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U. S. Army Corps Of Engineers
Mobile District Office

Geographic Information System (GIS) Implementation Plan for the U. S. Army Corps of Engineers, Mobile District

Final Submittal

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1 Executive Summary

The preparation of an implementation plan for use by the Mobile District Corps of Engineers is to provide guidance for the implementation of Geographic Information Systems (GIS) technology. By implementing GIS technology, the District seeks to manage its large spatial data sets and streamline planning and operations activities. Demands for timely and accurate geospatial data throughout the District are considerable. The GIS will aid in the day-to-day operations and assist in decision-making processes.

As a tool to assist in the planning and operation activities of the District, the GIS will serve to provide uniform and timely geospatial information to Corps personnel and other interested parties. When fully implemented, the GIS will promote optimal management of the District's geospatial resources, and ultimately, federal projects.

A GIS is used to model "real world" systems as well as operations and business processes. These systems and processes are dynamic and the GIS must constantly represent changing systems. Also influencing the GIS are technology changes that allow GIS users to do things more efficiently and economically than previously obtainable with legacy or predecessor systems.

While individualized GIS projects have been developed among various Divisional Offices within the District to integrate the data and projects, there remains much work to be performed. Geospatial data sets and the production of project specific GIS applications have produced "pockets" of data and GIS tools. These disparate "pockets" of data, once cohesively managed as a strategic resource, will strengthen the Mobile Districts' project management capabilities through GIS implementation.

There is a compelling need for GIS to support virtually all divisions and functions of the District. Initially the GIS development planning activities must start at a project level. By working on GIS components (i.e., divisional level implementation planning), the GIS implementation and development activities can occur while focusing the Districts limited resources on those GIS applications that are most vital and have the greatest potential to succeed in meeting the District's most critical missions. By working at the divisional level, policies for coordinate systems, spatial accuracy and data model structure can be established so that the framework of the GIS will serve interdivisional goals. From the divisional approach, the implementation will ultimately evolve into a corporate development activity. Using this approach the GIS will develop gradually to facilitate geospatial data sharing amongst all divisions. Using a "percolate up" approach, project sites, Units, Section, and eventually entire Branches will utilize the GIS standards established to best serve the overall District mission requirements.

GIS is not a static tool that can remain unaltered once implemented. Subject to a constant metamorphosis, as systems and processes evolve, the GIS will remain as a dynamic environment. The GIS implementation plan sets forth the steps necessary for an evolutionary process for the Mobile District Corps of Engineers. For these reasons alone, the Mobile District Corps of Engineers has created the Spatial Data Branch within the Operations Division. The management of the Spatial Data Branch stands in support of the GIS implementation approach and methodology documented in this report

2 Purpose, Objectives and Background

2.1 Purpose

The purpose of this implementation plan is to present the current status of GIS at the Mobile District Corps of Engineers (COE) and lay forth a schedule and associated costs for initial GIS integration throughout the District. This plan present the GIS activities presently conducted by the Mobile District office District Field Offices, recommending management structure procedures, processes and technology required for the initial integration of GIS technology. The focus of this report will be on the implementation of the GIS as a data management and analysis tool. A Glossary of Terminology is provided for individuals unfamiliar with GIS its components in Appendix A of this document.

Within the Mobile District offices, various forms of geospatial data are created, manipulated, used, and maintained. However, there is no collaborated data management procedure in place. Without a collaborate effort the District at large could possibly be reproducing the same data sets innumerable times. By implementing GIS technology and procedures, the District Office can replace a redundant system of operation with an efficient and technologically advanced system of operation.

Data management must be considered during the GIS development for compliance with Executive Order (EO) 12906, Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure (NSDI), and Draft ER 1110-1-8156. The EO 12906 states that the National Performance Review (NPR) recommends the executive branch develop a coordinated National Spatial Data Infrastructure to support public and private sector applications of geospatial data in areas such as transportation, community development, agriculture, emergency response, environmental management, and information technology.

2.2 Objectives

The objective of this implementation is to lay forth project-based GIS initiative and the associated costs for integration within the Mobile District Corps of Engineers. The GIS is expected to assist the Mobile District in meeting some significant goals. The goals, once met, will have far-reaching impacts on the future of the GIS integration in the District. The most significant goals are as follows:

Objectives for the GIS have been established based upon the summation of needs that were identified through a previous assessment process and the Consultant’s evaluation of the factors most significant for implementation of the GIS. The planning framework of the GIS implementation and the overall objectives of the system must first be expressed in broad terms and then further defined by the plan at appropriate subject matter levels to explain the required processes. All of the broad goals for the GIS are aligned with the need to improve operational, planning and administrative costs and activities at the District. Furthermore, since it is desirable to exploit the vast amount of valuable geospatial data, it is important to first express the objectives in a simple and concise manner.

Each of the implementation tasks discussed in this plan relates back to the broad objectives for the GIS. Each task or associated cost for the implementation activity is intrinsically intertwined with the objectives and ultimate success of the GIS.

- Establish common mapping guidelines
- Implement data sharing protocols that will enable the free flow of geospatial data within the District
- Establish better management procedures for large quantities of spatial data
- Deploy GIS analysis software for decision-making support
- Reduce the redundant production of data
- Provide a common physical data model for the GIS
- Set forth archived data into an easily retrievable format

The GIS will serve many purposes that are inclusive of map production, spatial analysis to support engineering, operations, planning environmental and other functions that require the examination of geographic data, and management and dissemination of these data throughout the District. The effectiveness of the GIS to serve the District will be largely achieved through data management functions. Future and current GIS users must see the value in imposing and using spatial data and metadata standards upon the data that they collect, process and analyze to facilitate the sharing of these data across functional lines. Efficiency will be achieved through avoidance of data redundancy and the sharing of costs for data acquisition or revision through partnering between functional units. Current database management systems facilitate the technical management of data within a database, but increasing operational effectiveness through GIS will only occur when functional units have willingness to adopt standards into their operational systems that align data with the shared geospatial databases.

This implementation plan builds upon initiatives identified in the Needs Assessment document and does not recapitulate, to any great extent, the historical data, findings or recommendations contained therein. Interviews conducted throughout the Mobile District and associated Field Offices were used for preparing the Needs Assessment prior to development of this guide. The reader is advised to gain some familiarity with the aforementioned Needs Assessment document, as this plan incorporates some of the findings and recommendations identified in that previous effort.

2.2.1 Establish mapping commonality

The ability to use a common set of installation maps and geospatial data to plan, design, build/construct, and operate and maintain DoD facilities requires that guidelines and standards be rigorously employed in the preparation of these maps and geospatial data. For example, maps and geospatial data are commonly developed that can support an installation's multidiscipline analysis environment. These environments are driven by specialized needs such as:

- Mission Requirements
- Installation master/comprehensive planning
- National Environmental Policy Act (NEPA) reporting
- Installation restoration program management
- Natural and cultural resource management
- Site planning and concept design
- Construction management
- Mobilization planning
- Environmental compliance
- Emergency response
- Range management
- Facilities management
- Work order management
- Privatization of Installation functions
- Base closure

Several initiatives are underway to perform research and development of viable methods and products or tools for developing and maintaining maps and other spatially referenced data to serve the installation's diverse informational needs. Considerable effort is expended in the identification of enterprise-wide solutions - where data collected once can be used by many. Enterprise-wide approaches are under development within the DoD. A few of the significant organizations researching and/or developing guidance for mapping and geospatial data maintenance within the DoD include the U.S. Air Force Center for Environmental Excellence (AFCEE), the U.S. Army Corps of Engineers Center for Public Works (CPW), Tri-Service CADD/GIS Technology Center (TSC), and the U.S. Navy's Naval Facilities Engineering Command (NAVFAC).

AFCEE develops information and provides resources and services related to Air Force wide environmental, architectural and landscape design, planning, and construction management. AFCEE has developed excellent on-line guidance for the preparation of the Installation General Plan at the Internet address http://www.afcee.brooks.af.mil. The site addresses developmental issues of the Air Force map series associated with installation planning and operations. Through the use of standardized planning documents and the development of tools to facilitate the standardization, the Air Force is taking an important step toward the preparation of usable spatial data on an enterprise-wide basis.

The U.S. Army Corps of Engineers Installation Support Center (ISC) has its Directorate of Public Works Automation Pamphlet available on the Internet at http://www.usacpw.belvoir.army.mil/pubs/pubs.htm. The pamphlet contains general guidance and status on current automation activities. Geospatial data systems discussed in the Automation Pamphlet include identification of the Real Property Management Tool (RMAT) and the Integrated Facilities System (IFS) which are both adopting geospatial or map based standards or guidelines for development and implementation. Additional Information is available in the ISC GIS Library at http://www.usacpw.belvoir.army.mil/pubs/pubs.htm. Appendix B provides Chapter 2 and Chapter 3 of the Tri-Service Guidelines for Installation Mapping and Geospatial Data. The entire publication of the Tri-Service Guidelines for Installation Mapping and Geospatial Data can be found at http://tsc.wes.army.mil/contacts/groups under "Mapping Guide".

2.2.2 Implement data sharing protocols

Sharing data or any information requires that a mechanism be placed to physically transmit, encode, decode and store large volumes of information efficiently and affordably. Over the past several years, Transmission Control Protocol/Internet Protocol (TCP/IP) has been adopted as the de-facto standard networking protocol for data access and non-streaming communications. TCP/IP borrows heavily from the DOD model, and allows for sub-netting, private Internets (Intranets), and encrypted tunneling. Nearly every hardware and software vendor supports TCP/IP, in fact, some GIS software corporations (notably ESRI) have mandated that TCP/IP is the *only* networking protocol they will support.

Based on the relative security required per application, a staged implementation of both "open", "private" and "tunneled" TCP/IP, over numerous media (fiber-optic, UTP Cat 5, etc.) should be undertaken to enable all future users to get the data they need. High volume GIS data that is updated frequently may need to be batch automated for nightly upload, when network traffic is lighter, however, only after user needs are addressed across the various GIS data layers.

One of the best ways to determine amounts and type of shared data is to initiate a pilot project. The pilot project will create data exchange between various partner agencies and contributing sections within the Mobile District. A this time, agreements can be made between partners as per their expectations of data exchange and return, as well as the value(s) added. A pilot project will provide the Mobile District with an understanding of how data is utilized in the office of generation and throughout the offices of project management. Data generated in one office of the District can and will be distributed throughout the District, based primarily on the type of project. By initiating a pilot project study, the District will have a clear understanding of how data can and will be shared between various District offices and extenuating agencies.

2.2.3 Manage large quantities of spatial data

Data management must be considered during the GIS development for compliance with Executive Order (EO) 12906, Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure (NSDI), and Draft ER 1110-1-8156. The EO 12906 states that the National Performance Review (NPR) recommends the executive branch develop a coordinated National Spatial Data Infrastructure to support public and private sector applications of geospatial data in areas such as transportation, community development, agriculture, emergency response, environmental management, and information technology.

2.2.3.1 SDTS - Towards an "open" GIS data format

The Spatial Data Transfer Standard (SDTS) is the Federal Government's mandated data structure for the encapsulation, storage, and transfer of digital geographic information. SDTS is a topological data format which stores geometric features, raster objects, attribute information, and metadata information is a set of files on disk. Several vendors, as well as developers in the Public domain, have written software to parse, decode and re-format SDTS data sets into formats more commonly used in the GIS industry (e.g.: SDTS2ARC, SDTS2XYZ, STDS2MGE, etc.). For all layers coming from the Federal Government a mechanism should be put in place to a.) test for recentness, b.) download and extract the appropriate SDTS file set, c.) integrate both the features with attributes, as well as the metadata, into the appropriate GIS layer.

2.2.3.2 Metadata

Metadata is loosely defined as data about the data, which describes the content, quality, condition and other characteristics of data. The Federal Geographic Data Committee is tasked by Executive Order 12906 to develop procedures and assists in the implementation of a distributed discover mechanism for digital geospatial data. Using the data elements defined in the Content Standards for Digital Geospatial Metadata, governmental, non-profit, and commercial participants worldwide can make their collections of spatial information searchable and accessible on the Internet using free reference implementation software developed by the FGDC (Appendix C)

Utilizing the Corps of Engineers CORPSMET95, a metadata database should accompany any GIS layer proposed for integration into the Mobile District GIS (Appendix D). Metadata is information about the GIS features: when and who digitized them, to what precision, etc. The collection and storage of current, accurate GIS metadata is crucial for nearly every application in the GIS. Metadata helps researchers and analysts avoid spurious conclusions and false correlation’s by only allowing users to compare datasets with appropriate spatial, temporal and attributes specifications. All layers marked for inclusion in the greater GIS (whether centralized or distributed throughout the District) should conform to a minimum of metadata standards, which should be determined from the results of the Pilot.

2.2.3.3 The Geo-Relational Model

For years, the Geo-Relational Model has ruled in GIS. The Geo-Relational model proposes an environment where the feature geometry (the x, y, and z coordinate values) were stored in an optimized data structure on disk while the attribute information (the feature's name, code, style etc.) were stored in a database table somewhere else on the disk. The GIS software maintains this relationship, enabling a user to "click" on a feature and then identify its attributes. While the Geo-Relational model is still widely used, it has been proven to be relatively slow, difficult to maintain, and not very scalable. In the GIS industry, we have used powerful workstations and servers, frequent backups, and tiling to attempt to deal with these shortcomings.

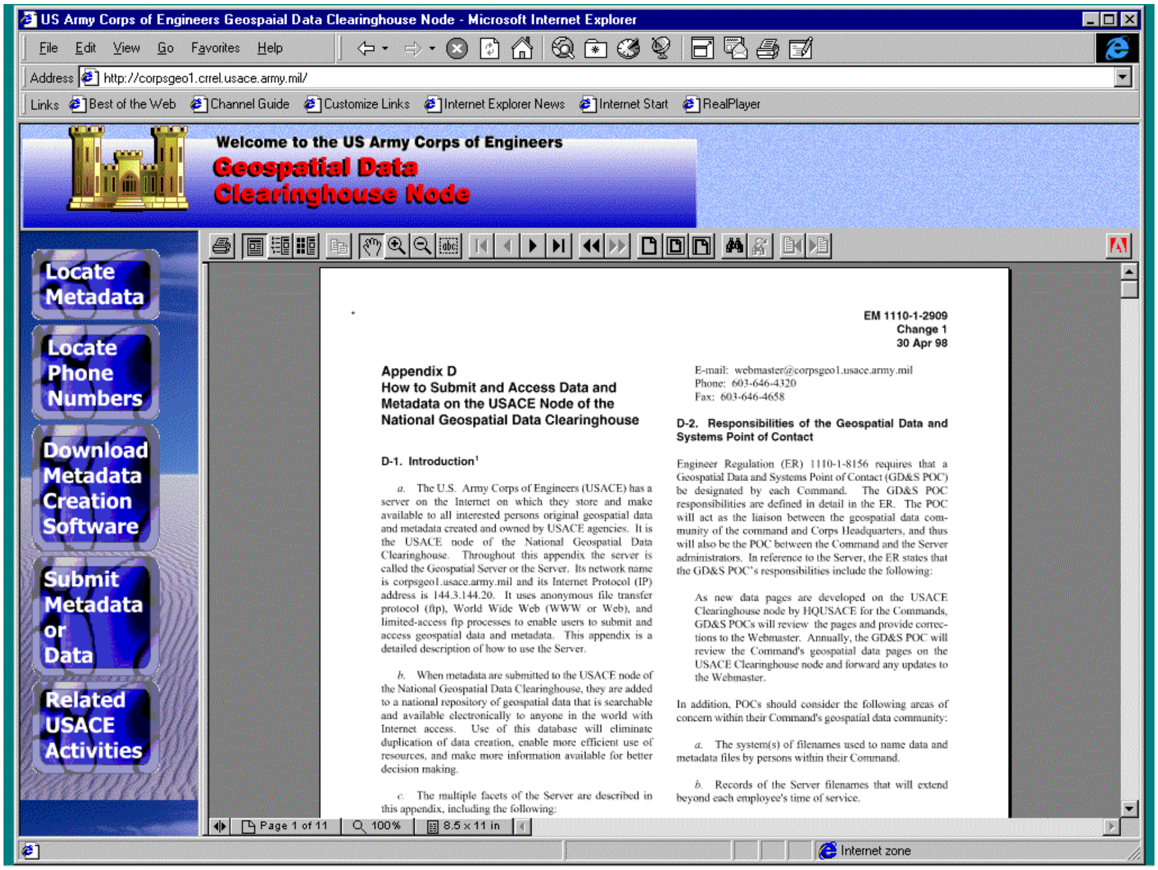

Figure 2.1. CORPSMET95 website.

2.2.3.4 Advances in GIS Database technology

Recent advancements in geospatial data warehousing have made it possible to encode geometric features directly within a database record in an enterprise RDBMS (e.g., Oracle, SQL Server, Informix). Once this data has been encoded in the RDBMS, it behaves like any other data in the table: It can be extracted, sorted and queried against very rapidly. This allows database administrators and GIS administrators to work together to build very large, scalable and reliable GIS databases that can be versioned, rolled-back, and managed with conventional RDBMS tools. In addition to being faster and easier to manage, these enterprise GeoSpatial RDBMS packages allow developers to attach behaviors to GIS features for automation, as well as implementing rule-driven approaches to data capture and management. In short, storing GIS feature data in individual rows facilitates much greater performance, scalability and customization, and accommodates a rule-driven GIS.

2.2.4 Deploy GIS analysis software for decision-making support

Probably the most important gains from employing a GIS come from the new and enhanced types of analyses. GIS users are often required to perform site selection, impact assessment, or system-modeling analyses as part of project-level and area wide plan. Site suitability analysis is an important application of GIS. For example, to determine the best site for a new landfill, the user must know a number of factors associated with the area(s) before making a recommendation. The most suitable site is the one that combines the greatest number of positive factors. The ability to combine and weigh different environmental factors is a task that can be done efficiently using the analytical capabilities of GIS. Additionally, many types of modeling require planners to know the acreage of specific parcels or geographic sub-areas. To model urban storm water runoff, it is necessary to know the amount of area with a given slope and ground area.

A GIS can tie together the two natural features to find each combination of attributes and automatically calculate the areas of each resultant polygon. Because GIS has a relational database to manage attribute data, it is possible to develop analytic models that use the values of attributes of various map features in their calculations.

2.2.5 Reduce the redundant production of data

Undoubtedly, a redundancy in the production of data exists within most organizations. Such redundancies may take different forms. For instance, data might be entered into digital form by one department and then given in hard copy form to another department, where it is then changed or updated and reentered into digital form on another computer or into a different database. In other cases, two or more departments in slightly different forms may collect very similar attribute data. For example, the planning division and engineering division may collect practically the same land-use information or parcel information yet, each using a slightly different type of collection system. Since the two divisions have different missions, each one is likely to manually update their own basemaps with information of specific interest to their division. Over time, it is likely that such redundancies may lead to greater inconsistency in some geospatial information. Such redundancies not only lead to inconsistent geospatial data but also lead to inconsistencies in database information. The less data is redundantly generated, the less data storage is needed, thereby reducing data storage expense.

2.2.6 Provide a common physical data structure for the GIS

The Tri-Service CADD/GIS Technology Center has created the Tri-Service Spatial Data Standards (TSSDS) with the intent to create standards that will satisfy the project life-cycle concept for digital data. This concept requires a set of CADD and GIS standards for initial data collection, analysis, design, construction, and subsequent master planning, facility management, and maintenance. This allows for direct integration from CADD engineering design or as-built to GIS master planning and facility management. The data dictionary (standard schema) part of the TSSDS effort has been evolving at Army, Navy, and Air Force specific installations and civil works organizations over the past few years.

The Tri-Service CADD/GIS Technology Center used parts of these initial efforts and incorporated other functional area specific schema to create a more robust standard for DOD facilities. Use of this standard will facilitate consistency in naming conventions for geographic features and will promote uniformity in graphic products derived from computer-based spatial data systems. In addition, they will provide a strong foundation for information exchange and consistency within the Mobile District and are designed to meet new requirements. The TSSDS employ terminology and data structures not specific to any software product.

Provisions for raster and vector data and CADD, GIS, and AM/FM systems have been made to accommodate the widest user base in the Tri-Services community. Some interpretation will be required on the part of all users, regardless of the system that they currently use. Differentiation between these systems is becoming increasingly obscure, as software developers add new features and capabilities to their systems. Fully integrated raster, vector, and CADD systems are now available.

While the Tri-Service Spatial Data Standards are intended to be data specific rather than application specific, certain elements within the standard are constrained to conform to the lowest common capability of applications most widely used by the facilities, installations, and civil works communities within DOD facilities. There is no guarantee, however, that all of the constraints applicable to a given software application have been adequately addressed. The user may still require judgement with respect to how the given data structures are defined in this standard will be applied. Given the great diversity of computer-based spatial data systems in use within the DOD facilities community, constructing a single reference document that is universally applicable is difficult.

To the larger extent, the terminology is consistent with the Federal Geographic Data Committees' definitions and the Spatial Data Transfer Standard. As such, it is not explicitly applicable to an ARC-INFO user, or an MGE user, or a GRASS user. Some interpretation will be required on the part of all users, regardless of the system they currently use. These standards are applicable to all DoD activities having civil works or public works, military construction, installation management, and environmental responsibilities.

2.2.7 Set forth archived data into an easily retrievable format

Geospatial data represents a significant asset. Any GIS system should have protection against the permanent loss of data by establishing an effective data archive. The archive should contain a copy of all data sets produced in-house or by contract, and have an effective cataloging system such that data sets can be retrieved in reasonable time. The data archiving process and frequency shall be appropriate for the application and sensitivity of the data. The FGDC recommends that any spatial database that has current or potential value and that cannot be easily replicated must be considered for archive. This guidance has the effect of including nearly all geospatial data.

2.3 Background

There is no collaborated approach to the GIS initiatives undertaken thus far at the Mobile District. However, there are several individual GIS implementation initiatives underway within the Mobile District. These initiatives are driven by the compelling need to utilize, manage and analyze spatial data for each of the Mobile District's projects. It is already apparent that much of the data and GIS systems created to date by the District's individualized operations may serve the needs of the District at large.

Disparate data is geospatial data with unique ownership and maintenance and can be found scattered throughout the Mobile District. In organizations where GIS has been implemented, the ownership of data is determined by functional activities or by departmental segregation. Presently within the District there is found a one database to one user relationship. A specific analyst develops a hybrid database for his/her specific purpose. When this scenario occurs, the geospatial data required for a corporate GIS is not easily, or willingly, shared between the functional areas or departments. In some cases, data needs for the GIS may have been collected in a non-standardized format or on a non-standardized hardware/software platform. The lack of standards exacerbates the ability to make this data available to others. In other words, geospatial data is found in various locations and in varying data formats throughout all offices within the Mobile District. And this disparate data is not being utilized to its fullest capacity (or not being shared between the District offices).

2.3.1 The Corporate GIS Approach vs. A Project-Based GIS Development

A corporate (or district-wide) GIS implementation would be a logical manner for utilizing vast amounts of data collected, maintained and processed by the Mobile District. Organizations that have the greatest potential for success in the implementation of a corporate GIS are generally focused on a few specific activities. For example, the corporate GIS approach works well when it is desirable to have many users doing similar tasks and sharing one (possibly huge) common database, on a corporate wide basis. The common database would be a repository where all information, pertinent to all projects, would reside. Staff specifically selected for maintaining the repository would perform all maintenance and update to the database. Users would be given access to the data on "need to know" basis. In the long-term, the corporate approach would work within the District. However, the District will gain more, in the short- to mid-term (1 - 3 years) by utilizing a project-based approach.

