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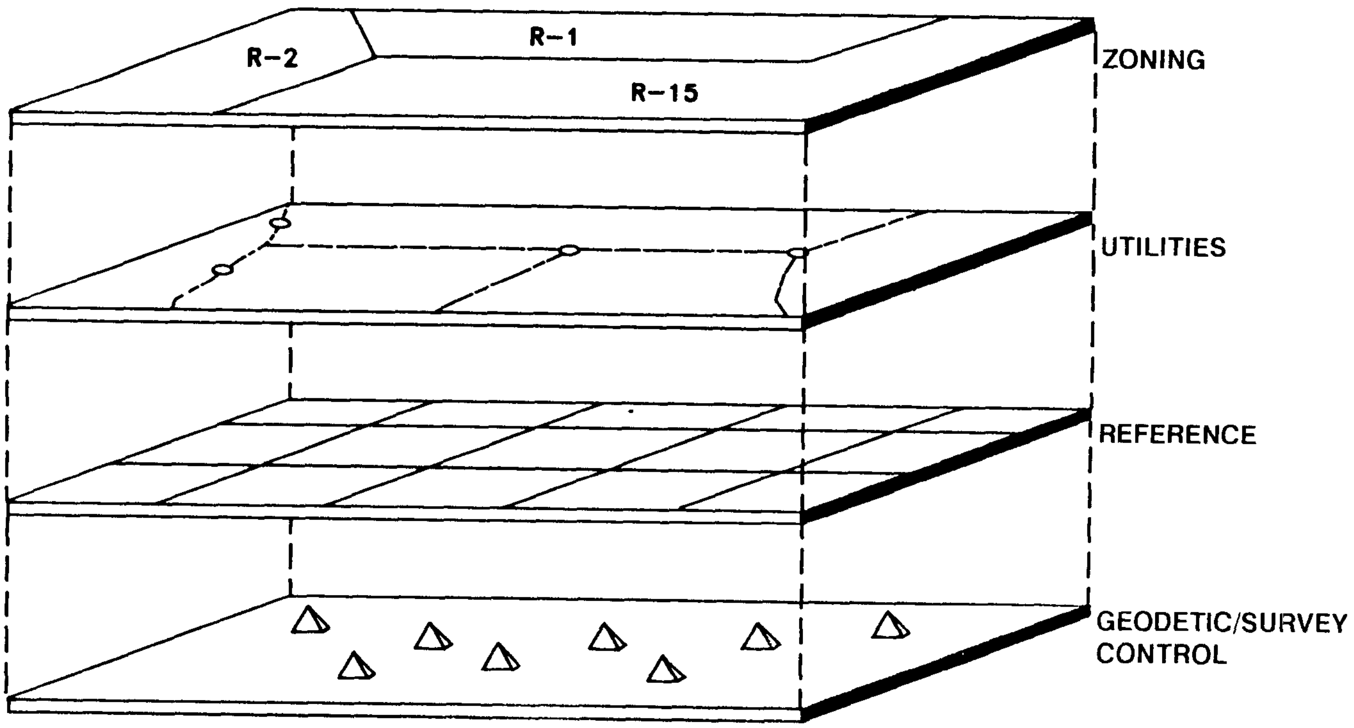
GEOGRAPHIC INFORMATION SYSTEM INDEX FOR THE STATE OF TENNESSEE



Prepared by the
U.S. GEOLOGICAL SURVEY

in cooperation with the
TENNESSEE STATE PLANNING OFFICE and the
TENNESSEE COMPTROLLER OF THE TREASURY

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GEOGRAPHIC INFORMATION SYSTEM INDEX FOR THE STATE OF TENNESSEE

By William R. Barron, Jr., and Pamela G. Norris

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Nashville, Tennessee
1989

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PREFACE

This publication is a reference manual for public Geographic Information Systems within Tennessee. As a result, it is written for use by people with various levels of expertise in different fields. The introduction is written for a reader who has no knowledge of GIS. As such it is generalized and non- technical. Other parts of the report such as the data communication section are intended for a reader with some knowledge of computer hardware. Other parts are addressed to experienced GIS users, and still other parts are for use by planners. It is hoped that each reader will find sufficient information to get started in the GIS area of his interest.

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* Use of brand names in this report is for identification purposes only and does not constitute endorsement by the USGS.

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ABSTRACT

Recently the use of Geographic Information Systems (GIS) has increased in Tennessee. As a result of this increase the U.S. Geological Survey, the Tennessee State Planning Office, and the Tennessee Comptroller of the Treasury entered into an agreement to conduct a survey of GIS users within the state. The objectives of the project were as follows:

1. *To conduct and document a survey and subsequently develop a GIS index data base of existing map coverages, location-specific data bases, available transformation software, and transfer techniques that exist at various state, federal, county, and municipal agencies*

2. *To develop suggested standards for digitized data*

3. *To promote sharing of data by describing, in general terms, communications techniques that can be used to transfer data from one system to another*

4. *To create a map coverage of Tennessee and the 7.5-minute quadrangle maps within the State that would allow identification of existing map coverages for these units through a retrieval from the GIS index data base.*

Two hundred and sixty-three agencies were contacted. Two hundred and sixteen used maps and kept maps on hand. One hundred and thirty-nine agencies maintained one or more computer system, including personal computers. Forty-eight had minicomputers or mainframe computers. Twenty-five agencies used GIS software. The number of coverages or layers that existed at the time of the survey as computerized digital data for Tennessee was 4,741. One hundred and twenty location-specific data bases were available.

The U.S. Geological Survey, National Mapping Division map accuracy standards and digital cartographic data standards were included as minimum guidelines for GIS users. Stricter standards could be used depending upon need.

General data sharing techniques were described. The most common one was the use of magnetic tapes. Asynchronous, synchronous, and network communications were also described.

A data base containing the survey data was built for inquiries. A 7.5-minute quadrangle coverage of Tennessee was created to allow for identificaiton on a quadrangle basis of existing coverages contained in the GIS index data base.

INTRODUCTION

In the summer of 1987, a Geographic Information System (GIS) user group met at Tennessee Wildlife Resources Agency. The attendees discussed the various mapping products that they were generating from computerized data. It became apparent that considerable work was being done and had already been done using GIS. As a result of that meeting, a committee was established to discuss joint GIS needs. The committee's first action was to seek a way to provide for the indexing of public GIS users within the State.

Several types of information to be contained within the index were discussed. First, the map images (coverages or layers) that various governmental agencies had already produced and the availability of those images would be included. Map data must originally be digitized into a computer format acceptable to the appropriate GIS software. This is the most costly, time consuming part of any GIS development, so all would benefit if existing data could be shared or sold at a reasonable cost. In addition, because location-specific data (data associated with a location such as latitude/longitude, State Plane coordinate, census tract number, panel-id, and so forth) can be mapped, overlaid, and analyzed using a GIS, the index would describe data bases available at each site.

Different map coordinate systems and projection systems are used for various purposes and for various presentation reasons. Because of this, the capability of an agency to transform an image from one set of coordinates to another (for example, State Plane to latitude/longitude) or from one type of projection to another (for example, Albers Equal Area to Universal Transverse Mercator) should be included in the index.

Indexing the type of computer equipment each agency had was also deemed important, mostly for the sharing of data and for the availability of communications links to retrieve location-specific data. This information would be of a technical nature and would be aimed at the computer person who would be responsible for making a computer to computer transfer.

Since GIS software packages differ in the way the data structure is designed, the types of system transformation software available at any site was selected for inclusion. For example, it would be valuable to know if a site had software available to transform Intergraph data into Arc/Info data.

In order to identify potential GIS users, the index would include information about the types of maps used by the various agencies and the availability of those maps. For agencies that did not already have a GIS, another section of the index would rate the potential for GIS development based upon map usage, existing computer equipment, and location-specific data bases maintained by the agency.

The committee also decided that a data base would be built to store the data obtained from the survey and retrieval programs would be written. To provide a demonstration of the capabilities of GIS, a digital map of the 7.5- minute quadrangle maps which cover Tennessee would be created so that existing map coverages for a particular quadrangle could be retrieved from the GIS index data base.

As a by-product of that committee, the Tennessee State Planning Office, the Tennessee Comptroller of the Treasury, and the USGS, Water Resources Division (WRD) entered into a cooperative funding agreement to perform the following objectives:

1. To conduct and document a survey and subsequently develop a GIS index data base of existing mapping coverages, location-specific data bases, available transformation software, and transfer techniques that exist at various state, federal, county, and municipal agencies

2. To develop suggested standards for digitized data

3. To promote sharing of data by describing, in general terms, communications techniques that can be used to transfer data from one system to another

4. To create a map coverage of Tennessee and the 7.5-minute quadrangle maps within the State that would allow identification of existing map coverages for these units through a retrieval from the GIS index data base.

Purpose and Scope

The purpose of this report is to summarize the information obtained from the GIS survey of public agencies in Tennessee and to document the method used to obtain the data. By making this information available in a published form, experienced and beginning GIS users will be aware that a GIS index data base exists that will enable them to (1) contact other users about existing coverages, resulting in less duplication of work, (2) ascertain if another agency has any location-specific data that would be helpful for mapping or decision-making, (3) determine which agencies have transformation software or system transformation software that would be useful, (4) evaluate the accuracy of published maps or digital data based upon a set of minimum standards, (5) contact a knowledgeable person about transferring data from one agency to another, and (6) retrieve information on the number and type of coverages available for an area contained within a particular 7.5-minute quadrangle map or a county boundary.

What Is a Geographic Information System?

A GIS is a means of using data stored on a computer to produce graphic images (primarily maps). The data are stored as either X and Y coordinates (sometimes with a Z coordinate) or as values associated with grid cells having a known reference point and a specific height and width. Most of the graphic images are two-dimensional (width and length). The depth or height (Z coordinate) of a given point can be used by many GIS software products to produce three-dimensional figures.

The data stored as X, Y, and sometimes Z coordinates are used to produce lines, points, and areas (polygons). Lines generally represent such features as railroads, highways, and political boundaries. Points represent such features as benchmarks, houses, wells, and so forth. An area (polygon) might be a geologic formation, a lake, or a drainage basin.

The data stored by grid cells is used to produce images similar to a patched, fill-in-the-square drawing. Each grid cell or patch has a data value associated with it which is used to determine the color of the area within the cell. In most cases, the grid cell values may be derived from a multispectral scanner mounted in Earth Resources Observation Systems (EROS) satellites. This type of data collection is useful for keeping track of changing earth conditions such as land use or vegetation.

In addition to producing GIS graphic images, GIS is also used to access information stored in data bases. This is one of the functions that distinguishes a GIS from a computer aided design (CAD) system. Both can be used to produce graphic images, but only the GIS provides a means of retrieving information from data bases, of manipulating and analyzing that information to create new information, and of displaying the result.

Another major difference between a GIS and CAD system is the manner in which the graphics data is managed. A CAD system stores the image as X and Y coordinates only. A GIS system stores the image not only with X and Y coordinates, but also with data indicating the relation of a point, line, or area with other points, lines, or areas adjacent to it. A GIS stores the spatial data associated with the image: the boundaries, the perimeter, the area identifier, the area identifiers adjacent to it, and so forth.

The basic equipment needed for a GIS consists of a computer processing unit (cpu) for running the programs, a disk for storage of the data, a digitizing tablet for data input, a graphic terminal for rapid display, and a plotting device for producing a paper copy. Depending upon the sophistication and complexity of a particular GIS, the equipment cost could range from $15,000 to several million dollars.

