Introduction

The purpose of this Foreword is to give the reader some insight as to the philosophy and inspirations guiding the author. The primary objective in writing the first edition was to serve the end user by identifying fundamental concepts underlying the use of spatial data—especially as related to the spatial data infrastructure. Given the success of the first edition, the concepts are extended in the second edition by applying well-known principles of solid geometry and information management to real-world applications. This second edition is offered with the hope that it will be useful to many users across the spatial data spectrum—from high-level scientific applications to the endless list of flat-Earth applications. The global spatial data model (GSDM) serves spatial data users all over the world and within the confines of near-space.

As described in the first edition, the GSDM includes functional model equations of solid geometry and stochastic model equations for error propagation. Building on those, this second edition includes additional information on least squares adjustment and applications of the GSDM. The focus of the least squares treatment is twofold—highlighting the use of linear least squares adjustments and being very specific on tools for handling both network accuracy and local accuracy. The impact of those concepts could be very far-reaching in the development of standards for monitoring the location of autonomous robots—be it driverless vehicles (land based) or drones (airborne). Knowledge of spatial data accuracy "with respect to what" is becoming absolutely essential.

Challenges to adopting and using the GSDM have been identified based upon feedback from first edition readers. It is not possible to address all challenges, but second edition readers can enjoy a "heads up" by familiarizing themselves with the following:

1. Geocentric $X/Y/Z$ coordinates are the primary definition for the location of any point worldwide. This includes all points in a point cloud.
2. Coordinate differences—$\Delta X/\Delta Y/\Delta Z$—define the 3-D vector between two points.
3. Using a rotation matrix, the same vector is viewed from the local perspective.
4. The origin of a local coordinate system is coincident with the tail of the vector.
5. A local tangent plane is perpendicular to the ellipsoid normal through the origin.
6. Except for orientation, the mathematical characteristics of a rotated vector are unchanged.
7. Resulting $\Delta e/\Delta n$ components are used for "flat-Earth" surveying computations.
8. Horizontal distance and azimuth "here" to "there" are computed from $\Delta e/\Delta n$ components.
9. The Δu component is the perpendicular distance from the tangent plane to the forepoint.

10. Computations are performed in 3-D space when using the GSDM. There is no need to reduce measured distances to the ellipsoid or to a mapping surface. The GSDM does not distort distances or angles. Geometrical integrity is insured by basing derived quantities on $X/Y/Z$ values that are not changed by the model.

But, because humans stand erect and walk on a "flat" Earth, a bigger challenge arises from a mind-set that separates horizontal and vertical. A common reaction to the GSDM is "we don't do it that way." That challenge reflects pedagogical issues that also need to be considered. René Descartes formalized concepts of solid geometry in 1637 and those tools (especially plane geometry) have been used extensively ever since. But, with the advent of the digital revolution, Descartes' fundamental principles also need to be implemented in the 3-D environment.

Embracing competence and more efficient ways of handling 3-D digital spatial data will also require consideration of those pedagogical issues. Traditional discussions about the difference between training and education remain relevant and should be actively pursued. But "learning how to learn" is more fundamental and will pay huge dividends to those having the foresight to accept that challenge. Equipment manufacturers, vendors, and numerous consultants are bringing "traditional solutions" to the marketplace and spatial data users are faced with an ever-expanding list of options regarding purchase of equipment, software, data, and professional services. Marvelous accomplishments are possible and many good things are being achieved but, increasingly, a "black box" is replacing the critical analysis processes of the licensed professional. That is a two-edged sword. Many data collection businesses are both legitimate and profitable. Society benefits from increased productivity but, on the other hand, the role of too many licensed professionals is in danger of being relegated to that of a button-pushing technician.

The author's aspiration is that more efficient methods of handling 3-D spatial data will be embraced in the educational and learning processes for various spatial data professionals. The GSDM is viewed as a unifying concept for spatial data disciplines worldwide and should be included as a standard part of both undergraduate and graduate spatial data curricula.

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