A project-based GIS approach will utilize the existent networking capabilities and geospatial data within the Mobile District during implementation. The project-based approach will enable the Mobile District to begin development of a district-wide GIS by building a repository of geospatial data. This data once input into a functioning GIS protocol can then be easily accessed, exchanged, and maintained by the Mobile District.

The GIS will be successful if electronic data is made available to all users at essentially the same time. A project-based implementation will provide individual projects fully functioning GIS capabilities and begin establishing an archive base for a corporate GIS. By using existent project data to implement the GIS, a corporate repository or archive is established.

As more projects become GIS functioning, the corporate GIS evolve. Basically, the corporate GIS is built in increments that are project-based. The physical database structure may be structured to allow portions of the database to reside on file servers distributed across the District's Wide Area Network (WAN). However, to users and the GIS software applications, the database will be seamless. The District GIS will maintain separation of project-based data within the individual District Divisions, establish a common database and establish a GIS of data distribution protocol. A data distribution protocol would be the process of moving data from one Divisional office to another as projects progress. Distribution of data into the District repository also requires procedures for data delivery when updates are mandated. Real time transactional databases are those data sets that are updated hourly and/or daily. Data accessibility, also known as read or read/write privileges, will provide security to appropriate datasets. Again, these developmental procedures will utilize existing data and provide a means for data distribution.

2.3.2 Database Models and Standards

The common physical database structure must be implemented and must function for all users of the system as a real-time information system. The Tri-Service Center's Architectural/Engineering/Construction Computer-Aided Drafting and Design Standards (A/E/C CADD Standards), the Facilities Management System Standards (TSFMS), and the Spatial Data Standards (TSSDS) have been developed to support the previously mentioned EO 12906. By establishing format and content standards within the DoD for geospatial, facilities management and CADD data, these standardized physical models will enable the efficient exchange of information.

2.4 Approach

If the Mobile District's various engineering, project management, planning and operational activities do not see a common mission, they will generally work in an uncoordinated fashion. Failure to coordinate the objectives of the GIS with organizations throughout the District will perpetuate lack of hardware/software compatibility, uncommon database structures and lack of data accuracy, as well as the continuation of redundant data generation. The District must recognize that successful GIS implementation will require management commitment, human and technical resources, financial capabilities and concise planning for the corporate GIS to reach fruition. Provided below are the major activities that must be performed in order to fully achieve the corporate development of the Mobile District GIS:

Establish Spatial Data Branch to lead GIS effort

- Select GIS Steering Committee
- Establish database standards
- Initiate a pilot project
- Select appropriate base maps in use by many of the District offices
- Data Translation for compliance with latest release of TSSDS, TSFMS and A/E/C CADD standards
- Identify new hardware/software/training requirement
- Prepare metadata for inclusion in GIS

A District GIS development will operate more efficiently provided the affiliated databases are standardized and data, both graphic and non-graphic, are placed in a uniform format that accommodates dissemination throughout the District. Geospatial data, currently possessed by individual Sections, Units, and Field Offices, that is recognized and identified as valuable to other District activities, should be made available for use throughout the District. By standardizing data formats, there will be an increase of consistent use throughout all District offices.

3 Mobile District GIS Platforms

3.1 District GIS Platforms

During the Needs Assessment, selected Divisional Offices and associated Field Offices were interviewed. These interviews resulted in an evaluation of the existing hardware, software and trained personnel within the individual offices. The existent hardware and software applications found at project sites will vary in nature as to the extent and use of the GIS employed at the project site. The following provides discussion as to the extent of CADD/GIS activities within the District. It is noted that although many offices were interviewed during the Needs Assessment, not all personnel and offices will be included in the following discussions. Should the reader have any questions concerning the Needs Assessment content, reference should be made to the Needs Assessment Report published by Michael Baker Jr., Inc, in November 1998.

3.1.1 Planning Division

3.1.1.1 Plan Formulation Branch

The mission of the Plan Formulation Branch is to prepare feasibility reports for solutions towards water resource problems, prepare economic evaluations for proposed and complete projects, and develop project maps for small water resource projects. Roger Burke, Chief of the Plan Formulation Branch explained that data produced in this branch was primarily CADD based applications used in emergencies, such as flooding and hurricanes. Data provided to external agencies include flood insurance studies for cities, civil defense agencies and others on an as needed basis.

External agencies in which detailed data is gathered includes water resources data from the Federal Emergency Management Agency (FEMA). The basis of information contained within the data generated in this branch include areas inundated, hurricane evacuation routes and times (provided via CADD drawings), 100-year flood plains identified properties within a given flood plan, evacuation information used for flood insurance companies and environmental projects.

The Plan Formulation Branch utilizes aerial photographs as their primary multimedia data. Varying analysis performed in this branch include HECI and HECII models and flood stage models, feasibility studies, identification problems and solutions, cost benefit ratios of partial construction projects, project life cycle costs, economic analysis, transportation cost model, and risk assessment model. All data is updated on an as needed basis and the branch is budgeted for economic analysis data to be updated every two years.

The GIS platform presently in place includes PC's with NT operating system. CADD/GIS applications in use in this branch are Intergraph and AutoCAD. The desire of a GIS implementation project would be to have urban and rural models developed, based on geographical location.

Primary data sharing partners would include, but not be limited to Water Management, Regulations, and Real Estate. Other agency prospects for data sharing would be the National Oceanographic and Atmospheric Agency (NOAA), the Environmental Protection Agency (EPA), the National Weather Service (NWS), the U. S. Geological Survey (USGS), and the Fish and Wildlife Service (FWS).

3.1.1.2 Inland Environment Section

Diane Findley, Chief of the Inland Environmental Section, Environmental and Resources Branch, explained to Baker that the mission of this section was to prepare and perform environmental documentation and studies that support the Mobile District rivers, streams and reservoir projects. The Inland Environmental Section provides monthly Water Quality Data and Annual Aquatic Plant survey, of which the external data is generated primarily from Lake Seminole/ Walter F. George Field Office.

The CADD/GIS platform for this office consists of ARC/INFO. The main data content of the section consists of annual aquatic plant surveys from Lake Seminole, mailing lists produced in ACCESS and the physical feature of Mobile District project. The primary analysis undertaken in this office is the Environmental Assessment/Analysis.

Ms. Findley feels that GIS could greatly improve other responsibilities of the section. Some of these responsibilities include habitat evaluations, which are presently contracted out, restoration and mitigation of wetlands, and wetland mitigation damages. She feels that all data collected and generated in the Field Offices could be optimally utilized in this section.

Most Environmental and Ecological work is generated in Planning, from which data is obtained from Engineering for environmental and habitat assessments and impact studies are performed. These studies are then sent to Operations and Maintenance (for work scheduling) and/or Real Estate for probably land acquisition.

3.1.1.3 Environmental Resources Planning Section

Karen F. Williams, Civil Engineer, William M. Youngman, Landscape Architect, and Susan Ivester Rees Ph.D., and Chief of the Coastal Environmental Section of the Environmental Resources Planning Division explained that the mission statement of this operational unit was to respond to all environmental complaints, to control civil works activities and to control military works activities, with the exception of Hazardous and Toxic Waste. Databases generated within the unit include state and federal environmental compliance databases and ocean disp. Database for the Waterway Experiment Station Headquarters.

Primary external databases used in the unit are chemical and biological. Most external data is used in the form of AutoCAD and MicroStation files. Data is extracted from the AutoCAD and MicroStation files and this information is then presented to both public and private sector agencies. MONITA, sediment analysis, design creation of wetlands, and long-term assessment of construction on/of wetlands is the primary data used throughout the section. And the primary data formats used include spreadsheets, USGS topographical quadrangles, aerial photography, and hardcopy maps, when available.

3.1.1.4 Plan Development and Flood Plan Management Section

The mission of the Plan Development and Flood Plan Management Section is to conduct flood plain studies and hurricane evacuation studies. John R. Eringham explained that the primary data internally produced in this section include hurricane evacuation, tidal surge data, and flood data. The primary data used from external resources included such data as shelter locations and demographic data obtained from both county and state agencies.

Analysis performed in this section is primarily demographic in nature, i.e., population in evacuation studies and transportation studies. John explained that hurricane maps are generated on a scale of 1:100,000 and/or according to FEMA requirements.

Easily accessible and electronic data desired within the section include city and county parcel data, aerial photos in a raster format and database information associated with all parcel data.

3.1.1.5 Environmental Resource Branch

Karl Burbamy and Glenn Coffee of the Environmental Resource Branch were interviewed. The mission of this branch is to evaluate environmental impacts of a variety of civil, military and international projects and managing project implementations. The primary internal data produced in this branch includes recreational master plan databases, project status reports, upgrading the management facilities master plan and the cultural master plan, watershed models from local city and county studies and any GIS databases produced using recreation and project status reports.

External data used in the Environmental Resource Branch is primarily project specific, but does include watershed data provided by internal and external agencies, State Historic Preservation Office data, USGS data, wetland reclamation and mitigation information and project specific military installation data (AutoCAD and ARC/OINFO formats).

Data generated in this branch is then provided to clients such as the military installation itself, civil works agencies, and associated project District Field Offices. The data generated primarily contains information on coastal regions, dredging and environmental compliance.

Analysis performed includes park visitation and park maintenance (general and routine) for recreational activities and grounds and utilities for facilities management, as well as archaeological data for cultural resources. Their present GIS platform consists of a UNIX (SparcII) with SUN operating systems. GIS/CADD applications utilized at the present are ARC/INFO for UNIX, Intergraph, MicroStation, Bernolli storage, AutoCAD, and ArcView.

Data desired in the Environmental Resource Branch include raster format aerial photography of project sites or the entire Mobile District, satellite images, terrestrial photos, USGS topographical quadrangles, and any necessary archaeological sites digitized. Linkage to databases both internal and external would include historical, coastal, environmental, and wetland remediation. Would like to be integrated with the Engineering and Planning Divisions of the Mobile District COE. External integration desired would include USGS, city, county and Mobile District Field Offices.

Analysis desired in the Environmental Resource Branch includes, but is not limited to, the amounts of acreage dedicated to recreation.

3.1.2 Engineering Division

3.1.2.1 Cost Engineering Branch

The Cost Engineering Branch is responsible for the cost of a project within the Mobile District. This branch advises and manages the project cost throughout the life of the project. Benny Anderson, Chief of the Cost Engineering Branch explained that the primary data internally produced within this branch are reports and RASER spreadsheets through the use of MCASCS, a COE developed software for estimating project cost. This data is then sent to external sources such as Architectural and Engineering firms and the Mobile District Engineering Design Branch. The data sent to the Design Section is primarily CADD drawings.

The CADD drawings from the project are given to the lead estimator. The lead estimator then assigns specific tasks and run an estimate of the tasks through MCASCS and generates a task and estimate report. This report and the specific task are then submitted to the appropriate sections for the work to be completed.

3.1.2.2 Project Support Section

George Poioux, Chief of the Project Support Section of the Design Branch of the Engineering Division stated the mission of the section to be a split mission. There are basically two units. First is the Specs unit, which puts together solicitation packages for construction contracts. And second is the Architectural and

Engineering unit, which negotiates new contracts.   An example of the data produced internally is the Military Design Schedule, which tracks milestones to a timekeeper program. Within the Specs unit, Requests for Proposals (RFP) are advertised on the Commercial Business Daily (CBD) and solicitation packages are delivered primarily on CD-ROM. The Architectural unit provides services as needed.

Primary data used within both units of the Project Support Section are technical drawings, technical specifications and CADD files. Analysis that is performed in this section primarily deal with cost estimate for negotiating delivery of service.

Design scales are usually set at a scale of 1:30. Use of USGS topographical quadrangles are used. Most all design files are in State Plane Coordinate systems. The bulk of this data is updated according to a military schedule.

CADD/GIS platform presently in place within the Project Support Section is PC's running NT operating systems with AutoCAD, MicroStation and InRoads applications.   Mr. Poioux would like to see data integration from the USGS and the Technical Specifications found in Washington, DC, as well as Wetland, Real Estate and all available boundaries maps within the Mobile District offices.

John Baehr, Geologist with the Geotechnical, Environmental and HTRW Branch of the Project Support Section, explains that the primary mission of this unit is to provide RIF investigations and remedial designs for Anniston Army Depot. The CADD/GIS platform is MicroStation on Windows NT operating system, using EXCEL spreadsheets and ACCESS databases to generate reports as needed. Present data generated within this section includes boring logs, geotechnical laboratory test data and groundwater data. These data are frequently shown in geological profile or cross section format using MicroStation software. These data types are generated for all types of design, not just for military construction. Seismic data is generally in digital format. There is existing compliance to GPS database for daily reports submitted to Anniston. John expressed interest in having GIS support public domain on the Internet, providing the public access to project sites, complete with photography of the site. At present there is an on-going initiative for building an "in-house" GIS for utilities. He notes that MGE is easily imported and environmental study data can also be easily imported into MicroStation. John also explained that there is an independent initiative to implement GIS at Anniston Army Base.

3.1.2.3 Project Design and Review Section

This Section provides civil site design for projects that are not contracted out. Mr. Hal S. Gates stated that they provide MECOM Support. The CADD/GIS platform presently in use is PC's running NT operating systems and using AutoCAD, MicroStation and ArcView applications. The bulk of the data produced in this section is delivered to designer as CADD files. Primary data used within the section consists of USGS topographical quadrangles, site planimetric maps, CADD drawings and design files.

The type of analysis performed within the Project Design and Review Section deals with 3_D modeling using CADD drawings. All data is updated every two years.

3.1.2.4 Coastal, Hydrology and Hydraulic Design Section

Howard Whittington, Hydrulic Engineer and James Hathorn, Data Manager, both from the Hydraulic Branch described their mission to be responsibility for creation of Hydraulic/Hydrographic design, water and resource management and resource management for the COE and public facilities.

Primary data produced includes all hydraulic and hydrological databases. Primary external data used in the branch includes river-forecast report for the City of Mobile, Jacksonville, Florida; real-time data collected in the Mobile District Office, rainfall data from the NWS, and local government data. These data types are used on a daily and weekly basis within the Coastal, Hydrology and Hydraulic Design Section.

Data generated for other offices and agencies include bridge clearing data and model reports. This data is provided using Oracle databases, SQL, Access, MicroStation, ARC/INFO, and ArcView. The contents of the data collected and generated in the section include stream flow records, station descriptions, station analysis, station abstracts, digital photographs of gage stations, rating curves and tables, discharge measurements, tidal data, flood profiles, low water profiles, high water descriptions, elevation, lock and dam records, just to name a few. Analysis performed in this section is as varied as the types of data collected and used, for example, reservoir cross sections and suspended sediment data.

The CADD/GIS platform presently in use within the Coastal, Hydrology and Hydraulic Design Section contains 30 workstations running NT operating systems, three NT servers, a water central data system (WCD), IVRS with ARC/INFO and MGE linked to an Oracle database.

They desire to have easy access to USGS topographical quadrangles, and Index Maps, as well as aerial photos and gage photos. External data that they would like to possess includes state agency information for Real Estate property data and associated reports. They would also like to see Hurricane Map generation and visualizations of river and dam discharge based on water flow for river flood stage. Linkage to the NWS and USGS data would be beneficial to the daily work requirements of this section.

3.1.2.5 Geotechnical and Dam Safety Section

This Branch of the Engineering Division provides support to district civil works, HTRW, dam safety programs, project instrumentation and reporting, and subsurface investigations. CADD/GIS platforms presently in use in this Branch include AutoCAD, MicroStation and ARC/INFO. Present data generated include geotechnical and geological profile data, borings and cross sections of military construction. ACCESS databases and EXCEL spreadsheets are used to report geologic profiles, narratives, design analysis, dam safety instrumentation plot data and monthly readings from project for updated graphical reports. Mr. Robert Chamlee, Chief of the Geotechnical, Environmental and HTRW Branch expressed interest in seeing an integration of all engineering and design files with data generated within the other District offices, such as Planning and Operations, possibly even construction, emphasizing an importance the ease of data access between the offices. He also expressed the desire to see database integration with external organizations such as the USGS, the SCS and District Field Offices.

Ron Nettles, Civil Engineer employed in this Branch explained that CADD databases utilized in this office are ASCII files using MicroStation Development Language (MDL) programs to read the data and draw boring logs. The MDL program draws boring location maps, top of rock spot elevations, groundwater spot elevations and geologic profiles in MicroStation format. Ron explained that boring log data is now being placed in .pdf format.

Ron expressed an interest in having GIS support rock and ground water data, as it is associated with subsurface investigations. Ron also expressed a need to have archived and historical data supported by the GIS. He feels the need to be able to access data from other sources, frequently including mapping (roads, buildings, utilities, and topography) and occasionally including aerial photos, daily lake level, and rainfall data. Geotechnical data integration, such as soil boring, and test data soil samples for all counties in the Mobile District could also be effectively utilized on projects within this office. Geotechnical laboratory testing (including shear, consolidation, compaction, moisture content and Atterberg Limits) is currently performed by other Government or commercial laboratories using software of their choice with the results usually furnished in hardcopy format.

3.1.3 Construction Division

Due to the nature of the Construction Division, it was deemed unnecessary to interview anyone in this Divisional Office.

3.1.4 Operation Division

3.1.4.1 Regulatory Branch

Within the Regulatory Branch mission is consists of permits, evaluations and enforcement activities relating to wetlands and the Clean Water Act. ArcView and ARC/INFO have been employed fully in providing GIS activities as they relate to regulation actions, Hydrographic, Roads, Endangered Species, Historical Sites, and pipelines. James McEnery maintains data in electronic formats and updates all data sources using ARC/INFO script on a daily and weekly basis. Training in ARC/INFO and ArcView has been provided internally. Present applications and electronic data available from this office include: 1) regulatory actions for specific locations; 2) wetlands and environmental data as they relate to this office; 3) acreage computations and distance measurements; 4) overlaying data from outside agencies with data generated in the office; and 5) using data in public notices and other documents to perform specific analysis.

3.1.4.2 Management Support Branch

Jim Walker and Meddie Clark are using PC ARC/INFO 1.0 and ArcView on a Unix environment. Although neither has been formally trained in software application procedure, Meddie has received some GIS education on a UNIX platform. The cursory training included methods of retrieving data. No design training was provided. There is a need expressed to be able to check history archives and expressed a want to employ GIS in providing visuals that benefit monetary decision making processes. The GIS would considerably aid financial argument in attaining additional funding by providing analysis results for political issues such as flood control.

3.1.4.3 Natural Resources Section

Kenneth Day, Park Manager with the Natural Resources Section explained the mission of the section to be one of management and conservation of any project natural resources, consistent with ecosystem principles, while providing quality public outdoor recreation.

This section primarily uses field office data collected and field office reports pertaining to projects on an as needed basis. However, Mr. Day feels that integration of electronic forms of data such as USGS topographical quadrangles, any field office site maps, aerial photography and associated database information could greatly enhance the production of this section. Mr. Day would like to see a consolidated database where general and specific data could be queried for reports and maps as needed in District summaries.

3.1.4.4 Regulatory Branch

Within the Regulatory Branch mission is consists of permits, evaluations and enforcement activities relating to wetlands and the Clean Water Act. ArcView and ARC/INFO have been employed fully in providing GIS activities as they relate to regulation actions, Hydrographic, Roads, Endangered Species, Historical Sites, and pipelines. James McEnery maintains data in electronic formats and updates all data sources using ARC/INFO script on a daily and weekly basis. Training in ARC/INFO and ArcView has been provided internally. Present applications and electronic data available from this office include: 1) regulatory actions for specific locations; 2) wetlands and environmental data as they relate to this office; 3) acreage computations and distance measurements; 4) overlaying data from outside agencies with data generated in the office; and 5) using data in public notices and other documents to perform specific analysis.

3.1.4.5 Navigation Section

The Navigation Sections uses hardcopy printouts of ArcView data provided by external resources and in turn provides other District offices and outside agencies with bathymetric surveys, inspection reports, photos, schedules as they pertain to Divisional activities such as safety, contracting, construction and planning. Linda Lillycrop utilizes a Dredging Information System (DIS) database to provide these inspection reports and schedules. To date, there is no formal GIS equipment utilized within the Navigation Section.

3.1.4.6 Spatial Data Branch

The Spatial Data Branch of the Operations Division is the Branch where all GIS activities will be originated. Jeff Lillycrop, Chief of the Spatial Data Branch explained the mission of the Branch as a tri-fold mission, consisting of three units. Basically, the Spatial Data Branch are the spatial data collectors for the Mobile District. Jeff Lillycrop is also in charge of the SHOALS unit of the Spatial Data Branch. Within the SHOALS unit, the GIS platform consists of data generation and data processing with a software specifically developed for SHOALS. Removal of data from data generated tapes is done using the SHOALS software. The SHOALS software computes and cleans the initial data. From this point, the dataset is then uploaded (or exported) into the Computer Aided Drafting and Design (CADD) package TerraModel for final production and plotting. The SHOALS unit believes this digital shoreline product could be valuable data for use in other District offices.

Don Thrower and Mike Nettles are the primary personnel in the Survey, Mapping, and Photogrammetry Unit of the Spatial Data Branch. This unit is in charge of providing survey mapping and photogrammetrical data for both civil and military projects within the Mobile District, as well as being tasked with providing Real Estate with boundary and boundary survey mapping. The GIS platform presently in use within the Survey, Mapping and Photogrammetry Unit of the Spatial Data Branch includes PC's with NT operating systems and MicroStation software applications.

Mark Penton heads up the GIS unit of the Spatial Data Branch. Mr. Penton is in charge of all GIS activities and functions within the District. These GIS activities include, but are not limited to, providing GIS technical support to the Mobile District offices, GIS implementation procedures throughout the Mobile District and marketing GIS to future customers within the Mobile District. The GIS Unit of the Spatial Data Branch is the focal point for all GIS activities. To date, Mr. Penton has developed a data translation product that provides TSSDS compliance for the data created and used in Engineering projects.

3.1.4.7 Field Offices

ACF Project Management Office (PMO) employees Linda Brown and Donald Morgan were interviewed. They established that the ACF PMO were utilizing ARC/INFO and ArcView on a Windows NT operating system for data generation for lakeshore use allocations of limited and protected resources, aquatic plant surveys, timber inventories and wildlife inventories. Databases used consist of dBase III and dBase IV. Mr. Morgan expressed that all personnel within the ACF PMO need formal training on ArcView.

Allatoona Project Management Office (PMO) Operations Manager, Ken Huddleston expressed that there is presently no formal GIS platform or applications used at this PMO. However, dBase databases are used for generating lakeshore permits and floating cabin permits.

BW&T / Alabama-Coosa Project Management Office operate 30 recreational areas with a total of 688 campsites, 500 picnic sites, beaches, boat ramps, and other recreation affiliated services. Forty site areas are under lease to city, county, and state government, private organizations, such as churches and scouting organizations. All of the information that is generated from these operations and activities has limited use for others. An annual report detailing the mentioned activities is generated using the Natural Resource Management System. With the RIF (Reduction in Force), 50% of staffing has been lost and Mr. Huddleston, Operations Manager at BW&T PMO, feels that any additional program requirements would hinder the already strained staff. Having little or no knowledge of GIS is also a concern to Mr. Huddleston.

He feels as though his staff could not offer any information to would be useful to other offices within the District.