The staff needed to operate a GIS also depends upon the sophistication and complexity of the system. One well-trained person could easily handle a personal computer (pc) based system, but with a large system serving numerous users, substantially more staff would be needed. A large system might require a GIS director, a GIS data base administrator, several programmers and technicians, and a staff for computer operations.

In summary, the function of GIS is to produce graphic images from computerized data and to access information from data bases to display with those images. To be able to do this, appropriate equipment and knowledgeable personnel must be available.

Why Use a Geographic Information System?

A GIS provides cost savings and results in improved efficiency in several ways. An increase in productivity in map drafting and maintenance becomes evident. Less manpower is needed for drafting. A study by Knox County estimated that drafting productivity could be improved by a factor of 3:1 to 8:1, particularly in the updating and maintenance of maps (Kevany and others, 1985). As a road or subdivision is added, a map can be updated within a short time by using a digitizer. In addition, any information about the feature being updated can be entered into a data base for future use.

In addition, the time necessary for compiling information is reduced. Rather than having to look through numerous files or at numerous maps to compile a variety of information, the graphic images and the information associated with them are all stored on the computer and are quickly and easily retrieved.

Redundancy of mapping activities can be reduced by consolidating the efforts of various offices. Instead of the water department, the electric utility, and the property tax office each drafting a new subdivision on different maps and usually at different scales, the subdivision can be entered once, scaled to any size desired, and used by each organization as the background reference for the features each needs for their agency's purposes. In addition, data on the subdivision are entered into the data base, and this information is then available to all who have a need for it, not only for accounting or maintenance purposes but also for planning purposes. This results in the elimination of the time lag associated with updating maps. Since one map image may be overlaid with other map images, when one is updated the entire series is instantly updated.

Furthermore, the flexibility of using maps and data are enhanced, and a cost reduction is realized in the production of maps for special purposes. For example, a city planner wants a map of potential sites for ground-water supply. The criteria for selection is that the site has to be in a particular geologic formation, in an agriculturally zoned area, and within one mile of existing water lines. To manually create such a map would be time intensive, but with a GIS it would be relatively quick and easy to specify a combination of such features at any desirable scale.

The accuracy of the information is also improved. An incorrect latitude/longitude for a well or a wrong location for a transformer will quickly show up when mapped. Also, due to the data base capabilities, values that are outside of acceptable ranges rapidly become apparent.

Most GIS packages also provide a means for performing calculations upon the data stored with a map and for manipulating that data. Maximums, minimums, and averages are some of the more basic calculations that can be performed quickly.

Satellite imagery also results in a more efficient manner of monitoring changing conditions on the earth. A vegetation map is more rapidly produced by using satellite data than by conducting a field survey, compiling the data, and manually drawing a map.

Also, less document storage is necessary. In an organization that uses maps extensively, the cost per square foot of storage can be considerable. Much of this storage space can be eliminated by storing the computerized digital maps on magnetic media such as disks or magnetic tapes.

In the long term, GIS provides cost savings and improves efficiency. Initially, however, because of investments in equipment, training of personnel, and conversion of maps to digital data, a GIS will cost more than manual mapping. The payback period is directly related to the sophistication and complexity of the GIS being developed. For a small, personal computer- based system it might be less than a year, but for large systems it might range from four to six years. As a result, funding for conversion to a GIS needs to be firmly committed for a sufficient length of time to allow it to realize its true potential.

DESCRIPTION OF THE SURVEY AND THE RESULTING DATA BASE

A list of the state agencies was received from the Tennessee State Planning Office (TSPO). The USGS worked closely with the TSPO for additional contacts at state agencies. In addition, all principal state and federal agencies listed in the telephone directory for Nashville were contacted. As the survey progressed, any other federal agencies that were suspected of having a GIS were contacted. The Directory of Tennessee County Officials (1987) was used to contact appropriate personnel in each of the counties. From the 1980 census report, the mayor or city planner of each city that had a population greater than 15,000 was contacted.

Each agency was initially contacted by telephone and mail. After phone contact, each agency was mailed a survey packet. The packet contained a letter drafted to give a brief description of the survey's purpose, a letter from the governor urging cooperation from the state agencies, and 10 survey forms designed to collect specific information. If the agency was found to have a large quantity of information, a personal interview was arranged.

The information obtained from the survey was entered into a data base called the GIS Index Data Base. For ease of data entry, a separate datafile was built directly from each survey form, that is, each item in the datafile matched an item on the survey form. Each datafile was built containing an AGENCY-ID which is a unique identifier for that agency. This item allows the records to be sorted and related. Also in each datafile, space for comments and extra space for future expansion of the data base were allocated. The datafile items are discussed in the following sections, organized according to the survey form in which they appear.

Address Datafile

The address form (Appendix A, fig. 1) was developed to collect agency location information. The computer datafile items, width, and type built from the form are: AGENCY-ID 5C; COUNTY 3I; AGENCY-NAME 64C; ADDRESS1 24C; ADDRESS2 24C; CITY 15C; STATE 2C; ZIP-CODE 9I; CONTACT 24C; AREA-CODE 3I; PHONE-NO 7I; COMMENT 36C; and DATE 8D. The number and letter after each data item indicate the length in bytes and the data type: C for character, I for integer, and D for date.

The AGENCY-ID is a unique identification assigned to each agency. The first character of the AGENCY-ID specifies the agency as S (state), F (federal), C (county), or M (municipal). For all agencies except county agencies, the next three characters are a sequential number starting at 001. For county agencies, the middle three characters are the Federal Information Processing Standards (FIPS) code for that county. The last character for the AGENCY-ID is a letter of the alphabet which identifies an agency suboffice or division. This may be left blank if there are no divisions within the agency or if all of the agency's information comes from one division. The second item is COUNTY. This item stores the FIPS code of the county where the agency is located. The DATE indicates the date that the agency's information was entered into the data base. The rest of the form is composed of the agency name, address, contact person, and phone number.

Map Datafile

Because maps are the base for a GIS, the map form (Appendix A, fig. 2) was an essential part of the survey. This form was used to collect all the specific information about the agency's paper and polyester maps. The datafile items are: AGENCY-ID 5C; TYPE 64C; USE 64C; SOURCE 64C; MEDIUM 8C; SCALE 16C; EXTENT 15C; FEATURES 20C; QUALITY 2I; NAME1 - NAME4 24C; COMMENT1 - COMMENT2 24C each.

The type of map used, the purpose of the map, and source of the map is the basic information stored in TYPE, USE, and SOURCE, respectively. A separate survey map form was used for each map type to accomodate the different maps used. Several map forms per agency were frequently used. With this information an inventory of maps is stored in the data base. This information will be helpful in locating specific map types across Tennessee.

The item MEDIUM stores the type of product the map is created on: paper, polyester, or photography. Knowing the type of medium allows a user to evaluate the map's preciseness. A polyester map may or may not be cartographically accurate, but it is precise. On the contrary, a paper map's precision may change due to stretching or shrinking of the paper. This information is important to an agency concerned with digitizing from a map because coverages will not match if the map stretches with use, or shrinks because of atmospheric conditions.

The more specific map information is stored in datafile items SCALE, EXTENT, and FEATURES. The scale of each map is stored as a ratio of one inch to a quantity of inches, feet, or miles. If not specified, the scale is stored in inches. The item EXTENT is used to store the area covered by the map or maps of that type and scale. The item FEATURES gives a brief description of the map's major features.

The maps are rated on a scale from one to ten, stored in the datafile item QUALITY. The rating is based on complexity of features, whether the map uses a standard coordinate system, and whether the map has a magnetic north. If a map has topographical features or features of similar complexity and is cartographically correct then a rating of ten may be assigned. A hand-drawn map is rated one and other maps are rated somewhere between one and ten.

The items NAME1 through NAME4 are for administrative contacts who use the maps most frequently. These would be the appropriate individuals to answer questions about the maps.

Equipment Datafile

The equipment form (Appendix A, fig. 3) collects information on each agency's computer equipment and data transfer techniques. The datafile items are: AGENCY-ID 5C; MAKE 24C; MODEL 6C; CONTACT 24C; TAPE-DRIVE 10C; TAPE-DENSITY1 - TAPE-DENSITY3 5I each; TAPE-PROT1 - TAPE-PROT3 6C each; TAPE-CASSETTE 10C; DISK-MB 6I; COM-CAPABILITY 12C; BAUD-RATE 15C; COM-PROT1 - COM-PROT3 12C each; DIGITIZER 12C; and PLOTTER 12C.

MAKE and MODEL store the names of the computer make and model. This information is important when considering the transfer of information. A contact person is listed who has thorough technical knowledge of the equipment.

Further detailed information is stored in TAPE-DRIVE, TAPE-DENSITY, TAPE- PROT, and TAPE-CASSETTE. TAPE-DRIVE refers to the type of device such as 9 track or 7 track. The three TAPE-DENSITY items store the density in bits per inch which the tape drive is able to write. Other items important for transferring data are TAPE-PROT1 through TAPE-PROT3. These items store the type of tape protocol translations available, such as ASCII, EBCDIC, or BCD. The item TAPE-CASSETTE stores the brand name of the system's tape cassette, if one exists.

DISK-MB records the actual amount of on-line storage that is available. Also important to machine connections are the items COM-CAPABILITY and BAUD-RATE. COM-CAPABILITY stores the type of communication transmission the site has available: asychronous, synchronous, both, or none. BAUD-RATE and COM-PROT1 - COM-PROT3 record, respectively, the transmission speed and any communications protocols used for interactive communication between a personal computer and a mainframe, micro, or minicomputer.

Information on the agency's plotter and digitizer is stored in the datafile items PLOTTER and DIGITIZER, respectively. Each contain the equipment's brand name and model number. An agency which does not have a GIS but has a plotter and digitizer has higher potential for a GIS because the agency would already have some of the equipment and data that a GIS requires.

GIS-System Datafile

The GIS-system form (Appendix A, fig. 4) inventories system types and available digital transformations. The datafile items are: AGENCY-ID 5C; CONSIDERING 1C; WHEN-INSTALLED 7C; SYSTEM-TYPE 20C; WHOSE-SYSTEM 32C; SYSTEM-CONNECT 32C; PRODUCT1 - PRODUCT6 20C each; COMPANY-NAME 24C; COMPANY-ADDRESS1 - COMPANY-ADDRESS2 24C each; COMPANY-CITY 15C; COMPANY-STATE 2C; COMPANY-ZIP-CODE 9I; COMPANY-AREACODE 3I; COMPANY-PHONE 7I; COORDINATES 32C; SYSTEM-TRANS1 - SYSTEM-TRANS3 20C each; COORD-TRANS1- COORD-TRANS10 32C each; PROJECT-TRANS1 - PROJECT-TRANS10 32C each; and COMMENT1 - COMMMENT3 24C each.

For agencies that do not have a GIS but are considering getting one, the item CONSIDERING records this information. The item WHEN-INSTALLED stores an approximate date for such installation. For agencies that already use a GIS, the item SYSTEM-TYPE stores the brand name of the system. If it is not owned in-house the item WHOSE-SYSTEM contains the system owner's name. If an agency is connected to any other GIS, the item SYSTEM-CONNECT stores the name of the agency to whose system it is connected. PRODUCT1 - PRODUCT6 stores the different types of software on the GIS system. The vendor's name, address, and phone are also stored in the event that any questions of the system's capabilities arise.

The type of coordinate system which is most often used for digital data is stored in the item COORDINATES. SYSTEM-TRANS1 through SYSTEM-TRANS3 store the type of GIS system transformations available. Other transformations covered by the survey are coordinate and projection information stored in COORD-TRANS and PROJECT-TRANS.

