give a webinar 11/9/2023 on the "New NGS Research Plan." I was hopeful that somehow the importance of using a "3-D model for 3-D data" might be part of the new vision. I listened in on that webinar yesterday. Dr. Pe'eri gave an excellent presentation which could also be characterized as abstraction on more steroids. NGS continues to serve scientists very well, but it appears that spatial data end users (surveying/engineering/GIS) are being short-changed. At some point, the difference between True 3-D & Pseudo 3-D (elephant-in-the-room) should be addressed. A recording of the NGS webinar "New NGS Research Plan" is now (11/27/2023) posted at https://geodesy.noaa.gov/web/science_edu/webinar_series/fy24-research-plan.shtml