Carters Project Management Office provides hydropower production, flood damage reduction and recreational and natural resources management. LuAnn Lackey, Site Manager and Brian Sapp at the Carter PMO described their CADD/GIS platform as a workstation with MicroStation. They envision training selected management personnel, administrative staff, natural resource management staff, and hydropower staff in GIS (four persons in all). Data generated in the Carter PMO consists of annual reports produced using (NRMS), Powerhouse log sheets (hardcopy), Financial reports using CEFMS, User Fee report (AUPS), Property Inventory (RAPPMS) and Citation Tracking (CRM). Types of data they desire to possess for GIS conversion consists of maps, plans, brochures, aerial photos, terrestrial photos, land use data, geologic data and forestry inventory data.

Okatibbee Project Management Office provides management of flood control projects, recreation, water quality and natural resources activities. Jack Huntley, Project Manager at Okatibbee PMO states that there is presently no CADD/GIS activities performed. CEFMS is the only database used at the PMO. Van McWhorter, Park Ranger at the Okatibbee PMO, has had limited exposure and education in GIS. The Okatibbee PMO does provide electronic data of water management and camp area data to the district. Van McWhorter, Park Ranger electronically transmits this data via e-mail. Van envisions having Teen-Tom Natural Resource GIS developed in ARC/INFO and ArcView. External organizations providing data that could be integrated with data generated at the Okatibbee PMO include data from MS Wildlife, Parks and Fisheries, State and Private utility companies for right of way data, permits and leasing of marina data, and the Master plans from Meridian Naval Station. Van expresses interest in generating a project wide forest inventory and management program.

Tenn-Tom Project Management Office provides Natural Resource, Wildlife and Navigational support to the Mobile District. Data collections are provided with AutoCAD release 14. GIS databases include natural resources and are provided by contractors and subcontractors. Dredging surveys have been internally generated since 1995 and placed in digital format for updating maintenance on locks. Base maps used in the development of GIS are provided through various agencies such as MS Automated Research Information Systems (MARIS), the USGS, and maps obtained through local government agencies. These agencies also provide GPS data on specific fauna species (i.e., the wood duck) in multi-species videography on CD ROMS. Non CADD/GIS databases are generated using EXCELL spreadsheets provides information on disposal areas. At present there are two PCs in the Tenn-Tom PMO. One PC runs AutoCAD on a Windows 95 operating system and the other runs MicroStation on a Windows NT operating system. There is a Solaris workstation for natural resource data generation. The PMO has obtained a copy of PC ARC/INFO, though it is not installed at this time. They have also acquired a CalComp Plotter, a Yamaha CD-Writer, a HP 75 Scan Plotter, a HP Scanner and a couple of digital cameras. Databases in use include Access, dBase, and CEFMS. They envision having USGS Quads, road data, contour data, dredging survey data, and Navigation aids made available for GIS activities. District wetland data, environmental data and aerial photography are a few of the data integration they would like to accomplish.

West Point Project Management Office provides natural resource management, recreation, hydropower and shoreline management tasks to the District. H.R. Ansley, Park Ranger at the West Point PMO described CADD/GIS platform to hardcopy data and CD ROM aerial photography provided by contractors. At present there is no GIS platform in place, yet funding is in place to implement GIS activities. Data generated at the PMO consists of inventory of natural resources, and shoreline management data. Interest was expressed as having GIS support silviculture treatment of timber stands, map development for recreational users, natural resource analysis, maintenance planning initiatives, shoreline management, permit data, cultural site data and vandalism.

Panama City Project Management Office provides surveying and maintenance for Operations and Engineering projects. The GIS platform consists of PCARC/INFO and ArcView. Michael Nelson, Civil Engineer with the Panama City PMO expresses a desire to have personnel formally trained in ArcView and ARC/INFO. Michael expressed interest in having the GIS support lakeshore management plans, permit activities, as-built drawings, soil surveys, recreational area maps, forest resources, inventories management, erosion and sediment data and dredging survey data.

3.1.5 Real Estate Division

3.1.5.1 Cadastral Section

The mission of the Cadastral Section is to provide real estate mapping, legal descriptions, boundary survey contracts, and lease exchanges for the Mobile District. Boundary maps are produced using legal descriptions from deeds and USGS topographic quadrangle maps. Data used from external sources include deed records, city and county legal records and contractors. Data from the Cadastral Section, used by others would include, but not be limited to, legal descriptions, boundary data, boundary survey maps, and computational reports. All data used in the section are in the form of hardcopy maps, aerial photographs and the legal descriptions from deeds.

Analysis performed in this section would include boundary disputes and encroachment issues. Data is not updated on a regular basis due to the lack of funding needed to update hardcopy maps. The present CADD GIS platform consists of one TD-40 workstation with a MicroStation application.

3.1.5.2 Control and Reports Section

John F. Croley and "Maze" Namejs Ercums was interviewed. They explained that the mission of the Control and Reports Section is to coordinate real estate funding, personnel actions, real estate records and reports, produce maps and auditing procedures. CADD generated maps using a MicroStation application is used primarily for visualization in real estate reports. However, not all maps used in this section are electronic format. The majority of maps used by this section are hardcopy.

External data used consists of boundary survey data from contractors and any available data found in legal documents at state and county courthouses. Data contents within this section include geographical presentations, ownership of land attributes, and historical documents. Some of the analyses performed include real estate planning reports, Command management interactions, and property ownership. There are presently two CADD applications housed within the section. A third CADD application has been ordered. However, all employees within the Control and Reports Section need to be trained to handle the CADD GIS applications before full utilization of the technology can begin.

The data desired by Mr. Croley and Mr. Ercums would be to integrate aerial photographs, terrestrial photographs, satellite imagery, environmental remediation maps and database information, land usage data, geologic data, soils data and SHPO data. They would really like to be able to use construction and engineering design plans, planning concepts, land ownership and parcel data the most.

Reid S. Ferril, Realty Specialist and System Administrator in the Real Estate Division was also interviewed and mentioned that land plats are data files that are internally generated within this section.

3.1.5.3 Acquisitions Branch

The Acquisitions Branch mission is to acquire all real estate interests, with the exception of leasing. This mission is handles all deeding of land and closing of real estate investments. At present there are no CAD/GIS data produced within the Branch. And the information provided to other departments resides only with the status of the acquisition for real estate property as it pertains to a specific project.

Mr. Givhan explained that the primary sources of maps used in the Acquisitions Branch are hardcopy maps. However, engineer drawings and design files are utilized as well. The analysis of information done within the Acquisitions Branch resides primarily with the relationship of landowners for negotiations, i.e., and disposal site in dredging projects. It would be Mr. Givhan desire to see number identifications tracked between sections and have the ability to review project operations and dredging sections.

3.1.5.4 Forestry Section

Supervisory Forester, Mr. Jimmy F. Hill explained the mission of the Forestry Section as a mission of contracting the sell and harvest of time and related forest products from Army installations, civil works projects, and NASA facilities.

Currently there is no CADD GIS platform in use in the Forestry Section. Data is produced in the Forestry section using the Timber Harvest Information System (THIS) on a singular PC. This data generated from THIS is primarily data collected and generated in District Field Offices and then is collectively shared with the Field Offices. Mr. Hill desires to have ease of access to electronic formats of the USGS topographical quadrangles and aerial photographs. He would like to be able to produce maps of sales areas, wetlands and archaeological/historical sites.

3.1.5.5 Military Management and Disposal Section

James A. Wagoner III from the Military Management and Disposal Section said that the mission of this section is to manage and dispose of military real property in the Mobile District and to handle grant and base realignments and closing including the ones in Central America. At present there are no CADD GIS data internally produced by this section. However, external data that is used includes real property information, term, leasing and permit payment information, real property customer billing services, base closures, disposals and BRAC. The hardcopy data that is primarily used within this section are maps, aerial photographs, legal descriptions (parcel, deed, survey), real property availability reports, environmental documents, rental property data.

The primary analysis would be to make sure that all regulations were followed when disposing of real property. Mr. Wagoner expressed interest in having maps, plans, agriculture, and aerial photography as the types of data desired for GIS conversion. He also expressed an ability to use state agency information reports.

3.1.5.6 Leasing Section

Calvin L. Hare, Chief of the Leasing Section explained the mission of this Mobile District office as on that acquires leases and other real estate for the Mobile District COE and other federal agencies upon request. Presently there is no CADD GIS platform in the Leasing Section. External data sources include DoD Army Leased Priority Parking Spaces, Leased office spaces, Helicopter sires for training, and Plans for space utilization. Mr. Hare would like to see GIS provide for the Leasing Section charted land areas, office space layouts, and aerial photographs for sites and installations. He would also like to have access to "as-builts" and CADD design files.

3.1.6 Program Management

3.1.6.1 Civil Works Programs and Project Management Branch

Mr. Robert "Bob" Bond, Chief of the Civil Works Project Management Branch explained that this Branch mission was to program and manage civil projects, submit budgets to Congress for funding, schedule the civil works projects and provide cost of civil works projects. This Branch office presently has no CADD GIS implemented. There are 14 PC's that are used in various administrative applications for producing maintenance status reports. Hardcopy format of GIS type data is generally reserved for the Project Managers. These types of hardcopy data would include, but not be limited to Navigational Charts and aerial photographs, as needed to give visualization to the status of ongoing projects. Mr. Bond feels that there could reside a need to access outside databases for feasibility studies that are conducted in the Civil Works Programs and Project Management Branch.

3.1.6.2 Strategic Initiatives and SFO Project Management Branch

Roger Simmons, Chief of the Strategic Initiative Branch quoted the mission as marketing, management and environmental support to the Mobile District and Latin American projects. There is presently no CADD GIS platform in the Strategic Initiative Branch. However, paper drawings, specifications, and various hardcopy maps are utilized in providing PRB reports. Mr. Simmons is unsure as to how GIS could or would benefit the Strategic Initiative and SFO Project Management Branch.

3.1.6.3 Programs and Project Management Division

The Programs and Project Management Division is the single point of contact for military installation design and construction, whether services are provided in-house or by contracting Architectural and Engineering firms. All needs requirement for the installation design and construction. Mr. Michael T. Abelin, PE explained that requests from military installations for services or project management are made to this division. The installation's request is then directed to the location or area in which the project can be completed, this is either within the Mobile District itself or through contracting Architectural and Engineering firms.

The Programs and Project Management Division provides suggested budgets and schedules needed for the military installation projects. The primary data used within this Division consist of Project Information Management System data (PROMISE), dikes, levees, etc. Mr. Abelin would like to be able to access a military installation's GIS or AM/FM data for linking database information. He would also like to be able to reduce redundant works efforts. In other words, Mr. Abelin would like to be able to use any data that the military installation has on electronic file versus regenerating the work within the Programs and Project Management Division.

3.1.7 Information Management

The District Information Management Section purveys the Mobile District Wide Area Network (WAN), which must serve as the communications backbone for the GIS. This WAN provides the infrastructure (devices) and protocol (communication rules) to support the distributed client-server communications required by the District and the proposed corporate wide GIS. Appendix D of this document provides a graphic depiction of the Mobile District WAN.

With the implementation of any GIS, data demands are known to increase approximately 25 – 40%. Unless the existent network capacity was initiated with intent to carry heavy loads, modifications will need to be made. Examples of network modifications include but are not limited to increasing bandwidth and upgrading data transmission lines. Upgrading the present District network will be necessary to support the District's data transmission demands, once the GIS is implemented. The following discussion provides the existent status of the Mobile District's network capacities and recommendations for future data network modifications.

The District's data communications backbone is currently a sufficient network for the loading presently encountered. General characteristics of the WAN are:

Thirty-five Local Area Networks (LANs)

- A TCP/IP operating protocol with FDDI Ring Ethernet Hubs
- Thick and Thin twisted pair cabling
- Unshielded telephone network speed communications of 56K dedicated modem lines
- Two T-1 data transmission lines (one to Irvington and one to Panama City)
- Personal workstations with CPU's of 266 MHz or higher and RAM of 32MB
- Personal computer workstations running Windows 95 and Windows NT operating systems

Peak operation and traffic activities for one week show that the 56K dedicated modem lines transmissions are primarily during working hours. Peak bandwidth operation is apparent on specific weekdays as demonstrated in the Figure below. Though the figure below denotes that the high use of bandwidth is primarily during weekday working hours, traffic activities are not consistent from week to week. Therefore it should be noted that this figure portrays only the peak operations of the network during the week of February 9, 1999. The graph clearly shows that the amount of data transmission into the District Office during this weekday working hours is considerably more than traffic movement from the District Office.

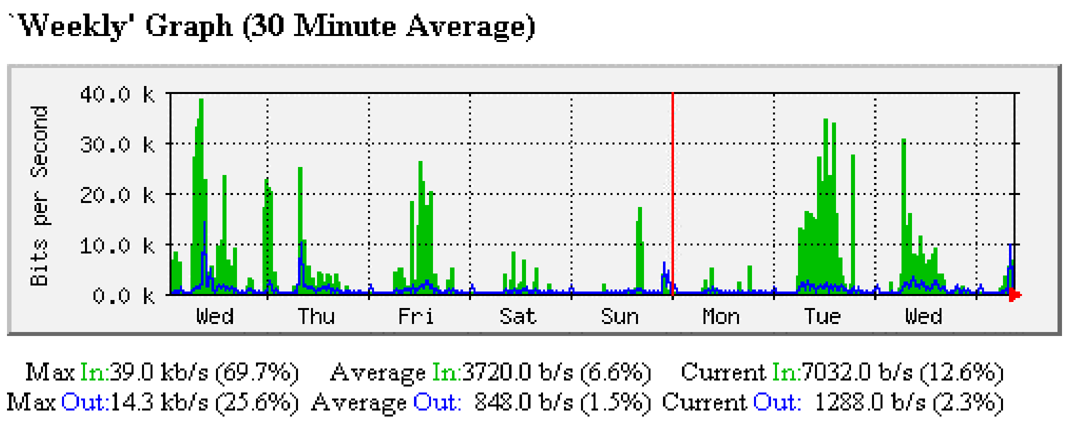

Figure 3.1 - Mobile District Data Communication Network Traffic Peaks

3.1.7.1 Servers

There are 50 servers functioning on the District WAN. Figure 3.2 depicts the number of servers found in the Mobile District Central Office. The remaining servers are distributed throughout the District and associated Field Offices.

Forty-six of the servers on the WAN are configured with Dual Processors 300 and Pentium II CPUs. The following is a composite list of the average of each server capacity:

File and Application Servers

RAM capacity between 64MB and 360MB

- Hard disk capacity up to 6GB
- All servers run Windows NT with SCSI adapters
- RAIDS are found in eight (8) of the servers with 6GB disk arrays

Daily backup is performed using Cheyenne ArcServe

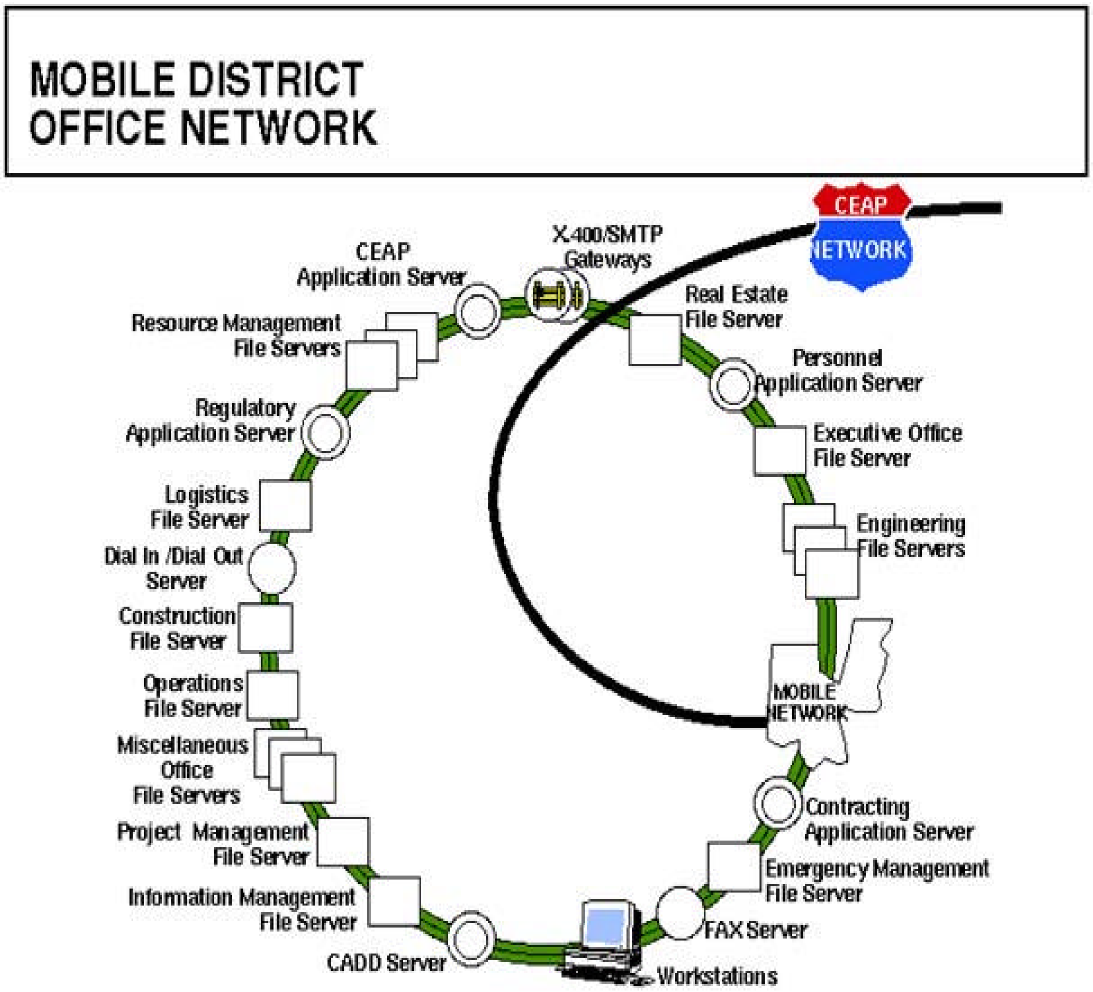

Figure 3.2 - Mobile District Central Office LAN

3.1.7.3 Internet Servers

Two servers dedicated to the Internet

- Each server has Dual Pentium II 300 MHz processors
- Each server provides Internet and Intranet access
- Each server has 8GB storage capacity
- Daily backup is performed wt. Cheyenne ArcServe
- One server used primarily for basic web applications and access
- One server used primarily for Lotus Domino

3.1.7.4 Databases contained on LANs

The envisioned GIS network will allow common resources and databases contained on LAN servers to be shared. Compliance of data standards ensures complete interoperability of data. At a minimum, the data interoperability will be related to basic topographic maps and some thematic data sets (e.g., land, timber, vegetation, etc.). In addition, those thematic data sets that describe integrated systems (e.g., utilities, hydrology, etc.) are applicable to data sharing across the network. From CEFMS (Corps of Engineers Financial Management System) to REMIS (Real Estate Management System) it is evident that many of the offices within the District Divisions are using Oracle databases. Another database that carries extensive use is dBase. Used primarily in the offices running ESRI (Environmental Scientific Research Institute) software such as ARC/INFO and ArcView. The following discussion provides a few of the databases that will support GIS activities, with the exception of CEFMS.

Oracle

Oracle database applications can be found on all of the LANs within the District. CEFMS (Corps of Engineers Financial Management System) is used universally throughout the Corps of Engineers. Within the Real Estate Division, REMIS (Real Estate Management Information System) is an Oracle database that stores data of varying magnitude; data as varied as leased priority parking spaces to information on land ownership and historical documentation. This data provides the Real Estate Division with analytical capabilities that range form planning reports to command management interactions. The Acquisition Branch of the Real Estate Division, uses REMIS for land track data and provides analysis used in negotiation with landowners for projects such as dredging for disposal sites.

In the Hydrology and Hydraulics Branch, Oracle is used to store attribute data as varied as streamflow records, discharge measurements, tides, high water descriptions, reservoir cross section, and the list goes on. SQL (Structured Query Language or sequel) within Oracle enables the Hydrology and Hydraulics Branch to perform station analysis, produce rating curves and tables, and determine flood profiles for flood insurance studies. And yet these types of data and analysis mentioned are only a few of the tasks the Hydrology and Hydraulics Branch perform.

dBase III and dBase IV

dBase applications are found primarily in use with software application such as ARC/INFO and ArcView, though they are not limited to this use. When using these software applications, a dBase database is automatically generated. Within the Flood Plan Management Section of the Planning Division, these databases are for hurricane evacuation studies.

Lake Seminole uses dBase III and dBase IV to internally produce an aquatic plant survey database used in mapping. This data is then provided to State agencies. Type of analysis performed at Lake Seminole include indication of yearly aquatic vegetation acreage changes and silviculture actions such as thinning and burning.

THIS

THIS (Timber Harvest Information System) an internally created database that enables timber data to be shared with Field Offices via modem data transmission. Jimmy Hill, Supervisory Forester in the Forestry Section of the Real Estate Division developed this database to aid in contracting the sell and removal of timber and related forest products from army installations, civil work projects and NASA facilities. The data contribution in this database supports several GIS activities.

ACCESS

ACCESS databases are used primarily in the District as a means of generating attribute data for specific projects. This data is then used in the generation of daily, weekly, monthly and annual reports. All ACCESS databases will support GIS activities.

As the GIS is brought on-line and use of the GIS increases, dedicated 56K dedicated circuits will no longer sufficiently handle the data transmission traffic during peak hours of operation. It is recommended that the Mobile District begin considering replacement of 56K dedicated lines with larger circuits. Reasoning behind this recommendation is simply bandwidth and the increase of data transfer capacity. Naturally, replacement of 56K dedicated lines will be dependent upon the amount of data transmission traffic and cost of replacement. Larger circuits range from frame relay to full T-1 dedicated lines. There is 24 times more bandwidth capacity in T-1 line than there are 56K dedicated line. Again, this is primarily dependent upon cost factors

4 GIS Implementation Methodology

In order to achieve the most economically feasible strategy for the Mobile District GIS implementation, Baker is recommending a GIS initiative implemented that is project-based. Because we recommend the GIS to be implemented on a project-by-project basis, the GIS implementation phases will vary slightly between different projects. The alternative is to create a single, huge dataset that all offices will feed into. This approach is not appropriate given the structure of the District and existing strengths. However, to be successful in a project-based approach, a strong leader and technically capable group must exist to ensure commonality and provide assistance. This group is the Spatial Data Branch of the Mobile District Corps of Engineers.

4.1 Organizational Recommendations

A Spatial Data Branch must be established to guide the network administration, engineers, technicians, and management personnel throughout the GIS implementation process. This branch will enable the dynamics of the GIS to grow in a positive direction. Spatial Data Branch will establish the application priorities, standards, mapping procedures, workflow, responsibilities, schedules, budget requirements and for the GIS. The Spatial Data Branch will also provide guidelines and selection of staff for any training needed for the success of the GIS. This panel of personnel must work in harmony with a selected technical working group.

A technical working group should also be formulated and consist of interim managers and technicians that work daily with the CADD and GIS applications. Data maintenance protocol and data integrity should remain within the technical working group, with decisions of access and support determined by the Spatial Data Branch. Careful control of the Technical Working Group must be must be maintained to make sure its growth does not impose impede effectiveness. This working should be composed of the best and brightest technical talent within the District. The Technical Working Group should be established before 3rd quarter FY99.

Creating a listing of all personnel directly involved in the project GIS implementation and establishing communication protocols between personnel will facilitate an approach to information sharing.

