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	Engineering and Design GEOSPATIAL DATA AND SYSTEMS	
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US Army Corps of Engineers
Washington, DC 20314-1000

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1 July 1998

Engineering and Design
GEOSPATIAL DATA AND SYSTEMS

1. This change 2 to EM 1110-l-2909, 1 Aug 96, adds Chapter 11, Accuracy Standards for Engineering, Construction, and Facility Management Surveying and Mapping.

2. Substitute the attached pages as shown below:

Chapter	Remove Page	Insert Page
Contents	i-ii	i-iv 11-l thru 11-31

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FOR THE COMMANDER:

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Engineer and Design
GEOSPATIAL DATA AND SYSTEMS

1. This Change 1 to EM 1110-1-2909, 1 Aug 96, adds instructions on how to submit and access data and metadata on the USACE node of the National Geospatial Data Clearinghouse, Appendix D.

2. Substitute the attached pages as shown below:

Chapter	Remove page	Insert page
Contents	ii	ii D-1 thru D-11

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Engineering and Design
GEOSPATIAL DATA AND SYSTEMS

1. Purpose. This manual provides detailed technical guidance and procedures for compliance with the policy in Engineer Regulation (ER) 1110-l-8156, regarding Geospatial Data and Systems (GD&S) within the U.S. Army Corps of Engineers (USACE).

2. Applicability. This manual applies to all USACE Commands having civil works, military construction, and environmental restoration responsibilities. This manual specifically applies to functional areas having responsibility for regulatory investigations and studies, planning studies, real estate, emergency operations, and other functions involving automated geospatial data systems for surveying, mapping, or geospatial database development, such as modeling, and to GD&S that are used to produce a variety of products including: river and harbor maps, charts, and drawings; real estate tract or parcel maps; small- and medium-scale engineering drawings; survey reports; environmental studies; hazardous, toxic, and radioactive waste studies; and channel condition reports. This manual applies to’ in-house and contracted efforts.

3. Discussion. ER 11l0-l-8156 establishes general criteria and presents policy and guidance for the acquisition, processing, storage, distribution, and utilization of non-tactical geospatial data throughout USACE. This policy is in compliance with Executive Order 12906, Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure (NSDI) and other appropriate standards, including the Spatial Data Transfer Standard/Federal Information Processing Standard 173, Federal Geographic Data Committee standards, and T&Service Spatial Data Standards. This manual also provides detailed technical guidance and requirements and identifies standards for GD&S. By using this manual, USACE will maximize its use of GD&S technologies; will promote interoperability among GD&S technologies; will reduce duplication of geospatial data collection and software development; will support the digital geospatial data life cycle; and will strengthen the USACE role in the NSDI.

FOR THE COMMANDER:

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Engineering and Design
GEOSPATIAL DATA AND SYSTEMS
TABLE OF CONTENTS

*

Chapter 1
Introduction

1-1. Purpose

This manual provides detailed technical guidance and procedures for compliance with the policy in Engineer Regulation (ER) 1110-1-8156. That regulation establishes general criteria and presents policy and guidance for the acquisition, processing, storage, distribution, and utilization of non-tactical geospatial data throughout the U.S. Army Corps of Engineers (USACE) and in compliance with Executive Order (EO) 12906, Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure (NSDI) and other appropriate standards, including the Spatial Data Transfer Standard (SDTS)/Federal Information Processing Standard (FIPS) 173, Federal Geographic Data Committee (FGDC) standards, and Tri- Service Spatial Data Standards (TSSDS). This manual also provides detailed technical guidance and requirements and identifies standards for Geospatial Data and Systems (GD&S). By using this manual, USACE will maximize its use of GD&S technologies; will promote interoperability among GD&S technologies; will reduce duplication of geospatial data collection and software development; will support the digital geospatial data life cycle; and will strengthen the USACE role in the NSDI.

1-2. Applicability

This manual applies to all USACE Commands having civil works, military construction, and environmental restoration responsibilities. This manual specifically applies to functional areas having responsibility for regulatory investigations and studies, planning studies, real estate, emergency operations, and other functions involving automated GDS for surveying, mapping, or geospatial database development, such as modeling, and to GD&S that are used to produce a variety of products including: river and harbor maps, charts, and drawings; real estate tract or parcel maps; small- and medium-scale engineering drawings; survey reports; environmental studies; hazardous, toxic, and radioactive waste (HTRW) studies; and channel condition reports. This manual applies to in-house and contracted efforts. USACE customers for reimbursable work who are required to comply with the EO 12906, such as the Department of Defense (DoD) installations, Environmental Protection Agency, and the Federal Emergency Management Agency, will determine their level of compliance. These customers may opt to incorporate compliance with the EO into contracts with USACE or may accomplish compliance unassisted by USACE.

1-3. References

Required and related publications are listed in Appendix A.

1-4. Abbreviations and Acronyms

Abbreviations and acronyms used in this publication are listed in Appendix B.

1-5. Definitions

a. Geospatial Data - non-tactical data referenced, either directly or indirectly, to a location on the earth.

b. Geospatial Data Systems (GDS) - any automated system that employs geospatial data including Geographic Information Systems (GIS), Land Information Systems (LIS), Remote Sensing or Image Processing Systems, Computer-Aided Design and Drafting (CADD) systems, Automated Mapping/Facilities Management (AM/FM) systems, and other computer systems that employ or reference data using either absolute, relative, or assumed coordinates such as hydrographic surveying systems.

c. Geospatial Data and Systems (GD&S) - Geospatial data and the GDS that create and process the data.

d. USACE Commands - all subordinate entities of the U.S. Army Corps of Engineers including districts, divisions, research laboratories, and field offices.

e. Metadata - descriptive information about the data. Metadata describes the content, quality, fitness for use, access instructions, and other characteristics about the geospatial data.

f. National Geospatial Data Clearinghouse (Clearinghouse) - a distributed, electronic network of geospatial data producers, managers, and users operating on the Internet. The Clearinghouse is a key element of EO 12906 and will allow its users to determine what geospatial data exist, find the data they need, evaluate the usefulness of the data for their applications, and obtain or order the data as economically as possible.

g. USACE Clearinghouse Node - HQUSACE established and maintains a computer network server on the National Geospatial Data Clearinghouse. This node functions as the primary point of public entry to the USACE geospatial data discovery path in the Clearinghouse. A separate electronic data page for each USACE Command has been established on the server. The Internet Universal Resource Locator (URL) address for the USACE Clearinghouse node is http://corps_geo1.usace.army.mil

1-6. Scope

This manual provides detailed technical guidance and requirements and identifies standards related to GD&S. This includes: requirements analysis; implementation plans; organizational issues such as staffing, training, and managerial support; system configuration and procurement of hardware, software, and telecommunications equipment; standards; data issues such as collection and acquisition, metadata (documentation), schemas (classification), and electronic clearinghouses (data locator and access service); applications; and evaluation criteria. Implementation actions are included in paragraph 7 of ER 1110-1-8156.

