Multi-Purpose Geographic Database Guidelines for Local Governments

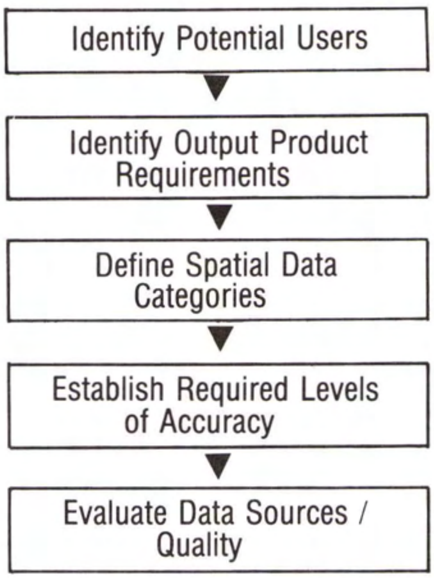
EDITOR'S NOTE: This document was prepared by the joint ACSM-ASPRS Geographic Information Management System (GIMS) Committee. This final version is the result of comments and discussion generated from publication of the draft in the June 1988 issues of both the ACSM Bulletin *and* Photogrammetric Engineering and Remote Sensing. *Comments from the panel discussion at the Virginia Beach Fall Convention in 1988 also contributed to this report. This committee hopes that this document will be freely and widely distributed to local government officials.*

These are practical guidelines to be utilized for identifying user needs, map products and data categories to support the development of a multi-purpose geographic information system by local governments. The methodology presented highlights common data needs, data quality and interrelationships of users. It examines data input sources/techniques to achieve levels of accuracy for spatial data categories.

These guidelines are directed to the multi-purpose mapping environment, specifically technical supervisors and their superiors, of local governments. These guidelines will assist a user in justifying trade-offs in the development of a multi-purpose land database, help in identifying common map elements to be used by other departments/divisions and as a basis for discussion to encourage cooperation and increase production. This will produce a "win-win" situation where all departments/divisions can address their specific needs while meeting the needs of other departments/divisions as well.

In conclusion, the potential for developing a multi-purpose geographic information system can be realized by understanding the relationship between user needs, sources, techniques and scales.

ESSENTIAL CONSIDERATIONS FOR DEVELOPING AN EFFECTIVE MULTI-PURPOSE GEOGRAPHIC DATABASE



Consideration For Guidelines

There are many situations found in local government which indicate a lack of efficient utilization of geographic information (recordation, taxation, mapping, etc.). As an example, a case study in the State of Wisconsin (Larsen et al., 1978) has identified seven basic problems with land records. These are: accessibility, availability, duplication, aggregation, integratability, confidentiality and institutional problems. This study looked at the problems and costs of maintaining land records by government and the utilities. The final costs were estimated as $17 per resident or $2.25 per acre (1976 dollars). Indications are that the public is not getting appropriate benefits from this costly annual expenditure. While these results are valid only for Wisconsin, there is no reason to expect that this is an isolated phenomenon.

The efficient utilization of geographic data requires the cooperation of various agencies. This cooperative effort results in widespread utilization of the geographic data thereby increasing the cost effectiveness of the data collection. As guidelines, this document should be used as a reference with the final decision-making at the local level where the users are familiar with their own particular circumstances.

Local government users who establish a multi-participant and multi-purpose geographic information system must define and clarify a number of issues during the planning process. First, local government users and potential external users must be identified and invited to participate early in the planning phase. Once the users are brought together, the spatial data categories needed for the widespread utilization of the system must be identified. It is inevitable that some data needs will not be identified because, as information systems evolve, new and diverse users and applications will emerge. Yet, it is essential to perform the data collection correctly in the beginning of the project.

Once the data needs are identified, the data quality and levels of accuracy must be defined. One must remember that if the data are collected at accuracies that exceed identified requirements, the costs may be excessive. If, on the other hand, the data are not accurate enough then the capital investment is wasted and the system is prone to failure because this deficiency will prevent implementing evolutionary change to the system in the future (NRC, 1983; Greulich, 1979).

Identify Multi-Purpose Geographic Information System Users:

Possible users of a multi-purpose geographic information system must be identified. These would include local government and external users, such as utilities, realtors, transportation systems, engineers, etc. Users should include both direct users of geographic information and those who are custodians and processors of the information.