4.2 Recommended Acquisition of hardware, software and training

Procurement and acquisition of additional hardware and software is provided through the IM/Facilities CAD2 Program. This program is committed to providing the best value to the Corps of Engineers. Primary vendors of hardware and software are Tracor-ES, who provides desktop products and services such as ESRI's ArcView, and Intergraph, who provides MicroStation products and services. Estimated cost for budgetary purposes of a typical GIS Implementation startup (excluding Oracle and ARC/INFO) will be $10,000. Further reference can be made using the price listing in Appendix F. The following are suggested hardware and software requirements needed to support GIS activities for any project office.

4.2.1 Hardware:

Microsoft Windows NT 4.0 or higher operating system

- Pentium II processor
- 32X CD/ROM drive
- 128 MB RAM
- 56K modem

**Estimated cost of hardware requirements: $ 4,500.00 per workstation

4.2.2 Software:

Oracle (estimated Cost: $ 15,000 per license)

- ODBC drivers (free)
- Selected software applications
- Intergraph based GIS software
- Estimated cost: $ 10,000 per workstation
- ESRI based GIS software
- Estimated cost: $ 15,000 per workstation

**Microsoft Office Suite Estimated cost: $500.00 per workstation

4.2.3 Training:

Formal

- Estimated Cost: $3,500 per person

- Informal
- Estimated Cost: $1,500 per person

4.2.4 Planning Division

Plan Formulation Branch

Install GeoMedia Viewer	(free via Internet)
Provide informal training for GeoMedia Viewer	(approx. $1,500/person)

4.2.4.2 Inland Environment Section

Upgrade to Windows NT operating system	(approx. $150/ea)
Upgrade ARC/INFO to latest release	(approx. $5,500/ea)
Procure ArcView license	(approx. $1,500/ea)
Install GeoMedia Viewer	(free via Internet)
Provide formal ARC/INFO training	(approx. $5,500/ea)
Provide informal GeoMedia training	(approx. $1,500/ea)

4.2.4.3 Environmental Resources Planning Section

Upgrade to Windows NT operating system	(approx. $150/ea)
Install GeoMedia Viewer	(free via Internet)
Provide informal GeoMedia training	(approx. $1,500/ea)

4.2.4.4 Plan Development and Flood Plan Management Section

Upgrade to Windows NT operating system	(approx. $150/ea)
Procure GeoMedia for integrating ARC/INFO and ArcView data with AutoCAD and MicroStation data	(approx. $1,500/ea)
Provide formal GeoMedia training	(approx. $3,500/ea)

4.2.4.5 Environmental Resource Branch

Upgrade to Windows NT operating system	(approx. $150/ea)
Procure GeoMedia for integrating ARC/INFO and ArcView data with AutoCAD and MicroStation data	(approx. $1,500/ea)
Upgrade to latest release of ARC/INFO for NT	(approx. $5,500/ea)
Upgrade to MicroStation release J	(approx. $3,500/ea)
Upgrade to ArcView 3.1	(approx. $300-800/ea)
Install GeoMedia Viewer	(free via Internet)
Provide formal GeoMedia training	(approx. $3,500/ea)
Provide formal ARC/INFO training	(approx. $5,500/ea)
Provide formal ArcView training	(approx. $3,500/ea)
Provide formal MicroStation training	(approx. $5,000/ea)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.5 Engineering Division

4.2.5.1 Cost Engineer Branch

Install GeoMedia Viewer	(free via Internet)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.5.2 Project Support Section

Install GeoMedia Viewer	(free via Internet)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.5.3 Project Design and Review Section

Install GeoMedia Viewer	(free via Internet)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.5.4 Coastal, Hydrology and Hydraulic Design Section

Install GeoMedia Viewer	(free via Internet)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.5.5 Geotechnical and Dam Safety Section

Install GeoMedia Viewer	(free via Internet)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.5.6 Spatial Data Branch

Procure ArcView 3.1 license	(approx. $1,500/ea)

Procure GeoMedia for integrating ARC/INFO and ArcView data with AutoCAD and MicroStation data	(approx. $1,500/ea)
Install GeoMedia Viewer	(free via Internet)
Install ArcExplorer	(free via Internet)
Provide formal training for ArcView	(approx. $3,500/ea)
Provide formal training for GeoMedia	(approx. $3,500/ea)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)
Provide informal training for ArcExplorer	(approx. $1,500/ea)

4.2.6 Construction Division

Not established at this time.

4.2.7 Operations Division

4.2.7.1 Regulatory Branch

This Branch is fully functional and synchronized with the overall Mobile District GIS objectives. Upgrade software as needed.

4.2.7.2 Management Support Branch

Upgrade to Windows NT operating system	(approx. $150/ea)
Upgrade to ARC/INFO for NT	(approx. $5,500/ea)
Upgrade to ArcView 3.1	(approx. $300-800/ea)
Install GeoMedia Viewer	(free via Internet)
Provide formal training for ARC/INFO	(approx. $5,500/ea)
Provide formal training for ArcView	(approx. $3,500/ea)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.7.3 Natural Resources Section

Upgrade to Windows NT operating system	(approx. $150/ea)
Procure GeoMedia for integrating ARC/INFO and ArcView data with AutoCAD and MicroStation data	(approx. $1,500/ea)
Install GeoMedia Viewer	(free via Internet)
Provide formal training for GeoMedia	(approx. $3,500/ea)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.7.4 Navigation Section

Upgrade to Windows NT operating system	(approx. $150/ea)
Install GeoMedia Viewer	(free via Internet)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.7.5 Field Offices

ACF Project Management Office

Upgrade to ArcView 3.1	(approx. $300-800/ea)
Upgrade to ARC/INFO 7.2 or higher	(approx. $5,500/ea)
Provide formal training for all employees in ArcView	(approx. $3,500/ea)

Provide formal training for ARC/INFO	(approx. $5,500/ea)

Allatoona Project Management Office

Upgrade to Windows NT operating system	(approx. $150/ea)
Install ArcExplorer	(free via Internet)
Provide informal training in ArcExplorer	(approx. $1,500/ea)

BW&T/Alabama-Coosa Project Management Office

Upgrade to Windows NT operating system	(approx. $150/ea)
Provide the BW&T with interdisciplinary staff	(1 to 2 person)
Procure ArcView license	(approx. $1,500/ea)
Provide formal training in ArcView	(approx. $3,500/ea)

Carters Project Management Office

Upgrade to Windows NT operating system	(approx. $150/ea)
Procure GeoMedia license	(approx. $1,500/ea)
Provide formal training in GeoMedia	(approx. $3,500/ea)

Okatibbee Project Management Office

Procure ARC/INFO license	(approx. $4,500/ea)
Procure ArcView license	(approx. $1,500/ea)
Provide advanced formal training in ARC/INFO	(approx. $5,500/ea)
Provide formal training in ArcView	(approx. $3,500/ea)

Tenn-Tom Project Management Office

Procure GeoMedia license	(approx. $1,500/ea)
Provide formal in GeoMedia	(approx. $3,500/ea)
Upgrade PC ARC/INFO to ARC/INFO for NT	(approx. $5,500/ea)
Provide formal training in ARC/INFO	(approx. $5,500/ea)
Procure ArcView license	(approx. $1,500/ea)
Provide formal training in ArcView	(approx. $3,500/ea)

West Point Project Management Office

Upgrade to Windows NT operating system	(approx. $150/ea)
Procure GeoMedia license	(approx. $1,500/ea)
Procure ArcView license	(approx. $1,500/ea)
Provide formal training in GeoMedia	(approx. $3,500/ea)
Provide formal training in ArcView	(approx. $3,500/ea)

Panama City Project Management Office

Upgrade to Window NT operating system	(approx. $150/ea)
Upgrade PC ARC/INFO to ARC/INFO for NT	(approx. $5,500/ea)
Upgrade ArcView to 3.1 version	(approx. $300-800/ea)
Provide formal training in ARC/INFO	(approx. $5,500/ea)
Provide formal training in ArcView	(approx. $3,500/ea)
Procure GeoMedia license	(approx. $1,500/ea)
Provide formal training in GeoMedia	(approx. $3,500/ea)

4.2.8 Real Estate Division

4.2.8.1 Cadastral Section

Upgrade to Windows NT operating system	(approx. $150/ea)
Procure ArcView license	(approx. $1,500/ea)
Procure GeoMedia for integrating ARC/INFO and ArcView data with AutoCAD and MicroStation data	(approx. $1,500/ea)
Provide formal training for ArcView	(approx. $3,500/ea)
Provide formal training for GeoMedia	(approx. $3,500/ea)

4.2.8.2 Control and Reports Section

Upgrade to Windows NT operating system	(approx. $150/ea)
Procure MicroStation J license	(approx. $7,000/ea)
Procure GeoMedia for integrating ARC/INFO and	(approx. $1,500/ea)
Provide formal training in MicroStation J	(approx. $5,000/ea)
Provide formal training in GeoMedia	(approx. $3,500/ea)

4.2.8.3 Acquisitions Branch

Upgrade to Windows NT operating system	(approx. $150/ea)
Install GeoMedia Viewer	(free via Internet)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.8.4 Forestry Section

Upgrade to Windows NT operating system	(approx. $150/ea)
Procure ArcView license	(approx. $1,500/ea)
Install GeoMedia Viewer	(free via Internet)
Provide formal training for ArcView	(approx. $3,500/ea)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.8.5 Military Management Section

Upgrade to Windows NT operating system	(approx. $150/ea)
Install GeoMedia Viewer	(free via Internet)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.8.6 Leasing Section

Upgrade to Windows NT operating system	(approx. $150/ea)
Install GeoMedia Viewer	(free via Internet)
Provide informal training for GeoMedia Viewer	(approx. $1,500/ea)

4.2.9 Program Management

4.2.9.1 Civil Works Program and Project Management Branch

Upgrade all PC's to Windows NT operating system	(approx. $150/ea)
Install GeoMedia Viewer on selected PC's	(free via Internet)

Provide informal training for GeoMedia Viewer (approx. $1,500/ea)

4.2.9.2 Strategic Initiatives and SFO Project Management Branch

Upgrade to Windows NT operating system (approx. $150/ea)

Install GeoMedia Viewer (free via Internet)
Provide informal training for GeoMedia Viewer (approx. $1,500/ea)

4.2.9.3 Programs and Project Management Division

Upgrade to Window NT operating system (approx. $150/ea)

Procure GeoMedia (approx. $1,500/ea)
Install GeoMedia Viewer (free via Internet)
Provide formal training for GeoMedia (approx. $3,500/ea)
Provide informal training for GeoMedia Viewer (approx. $1,500/ea)

4.3 Data

Varying types of data formats (aerial photography, digital files, hardcopy maps, etc.) are used on a daily basis within the Mobile District. These data types range from hardcopy maps stored in an archive library to digital maps and drawings generated within the District Offices. External organizations and agencies outside of the Mobile District also provide data to the Mobile District for supporting all types of military and civil projects. Some of the data resources obtained outside of and used by the Mobile District include, but are not limited to, USGS topographical quadrangles, contractor generated map sheets, aerial photography and Soil Conservation Service (SCS) database reports. The many uses of any externally generated data can be found listed in Chapter 3 of this document. A listing of the differing data formats must be documented and made available to the Steering Committee no later than the end of the 4th quarter FY99.

A fundamental step to efficiently and effectively using a GIS is to develop a robust spatial database applicable to many purposes. Ideally, topographic, planimetric, hydrographic, land use, and other geographic information will be obtained for the entire District and affiliated projects at a spatial scale and level of accuracy that will suit a wide variety of analysis needs. In the course of building the base map GIS, strict adherence to database standard is required. One objective of any project is to formulate project alternative for construction. To meet this objective it may be necessary to build base maps for upland and/or aquatic sites that do not yet exist.

A well-presented set of alternatives, each accompanied by a consistently formatted map product, is needed for clear communication of project objectives to diverse audiences. Figure 4.1 provides an example of the electronic data available from the Internet. This data can be made use of immediately throughout most of the Mobile District. Agreements made with primary agencies will need to be made by the end of the 3th quarter FY99.

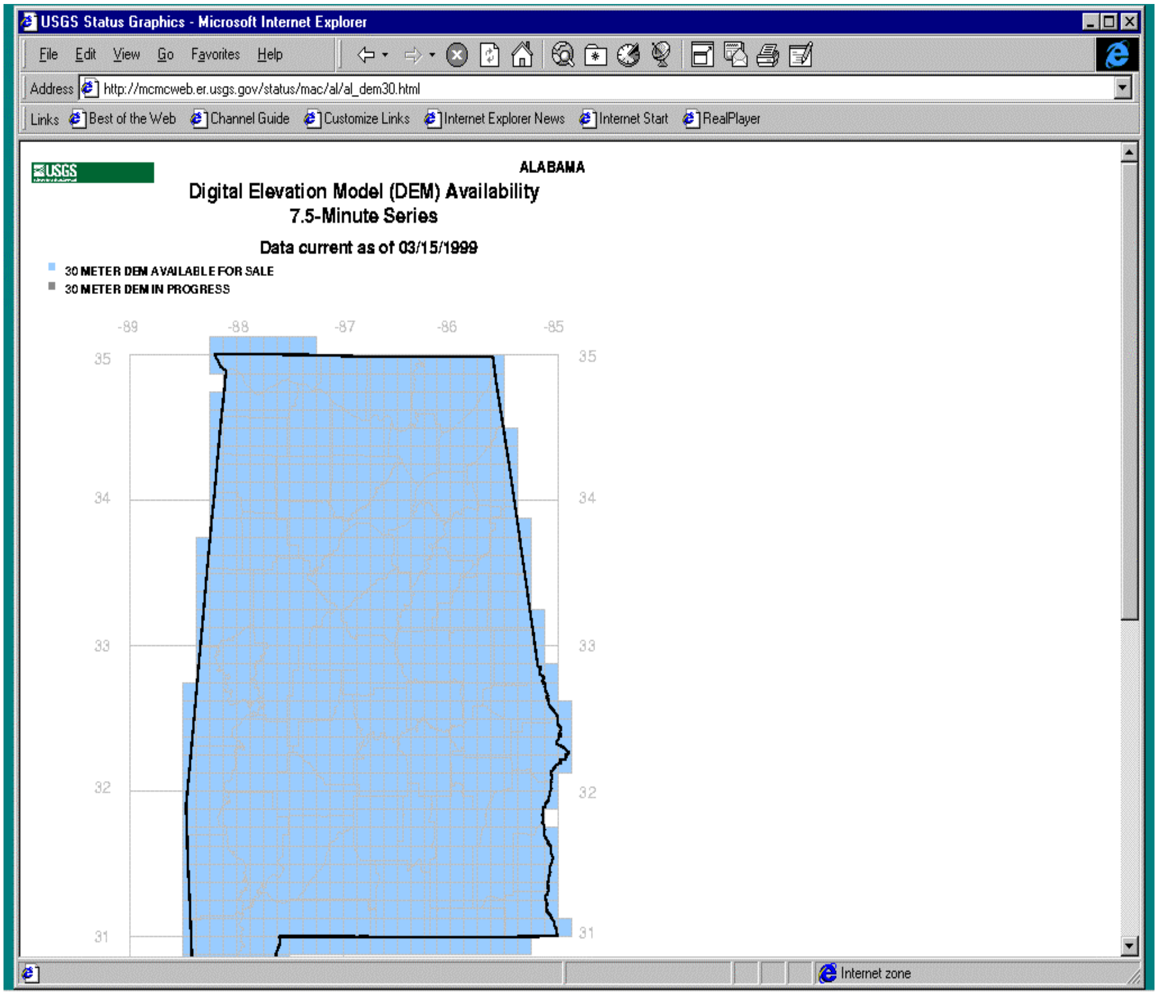

Figure 4.1. Digital Elevation Model (DEM) Availability

4.4 Database Design

Data integration into a common database structure will prove to be one of the biggest tasks undertaken. Addressing issues as they pertain to level/layer use within the TSSDS will prove to be one the biggest undertaking involve in complying to the standard. Built for only one graphic feature per level/layer, compliance with the standard will prove to be tedious, time-consuming and costly. It is recommended that TSSDS data conversion be contracted to organizations with experience in this type of task of data conversion.

In August of 1995, the Tri-Service Center published release 1.4 of the Tri-Service Spatial Data Standards (TSSDS) and in November 1996 the release of 1.6 of the TSSDS. In August of 1997, Release 1.75 was distributed and Release 1.75 was distributed in April 1998. Release 1.8 of the TSSDS has been scheduled for publication and distribution in the fourth quarter of 1998 or early the first quarter of 1999.

By placing major groupings of phenomenon into Entity Sets, the TSSDS expands on the concept of geospatial phenomenon, which exists in the real world or is defined to exist in the real world. The Entity Set is then further broken down in a hierarchical format that includes Entity Classes. The concept of the Entity Class begins the spatial data definition and shows how this spatial data is stored for retrieval.

The Entity Type explains exactly what type of graphic feature is being referred to, such as a line, point, or area. The Entity is the actual graphic feature that is displayed on a map. An example of an Entity would be the graphic symbol representation of a picnic table on a recreational area map of a state park. The attribute tables, both graphic and non-graphic, refer directly or indirectly to the graphic feature, the Entity, displayed on the medium of choice, i.e., maps, either hard copy or electronic format. Attributes within the attribute tables are the actual data/information pertinent to the graphic feature. Examples of the various attributes would include the name of the state park, the state the park is located, the coordinates of the state park boundaries, etc. Attributes can further provide information about the individual graphic feature/entity by use of discriminators. Discriminators and their tables are called domain tables and domain values. The domain tables care classified as being either list or range domains. The domain values lend explicit detail to the graphic feature or entity. Examples of domain values would include the various types of construction material used during road construction, i.e., concrete, asphalt, gravel, etc. Appendix F provides an example of the Communications Entity Set as broken down into listing of Entities, Attributes and Domains. Appendix G provides a preliminary correlation matrix of the Divisional office data responsibilities to that TSSDS version 1.8 database model.

Evident from the Needs Assessment interviews is that the Mobile District utilizes geospatial data from numerous other agencies. Agreements must be made with the various agencies (i.e., USGS NOAA, SCS) that will contribute geospatial data to the District. The agreements must be reached with the data exchange agencies as per their expectations for value added data in return. Contributing agencies will require information in a form that will minimize the effort to refresh their respective databases. These agreements should strongly illustrate the priority of acceptance of the TSSDS. In the case of those agencies contributing a large proportion of data, specific standards may already be in place. District staff who will process data from sponsoring agencies must have knowledge of the physical structuring of the TSSDS. Staff must be familiar with methods to restore data for project needs, but also how to translate and compress information for distribution to other District offices. Synchronization of all internal and external data resources exchanges is imperative. Arrangements should be made to address these issues, and efficiently synchronize the data to fit and overlay properly.

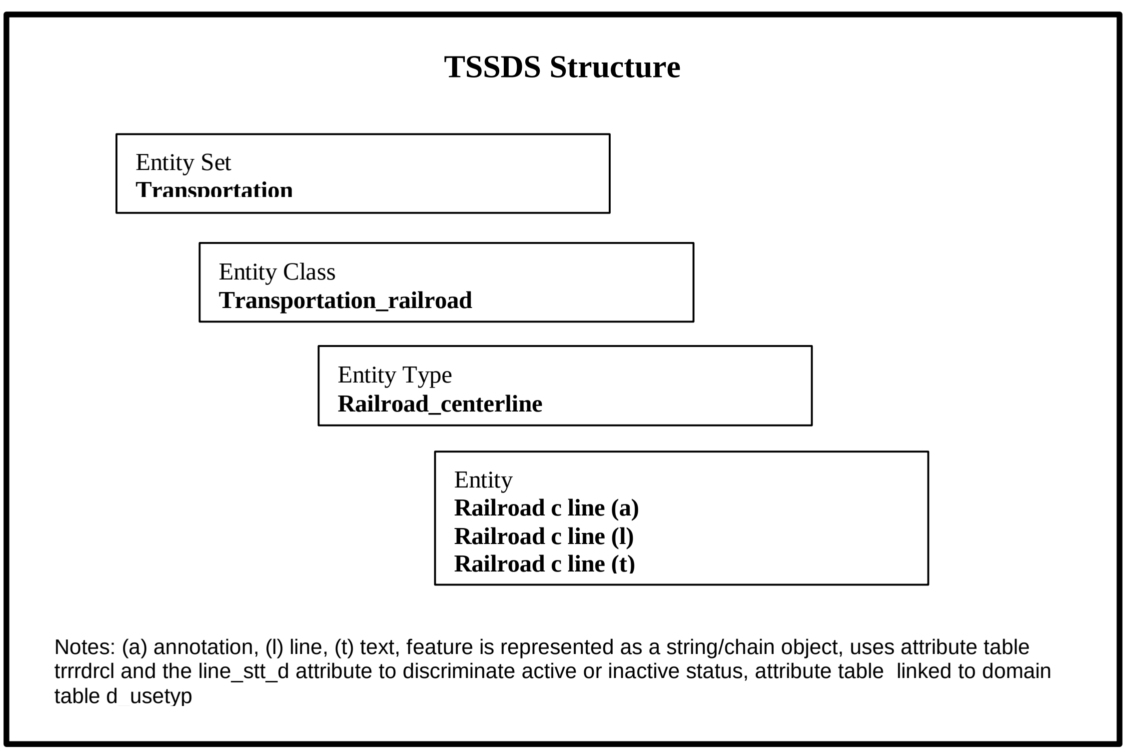

Figure 4.2. The TSSDS Scheme

4.5 Quality Assurance/Quality Control Plan

As is the case with any large-scale GIS analysis, a QA/QC of the project data are required before critical path processes are made. Often, a data set “right out of the box” may omit or incorrectly delineate a boundary. Protocol must be established to maintain the integrity of all data used in the Mobile projects. Through the course of visits to field offices involved with potential projects, it is found that data gaps do exist. A plan of action must be formulated to identify where, and if, additional data are needed. To fill data gaps in primary map layers. Queries to additional agencies or GIS data vendors must be made to compile a comprehensive database for the project area(s). Because data used to build a GIS can come from many sources. Ideally, the goal when constructing a GIS is to obtain all available data that bears weight on the project. Upon review of all these datasets, it may be apparent that data gathered from two or more source’s conflict. To resolve such a conflict, it is necessary to analyze the validity of the datasets in discord.

District personnel directly involved with the project site should agree on a data testing procedure. This is important for ensuring the District of quality GIS products, but also enables discussion on any perceived discrepancies that are unveiled in the process.

4.6 Establish data transfer protocol

Upon successful completion of GIS implementation for any given project, the server used to house the data should be resident at the project location, given, if possible. If project site location cannot house the data, then it should be delivered to the District office for placement on an appropriate server. Once on the server, access should be established through the Information Management Office. Accessibility to the data via server should be as easy as accessing a directory on the District LAN or WAN. This data is intended to be dynamic, that is, as new information is added in the course of sustaining or expanding the project, it should be updated on the resident server (or on the District server). All copies of the project dataset will be housed on a server within District Office. This will begin the evolution of the District GIS data repository.

Dependent of the size of data files transmitted along the WAN, several media options could prove sufficient for the data transfer. Data files of considerable size will need to be placed on ftp sites. It is recommended that as the GIS is brought on-board, 56K dedicated modem lines will not be sufficient for transferring large data files between offices within the Mobile District.