1-7. Exclusions

a. Spatial data and computer systems that do not use coordinates that are directly or indirectly referenced to a position on the Earth are not required to adhere to this regulation. This exempts architectural, mechanical, electrical, structural, and sanitary engineering data and drawings of objects typically inside buildings, as well as the CADD systems used to develop such data and drawings.

b. Site plans showing building structure footprints or any data set about features on the exterior of a building or structure are geospatial data, are compatible wtih the NSDI concept, and are not excluded from this regulation. This data may use relative, assumed, or geographic coordinates and may be stored in a CADD or GIS environment.

c. This regulation also excludes business systems, such as those that focus on textual and statistical information that is created, stored, manipulated, queried, displayed, and transferred differently than geospatial data.

d. This regulation also excludes tactical spatial data and associated computer systems such as those used for fire control, targeting, and mission planning.

e. Users of excluded systems may find this document useful in implementing, organizing or managing their particular type of automated system; in identifying applicable standards; or in creating and maintaining a database. This manual may enhance interoperability among GDS and other data systems, and users of all automated systems are encouraged to coordinate, when appropriate, with users, managers, and administrators of other automated systems.

1-8. Brand Names

The citation in this manual of brand names of commercially available products does not constitute official endorsement or approval of the use of such products.

Chapter 2
GD&S Applications in USACE

2-1. Introduction

a. This chapter is intended to provide the reader with a feel for the variety of Geospatial Data and Systems (GD&S) applications in USACE. This chapter begins with the project development process in USACE as it relates to GD&S. The types of GD&S projects at the District, Division, Headquarters, and Laboratory levels are then discussed. Information on the many application areas and the Districts where they occur is presented, along with several typical and atypical sample applications.

b. A Geospatial Data System (GDS) has been defined as the computer hardware and software used to input, store, retrieve, manipulate, analyze, and plot/print geospatially (geographically) referenced digital data, referred to as Geospatial Data. Collectively these are referred to as GD&S for Geospatial Data and Geospatial Data System. GD&S is one of the fastest growing technologies and has changed the way USACE operates. GD&S technology provides a tool for planners, resource managers, engineers, scientists, real estate specialists, and others to perform complex analyses faster and more reliably than ever before. More types of data can be archived, retrieved and studied, making it possible to examine both new and old problems in a more comprehensive way. Even hardcopy products, such as maps and photographs, can be scanned or features can be extracted to allow more advanced processing.

c. Data sharing capability among geospatial data users in a geographical region is important. USACE Districts and Divisions may be called upon to share geospatial data with other Federal agencies, State and Local governments, and municipalities more often than with other USACE commands. Also, billions of dollars are spent annually by federal, state and local governments, and industry developing databases that could be used by USACE. The ability to incorporate geospatial data developed by organizations is vital if USACE is to cost-effectively and rapidly implement GD&S technology.

d. USACE has a great diversity of GD&S applications including Wetlands Permitting and Analysis, Environmental Restoration, Resource Management, Habitat Analyses, Environmental Change Detection, Aquatic Plant Tracking, Historical Preservation, Hydrology and Hydraulics, Channel/Inland Waterways Maintenance, Emergency Response, Flood Plain Mapping, Real Estate/Cadastral, Master Planning, District/Construction Management, Socio-economic Analysis, and Geologic/Geomorphic Analysis. These applications support both the USACE civil and military missions. These applications emphasize providing access to geospatial data and rendering the data into information through: (1) quantitative and qualitative analyses, and (2) visual products.

2-2. The GD&S Development Process in USACE

GD&S technology is an enabler that may belong in many offices. It should not be viewed as exclusive to one portion of a USACE Command, but should be diffused throughout the Command to those functions where it is useful.

2-3. USACE GD&S Application Categories

a. District GD&S Application Categories. GD&S at the District level is employed for geospatial data analysis in support of engineering projects. Numerous District level data sets are geospatial in nature and are best accessed and managed by using GD&S technologies. Among the means of access are visualization, spatial query and geospatial data layer integration. These technologies support basic analysis and can provide modeling support. The result is a focusing of resources to support both quantitative and qualitative decision making in the District mission areas and the preparation of decision support materials for the Division and Headquarters.

b. Division and Headquarters GD&S Application Categories. GD&S at the Division and Headquarters level is not one of analysis but the visualization and display of District geospatial analytical products for USACE-wide or corporate decisions. This is essentially an Executive Briefing System.

c. Laboratory GD&S Application Categories. GD&S at the laboratory level is complex with many unique analysis and modeling applications in a variety of advanced research areas and for project support to districts. The results are again subject to review at Headquarters through visualization and query. Laboratory efforts are also directed to the development of configuration managed geospatial applications for the civil side of USACE. Advanced GD&S projects at USACE Laboratories include terrain visualization, modeling and simulation of environmental phenomena, hyper-spectral analysis of imagery to support change detection, and applications research.

d. Sample GD&S. There are many application areas for GD&S in USACE. A typical application is real estate land records management. Tract data can be entered into a GD&S for all USACE-owned lands. Attribute data includes values such as parcel numbers, ownership status, dates when interests were acquired and easements. Accuracy of data is best maintained at the cadastral level to support real estate management [North Central Division Implementation Plan, 1989].

Occasionally there are atypical applications as well. These are applications which are unique to a particular USACE Command because of its unique mission or capabilities. One example is the prediction of ice jam flooding by the Cold Regions Research and Engineering Laboratory (CRREL).

