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THE FUTURE OF DIGITAL ORTHOPHOTOGRAPHY IN GIS IN THE U.S.A.

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1. INTRODUCTION

Digital Orthophotography will become a major landbase layer in GIS in the United States, in the author's opinion. There are many reasons for this:

* It is a truly generic landbase, suitable for everyone
* Computer capability for handling raster is increasing
* Interest from the various Federal Government Agencies
* Interest from some State Agencies
* Interest from Utility Companies
* Interest from Cities and Counties

1.1 Digital Orthophotography is a Generic Landbase

Most current GIS landbases in the USA are 1"=100' (1:1,200) scale vector maps created from photogrammetry, usually with two foot contours. Some are being created from cadastral information tied at half-mile intervals to GPS control, without using photogrammetry. At this date, at least fifteen major projects are in progress, of which none has been fully completed.

All of the photogrammetric vector landbases have selectively chosen the planimetric features which their users require. Some have only bare essentials such as roads and rivers and commercial buildings; others have chosen to capture everything visible on the photography. The pure cadastral landbases show only cadastral information, i.e. property boundaries, and no land features at all.

An additional layer of raster photographic imagery, registered exactly to the vectors, would form an ideal store of information as virtually everything on the ground would be visible and interpretable by all users.

Consider, for instance, a gas utility company. A raster landbase would show all the land features such as roads, buildings, sidewalks, driveways and other features which could influence the placement of underground gas pipelines, while the actual utility structures would be depicted by vectors.

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1.2 Computer Capability

The almost incredible increase in computer speed in the past few years has made the handling of large raster files possible, even on relatively inexpensive workstations. Although not all of the GIS software vendors can yet display raster files in registration with vector files, it will not be long before hybrid vector/raster GIS systems become commonplace, making it possible to use digital orthophotographic imagery as a backdrop to the important cadastral and utility vector layers.

1.3 Interest from Federal Government Agencies

In April, 1990 a seminar on Orthophotography was held at Goddard Space Center, Maryland which was attended by over two hundred Federal employees from nine Federal Agencies and a few people from the private sector. There was overwhelming interest in a proposal to map the entire USA (excluding Alaska) from the new National Aerial Photography Program (NAPP) which is designed to fly 1:40,000 black & white or false color photography along N-S lines covering quarter-quad sheets over the whole country, and produce 1:12,000 digital orthophotos from this photography, at (probably) 2 meter pixel resolution on a UTM grid.

(A quarter-quad sheet is a quarter of a regular 1"=2,000' USGS map sheet which covers 7.5 minutes of latitude and longitude.)

A paper was presented at the seminar which put the cost of the program at about $350 million, and called for financial participation from State and County governments.

1.4 Interest from State Agencies

Many of the individual states have formed State Mapping Advisory Boards, amongst them the States of Georgia and Florida. The State of Georgia recently chose orthophotography at 1"=400' (1:4,800) as their future map base, in 10,000 feet squares, i.e. 25" by 25" map sheets. Although they have not yet decided that the medium shall be digital, it will almost certainly end up that way, as the digital approach has proved to be competitive in cost with conventional orthophotography.

1.5 Interest from Utility Companies

The utility companies are probably more willing and able to invest large sums of money in GIS than governments, and several of the larger companies such as Southern California Gas Company, Florida Power & Light, Alabama Power Company and others are showing interest in digital orthophotography. In the author's opinion, raster imagery is an ideal GIS landbase for large utilities covering huge areas of land. Another factor is that the utilities will wish to share their

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costs with other potential GIS users, and digital orthophotography will have great appeal to a large variety of other users as it is so generic in nature.

1.6 Interest from Cities and Counties

A number of cities have decided to use the technology, at least in pilot studies, among them the cities of Alhambra and Riverside in California, and Omaha, Nebraska. Riverside County and Sacramento County in California and Clark County, Nevada are also considering its use.

2. The Nature of GIS in the USA

There are three major layers of information in GIS projects in the USA:

* Landbase (vector or raster)
* Cadastral (property or parcel maps)
* Utilities

There are other minor layers of information:

* Thematic (soils, flood plains, forest types, etc.)
* Political (city boundaries, voting districts, etc.)

The raster imagery would form an ideal landbase for all the informational layers, most of which will be displayed as vectors.

NOTE: Color raster imagery will probably not be as widely used as grey-scale imagery, because color vectors will not be clearly visible when superimposed on a color raster background.

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3. Case Study: City of Riverside, California

Area being mapped	80 square miles
Scale of Mapping	1" = 100'
Scope of Mapping:	
	Contours
	Planimetry
	Cadastral
	Digital Orthophotography
	Utilities:
	Electric
	Water
	Sewer
	Stormwater
Contract Value	$ 3.7 million
Technical Details:	
Software	ARC/INFO
Hardware	IBM RS-6000 workstations
Photo scale: mapping	1" = 600' conventional color
orthos	1" = 830' B&W with 60% sidelap
Scanned pixel size	25 microns
Ortho pixel size	1.0 feet
Raster database size	2.2 gigabytes

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4. Case Study: Florida Power & Light

NOTE: This project is envisaged, not yet implemented.