4.7 GIS Viewing

There are two very good, easy to use viewers that should serve as the interface for non-GIS personnel viewing. ESRI’s viewer, ArcExplorer, is an excellent (and free) product for viewing project data that resides in an ESRI format. GeoMedia is a viewing software application that has the ability to retrieve data from a variety of data warehouses (sources) simultaneously. The various data warehouses can be used to view existent data, create queries of this data, and provide the viewer analysis capabilities. This viewing software can be downloaded free from the Internet at this time. Arc/Info, ArcView, FRAMME, MGE, MGSM, MicroStation and ORACLE data can be interactively collaborated on the same display within GeoMedia. Eventually, as GIS is implemented for projects throughout the District in different formats, it will be necessary to download both ArcExplorer and GeoMedia Viewer for all non-GIS personnel. It is quite possible that with exposure to the software applications, non-GIS users will begin to establish certain GIS terminology and application procedures needed in the further development of the District-wide GIS.

4.8 Develop www-based site for public data display

Identify project GIS data that can be made available on the Internet. An economical and logical choice for distributing information to the public is through use o f the Work Wide Web (WWW). There is an important need to create a GIS web site for any or all projects. Many issues surrounding high profile projects can be identified as socially sensitive in many areas. A system where the public can obtain simple visual map displays, concise explanations of project objectives, and summary charts and tables would be very beneficial. Public comments and input could be sought through email linkages via the web site complete with forms to facilitate easier data management and record keeping. Use of a desktop GIS application is instrumental in creation of a project description web site. The Mobile District GIS Implementation web site will need to be created with the completion of this document. The GIS web site should then expand along with the project-based expansion of the GIS itself.

4.9 GIS Demonstration

"Show and Tell" is a great way to interest other personnel who could add valuable insight to taking the GIS to higher levels of support. Upon completion of a pilot project, the Mobile District will need to demonstrate the completed GIS project to an open forum of District Office personnel. An open forum discussion will bring to light additional questions that could be answered by the project GIS, as well as open the minds of others as to the possibilities a GIS could provide for their projects. This open forum will also bring to light the amount of funding and the number of personnel that were required for that particular project.

Appendix A
Glossary of GIS Terminology

Glossary of GIS Terminology

- **accuracy.** Conformity with a standard or correctness in measurement. Accuracy relates to the quality of a result and is distinguished from precision, which relates to the quality of the operation by which the result is obtained.
- **ADMATCH (address matching).** A computer program that can match street addresses with census tracts and/or block codes and that can convert street addresses to coordinates for computer mapping.
- **algorithm.** Statement of the steps to be followed in the solution of a problem.
- **arc.** A line established by connecting a set of points. It has length but no area and often serves as one side of a polygon. Arcs may begin and end with nodes and have points of inflection defined by vertices.
- **area.** (1) A polygon that encloses a homogeneous unit (e.g., lake, country, state, county). (2) A level of spatial measurement that references the size or extent of a two-dimensional defined space.
- **aspect.** Horizontal direction in which a slope faces. Commonly expressed in degrees clockwise from north (e.g., a southeast facing slope has an aspect of 135 degrees). Contrast with slope.
- **attribute.** A numeric and/or text description of a spatial entity (e.g., attributes of a parcel might include address, owner's name, and property value). Attribute data is typically stored in tabular format.
- **automated mapping/facilities management (AM/FM).** A system that integrates automated mapping with facilities management (e.g., management of power lines, utilities, and energy services). AM/FM provides digital or computer-based storage, management, retrieval, and display of urban data for cadastral mapping and utilities management.
- **azimuth.** The horizontal direction measured clockwise from north (e.g., due south has the azimuth 180 degrees).
- **base layer.** A layer containing a variety of features often used for locational reference (e.g., section corners, political boundaries, and other major features) or to establish geodetic control, which ensures geographic fidelity between data sets in the GIS.
- **base map.** Mapped data which seldom change and which are used repeatedly for locational reference and control. It also establishes the lowest common denominator for map scale, coordinate system, and projection for other maps in a GIS database. Contrast with thematic map.
- **benchmark.** A reference point for measurements, normally one that is used for elevation reference.
- **benchmark test.** A test to evaluate the capabilities of a computer system in terms of performance and ability to meet customer requirements.
- **Boolean operators.** Search strategy for information retrieval based on the use of the logical operators AND (union), OR (intersection), NOT (complement), and XOR (exclusion) to represent symbolic relationships.
- **browse.** System capability to search for an undefined feature or set of features in a database.
- **buffer.** An area of specified distance (radius) around a map item or items. See proximity analysis.
- **cadastral parcel.** The smallest legally defined piece of land. Used for recording ownership and related attributes.
- **cadastre.** A survey that creates, defines, retraces, or reestablishes the boundaries and subdivisions of public lands and private estates. The ownership, characteristics, and value of private lands are recorded for taxation purposes.
- **Cartesian coordinates.** A plane coordinate system in which the locations of points in space are expressed by reference to two or three planes, called the "coordinate planes" (x,y or x,y,z).
- **cartographic modeling.** The use of basic GIS manipulation functions or tools in a logical sequence to solve spatial problems.
- **cartography.** The science of map making, including the art and technology of map making.
- **centroid.** The mathematical or geographical center point of a polygon or the midpoint of a line. It is described as an x,y coordinate.
- **choropleth map.** A map with areas colored or shaded such that the darkness or lightness of an area symbol is proportional to the density of the mapped phenomena or is symbolic of the class.

- **classification.** Process of assigning individual observations or features into groups, categories, or classes.
- **clip.** The process of extracting a portion of a coverage or map from a larger coverage, much like a cookie cutter.
- **coincidence analysis.** Process of examining the co-occurrence of mapped phenomena.
- **computer aided design (CAD).** Software with the capability of performing standard engineering drawing and architecture design functions. It is graphically oriented rather than geographically based. Unlike a GIS, the database is generally not structured to allow spatial analysis. However, some data developed in CAD systems can be incorporated into a GIS.
- **computer aided mapping (CAM).** Software with the capability of performing standard mapping functions, typically using a vector format. Unlike a GIS, it cannot analyze or process the database.
- **conflation.** Procedure of reconciling the position of corresponding features in different themes so that the corresponding features overlay precisely.
- **connectivity analysis.** See network analysis.
- **contiguity analysis.** See neighborhood analysis.
- **contour.** An imaginary line on the ground, all points of which are at the same elevation, usually expressed as a length or elevation above some datum such as mean sea level.
- **control point.** A permanently fixed point on the ground, the location of which has been accurately determined and recorded for reference and future use.
- **coordinate.** Coordinates are used to represent location on the earth's surface relative to other locations in either 2 (x,y) or 3 (x,y,z) dimensions.
- **coordinate geometry (COGO).** The conversion of surveying data into geographic locations.
- **coordinate system.** A particular kind of reference frame or system, such as plane rectangular coordinates or spherical coordinates, which use linear or angular quantities to designate the relative position of points within that particular reference frame or system.
- **corridor analysis.** A type of proximity analysis that utilizes specified distances or buffers along a line (e.g., amount of timber within 50 feet of proposed power transmission line). See buffer.
- **cost-benefit analysis.** A comparison of the costs and benefits of the current system or processes versus a proposed GIS. A cost-benefit analysis is developed to assist with making an acquisition decision.
- **coverage.** The graphic and attribute data related to a particular data theme for a study area. A coverage usually represents a single layer or theme.
- **cross tabulation.** Comparison of attribute data by location in two or more map layers. Results are given in a tabular report format.
- **data (singular datum).** Facts about real-world entities, organized for analysis. Includes results of observations or measurements of such entities. Three components of a datum are of direct relevance to GIS: (1) attribute information that describes the substance, characteristics, variables, values, and similar qualities of the entity; (2) geographical information that describes the position of the entity in space relative to other things in space; and (3) temporal information that describes the instant or period of time during which the entity is at a defined location or in an observed state or condition (attribute).
- **data capture.** Operations that are required to encode data in a computer readable digital form (e.g., digitizing, scanning). See also data input.
- **data conversion.** The translation of data from one storage format or media to another for the purpose of transferring it from one GIS to another. It is also the process of transforming maps from manual to digital form.
- **data dictionary.** A directory of all data items, giving the name and structure of each. It does not contain the actual data. The contents of a data dictionary are sometimes called metadata.
- **data encoding.** To apply a code to represent individual data or groups of data.
- **data input (data capture).** Series of operations required to enter map or attribute data into a computer. Geographic data are generally entered into a GIS database via a digitizer, scanner, or keyboard.
- **data model.** The conceptual organization of a database. It can be thought of as the style of structuring, describing, and manipulating the data in a database.
- **data quality.** The degree of excellence exhibited by the data in relation to a correct portrayal of the actual phenomena.

- **data standardization.** The process of achieving agreement on common data definitions, representation, and structures to which all data layers and items must conform.
- **database.** A logical collection of files managed as a unit. A GIS database includes data about both the position and the attributes of geographic features.
- **database management system (DBMS).** A systematic approach to maintaining, accessing, reporting, and analyzing attribute data. GIS packages may use DBMS to handle some data management tasks.
- **database structure.** The physical organization of data elements assigned to files and relationships among files.
- **datum.** A base or reference elevation used as the origin to define subsequent elevation. Often refers to mean sea level.
- **delineation.** The legal description of the locations of points that mark the boundaries of a cadastral parcel.
- **demarcation.** The field measurements (e.g., land survey) that determine the physical locations of boundary markers of cadastral parcels.
- **derived map.** A map created as the result of analyzing, altering, or combining a pre-existing map or a series of maps in the GIS.
- **digital data.** Collection of similar and related data records that are converted into a form for use by a computer.
- **digital elevation model (DEM).** A data file of a topographic surface arranged as a set of x,y,z coordinates where z represents surface elevation. It is the digital equivalent of the elevation data portrayed on a topographic base map.
- **digital exchange format (DXF).** A standard format for exchanging digital cartographic (map) files and associated spatial data between different GIS systems.
- **digital line graph (DLG).** A file or data structure from the US Geological Survey (USGS) that includes digital non-topographic information from the USGS map base categories such as transportation, hydrology, and public land survey boundaries.
- **digital terrain model (DTM).** See digital elevation model.
- **digitize.** A process used to create digital data from non-digital or analog data. See data conversion.
- **digitizer.** A device consisting of a table and a cursor (often with crosshairs and keys) that is used for capturing and recording the locations of map features as x,y Cartesian coordinates.
- **dissolve.** The process of removing boundaries between adjacent polygons having the same values for a specified attribute.
- **distance analysis.** Geographic computations based on Euclidean and/or non-Euclidean distances between features.
- **drum plotter.** A device with a rotating cylindrical drawing surface and paper reels for plotting graphic images on a continuous roll of paper.
- **easting.** One of two geographic coordinate values (the other being northing) used to specify the exact location of a feature on a map. Eastings and northings are specified as x,y coordinates respectively for universal transverse mercator and state plane coordinate systems.
- **edge matching.** The comparison and graphic adjustment of features that cross adjoining map sheets to ensure that the features intersect the boundary at a common, coincident location. A "seamless" database is thereby created.
- **electrostatic printer** . A "Xerox-like" device for printing graphic images by placing small electrical charges on the paper so that a dark or colored powder, or toner, will adhere in these spots.
- **encode.** Convert data to a form that is suitable for entry into a computer.
- **entity.** Object or feature about which information is stored. The information describes where the entity is (location — stored as points, lines, or polygons) and what the entity is (identity — e.g., lake, tree, house). An entity is usually a person, place, thing, or event. It may be tangible or intangible and can be further defined by attribute data.
- **export.** Process of transferring data or software from one GIS system to another.
- **feature.** A geographic component of the earth's surface that has both spatial and attribute data associated with it (e.g., well, road, lake).

- **feature oriented.** The use of points, lines, and polygons to represent real world entities in a GIS database.
- **field.** See item.
- **file.** A collection of related records treated as a unit.
- **flatbed plotter.** A device with a flat drawing surface for pen-plotting a graphic image from a list of point coordinates and pen codes.
- **gap.** The distance between two entities (usually lines) on a digitized map. Gaps may indicate errors made while digitizing or scanning a map. See sliver.
- **generalize.** A reduction of detail through resampling to larger spacing or a reduction in the number of points or vertices in a line.
- **geocode.** The process of creating an x,y coordinate location from another geographic location description, such as an address. The term evolved from geographic coding.
- **geodesy (also geodetic, of or pertaining to geodesy).** Science of the size and shape of the earth.
- **geographic coordinates.** Values specifying the location of features in a standard, absolute worldwide coordinate system (e.g., latitude/longitude, state plane coordinates, universal transverse mercator).
- **geographic data.** Data that convey the locations and descriptions of geographic features.
- **geographic information system (GIS).** System of computer hardware, software, and procedures designed to support the compiling, storing, retrieving, analyzing, and display of spatially referenced data for addressing planning and management problems. In addition to these technical components, a complete GIS must also include a focus on people, organizations, and standards.
- **geometric correction.** Alters data to correspond with true ground or image space in a known coordinate system.
- **geoprocessing.** The automated manipulation and/or analysis of geographic data.
- **georeferencing.** A process of referencing points on the surface of the earth to points on a map. Examples of referencing systems include latitude/longitude, universal transverse mercator, and state plane coordinates.
- **global positioning system (GPS).** A system that uses NAVSTAR satellites to locate positions on the earth's surface. Sometimes referred to as global positioning satellites.
- **grid.** A data structure that uses rectangular units or grid cells arranged in rows and columns to represent map features. Also known as a raster.
- **ground control point.** See control point and tics.
- **ground truth.** To verify the correctness of remote sensing information by use of ancillary information such as field studies.
- **hard copy.** An analog image of a map or diagram (e.g., a paper map produced by a printer or plotter) generated from a digital data set.
- **hierarchical database.** A method of structuring data or other information so that the units of data storage are connected by a hierarchically defined pathway.
- **horizontal control.** A network of stations of known geographic or grid positions referenced to a common horizontal datum, which controls the horizontal positions of mapped features with respect to parallels and meridians or northing and easting grid lines shown on the map.
- **image processing.** Computerized routines for information extraction (e.g., pattern recognition, classification) from remotely sensed images to obtain categories of information about specific features.
- **import.** Process of bringing data or software from one system into another.
- **infrastructure.** Human-made systems that provide any or all of the normal public services to an urban area (e.g., water supply, sewage, utilities, traffic control).
- **ink jet plotter.** A plotter that creates images by projecting a jet of ink onto the paper.
- **input.** (1) Data that have been entered into a computer system. (2) To enter data into a computer.
- **interpolation.** The process of estimating the value of an unsampled data point for a given x,y,z location based on the values of surrounding sampled data points.
- **intersection.** The coexistence of points at a specific geographic location; the set of all objects common to two or more intersecting sets.

- **intervisibility functions.** Planning tool used for siting features in a landscape through application of digital elevation data. It shows what can be "seen" from specified target locations. It can map the area visible from a scenic lookout or the area that can be detected by a radar antenna. It can show how a road or cleared land can be effectively hidden from view. Sometimes referred to as viewshed modeling or viewshed mapping.
- **island.** A polygon lying completely within another and not sharing a common boundary (e.g., an island in a lake).
- **isoline map.** See isopleth map.
- **isopleth map.** A map displaying the distribution of an attribute in terms of lines connecting points of equal value (e.g., a contour map).
- **item.** A single attribute descriptor or characteristic of a feature (e.g., an address for a house in an attribute table that contains information about houses in a community). Commonly displayed as a column in an attribute table. Contrast with record.
- **kriging.** An interpolation technique for obtaining statistically unbiased estimates of surface elevations from a set of control points. Pronounced creeging.
- **label.** A unique name or other nominal code assigned to identify the geographic representation of a map feature. It is distinguished from attribute data by serving as the unique identifier for geographic features (e.g., label: Jones Lake; attributes: area, depth, water quality).
- **labeling.** The process of assigning unique labels to polygons.
- **land information system (LIS).** A special type of GIS that manages and analyzes data related to land ownership (e.g., tax parcels, urban infrastructure, property assessment). A GIS used for municipal or county level applications is typically structured as an LIS. Data stored in an LIS are commonly recorded very accurately on a large-scale map (e.g., at scales of 1:1,000 to 1:10,000).
- **land record.** A document stored in a public file that contains the definitive statement of some characteristic of a piece of land that is a matter of public interest.
- **LANDSAT.** The generic name for a series of natural resource scanning satellites launched by the United States beginning in 1972.
- **large scale.** A map scale that covers a relatively small area on the ground and has a high level of detail. A small area of the earth's surface on one page is a large-scale map (i.e., a 1:500 map where 1 map unit equals 500 ground units is large scale compared with a 1:1,000,000 map). Contrast with small scale.
- **latitude.** A system of referencing relative north-south locations on the earth's surface. It is measured in degrees, minutes, and seconds north or south of the equator to the poles.
- **layer.** A logical separation of mapped information representing a theme (e.g., roads, soils, vegetative cover). Layers are registered to each other by control points and the common coordinate system of the database.
- **line.** A set of ordered coordinates that represent the shape of a linear geographic feature. It has a length and direction but no area. Examples include streams, roads, and telecommunication lines.
- **lineage.** Information about the source of data, its origin, accuracy, and scale that is normally kept in the data dictionary.
- **longitude.** A system of referencing relative east-west locations on the earth's surface. It is measured in degrees, minutes, and seconds east or west of the "Prime Meridian" which runs through Greenwich, England.
- **macro.** A set of instructions written in a high-level programming language that manipulate the commands in a GIS to perform specific predefined tasks or processes. Macros typically provide enhanced user access both to limited portions of an extensive GIS database as well as to certain GIS analysis tools or procedures. Sometimes called "shells." .
- **map.** A two-dimensional abstract graphic representation of the earth's surface that displays spatial relationships among features, generalizes their appearance to simplify them for the purpose of communication, and applies symbols to aid in interpretation.
- **map algebra.** Process of adding, subtracting, multiplying, and dividing maps by applying mathematical operations to map themes. Map algebra utilities allow the user to specify mathematical relationships between map layers. For example, a new map can be generated by determining the difference in elevation between a topographic map and the corresponding map of the water table.

- **map analysis.** See spatial analysis.
- **map extent.** The rectangular limits (xmin, ymin, xmax, ymax) that include all the features displayed on a graphics display terminal or on a plotted map.
- **map generalization.** The process of reducing detail on a map.
- **map projection.** See projection.
- **map theme.** See theme.
- **merge.** To take two or more maps or data sets and combine them together into a single, coherent map or database without redundant information.
- **metadata.** See data dictionary.
- **model.** A set of rules and procedures that represent a view of reality for conducting spatial analysis to generate a result.
- **monument.** A ground surveyed point of known x,y,z coordinates that is assumed to be correct for general mapping purposes.
- **mosaic.** Process of assembling GIS database files for adjacent areas into a single file.
- **NAD 27.** Datum used as the base level for topographic information, as established by the North American Datum, 1927.
- **NAD 83.** Datum used as the base level for topographic information, as established by the North American Datum, 1983.
- **National Center for Geographic Information and Analysis (NCGIA).** A center funded by the National Science Foundation that is jointly headquartered at the University of California, Santa Barbara, the University of Maine, Orono, and the State University of New York at Buffalo. The Center encourages the development of quality GIS education programs in universities in the United States and worldwide. It developed a core curriculum; a set of teaching materials for a three-course sequence in GIS. It also sponsors workshops, seminars, and meetings and produces technical publications related to GIS.
- **neatline.** A border line commonly drawn around the extent of a plotted map.
- **needs analysis** . See user requirements analysis.
- **neighborhood analysis.** Analytical technique to determine whether a set of areas (polygons) are situated next to each other and to examine their interrelationships.
- **network analysis.** Technique used to conduct analyses on a set of points (nodes) and lines that are connected to each other.
- **node.** A point at which two or more arcs or lines meet. Also the distinct point in a feature where lines begin and end. They are required in vector GIS to define topology.
- **northing.** See easting.
- **object.** A single, identifiable unit or entity. An object can comprise other, smaller objects.
- **object oriented.** The intrinsic representation and storage of real world entities in a GIS database rather than the use of cells, points, lines, or polygons to store the object.
- **orthophotograph.** An aerial photograph that has the distortion due to tilt, curvature, and ground relief corrected.
- **orthophoto quad.** A photomap made from an assembly of orthophotographs.
- **output.** Anything that comes out of a computer to any other device. With a GIS, output may come in the form of a printed map, screen displays, a tabular data summary, or a data file.
- **overlay analysis.** The process of combining spatial information from two or more maps from the same geographic area to derive a map consisting of new spatial boundaries and entities or themes.
- **pan.** To widen the view perspective in a graphic display (i.e., "zoom out").
- **parcel.** See cadastral parcel.
- **pen plotter.** A plotter that uses pens as drawing elements.
- **pixel.** Short for "picture element." The smallest discrete element which makes up a raster image. Refers also to individual grid cells in a raster.
- **planimetric data.** Spatial data that do not take topographic relief information into account for establishing position.

- **planimetric map.** A map that represents only the horizontal positions of features. It is typically used as part of a base map.
- **plat.** A diagram drawn to scale showing all essential data pertaining to the boundaries and subdivisions of a tract of land. It is often a legal document.
- **point.** A single x,y coordinate that represents a geographic feature that is too small to be displayed as a line or a polygon at a particular scale. Map examples include wells, weather stations, and navigational lights.
- **polygon.** A two-dimensional figure with three or more sides intersecting at a like number of points. It is defined or bounded by a closed line or arc and has attributes that describe its geographic features.
- **precision.** (1) The degree of discrimination with which a quantity is stated. For example, a three-digit number discriminates among 1,000 possibilities. (2) Statistical measure of repeatability, usually expressed as variance or standard deviation of repeated measurements about the mean.
- **preprocessing.** Preliminary processing or transformation of raw data required to facilitate further cartographic processing.
- **projection (map projection).** A mathematical model that transforms the locations of features on the earth's surface to locations on a two-dimensional map surface. Some map projections minimize distortion of the feature's shape; others minimize distortion of area, distance, or direction.
- **projection conversion.** The mathematical transformation of a map from one projection system to another. It is most often used to standardize projections when maps from two or more projection systems are integrated into a GIS.
- **proximity analysis.** Analytical technique used to determine the relationship between a selected point and its neighbors.
- **proximity search.** Analytical procedure to identify occurrences of predefined data elements in the neighborhood of a selected point or feature.
- **quadrangle maps (quads).** A rectangular, or nearly rectangular, area covered by a map. The outline is generally defined by latitude and longitude.
- **quadtree.** A hierarchical data model that provides a compact raster representation by using a variable-sized grid cell. Finer subdivisions are used in areas requiring finer detail, providing a higher level of resolution. As the map theme becomes more variable or complex, a quadtree structure is not as efficient as some other data models.
- **query language.** A high-level programming language, using words that closely resemble ordinary language, that provides for the easy retrieval of information.
- **raster data.** Cell data arranged in a regular grid pattern in which each unit (pixel or cell) in the grid is assigned an identifying value based on its characteristics.
- **raster/vector conversion.** To convert data from raster format to vector format with position and orientation selected by the user. Also known as a raster-to-vector conversion, or vectorization.
- **rasterization.** See "vector/raster conversion." .
- **reclassify.** Procedure to change the classification of existing data.
- **record.** A group of logically related attribute descriptors for one feature (e.g., a house in an attribute table that contains information about houses in a community). It is commonly displayed as a row in a relational attribute table. Contrast with item.
- **rectification.** The process of removing the effects of tilt, relief, or other nonsystematic distortions from imagery, photographs, or maps.
- **registration.** Process of registering different themes to a common coordinate system or to one theme that is used as a standard so that themes can be consistently overlaid.
- **relational database.** A method of structuring data in the form of records so that relations between different entities and attributes can be used for data access and transformation.
- **relational join.** The operation of relating and physically merging two attribute tables using a common or relational item.
- **relational operators.** Phrases such as "greater than," "less than," "maximum," "minimum," and "contains" that are used to compare values associated with spatial data.