Chapter 3
GD&S Organizational Issues

3-1. Organizational Model for GD&S Usage Within USACE

This chapter describes an organizational model for GD&S usage within USACE and can be used as a guide in determining the level of GD&S functionality and responsibility that is appropriate for each Command. The exchange of geospatial products and information is to be accomplished among all USACE Commands using the Internet.

a. Districts. The Districts are to have fully functional geospatial data systems to meet project needs and mission requirements. This includes the GD&S necessary for data collection and database creation, geospatial analysis, and product generation. Data collected, acquired, or created at the District is to be documented (metadata) and maintained at the District unless it is developed for and delivered to a customer. The District shall make the metadata for in-house data sets available to the National Geospatial Data Clearinghouse, where appropriate. An agreement should be reached with a customer, prior to beginning a project, as to who is responsible for providing the metadata to the Clearinghouse.

GD&S activities will normally be distributed across the various functions in the District. Each function -- Planning, Real Estate, Operations, etc. -- will operate a GDS that meets their particular requirements. Centralized oversight and technical committees will provide the structure necessary to eliminate redundant data acquisition and improve efficiency by providing guidance on training and hardware and software purchases and through the sharing of experiences and expertise.

b. Divisions. The Divisions typically require less geospatial data system functionality than the Districts. The functionality required is that which will allow Division staff to view, using commercially available tools such as ArcView, geospatial data products created by the Districts so they can make management decisions, conduct executive briefings, maintain an overview of the Division activity, and coordinate GD&S activities within the Division. The Division shall make the metadata for any in-house data sets available to either the National Geospatial Data Clearinghouse where appropriate.

c. Research and Development Laboratories. The Research and Development (R&D) Laboratories require complete geospatial data systems functionality to meet their research and customer needs. The R&D Laboratories need to be able to advise the field on GD&S technologies, provide project support where project GD&S environments vary, evaluate new GD&S technologies, and develop algorithms and designs for systems to be fielded. The choice of GD&S must be kept flexible in the R&D Laboratory environment. Data collected, acquired, or created at the Laboratory is to be documented and maintained at the Laboratory unless it is delivered to another USACE Command or customer. The Laboratory shall make the metadata for in-house data sets available to the National Geospatial Data Clearinghouse, where appropriate. An agreement should be reached with a customer, prior to beginning the project, as to who is responsible for providing the metadata to the Clearinghouse

d. Headquarters. Headquarters typically requires less geospatial data system functionality than the Districts, Divisions, or Laboratories. The functionality required is that which will allow HQUSACE staff to view, using a commercially available tool such as ArcView or VistaMap, geospatial data products created by the field so they can make management decisions, conduct executive briefings, maintain an overview of and coordinate USACE GD&S activity.

3-2. Location of GD&S Within a Command

The location of GD&S within a USACE Command is a determination to be made at the Command level. The considerations are: (1) the current and future GDS functionality and data requirements, (2) the sources of support and funding within the Command, and (3) the location of GD&S expertise within the Command. In most cases, a close linkage to the individual divisions will be preferable because geospatial data exploitation is just one of many enabling technologies supporting the Command missions. The establishment of the oversight and technical committees and informal users groups will aid divisions that are acquiring GD&S technology for the first time by providing expertise and experience.

3-3. HQUSACE Geospatial Data and Systems Manager

The Chief, Engineering Division, Directorate of Civil Works, HQUSACE (CECW-E) will serve as the USACE GD&S Manager and will represent Civil Works on the Tri-Service CADD/GIS Technology Center Executive Steering Group and will represent DoD facilities, civil works, and environmental interests on the FGDC.

3-4. HQUSACE Geospatial Data and Systems Coordination Committee

The HQUSACE GD&S Coordination Committee is chaired by CECW-EP-S, composed of HQUSACE personnel who play a role in GD&S, and addresses GD&S issues from a corporate perspective. Each participating HQUSACE Directorate, such as Information Management, Real Estate, Civil Works, Military Programs, and Research and Development, will nominate a member to this committee. The Coordination Committee will meet at least twice per year. The chair will support the USACE GD&S Manager, will grant waivers of compliance for ER 1110-1-8156, will review information copies of Command GD&S implementation plans and evaluation reports, and will consider funding GD&S Field Advisory Group recommendations and other corporate GD&S activities.

3-5. USACE Geospatial Data and Systems Field Advisory Group

The USACE Geospatial Data and Systems (GD&S) Field Advisory Group assists HQUSACE in defining the role of the Corps of Engineers in the National Spatial Data Infrastructure and also recommends implementations of geospatial data standards and related technologies within USACE. The GD&S Field Advisory Group is composed of approximately one representative from a District in each Division and one from each USACE R&D Laboratory. The members are selected by CECW-EP-S based on their expertise in GD&S technologies and applications. They usually meet twice per year and they elect the chair.

3-6. USACE Commanders.

Commanders have two actions per ER 1110-1-8156. They will appoint a GD&S Point of Contact (POC) to act as a liaison between the command and HQUSACE/CECW-EP-S. Beginning with the FY97 Civil Works budget cycle, USACE Commanders will certify that their Command has accessed the Clearinghouse, contributed metadata to the Clearinghouse, determined via the Clearinghouse that needed geospatial data are not available from an existing source, and that possible data collection partnerships have been explored. This certification, included as Appendix B in ER 1110-1-8156, will be submitted to USACE annually as part of the Civil Works Budget submittal.

3-7. Geospatial Data and Systems Oversight Committee

The Geospatial Data and Systems (GD&S) Oversight Committee is a requirement of ER 1110-1-8156. The purpose of this committee is to promote interoperability among the various GD&S efforts within the USACE Command from a corporate or administrative perspective and to approve the plans and procedures drafted by the GD&S Technical Committee for complying with this manual and ER 1110-1-8156. The oversight committee will address funding, administrative, and policy issues in coordination with the commander and executive board as necessary.

