The 3-D Global Spatial Data Model:

Foundation of the Spatial Data Infrastructure
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Foreword

Spatial data are digital and four-dimensional (4-D). Spatial location is 3-D and time is the 4^{th} dimension. Spatial data that are referenced to Earth's center of mass, an absolute location, are called geospatial data. Time is a relative quantity referenced to some named epoch (see Ch 2). The global spatial data model (GSDM) is an arrangement of existing solid geometry equations and proven mathematical procedures. In that respect, it contains nothing new. But, the GSDM is built on the assumption of a single origin for 3-D geospatial data and formally defines procedures for handling spatial data that are consistent with digital technology and modern practice. In that respect, the GSDM is a new model.

Why another spatial data model? Compatibility is essential when persons from disparate disciplines share data. Success is assured to the extent fundamental concepts are clearly defined and basic procedures for data exchange are formalized. Such standardization and centralization provide economies of scale to the user community. Subsequently, additional benefits are derived through decentralization in which innovative applications expand upon the capabilities supported by the underlying standard. Such benefits, in turn, spawn new markets and applications. As the cycle continues, the underlying standards and the assumptions upon which they were established need to be re-examined and, if appropriate, up-dated. The telephone is an example. A centralized regulated monopoly was largely responsible for placing a telephone in most homes in the United States. With the underlying infrastructure in place, additional benefits were realized as the industry was deregulated and competition between providers brought the consumer more options relative to telecommunication equipment and services. The twisted-pair analog standard upon which the telecommunications network was built is no longer adequate and digital technology has been implemented to support significantly greater levels of service. Consumers can now select various (even wireless) network connections for data, voice, fax, and cable.

Geospatial data are another example. In the past, analog storage of geospatial data on a map was standard practice. Geographic coordinates provide global standardization and derivative uses such as map projection (or state plane) coordinates are commonplace. The benefits of such centralization were a driving force in the early stages of building geographic information systems (GIS's) as users and agencies needed to pool resources to achieve desired economies of scale. But spatial data users are experiencing the same analog/digital transition as the telecommunications industry and the underlying model needs to be re-examined. With the advent of affordable digital technologies; i.e. global positioning systems (GPS) and related computer resources, the demand for spatial data products is growing rapidly. Enormous gains in productivity have been achieved by automating procedures for handling spatial data and by switching from analog to digital spatial data storage. However, traditional (horizontal and vertical) spatial data models fail to exploit fully the wealth of data available. In a sense, the spatial data user community continues to "put new (digital) wine into old bottles". The GSDM is a new bottle model that preserves the integrity of 3-D spatial data while providing additional benefits, i.e. simpler equations, worldwide standardization, and the ability to track spatial data accuracy with greater specificity and convenience.

Computer databases are digital. Analog maps are still used but, increasingly, maps and data visualizations are generated upon demand from a digital database. Rarely is a map now used for primary spatial data storage. Spatial data are 3-D and maps are 2-D. Modern measurement systems collect 3-D data, yet many computer databases store spatial data as 2-D horizontal data and 1-D vertical (elevation) data. An improved practice is to build and share a 3-D database which supports both 2- and 3-D applications in either analog or digital mode. Separately, the importance of spatial data accuracy has come to the fore as evidenced by efforts to develop meta-data standards and specifications. These issues and others are addressed by re-examining the underlying spatial data model and by designing spatial data collection, storage, manipulation, adjustment, and visualization procedures based upon the 3-D global spatial data model (GSDM).

But, perhaps even more compelling arguments favoring adoption of the GSDM can be derived from publication of two documents prepared by the U.S. National Academy of Public Administration:

- "The Global Positioning System: Charting the Future" was prepared for the U.S. Congress and Department of Defense, was published in 1995, and describes the history, performance, and future of GPS. This document is particularly important to those who build, operate, and utilize the systems that generate reliable geospatial data. The Executive Summary states, in part, "GPS is much more than a satellite system for positioning and navigation. It represents a stunning technological achievement that is becoming a global utility with immense benefits for the U.S. Military, civil government, and commercial users and consumers worldwide."

- "Geographic Information for the 21st Century" was prepared for the Bureau of Land Management, Forest Service, United States Geological Survey, and the National Ocean Service, was published in 1998, and describes the instrumental roles that agencies of the U.S. government have played in "surveying, mapping, and other geographic information functions since the beginning of the Republic." The report includes various excellent recommendations based upon use of geographic information systems (GIS's) under the conceptual umbrella of the National Spatial Data Infrastructure (NSDI).

Many persons in various professions are comfortable with both reports. But, by and large, the GPS group includes highly technical specialties such as aerospace engineers, electrical engineers, geodesists, physicists, and photogrammetrists. The GIS group probably involves a greater number of people and includes spatial data users whose professional/technical focus tends toward administration, local government services, information technology (IT), civil engineering, surveying and mapping, planning, and business. In addition to professional interests, the number of people using GPS and/or GIS on a personal level is growing exponentially, a trend reasonably expected to continue.

Interoperability is the key. The GSDM builds a conceptual bridge between the two NAPA reports by providing a consistent 3-D geometrical framework for both GPS and GIS. The GSDM serves the scientific end of the spectrum without sacrificing technical rigor while simultaneously providing local spatial data users the opportunity to work with local flat-Earth coordinate differences and to view the (virtual) world from any location. Examples of this interoperability bridge are highlighted at various places throughout the book.