

Digital Twins and the Elephant in the Room ©

Surveying and Geomatics Educators Society

August 2, 3, and 4, 2022

Assertion. . .

A 3-D Model should be used for 3-D data!

Presented by:

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- **BS Michigan 1973, MS Purdue 1980.**
- **Fellow and Life Member of ASCE.**
- **President, Global COGO, Inc.**
- **Editor, Journal of Surveying Engineering, two 4-yr. terms.**
- **Surveying Professor, OIT 1980-1993 & NMSU 1998-2010.**
- **Chair, ABET Related Accreditation Commission 2000/2001.**
- **Chair, ASCE Geomatics Division 2011/2012.**
- **Consultant, SE Wis. Regional Planning Comm. & other.**
- **Author of numerous articles and two books by CRC Press. . .**
 - The 3-D Global Spatial Data Model: Foundation of the Spatial Data Infrastructure.**
 - The 3-D Global Spatial Data Model: Principles and Applications, 2nd ED.**

DEFINITION¹ – DIGITAL TWIN (DT)

- **Short definition. . .**
 - DT is a virtual representation of a connected physical asset.
- **Longer definition – DT includes:**
 - Virtual information that mimics
 - Characteristics/behavior of a physical asset
 - Which is dynamically updated throughout its life cycle.
- **DT can include various sets/kinds of information:**
 - Records of transactions – business/medical/legal.
 - Works of art – paintings/sculpture/video/music.
 - Manuscripts – books/correspondence/software.
 - Spatial/geospatial data – mathematical definition of location.
- **Many disciplines use spatial/geospatial data extensively.**

¹ [Position paper](#) by AIAA Digital Engineering Integration Committee.

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The Whole World is Going Digital!

- **World Geospatial Industry Council (WGIC). . .**
 - Launched “WGIC Spatial Digital Twins Report” April 5, 2022.
- **“Government Technology” March 2022 issue**
 - Editorial: Broadband Trifecta - Maps, Digital Equity, Infrastructure.
 - Plus, added articles on “smart cities” and other things digital.
- **Google Earth covers the entire world (or not?).**
- **Future World Vision is an initiative by the ASCE Foundation.**
- **Infrastructure Investment Jobs Act - includes digital vision.**
- **Drones enable anyone to collect spatial data (scanning).**
- **“Everyone” now communicates with a smart phone.**
- **The geometrical integrity of a geospatial digital twin is very important – see www.globalcogo.com/GSDM-and-DT.pdf.**

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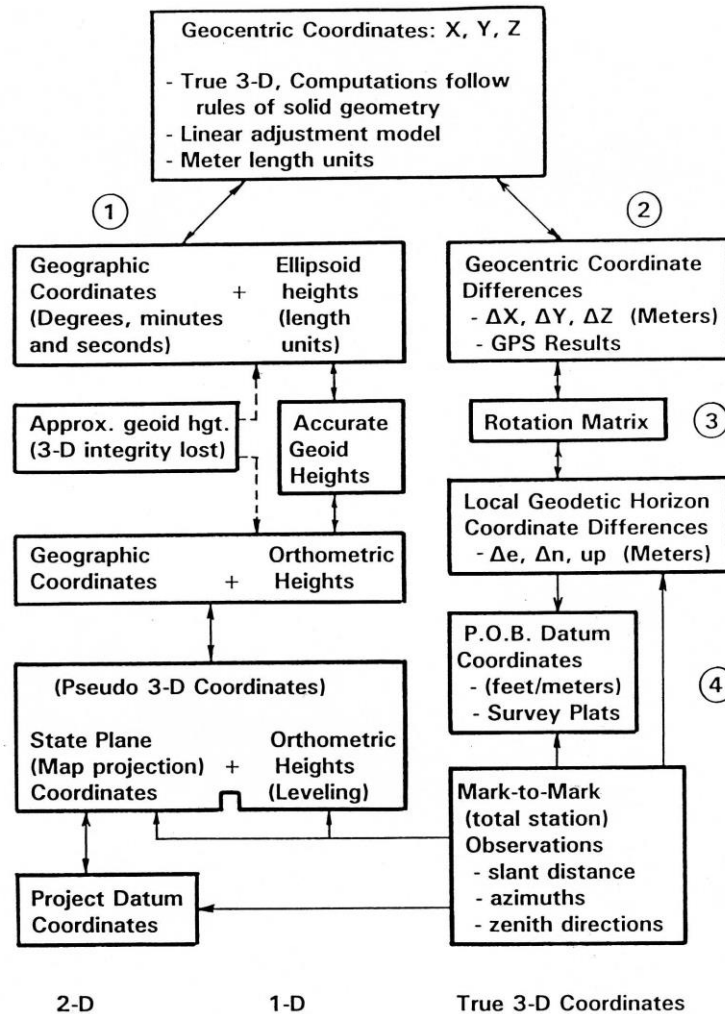
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ELEPHANT IN THE ROOM. . .