The GD&S Oversight Committee consists of the chief, or a designated representative, of any division or office within the USACE Command that has an interest in geospatial data. This includes, but is not limited to, those working in the areas of planning, environmental analysis, project management, aerial photography and remote sensing, information management, waste water control, water quality analysis, emergency management, engineering design, facility management, real estate, regulatory functions, geotechnical analysis, hydrographic and land surveying, terrain analysis, economic analysis, and forestry. The final composition of the Committee, including the chair, is defined by the Command. Meeting schedules and procedures are to be developed by the Command. However, they should meet at least twice a year and as necessary to react to actions of the GD&S Technical Committee. If a Command has a pre-established group that performs functions similar to or a superset of the Oversight Committee, it may choose to continue with that group as long as the functions described in this EM and ER 1110-1-8156 are performed effectively.

The responsibilities of the GD&S Oversight Committee are:

` Review and approve the GD&S Implementation Plan (IP) developed by the GD&S Technical Committee

` Forward an information copy of the initial or base IP to HQUSACE, as well as subsequent IP revisions which are created at least every three years.

` Review the GD&S Performance Evaluation submitted annually by the GD&S Technical Committee. Forward an information copy of the Evaluation to HQUSACE/CECW-EP-S.

` Ensure that the Command documents new geospatial data (data created after January 1995) using the FGDC Content Standard for Digital Geospatial Metadata.

` Ensure that the Command documents existing (pre-Janaury 1995) geospatial data to the extent practicle.

` Ensure that the Command submits metadata to the Clearinghouse**.**

` Ensure that the Command Utilizes the Clearinghouse prior to spending Federal funds on data collection or creation, to determine if the required data already exists.

` Ensure that the Command provides public access to geospatial data.

3-8. Geospatial Data and Systems Technical Committee

a. The Geospatial Data and Systems (GD&S) Technical Committee is a requirement of ER 1110-1-8156. The purpose of the GD&S Technical Committee is to promote interoperability among the various GD&S efforts within the USACE Command from a technical perspective and to ensure adherence to this manual and ER 1110-1-8156, also from a technical perspective. If a Command has a pre-established group that performs functions similar to or a superset of the Technical Committee, it may choose to continue with that group as long as the functions described in this EM and ER 1110-1-8156 are performed effectively.

b. The GD&S Technical Committee is comprised of members selected from all persons responsible for geospatial data management and other interested persons in the USACE Command. This includes, but is not limited to, those working in the areas of planning, environmental analysis, project management, aerial photography and remote sensing, information management, waste water control, water quality analysis, emergency management, engineering design, facility management, real estate, regulatory functions, geotechnical analysis, hydrographic and land surveying, terrain analysis, economic analysis, and forestry. The final composition of the Committee, including the chair, is defined by the Command. The meetings should be held in an open forum with a published agenda. An invitation for all interested parties to attend the meetings of the Technical Committee is encouraged.

c. The GD&S Technical Committee shall meet at least four (4) times per year to discuss GD&S activities within the USACE Command. The Committee shall keep everyone in the Command, including personnel at the field offices, informed of the GD&S efforts in the Command. It is recommended that the chair of the Technical Committee be rotated annually.

d. The responsibilities of the GD&S Technical Committee are:

- Prepare the initial GD&S Implementation Plan and forward it to the GD&S Oversight Committee for approval.

- Evaluate the execution of the GD&S Implementation Plan annually to determine if the execution is on schedule and moving in the direction set by the GD&S Implementation Plan. Forward this evaluation to the GD&S Oversight Committee.

- Review the GD&S Implementation Plan itself every three years, revise it as necessary and forward it to the GD&S Oversight Committee for review and approval.

- Ensure that the Command documents new geospatial data (data created after January 1995) using the FGDC Content Standard for Digital Geospatial Metadata.

- Ensure that the Command documents existing (pre-Janaury 1995) geospatial data to the extent practicle.

- Ensure that the Command submits metadata to the Clearinghouse.

- Ensure that the Command Utilizes the Clearinghouse prior to spending Federal funds on data collection or creation, to determine if the required data already exists.

- Ensure that the Command provides public access to geospatial data.

- Establish priorities for and coordinate data acquisition and development within the organization.

- Appoint representatives, where appropriate to the organization's mission, to coordinate with local, state, and National GD&S Technical Committees and Task Forces.

3-9. Geospatial Data and Systems Point of Contact

The GD&S Point of Contact (POC) is a requirement of ER 1110-1-8156. Each USACE Commander shall appoint an individual to act as the GD&S POC. The selection of the GD&S POC is an internal organizational decision. The GD&S POC may be drawn from any area of geospatial data expertise including, but not limited to, GIS, remote sensing, surveying and cartography, or CADD. The GD&S POC has the responsibility to disseminate relevant information to all members of the Command’s geospatial data community, including field offices and will be the focal point for information exchange with HQUSACE. The GD&S POC will sit on the GD&S Technical Committee and may be, but is not required to be, the chairperson. The GD&S POC will also be an advisor to the GD&S Oversight Committee.

As new data pages are developed by HQUSACE on the USACE node of the National Geospatial Data Clearinghouse GD&S POCs will review their Command’s pages and provide corrections to the Webmaster. Annually, the GD&S

POC will review his Command's geospatial data pages on the USACE Clearinghouse node and forward any updates to the Webmaster.

3-10 GD&S Users Groups and Special Interest Groups

The Technical Committee may choose to form one or more GD&S users groups or special interest groups. These less formal groups, comprised primarily of technical experts, have been found to be effective at addressing specific GD&S issues. Users/special interest groups may be established to address functional areas, e.g., a real estate users group; technology areas, e.g., an Internet special interest group; or standards issues, e.g., the data interchange users group. These groups should keep the GD&S Technical Committee informed of the activities and may be tasked with focused studies, as needed.

3-11. Management Issues

a. Once a GD&S Implementation Plan is in place, a number of management issues will arise. A critical one is the need for upper management support. By their approval of the Implementation Plan, the GD&S Oversight Committee has provided middle management approval and support.

b. USACE Command management needs to address funding to implement the Implementation Plan. This includes funding for the initial GD&S and geospatial data and funding for operations and maintenance (O&M). These O&M costs may need to be allocated to projects or may be charged to Command overhead. Funding for GD&S implementation entails considering the life cycle and staffing costs.

c. The costs that must be considered include:

- Initial software cost for software licenses.
- Initial hardware cost.
- Modifications to existing hardware that may be caused by the introduction of new hardware.
- Modifications to existing software that may be necessary to work in the new environment.
- Network implementation or modifications.
- Furniture and site modifications.
- Hardware installation.
- Software installation.
- Integration services.
- System test.
- Training of staff in system and new procedures.
- Software test.
- Data validation.
- Supplies such as media for data and output.
- Data collection and conversion of old data sets to new formats.
- Data maintenance.
- Supplemental utility programs.
- Maintenance contracts on hardware and software.
- Future system upgrades.

