2001, A GIS SPATIAL ODDESSY

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Biographical Sketch

James G. Donahue is a licensed land surveyor in private practice. He is currently employed by Post, Buckley, Schuh & Jernigan of Irvine, California, as R/W Coordinator for one of California's first toll highways in Eastern Orange County and Principal GIS Consultant. He has practiced land surveying since 1953. He is a member of several state surveying societies and has been active as a member, officer, and director of the American Congress on Surveying and mapping.

From 1963 to 1980, he served as a principal in the firm of Donahue and Thornhill of Geneva, Illinois. In 1974-75, he was an Instructor of Surveying at the University of Alaska in Anchorage. From 1980 to 1982, Mr. Donahue served Du Page County, Illinois as its "Surveyor in charge", consulting and advising on its current Remonumentation; and Integrated Computer Mapping Program. From 1983 to 1985 he directed the preliminary engineering design surveys for two major Transmission Line Projects in the United States. Since 1985 he has been employed by several Southern California Civil Engineering firms as a Project Manager.

Abstract

The licensed Land Surveyor is today and tomorrow's GIS specialist. He or she is uniquely trained and qualified to deal with the basic element of any GIS, the <u>LAND</u>.

The Cadastral parcel, being the basis for indexing spatial relationships to geographic locations on, below, or above the earth's surface, makes he or she the most familiar with our systems of land tenure and its unique characteristics. The statues and common law interpretations of matters relating to real property are thoroughly understood by the spatially oriented Land Surveyor.

His or her legal and mathematical abilities make him or her invaluable to the creation of any meaningful Land Information System or Geographic Information System.

The creation of a parcel based GIS/LIS is a process which will be described in some detail here, noting the advantages and disadvantages of various methodologies, including cost, utility, and longevity. Also the current and future status of automated GIS/LIS Systems will be discussed, along with the different types of environments that utilize Parcel Based Systems as the basic element for spatial reference.

1 Introduction

By the year 2001 almost every entity will have converted to some sort of GIS/LIS automated system for defining their specific relationship to the world as it is known to affect their everyday operations.

The dilemma almost all GIS/LIS creators face is how good should it be. That is how much data is needed, and how accurate should the spatial relationship be. All of this relates to cost and longevity. That is, should we only look at things on an interim basis and change or upgrade as the need arrives, or to develop a system for long term goals as well as interim needs. This will depend on each entities need and its budgetary constraints.

2 Land Base Creation

The one data base layer that is common to all spatially related systems is the Land Base or coordinate systems that will allow for defining spatial relationships in 3D.

1. There are five basic types of Land Bases that can be used depending on the factors mentioned above:
2. Existing maps from within (In house maps of various types)
3. Commercially acquired data (Map Info., ETAK, etc.)
4. Quad Maps
5. Aerial Photography (Rectified or UnRectified) or Digital Orthophotography Computed (Coordinate Geometry) Created from Ground Survey Control measurements related directly and Recorded Maps and Documentation.

3 Existing Maps

This type of Land Base is created by digitizing or scanning existing "in-house" records such as Operating Maps or hand drawn City or County Maps showing existing facilities and thoroughfares. This creates a system of low grade horizontal relationships. Some vertical information may be on existing maps but is not extensive enough to allow for any 3 D type analysis. The cost is considered to be "Low" with only minimal accuracy within itself.

4 Commercially Acquired Land Base

This type of Land Base is usually a large scale delineation of street center line networks in urbanized areas of the country derived from Census Tract "Tiger Files," existing City/County maps, and or large scale aerial photography obtained from government and commercial entities. This type of Land Base is usually used for regional planning, regional business marketing, route system planning, and demographic studies. The cost of this type of land base is usually "moderate" and has little or no 3-D capabilities, and is positionally accurate to 10 to 100 meters depending on the type of ground control that may have been available for any particular area.

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11 Create and Install Cadastral Database

Assuming all previous cadastral computations have met the predetermined standards for positional tolerance a digital cadastral database should be created in two parts:

1. Original cadastral map closure layer.
2. Adjusted cadastral map layer.

Depending on the particular hardware/software platform being used, a proper digital file should be created for both of the above layers of cadastral data for installation on the end users GIS/LIS system. A series of test runs should be run to verify the correctness of the two cadastral layers.

If the system has an aerial orthometric layer a series of overlay checks should be made to determine the exact quality of the overlay. One problem that arises is that the aerial layer and the cadastral layer may have been referenced to different coordinate systems. One must always be sure that the same Geodetic Control System is used for both layers.

12 Future Trends

New technologies will play a significant role in the future of GIS/LIS systems. The current GPS technology will proliferate into low cost accurate coordinate data collectors, being used by almost everyone to some extent. The age of soft copy photogrammetry will continue to provide lower cost desk top images of the real world underneath other layers of data.

Many new applications will emerge as technology continues to drive the market. The world of government and private business will develop more joint-venture projects to get the most out of their shrinking U.S. dollars. Third party agreements will also proliferate as more hardware and software become less and less proprietary. Cost will continue to go down on a per capita basis for GIS/LIS systems.

New laws relating to the reuse of GIS/LIS data by others will emerge to assist the integration of digital data into the lives of the general public.

Whether we like it or not the computer age is here to stay and will dominate the way the world operates for the unforseeable future. We are indeed on a "Spatial Oddessy" of unknown duration. How we create it and use it will determine "its" and our fate.