- **The definition of a “Digital Twin” is straight forward.**
- **A Geospatial Digital Twin includes:**
 - **Spatial data that are characterized by “flat-Earth” geometry.**
 - **Geospatial data that are referenced to planet Earth.**
- **Geometry of spatial data is a sub-set of geospatial data.**
- **Geospatial data are defined by coordinates:**
 - **Geodetic latitude/longitude/elevation – pseudo 3-D.**
 - **Geodetic latitude/longitude/height – true 3-D (geodesy equations).**
 - **Geocentric Earth-centered Earth-fixed (ECEF) rectangular coordinates.**
 - **ECEF coordinates are also true 3-D and use solid geometry equations.**
- **Choice of coordinate system is the ELEPHANT!**

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True 3-D is based on Earth-centered Earth-fixed X/Y/Z coordinates.

Pseudo 3-D uses geodetic latitude, longitude, and orthometric height.

(See Figure 6, "Using GPS Results in True 3-D Coordinate System," www.globalcogo.com/Tru3d.pdf)

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The 3-D Global Spatial Data Model (GSDM):

- Provides a rigorous mathematical mimic of physical location.
- Is based on the global ECEF geocentric coordinate system.
- Uses X/Y/Z coordinates to define unique position globally.
- Computes positions in 3-D space using rules of solid geometry.
- All equations are in the public domain.
- Includes stochastic model for tracking error propagation.
- Rotates geocentric differences (a vector) to local differences.
 - True 3-D integrity is preserved. Geometry is globally seamless.
 - User can view “cloud of points” from any chosen perspective.
 - Local differences can be used as flat-Earth spatial data.
 - Local distances are not distorted by a map projection, azimuths are true.
 - User enjoys great flexibility in choosing form of results/output.

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This slide is supplemental but included here for “background.”

- **Formal definition of the 3-D Global Spatial Data Model (GSDM).**
<http://www.globalcogo.com/gsdmdefn.pdf>
- **Schematic global visualization of GSDM components.**
<http://www.globalcogo.com/CR002.pdf>
- **Mathematical definition of spatial data accuracy.**
<http://www.globalcogo.com/accuracy.pdf>
- **Poster of challenge to modernizing National Spatial Reference System.**
<http://www.globalcogo.com/poster.pdf>

ELEPHANT REVISITED (this issue is HUGE!):

Although the GSDM provides true 3-D, traditional practice. . .

- **Uses geodetic latitude/longitude and elevation – pseudo 3-D.**
- **Is used extensively all over the world.**
- **Has a long history of separate horizontal and vertical datums.**
- **Is based on two origins – one for horizontal, one for vertical.**
- **References horizontal and vertical computations separately while true 3-D computations are performed in 3-D space.**
- **Requires knowledge of geoid heights (geoid modeling) to obtain ellipsoid heights from elevation - needed for true 3-D.**
- **Will ultimately be replaced by a single 3-D datum. See. . .**
<http://www.globalcogo.com/ImpactOfGravity.pdf>.

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Digital Revolution impacts many areas, including geospatial data.

- **Convergence of abstraction/technology/policy/practice influences many areas, not limited by traditional boundaries.**
- **Increasing levels of abstraction related to geospatial data:**
 - **Historically surveying and mapping are focused on geometry.**
 - **Geographic information system practice includes metadata.**
 - **Computer experts add algorithms and management of databases.**
 - **Electrical engineers make signal processing more efficient.**
 - **Manufacturers miniaturize sensors for physical measurements.**
 - **Industrial engineers automate data collection and workflow.**
 - **Statisticians provide stochastic documentation of data quality.**
 - **Economists rely on data scientists for hypothesis testing.**
 - **Many tools (both hardware & software) are available to all users.**
- **Spatial data users come from various disciplines.**

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Which is more correct?

- **Policy follows innovation and leads to practice.**
- **Innovation drives practice which leads to adoption of policy.**

Should the question be re-worded?¹

“Given” – the Digital Revolution drives disruptive innovation.

- **The impact is global and affects all areas of civilization.**
- **Motivation includes both selfish and altruistic attitudes.** (Can governments, corporations, and professionals be relied upon to make ‘good’ decisions?)
- **Licensure exists to protect public health, safety, and welfare.**
- **In what way is the public protected from unlicensed practice?**
- **Fulfilling professional obligation requires due diligence.**

¹ Dr. John D. McLaughlin (Emeritus President - UNB) at 1984 Surveying Educators conference.

“Asking the right question is more important than having the right answer.”