- **remote sensing.** The act of detection and/or identification of an object, series of objects, or landscape without having the sensor in direct contact with the object. Often results in the generation of image data. See also image processing.
- **resampling.** A process of assigning values to new, rectified, or rescaled (re-sized) cells in a raster database.
- **resolution.** The minimum distance between two objects that can be distinguished by a sensor. While most often it is a synonym for spatial resolution, it also applies to spectral and temporal aspects of remote sensing imaging systems.
- **routing analysis.** A type of network analysis that is used to optimize vehicle routing (e.g., routing of emergency services, school buses, mail delivery, municipal garbage collection).
- **rubber sheeting.** A procedure to stretch or shrink a subarea or portion of a map or image to fit or come into registration. This process is sometimes called warping. The warp is completed using control points.
- **scale.** The ratio or fraction between the size of an object on a map and its size in the real world. A scale represented as 1:15,840 means that one unit of distance on the map represents 15,840 of the same units of distance on the earth.
- **scale bar.** A map component that graphically depicts the map scale.
- **scanning.** Process of using an electronic input device (a scanner) to convert analog information from maps, photographs, or overlays into a digital format usable by a computer.
- **scroll.** To adjust the display window so that the user can view seamless windows across a display.
- .**sliver.** A gap or overlap that is generated by combining two or more coverages that are not coincident or perfectly conflated.
- **slope.** The rate of rise or fall of a quantity against horizontal distance. It may be expressed as a ratio, decimal, fraction, percentage, or the tangent of the angle of inclination. Contrast with aspect.
- **small scale.** A map scale that covers a relatively large area and has generalized labels. A large area of the earth's surface on one page is a small-scale map (i.e., a 1:1,000,000 map where 1 map unit equals 1,000,000 ground units is small scale compared with a 1:500 map). Contrast with large scale.
- **smoothing.** The reduction of the local variability of data and, when applied to a spatially distributed variable, results in a reduction of local variance. Smoothing, applied to a line, results in a reduction in the sharpness of angles between line segments.
- **snap.** The automatic intersecting of disjoint lines or nodes that arise when map data are being digitized or scanned.
- **soft copy.** A temporary image of a map or diagram on the screen of a computer display.
- **spaghetti digitizing.** Refers to the digitizing of map features without any initial regard to the sequence or identification of line/point intersections.
- **spatial.** Refers to phenomena distributed in space and therefore having physical dimensions and geography.
- **spatial analysis.** Analytical techniques associated with the study of the location of geographical entities together with their spatial dimensions.
- **spatial data.** Data pertaining to the location, shape, and relationships among geographical features. These can be classified and stored as point, line, area, polygon, grid cell, or object.
- **spatial data transfer standard (SDTS).** Federal information processing standard in the United States for exchanging digital cartographic files and associated spatial and attribute data between GIS systems. The purpose of the standard is to ensure that no data will be lost during transfer, that the fidelity of the data and data relationships will be preserved.
- **spatial database.** A collection of spatial information related by common facts or themes.
- **spatial decision support system (SDSS).** A customized computer-based information system that utilizes decision rules and models and incorporates spatial data.
- **spatial resolution.** A measure of the ability of an imaging system, such as LANDSAT, to separate the images of closely adjacent objects. It is also the smallest area identified as a separate mapping unit.
- **SPOT.** The generic name for a series of natural resource scanning satellites launched by France.
- **standards.** See data standardization.

- **state plane coordinates.** A system of x,y geographic coordinates defined individually for each state. Locations are based on the distance from a unique origin for each state or portion of a state.
- **stereo pair.** Two photographs having sufficient perspective overlap to record parallax of detail to make possible stereoscopic examination of an object or an area common to both photographs. A three-dimensional perspective is provided.
- **stereoplotter.** A machine which, when loaded with a pair of overlapping aerial photographs, can be used to determine precise location and altitudes of objects that appear in the photographs.
- **tabular data.** Data (usually attribute) organized into logical tables. Tables contain items and records or rows and columns.
- **terrain analysis.** Analytical techniques that quantify terrain parameters (slope, aspect) or the effect of terrain on a particular operation.
- **tesselation.** The process of splitting an area into small, manageable units or subareas. Subareas may consist of tiles or rasters.
- **thematic map.** A map related to a topic, theme, or subject of discourse. Also called topical, geographic, special purpose, distribution, parametric, or planimetric maps. Thematic maps emphasize a single topic such as vegetation, geology, or land ownership. Contrast with base map.
- **theme.** The overall topic of a map layer in which the spatial variation of a single phenomenon is illustrated (e.g., a vegetation theme map might illustrate vegetative areas such as hardwoods, conifers, and sage brush).
- **thinning.** A process whereby a line is generalized through a series of rules that reduce the number of data points while maintaining the basic shape of the feature. See generalize.
- **tics.** Geographic control points representing known or identifiable locations on the earth's surface (e.g., longitude, latitude). Also called ground control points.
- **TIGER (topologically integrated geographic encoding and referencing file).** The nationwide digital database of planimetric base map features developed by the U.S. Bureau of the Census for the 1990 Census. TIGER files contain street address ranges along lines and census tract and block boundaries.
- **tile.** A spatial unit by which data are organized, subdivided, and stored. A tile can be a regular, geometric shape (e.g., corresponding to USGS quadrangle map sheets) or an irregular area, such as state boundaries or watersheds. It is used to subdivide large areas into small, manageable units or subareas.
- **tool.** A computer program provided within a GIS to allow the user to perform a specific set of operations on map and attribute data. Examples of spatial analysis tools include overlay, window, proximity and network analysis, and map algebra.
- **topography.** The shape of the surface of the earth in a given area.
- **topology.** The spatial relationships between connecting or adjacent coverage features (e.g., points, lines, and polygons). It provides a way in which geographic features are linked together.
- **topological relationships.** How data elements relate to each other within the database. Changing one element affects other elements.
- **topological structuring.** Organizing data topologically so that the relationships and reference linkages are specified.
- **transform.** The process of changing the scale, projection, or orientation of a mapped image. Sometimes refers to the conversion of data from one GIS system to another.
- **triangulated irregular network (TIN).** A data structure that describes a three-dimensional surface as a series of irregularly shaped triangles. Often used in connection with terrain modeling where terrain characteristics are determined from sets of irregularly distributed points.
- **universal transverse mercator (UTM) grid.** A system of plane coordinates based upon 60 north-south trending zones, each 6 degrees of longitude wide, that circle the globe. Used to derive geographic coordinates, normally in meters, east and north of an origin that are defined uniquely for each zone.
- **user interface.** Method by which the human operator communicates with the various database, system, and applications modules.

- **user requirements analysis.** A strategic planning approach for implementing a GIS. Provides a comprehensive assessment of the analytical capabilities and products required by potential system users. Sometimes called needs analysis.
- **vector data.** Data comprised of x-y coordinate representations of locations on the earth that take the form of single points, strings of points (lines or arcs), or closed lines (polygons).
- **vector/raster conversion.** To convert data from vector or point formats to raster format with grid cell size, position, and orientation selected by the user. It is also known as a vector-to-raster conversion, or rasterization.
- **vectorization.** See raster/vector conversion.
- **vertex (plural vertices).** Intermediate points along a line curve, or arc. They represent the critical points of inflection along the arcs, thereby reflecting its shape.
- **viewshed modeling.** See intervisibility functions.
- **warping.** See rubber sheeting.
- **weighting.** Process of systematically increasing the value of a particular data element or elements so as to give that element more significance in the analysis or calculations.
- **window.** A user-defined area that is used to view a subset of the original map.
- **workstation.** A computer that consists of a graphic terminal, central processor, digitizer, graphics tablet (optional), and a mouse (optional). It may also be a stand-alone central processing unit (CPU) and its peripheral devices. It is often linked to other computers through a network.
- **z coordinate.** The attribute coordinate in a data triplet is often used for representing height or elevation in a three-dimensional x,y,z coordinate system.
- **zoom.** Used in phrases "zoom in," meaning to enlarge the scale of a display to see more detail, and "zoom out," meaning to decrease the scale to see a more overall view. See pan and scroll.

Glossary of Computer Network Terminology

- **Attachment Unit Interface (AUI).** Also called thicknet. The AUI is a transceiver cable that provides a path between a node's Ethernet interface and the Media Access Unit (MAU).
- **Bandwidth.** The difference between the highest and lowest frequencies of a transmission channel. A measure of the information capacity of the transmission channel. Bandwidth is often expressed in hertz (cycle per second).
- **BNC connector.** Acronym stands for British Naval Connector. A standard connector from a thin coaxial cable to a transceiver.
- **Bridge.** A device that interconnects local or remote networks across all higher level protocols. Bridges form a single logical network, centralizing network administration. Bridges operate at the physical and link layers of the Open Systems Interconnect (OSI) reference model.
- **Cabling.** The medium by which nodes on a LAN are connected.
- **CAD/CAM.** Computer Aided Design/Computer Aided Manufacturing.
- **Client / Server.** A common form of distributed system in which software is split between server tasks and user or client tasks. A client sends requests to a server asking for information or action, and the server responds. There may be either one centralized server or several distributed ones.
- **Coaxial cable.** A type of electrical cable in which a solid piece of metal wire is surrounded by insulation, which in turn is surrounded by a metal tube. Coaxial cables have wide bandwidths and can carry many data, voice and video signals simultaneously.
- **Collapsed Backbone.** Network architecture under which the backplane of a device such as a hub performs the function of a network backbone; the backplane routes traffic between desktop nodes and between other hubs serving multiple LANs.
- **Ethernet.** IEEE-standard data link protocol that specifies how data is placed on and retrieved from a common transmission medium. Data is broken into packets, which are then transmitted using the Carrier Sense Multiple Access / Collision Detect (CSMA/CD) algorithm until they arrive at the destination without colliding with any other. A node is either transmitting or receiving at any instant. Bandwidth ~10Mbit/s. Disk-Ethernet-Disk transfer rate with TCP/IP is typically 30 kilobyte per

second. The cable is a 50 ohm coaxial cable with multiple shielding. Forms the underlying transport vehicle used by several upper-level protocols, including TCP/IP and XNS.

- **Fiber Distributed Data Interface (FDDI).** A 100 Mbit/s standard LAN architecture. The underlying medium is fiber-optic cable (though it can be copper cable, in which case it may be called CDDI) and the topology is a dual-attached, counter-rotating token ring. FDDI rings are normally constructed in the form of a "dual ring of trees". A small number of devices, typically infrastructure devices such as routers and concentrators rather than host computers, are connected to both rings. Host computers are then connected as single-attached devices to the routers or concentrators. The whole dual ring is typically contained within a computer room.
- **Fiber optic cable.** A transmission medium that uses glass or plastic fibers, rather than copper wire, to transport data or voice signals. The signal is imposed on the fibers via pulses (modulation) of light from a laser or a light-emitting diode (LED). Because of its high bandwidth and lack of susceptibility to interference, fiber-optic cable is used in long-haul or noisy applications.
- **Gateway.** Device that can interconnect networks with different, incompatible communications protocols. The gateway performs a layer-7 protocol-conversion to translate one set of protocols to another. A gateway operates at Open Systems Interconnection (OSI) layers up through the Session Layer.
- **Hub.** A device connected to several other devices, also called a repeater. Strictly, it is a non-retiming device.
- **Local Area Network (LAN).** A data communications network which is geographically limited allowing easy interconnection of workstations and servers within adjacent buildings. Ethernet and FDDI are examples of standard LANs. Because the network is known to cover only a small area, optimizations can be made in the network signal protocols that permit data rates up to 100Mb/s.
- **Metropolitan Area Network (MAN).** A data network intended to serve an area the size of a large city.
- **Network Interface Card (NIC).** Also called an adapter card. A board installed in a computer to provide a physical connection to and from that computer system.
- **Network Operating System (NOS).** The software that controls the operation of the network. A NOS enables users to communicate and to share files and peripherals. It provides the user interface to the LAN and communicates with the LAN hardware or network interface card (NIC).
- **Open Systems Interconnection (OSI).** OSI is the umbrella name for a series of non-proprietary protocols and specifications. The OSI architecture is split between seven layers, from lowest to highest: .

  1.Physical layer: this layer determines how signals are transmitted on the network cabling.
  2.Data Link: incorporates the logical link (LLC) and media access control (MAC) sublayers. The data link layer transmits data grouped into frames using the Ethernet or Token ring access methods.
  3.Network layer: handles the routing of data in packets using the networking protocols.
  4.Transport layer: ensures error free data transmissions.
  5.Session layer: establishes and maintains connections between nodes according to the appropriate protocol.
  6.Presentation layer: handles data encoding and formatting; provides data compression.
  7.Application layer: provides the means for application processes to use the network services; the interface to user database, file and email software often implemented with API's (application programming interfaces).
  Each layer uses the layer immediately below it and provides a service to the layer above.
- **Protocol.** A set of formal rules describing how to transmit data, especially across a network. Low level protocols define the electrical and physical standards to be observed, bit- and byte-ordering and the transmission and error detection and correction of the bit stream. High level protocols deal with the data formatting, including the syntax of messages, the terminal to computer dialogue, character sets, sequencing of messages etc.
- **Redundant Array of Independent (/Inexpensive) Disks (RAID).** A technology using a software or hardware controller with several disk drives to allow varying degrees of either increased performance or data integrity. Levels of redundancy or data security are dependent on the number of drives in the

array, as well as the way the data is stored across the drives. These "RAID levels" go from Level 0 with no redundancy to Level 5 with maximum data security.

- **Repeater.** A device which propagates electrical signals from one cable to another. Less intelligent than a bridge, gateway or router.
- **Router.** A device that forwards packets between networks. The forwarding decision is based on network layer information and routing tables, often constructed by routing protocols.
- **Server.** A computer which provides service for other computers connected to it via a network. The most common example is a file server which has a local disk and services requests from remote clients to read and write files on that disk using the Network File System (NFS) protocol or network operating system software.
- **Shielded Twisted Pair (STP).** Common transmission medium which consists of a Receive (RX) and a Transmit (TX) wire twisted together to reduce crosstalk. The twisted pair is shielded by a braided outer sheath.
- **Thinnet.** 10BASE2 standard cable. Also called cheapernet in reference to this less expensive, thinner version of traditional Ethernet cable.
- **Token Ring (TR).** A communications method that uses a token to control access to the LAN. The difference between a token bus and a token ring is that a token ring LAN does not use a master controller to control the token. Instead, each computer knows the address of the computer that should receive the token next. When a computer with the token has nothing to transmit, it passes the token to the next computer in line.
- **Topology.** A network topology shows the hosts and the links between them. A network layer must stay abreast of the current network topology to be able to route packets to their final destination.
- **Unshielded Twisted Pair (UTP).** Normal telephone wire (in the U.S.). It may be used for computer to computer communications. It is much less expensive than standard Ethernet cable.
- **Wide Area Network (WAN).** Public or private computer network serving a wide geographic area.
- **Workstation.** A general-purpose computer designed to be used by one person at a time.

Appendix B
Mapping Guide

Installation Map Schema

Common Installation Geospatial Data

Collection and analysis of geospatial data are vital to the management of the installation. This effort must focus on ensuring data are available to meet the requirements of installation commander's and their subordinate units. Most of the geospatial data maintained by an installation will eventually be represented in a graphic format e.g., plan graphics, digital image, or a map. In general, an installation maintains maps that depict the following, or similar, geospatial information:

A-Natural and Cultural Resources

A-1 Areas of Critical Concern

- Historic Preservation and Archeology
- Threatened and Endangered Species
- Wetlands & Floodplains
- State Coastal Zones
- Lakes, Rivers, Streams, and Water Bodies
- Soil Borings & Soil Types

A-2 Management Areas

- Geology, including Surface Features
- Topography & Physiology
- Hydrology
- Vegetation Types
- Forest (Commercial Timber)
- Agriculture Grazing/Crops
- Fish and Wildlife
- Prime & Unique Soils
- Grounds Categories
- Climate & Weather
- Bird Aircraft Strike Hazard (BASH)
- Outdoor Recreation
- Pest Management

B-Environmental Quality

B-1 Environmental Regulatory

- Hazardous Waste Generation Points
- Permitted Hazardous Facilities
- Solid Waste Generation Points
- Solid Waste Disposal Locations
- Fuel Storage Tanks
- Installation Restoration Program (IRP)

B-2 Environmental Emissions

- Air Emission

- Waste Water NPDES Discharge

- Storm Water NPDES Discharge

- Drinking Water Supply Sources

- Electromagnetic and Radiation Sources

- Radon Sources

C-Layout and Vicinity Maps

C-1 Installation Layout

C-2 Off-base Sites

C-3 Regional Location

C-4 Vicinity Location

C-5 Aerial Photographs

C-6 Installation Boundary

D-Land Use

D-1 Existing Land Use

D-1.1 Future Land Use

D-2 Off-base Sites Land Use

D-2.1 Off-base Sites Future Land Use

D-3 Real Estate

D 4 Explosive Safety Quantity-Distance (QD) Arc

D-5 Hazard Analysis Constraints

D-6 Composite Installation Constraints and Opportunities

D-7 Area Development

E-Airfield Operations

E-1 On base Obstruction to Airfield and Airspace Criteria

E-2 Approach and Departure - Zone Obstructions to 10,000 Ft

E-3 Approach and Departure Zone Obstructions Beyond 10,000 Ft

E-4 Airspace Obstruction - Vicinity

E-5 Terminal Enroute Procedures (TERPS) Automation Plan

E-6 Airfield and Airspace Clearances

- Waivers

- Clear Zones

- Primary Surfaces

- Transitional Surface (7:1)

- Approach &Departure Surface (50:1)

- Approach and Taxiway Clearances

E-7 Airfield Pavement Plan

E-8 Airfield Pavement Details

E-9 Aircraft Parking Plan

E-9.1 Proposed Aircraft Parking Plan

E-10 Airfield Lighting Systems

F- Reserved

F-1 Reserved

F-2 Reserved

G-Utilities System Plan

G-1 Water Supply System

G-2 Sanitary Sewerage System

G-3 Storm Drainage System

G-4 Electrical Distribution System (Street & Airfield)

G-5 Central Heating and Cooling System

G-6 Natural Gas Distribution System

G-7 Liquid Fuel System

G-8 Cathodic Protection System

G-9 Cathodic Protection System Details

G-10 Industrial Waste and Drain System

G-11 Composite Utility System Constraints

G-11.1 Central Aircraft Support System

G-12 Other Utility Systems

H-Communication and NAVAID Systems

H-1 Installation Communication (Base and civilian communications units)

H-2 NAVAIDs and Weather Facilities

I-Transportation System

I-1 Community Network Access to Base

I-2 On-base Network

I-2.1 Future Transportation Plan

J-Energy Plan

K-Architectural Compatibility

L-Landscape Development Area

M-Future Development

M-1 Current Status

M-2 Short-Range Development

M-3 Long-Range Development

N-Reserved

N-*1 Reserved*

N-2 Reserved

O- Force Protection

O-1 Surge Capability (Beddown and Support of Deployed Forces)

O-2 Physical Security

O-3 Disaster Preparedness Crash Grid Map

O-4 Air Base Survivability and Theater-Specific Requirements

P - Ports and Harbors

R - Range and Training Areas

Necessary Installation Maps

Each installation is guided by its respective service's comprehensive or master planning requirements. Each installation, depending on its mission, may have substantially more or fewer theme specific maps. It is the responsibility of the installation's planning, environmental operations, engineering, and administrative staff to understand the mapping needs for their installation. Each installation is unique and the specific quantity and type of maps required for an installation depend upon its individual features, conditions and requirements. An installation will generally produce and maintain a set of maps to meet both its planning and operational needs.

The services have in the past documented their installation map requirements to support installation comprehensive planning. The Army identified guidelines for installation mapping in technical bulletins entitled Installation Master Plan Preparation (TB ENG 353) and Guidelines for the Preparation of Automated Map Databases at Army Installations (TB 5-803-3-1). While both of these documents are generally considered obsolete due to the recent technological advancements associated with digital technology and computer databases, they nevertheless offer good guidance on the salient issues of map generation for master planning purposes. The Air Force has documented mapping guidance in its "The Basic Master Statement of Work for Preparation of Comprehensive Plans for Air Force Installations." The Navy has similar guidance for its shore-based facilities and is covered in OPNAV instruction 11000.16A, titled Command Responsibility for Shore Land and Facilities Planning. It has been rewritten to address regionalization but has not been formally adopted by the Navy at the time of this writing.

Notwithstanding the various maps required by each DoD service to meet their unique and respective planning requirements, the references to the maps are also generally unique. The development of common terms of reference for map products is necessary to move toward the standardization of installation mapping. Once an accepted common mapping vocabulary is established, similarities in planning requirements will emerge. A glossary of common terms is included at the end of this document.

Table 2-1, Common Installation Map Types, provides a list of common installation maps. Included is the map name, whether the map is a mandatory or optional product as a part of the component or element plan, map scale, accuracy requirement, contour intervals, and a description of the map and its common features. As well, map data may be treated as a foundation theme that, combined or grouped, forms a composite map.

Table 2-1
Recommended Installation Maps

NOTE: UNLESS OTHERWISE SPECIFIED THE INSTALLATION LAYOUT MAP WILLBE USED AS A BASE FOR THE PREPARATION OF OTHER SPECIFIED MAPS.