There are also unique costs brought about by the requirement for a National Geospatial Data Clearinghouse. These Clearinghouse costs include:

- Internet connectivity and system administration.
- Server hardware purchase and maintenance.
- Metadata creation for new and existing data sets.
- Maintenance of inactive data sets.
- Metadata distribution.
- Responding to data requests from Clearinghouse users.

Once the implementation is underway the management of expectations will begin. Here the goal is to deliver some operational capability through a pilot project which can be used to demonstrate capabilities using an initial geospatial data base. This serves to show the capabilities in an USACE environment while delivering on a functional requirement and to achieve a first success which should solidify management support. At the same time it allows the beginning of staff training and provides a set of lessons learned for the larger implementations to follow.

3-12. Staffing GD&S Positions

USACE Commands will not create new positions to support the requirements of ER 1110-1-8156. However, as GD&S

technology advances within the organization and becomes an integral part of conducting the mission, GD&S skills will become part of many job descriptions. This section provides some guidance on GD&S staffing.

Currently there are no formal GD&S titles in the Federal Civil Service; however, it is not uncommon to include specific GD&S skills in position descriptions or even to use informal titles, such as GIS Specialist, in job announcements. There have been attempts to develop them in the past with no success and there is unlikely to be success in the current environment which emphasizes general categories to promote staffing flexibility. A logical set of titles, grades and responsibilities is listed in Table 3-1. Representative paragraphs that may be adapted and inserted into job descriptions for GD&S-related positions are provided in sections 10.a-10.c of this manual.

a. GD&S Supervisory Position Skills. Oversees the development and use of the GDS to support the planning, design, operation and maintenance efforts of the USACE Command. Based on professional knowledge of the needs of the Command and an in-depth knowledge of the use and application of the GDS, advises and assists the Command management and GD&S committees, engineering and associated staff in the Command as to the uses of the GDS in the various Command activities.

(1) Monitors GDS function to determine problems and solutions. Keeps up-to-date on software and hardware availability and changes. Applies in-depth knowledge of the hardware and software to determine specific uses of the system and to establish procedures and policies for usage. Examines new applications software and hardware developments and assesses their use and cost effectiveness; initiates actions to purchase, when appropriate. Analyzes work for which software does not exist or where programs do not meet local needs, and determines feasibility of preparing local applications.

(2) Establishes procedures for use of equipment and software and updates as changes occur or as needed to correct problems. Recommends specific actions, policies, and procedures for supervisory/management review, approval and implementation. Maintains liaison with Command Systems Manager and advises manager on technical matters for contract actions involving GDS applications or requirements. Reviews comments on GDS applications and recommends changes in Command GDS policy.

(3) Recommends, coordinates, and schedules GDS training for Command employees. Provides specialized in-house training to GDS users. Maintains status report, software documentation, and GDS supplies.

(4) Participates in internal technical planning meetings and meetings with representatives from other USACE Commands for purposes of technical coordination. Participates in negotiation with universities and other research organizations for performance of contract work, in review of contract work, and in integration of services obtained.

b. GD&S Analyst Skills. Is responsible for planning and executing studies relating to the characterization of physical and cultural attributes of environments for use in USACE civil works projects and military activities/ operations. Duties and responsibilities require a knowledge of and experience with GDS, computers, the geographic sciences, and digital geospatial data processing. Must be able to design and build new GDS applications using commercial software tools. Provides expert knowledge to other engineers and scientists (e.g., geologists, geographers, hydrologists, mathematicians, ecologists, and physicists) in setting up and conducting programs and projects and in the presentation of technical data. Formulates conclusions from spatial analyses to supplement that of the lead scientist.

(1) Plans and directs field studies to collect data to determine the quantitative relation between various environmental factors and components of structural and nonstructural alternatives for civil works and military projects. These studies include on-site data acquisition, airborne remote sensing missions, use of conventional surveying techniques, and use of automatic sensing and recording instrumentation.

(2) Participates in the direction of office studies, negotiates with other offices (USACE Districts and Divisions, U.S. Department of Agriculture, USGS, etc.) and organizations such as universities, research institutions, and commercial concerns, for existing information or cooperative work relying on own professional skills to review, interpret, and analyze information; formulate approaches; reach conclusions; and make recommendations. Develops methods and performs studies involving the comparison of geographical regions and specific sites for the purpose of determining degrees of analogy. Designs and develops computer programs to reformat acquired data as necessary for import into host GDS. In support of these and other studies develops and applies computerized methods for best portrayal of environmental data.

(3) Performs administrative duties appropriate for the technical work described, directs the work of professional and nonprofessional employees as assigned for accomplishing the work of assigned projects. Makes assignments and instructs employees of lower grade and checks performance for quality of work and rate of performance; is responsible for knowledge and observance of all regulations applicable to the work described.

Table 3-1
Sample GD&S Responsibilities

Title	Grade	Representative Responsibilities
GD&S Manager	GS 11-12-13	GD&S POC. Coordinates the GD&S efforts within the USACE Command. Serves as technical advisor to the Oversight Committee. Permanent member of the Technical Committee.
Geospatial Data Manager	GS 7-9-11-12	Maintains metadata and data for the Clearinghouse. Responsible for establishing and maintaining a geospatial data archive and library. Designs and constructs new databases. Provides recommendations on database issues to Technical Committee and GD&S Manager.
GD&S Spatial Analyst	GS 7-9-11-12	Uses GD&S technology to design and produce decision support products. Customizes and uses GDS tools to analyze spatial data of various types. Formulates conclusions from this analysis and recommends additional analyses to help further refine solutions.
GD&S System Operator	GS 7-9-11	Uses GD&S technology to produce decision support products. Knowledgeable of capabilities and operation of GDS. Constructs new databases. Customizes commercial GDS to perform specific applications. Oversees activities of GD&S Technician.
GD&S Technician	GS 5-7-9	Knowledgeable in the operation of GDS products. Operates peripheral devices to build and maintain geospatial databases.

c. GD&S Operator Skills. Is responsible for assisting in the planning and executing studies relating to the characterization of physical and cultural attributes of environments for use in USACE civil works projects and military activities/operations. Duties and responsibilities require a knowledge of and experience with GDS, computers, and digital data processing to acquire, store, retrieve, and display data in a form best suited to the user's needs. Must be able to design and build new GDS applications using commercial and custom software tools. Works cooperatively with other engineers and scientists (e.g., geologists, geographers, hydrologists, mathematicians, ecologists, and physicists) in setting up and conducting programs and projects.