Project Datafile

The project form (Appendix A, fig. 5) is used primarily to aid in the recording of digital layer or coverage information. This form breaks the coverages into the various projects for which they were digitized. The datafile items are: AGENCY-ID 24C; PROJECT# 4I; PROJECT-NAME 24C; AREAL-EXTENT 24C; TILE-COMP1 - TILE-COMP4 72C each; CONTACT 24C; and COMMENT1 - COMMENT2 24C each.

PROJECT# is an arbitrary number used to distinguish amongst the coverages. PROJECT-NAME stores the name of the project. The actual area covered by the project is stored in AREAL-EXTENT. TILE-COMP stores the quadrangle numbers or map-units covered by this project. An item for a contact person involved with the project is also included.

Coverage Datafile

The coverage form (Appendix A, fig. 6) inventories all digital data layers or coverages. The datafile items are: AGENCY-ID 5C; PROJECT# 4I; NAME 24C; TYPE 12C; EXTENT 24C;

FEATURES 48C; ATTRIBUTES 24C; DATE 4I; ORIGIN 32C; QUAD 6C; COUNTY 3I; CITY 15C; STATE 4C; HUC 8I; OTHER 12C; SCALE 16C; GRIDSIZE 16C; COORDINATES 32C; PROJECTION 32C; and COMMENT1 - COMMENT3 24C each.

NAME, TYPE, EXTENT and FEATURES store most of the basic information of the coverage. TYPE stores information about the coverage such as whether it is point, line, polygon, vector, grid cell, and so forth. Although the EXTENT is contained on the PROJECT form, it is recorded again in case the data layer only covers part of the project area. FEATURES briefly describes the information the coverage contains.

ATTRIBUTES stores information associated with the map features such as statistical information, road names, or street names. The DATE that the digital layer or coverage was created is very important because it gives some indication of the accuracy of the data. ORIGIN stores the name of the agency which created the coverage.

This form also indicates how the data layer is geographically related. Information on the quad, county, city, state and hydrologic unit code (HUC) is collected and stored in the respective datafile items. The item OTHER is available to store any other geographical region or division name unique to the site.

The SCALE or GRIDSIZE of the coverage is specified depending on which the agency uses. The coordinate and projection system used to create the coverage are stored in the items that have the same name. Most systems can convert to any standard coordinate system or projection.

Location-specific Data Base Datafile

The location-specific data base form (Appendix A, fig. 7) gathers information on the computerized data bases that contain data associated with specific geographical locations. This information is included in the survey because it has a high potential for being used with a digital coverage. The datafile items are: AGENCY-ID 5C; DB-NAME 24C; PURPOSE1 - PURPOSE2 24C; LOCATED-BY1 - LOCATED-BY2 24C each; DB-SOFT 12C; RETRIEVAL-CAP 1C; SORT-CAP 1C; RESELECT-CAP 1C; STATISTIC-CAP 1C; GRAPHICS-CAP 1C; DATA-SOURCES 32C; UPDATED 1C; VERIFIED 1C; COORDINATES 32C; EXTENT 20C; RECORD-NO 15C; and COMMENT1 - COMMENT3 24C each.

DB-NAME stores the name of the data base. Also included is a brief description of the purpose of the data base. LOCATED-BY stores how the data base is geographically related by describing the manner in which the information is located (street address, State Plane coordinate, county, latitude/longitude, city, and so forth).

A portion of this form is also used to store information pertaining to the software used with the data base. DB-SOFT is used for the brand name of the software. The form permits the documentation of as many as five software capabilities. The responses are noted by a 'Y' or 'N' for the availability or nonavailability of each capability. The items RETRIEVAL-CAP and SORT-CAP are basic capabilities which allow a user to call up the information and sort it in a specific order. RESELECT-CAP notes the ability to retrieve information given certain criteria, for example, data for a specific county or data for a geologic formation. STATISTIC-CAP stores whether a method is provided for calculating percentages, means, and general statistical characteristics. GRAPHICS-CAP indicates whether the software can produce graphs, charts, and plots from the data base.

This form also covers the origin or source of the data and information specifying whether or not the data is updated and verified. The coordinate system used and the extent of the coverage provide additional information to agencies interested in converting to digital data. RECORD-NO indicates the size of the data base. If the data base was too large to determine the record length then no entry was made.

Uncomputerized Information Datafile

If the agency has any uncomputerized information that references a geographical location, it is recorded on the UNCOMPUTERIZED FILE form (Appendix A, fig. 8). This information has some potential for being used with a digital coverage. The datafile items are: AGENCY-ID 5C; NAME 24C; STORED 24C; QUANTITY 20C; PURPOSE1 - PURPOSE2 24C; DATA-SOURCE 32C; UPDATED and VERIFIED 1C each; and COMMENT1 - COMMENT3 24C each.

This form covers the same type of information as the location-specific data base form. The name of the data base, how the data is stored, quantity of information, and purpose of the data are the basic fields. DATA-SOURCE indicates where the data originated. Additional information regarding the accuracy of the data is included in VERIFIED and UPDATED.

GIS Potential Datafile

Each agency surveyed that did not have a GIS was rated for its potential for using a GIS (Appendix A, fig. 9). Each agency was rated in three categories: (1) extensiveness of the agency's map usage; (2) computer equipment available; and (3) existing computerized location-specific data bases. Each category was rated on a scale from 1 to 10, with 10 corresponding to a high potential. The datafile items are: AGENCY-ID 5C; MAP-USE 2I; EQUIPMENT 2I; and DATABASE 2I.

Conversion Software Datafile

A section of the GIS data base records various types of GIS system-to-system conversion software as they were encountered. These were recorded on the conversion software form (Appendix A, fig. 10). Listings from several sources are included in the datafiles CONVERSIONS and CONV-DESCRIPTION. The CONVERSIONS datafile items are: ID 3I; NCIC-ID# 6C; ITEM-NAME 72C; PRODUCER-NAME 36C; ADDRESS1 36C; ADDRESS2 36C; CITY 15C; STATE 2C; ZIP-CODE 9C; AREA- CODE 3I; PHONE 7I; USES 72C.

The datafile item ID is an arbitrary number unique to each record. The item NCIC-ID# was added to correspond to the list of conversion software from the National Cartographic Information Center (NCIC). Only the software which is on the NCIC list has an NCIC-ID#. Inquiries to NCIC on this software will need this number to identify which software is being referenced. The remaining items in the datafile CONVERSIONS contains the company's name, address, telephone number, and a brief explanation of the software's uses.

The datafile CONV-DESCRIPTION contains desciptions of the conversion software. The datafile items are ID 3I and DESCRIP1 - DESCRIP22 72C. ID corresponds to the item in the CONVERSIONS datafile. This allows the identification of the software being discussed. Twenty-two lines of 72 characters each were reserved for a description of the software's capabilities, hardware requirements, and examples of uses.

Improvements to the Survey and Data Base

After conducting the GIS survey and entering the data, a few things were noticed that could be changed to improve the survey and the data base. Anyone having any additional suggestions for changes, please contact the authors at:

U.S. Geological Survey, WRD
A-413 Federal Building
Nashville, TN 37203

Since the survey was to be conducted on a person-to-person basis, the survey forms were designed for ease of use by the person conducting the survey rather than for the person being questioned. For responses via mail rather than personal interview, the survey could be improved by clarifying some of the questions. Many of the items are self-explanatory and require no further comment; others, especially those that deal with technical subjects, need further explanation.

Because of the diversity of systems discovered, additional space is needed for comments in each data file. Additional space is also needed in the location-specific data base file and uncomputerized file for PURPOSE and SOURCES.

Many sites had far too many specific features per coverage to be entered in the limited amount of space allotted for that item. For instance, the features on one coverage might be interstates, four-lane state highways, two-lane state highways, four-lane county roads, two-lane county roads, unimproved state roads, unimproved county roads, bicycle paths, walking paths, and trails. Because of the amount of computer space required to store this quantity of information, these features were generalized into one feature called transportation. This appeared to be a better method than trying to record each individual feature.

The date that the coverages were digitized was entered into the data base. Along with this the date of the map or aerial photograph from which those coverages were digitized should be entered also. The date it was digitized could be 1988, implying that the information was current, but the date of the map from which it was digitized might be 1948. One of the reserved spaces in the data base could be used for that information.

Summary of GIS Survey Results

Of 263 agencies contacted, 216 used and maintained maps. One hundred and thirty-nine agencies maintained a computer system. One hundred and thirty-eight agencies had one or more personal computers. Forty-eight agencies had minicomputers or mainframes. GIS systems were being used at 25 agencies; two were considering purchasing a GIS. The number of digital coverages that existed for Tennessee at the time of the survey was 4,741. The USGS, NMD had 2,153 of these digital coverages. One hundred and twenty location data bases were available.

The size of computer equipment ranged from small personal computers to large mainframes. In many agencies the only computing power available was a personal computer; in others there was a multitude of computing resources. One hundred and thirty-nine agencies had computer systems. There were forty-one minicomputer systems and seven mainframe systems. One hundred and thirty-eight agencies had one or more personal computers. Some of these agencies had only one personal computer and others had several available with most being used for word processing. In many instances the only computer available was the National Cash Register (NCR) personal computer provided by the State Comptroller of the Treasury for property appraisal.

Of the 25 agencies with a GIS, 9 are federal agencies, 8 state, 3 county, and 5 municipal. Three federal and five state agencies are using Environmental Systems Research Institute's (ESRI) software. Two federal agencies, one state, and one county agency are using Intergraph. One county and one state agency are using Atlas. The remainder use different systems. If an agency had a computer system that had GIS software loaded, the agency was considered a GIS user even if the primary purpose of the computer system was for something other than GIS. Below is a listing of the 25 agencies.

Agencies using a GIS system

AGENCY-ID	AGENCY-NAME	SYSTEM-TYPE
C093A	Knox County Government	Intergraph
C149	Rutherford County Planning Commission *	Atlas/AGIS,remote-sensing
C157A	Memphis and Shelby Co. Plan. & Develop.	Geographic Data Mngmt. System
F001	U.S. Geological Survey	ESRI
F002	U.S. Corps of Engineers **	Intergraph
F003	Tennessee Valley Authority	Intergraph
F004	Environmental Protection Agency	ESRI
F005A	Oak Ridge National Laboratory	ESRI, ERDAS
F005B	Oak Ridge National Laboratory	Oak Ridge Geographic
F006B	U.S. Department of Agriculture	STSC
F007B	Great Smokey Mt. National Park	ERDAS
F007C	Great Smokey Mt. National Park	ERDAS
M001	Memphis Light, Gas and Water	GFIS
M002	City of Chattanooga	McDonnell Douglas
M003	Nashville Metro Water Services GIS	Synercom
M004	Johnson City Transit Headquarters	Autometric AutoGIS
M021	City of Dyersburg	AutoCAD
S001	Tennessee Wildlife Resources Agency	ESRI, ERDAS
S002	Tennessee Technological University	ESRI
S003A	Tennessee Department of Conservation	Autocad/CPSPC
S005	Tennessee Department of Transportation	Intergraph
S006	Middle Tennessee State University	Atlas/AGIS, remoting sensing
S008	University of Tennessee, Knoxville	ESRI
S012A	Memphis State Univ., Dept. of Civil Eng	ESRI
S012B	Memphis State Univ., Dept. of Geography	ESRI, ERDAS

* Uses Middle Tennessee State University system
** Used for computer aided design (CAD)

Over 120 location-specific data bases existed within the State. Where more than one agency used the same data base, the data base information was recorded only for the agency responsible for maintaining, updating, and verifying it. The data were located in a variety of ways, including county codes, latitudes and longitudes, and map-parcel number. The agencies with three or more data bases are listed below.