Area being Mapped	28,000 square miles
Number of customers	3.3 million
Scale of Mapping	1"=200', 1"=400' and 1"=1,000'
Scope of Mapping:	
	Digital Orthophotography Cadastral Electric Utilities
Contract Value	Approximately $40 million

Technical Details:

Software	IBM GFIS
Hardware	IBM
Photo scale	1"=1,300' and 1"=3,333' B&W
Scanned pixel size	25 microns
Ortho pixel size	2 feet (8,000 sq.mls.) 4 feet (8,000 sq.mls.) 8 feet (12,000 sq.mls.)
Raster database size	75 gigabytes

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5. Why Not Use a Vector Landbase?

Some of the advantages and disadvantages of vector or raster landbases are as follows:

VECTORS	Advantages	Disadvantages
*	Clearly interpreted lines	* High cost
*	Topological structure possible	* Only selected features are visible
*	Small database size	* Unsuitable for other users
*	Small features easily updated or modified	* Updating of complete landbase is expensive
*	Separate layers of information	

RASTER	Advantages	Disadvantages
*	All features are visible	* Some features not clearly interpretable
*	Relatively low cost	* Updating requires re-photography
*	Suitable for most users	* Large database size
*	DTM is a by-product	* No topology
*	Updating of complete landbase is relatively inexpensive	

6. Storage, and Other Issues

The biggest obstacle to wide acceptance of raster imagery as a landbase for GIS is file size.

However, the display of raster at varying resolutions is a comparatively easy matter, as raster imagery is very easily resampled into data sets of lesser resolution. It is envisaged that as many as seven or eight different separate data sets will be created from the same original imagery.

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Consider, for example, the City of Riverside project described above which covers an area of 80 square miles.

Pixel Size (feet)	Size of Database (megabytes)
1	2,230
2	556
4	139
8	35
16	9
32	2
64	0.5

Note that all the various data sets combined would total only one third more than the basic high resolution data set. A strong case can be made for storing all the different sets separately, so that resampling of data would not be necessary when zooming in or out of the screen image. Also, some users would never require the high resolution data, so they would store only those data sets which they need.

Using the high resolution data set, one would be able to zoom in to a street intersection and see cracks in the roadway. Using the low resolution data (about the same as SPOT or LANDSAT imagery), the whole City could be viewed on the screen at one time.

There are many aspects of the problem which will require research and development, including:

File Size

* Image resolution (lines per inch)
* Image compression
* Workstation screen resolution
* Workstation memory
* Ability to pan and zoom
* Pixel size (6, 7 or 8 bits)
* Disk Storage (magnetic, optical, CD-ROM)

Display Speed

* Tiling
* Image decompression
* Disk speed
* Communications (I/O)
* Network hardware
* Network protocols

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Other Issues

* Metric or Imperial units
* Registration with vector overlays
* Color or grey scale
* Display of multiple files
* Display of satellite imagery

All these aspects need to be investigated and choices made on conflicting issues like "image resolution versus storage capacity".

7. Cost of Digital Orthophotography (Large Projects)

The cost of digital orthophotography will vary with several parameters, particularly the cost of obtaining good digital elevation data. As a rough guide, some costs are given below. They include photography, aerial triangulation and collection of elevation data, but do not include the cost of ground control or mylar hard copies.

Scale	Photo Scale	Pixel Size	Cost per sq.ml.
1: 1,200	1:10,000	1.0 feet	$1,200
1: 2,400	1:16,000	2.0 feet	$ 400
1: 4,800	1:24,000	4.0 feet	$ 200
1:12,000	1:40,000	8.0 feet	$ 100

REFERENCES

"A Strawman Proposal For A National Digital Orthophotoquad Program"
--Gale TeSelle, Director of Cartography GIS Division, USDA, Soil Conservation Service, Washington, D.C., May 1990
National Orthophotography Forum, NASA Goddard Space Flight Center, Maryland, USA

"Digital Orthophotography: An Alternate Landbase"
--John A. Thorpe, April 1991
GFIS Workshop, Phoenix, Arizona

"A Practical Method for Handling Digital Orthophoto Files"
--John A. Thorpe, March 1991
AM/FM International, San Diego, California.

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"Raster Digital Orthophotography in a GIS Environment"
--John A. Thorpe, May 1990
ESRI User Conference, Palm Springs, California.

"Digital Orthophotography in AM/FM Systems"
--John A. Thorpe, April 1990
AM/FM International, Baltimore, Maryland.

"Digital Orthophotography - A New GIS Tool"
--John A. Thorpe, March 1990
GIS 90, Vancouver, British Columbia

ABSTRACT

This paper presents the current status of the use of digital orthophotography in Geographical Information Systems in the USA. Reasons for the development of the technology are discussed, and case studies of two different projects are given. A case is made for the use of multiple data sets at varying resolutions of the raster imagery. Finally, some approximate costs of producing accurate raster imagery are listed.

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