MAP AND GRAPHIC LAYERS *M=mandatory* *O=optional* *TBD=to be determined*		MAP SCALE 1"=xxxx'	MAP CLASS-ACCURACY	CONTOUR INTERVAL (feet)	DESCRIPTION AND FEATURES SHOWN
A- NATURAL AND CULTURAL RESOURCES A-1 AREAS OF CRITICAL CONCERN	M	1"=400' 1:4,800	Class 1	5	Shows historic and archeological sites, areas of threatened and endangered species, primary habitat areas, flood plains, wetlands, coastal zones, lakes, rivers, water bodies, soils and soil boring locations, and similar information.
A- NATURAL AND CULTURAL RESOURCES A-2 MANAGEMENT AREAS	O	1"=400' 1:4,800	Class 1	5	Shows surface/subsurface geology, paleontology, topography, hydrology and surface drainage, vegetation areas, forests, commercial timber areas, agriculturaloutleasing areas, fish and wildlife areas, prime soils, grounds maintenance areas, outdoor recreation areas, pest management areas, and similar information.
B- ENVIRONMENTAL QUALITY B-1 ENVIRONMENTAL REGULATORY AREAS	M	1"=400' 1:4,800	Class 1	5	Shows hazardous waste generation points, hazardous waste storage facilities, solid waste disposal and recycling points, fuel tanks, Resource Conservation and Recovery Act sites, installation restoration program sites/areas, and similar information.
B- ENVIRONMENTAL QUALITY B-2 ENVIRONMENTAL EMISSIONS AREAS	O	1"=400' 1:4,800	Class 1	5	Shows sources of air emissions, wastewater Non-point Pollution Discharge Elimination System (NPDES) point source discharges, storm water non-point discharges, drinking water supply, electromagnetic radiation sources, sources of radon emissions and

Table 2-1
Recommended Installation Maps

NOTE: UNLESS OTHERWISE SPECIFIED THE INSTALLATION LAYOUT MAP WILLBE USED AS A BASE FOR THE PREPARATION OF OTHER SPECIFIED MAPS.

					similar information.
C-INSTALLATION LAYOUT AND VICINITY C-1 INSTALLATION LAYOUT	M	1"=100' 1:1,200	Class 1	2	Shows the installation boundary; buildings (facility identification numbers and type: permanent, semi-permanent, temporary); structures; roads and parking areas; walkways and trails; railroads; fences; recreation areas; cemeteries; training ranges; contours; water areas; coordinate grid; embankments; below/above ground tanks; embankments; spot elevations and survey control; neighboring land use (outside installation boundary); historic buildings and places, archeological sites and similar information.
C-INSTALLATION LAYOUT AND VICINITY C-2 OFF-INSTALLATION SITES	M	1"=400' 1:4,800	Class 1	5	Shows the same information as the installation layout map, but this map is prepared for those facilities that are outside the installation's primary boundary.
C-INSTALLATION LAYOUT AND VICINITY C-3 INSTALLATION REGIONAL LOCATION	O	1"=2,000' 1:24,000	NA	20	Shows information of interest to regional planning and major transportation systems, cities, towns, political jurisdictions,DoD installation boundaries, aeronautical data, woodlands, recreation areas, towers, significant physical characteristics of the region and other similar information.
C-INSTALLATION LAYOUT AND VICINITY C-4 INSTALLATION VICINITY	O	1"=1000' 1:12,000	Class 1	10	Shows the installation boundary, airfield and operations areas, major roads, proposed roads and highways, railroads, bombing and test ranges, vertical obstructions, topography, recreation areas, waterways and bodies, towers and similar information.
C-INSTALLATION LAYOUT AND VICINITY C-5 AERIAL PHOTOGRAPHIC COVERAGE AND CONTROL STATIONS	O		NA	NA	Prepared as an index of the aerial photographic coverage for the installation, shows the center point of individual photographs as well as the location of survey control stations and control points used for the aerial photography.
C-INSTALLATION LAYOUT AND VICINITY C-6 INSTALLATION BOUNDARY	M	Legal Records	Class 1	1	Shows the land area comprising the installation boundary including survey monuments.

Table 2-1
Recommended Installation Maps

NOTE: UNLESS OTHERWISE SPECIFIED THE INSTALLATION LAYOUT MAP WILLBE USED AS A BASE FOR THE PREPARATION OF OTHER SPECIFIED MAPS.

D- LAND USE D-1 INSTALLATION LAND USE D-1.1 FUTURE LAND USE	M	1"=400' 1:4,800	Class 1	5	Shows installation land use including airfields; maintenance and repair areas; manufacturing industrial areas; supply/ storage areas; administration areas; training and ranges areas; troop and family housing; community facilities (commercial and service); medical facilities; outdoor recreation; open spaces; and similar information
D- LAND USE D-2 OFF SITE LAND USE D-2.1 FUTURE OFF SITE LAND USE	O	1"=400' 1:4,800	Class 1	5	Shows off-site land use including airfields; maintenance and repair areas; manufacturing industrial areas; supply/ storage areas; administration areas; training and ranges areas; troop and family housing; community facilities (commercial and service); medical facilities; outdoor recreation; open spaces; and similar information
D- LAND USE D-3 REAL ESTATE	O	1"=400' 1:4,800	Class 1	2	Shows the land area comprising the installation including parcel information on fee title, lease, license, permit and easement areas inclusive of tract, acreage, data of acquisition, lease period and similar information.
D- LAND USE D-4 EXPLOSIVE SAFETY QUANTITY-DISTANCE CLEARANCE ZONES (QD-ARCS)	M	1"=400' 1:4,800	Class 1	5	Same as installation layout map, but includes the distance clearance zones for explosives.
D- LAND USE D-5 HAZARD ANALYSIS CONSTRAINTS	M	1"=400' 1:4,800	Class 1	5	Same as installation layout map, but includes areas of catastrophic potential to include flooding, subsidence, avalanche, erosion, earthquake, tsunami, snowfall, windstorm, volcanic ash and similar information.
D- LAND USE D-6 COMPOSITE CONSTRAINTS	M	1"=400' 1:4,800	Class 1	5	Same as installation layout map, but emphasizes areas of catastrophic potential from natural occurrences e.g., flooding, subsidence, avalanche, earthquake, tsunami and technological occurrences, accident potential zones, hazardous noise areas, noise contours, environmental management areas and other similar information.
D- LAND USE D-7 AREA DEVELOPMENT	O	1"=100' 1:1,200	Class 1	2	Same as installation layout map, but includes information on the planned development of areas within the installation.

Table 2-1
Recommended Installation Maps

NOTE: UNLESS OTHERWISE SPECIFIED THE INSTALLATION LAYOUT MAP WILLBE USED AS A BASE FOR THE PREPARATION OF OTHER SPECIFIED MAPS.

E-AIRFIELD OPERATIONS E-1 ON-BASE OBSTRUCTIONS TO AIRFIELD CRITERIA	M	1"=1,000' 1:12,000	Class 1	5	Same as airport pavement map and includes information on any obstructions to navigation and ground movement of aircraft within the installation boundary.
E-AIRFIELD OPERATIONS E-2 APPROACH/DEPARTURE ZONE OBSTRUCTIONS (to 10,000 feet)	M	1"=800'	Class 1	5	Shows obstructions within the glide angle approach zone and other similar information within the distance specified.
E-AIRFIELD OPERATIONS E-3 APPROACH/DEPARTURE ZONE OBSTRUCTIONS (from 10,000 feet to 10 miles)	M	1"=2,000' 1:24,000	Class 1	10	Shows obstructions within the glide angle approach zone and other similar information within the distance specified.
E-AIRFIELD OPERATIONS E-4 AIRSPACE OBSTRUCTION-VICINITY	M	1"=1,000' 1:12,000	Class 1	10	Shows obstructions within the vicinity of the airfield, but not those already shown on approach/departure zone maps, topography, cities, towns, other obstructions, water courses and water bodies and similar information.
E-AIRFIELD OPERATIONS E-5 TERMINAL ENROUTE PROCEDURES (TERPS) AUTOMATION	M	TBD	TBD	TBD	Shows all NAVAIDS with latitude and longitude.
E-AIRFIELD OPERATIONS E-6 AIRFIELD/AIRSPACE CLEARANCES	O	1"=100' 1:1,200	Class 1	2	Shows airfield waivers, clear zones, primary surface, transitional surface (7:1), approach and departure surface (50:1) approach and taxiway clearances, wing tip clearances, turning radii, and other similar information necessary for aircraft movement on the ground.
E-AIRFIELD OPERATIONS E-7 AIRFIELD PAVEMENT	O	1"=400' 1:4,800	Class 1	5	Shows runways, taxiways, aprons, warm-up pads,hardstands,helipads, stabilized shoulders, overruns and similar information.
E-AIRFIELD OPERATIONS E-8 AIRFIELD PAVEMENT DETAILS	O	1"=100' 1:1,200	Class 1	2	Shows runways, taxiways, aprons, warm-up pads,hardstands,helipads, stabilized shoulders, overruns and similar information, but includes cross sections and elevation profiles.
E-AIRFIELD OPERATIONS E-9 AIRCRAFT PARKING E-9.1 PROPOSED AIRCRAFT PARKING	O	1"=100' 1:1,200	Class 1	2	Shows the parking plan for aircraft including alert hangars, refueling outlets, blast fences, aircraft orientation, control tower, fire station, cargo holding pads, maintenance docks, maintenance lights, aircraft revetments and similar information.
E-AIRFIELD OPERATIONS E-10 AIRFIELD LIGHTING SYSTEMS	O	1"=100' 1:1,200	Class 1	2	Shows the major components of airfield lighting system including runway, taxiway, end reference lights, location size and type of underground ducts, obstruction lights, stand-by generator equipment

Table 2-1
Recommended Installation Maps

NOTE: UNLESS OTHERWISE SPECIFIED THE INSTALLATION LAYOUT MAP WILLBE USED AS A BASE FOR THE PREPARATION OF OTHER SPECIFIED MAPS.

					and similar information.
F- Reserved					
G-UTILITY SYSTEMS G-1 WATER SUPPLY SYSTEM	M	1"=50' 1:600	Class 1	1	Shows all significant components of the water supply system.
G-UTILITY SYSTEMS G-2 SANITARY SEWERAGE SYSTEM	M	1"=50' 1:600	Class 1	1	Shows all significant components of the sanitary sewerage system.
G-UTILITY SYSTEMS G-3 STORM DRAINAGE SYSTEM	M	1"=50' 1:600	Class 1	1	Shows all significant components of the storm drainage system.
G-UTILITY SYSTEMS G-4 ELECTRICAL DISTRIBUTION SYSTEM (STREET AND AIRFIELD)	M	1"=50' 1:600	Class 1	2	Shows all significant components of the electrical distribution and exterior lighting systems.
G-UTILITY SYSTEMS G-5 CENTRAL HEATING/COOLING SYSTEMS	M	1"=50' 1:600	Class 1	1	Shows all significant components of the central heating/cooling systems.
G-UTILITY SYSTEMS G-6 NATURAL GAS DISTRIBUTION SYSTEM	M	1"=50' 1:600	Class 1	2	Shows all significant components of the natural gas distribution system.
G-UTILITY SYSTEMS G-7 LIQUID FUEL SYSTEM	M	1"=50' 1:600	Class 1	1	Shows all significant components of the liquid fuel system.
G-UTILITY SYSTEMS G-8 CATHODIC PROTECTION SYSTEM	O	1"=100' 1:1,200	Class 1	2	Shows all significant components of the cathodic protection system for all underground utility systems and structures subject to electrochemical corrosion .
G-UTILITY SYSTEMS G-9 CATHODIC PROTECTION SYSTEM DETAILS	O	1"=50' 1:600	Class 1	2	Shows all significant components of the cathodic protection system including details of other utilities in proximity to ground beds for all underground utility systems.
G-UTILITY SYSTEMS G-10 INDUSTRIAL WASTE AND DRAIN SYSTEM	O	1"=50' 1:600	Class 1	2	Prepared when these systems are of such a complexity or nature it requires the production of a separate map to portray their characteristics.
G-UTILITY SYSTEMS G-11 COMPOSITE UTILITY SYSTEM	M	1"=100' 1:1,200	Class 1	2	Shows the water, sanitary sewer, storm drainage, electrical, central heating/cooling, gas compressed air, industrial waste and other utility systems combined on a single map.
G-UTILITY SYSTEMS G-11.1 CENTRAL AIRCRAFT SUPPORT SYSTEMS	O	1"=50' 1:600	Class 1	2	Shows all the utilities systems that serve the airfield apron and related servicing of aircraft.
G-UTILITY SYSTEMS G-12 FIRE PROTECTION SYSTEMS AND UTILITIES	M	1"=400' 1:4,800	Class 1	5	Shows fire hydrants, water deluge systems, safety buffer distances, vehicle maneuverability areas, and

Table 2-1
Recommended Installation Maps

NOTE: UNLESS OTHERWISE SPECIFIED THE INSTALLATION LAYOUT MAP WILLBE USED AS A BASE FOR THE PREPARATION OF OTHER SPECIFIED MAPS.

					similar information related to fire protection or safety.
G-UTILITY SYSTEMS G-13 OTHER UTILITY SYSTEMS	O	1"=100' 1:1,200	Class 1	2	Show utilities not displayed on other maps.
H-COMMUNICATION AND NAVAID SYSTEMS H-1 INSTALLATION-WIDE COMMUNICATIONS AND COMPUTER SYSTEMS	M	1"=400' 1:4,800	Class 1	5	Uses the installation layout map as a base to show installation-wide communications systems.
H-COMMUNICATION AND NAVAID SYSTEMS H-2 NAVAID SYSTEMS	M	1"=400' 1:4,800	Class 1	5	Shows NAVAID components such as radio transmitters, radio relay facilities, high and ultra high frequency direction finders, radio beacon shelters, GCA units, RAPCON units, PAR structures, TACAN buildings and facilities and similar information.
I-TRANSPORTATION SYSTEM I-1 COMMUNITY NETWORK - ACCESS TO BASE	M	1"=400' 1:4,800	Class 1	10	Shows all major arterial, collector streets that have direct relationship to the installation and local streets providing access to the installation.
I-TRANSPORTATION SYSTEM I-2 ON-BASE NETWORK	M	1"=400' 1:4,800	Class 1	2	Shows the transportation network including parking areas, sidewalks, bike/hike/jogging trails on the installation.
I-TRANSPORTATION SYSTEM I-2.1 FUTURE ON-BASE NETWORK	O	1"=400' 1:4,800	Class 1	2	Shows the planned transportation network including parking areas, sidewalks, bike/hike/jogging trails on the installation.
J-ENERGY SYSTEMS	O	1"=100' 1:1,200	Class 1	2	Shows data related to the installation's energy planning systems.
K-ARCHITECTURAL COMPATIBILITY	O	1"=400' 1:4,800	Class 1	2	Shows the installation's architectural compatibility zones and architectural districts.
L-INSTALLATION LANDSCAPE DEVELOPMENT AREA	O	1"=400' 1:4,800	Class 1	2	Shows the installation's landscape areas and planned flora.
M-FUTURE DEVELOPMENT M-1 CURRENT	M	1"=400' 1:4,800	Class 1	5	Shows the current installation layout; e.g. streets, parking lots, buildings, utilities etc, to include those facilities presently under development.
M-FUTURE DEVELOPMENT M-2 FUTURE DEVELOPMENT SHORT-TERM (1-5 YEARS)	M	1"=400' 1:4,800	Class 1	5	Shows planned development on the installation including streets and parking lots, buildings, utilities and similar information.
M-FUTURE DEVELOPMENT M-2 FUTURE DEVELOPMENT SHORT-TERM (> 5 YEARS)	M	1"=400' 1:4,800	Class 1	5	Shows the facilities that will be developed beyond a five-year time frame on the installation including streets and parking lots, buildings,

Table 2-1 **Recommended Installation Maps** NOTE: UNLESS OTHERWISE SPECIFIED THE INSTALLATION LAYOUT MAP WILLBE USED AS A BASE FOR THE PREPARATION OF OTHER SPECIFIED MAPS.					
					utilities and similar information.
O-FORCE PROTECTION 0-1 SURGE CAPABILITY (BEDDOWN AND SUPPORT)	O	1"=400' 1:4,800	Class 1	5	Show areas that can be suited for temporary billeting of troops in the case of surge requirements.
O-FORCE PROTECTION 0-2 PHYSICAL SECURITY	M	1"=400' 1:4,800	Class 1	5	Shows security fences, proposed and existing access points, sensor devices, location of security police units, fire stations and other similar information.
O-FORCE PROTECTION 0-3 DISASTER PREPAREDNESS CRASH GRID	M	1"=400' 1:4,800	Class 1	5	Shows all buildings and building numbers with hospitals and fallout shelters, protection factors and similar information.
O-FORCE PROTECTION 0-4 INSTALLATION SURVIVABILITY	O	1"=400' 1:4,800	Class 1	5	Prepared for installations to show operational contingencies.
P-PORTS AND HARBORS	O	1"=100' 1:1,200	Class 1	2	Shows berths, breakwater, channel, cable and pipeline areas, hazard areas, dry dock, navigation aides, jetties, wrecks, bouys, piers, quays, reefs, safety fairway, wharf, and other similar information.
R-RANGE AND TRAINING AREAS R-1 RANGE AREA	0	1"=400' 1:4,800	Class 1	5	Shows surface danger zones, target areas, impact areas,dudded areas, bomb circles, firing points, firing fans and lanes, range control points, and other similar information.
R-RANGE AND TRAINING AREAS R-2 TRAINING AREA	0	1"=400' 1:4,800	Class 1	5	Shows landing zones, drop zones, bivouac areas, training sites, foot traffic areas, perimeter defense, obstacle course areas, drill fields, marching areas and other similar information.

TSSDS Schema

While assembling the installation's mapping needs, it was apparent that a standardized database schema would facilitate sharing data between agencies, installations, and even across the services. Like the mapping structure discussed in the preceding section, the TSSDS uses a similar methodology for distinguishing various types of Geospatial data. The overall structure of the Tri-Service Spatial Data Standards is based upon the concept of features, attributes, and values. The feature is the representation of the phenomenon as it exists in the real world; in the TSSDS this is known as a discriminated entity type. These features are organized into thematic groups or sets, then into maps or classes, and finally into types or coverage's. The figure below outlines the overall organization of these elements giving an example from the transportation entity set for a railroad centerline feature.

The TSSDS uses "entity sets" to classify graphic (maps) and non-graphic data (tabular files, reports, database files etc). There are a total of 24 entity sets in the TSSDS (see below). For the novice, it is helpful to think of an "entity set" as a map display. For example, the installation has identified the maps needed to meet mission requirements. One set of information needed by the base is a map of the transportation network that supports the base, a map that shows how people and supplies enter and leave the base. In this case, the entity set is transportation. It contains all forms of transportation to include airfields, roads, railroads, and ports and harbors. In order to examine an individual or separate transportation network, such as railroads, we need to go to the next level within the TSSDS.

Auditory	Demographic	Land Use
Boundary	Environmental Hazards	Landform
Buildings	Flora	Military Operations
Cadastre	Fauna	Olfactory
Climate	Geodetic	Soil
Common	Geology	Transportation
Communications	Hydrography	Utilities
Cultural	Improvement	Visual

The next lower level of geographical features within the TSSDS is the "entity class". For our example, this is the railroad network. This map will display the entire railroad system. The individual items that comprise the railroad system e.g., rails, centerline, spurs, gates, right of way, and roundhouses are referred to as "entity types". An entity type is the logical name of an object that can be graphically depicted on maps or overlays.

Below the "entity type" is the entity. An entity is a further breakdown of the Geospatial image shown on the map. Using the same example from above, the entity would depict multiple or single tracks abandoned or active tracks.

TSSDS Structure

Entity Set
Transportation

Entity Class
Transportation_railroad

Entity Type
Railroad_centerline

Entity
Railroad c line (a)
Railroad c line (l)
Railroad c line (t)

Notes: (a) annotation, (l) line, (t) text, feature is represented as a string/chain object, uses attribute tabletrrrdrcl and the line_stt_d attribute to discriminate active or inactive status, attribute table linked to domain table d use

For general map tasking, some understanding of attributes is necessary, as some entities will usually require limited attribute data population during the mapping task. An entity is an individual data element containing information regarding a geo-spatial object or entity _type. An attribute contains values (or no value) based on the characteristics of the attribute. Attributes may be either numeric of varying precision or character. The precise data type of the attribute is a function of the Relational Database Management System (RDBMS) used to store the attached attribute data. Attributes may also have Domains, which contain lists of acceptable values for the attribute or define a range of acceptable numeric values. Domains can be of the list or range type.

The Tri-Service CADD/GIS Technology Center has available on its web site for download implementation guidance for the MGE, ARC/INFO, and ArcView software. To gain an appreciable understanding of how to implement projects using the TSSDS, this guidance should be used. The reports are available at **http://tsc.wes.army.mil**.

For installations that already possess mapping or Geospatial data sets, the migration to the TSSDS is more complex to implement. This migration complexity is due to the non-uniformity of structure, in virtually all cases, of graphic file and associated RDBMS tables with the TSSDS. It is best that a strategy be well planned and documented prior to undertaking such a migration. Priorities must be set and weighed carefully against the benefits of migration. In many cases, some legacy databases may not be suitable for migration, especially if the databases have a “flat file” non-relational format or the context is of questionable accuracy.

A tremendous effort can be associated with migration, even in cases of pure graphical data. Careful planning under the guidance of competent staff, an A-E contractor, or through support from the Tri-Service CADD/GIS Technology Center is a necessity with most migration efforts. It is recommended that a correlation be prepared for all graphic files and database tables before migration is performed. The correlation should include, as a minimum, the feature to feature, entity type to entity type, attribute to attribute, and domain table to domain table comparison. From this correlation, an appropriate migration strategy can be developed.

Relationship of TSSDS Schema with Installation Mapping Requirements

As stated earlier, the TSSDS entity set can generally be thought of as a map. However, there is no direct correlation between the references to TSSDS entity classes and the installation mapping requirements currently specified within the guidance for an Air Force General or Army Master plan. Specifically, in release 1.75 of the TSSDS there are 123 entity classes. A list of the entity classes with associated map name prefixes is contained in Appendix A, TSSDS Map Name Prefix Schema.

Of those 123 entity classes, three within the common entity set (common_general, common_metadata, and common_dictionary) possess data that is generally not best represented on a map. So there are approximately 120 maps that are specified within the TSSDS that could be produced for an installation, if the installation had all conceivable occurrences of Geospatial data of the type represented by the entity classes. As evidenced by the number of entity classes, installation-mapping requirements could be enormous to perform and maintain.

The Air Force General Plan presently specifies over sixty thematic maps that could be prepared for an installation. The Army specifies twenty existing condition maps within its Master Planning Guidance. Navy personnel are currently addressing their mapping needs and have identified twenty-two potential thematic maps. It is important that the DOD services understand the relationship of the TSSDS to their respective planning and operational map tasking requirements and that future furnished DOD guidance accurately reflects the requirements contained within the TSSDS.

Guidelines for the Preparation of Installation Maps and Geospatial Data

Map Basics

The term “map” refers to a two-dimensional graphic image, which shows the location of things in space, that is, in relationship to the Earth’s surface (Keates). A typical map uses an orthogonal viewpoint - where every point on the map is viewed as if looking straight down from above - to represent the Earth’s three-dimensional surface onto a plane. It does not describe or depict individual features, but represents them by symbols, e.g., points, lines, polygons, area patterns and colors etc., that place them into classes or categories. Maps are unlike photographs. Where a photograph shows all objects in its view, a map is a simple abstraction of reality. A map can be made to represent the subject that is of interest to the user or reviewer. Maps are the most common graphic used for installation planning.

Map Scales

Scale is used to establish the relationship between the distance of two points on the earth and the distance between two corresponding points on the map. As a rule, scale is referred to as a numerical ratio of map distance

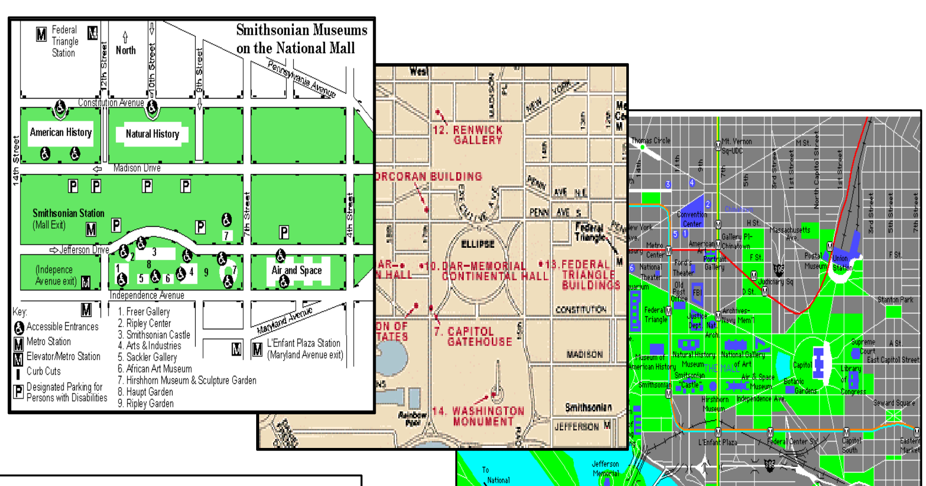

Figure 3-1 Large Scale Maps

to ground distance. It is usually written as 1/24,000 or 1:24,000, meaning that one unit of measurement on the map represents 24,000 of the same units on the ground. Maps should be prepared at a scale appropriate for the information or subject being illustrated. When scale is expressed in words, for example one inch equals 50 feet , it is referred to as a verbal scale. The bar scale or visual scale can be used for measuring distance. It graphically displays the relationship between map distance and ground distance.