FIGURE 2

- TAXATION/ASSESSMENT
- PUBLIC WORKS
  - —WATER AND SEWER
  - —GAS AND ELECTRICITY
  - —TRANSPORTATION
  - —STORM DRAINAGE
  - —ENGINEERING/SURVEYING
  - —WASTE MANAGEMENT
- PUBLIC SAFETY (EMERGENCY SERVICES)
- PLANNING
- ZONING
- RECREATION
- BUILDING INSPECTION/PERMITS
- COMMUNITY DEVELOPMENT
- ADMINISTRATION
- REGISTRAR OF VOTERS
- SCHOOLS
- DATA PROCESSING
- RECORDER OF DEEDS
- COURTS
- SOCIAL SERVICES/HUMAN RESOURCES
- AGRICULTURAL EXTENSION SERVICE
- OTHER LOCAL GOVERNMENT USERS
- EXTERNAL USERS

Determine User Requirements

After developing the list of potential users, interviews and questionnaires should be utilized to identify each user's data needs, output product requirements, how they use it, positional accuracies and who the data comes from and goes to. An example of an interview checklist is included in Appendix A. The user data needs can be summarized for all users to identify common data and process requirements. This compiled list of requirements is useful when prioritizing the implementation of the database.

Map scales are shown as representative fractions within this document. In this form either Imperial or metric map scales can easily be found. To obtain the scale in Imperial units (inches per feet) simply multiply the scale by 12 inches/foot. For example, a scale of 1:600 becomes:

$$\frac{1}{600} \times \frac{12''}{1'} \qquad 1'' = 50'$$

A scale of 1:1,000 becomes:

$$\frac{1}{1000} \times \frac{12''}{1'} \qquad 1'' = 83.3'$$

This would normally be rounded off to 1″ = 100′. To obtain a metric scale (millimeters per meter) multiply the scale by 1,000 millimeters/meter. A scale of 1:1,000 is shown as:

$$\frac{1}{1000} \times \frac{1000\text{mm}}{1\text{m}} \qquad 1\text{mm} = 1\text{m}$$

FIGURE 3

Examples of Output Products

Tax Map: 1:5,000
Emergency Response Map: 1:10,000
Zoning Map: 1:5,000
Land Development Suitability Model
Appraisal Routing Directory
Geodetic Control Index
Demographic Analysis Table
County Road Map: 1:60,000
Utility / Facility Inventory Map: 1:5,000
Engineering Map: 1:600
Topography Map: 1:1,000

Consideration must be given in the needs assessment to the scale/resolution of the data items contained on the map. The user must be aware of the fact that map content changes as the scale of map changes. For each product identified, a data item breakdown must be performed. As an example, listed below are data items that are commonly displayed on a typical assessment map.

*Parcels
Parcel Dimensions

*Parcel Identifiers
Subdivisions
Subdivision Names

*Easements
Road/Streets
Road Names
Lot and Block

*Hydrography

*Railroads
Exempt Properties
Parcel Hooks

*State Plane Coordinate Grid and Public Land Survey System Grid

*Original (Plat) Lines

**Requires decision about positional accuracy at some level*

Some Items Requiring Decisions About Positional Accuracy at Different Levels

After the user needs assessment has been completed for all of the identified users, the results can be cross-referenced in a data matrix. One matrix may correlate the data items to the users. A second matrix can be developed to correlate data items to output products. The matrices are useful for clarifying multiple users of data, resolving varying accuracy requirements and defining processing requirements. Examples of data items requiring positional accuracy decisions are given below:

Administrative Boundaries
Building Footprints
Block Lines
Bridges
Cable Utilities
Control—first, second and third order benchmarks
Control Grid
Culverts
Docks
Driveways
Easements
Electric Utilities
Edge of Pavement Lines
Fence Lines
Gas Utilities
Manholes
Parcel Centroids
Parcel Lines
Physical Geography (Soil, Geology, Hydrography)
Poles
Railroads
Ridge Lines
Right-of-way Lines
Sewer Utilities
Sidewalks
Spot Elevations
Street Centerlines
Subdivision Lines
Swimming Pools
Telephone Utilities
Topography (Contours)
Water Utilities
Zoning Lines

DATA ITEMS vs. PRODUCTS

PRODUCTS	Building Footprints	Control Grid	Street Network	Edge of Pavement	Soils	Flood Plain	Wetlands	Contours	Zoning	Control Monuments
1:5,000 Tax Map	■	■	■							■
1:10,000 Emergency Response Map	■	■	■							
1:5,000 Zoning Map		■	■				■		■	
Land Development Suitability Model		■	■		■	■	■		■	
Geodetic Control Index		■	■							■
1:600 Engineering Map	■	■	■	■		■		■		■