13 Conclusion

It is apparent there are several ways of establishing a Land Base for a GIS/LIS automated systems. According to a recent article in AM/FM Internationals "Networks" (Vol. 10 No. 3) regarding Land Base Accuracy, Mr. Reinford Meihsner, of Wisconsin Gas states: "There is no substitute for an accurate Land Base. Without an accurate Land Base, maintenance becomes more expensive and difficult to manage. Problems frequently occur when trying to get new plotting information into an existing Land Base. The difficulties of an inaccurate Land Base become even more pronounced as the integration of new technologies proliferate." Meihsner advised, "GET THE MOST ACCURATE LAND BASE YOU CAN AFFORD; IT WILL PAY BIG DIVIDENDS."

5 U.S.G.S. Quad Maps

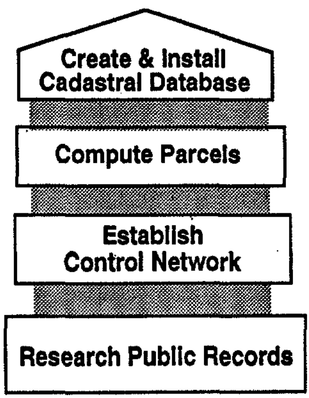
This Land Base is created by digitizing or scanning currently available U.S.G.S. quad maps usually 7.5' series. However, some areas may only be available in 30' series maps. This type of map yields both horizontal and vertical information to allow for some 3-D analysis such as "slope" and drainage area studies. The positional accuracy is considered to be plus or minus 12 meters on the 7.5 min. series while the 30 min. series may only be 50 meters. This Land Base is generally used for regional planning, and large area facilities inventory. The cost is considered to be in the "medium" range.

6 Aerial Photography (see Tables 1 through 8)

Land Bases created from either unrectified or rectified aerial photography are considered to be of minimal use and are low cost items to purchase. The accuracy can vary considerably depending on the type of terrain. Ground controlled aerial photography and orthometric processing can yield a very desirable less than 1 meter Land Base. It can yield 3-D information accurately to about 30 cm horizontally and vertically. It yields visual planimetric data that cannot be gathered cost effectively by any other means. The initial cost of this type of Land Base is considered to be in the higher range but is offset by its many uses. The uses in a GIS environment are planning, zoning, and preliminary and final engineering of capital projects when mapping Specifications are precise enough. The need for remapping is dictated by how much change takes place over time.

7 Computed Digital Land Base

This type of Land Base combined with Orthometric Aerial Photography will yield the highest quality Land Base having the longest use over time. This type Land Base is considered the cadastral portion of the entire Land Base. This is the area where the licensed land surveyor is most needed due to his or her particular expertise in mathematics and boundary law. This type of Land Base is based on the "cadastral parcel" integrated with the U.S. Geologic Control System and the specific legal document of record in the area of concern. The preservation of "property rights" and the determination of the quantity of land held is of paramount importance. Therefore, proper identification of the "cadastral parcel" and all of its attributes require the specific expertise of the Licensed Land Surveyor. The cost can arange form approximately $3 to $15 per parcel depending on density of population and size of the parcels being computed. The following outline generally describes how this type of Land Base should be created:



8 Research Public Records

All geodetic and cadastral parcel information must be obtained and organized in a fashion so as to minimize work efforts. This includes assessors parcel records, as well as recorded parcel records. This will require cooperation with the public agencies maintaining these records, as well as private title companies.

It is in the best interests of all concerned to "share data". Agreement should be reached as to "who" is going to do "what" with "what" for "whom". Reciprocal Data Exchange Agreements work well in accomplishing this phase of the work.

9 Establish Control Network (Geodetic Control)

Before beginning this phase of the work, one must predetermine the positional accuracy that will be required for the final "Cadastral Data" layer. This will usually be determined by the accuracy of the existing maps of record in the region.

Primary Control is obtained by observing existing Geodetic Control measurements of known position and accuracy (1st, 2nd or 3rd order). Secondary control is then set at predetermined intervals such as 1,500, 3,000, 5,000 meters (1-3 miles) apart and observed to determine geodetic positions. Spacing of secondary control depends on the final positional accuracy required for cadastral corners. The use of Global Positioning Systems (GPS) has become the method of choice for accomplishing the Geodetic Control due to its apparent speed and lower cost per point observed ($100 to $500 per point) depending on logistics and accuracy required. Most cadastral corners which control the researched maps of record should be tied to the established secondary control in order to determine at geodetic position of each controlling corner.

10 Compute Parcels (Coordinate Geometry)

After determining the geodetic position and the State Plane Coordinates values at ground level of each cadastral controlling corners, one should organize the coordinate geometry computations into blocks within the spacing of the cadastral geodetic control measurements. The assignment of specific blocks of computations should be done so as to keep all computations isolated within the previously adjusted cadastral control network block.

All original maps should be closed, and preserved for future use in checking the final cadastral map layer. Being as the geodetic control is probably more accurate than the cadastral maps of record, one should determine adjustment processes, such as least squares, or other appropriate adjustment process that will maximize the positional accuracy of any point within a certain block of computations.

After all cadastral blocks have been computed and adjusted several cross-block checks should be made to determine the positional accuracy of the end product. This is done by an inverse procedure using final cadastral coordinates and comparing each inverse with its original record inverse. If the inverses check within the predetermined accuracy requirements than the cadastral layer is complete. If the cross checks are not checking within tolerance, each block should be re-evaluated in order to isolate probable areas of concern for re-computation.