(1) Plans field studies to collect data to determine the quantitative relation between various environmental factors and components of structural and nonstructural alternatives for civil works and military projects. These studies include on-site data acquisition, airborne remote sensing missions, use of conventional surveying/ techniques, and use of automatic sensing and recording instrumentation.

(2) Participates in the direction of office studies, negotiates with other offices (USACE Districts and Divisions, Natural Resources Conservation Service, U.S. Department of Agriculture, U.S. Geological Survey, etc.) and organizations such as universities, research institutions, and commercial concerns, for existing information or cooperative work relying on own professional skills to review, interpret, and analyze information; formulate approaches; reach conclusions; and make recommendations. Develops methods and performs studies involving the comparison of geographical regions and specific sites for the purpose of determining degrees of analogy. Designs and develops computer programs to reformat acquired data as necessary for import into host GDS. In support of these and other studies develops and applies computerized methods for best portrayal of environmental data.

(3) Performs administrative duties appropriate for the technical work described, directs the work of professional and nonprofessional employees as assigned for accomplishing the work of assigned projects. Makes assignments and instructs employees of lower grade and checks performance for quality of work and rate of performance; is responsible for knowledge and observance of all regulations applicable to the work described.

d. GD&S Technician Skills. Is responsible for assisting in the conduct of studies relating to the characterization of physical and cultural attributes of environments for use in USACE civil works projects and military activities/operations. Duties and responsibilities require a knowledge of and experience with GDS, computers, and digital data processing to acquire, store, retrieve, and display data in a form best suited to the user's needs. Works cooperatively with other engineers and scientists (e.g., geologists, geographers, hydrologists, mathematicians, ecologists, and physicists) in conducting programs and projects and in the interpretation, analysis and presentation of technical data.

(1) Participates in GD&S studies within the USACE Command. Assists in the interpretation and analysis of information; helps to formulate approaches and reach

conclusions; and makes recommendations. Helps to develop methods for performing studies involving the comparison of geographical regions and specific sites for the purpose of determining degrees of analogy. Writes computer programs to reformat acquired data as necessary for import into host GDS. In support of these and other studies, applies computerized methods for best portrayal of geographic data.

(2) Operates a GDS. Builds geospatial databases to specification by using a GDS application to enter coordinates and attribute data, operating a scanner, or other computerized method. Recommends improvements to the data entry system.

3-13. Training GD&S Staff

Required training in the GD&S area of expertise has not yet been formalized. The field is still evolving and academic studies have shown that curricula vary greatly. In general, the requirement is training in a field with a spatial component (e.g., geography, cartography, remote sensing, civil engineering, biology, oceanography, urban and regional planning, agronomy, forestry, landscape architecture, or geology) and course work in GD&S topics. In the present environment the progression is like the apprentice, journeyman, master sequence in the crafts.

3-14. Training Sources

There are a number of sources for GD&S training which make entry into the area and continuing education readily available.

a. USACE Training. The Training Symposium on Surveying, Mapping, Remote Sensing and Geographic Information Systems is sponsored by Headquarters USACE to transfer new technology developments to USACE users. This symposium is held every three years and provides short courses, plenary sessions and technical sessions. Exhibits of commercial and USACE capabilities are provided. Announcement of the symposium is made by a memorandum from HQUSACE (CECW-EP).

The Proponent Sponsored Engineer Corps Training (PROSPECT) Program courses are developed to meet unique USACE training needs. They are taught by USACE employees or by contractors and some provide continuing education credits. Of particular interest is a course entitled "GIS Introduction." The POC for PROSPECT courses is:

Commander
U.S. Army Engineering Support Center, Huntsville
ATTN: CEHNC-TD-RG (Registrar)
P.O. Box 1600
Huntsville, AL 35807-4301

GRASS Conferences and Courses provide instruction on the operation of the GRASS GIS developed by the Construction Engineering Research Laboratory. The POC for GRASS Conferences and Courses is:

Center for Remote Sensing and Spatial Analysis
P.O. Box 231
College Farm Road
Cook College
Rutgers University
New Brunswick, New Jersey 08903
coneil@ocean.rutgers.edu

b. Other DoD Training. The Defense Mapping School at Fort Belvoir, Virginia has several courses related to GD&S technologies including database production, remotely sensed imagery, GIS, cartography, and an introductory ARC/INFO course under development. The POC for the Defense Mapping School is:

Director
Defense Mapping School
ATTN: HR-DMSO
Fort Belvoir, VA 22060-5828

Training is also available through the Tri-Service CADD/GIS Technology Center and the CAD2 Contract. The POC is:

Tri-Service CADD-GIS Technology Center
U.S. Army Engineer Waterways Experiment Station
ATTN: CEWES-ID-C
Vicksburg, MS 39180-6199
601-634-2945

c. Universities. Hundreds of universities are now offering GDS programs usually integrated with a well established academic department such as geography, geology, forestry, civil engineering, or agronomy. Many universities also offer GD&S short courses. A listing is available in *Directory of Academic Departments Offering GIS Courses* published by The American Society for Photogrammetry and Remote Sensing (ASPRS) and the American Congress on Surveying and Mapping (ACSM).

d. Vendors. Vendors provide training in the operation of hardware and software as opposed to universities that emphasize concepts and applications to problems. This training may be acquired as part of a GDS procurement or through user groups and workshops.

e. Professional Meetings, Conferences and Symposia. Many professional organizations conduct technical meetings and offer workshops and training in GD&S technology arena. A few are listed below:

