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

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A Fascinating Musical Analogy
Even Temperament and the GSDM have much in common!

This comparison looks at efforts to adhere to physical principles while simultaneously attempting to maximize efficiency and standardization. A legitimate tension develops as advantages of conflicting goals are identified, emphasized, and pursued. In some cases, a resolution may emerge rather quickly. In the case of "even temperament" as applied to the musical scale, resolution took about 2000 years. Hopefully, the advantages and efficiencies of performing spatial data computations in 3-D space will be realized before the year 4015.

What does it take to tune a piano correctly? It may depend upon who you ask.

Probably the best answer for the past 400-500 years has been "A piano is tuned using even temperament in which the 12 frequency intervals between successive do's are identical." That has not always been the case. The frequency of vibration of a given note on the musical scale is either double or half the frequency of the note one octave above or below the given note. The ratio is 2:1. Musical harmonies and pleasing sounds arise from ratios other than the octave. A perfect fifth is based on the 3:2 ratio, a perfect fourth uses the 4:3 ratio, and a major third is based upon the 5:4 ratio. But, it is impossible to tune a piano such that octaves, thirds, and fifths can all be played in a given key. The even temperament solution adopted in the 15^{th} and 16^{th} centuries avoids discordant sounds by allowing small tuning deviations (too small to be heard by all but the most discriminating ear) from the "ideal" to preserve the even intervals now standard on the piano keyboard.

Pythagoras (about 530 B.C.) studied the vibrations of a string and analyzed various frequency combinations. He became aware that certain combinations were incommensurable and, like $\sqrt{2}$, could not be expressed as a ratio of integers. That dilemma captured the imagination of learned persons for several thousand years - Plato, da Vinci, Galileo, Kepler, Descartes, Newton, and others. In the Prelude of "Temperament: How music became a battleground for the great minds of western civilization" Stuart Isacoff (2001, 2003) writes:

> The general acceptance of equal temperament led to some of the most exquisite music ever written. Why the resistance to it lasted so long and how it was gradually overcome, is a story that encompasses the most crucial elements of Western culture – social history, religion, philosophy, art, science, economics and music evolution.

Links to other sources are available via a Google search of "even temperament."

What is the comparison with the global spatial data model (GSDM)? Although not an exact parallel, there are common elements highlighted by the digital revolution of the past 50 years.

The convergence of three technologies – computers (data storage), GPS (positioning), and WWW (communication) – has revolutionized many aspects of modern society and especially the use of spatial (and geospatial) data. A somewhat abstract summary of how 3-D digital spatial data are perceived is included in an "award-winning" paper presented at the NMSU Science, Engineering, & Technology Education Conference in January 2004.

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

A consequence of technological advancement is that spatial data computations can now be performed in 3-dimensional space more efficiently than have been traditionally performed on the ellipsoid using geodesy equations or on a map projection using the state plane coordinate systems. A link to a description of an Idea whose time has come is:

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

Fundamental justifications for considering and/or using the GSDM include:

1. The GSDM assumes a single origin for 3-D digital spatial data.
2. The DoD earth-centered earth-fixed (ECEF) geocentric coordinate system is the basis for computations and data storage. It is one system for the entire world.
3. Computations are performed using long standing (proven) rules of solid geometry.
4. Spatial data accuracy is computed using standard error propagation equations.

It is acknowledged that traditional (geodesy and map projection) models are used extensively and that users are heavily vested in their continuing use. However, in the same way in which standardized practices of even temperament eventually won-the-day in music, the advantages of implementing the integrated 3-D global spatial data model (GSDM) will eventually carry-the-day in worldwide use of 3-D digital spatial data.

Additional links to various features of the GSDM can be found at:

1. Comprehensive list www.globalcogo.com/refbyefb.html
2. Focused/abridged list http://globalcogo.com/QuickLinks.pdf