Agencies maintaining location-specific data bases

AGENCY-ID	AGENCY-NAME	NUMBER OF COMPUTERIZED LOCATION-SPECIFIC DATA BASES
C093	Knox County Government	22
F005	Oak Ridge National Laboratory	18
S003	Tennessee Department of Conservation	10
M002	City of Chattanooga	9
F001	U.S. Geological Survey	7
S004	Tennessee Department of Health and Environment	6
M003	Nashville Metro Water Services GIS	4
F003	Tennessee Valley Authority	3
F004	Environmental Protection Agency	3
M004	Johnson City Transit Headquarters	3
S008	University of Tennessee Knoxville	3
S019	Tennessee State Housing Development Agency	3

Location-specific data not stored on a computer existed at 24 sites. These were organized, standardized data, stored as paper copy, for which the manpower, resources, or need had not been substantial enough to transfer to computer. Most of the 24 sites had only 1 or 2 uncomputerized data bases, but 3 agencies had 6 or more uncomputerized data bases.

Agencies with six or more uncomputerized data bases

AGENCY-ID	AGENCY-NAME	DIVISION	DATA BASE NAME
M003	Nash. Metro Water Srvcs. GIS		property ownership
M003	Nash. Metro Water Srvcs. GIS		house number
M003	Nash. Metro Water Srvcs. GIS		benchmarks
M003	Nash. Metro Water Srvcs. GIS		valve cards
M003	Nash. Metro Water Srvcs. GIS		DCIS manual job order
M003	Nash. Metro Water Srvcs. GIS		construction records
S003A	Tenn. Dept. of Conservation	Div. of Geo.	archival photos
S003A	Tenn. Dept. of Conservation	Div. of Geo.	cave reports
S003A	Tenn. Dept. of Conservation	Div. of Geo.	directory Tenn. mining
S003A	Tenn. Dept. of Conservation	Div. of Geo.	driller logs
S003A	Tenn. Dept. of Conservation	Div. of Geo.	geology field notes
S003A	Tenn. Dept. of Conservation	Div. of Geo.	low alt. aerial photo.
S003A	Tenn. Dept. of Conservation	Div. of Geo.	mineral resources files
S003A	Tenn. Dept. of Conservation	Div. of Geo.	stratigraphic sections
S003A	Tenn. Dept. of Conservation	Div. of Geo.	written logs
S003C	Tenn. Dept. of Conservation	Ecol. Srvcs. Div.	area files
S003C	Tenn. Dept. of Conservation	Ecol. Srvcs. Div.	geographic manual file
S003D	Tenn. Dept. of Conservation	Hist. Commission	historical markers
S003E	Tenn. Dept. of Conservation	Facilities Mgmt.	land band
S003F	Tenn. Dept. of Conservation	Planning	recreational facilities
S003F	Tenn. Dept. of Conservation	Planning	1970 recreation survey
S003F	Tenn. Dept. of Conservation	Planning	recreation information
S003F	Tenn. Dept. of Conservation	Planning	recreation maps
S003G	Tenn. Dept. of Conservation	Div. of Parks	state parks inventory
S003G	Tenn. Dept. of Conservation	Div. of Parks	parks resource inventory
S003H	Tenn. Dept. of Conservation	Div. of Forestry	seed orchards studies
S003H	Tenn. Dept. of Conservation	Div. of Forestry	state forest
S003I	Tenn. Dept. of Conservation	Land Reclamation	quad data sheets
S004A	Tenn. Dept. of Hlth. and Env.	Superfund	Superfund file
S004B	Tenn. Dept. of Hlth. and Env.	Water Poll. Ctrl.	7.5-minute quadrangles
S004F	Tenn. Dept. of Hlth. and Env.	Solid Waste Mgmt.	Groundwater Monitoring
S004F	Tenn. Dept. of Hlth. and Env.	Solid Waste Mgmt.	TSD facility locations
S004G	Tenn. Dept. of Hlth. and Env.	Groundwater Prot.	wells
S004G	Tenn. Dept. of Hlth. and Env.	Groundwater Prot.	Knox well file

Over 4,741 coverages already existed at the time of the survey. The areal extent of the coverages ranged from the world to a small land parcel. The areal extent of most of the coverages were based upon 7.5-minute quadrangle maps, county boundaries, State Plane coordinate areas, or the state boundary. Very small coverages were excluded from the data base.

Many coverages were reported for areas outside of Tennessee. Most of these were excluded from the data base. Those entered into the data base were part of some geographic feature that was contiguous with the same feature in Tennessee, such as the Kentucky portion of the Cumberland River basin.

The number of coverages at each site is listed below. Many more coverages probably exist now. The number of coverages is not necessarily indicative of the quantity of work done. For instance, Memphis Light, Gas and Water has only one coverage listed, but this is a "seamless" map of Shelby County which has numerous features on it with many attributes per feature. The number of coverages is directly related to the areal extent that each site determines as its smallest base unit. Some municipal governments use very small base units and would thus have a large number of coverages.

Number of coverages available at each GIS site

AGENCY-ID	AGENCY-NAME	NUMBER OF DIGITAL COVERAGES
C093A	Knox County Government	30
C149	Rutherford County Planning Commission *	204
C157A	Memphis and Shelby Planning and Development	6
F001	U.S. Geological Survey, WRD, Tennessee District	31
F002	U.S. Corps of Engineers	69
F003	Tennessee Valley Authority	269
F004	Environmental Protection Agency	89
F005A	Oak Ridge National Laboratory	5
F005B	Oak Ridge National Laboratory, Computing/Telecom. Div.	16
F007C	Great Smokey Mt. National Park	38
F008	U.S. Geological Survey, National Mapping Center	2,153
M001	Memphis Light, Gas, and Water	1
M004	Johnson City Transit Headquarters	72
S001	Tennessee Wildlife Resources Agency	1,389
S002	Tennessee Technological University	59
S005	Tennessee Department of Transportation	258
S006	Middle Tennessee State University	16
S008	University of Tennessee, Knoxville	36

* Coverages are located on Middle Tennessee State University computer system.

STANDARDS

Various accuracy standards are already in place among the surveyed GIS users. To suggest that one is "better" than another would be unreasonable. Generally, municipal and county governments set very strict accuracy standards on their data because the data are used for utility engineering. The stricter the accuracy standard, the more difficult it is to update and maintain the data base. The USGS, NMD has specified a set of technical standards for its own maps and for maps input into NMD from other sources. The NMD standards can, therefore, be used as a set of minimum standards to which various maps could conform. Information concerning these standards follows.

United States National Map Accuracy Standards

(from U.S. Bureau of the Budget, Issued June 10, 1941, Revised April 26, 1943, Revised June 17, 1947)

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, and so forth.; corners of large buildings or structures (or center points of small buildings); and so forth. 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 with 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, and so forth.

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, wherever economically 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.

Guidelines for Acceptance of Digital Cartographic Base Data into the National Digital Cartographic Data Base

(5/26/87, Revised 8/24/87)

I. Introduction

On April 4, 1983, the Office of Management and Budget established the Federal Interagency Coordinating Committee on Digital Cartography (FICCDC) to coordinate digital cartographic activities of the Federal agencies. Two important duties of the committee are to: 1) develop and adopt common standards of content, format, and accuracy for digital cartographic base data; and 2) determine category content of the National Digital Cartographic Data Base (NDCDB), assist in establishing and publishing standards and specifications for the data, and assist in establishing priorities for digital cartographic data production.

The U.S. Geological Survey's National Mapping Program is providing Federal, State, and private organizations with base data at large, intermediate and small scales for the United States. The principal data source for the National Mapping Program in the future, including the maintenance of the major map series, preparation of derivative products, and support of geographic information systems, will be the NDCDB. The U.S. Geological Survey's National Mapping Division (NMD) is attempting to populate and maintain the NDCDB with high quality data in response to FICCDC directives and similar legislative mandates.

Currently, the NDCDB contains base categories of digital cartographic data which include: geographic and other coordinate reference systems, hydrography, hypsography, transportation, boundaries, miscellaneous culture, geodetic control, and vegetative and non-vegetative cover. In addition, geographic names and the land use/land cover and associated mapped categories of census tracts, political boundaries, hydrologic units, and Federal and State land ownership are included in the NDCDB.

The primary digital products collected from NMD source graphics and supported in the NDCDB are digital line graph (DLG) data at 1:24,000; 1:100,000; and 1:2,000,000 scales; digital elevation models (DEM) at 1:24,000 and 1:250,000 scales; and land use/land cover at 1:100,000 and 1:250,000 scales. In the future the NDCDB may include additional categories of a thematic nature or data collected from non-NMD source graphics. In those instances where non-NMD source graphics are involved, special procedures will have to be implemented. The scope of this paper, however, focuses only on base category digital cartographic data collected from NMD source graphics.

Current requirements from Federal and State governments, and private industry for DLG and DEM data exceed current production capacity. One strategy to help satisfy agencies' requirements and accomplish mission goals for populating the data base is to include in the NDCDB base category data collected by other Federal, State, or private sources. The purpose of these guidelines is to: 1) encourage arrangements with other organizations for the production of base category data for input into the NDCDB, and 2) to establish technical and programmatic guideline related to the acceptance of data.

This document describes acceptance criteria for base category digital cartographic data collected by other organizations from NMD source graphics. For example, levels of accuracy, data content, format, and lineage of data are considered. Other items presented include procedures for determining the value of data to be accepted, procedures for furnishing appropriate software and training, and relevant Bureau and Department policies for entering into agreements with Federal, State, and private organizations.

II. U.S. Geological Survey Data Standards

The National Mapping Division currently produces digital cartographic data for entry into the NDCDB in accordance with its published standards as described in the following series of technical publications. Portions of these documents prescribe the positional accuracy of the digitized map features or elevations, the procedures for preparation of materials, the assignment of attribute codes to map features, and the format and content level of the data files. The planimetric data described in these published standards are referred to as DLG-3 data, and the elevation data as DEM level 1, 2, or 3. A list of applicable publications is given below.

- Standards for Digital Elevation Models, U.S. Geological Survey Open-file report 86-004.

- Standards for Digital Line Graphs .

  --Part 1 General (draft)
  --Part 2 Specifications (draft)
  --Part 3 Attribute Coding (published)
  --Part 4 Data Collection (draft)
  --Part 5 Quality control and Verification (draft)
  --Part 6 Revision (draft)

  *Note: Parts 1, 2, 4, and 5 should be available in published form by October 1987. Part 6 should be available by January 1988.

- Data Users Guide Series replacing U.S. Geological Survey Data Standards Circular 895 B through F.

1. Digital Line Graphs from 1:24,000-Scale Maps
2. Digital Line Graphs from 1:100,000-Scale Maps
3. Digital Line Graphs from 1:2,000,000-Scale Maps
4. Land Use and Land Cover Digital Data from 1:250,000- and 1:100,000-Scale Maps.
5. Digital Elevation Models (at printers)
6. Geographic Names Information System
7. Alaska Interim Land Cover Mapping Program

- Pre-Scan Edit Procedures for Scitex Processing (draft).

- DEM Editing System Procedure Manual.