DATA ITEMS vs. USERS

DATA ITEMS	Taxation	Public Safety	Planning	Community Development	Water & Sewer	Schools
Parcels	■		■	■	■	
Street Network	■	■	■	■	■	■
Control Grid	■		■	■	■	
Zoning			■	■		
Contours			■	■	■	
Sewer Lines				■	■	
City Limits	■	■	■	■	■	■
Building Footprints	■	■		■	■	

Accuracy Determinants For Geographic Database:

SOURCE INFORMATION ◄ ► **DERIVED DATA**

CONVERSION
▼
DATABASE
▼
PRODUCT GENERATION
▼
USER

SOURCE INFORMATION:
DEED RECORDS
EXISTING MAPS
DIGITAL SOURCE
EXISTING CONTROL

DERIVED DATA:
GLOBAL POSITIONING SYSTEM
CONVENTIONAL SURVEY
INERTIAL
PHOTOGRAPHY

PROCESS CONVERSION:
COORDINATE GEOMETRY
DIGITIZING
SCANNING
STEREO COMPILATION
KEY ENTRY

DATABASE:
STORAGE RESOLUTION
MEASUREMENT ERROR
SURVEY INCONSISTENCIES
TECHNIQUE ERROR

PRODUCT GENERATION:
PLOTTER RESOLUTION
SCALE
GENERALIZATION

The accuracy of the data will be effected by the quality of the source data and the techniques selected to process the data for the users.

Scales For Local Government Maps

1: 600 1,000 2,500 5,000	10,000 12,000	24,000	48,000 MILE
PARCEL OWNERSHIP / TAX			
	COMMUNITY DEVELOPMENT / THEMATIC		
FACILITY			
TOPOGRAPHY			
ENGINEERING		**USGS QUAD**	

The scales of maps used in local government are diverse as indicated above. Because of this, it can be inappropriate to combine the data contained on the various maps because of the significant differences in spatial resolution.

Scales of Local Government Maps

Some recommended map scales for local government have been presented as follows (NRC, 1983; Wilcox, 1983, 1984; IAAO, 1986):

Type Of Area	Customary Lot Frontage	Base Map Scale	Typical Contour Interval
Urban	15′–40′	1:600	1′, 2′
Urban	50′–90′	1:1,000	1′, 2′, 5′
Suburban	100′–180′	1:2,500	2′, 5′
Rural	200′ and grants	1:5,000	2′, 5′, 10′
Resources		1:12,000	5′, 10′, 20′
Resources		1:24,000	5′, 10′, 20′, 30′

Cadastral mapping involves scales of up to 1:=5,000 (IAAO does allow the use of a 1:9,600 scale cadastral map for rural areas). The scale selected should be appropriate for the density of the number of lots in a given area. Since the parcel is the smallest unit mapped, this will dictate the scale to be used. As an example, North Carolina uses the criteria that the lot should be at least ¼″ wide on the map. Utility/facility management maps also vary depending upon the item mapped. The larger scale maps will be used to delineate underground features where service to the facility requires accurate knowledge of that feature for excavation.

On the other hand, mapped objects such as telephone poles could easily be shown on map scales smaller than 1:2,500 since service technicians need only get to the general vicinity from which they can see the location of the pole. Facility and tax maps seldom will use contours except where boundary determination is defined by a contour line such as high water lines.