Corollary: “Greatest progress is made by those who ask the right questions.”

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Another ELEPHANT?

Do technological advances outpace professional licensure?

- **City of Flint “lead in the water” crisis – bad consequences!**
- **NCEES “Future of Surveying Forum” – January 2016.**
- **NM Basis-of-Bearing example – correction took 6 years.**
- **Exemptions to licensure requirements –**
 - **Services not provided directly to the public – where is accountability?**
 - **Corporations, global businesses, governments, and military activities.**
- **Who has responsibility to protect welfare of the public?**
 - **“O” rings on Challenger – “rush to launch” resulted in death of crew.**
 - **Clean-up at Three-Mile Island – unreviewed procedures challenged.**
 - **Licensed professionals are (should be) first line of defense.**

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Now, back to the assertion. . .

A 3-D model should be used for 3-D data!

Some details, the 3-D GSDM. . .

- Is already in place, proven, and available to anyone.
- Uses the same set of solid geometry equations worldwide.
- Puts the end user in control of how geospatial data are used.
- Supports local spatial data applications – even plane surveying.
- Can provide reliable standard deviations for derived values.
- Avoids grid factors, elevation factors, and combined factors.
- Obviates need for geoid modeling & low-distortion projections.
 - See “Gravity” paper <http://www.globalcogo.com/ImpactOfGravity.pdf>.
 - GSDM “simplicity” <http://www.globalcogo.com/simple.pdf>.

We are where we are because of where we came from!

Previous investments in horizontal and vertical datums.

- NGS has adjusted networks and publishes separate datums.
- Software for spatial/geospatial activities – writing, testing, using.
- Standards, specifications, policies, and practice are in place.

EVENTUALLY, TRANSITION TO TRUE 3-D IS INEVITABLE!

Digital Twins provide conceptual framework for transition to 3-D.

- Impetus is provided by a worldwide better true 3-D model.
- GSDM provides superior integrity and functionality.
- GSDM is compatible with concepts of Digital Twin.
- Bonus: Thankfully, the GSDM is also compatible with existing. . .
 - Plane surveying/mapping – local tangent plane distances & true azimuths.
 - Engineering design – local $e/n/u$ components same as before.

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The Innovators: How a Group of Hackers, Geniuses, and Geeks Created the Digital Revolution - By Walter Isaacson 2014

What is a packet-switched network? Look it up on Wikipedia . . . It is how the internet breaks up, transmits, and re-assembles messages sent via the internet.

Chapter 7 – The Internet

Isaacson describes the work of an internet pioneer, Paul Baran, who tried to “sell” the concept of a packet-switched network to AT&T executives who were firmly committed to their “open circuit” telephone network. In desperation AT&T attempted to explain “how telephones work.” After a comprehensive demonstration, Paul was asked, “Now do you see why packet switching wouldn’t work?” He simply replied, “no.”

The 3-D global spatial data model (GSDM) provides similar digital efficiencies in the spatial data arena. In time, true 3-D will be adopted and used extensively worldwide – replacing use of pseudo 3-D.

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Possible “next steps” – what is best for users?

- **Webinars – monthly, weekly, on-demand**
- **Continuing education courses**
 - Professional organizations
 - Commercial providers
- **Formal university offerings**
 - Undergraduate courses
 - Graduate courses
 - Result of research - Thesis/Dissertation
- **Self-study**
- **Vendor supported training**
- **Development of geospatial digital data standards**

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Spoof – A Lot of People are saying. . .

Would it not be simpler if the world were flat? It is and here is proof!

- 1. No matter where you go, a plumb bob always points “down.”**
- 2. Under equilibrium, a water surface is always perpendicular to plumb line.**
- 3. Therefore, the world is “flat!”**

How can that assertion be disproved?

- 1. I was taught that the world is round.**
(Although true, it is not a valid rebuttal!)
- 2. We need credible physical evidence.**
 - a. First see top of mast of distant ship.**
 - b. Global circumnavigated in 1522.**
 - c. Shadow of the Earth on the moon.**
 - d. Pictures of the Earth from space.**



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Each person is responsible for what they believe and do!

- **I will do my best to convey correct information.**
- **Nothing is true because Burkholder said so.**
- **“A lot of people are saying” does not make something true!**
- **The purpose of education is to “learn how to learn:”**
 - **Learn details about topic being studied.**
 - **Become informed of the context of information learned.**
 - **Develop critical thinking skills and asking good questions.**
 - **Question how or why things are the way they are.**
- **A technician collects and processes data.**
- **A professional shares insights and solutions with others.**

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Thank you for participating!

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Inspired by ‘Jonathan Livingston Seagull’
Richard Bach - 1970

Send questions/comments to:
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