Technical publications (unless in draft) are available from:

User Services Branch
National Cartographic Information Center
U.S. Geological Survey
507 National Center
Reston, VA 22092
(703) 860-6045
FTS 959-6045

For publications listed as "draft" or for technical questions contact:

Branch of Technical Management (RSTM)
U.S. Geological Survey
510 National Center
Reston, VA 22092

III. Criteria for Acceptance

A. Data Acceptability Criteria

While data that fully meet the published or draft standards are most desirable, data will be considered for acceptance into the NDCDB if they meet the minimum standard described in this document. This minimum level is based on data characteristics, presented below, which will permit further processing by NMD to reach the level prescribed by the published or draft standards. If data do not meet these minimum acceptance criteria they would be more costly or more labor-intensive for NMD to bring them up to standards than it would for NMD to collect the data directly. The acceptance criteria state the required levels of accuracy, content, format, and lineage.

1. Accuracy

<u>DLG</u>: Accuracy must meet a minimum standard level with regard to position and attribute coding. For positional accuracy of planimetric data, 90 percent of a minimum of 20 tested points must be within plus or minus 0.005 inch from the true (correct) position of the map feature as indicated on a stable base copy of the U.S. Geological Survey source graphic.

Attribute coding of digital planimetric data must be consistent with the Attribute Coding Standards cited in Section II. This means that any attribute codes used must conform to the usage prescribed in the Technical Instructions. If the full set of attribute codes for a category are not included in the data file, the attribute coding must be internally consistent so that NMD may determine the level of effort necessary to complete the coding. For example, if the data file contains only codes on first class roads, then all first class roads, as defined in the attribute coding standard, must be identified with the specified code and no other roads be identified with that same code.

<u>DEM</u>: The desired vertical accuracy of digital elevation data is 7-meter root mean square error (RMSE). However, under some circumstances 15-meter RMSE may be accepted when the scale of the source photography is smaller than 1:80,000-scale. This evaluation should be based on a minimum of 20 well distributed test points of known elevation in the model. Grid points must be no further than 30 meters apart. The data must meet the level 1 or level 2 DEM requirements as stated in the Standards for Digital Elevation Models for photographic source or contour source respectively.

2. Content

<u>DLG</u>: Data must be in separate files according to the base category of data as defined in the NMD attribute coding scheme. All of one category and only one category should be included in each file.

Also, if all of the features in a category are not digitized the files must be internally consistent as to the features that are collected. For example, if the only feature of interest to the collector of the data are the perennial streams in a given hydrologic unit but the source graphic spans several hydrologic units, all of the perennial streams on the source graphic must be digitized whether in the hydrologic unit of interest to the collector of the data or not. Without this internal consistency it will require too much analysis to determine what has been collected for the data to be of any use to the NMD. It also should be noted that this type of data is of a lower level of acceptability to the NMD than complete categories because of the amount of labor necessary to complete the category.

<u>DEM</u>: DEM data must cover a complete U.S. Geological Survey source graphic.

3. Format

DLG: The data must be delivered in a format that can be input directly (or easily converted) into the NMD data processing systems. Since formats are often system-specific, each case will have to be considered separately.

Formats will be supplied upon request to potential data collectors for evaluation. Data from a raster based scanning system may require pre-scan edit procedures such as those used by the NMD to facilitate identification of the map features for addition of attribute codes at a later step of processing.

DEM: DEM data must be in the format specified in the Standards for Digital Elevation Models.

4. Lineage

Data lineage is necessary for source suitability evaluation by NMD and other users. Lineage includes the name of the source graphic, the scale, the compilation and revision dates of the source graphics, the category of data, the corner coordinates of the source and corresponding corner coordinates of the data file. If the file does not contain all of the features in a category or attributes on all features digitized, a complete description of what is included in the file is necessary.

B. Mode of Operation Criteria

To establish a common understanding between U.S. Geological Survey and other data producing organizations, a formal agreement may be necessary. This agreement would include: a set of data specifications; a description of the deliverable data files; criteria for acceptance and rejection of the data; a description of any NMD furnished materials; training, or processing facilities; terms for cost-share and work-share; and provisions for termination of the agreement by both organizations.

An inspection of the production facilities, personnel qualifications, and sample data sets may be required to evaluate any proposed agreement. A benchmark or demonstration project may be a prerequisite for establishing a cooperative arrangement.

C. Validation Criteria

The NMD is currently developing procedures for use in validating data collected by non-NMD agencies or offices. For agreements reached before these procedures are available, data will be validated using current NMD DLG and DEM processing systems.

IV. Valuation of Non-NMD Data

The overall objective of the guidelines is to encourage work share or similar agreements to help the National Mapping Program reach its goal. Thus, there must be a clear benefit to the National Mapping Program in terms of satisfying requirements and mission goals of other agencies as well as U.S. Geological Survey. Factors used to determine value of benefits derived from interagency agreements will include resources required to add data to the NDCDB as well as possible intangible factors.

To determine value of data digitized by other organizations, the NMD and the cooperating organization will assess the cost of converting non-NMD data for inclusion in the NDCDB compared to the costs and production capacity to produce the data within NMD. A sample data set provided to NMD for this purpose should include information on source materials, digitizing equipment, data format, and the producer's data specifications and coding. Again, dollar, personnel, and equipment resources will not be the only factors considered. Intangible benefits may be identified which would also have a value to either organization.

V. Hardware/Software/Training

In instances where clear benefits to the government have been identified, NMD may furnish copies of non-proprietary software.

Training (for digitizing, coding and quality control procedures) may be conducted at non-NMD data producing sites or at U.S. Geological Survey regional centers. Agreements may require appropriate training on the equipment to be used by the potential supplier. Agreements may provide access to NMD computing facilities or to NMD digitizing equipment.

VI. Relevant Department/Bureau Policies

Three chapters of the Survey Manual provide guidance for the establishment of working agreements with Federal, State, and private organizations.

500.1-- Policy of U.S. Geological Survey in Cooperative Work with States, Counties, Municipalities, and Other Related Political Subdivisions.

500.3-- Policy on Work for Other Federal Agencies.

500.20-- Contributions from and Collaborative Projects with Private Sources.

These three chapters are very specific in how U.S. Geological Survey/NMD can do business outside the Bureau. The relevant policy for developing agreements for exchanging data with other Federal agencies is very flexible. There is also considerable flexibility in dealing with States. Working with private sources is feasible but more restrictive.

VII. Summary

This document provides guidelines for establishing data exchange agreements with other Federal, State, or private organizations. Flexibility in dealing with technical and programmatic issues is stressed; however, established standards are not sacrificed for expediency. The NMD produces digital cartographic data according to published standards. Data from outside the NMD must meet a minimum level of acceptability based on accuracy, content, format, and lineage. The NMD programmatic guidelines related to valuation of data and options for supplying hardware, software, and training are meant to encourage agreements by having a flexible acceptance policy that allows other producers of digital data to input base category data into the NDCDB. By establishing data exchange agreements to benefit both parties, the National Mapping Program stands to gain a great deal, including an increased rate for populating the NDCDB.

In addition to accuracy standards, two types of base maps have already become standards: (1) the USGS, NMD products and (2) the property tax maps. The USGS maps are used primarily by resource agencies interested in large areas. Typical scales for these products are 1":24,000", 1":100,000", and 1":250,000". The property tax maps are used primarily by municipal and county governments. Typical scales for these maps are 1":50', 1":100', 1":200', and 1":400'. One standard scale base map for the entire state would be convenient, but impractical.

The State Plane coordinate system has already immerged as a standard. By far, most of the map coverages used within Tennessee have been digitized from a State Plane coordinate map or have been converted into that coordinate system. Most of the GIS software packages contain coordinate transformation software so that converting from one coordinate system to another is relatively easy. However, to facilitate interchange of coverages and information, the State Plane coordinate system appears to work best. Other coordinate systems are also in use including latitude and longitude, Universal Transverse Mercator (UTM), and Albers Equal Area. For coverages that cross state lines, one of these coordinates systems might be a better choice.

Within the State government a convention for naming features should follow the USGS, NMD standardized set of names as closely as possible. For example, all agencies would call a "man-made facility maintained for the use of aircraft" an "airport" (the NMD standard name) rather than an "airfield" and or a "landing strip." In many cases, names for several features are not included in the NMD standardized set of names. In such a case the State should establish a standard set of feature-naming conventions so that one agency does not call an unimproved, county-maintained road "UCMR" and another agency call the same feature "CNTYR".

Names for geographic features such as streams, lakes, airports, and so forth, should conform to the Geographic Names Information System (GNIS) of the USGS. This system was designed to establish uniform geographic names, provide an index of names on maps, and to provide for the standardization of data elements and their coded presentation for use within the information processing community. By following these standards, a feature is referenced by one name throughout its extent (for example: Browns Creek, rather than Browns Creek in one county, Gray Creek in another, and Smith Creek in another).

A standard naming convention for coverages should also be adopted within the State government. Because of differences in the number and type of characters required by the computer systems involved, the managers of each system need to reach an agreement concerning this. This should also be a consideration as more state agencies acquire GIS systems. At present, a coverage for Lake County roads might be called LKRDS on one system, HWY095 on another, and R001.880426 on another.

A standard organizational scheme also should be developed. For instance, each State GIS site should organize its coverages using the same method (for example, by county or quadrangle or State Plane coordinate area). This would enhance the transfer of a coverage from one system to another.

DATA COMMUNICATIONS TECHNIQUES

Data from one computer can be transferred to another by a variety of techniques. The most common technique for mainframe or minicomputers is magnetic tape. Magnetic tapes can generally be written to various technical specifications, and can also generally be read if certain criteria are known. The basic criteria are:

1. bits per inch (bpi) - usually 800, 1600, or 6250

   For data transfer the tape drive at the source machine must be capable of writing a tape at the same bpi required for the receiving machine.

2. tape protocol - usually ASCII, EBCDIC, or BCD

   For data transfer the source machine must have the appropriate software for writing a tape in a protocol that can be read by the receiving machine.

3. logical record length - a fixed or variable number

   The logical record length depends upon the record length of the data. The data can either have a fixed length or a variable length. Fixed- length data is generally much easier to transfer.

4. block size - varies

   The block size is an indication of the number of logical records grouped together. If 10 logical records that are 80 characters long are put together as a block of data, then the block size is 80 x 10 = 800. Many systems require a blocking factor which is the block size divided by the logical record length, in the example above 800 / 80 = 10. The sender must let the receiving user know either the block size or the blocking factor.

5. labeled or unlabeled - Many computer systems write information in the form of a label at the beginning of each file. Sometimes another machine cannot read the label. Most tape transfers are sent as unlabeled to avoid this problem.

Another form of data transfer is from one mainframe or mini-computer to another by means of synchronous telecommunication lines. Synchronous mode communications normally require a more sophisticated modem to recover "clock" signals from the data on the telephone lines. The data are transmitted in blocks, usually eight bits at a time, over data-quality telephone lines at baud rates ranging from 4800 to 56,000. This form of communication is much faster and also more expensive. The two computers must utilize remote job entry procedures and must be configured as look-a-like units with one serving as the host computer and the other serving as the remote unit. Some type of emulation protocol is required to reside on each.

The most common method for transferring data from mainframe or minicomputers to micro or personal computers is by means of terminal emulator software and file transfer protocols. Most terminal emulator and file transfer software must reside on both the sending and receiving device. The most common file transfer protocols are Kermit and Xmodem. Numerous commercial software packages have been written which incorporate both terminal emulator and file transfer protocols. The terminal emulator software makes the mainframe or mini-computer think the micro or personal computer is just another terminal for sending or receiving data, and the file transfer protocols allow for reading data from the input buffers and writing it to disk in a logical manner.