The ranges of map scale are defined as large scale and small scale. The map series shown in Figures 3-1 and 3-2 demonstrate the effect of zooming "in" or "out" from the surface of the earth. A large-scale map shows a small area with a large amount of detail, e.g. small area development map, or a site plan.

A small-scale map "zooms out" from the source, displaying a larger area with a small amount of detail. For an installation, a small-scale map would be comparable to a "regional map" showing the relationship of the installation to the surrounding area.

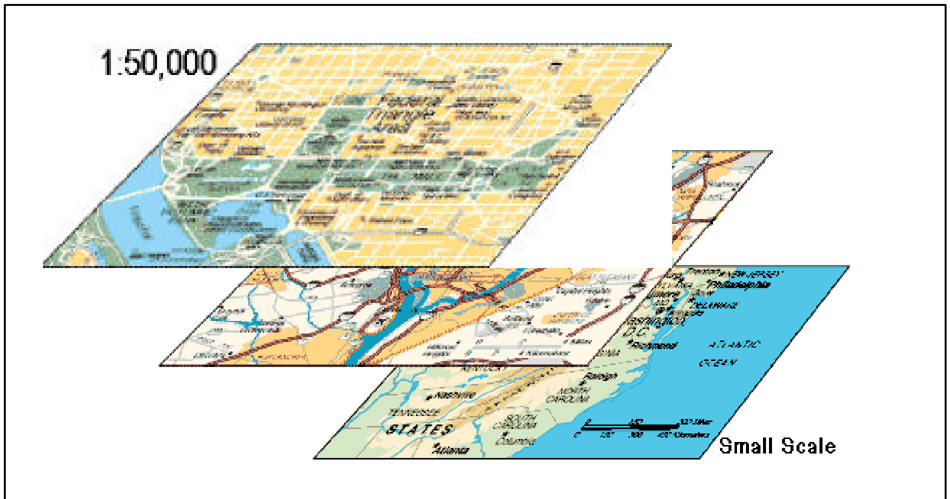

Figure 3-2 Small Scale Map

Usually specific small-scale mapping projects are not performed for military installations. Maps of the installation are normally produced at larger scales. Small-scale maps are appropriate when it is necessary to show the entire region on a single map for a macro review of subject themes such as the following:

- regional setting
- transportation profile
- change detection (natural resources)
- environmental control

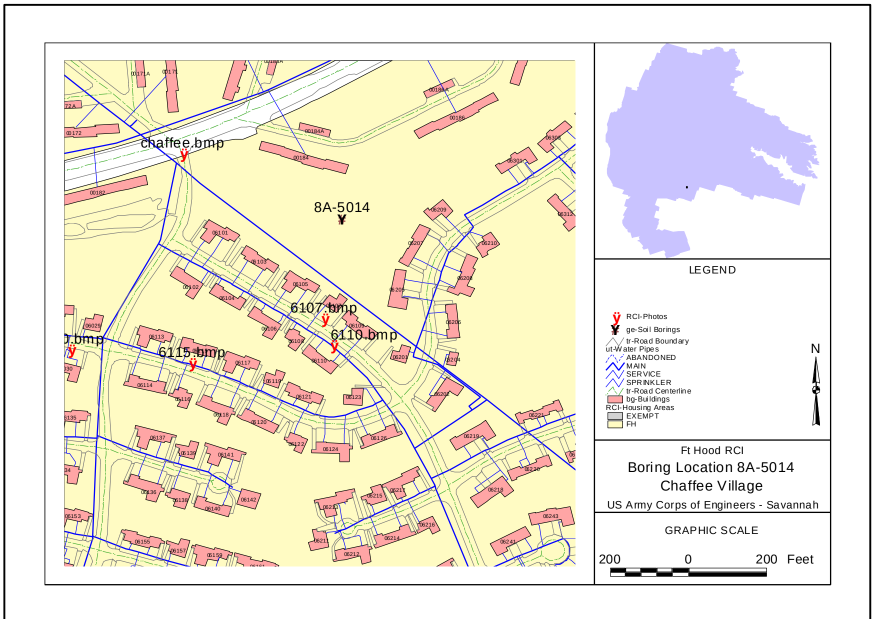

Figure 3-3 Map Composition

It is appropriate that all maps be prepared with a legend to describe the depicted themes, a bar scale or note specifying the map scale, and a north arrow that orientates the map. A bar scale is preferred over a scale note, as maps are often photographically copied, enlarged or reduced. The bar scale maintains the appropriate reference to scale as the copy, enlargement, or reduction is applied. A note cannot maintain this relationship.

Map users should be aware that any copied map, even with a bar scale on the map, might have an actual map scale that could vary from the original. This variation is due to distortions inherent in the reproduction process. This is especially true if maps are copied, enlarged, or reduced on a common copy machine. If the scale of the copy is not certain, then the labels such as "Not to Scale" or a label, such as 1" = approximately 50', should be used.

The next section provides a discussion of accuracy considerations, specifications and classes, which affect the original production, and reproduction of maps. The user of any map product, especially one reproduced from enlargement or reduction, should be aware of the potential for the introduction of inaccuracy into such products.

Accuracy Considerations

The Department of Defense (DOD) has not adopted a specific mapping standard of its own. In lieu of establishing a separate standard, DOD uses the guidance contained in the Office of Management and Budget (OMB Circular No. A-119, ***Federal Participation in the Development and Use of Voluntary Standards***. This circular prescribes that federal agencies maximize the use of industry standards. "Specifications for surveying and mapping shall use industry consensus standards established by national professional organizations such as The American Society of Photogrammetry and Remote Sensing (ASPRS)..."There are several professional groups that have established "industry" standards. The Army Corps of Engineers have adopted the ASPRS standards for large scale mapping (***areas under 10,000 acres***). The Departments of the Army, Navy, and Air Force follow suit on this adoption.

Horizontal accuracy requirements are established by the ASPRS Horizontal (planimetric) Standards for Large Scale Mapping (Appendix C). These limits of accuracy pertain to well-defined map test points only. Horizontal spatial accuracy is defined as the circular error of a data set's horizontal coordinates at the 95% confidence level.

As depicted in Figure 3-4a, using second order survey ground control marks, the probability distribution for a point is +/- 40' using a 1:24,000 (1"=2,000') scale map.

Vertical spatial accuracy is established by the ASPRS Vertical (Topographic) Standards for Large Scale Mapping (Appendix C) is defined by the linear error of a data set's vertical coordinates at the 95% confidence

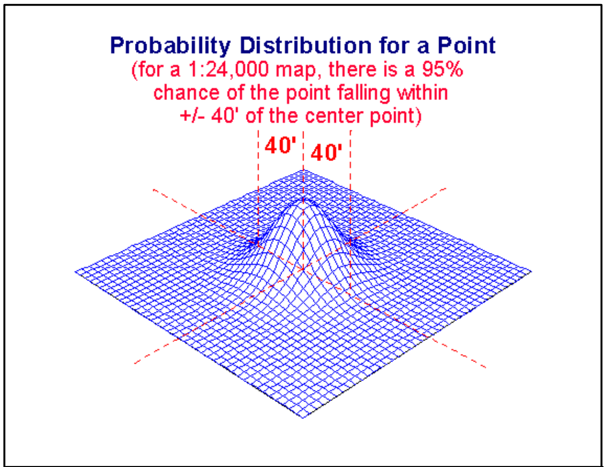

Figure 3-4a Point Probability

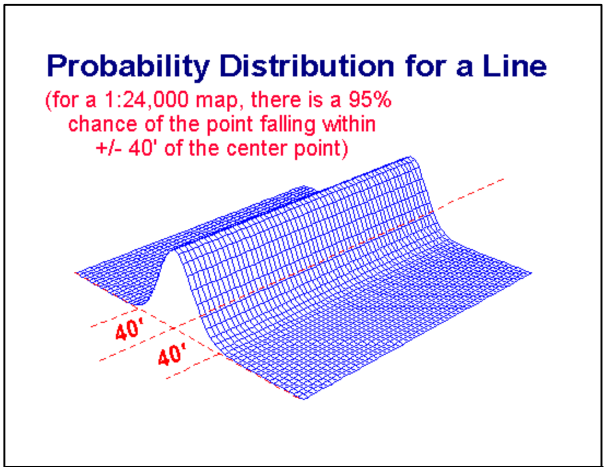

Figure3-4b Line Probability

level. As shown in Figure 3-4b, using second-order survey ground control markers, the probability distribution for a line is +/- 40' using a 1:24,000 (1"=2,000') scale map.

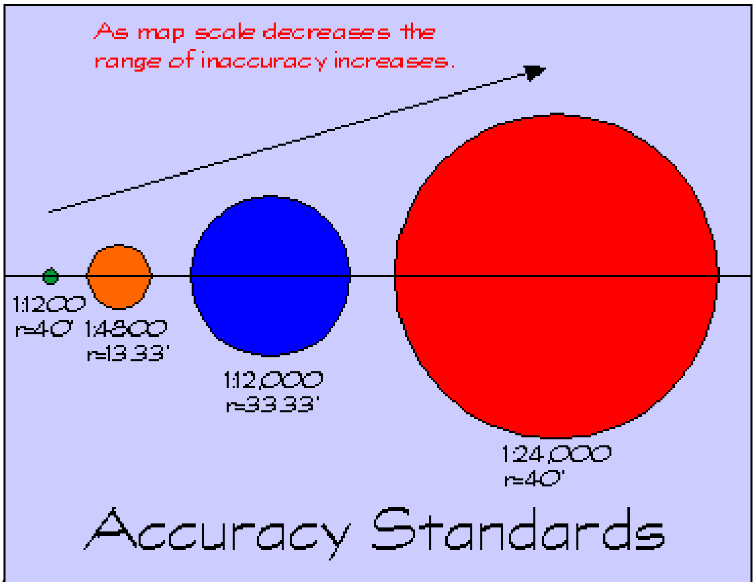

Figure 3-5 Map Accuracy VS Map Scale

Basically this means, that when we see a point (feature) on a map we know we have the "probable" location within certain limits - in the examples below we have the probable location of the feature within 40 feet. Caution must be exercised here. We must remain cognizant of the dangers of false accuracy-- that is reading locational information from map levels of accuracy beyond which they were created. This is inherent in computer systems that allow the user to pan and zoom at will to an infinite number of scales.

Accuracy is tied to the original map scale and does not change even if the user zooms in and out. Zooming in and out can mislead the user into the false belief that the accuracy has improved. See Figure 3-5.

Accuracy reported at the 95% confidence level means that 95% of positional accuracy would be equal to or smaller than the reported accuracy value. The reported accuracy value is the cumulative result of all uncertainties, including those introduced by local project control coordinates, field topographic surveys, photogrammetric compilation, or final extraction of ground coordinate values in the spatial data. The reference scheme for radial or linear errors must be defined as relative to absolute Geospatial reference networks or local (internal construction) schemes. Spatial data may be compiled to comply with one level of accuracy in the vertical component and another in the horizontal component. In both cases, establishing well-defined ground control points is necessary to develop the horizontal and vertical accuracy needed by military installations.

It is essential that mapping and surveying specifications originate from the functional requirements of the project, and that these requirements are realistic and economical. Specifying mapping accuracy in excess of those needed to accomplish the work results in increased costs. See Table 3-1 for general guidance on mapping scales and accuracy. Even at scales where centimeter accuracy is allowable, it may be unnecessary or impractical to develop products to that accuracy due to excessive cost, time, or perhaps more importantly, the lack of justifiable need. Again, it is essential that the map be developed at a scale appropriate for its intended purpose and that the map's accuracy meets existing standards or specifications.

Map Accuracy Specifications

Standards have been established for the expected accuracy for maps regardless of scale. These standards have been developed so users of maps are able to use the products with confidence. Map standards are usually given in terms of an allowable error at a specific scale. The American Society for Photogrammetry and Remote Sensing (ASPRS) Map Accuracy Specifications state that the following maximum errors are permitted on maps:

Horizontal accuracy. The ASPRS standards state that 95% of all planimetric features that are well defined on the photographs (assumes using photogrammetric techniques for map production) shall be plotted so that their position on the finished maps shall be accurate to within at least 1/40" of their true coordinate position, as determined by test surveys, and none of the features tested shall be misplaced by more that 1/20" from their true coordinate position.

Vertical accuracy. The ASPRS states that 95% of the elevations determined from solid-line contours (dashed contour lines usually indicate approximate elevations) of the topographic maps shall have an accuracy with respect to true elevation of ½ the contour interval or better and the remaining 10% of such elevations shall not be in error by more than one contour interval. Furthermore, 95% of the shown spot elevations must have an accuracy of at least ¼ the contour interval, and the remaining shall not be in error by more than ½ the contour interval.

Accuracy Classes

The U.S. Army Corps of Engineers' Photogrammetric Mapping, Engineer Manual refers to accuracy standards for large-scale maps that consist of three levels. Class 1 is the most accurate, while class 2 accuracy has an allowable Root Mean Square Error (RMSE) that is twice that if the Class 1 map. Class 3 has an allowable RMSE three times that of the Class 1 map. Maps may be in one class in horizontal accuracy and another in vertical.

The RMSE is defined to be the square root of the average of the squared discrepancies. While the discrepancies are the differences in the coordinates or elevation values as determined by an independent survey of higher accuracy. The RMSE is defined in terms of feet or meters at ground scale. So, as map scale decrease the RMSE increases in a linear relationship. See Figure 3-5, Map Accuracy vs. Map Scale, for graphic depiction of this concept. Table 3-1 shows the maximum permissible RMSE for well-defined points as established by the standard.

There are some common understandings related to aerial mapping practices and the use of standards. For example, to obtain a 3 foot contour interval it is accepted that you fly photography at a scale no greater than 1:1,200 (when using analytical stereo-plotting instruments to produce the map). So 1:1,200 scale maps are generally accepted to require 3 foot contours. 1:600 maps get a 1.5 foot contour, 1:2,400 scale map can get a 6 foot contour and 1:60,000 scale maps a 30 foot contour. A 1:100 ,000 scale map usually will have a 150 foot contour. Another rule of thumb is that a map produced on an analytical stereo-plotter (unlike a digital orthogonal discussed earlier in this report) should not be produced at a scale larger than six times the original data acquisition scale. So good quality 1:3,000 scale aerial photography could be used to produce a map at 1:600 (1”=50’).

Table 3-1

Planimetric Feature Coordinate Accuracy Requirement (Ground X or Y in Feet) for Well-Defined Points

Target Map Scale	Limiting RMSE in X or Y			
1"=x'	Ratio, ft/ft	Class1	Class 2	Class 3
5	1:60	0.05	0.10	0.15
10	1:120	0.10	0.20	0.30
20	1:240	0.2	0.4	0.6
30	1:360	0.3	0.6	0.9
40	1:480	0.4	0.8	1.2
50	1:600	0.5	1.0	1.5
60	1:720	0.6	1.2	1.8
100	1:1,200	1.0	2.0	3.0
200	1:2,400	2.0	4.0	6.0
400	1:4,800	4.0	8.0	12.0
500	1:6,000	5.0	10.0	15.0
800	1:9,600	8.0	16.0	24.0
1000	1:12,000	10.0	20.0	30.0
1667	1:20,000	16.7	33.3	50.0

Red = Limits of Satellite Imagery. Blue = Limits of Aerial Photography.
Green = Ground Survey Methods required.

Coordinate System

The U.S. Army Corps of Engineers’ Photogrammetric Mapping, Engineer Manual states that the most commonly encountered map projections in engineering surveying and mapping are the State Plane Coordinate Systems (SPCS) and the Universal Transverse Mercator (UTM). State Plane Coordinate Systems are defined for both the NAD 27 and NAD 83 datum. For the NAD 27 SPCS definition, the unit of length is the US Survey Foot. For

NAD 83 SPCS definition, the unit of length is variable among the states. Care must be exercised when using NAD 83 SPCS values in feet since either US Survey Foot or International Foot may be used in a specific state of locality.

The UTM projection is also commonly used in the military. UTM uses a scale factor of 1/2500 (0.9996 = 1/2500) to reduce the number of UTM zones for the entire world to 60. In 1930, the U.S. National Geodetic Survey developed the State Plane Coordinate System (SPCS) to increase the coordinate system accuracy for civil use. The SPCS uses a scale factor of 1/10,000. Measured distances on the ground more closely correspond to grid distances with a Grid System judiciously designed for civil use (Mugnier, 1998). The SPCS is the recommended coordinate system for installation maps within the Continental United States (CONUS).

Aerial Photography Parameters

Flight height for aerial photography acquisition is usually given as an average above ground elevation and planned in accordance with the desired accuracy specifications for the intended mapping. For most installation mapping activities aerial cameras with a 6” focal length are employed. Table 3-2, Arial Photography Acquisition Parameters, displays parameters needed to obtain mapping specifications indicated in this guide.

Table 3-2: Aerial Photography Acquisition Parameters

Photo Scale Range	**Altitude (meters)**	**Altitude (feet)**	**Map Scale Range**	**Map Scale 1"=x'**	**Contour Interval (meters)**	**Contour Interval (feet)**	**Typical Use**
1:2400 - 1:3000	450	1500	1:480 - 1:500	1"=40'	0.4	1.5	Site map
1:3000 - 1:4000	600	2000	1:600	1"=50'	0.5	1.5	Small Area Development Map Utility Maps
1:4000 - 1:5000	760	2500	1:1200	1"=100'	1	3	Area Development Map Special Area Maps - Airfields, Ports, Harbors etc.
1:5000 - 1:12000	900	3000	1:2400	1"=200'	2	6	Cantonment Area Map Land Use Map
1:12000- 1:24000	1060	3500	1:4800	1"=400'	5	16	Environmental Concern Area Transportation Access Map
1:24000 - 1:25000	1200	4000	1:6000	1"=500'	5	16	Installation Layout Map
1:25000 - 1:26000	1350	4500	1:9600	1"=800'	5	16	Special Study - Environmental Change Map
1:26000 - 1:72000	1520	5000	1:12000	1"=1000'	5	16	Vicinity Map
			1:24000	1"=2000'	5	16	Regional Map

The following paragraphs identify typical parameters for aerial photography:

Aerial film negatives that have a departure from the specified scale of more than 5% due to tilt or flight height variations are normally unacceptable. Flight height variation of the actual height exceeding the specifications by, for example, 2% low or 5% high may be grounds for rejection of the aerial photography. Cloud cover greater than 5% in a single image is unacceptable.

To support stereocompilation, end-lap for the aerial photography is usually specified at 60% with a permissible variation of no more than +/- 5%. Lateral side-lap is normally 30% with a permissible variation of no more than +/- 10%. Absolute crab (displacement of the principal point in a photography) exceeding 5-10 ° between two or more photos is usually cause for rejection. Average crab for a flight line should not exceed 3-5 degrees.

Tilt specifications are given for frames (i.e., no more than 4 °). Also specified is the average tilt for a series of consecutive photos (i.e., no more than 2 ° for any specified count of consecutive photos), as an average for the entire project (i.e., no more than 1 °), and relative tilt between consecutive photographs (i.e., no more than 6 °). The particular requirements for the aerial mission may modify one or more of these parameters, but these are useful guidelines for specifying the aerial photography requirement.

Map Production Process and GIS Development Strategy

Map tasking may ultimately result in the preparation of a land base used for a geographic information system. While map tasking does not necessarily require implementation of a GIS, those individuals involved in tasking must have an awareness of the importance of the preparation of mapping that ultimately serves a GIS enterprise-wide approach. When utilizing aerial photography and photogrammetric techniques it is important to understand the primary processes associated with the performance of installation map tasking.

The steps involved in the preparation of topographic map tasking using photogrammetric techniques (photo-mapping) and associated with the development of installation maps are provided below (Nale). There are slight variations in techniques when airborne GPS is used in lieu of traditional ground control surveys; in general however, the tasks below are required with most photogrammetric mapping projects. Other sections of this report provide more information on the specific requirements associated with the significant tasks.

Specify the area to be mapped, the desired map scale(s), contour interval and accuracy necessary for the map tasking (refer to Table 2-1).

Determine the aerial photography parameters such as flight height, photo scale, use of ground control surveys or airborne GPS for photo control and type of film.

Prepare the flight line map to be used for flying the mission to acquire the aerial photography.

Plan locations and place targets for aerial photography control purposes and mark/paint utilities or structures (optional) in preparation of installation over flight.

Acquire photography, process film, perform quality control and produce contact prints and diapositives.

Produce photographic indexes.

Perform field surveys to establish the control for mapping.

Perform survey adjustments and deliver survey report for approval.

Mark (drill) and measure diapositives in preparation of aerotriangulation, perform analytical aerotriangulation and deliver aerotriangulation report for approval.

Perform stereocompilation (inclusive of digital elevation and terrain models) or the generation of orthophoto maps inclusive of quality control.

Generate final photogrammetric map products. Include the preparation of the data with the topological structures necessary for GIS compliant data and apply TSSDS specifications.

Convert other records to add thematic data sets not developed from the photogrammetric data (map tasking) and add other attribute data associated with the map tasking or thematic data sets. This process may include the scanning and digitizing of ancillary maps or other sources of data. These data are referenced to the new mapping. Apply necessary topological structures and TSSDS specifications to the data.

Deliver mapping data to the installation and include meta data.

Figure 2-2 shows the summary of the photo-mapping production flow as presented in U.S. Army Corps of Engineers Photogrammetric Mapping engineer manual (EM 110-1-1000)

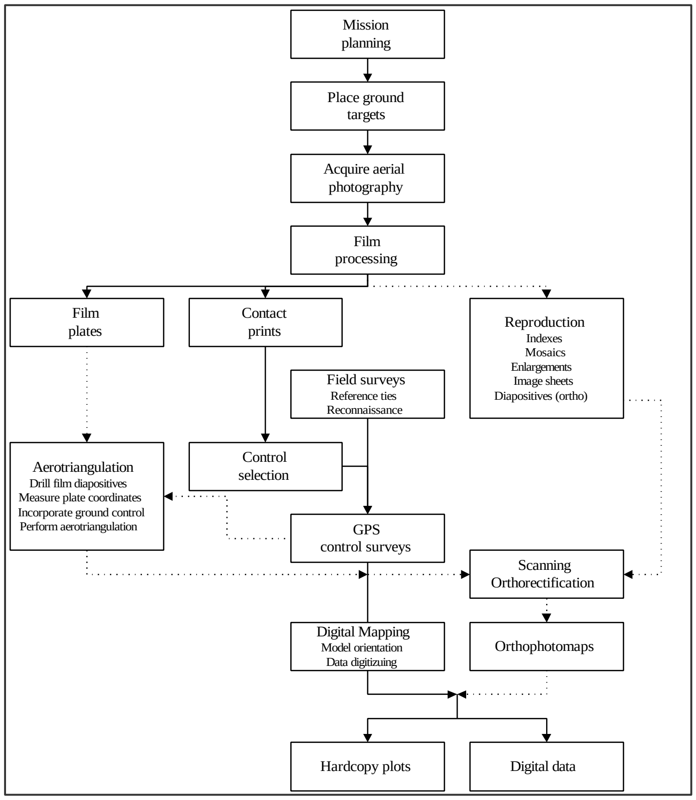

Figure 2-2. Photomapping production flow diagram