The American Congress on Surveying and Mapping (ACSM), Suite 100, 5410 Grosvenor Lane, Bethesda, MD 20814-2122

The American Society for Photogrammetry and Remote Sensing (ASPRS), Suite 210, 5410 Grosvenor Lane, Bethesda, MD 20814-2160

Automated Mapping/Facilities Management International (AM/FM), 14456 East Evans Avenue, Aurora, CO 80014-1409

The Association of American Geographers (AAG), 1710 Sixteenth Street, NW, Washington, DC 20009-3198

The Urban and Regional Information Systems Association (URISA), Suite 304, 900 Second Street, NE, Washington, DC 20002

The five professional organizations listed above jointly sponsor an annual meeting known as GIS/LIS. This large national meeting is designed to be an interdisciplinary educational and scientific meeting which promotes interaction among individuals and groups interested in the design and use of GIS, LIS, and related specialties and technologies. GIS/LIS workshops are taught at introductory and advanced levels and address a range of technical and managerial topics. Exhibits provide a chance to interact with vendors and learn about product enhancements and revisions and make near-direct comparisons among different products and thus save considerable time and effort if you are shopping for software, hardware, or services.

There are also Federal Government and State Government conferences which are dedicated to GIS such as the Federal Geographic Technology Conference, Exposition, and DataMart, the National Geodata Policy Forum, and the National GIS Council (NSGIC) Annual Meeting

Chapter 4
Requirements Analysis

4-1. General

a. Geospatial Data Systems are successful only when they comprehensively and consistently meet the needs of users. As such, the procurement, installation, and use of a successful GDS depends on well-defined user requirements obtained through a development stage known as requirements analysis. Requirements analysis is a detailed study of the needs of potential users of the GDS which helps cut down the costs of acquiring and maintaining a GDS. The requirements obtained during this study may come from a variety of sources including system operators, domain experts (someone with an in-depth knowledge of the functional area), requirements and software engineers, managers, existing systems and standards, specifications, and any other potential users. When completed, the requirements analysis should result in a clear statement of end-product characteristics, required production rates, estimated data volumes, and a cost/benefit rationale.

b. The documentation required to justify and validate the acquisition of Automated Information System (AIS) hardware and/or software is currently in transition between the General Services Administration (GSA) and the Office of Management and Budget (OMB). It is anticipated that policy and direction down to MACOM level will not be received until the Fall, 1996. Project Managers should contact their local Director or Chief of Information Management for guidance and assistance in the required documentation. Experience has shown that a more rigorous requirements definition is needed for GDS.

4-2. What is a Systems Requirements Analysis?

a. This section defines a systems requirements analysis and explains many of the elements of a good requirements analysis. GD&S require data to operate, so a separate, but similar, data requirements analysis is needed to ensure that the system has the data sets needed to perform the specified functions. The data requirements are discussed in detail in Chapters 7 and 8 of this manual.

b. The earliest stages of the system development cycle should involve information gathering about the system to be procured. A committee determines the GD&S needs of each potential user through written, verbal and face-to-face contact. These needs or requirements can include anything from types of data the GDS can handle to necessary product output types. Once the requirements have been gathered and compiled into a manageable set, they form the basis for a System Requirements Specification (SRS) which is used to determine all the external features of the GDS. Requirements analysis is the activity of understanding the application domain, the specific problems and needs of the users, and the constraints upon possible solutions. When a requirements analysis is done properly, it is possible to match the description contained in the SRS to several systems and pick the GDS which best suits all the users in the agency.

c. One of the misconceptions about requirements analysis is the “what versus how” dilemma. A requirements analysis study should only include any external behavior of the GDS, however, many people tend to confuse the external and internal behaviors and try to describe not only their needs but also how the system should solve those needs. The “how” aspect of the system should be left to the design phase of the development cycle which comes after the requirements analysis has been completed. GDS system requirements are capabilities needed by users to solve GDS problems (e.g., performing a site suitability analysis which involves graphical and textual data and multiple maps with differing projections), and these requirements must be met by a system component (e.g., computer system, software, data, etc.) in order to satisfy a contract, standard, or system specification. System requirements can be broken down into seven main categories:

- Functional requirements specify transformations that take place in the software system (i.e., the inputs and outputs for each function).

  Example: The software shall identify all overshoots and undershoots by placing a box around the dangling end of each line segment.

- Behavioral requirements specify the way the system reacts to external and internal stimuli (i.e., what causes certain activities to start, stop, etc.).

  Example: The program shall pause and return to the previous condition when the *escape* key on the keyboard has been depressed.

- Performance requirements specify timing, throughput, and capacity of the system.

  Example: The system shall be able to return the geographic location of any address in under 3 seconds.

- Operational requirements specify how the system will run and communicate with its human users.

Example: The system shall provide a help facility, accessible from software, that describes the system components.

- Interface requirements specify characteristics of the human/computer interaction, such as screen layouts and validation of user data entry. In the case of system, an interface requirement can also specify hardware interfaces.

Example 1: Error messages must be displayed on the screen starting at row 1, character position 1.

Example 2: The system must be targeted to run on Sun workstations with the Solaris 2.1 Unix operating system.

- Quality Requirements specify system reliability, useability, and maintainability.

Example: The system must not fail more than 3 times during 1,000 CPU hours of operation.

- Constraints specify restrictions that impact the system in some way.

Example: Each line segment will be limited to 255 coordinate pairs.

d. In addition, there can also be security requirements when the system is going to be working with classified data and data requirements dealing with the validation and accuracy of the data sets passed to the system.

e. When the task of gathering the system requirements is over, it is important to sort through them to build a manageable set for the SRS. You will probably find that many requirements have been repeated several times although they may be worded differently. Others may be ambiguous, needing additional input from the source of the requirement. The Carnegie Mellon Software Engineering Institute has developed guidelines for generating such manageable sets. In these guidelines, they describe the seven requirements error types to watch out for when organizing the requirements set:

- System requirements are ambiguous if there is more than one interpretation. Ambiguity arises due to the pitfalls of natural language.

Example: Total item count is taken from the last record.

Problem: How do you interpret last record?

- System requirements are incorrect if some fact within the requirement has been misrepresented.

Example: For all computations, use the northwest corner as the origin of the data set.

Problem: What if the southwest corner were the origin for some of the data sets?