This form of communication requires that asynchronous lines be available at the mainframe or mini-computer. In asynchronous mode the characters travel individually down the line as they are keyed in by the user. Usually voice quality phone lines are sufficient in this mode at transmission rates of 300 to 1200 baud.

Data can also be transferred via a network. A network can be simply personal computers and terminals connected to a mainframe or mini-computer by means of co-axial cable in a localized area (Local Area Network, LAN) or can be several computers connected together over dedicated, leased telephone lines (Wide Area Network, WAN). Considerable expertise is required for either a LAN or WAN. Specialized software is required for each.

The type of data transfer selected depends upon the equipment and software available at each site, the frequency of data transfer, and the amount of funding available to establish a communication link. As technology continues to develop and as demands for better communications are placed upon vendors, the dependency upon the type of equipment and software at each site is becoming less important, and the cost is decreasing.

MAP COVERAGE RETRIEVALS FROM THE GIS INDEX DATA BASE

The GIS index data base currently resides on a 9955II Prime super-minicomputer operated by the Tennessee District of the USGS, WRD. The data are stored in an INFO relational data base.

The data base is menu-driven and is capable of producing output reports based upon several reselection criteria: agency-id, county, quadrangle, city, and hydrologic unit code.

A county coverage, a 7.5-minute quadrangle coverage, and a hydrologic unit coverage were created to facilitate retrieval of available layers for each of these political or geographic areas. For instance, once a user connects and logs into the USGS computer system, typing TENNIS (the ancronym for TENNessee Information System) displays a menu with several options. By selecting option 5, TENNESSEE GIS QUAD PLOT, a plot of all of the 7.5-minute quadrangle maps which cover Tennessee is drawn on the screen (a Tektronix 4107 or 4207 terminal must be used) and the user is prompted for a quadrangle identifier. The plot displays the quadrangle name and identifier in the center of each quadrangle. After zooming in on the area of interest, the user enters the quadrangle identifier. The number of coverages available for the quadrangle is displayed and a report of each coverage is displayed. Similar reports for listings by county or hydrologic unit may be obtained by selecting option 4 or 6, respectively, from the TENNIS menu.

Computer to computer access is available over asynchronous communication lines, 1200 baud modems, and a regular phone line. Computer access must be first established by means of a Cooperative Memorandum of Understanding. Presently no funding is available for sustained access to the data base or for data base maintenance and update. Use of the data base would, therefore, be at the discretion of the District Chief. For additional information contact:

District Chief
U.S. Geological Survey, WRD
A-413 Federal Building
Nashville, TN 37203
(615) 736-5424

Hard copy data may also be obtained from the above location.

OBSERVED TRENDS AND NEEDS OF GIS SYSTEMS IN TENNESSEE

Trends

Several GIS trends have developed in Tennessee. Most of the trends are related to the size of the geographic areas being studied and to different agency needs.

One of these trends is that universities and agencies that are concerned with natural resources typically use USGS 7.5-minute quadrangle maps as their base coverages. This may be dictated by historical precedence or is possibly because the USGS has many of the maps already in digital form. Within these organizations, however, there appears to be a need for studying large areas (a river basin, for example). Political boundaries are generally of little importance, and accuracy within several yards is acceptable.

On the other hand, county and municipal GIS users typically use property tax maps as their base coverages. Their area of interest generally lies within a fixed political boundary. They are also normally concerned with greater accuracy (2-foot contour intervals or 3-foot accuracy, for example) for utility engineering purposes. Most of the municipal GIS users, therefore, conduct their own aerial surveys from which the data is digitized. This is an expensive procedure that is approximately 25 to 50 percent of the GIS budget for the first 5 years. Another result of the need for greater accuracy for engineering purposes is that the GIS equipment and software normally requires CAD capabilities.

As a consequence, two sets of base maps are being developed by GIS users. One is based upon the USGS quadrangle maps and another is based upon county and municipal digital aerial photography with property tax boundaries being one of the basic coverages.

Another trend is that municipal and county governments are using a variety of divergent GIS software. Eight GIS systems exist at the city and county level. All are different software packages.

County and municipal GIS systems

AGENCY-ID	AGENCY-NAME	GIS SOFTWARE
C093A	Knox County Government	Intergraph
C149	Rutherford County Planning Commission *	Atlas/AGIS, remote-sensing
C157A	Memphis and Shelby County Planning and Devel.	Geographic Data Management System
M001	Memphis Light, Gas, and Water	Geographic Facitlities Management System
M002	City of Chattanooga	McDonnell Douglas
M003	Nashville Metro Water Services GIS	Synercom
M004	Johnson City Transit Headqaurters	Autometric AutoGIS
M021	City of Dyersburg	AutoCAD

* Coverages are located on Middle Tennessee State University computer system.

Partially because of the expense of a GIS system, some of the municipal and county governments are seeking to develop projects with surrounding counties. This may result, in time, in regional GIS systems of several types.

In educational institutions the trend is toward the use of Environmental Systems Research Institute's ARC/INFO software. This software has recently been purchased by four institutions. Middle Tennessee State University, the remaining educational institute with a GIS, has been using an Atlas/AGIS system for several years.

Educational institutions that use ARC/INFO

AGENCY-ID	AGENCY-NAME
S002	Tennessee Technological University
S008	University of Tennessee, Knoxville
S012A	Memphis State University, Department of Civil Engineering
S012B	Memphis State University, Department of Geography

From the technological side, the trend is toward using enhanced personal computers or workstation systems although few micro computers are currently running GIS within the State. Small computers have become increasingly more powerful, and disk size and cost have decreased while storage capacity has increased. The result is that small agencies with limited budgets can now procure a personal computer- or workstation-based GIS for about $20,000 to $50,000.

Needs

Within the GIS community as a whole there are some needs which should be met to enhance all efforts. One of these needs is for designation of which agency becomes responsible for certain coverages. At the present time, several agencies might be maintaining a roads coverage. The roads coverage at one site might have been digitized from a 1948 USGS 7.5-minute quadrangle map, at another from a 1984 aerial photograph, and at another the digital data may have been procured from the NMD. Perhaps none of the above coverages truly represents the roads. There is a need for definitive (most reliable and complete) coverages, and for placing the responsibility for these coverages upon specific agencies.

Another need is for a statewide GIS newsletter. Many organizations operate almost exclusively on their own without any exchange of information. Other organizations publish a newsletter but only for their immediate area. In addition, several small user groups within the State have developed newsletters, but these are distributed only to their members. A Statewide newsletter would help to keep all GIS users within Tennessee aware of any new map coverages or any hardware or software development.

There is also a need to be able to rapidly ascertain who has particular map coverages, how easy it would be to obtain the coverage, and how much cost would be involved in obtaining the coverage. A few of the larger municipalities have established marketing departments for this purpose, but for the most part, the only way of obtaining this information is to consult the data base established for this project. The useful lifespan of this data base is limited considering that more mapping coverages are created each week. Provision has not been made for the continuing update of the data base.

A possible solution for meeting the needs just described would be the creation of a mapping center. General reponsibilities could include designating the responsibility of definitive coverages, publication of a Statewide newsletter, and maintenance and updating of the existing data base for inquiry purposes. A mapping center could also host an annual meeting of GIS users for the exchange of ideas, procedures, and technological information. Other responsibilities might include resolution of, or at least assistance with, technical problems such as telecommunications, transfer of data from one system to another, and so forth.

Various states have established or attempted to establish such centers. The success of mapping centers in those states has largely been dependent upon the enthusiasm of the committee members which serve as staff (usually an additional assignment along with their other duties). To resolve the problem of inadequate, full-time staffing, funding should be made available to provide a permanent staff for a mapping center, whose sole responsibilty would be to run the center on a full-time basis with appropriate equipment and support. In the initial phase, this could be two people. If the need or desire grows the staff could be increased.

Funding for such a center could be provided by the state, federal, municipal, or county agencies that would profit from such a center. Many different schemes for designing and implementing such a center would be possible. The main point is that some type of mapping or GIS center is needed.

SUMMARY

In 1987, because of the increasing use of GIS, the USGS, TSPO, and the Tennessee Comptroller of the Treasury entered into a jointly funded project to conduct a survey of public GIS users in Tennessee. The following tasks were accomplished as a result of that project:

1. A GIS survey was conducted and documented. The survey included information about existing map coverages, location-specific data bases, uncomputerized data bases, existing computer equipment, existing GIS systems, system to system conversion software, and potential GIS sites.

2. A GIS index computerized data base was created for entering, storing, and retrieving data collected from the survey.

3. General standards were defined for digitized data.

4. Several communication techniques for tranferring data from one site to another were described in general terms.

5. A county coverage, a 7.5-minute quadrangle coverage, and a hydrologic unit coverage were created to facilitate retrieval of available layers for each one of these political or geographic areas.

Due to the extensive quantity of data, publication of the entire GIS Index Data Base is not feasible. Information in the form of magnetic media, direct computer access, or hard copy may be obtained at the discretion of the District Chief from U.S. Geological Survey, WRD, A-413 Federal Building, Nashville, TN 37203, (615) 736-5424.

At this time, GIS efforts across the State are quite fragmented. A variety of equipment and software are being used across the State, primarily by large municipal and county governments and resource agencies. Other than the occasional formation of user groups, there is no organized, planned strategy for GIS development on any other scale than that of each individual GIS site.

Within the state government itself, there are three possible ways of approaching the development of GIS's. Each has its advantages and disadvantages.

The first option is for the state government to decide upon one type of GIS software and hardware for use by any of its agencies. This could be one large, centralized system or several smaller systems. Because of storage size and CPU limitations, the use of several smaller systems would probably be more feasible. The main advantage to having one type of GIS software and hardware is obvious: total compatibility. The disadvantages would be (1) one GIS software package might not meet the various needs of different agencies, (2) since more than one system already exists, one would have to be salvaged and all coverages converted, resulting in loss of money and manpower, and (3) the cost and time involved in selecting one system would be substantial.

A second option is for the State to procure, develop, or arrange for the development of system-to-system transformation software so that digital data can be transferred with minimal effort between the two major existing systems (Department of Transportation Intergraph and Tennessee Wildlife Resources Agency Arc/Info). Then other agencies could select any GIS vendor that meets their needs and permits their data to be used by both existing systems and vice versa. In brief, the State would allow different GIS systems provided data can be fully shared among agencies. The main advantage to this is the reduction of duplicated work. The disadvantage is that transformations between two or more systems do not generally result in 100 percent data transfer. Also, the more systems involved, the greater the complexity.

A third option may be to allow GIS efforts to continue to develop in the fragmented manner in which they are currently going but with some guidelines or centralized authority. The term "fragmented" tends to have a negative connotation. However, "fragmented" GIS efforts have some definite advantages: (1) each agency is able to meet its needs with whatever software and hardware it thinks is most appropriate, (2) diversity of software and hardware could generate a higher degree of functionality (one system might be able to do something another cannot), and (3) if one or more GIS vendor leaves the market, other systems are still up and running. Of course, there are the disadvantages of: (1) duplicated work, (2) software and hardware incompatibility, and (3) lack of control, organization, or authority.

In summary, GIS can indeed be useful, by reducing long term mapping costs, by improving mapping efficiency, and by enhancing decision-making, but it is not an absolute necessity. "Lukewarm" approaches to establishing an effective GIS do not generally work. GIS efforts do not pay off on a short term basis; to be cost effective they should continue across changes in administration and should be funded for a sufficiently long period of time to allow for pay back.