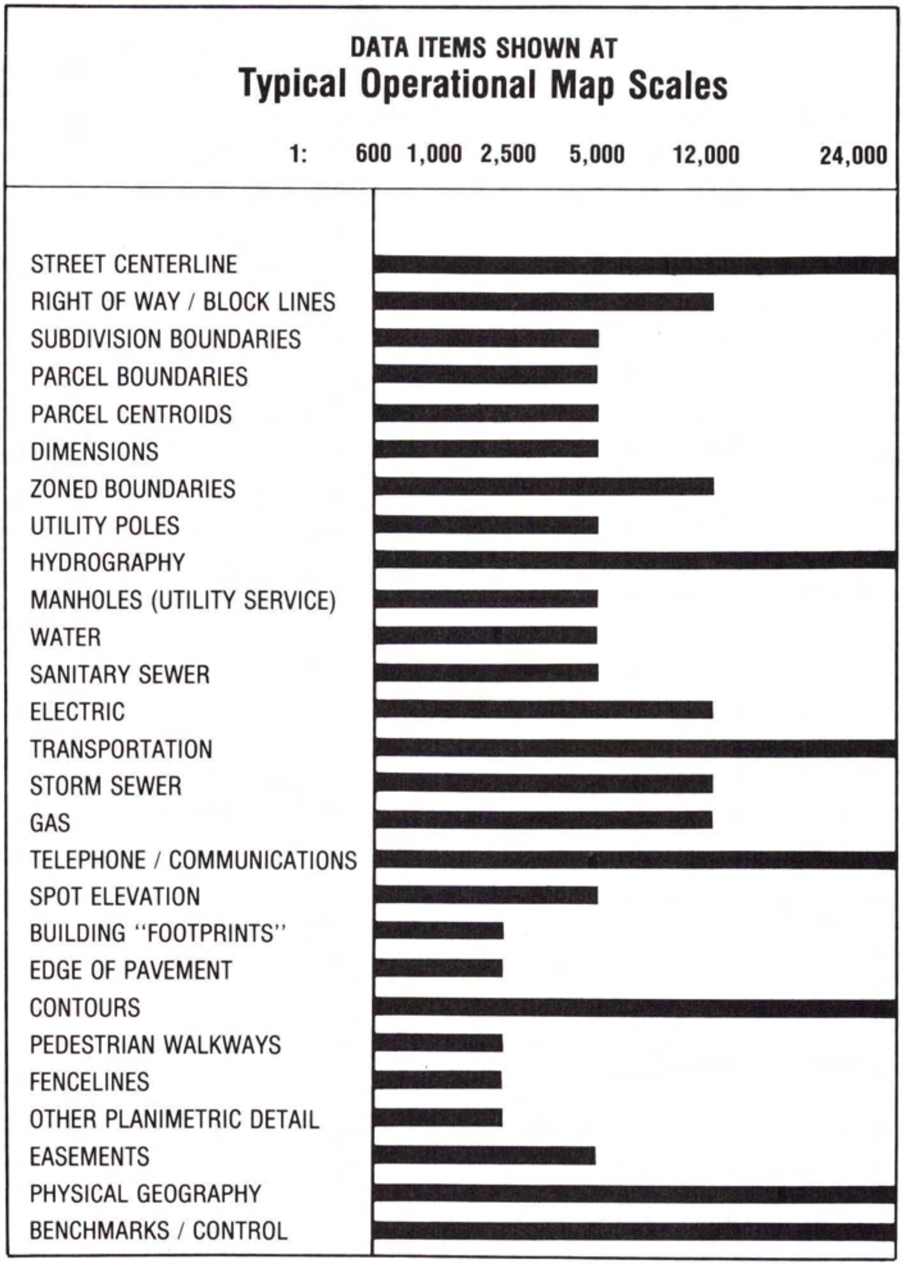
Large-scale engineering maps generally utilize map scales from 1:600 to 1:1,000, and on occasion as small as 1:2,500, depending upon the particular application. These maps are used primarily for engineering design and, thus, often contain topographic information.

The chart above presents some typical contour intervals for the recommended base map scale (NRC, 1983; Wilcox, 1983, 1984; IAAO, 1986). The complexity of the topographic/engineering maps results from the fact that the scale can change significantly depending upon the desired use. Examples showing how contour intervals correspond to scale can be found in Pryor (1983).

Medium- to small-scale maps used in local government are generally community development/thematic maps and USGS quadrangles. These maps are used for planning purposes where the contents are viewed in a global context. One important need is the ability to view the interactions between various phenomenon and measure their impact on future growth and development within the region. In this context, these maps are inappropriate for the generation of a multi-participant base map at the parcel level.

All map products within a Geographic Information System should meet acceptable industry standards (such as National Map Accuracy Standards, see Appendix B, and the standards developed by the Federal Task Force on Digital Cartographic Data Standards as published in *The American Cartographer*, Jan. 1988).

The following chart depicts items commonly shown on typical maps used in local government. One can quickly recognize that the majority of data items are found on the map scales that range from 1:600 to 1:5,000.



