Digital Twins and the Elephant in the Room ©

Surveying and Geomatics Educators Society
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Assertion. . .
A 3-D Model should be used for 3-D data!

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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.

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DEFINITION[1] – 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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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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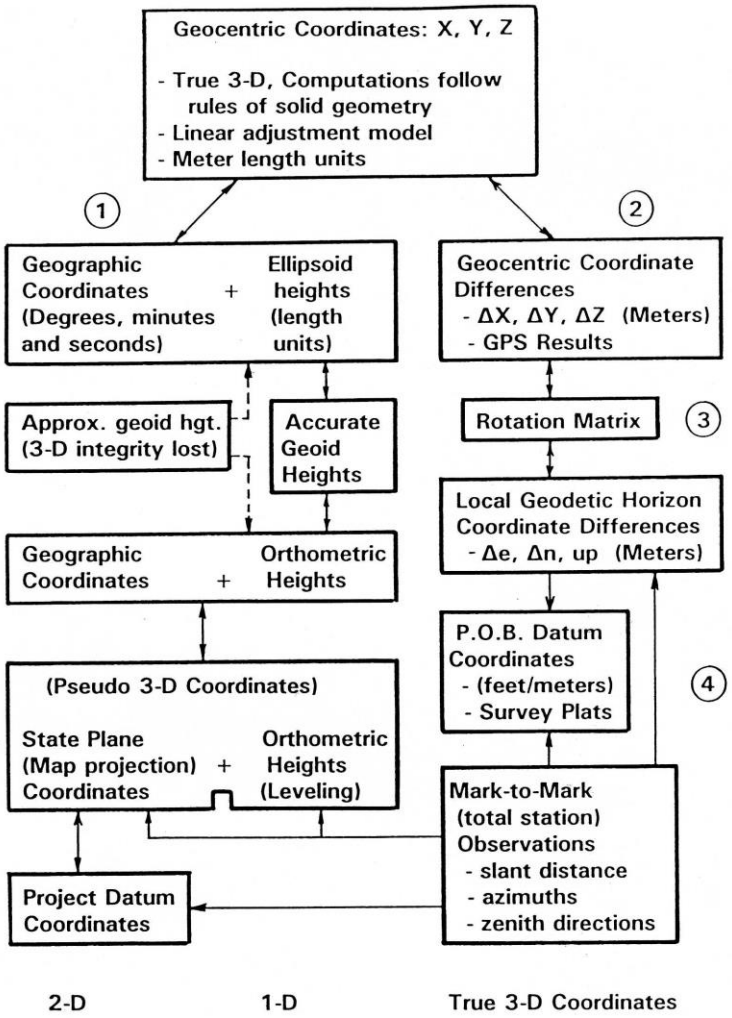

True 3-D is based on Earth-centered Earth-fixed X/Y/Z coordinates.
Pseudo 3-D uses geodetic latitude, longitude, and orthometric height.
(See Figure 6, "Using GPS Results in True 3-D Coordinate System," www.globalcogo.com/Tru3d.pdf)

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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 GSDM 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.

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.**

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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, THE 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.**

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.