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GEODESY – A course in 15 sessions

INTRODUCTION

This pay-per-view course fills a critical void left by the academia. It is driven by customer questions and answers that were collected over 20 years during my GIS and geomatics consulting efforts, in this course provides down-to-earth and practical knowledge. As such, this course is designed to build improved professional judgment.

Relevant academic subjects are inserted only where necessary. The complex concepts are easy to understand and apply. “A ton of good information” (to quote one of our students) is provided. After all, “pressing the right button is of critical importance” (another student).

If you work in mapping, surveying, or engineering, or with GPS, GIS and other land technologies, this course is for you. A sampling of the type of students who have taken the course includes:

- GIS (technicians, professionals, and administrators)
- Surveyors (technicians, surveyors, Chief for a City)
- Company staff (civil engineers, mappers)
- Public agency personnel

This course provides the basic understanding of those things that can make life hard. Geodesy (“dividing the earth”) is the actual science that supports the above work. It is the one that defines geoids, ellipsoids, datums, projections, satellite positioning and any image georeferencing. It provides the math for everything that deals with the size and shape of the earth, and how to position things uniquely on them. It addresses, for example, where community coordinate systems and elevations come from. However, the math is only presented as an aid to explain things, but you will have enough information to go further if you want to.

1. TRIGONOMETRY REFRESHER

To start, we undertake a review of what most of us forgot from high school. The intent is to make you feel comfortable when encountering trigonometric concepts in the other sessions. We will also solve some basic surveying problems. You may want to have a calculator with trig functions at hand.

- Angles, units, conversions
- How survey trig differs from high school trig
- Azimuths and bearings
- Direct and inverse calculations
- Areas

2. COORDINATE SYSTEMS AND TRANSFORMATIONS

This session covers coordinate systems that are used for project reference systems. The intent is to clearly outline and explain the foundations of spatial geometry for any engineering, mapping, or imaging project.

- Cartesian systems
- Transformations (Helmert, affine, advantages/dangers, etc.)
- DEM, TIN, DTM, DSM
- Contour Lines
- Breaklines

3. LEAST SQUARES CONCEPTS

Born out of statistics, least squares methods affect GIS, GPS, mapping, etc., and are therefore especially important (but badly misunderstood) concepts. This review will clearly provide an understanding of what least squares does, and why. With a simple example, the student will learn what it is used for, and how it leads to concepts of precision and accuracy.

- From linear equations to over and under-determined problems
- A simple project
- A mathematical model
- A best fit
- Residuals, Sigmas, RMSE, confidence intervals
- Least squares and statistics (unknowns vs. observations)
- Uses in GIS, surveying, and mapping

4. GEOIDS

Geoids are the new zero elevation reference. Presented are the methods that were used to determine them, historic attempts to approximate them, problems in a moving world, and what one has know before discussing datums.

- Gravity
- Geoids
- Orthometric heights
- Deflections of the vertical

5. ELLIPSOIDS

Then we discuss ellipsoids that were mathematical models of earth that were developed based on geoids. An understanding of ellipsoids leads to an understanding of geodetic coordinates and their use.

- Ellipsoids
- Greenwich
- Ellipsoidal heights
- Geoidal heights
- Basic Astronomy

6. GPS

What does a GPS really measure? This question has a complex answer, and discussions about accuracy are sparse. How does GPS relate to the previous topics, and what really does one have to do to achieve promised GPS accuracies?

- GNSS
- GPS Components
- Constellations
- DOP
- Error Sources
- DGPS
- WAAS

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7. PRECISION AND ACCURACY

No professional can escape the need to prepare accuracy statements. Not only will we cover what such a statement would have to contain, but how one sets up meaningful messages that withstand detailed scrutiny.

- Quality
- Scales vs. Accuracy
- Precision vs. Accuracy
- Standard Deviations and RMSE
- Confidence Intervals
- Error Ellipses and Ellipsoids
- Equipment Errors
- Orthorectification Errors
- QA/QC

8. PROJECTIONS

Projections are complex concepts that come out of geodesy. They can be difficult to understand and use, but a major effort was done in this course to simplify these concepts. Clean equations will be provided, and instructions for their use will be given.

- Basic Projection Concepts
- Lambert
- UTM
- Colorado State Plane System
- Zones
- Conversions
- Coordinate Jumps
- Various Norths

9. PROJECTIONS MATH

The session includes a look at projections math. We will demonstrate that projections calculations can be calculated with a hand-held calculator, with Excel, or through Python programming. We will review all the information that is necessary to do that, such as:

- State-by-state and zone-by zone projection types
- Zones
- Origin coordinates
- Scale factors

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10. HORIZONTAL DATUMS

This track covers horizontal and vertical datums that fix the position of maps and GIS databases. Included in this track is the Public Land Survey System (or American Rectangular System), which is the basis for sections and townships, and which therefore affects CAD work that deals with land parcels. A significant effort was made to simplify the complex topic of horizontal datums.

- History
- Datum Conversions
- Datum Errors
- New Datums
- The Role of GNNS
- The Changing Nature of datums

11. VERTICAL DATUMS

Vertical datums are also covered. One of the most misunderstood aspects in large project management is related to vertical datums. Discussed are mean sea levels, gravity and geoids, and benchmarks.

- History
- Ellipsoidal vs. Orthometric Heights
- Deflections of the Verticals
- The Changing Nature of datums
- Modern Efforts
- Leveling
- The Earth is Flat?
- Engineering concepts

12. PLSS AND GIS

Here, the Public Land Survey System (aka American Rectangular Survey System) is covered in more detail. The American survey fabric was developed to facilitate land ownership control, something that is of universal concern. Even if this is an American solution, It has historic and practical significance in GIS, even if a project is not in the US. Anyone dealing with a cadastral project (parcel mapping) will see that engineers and surveyors can have opinions that differ from those of GIS personnel. This session builds a bridge between seemingly contradicting concepts, methods and tools.

- Construction History
- Key Basic Rules
- Townships and Ranges
- Distances and Directions
- Metes-and-Bounds
- Modified State Plane Method
- Why does my Plat not fit my GIS?

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13. LiDAR

LiDAR is a valuable tool for the collection of three-dimensional data and some remote sensing information, often in support of photogrammetric projects. LiDAR has an important role in the preparation of ortho maps. This session looks at the technology, the georeferencing, classification, editing processes, and delivery formats.

- Sensor
- Beams and returns
- Adjustments
- Processing
- Accuracy
- Formats

14. PHOTOGRAMMETRY 1

Presented are the major components of a large photogrammetric project. In general, projects still have the same general components, even if nowadays these actions are done digitally.

- Purpose of photogrammetry
- Lens distortion
- Image resolution
- Orientations
- AGPS/IMU payloads
- Collinearity condition
- Orthorectification
- Autocorrelation
- Epipolar geometry

15. PHOTOGRAMMETRY 2

This final session of the course is left for a review of a handful of real projects, and their results, plus a demonstration of photogrammetric software.

- Sample projects
- Software demonstration