Spatial Data Categories

Examples of the data content (including attributes) that a multi-purpose geographic database should include are:

I. Control - Reference Framework
II. Street Network - Centerline
III. Hydrography
IV. Parcel/Parcel Identifier
V. Planimetry
VI. Topography

The following diagrams illustrate the potential input techniques for each spatial data category and what one can expect to achieve at a given output product scale. These diagrams can be used as a guide in helping to determine what input techniques can be used to achieve the required accuracy. Similar diagrams can also be developed for utilities, political boundaries, etc.

Diagram I

CONTROL REFERENCE FRAMEWORK

Map Scale: 1:	600	1,000	2,500	5,000	10,000	12,000	24,000
GPS	✓	✓	✓	✓	✓	✓	✓
INERTIAL			✓	✓	✓	✓	✓
CONVENTIONAL TERRESTRIAL SURVEY	✓	✓	✓	✓	✓	✓	✓
AEROTRIANGULATION PHOTO SCALE:							
2,000′				✓	✓	✓	✓
1,320′			✓	✓	✓	✓	✓
1,000′			✓	✓	✓	✓	✓
660′		✓	✓	✓	✓	✓	✓
500′		✓	✓	✓	✓	✓	✓
PHOTOGEODESY	✓	✓	✓	✓	✓	✓	✓
**DIGITIZE EXISTING SOURCES							

*** Accuracy cannot be any better than the accuracy of the original document.*
Accuracy level will vary depending upon the existence/nonexistence of control in digitizing process.

Diagram II

STREET NETWORK

Map Scale: 1:	600	1,000	2,500	5,000	10,000	12,000	24,000
SURVEY (AS BUILT)	✓	✓	✓	✓	✓	✓	✓
LEGAL (COGO)	✓	✓	✓	✓	✓	✓	✓
ORTHO (POST-PRODUCTION DIGITIZING)			✓	✓	✓	✓	✓
STEREO COMPILATION PHOTO SCALES:							
2,000′				✓	✓	✓	✓
1,000′			✓	✓	✓	✓	✓
500′		✓	✓	✓	✓	✓	✓
250′	✓	✓	✓	✓	✓	✓	✓
*DIGITIZING EXISTING MAPS							
*EXISTING DIGITAL DATA							

** Accuracy cannot be any better than the accuracy of the original document.*
Accuracy level will vary depending upon the existence/nonexistence of control in digitizing process.

Diagram III

HYDROGRAPHY

Map Scale: 1:	600	1,000	2,500	5,000	10,000	12,000	24,000
SURVEY (AS BUILT)	✓	✓	✓	✓	✓	✓	✓
LEGAL (COGO)	✓	✓	✓	✓	✓	✓	✓
ORTHO (POST-PRODUCTION DIGITIZING)			✓	✓	✓	✓	✓
STEREO COMPILATION PHOTO SCALES:							
2,000′				✓	✓	✓	✓
1,000′			✓	✓	✓	✓	✓
500′		✓	✓	✓	✓	✓	✓
250′		✓	✓	✓	✓	✓	✓
*DIGITIZING EXISTING MAPS							
*EXISTING DIGITAL DATA							

** Accuracy cannot be any better than the accuracy of the original document.*
Accuracy level will vary depending upon the existence/nonexistence of control in digitizing process.

Diagram IV

PARCEL

Map Scale: 1:	1,000	2,500	5,000
LEGAL COGO	✓	✓	✓
*DIGITIZING EXISTING MAP	✓	✓	✓
*EXISTING DIGITAL DATA	✓	✓	✓

** Accuracy cannot be any better than the accuracy of the original document. Accuracy level will vary depending upon the existence/nonexistence of control in digitizing process.*

Diagram V

PLANIMETRY

Map Scale: 1:	600	1,000	2,500	5,000	10,000	12,000	24,000
SURVEY (AS BUILT)	✓	✓	✓	✓	✓	✓	✓
ORTHO (GROUND-LEVEL DETAIL ONLY)			✓	✓	✓	✓	✓
STEREO COMPILATION PHOTO SCALES:							
2,000′				✓	✓	✓	✓
1,000′			✓	✓	✓	✓	✓
500′		✓	✓	✓	✓	✓	✓
250′		✓	✓	✓	✓	✓	✓
*DIGITIZING EXISTING MAPS							
*EXISTING DIGITAL DATA							

** Accuracy cannot be any better than the accuracy of the original document. Accuracy level will vary depending upon the existence/nonexistence of control in digitizing process.*