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APPENDIX A: GIS survey forms

ADDRESS FORM

AGENCY ID: ___ | ______ | ___
Type | Agency# | Suboffice

Type: S - STATE
F - FEDERAL
C - COUNTY
M - MUNICIPAL

(A unique identification number is assigned for each organization.)

COUNTY CODE ______

AGENCY: Name ______

Address ______

______

______ City ______ State ______ Zip Code

CONTACT: Name ______ Last | ______ First

PHONE: ______ Area Code | ______-______

COMMENT:

Figure 1.--GIS survey form for collecting address information.

MAP FORM

Do you use maps? Y N

What type of maps do you use? ______________________________

What do you use the maps for? ______________________________

Where do you get your maps? ______________________________

Medium: ______________________________

Scale: ______________________________

Extent: ______________________________

Main Features: ______________________________

Quality: 1 2 3 4 5 6 7 8 9 10

Names of persons who use this type map:

	Last	First
1.	____________	____________
2.	____________	____________
3.	____________	____________
4.	____________	____________

COMMENTS 1. ______________________________

2. ______________________________

Figure 2.--GIS survey form for collecting map information.

EQUIPMENT FORM

COMPUTER? Y / N   Make: ______________________   Model: ____________

CONTACT: ______________________ (Last) | ______________________ (First)

What type of tape drive is available for copying data to magnetic tape for transfer? (9 TRACK, 7 TRACK)   TAPE DRIVE: ______________

What density in bits per inch is the tape drive able to write?   TAPE DENSITY : 1. ________ 2. ________ 3. ________

TAPE PROTOCOLS AVAILABLE:

What type protocol translations are available for system compatibility? (ASCII, EBCDIC, BCD)   1. ______________ 2. ______________ 3. ______________

What type tape cassettes are available, if any?   TAPE CASSETTE: ______________

How much on-line storage is available?   DISK MEGABYTES: ______________

What telecommunication capabilities exist at the organization for possible machine to machine connections for data transfer? (SYNC, ASYNC)

COMMUNICATION CAPABILITY: ______________

BAUD RATE: ______________

What file transfer protocols exist at the organization for interactive transfer of data?   COMMUNICATION PROTOCOLS: 1. ______________ 2. ______________ 3. ______________

What type digitizer is used?   DIGITIZER: ______________

What type plotter is used?   PLOTTER: ______________

COMMENTS 1. ______________________________________

2. ______________________________________

Figure 3.--GIS survey form for equipment inventory.

G I S   S Y S T E M   F O R M

Do you have a GIS system? Y N

If no GIS system exists: Are you considering getting one? Y N
If Yes, approximately when? ________________

What type of GIS system exists at the organization? GIS SYSTEM TYPE: ________________

Is the system your own? Y N

If No, whose system is it? ________________

Are there any telecommunications connections to other systems? Y N

If Yes, to what other system is it connected: ________________

What type of GIS software products are available? (Include Version)

PRODUCT:
1. ________________
2. ________________
3. ________________
4. ________________
5. ________________
6. ________________

Company Name: ________________
Address: ________________
____
________________ City ________ State ________ Zip Code

Company Phone: _____ (Area Code) | _____ - _______

What type of coordinate system is used for most coverages? Coordinates: ________________

What GIS system to system transformations are used? System Transformations Available:

1. ________________
2. ________________
3. ________________

Figure 4.--GIS survey form for gathering GIS system data.

What coordinate transformations can be performed?

Coordinate Transformations Available:

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________

What projection transformations can be performed?

Projection Transformations Available:

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________

Comments

1. ____________________
2. ____________________
3. ____________________

Figure 4.--GIS survey form for gathering GIS system data--Continued.

P R O J E C T   F O R M

Project #: __________

Name of Project: ______________________________

Areal Extent: ______________________________

<u>Tile Composition</u>:

____

____

____

____

Contact: ______________ | ______________
Last | First

Comments 1. ______________________________

2. ______________________________

Figure 5.--GIS survey form for assigning project numbers for coverages.

COVERAGE FORM

Project # : ____________

Coverage Name: ____

Coverage Type: Network___ Point___ Vector___ Gridcell___ Line___

Polygon___ Satellite imagery___ Other______________________

Coverage Extent: ____

Coverage Features: ____

Coverage Attributes: ____

Date of the coverage: ____

Origin of coverage: ____

How is that coverage related to geographic divisions?

Quad: _______ | _______
Quad-No. | Quad-Dir.

County Code: _______

City: ______________________

State: ______________________

Hydrologic Unit Code (HUC): ___________

Other: ______________________

What scale is the coverage? Scale: ______________

Gridsize: ______________

What type of coordinate system did the map use from which the coverage was digitized? Coordinates: ______________

Projection of coverage: ____

Comments 1. ____

2. ____

3. ____

Figure 6.--GIS survey form for coverages or layer information.

LOCATION DATA BASE FORM

Data Base Name: ______________________________

Purpose: 1. ______________________________

2. ______________________________

Located by: 1. ______________________________

2. ______________________________

Data Base Software: ______________________________

Retrieval Capability? Y N

Sort Capability? Y N

Reselect Capability? Y N

Statistical Capability? Y N

Graphics Capability? Y N

What are your data sources? ______________________________

Is the data updated on a regular basis? Y N

Has the data been verified? Y N

What coordinate system is used for the data? ______________________________

What extent is the coverage? ______________________________

How many records are there? ______________________________

Comments 1. ______________________________

2. ______________________________

3. ______________________________

Figure 7.--GIS survey form for identifying location-specific data bases.

UNCOMPUTERIZED FILE FORM

Do you have any geographically related
data that is not in a computer? Y N

Name: ______________________________

How is it stored? ______________________________

Quantity of data: ______________________________

Purpose: 1. ______________________________

2. ______________________________

How do you get your data? ______________________________

Is the data updated regularly? Y N

Has the data been verified? Y N

Comments 1. ______________________________

2. ______________________________

3. ______________________________

Figure 8.--GIS survey form for collecting information about uncomputerized data bases.

POTENTIAL FOR GIS DEVELOPMENT										
Based upon mapping usage:	1	2	3	4	5	6	7	8	9	10
Based upon existing equipment:	1	2	3	4	5	6	7	8	9	10
Based upon existing data bases:	1	2	3	4	5	6	7	8	9	10

Figure 9.--Form used for evaluating potential GIS development.

C O N V E R S I O N   S O F T W A R E

SOFTWARE NAME: ______________________________

COMPANY NAME: ______________________________

ADDRESS: ______________________________

____

______________________ ______ ________
City State Zip Code

SOFTWARE DESCRIPTION:

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

Figure 10.--GIS form for conversion software survey.

APPENDIX B: ACQUISITION OF PAPER MAPS AND DIGITAL DATA

Maps may be purchased from two locations in Tennessee. The State of Tennessee, Department of Conservation, sells USGS maps for Tennessee at 1":24,000"; 1":100,000"; and 1":500,000" scales. They also sell Tennessee geologic maps and maintain an index of Landsat data on microfiche. Maps and information may be obtained from:

James Moore
Tennessee Department of Conservation
Division of Geology
701 Broadway
Nashville, TN 37219
(615) 742-6696

The Tennessee Valley Authority (TVA) serves as a Public Information Office for the National Cartographic Information Center. Maps at 1":24,000"; 1":100,000"; and 1":250,000" scales are available as well as Water Navigation Maps, Recreation Maps, Cadastral Maps, and aerial photographs. Maps and information may be obtained from:

Jack Dodd
Tennessee Valley Authority, Mapping Services Branch
101 Haney
Chattanooga, TN
(615) 751-6277 or (615) 751-MAPS

In addition, the Tennessee Comptroller of the Treasury, Division of Assessment, maintains planimetric maps of the state at 1":50', 1":100', and 1":400' scales. These maps were digitized from aerial photographs made in 1966. The medium is polyester. Property lines for assessment purposes have been recorded on the maps. The property lines have been updated every other year and in some cases more often. Additional information may be obtained from:

Roger Lowe
Tennessee Comptroller of the Treasury
Division of Assessment
Suite 1400
James K. Polk Building
505 Deaderick
Nashville, TN 37219
(615) 741-7628

Information about digital map data from the USGS,NMD may be obtained from:

John Lear
U.S. Geological Survey
National Mapping Division
Eastern Mapping Center
561 National Center
Reston, VA 22092
(703) 648-5577
1-800-USA-MAPS
(703) 860-6045

APPENDIX C: Guidelines for Initiating a GIS

Different agencies have different levels of operation for which a GIS may be used. Needs of an agency are based upon scope of work, urgency of work, purpose of the agency, and even legislative demands. In turn, the fulfillment of needs must be approached based upon the amount of funding available. Three fairy tale characters, Papa Bear, Mama Bear, and Baby Bear, will be used to illustrate the interaction between recognized needs and available funding for the development of a GIS.

Papa Bear is big and has a big budget. Papa Bear might be characterized as follows:

Population supported – 250,000 and up;
Mapping interest – desires to make maps of area of interest from orthographs;
Level of accuracy for maps – 1/30 to 1/50 inch for 1":200' scale;
Establishment of monument control – requires monument control at the first-order level for achieving map accuracy;
Possible available funding – $1,000,000 and up;
Purpose of maps – planning, utility engineering, zoning, property assessment;
Number of offices involved – 5 and up, including utilities.

A typical Papa Bear is a large city with a population of 750,000. A GIS is being developed to consolidate the various mapping efforts. Several agencies including the various utilities will be using the maps. Because of engineering purposes the accuracy must be 1/40 inch for a 1":200' scale. Land elevation contours will also be neccessary. Prior to aerial photography, monument control must be established to insure accuracy. Numerous first order monuments must be established at a cost of $1,300 each over a 325 square mile area. Previously established monuments will also be used, but the accuracy must be verified. The map area must then be flown for orthographs at a scale of 1":100'. The orthographs are then digitized to a scale of 1":200' at 1/40 inch accuracy or 2.5 feet. The total cost of the digital data is 1.2 million dollars for a 325 square mile area. To maintain the accuracy of the map, the orthographs would need to be reflown every five years at a cost of $300,000 to $500,000. Total GIS funding is 4.4 million dollars over a 10 year period.

In the above illustration, several additional comments need to be made. First, please note that this process involves map preparation from scratch. If greater accuracy were desired, for example 1/50 inch for 1":100', the cost would be $5,000 to $10,000 per square mile depending upon the quantity of urban development and the topology of the land surface. Conversely, the less accuracy desired, the less the cost.

Mama Bear is neither big nor small and has a moderate budget. Mama Bear might be characterized as follows:

Population supported – 50,000 to 250,000;
Mapping interest – desires to digitize existing maps;

Level of accuracy for maps – dependent upon accuracy of existing maps, digital data must be within + or -0.005 inch of the stable base map;
Establishment of monument control – no desire, must depend upon controls used by previous map makers;
Possible available funding – 100,000 to 1 million dollars;
Purpose of maps – planning, zoning, property assessment;
Number of offices involved – less than 5.

A typical Mama Bear is a medium size city with a population of 150,000. Only a few agencies will be using the GIS. A utility might use it, but not for engineering purposes so the accuracy is not a major concern. The agency evaluates maps that it has available and decides to use the Tennessee Assessor planimetric maps that were created from aerial photographs taken in 1966. The accuracy is 1/20 inch on each of the scales 1":50', 1":100', and 1":400'. The maps are made of polyester and will not shrink or stretch while being digitized. They already contain up-to-date property lines for the area of interest. The city realizes that many features will need updating because of the age of the maps. The total GIS funding is $500,000 for a 5-year period.

