The Global Spatial Data Model (GSDM) Preserves the Geometrical Integrity of a Geospatial "Digital Twin"

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The concept of a "Digital Twin" is somewhat intuitive and the underlying definition is rather broad. This article looks specifically at a Digital Twin as related to geospatial data (as opposed to non-metrical information). The thesis is that the global spatial data model (GSDM) is one of the three essential elements defining a geospatial Digital Twin.

The following definitions come from the same Aerospace Industry source.[1]

1. A Digital Twin is a virtual representation of a connected physical asset.

2. A Digital Twin is a set of virtual information constructs that mimics the structure, context and behavior of an individual/unique physical asset, or a group of physical assets, is dynamically updated with data from its physical twin throughout its life cycle and informs decisions that realize value.

Another quote from the same article is, "The essential elements of a Digital Twin are a virtual representation (model), a physical realization (asset), and a transfer of data/information (connected) between the two." In the context of geospatial data, the physical environment is the asset, the global spatial data model (GSDM) is the virtual representation, and the processes of data collection/processing constitutes the transfer of information. A 3-D model for 3-D data[2] is vital for a geospatial Digital Twin. Time is acknowledged to be a 4th dimension associated with use of the GSDM.

The 3-D global spatial data model (GSDM) is based on the Earth-centered Earth-fixed (ECEF) geocentric coordinate system and defines the unique location for any point worldwide. Long-standing rules of solid geometry facilitate converting ECEF differences to local $\Delta e/\Delta n/\Delta u$ components encountered in myriad applications. Including both functional and stochastic components, the GSDM[3] is defined in a document filed with the U.S. Copyright Office in 1997 and described further in various documents posted at http://www.globalcogo.com.

The digital revolution is the driving force behind many (largely beneficial) changes to the manner in which geospatial data are generated, stored, manipulated, displayed, and used. The convergence of abstraction/technology/policy/practice[4] enables users in disciplines such as engineering, surveying, mapping, navigation, remote sensing, and spatial data management to enjoy the benefits of a Digital Twin as manifest in terms of a common spatial model.

The geometrical integrity of a geospatial Digital Twin, especially in applications involving artificial intelligence and machine learning (AI/ML), is absolutely essential – due to absence of human intervention and/or possible devastating consequences. Such compatible geometry cannot be taken for granted due to fundamental differences arising from past practice – that is relying on separate horizontal and vertical datums as opposed to using an integrated 3-D datum such as the GSDM.

Using the geoid as a reference for the third dimension presumes continued use of separate horizontal and vertical datums. That policy is recognized and applauded, for now, as “doing what needs to be done.” But, as practice continues to evolve, a transition to using a 3-D datum needs to be studied and implemented carefully. Some of the challenges of “Reconciling Gravity and the Geometry of 3-D Digital Geospatial Data” are discussed in a separate paper by the author[5].

[1] AIAA, 2020, “Digital Twin: Definition & Value,” Position paper authored by the AIAA Digital Engineering Integration Committee.

https://www.aiaa.org/docs/default-source/uploadedfiles/issues-and-advocacy/policy-papers/digital-twin-institute-position-paper-(december-2020).pdf.

[2] It can be argued that geodetic latitude/longitude/height fulfills the requirement for a 3-D geometrical model. Advantages of the GSDM are provided by discussing “The Role of a Model” (Burkholder 2020). The GSDM is described as being both adequate and “simple” – preferred by end users.

http://www.globalcogo.com/role.html.

[3] Burkholder, E.F., 1997, “Definition and Description of a Global Spatial Data Model,” Filed with the U.S. Copyright Office, Washington, D.C., April 17, 1997.

http://www.globalcogo.com/gsdmdefn.pdf.

[4] Burkholder, E.F., 2021, “Geospatial Data: Convergence of Abstraction/Technology/Policy/Practice,” Presented via Zoom to New Mexico Geospatial Advisory Committee – George Clarke, Chairman, November 9, 2021.

http://www.globalcogo.com/abstraction-1.pdf.

[5] Burkholder, E.F., 2021, “Reconciling Gravity and the Geometry of 3-D Digital Geospatial Data,” Filed with the U.S. Copyright Office, Washington, D.C., September 16, 2021,

http://www.globalcogo.com/ImpactOfGravity.pdf.