Diagram VI

TOPOGRAPHY

Map Scale: 1:	600	1,000	2,500	5,000	10,000	12,000	24,000
SURVEY (AS BUILT)	✓	✓	✓	✓	✓	✓	✓
STEREO COMPILATION PHOTO SCALES:							
2,000′				✓	✓	✓	✓
1,000′			✓	✓	✓	✓	✓
500′		✓	✓	✓	✓	✓	✓
250′		✓	✓	✓	✓	✓	✓
*DIGITIZING EXISTING MAPS							
*EXISTING DIGITAL DATA							

** Accuracy cannot be any better than the accuracy of the original document. Accuracy level will vary depending upon the existence/nonexistence of control in digitizing process.*

Input Sources/Techniques

Global Positioning System (GPS)

The Global Positioning System (GPS) has the capabilities of providing very accurate relative positioning of closely spaced control. Test results have shown that first order surveys can be achieved. The main limitations of GPS are that, at present, the window in which the satellites can be viewed by the receiver is only a short period of the day. Since there must be a clear line of sight between the receiver and the satellite, its use may be limited in urban core areas, where buildings are tall. The advantage of GPS is the high relative accuracies that can be obtained at a considerable savings when compared to conventional terrestrial surveying techniques. Specifications for the use of GPS are being developed (FGCC, 1987).

Inertial Surveying System (ISS)

Inertial Surveying System (ISS) is another approach that can be considered in establishing control. One of the problems with the ISS is the presence of a considerable amount of drift which is a function of time and, to a lesser degree, to the direction of the vehicle. Proper planning of the survey coupled with post-processing can significantly reduce these problems. Accurate results have been obtained in inertial surveys. Another major disadvantage of this technology is the high cost of equipment, although this is somewhat negated when one considers that ISS is a very rapid survey system.

Conventional Terrestrial Surveying

Conventional Terrestrial Surveying has been the historic method of developing control for a site. While triangulation and trilateration have been used in the past, the preferred method is by traversing. Conventional terrestrial surveys are very labor-intensive although some automation has occurred with the introduction of the total station data recorders. The error in traversing will depend upon the number of points occupied, the redundancy of the measurements, the geometric strength of figure, and the instrumentation employed. Specifications for control using these techniques have been developed (FGCC, 1978).

Aerotriangulation

Aerotriangulation, particularly photogeodesy, offers yet another alternative in establishing control for mapping. Using standards and specifications outlined by Slama (1980), positional tolerances required for most mapping applications can be achieved using photogeodesy. Error in photogrammetry is primarily a function of the scale. Thus, with a smaller photographic scale a corresponding higher order of measurement and geometry is required. The advantage with small-scale photography, such as 1: 24,000, is that few measurements are required since fewer photographs are necessary. To achieve second-order Class I standards, as an example, requires special cameras fitted with a reseau, first-order ground control, and a simultaneous bundle adjustment.

Existing Digital Data Sources

Existing digital data sources are characterized as previously computerized records which have a spatial component. These records may have high positional accuracies or may have recorded relationships, or relative accuracies, to other spatial data items (e.g., a telephone pole which is 2.5 feet north of the edge of pavement and two feet east of a fire hydrant). Digital data must be evaluated carefully before assigning an output product scale suitable to it, since it maintains its own positional accuracies. It can also be dependent on the accuracies of other spatial features which themselves have an inherent level of positional accuracy depending on the method used to enter this data into the database. Existing digital data should be considered as a viable data source depending on its origin and the ease in which it can be entered into the database.

Existing Maps

Digitizing data items from existing maps cannot produce positional accuracies better than the accuracy of the original document. The accuracy level achieved is dependent upon the presence and accuracy of map control points. Originally compiled source maps on stable base material should be used for digitization whenever possible. The lineage of source maps should be examined to determine the data quality and accuracy.

Coordinate Geometry

Coordinate geometry (COGO) is a technique used to enter data by angle and distance or coordinates into the database. This technique achieves accuracy levels matching the source data but is relatively slow compared to other data input techniques. Sufficient data may not be available for COGO input for many data layers of all geographic areas.

Orthophotography

Orthophotos are maps of photographic imagery in which the ground-level distortion has been corrected by a process known as differential rectification. These maps are referenced to selected control grids (Universal Transverse Mercator, State Plane Coordinates). When properly produced, these types of maps meet National Map Accuracy Standards.

Orthophotos can also be used to digitize photo-identifiable features.