Baby bear is small and has an allowance. Baby Bear might be characterized as follows:

Population supported – 10,000 to 50,000;
Mapping interest – desires to acquire previously digitized data or to digitize areas of interest as necessary;
Level of accuracy for maps – dependent upon accuracy of existing maps, digital data must be within + or -0.005 inch of the stable base map;
Establishment of monument control – no desire, must depend upon controls used by previous map makers;
Possible available funding – less than $100,000;
Purpose of maps – planning, community development;
Number of offices involved – 1 or 2.

Baby Bear is typical of a small city with a population of 15,000. The planning office and the community development office will be using the system so engineering accuracy is not necessary. As much as possible, digital data that already exists from NMD will be used. If other data are needed they will be digitized from existing maps. Each office is interested in the overall development of the area of interest, so accuracy within + or -60 feet at a 1":24000" scale is quite acceptable. Major roads and major distribution lines are sufficient. The total GIS funding is $70,000 for a 3 year period.

Papa Bear, Mama Bear, and Baby Bear are stereotypes of various GIS users. The characterization of each is not necessarily applicable to every user. A small, booming town with a population of 25,000 might decide to use the Papa Bear method to initiate a GIS. In actuality, each might mix and match the methods of developing a GIS. For example, Mama Bear might have a 3-square mile area that is growing rapidly and as a result might want to create a map for that location similar to the way Papa Bear did for the entire area. At the same time, Mama Bear might also want to utilize the USGS 1":24000" Digital Line Graph (DLG) data for resource investigations.

In each case the process for developing a GIS is similar. This process is listed below. Please note that numerous decisions must be made during the process and that each decision limits or expands the options for the next decision.

Papa Bear, Mama Bear, and Baby Bear would first determine if the GIS system would be a single-user system or a multiple-user system (see the flow chart in fig. 11). In most instances, it would be a multiple-user system; therefore, that approach will be followed here.

Each of the three bears would next identify who the system users would be. In the case of Papa Bear, this would be the planning office, the utilities, the zoning office, and the property assessment office. For Mama Bear it would be the planning office, the zoning office, and the property assessment office. For Baby Bear it would be the planning office and the community development office. In each case a study group composed of the system users, consultants, legal representatives, and vendors should be formed. This group would be involved in decision-making and re-evaluation.

Identification of the users sets the stage for determining what the output products will be. Because there are different users at each location with varying needs, each will select the appropriate output products based upon those needs and the availability of funds. The following is a list of typical products (Multi-Purpose Geographic Database Guidelines for Local Governments, Photogrammetric Engineering and Remote Sensing, 1988):

Tax Map	1":200'
Emergency Response Map	1":800'
Zoning Map	1":400'
Land Deveopment Suitability Model	
Appraisal Routing Directory	
Geodetic Control Index	
Demographic Analysis Table	
County Road Map	1":5,000'
Utility / Facility Inventory Map	1":200'
Engineering Map	1":50'
Topography Map	1":100'
USGS 7.5-minute Quadrangle Map	1":2000'

Once the products have been defined, the data items necessary for each product would need to be determined. For example, the following data items would be needed for a typical assessment map (Multi-Purpose Geographic Database Guidelines for Local Governments, Photogrammetric Engineering and Remote Sensing, 1988):

*Parcels	Lot and Block
Parcel Dimensions	*Hydrography
*Parcel Identifiers	*Railroads
Subdivisions	Exempt Properties
Subdivisons Names	Parcel Hooks
*Easements	*State Plane Coordinate Grid and Pulic Land Survey System Grid
Roads/Streets	
Road Names	*Original (Plat) Lines

*Requires decision about positional accuracy at some level

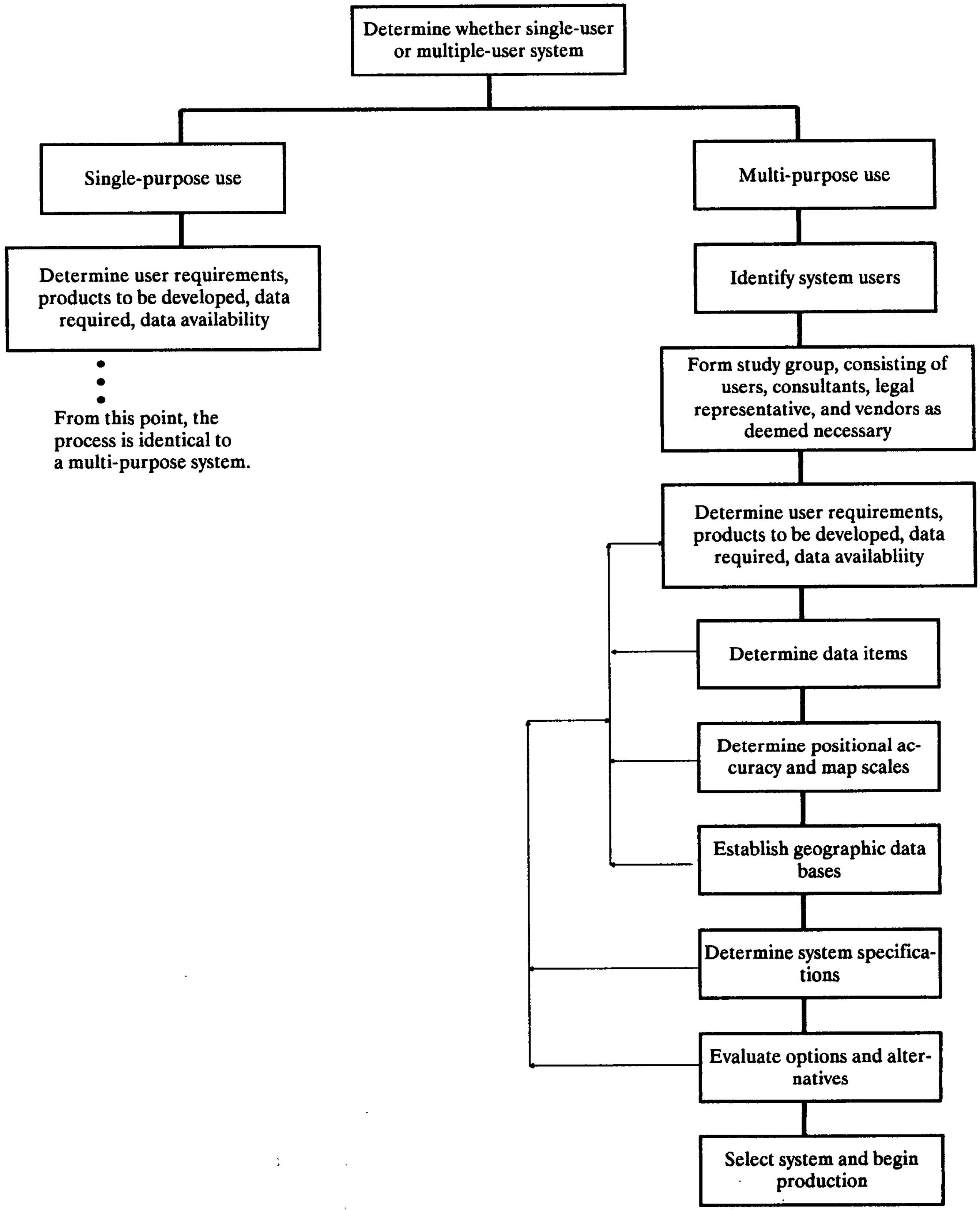

Figure 11.--GIS system design model.

Once the data items are known for each product, decisions need to be made on the degree of positional accuracy and the map scale. For example, Papa Bear might need very close accuracy for his right-of-way lines, 1/50 inch on a 1":200' scale, because the map will be used for engineering purposes by the city transportation department. Mama Bear might need the same accuracy or might need 1/40 inch on a 1":400' scale because her transportation department does little of its own engineering or because the small amount that they do would not cost justify a fine degree of accuracy. Baby Bear will not be using his system with the transportation department so this would not even be a data item. Some standard items requiring decisions are listed below (Multi-Purpose Geographic Database Guidelines for Local Governments, Photogrammetric Engineering and Remote Sensing, 1988):

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

Once positional accuracy has been determined the data content of the geographic database should be designed. A typical data base should include (1) control - reference framework, (2) street network - centerline, (3) hydrography, (4) parcel/parcel identifier, (5) planimetry, and 6) topography (Multi-Purpose Geographic Database Guidelines for Local Governments, Photogrammetric Engineering and Remote Sensing, 1988).

At this point Papa Bear, Mama Bear, and Baby Bear must evaluate how much they can spend to meet their needs. This directly relates to the user needs, the products each user desires, and the positional accuracies selected for the various products.

Next, system specifications need to be developed based upon the data requirements, data resources, geographic reference scheme, and the system products. Basic system capabilities (Tomlinson, 1981) include the following:

1. Digitization – Insure that software, hardware, and digitizer are all compatible. Insure that the accuracy of the digitizer is within a + or -0.005 inch.
2. Edgematching – The ability to join two maps together to form a larger map.

3. Report generation and editing of lines
4. Polygonization – The ability to create areas that can have data associations.
5. Labeling
6. Plotting – Insure software, hardware, and plotter compatibility.
7. Data storage – Allow sufficient storage for data and software. Insure that hardware will allow for expansion of data storage.
8. Data management - The ability to add, update, delete, sort, and select subsets of data.
9. Browsing and plotting a derived map
10. Updating

Typical map handling capabilities (Tomlinson, 1981) are

1. Data manipulation
    - Reclassify - attributes
    - Generalization
        - Dissolving and merging
        - Line smoothing
        - Complex generalization
    - Interpolation
        - Centroid allocation
        - Contouring
    - Scale change
    - Distortion elimination - linear (rubber sheeting)
    - Projection change

2. Generation
    - Points
    - Lines
    - Polygons
        - Simple five-sided polygons
        - Irregular polygons with islands
        - Circles
        - Grid cell nets
        - Latitude and longitude lattices
        - Corridors

3. Data extraction
    - Search and identification
        - Attributes
        - Shapes
    - Measurement
        - Number of items
        - Distances (straight line between points, along convoluted lines)
        - Size of areas
        - Angle direction
        - Volume (cubic measure)

4. Comparison
    - Intersection - overlay
        - Point-in-polygon
        - Polygon-on-polygon (grid cell on polygon, circle on polygon)
    - Juxtaposition (proximity)
        - Shortest route
        - Nearest neighbor
        - Line of sight
    - Contiguity
    - Connectivity
    - Complex space-attribute-time correlation, rate of change

5. Interpretation
    - Determination of optimum location
    - Determination of suitability
    - Determination of desirability

After evaluating the various vendor products, a re-evaluation process should begin within the study group to determine options and alternatives. Once this has been accomplished, the system can to be selected and full speed GIS work can begin.

A warning is in order at this point. The above is a model for initiating a GIS. As such, one should feel free to modify it, add to it, or delete from it. Many different paths can lead to the same result. In reality, very few GIS efforts evolve in a nice orderly fashion as described above.

Numerous non-graphics tasks can be worked on prior to having software or hardware. Many tasks such as education, the starting of a user newsletter, conference attendance, meetings of encounter groups, committee planning, consortiums for financing, data base development, and verification of existing data can all be worked on simultaneously.

A GIS does not necessarily have to start with a wide range of users and several applications. One single, high priority application can be the foundation for GIS development. For example, a GIS could be used to resolve a transportation problem or for complaint administration or to keep track of building permits. Once started, other offices can then be brought into the GIS arena.

Each GIS is similar and each is very different. Success is measured in terms of how satisfied the user is with the product being created. If the system provides information in the form and quality required and at acceptable cost, then the system is a success.

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