Guidelines Summary

These guidelines present, in outline form, an idea as to the steps required in creating a multi-purpose geographic information database for local government. The goal has been to provide guidance in the selection of appropriate input sources to meet the desired accuracy level of the system. Decisions as to what course of action to take must be made by the particular local government officials who have the knowledge of their area's unique characteristics.

The best approach in selecting the appropriate input sources would be to use the data matrix that correlates data items to output products. The next step, after identifying the commonality of elements, is to assign minimum values to each element. For example, the control grid for an engineering and design map needs to be known at the nearest tenth of a foot. For tax maps, this grid might only need to be accurate to two feet. The design of the database would then be dependent upon the most stringent accuracy requirements of the normal user. This is accomplished by matching the input sources to the required accuracy level.

It is important to understand that many other aspects must be considered if the project is to succeed. One major item pertains to institutional problems. In order to maximize the benefits of the information system, it is important that all of the major users of this geographic data support the project. ■

APPENDIX A

Checklist of Map Features

Agency: ____________________

Contact (Name): ____________________ Telephone: ____________

From the following list select the map features that are used by your agency or unit. Please note the ones you NOW use with "N" and the ones that are desired in the FUTURE with "F". Also indicate the positional accuracy that is required. Use letter alone when accuracy is not important.

EXAMPLE: N-2 = Now + 2′ ± accuracy required OR F-3 = Future need with 3′± accuracy.

GEODETIC CONTROL

_____ Horizontal
_____ Vertical

ROADS AND STREETS

_____ Centerlines
_____ Right-of-way
_____ Edge of pavement
_____ Curb and gutter
_____ Name(s)
_____ Pavement types
_____ Traffic controls
_____ Bridges
_____ Parking lots
_____ Safety features

PLANIMETRY FEATURES

_____ Railways
_____ Streams
_____ Bodies of Water
_____ Fence Lines
_____ Dams
_____ Flood Controls
_____ Commercial bldgs.
_____ Other bldgs.

UTILITIES

_____ Manholes
_____ Water mains
_____ Valves
_____ Hydrants
_____ Pumping Units
_____ Storage Units
_____ Meters
_____ Sewer mains
_____ Lift/Pumping stations
_____ Lines (service)
_____ Gas lines
_____ Gas valves
_____ Pump station (gas)
_____ Telephone lines (u/g)
_____ Telephone poles
_____ Underground vaults
_____ Booths/pedestals

ELECTRICAL

_____ Poles
_____ U/G lines
_____ Street lights
_____ Substations
_____ Transformers
_____ Generating stations

LAND-RELATED FEATURES

_____ Parcel boundaries
_____ Parcel dimensions
_____ Existing parcel number
_____ Geo-coded parcel number
_____ Parcel address
_____ Owner address
_____ Land use
_____ Easements
_____ Zoning
_____ Census tracts
_____ Subdivision names
_____ Subdivision limits
_____ Political boundaries
_____ City boundaries
_____ County boundaries
_____ Grid base (State Plane Coordinates)
_____ Tax-exempt properties
_____ Public use properties
_____ Cemeteries (public or private)
_____ Rapid transit facilities
_____ Airports (public or private)

Other features not listed above (add any features that are not defined above):

_____ ____________________
_____ ____________________
_____ ____________________
_____ ____________________
_____ ____________________
_____ ____________________
_____ ____________________
_____ ____________________
_____ ____________________

Also attach a map showing limits of your present mapping coverage and indicate where you would need mapping in the near future.

APPENDIX B

United States National Map Accuracy Standards

With a view to the utmost economy and expedition in producing maps which fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined as follows:

1. Horizontal accuracy. For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as bench marks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc. In general what is well defined will also be determined by what is plottable on the scale of the map within 1/100 inch. Thus while the intersection of two road or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable within 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. In this class would come timber lines, soil boundaries, etc.
2. Vertical accuracy, as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.
3. The accuracy of any map may be tested by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of such testing.
4. Published maps meeting these accuracy requirements shall note this fact on their legends, as follows: "This map complies with National Map Accuracy Standards."
5. Published maps whose errors exceed those aforestated shall omit from their legends all mention of standard accuracy.
6. When a published map is a considerable enlargement of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."
7. To facilitate ready interchange and use of basic information for map construction among all Federal mapmaking agencies, manuscript maps and published maps, wherever econom-

ically feasible and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes of latitude and longitude, or 7.5 minutes, or 3-3/4 minutes in size.

ACKNOWLEDGMENT

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Reference List

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