- System requirements are incomplete if one or more necessary facts (or requirements) have been omitted.

Example: Error messages must be displayed on row 24 of the terminal screen.

Problem: How will the system display multiple, simultaneous error messages?

- System requirements are inconsistent if they are in conflict.

Example: C must be computed as A + B
C must be computed as A - B

Problem: C has two definitions.

- System requirements are volatile if they are susceptible to change.

Example: The system shall handle only one data set at a time.

Problem: Although this may satisfy current needs, what happens if you need to work with multiple data sets simultaneously?

- System requirements are untestable if no cost-effective way exists to verify them.

Example: The system shall have a good user interface?

Problem: There is no way to define a "good" interface, so there is no way to verify it.

- System requirements are nonapplicable if they are not relevant to the problem.

Example: The operator of the system must be standing upright during operation of the system.

Problem: This requirement has nothing to do with the development or procurement of the system.

f. These guidelines should help throughout the systems requirements analysis process. The requirements analysis is described from start to finish in Chapter 4. Remember, that once you have formulated an SRS from your requirements set, it should be used as a "bible" from which a GDS will be procured. The SRS can help identify potential errors before they become costly to fix, so you should treat this stage in the GDS life cycle with the utmost importance.

4-3. Why is Requirements Analysis Important?

A requirements analysis can appear to be an overwhelming task to complete for a Command-wide GD&S procurement. However, the benefits of performing a comprehensive analysis prior to system acquisition are well-documented and easily justify the effort.

Errors are much easier and less costly to correct when they are detected early in the development stage rather than later on. The reason for this is that one component in a system will often build upon the capabilities of another until you have a fully-integrated system. In any failed system development, it can be demonstrated that when one component is missing certain required capabilities, this problem will propagate itself through the rest of the system. Other components will not be able to meet certain needs, and so on with a cumulative effect on the entire system. This lesson is equally true for an "off-the-shelf" GDS and a custom-developed GDS.

The document most often used to record the system requirements is the System Requirements Specification (SRS). It clearly explains every detail of the system without ambiguity or error, so that the buyer can make intelligent choices about the system to be procured. In addition, this document also serves as contract between the buyer and developer/supplier; the GDS is not complete until the developer/supplier has met every requirement contained in the SRS.

4-4. Who Should Perform the Requirements Analysis?

In "A Process for Evaluating Geographic Information Systems," Guptill writes:

The first problem faced by any organization considering the implementation of a [GD&S] is to determine who should perform the requirements analysis. Requirements Analysis' for successful [GD&S] installations have been performed by in-house staff, contractor staff, or through a combination of both approaches. There are many valid reasons for opting for any given approach, however, the desired result is the same, to develop a comprehensive assessment of the analytical capabilities and products required by potential [GD&S] users. The requirements of the users can then be matched with system capability to determine optimal configurations for the organization's [GD&S] procurement. In-house staff inherently have a greater understanding of the tasks which are to be considered for automation through [GD&S] technology. This unique knowledge may justify training staff members in [GD&S] technology and requirements analysis techniques so that the requirements analysis may be performed in-house. In cases where existing staff members have expertise in GD&S's there may be little reason to consider bringing in outside assistance.

When staff time or skills are not available, or when new programs and concepts are being proposed that staff is not experienced with, outside resources may be required to perform the requirements analysis. Assistance may also be available from resources within the parent agency of the organization considering the [GD&S] implementation. Assistance in developing Requests for Proposals (RFPs) for requirements analysis services may similarly be available within the agency.

The important element in determining who should perform the requirements analysis is assuring that the provider of the service has a thorough understanding of both [GD&S] technology and the operations of the organization. When an outside organization is brought in to perform the requirements analysis, it is the responsibility of the technical representative or point of contact for the requirements analysis services procurement to assure that the contractor fully understands the organization's products, services, missions, and needs.

Possible conflicts of interest should also be considered before a final determination is made as to who should perform the requirements analysis. Organizations and individuals may, in some instances, have a vested interest in certain hardware or software types, and may be inclined, whether intentionally or unintentionally, to bias the results of the requirements analysis toward particular systems. The objective of the requirements analysis is to identify the needs of an organization and then to select the [GD&S] that best fits those needs, if such a system exists. All reasonable effort must be made to assure this goal is realized, including assessing possible conflict of interests, or biases, on the part of persons or organizations that potentially could perform the requirements analysis.

4-5. Performing a Requirements Analysis

The purpose of this section is to lay out a generic framework for performing a requirements analysis with some key tips where appropriate.

a. Elicitation. The first step in performing a requirements analysis is to obtain system requirements from all persons involved with the use of the GD&S system. This step, known as requirements elicitation, can involve any of the following activities:

- Interviewing.
  - Face-to-face contact with potential users, manager, etc.
  - Should identify relevant positions from a formal organizational chart.
  - Identify the work flow interactions between users and the rest of the organization.
  - Ask context free questions such as:

    "Who else should I talk to?"

    "Who else may use the system?"

    "Who else interacts with you?"
  - Inform interview candidates ahead of time and give them any relevant material.
  - Secure an adequate time commitment from candidates.
  - Give the person reasonable courtesies in terms of answering your questions.
  - Periodically confirm your understanding of the person's responses.
  - Summarize your understanding at the conclusion of the interview.
- Brainstorming.
  - A simple technique for generating ideas.
  - Can be used for generating alternate viewpoints of the problem.
  - Works best with groups of 4-10 people.
  - Outcome depends on the expertise and knowledge base of the participants.
  - Generation phase: a leader provides a seed expression to the problem.
  - Generation phase: participants freely generate ideas relevant to the problem.
  - Generation phase: all ideas are placed on a large board or sheets of paper.
  - Generation phase: should be stopped when ideas become low (~ 15-20 min.).
  - Consolidation phase: ideas evaluated, outliers removed, related ideas combined.
  - Consolidation phase: remaining ideas are grouped and classified.
- Scenario generation.
  - Determine needs through real world system usage scenarios.
- Rapid prototyping.
  - Quick user interface or basic system shell construction.
- Modeling.
  - System portrayal through means such as data flow diagrams.

b. Analysis. The next step in the process is to organize the information received from the elicitation process. At this stage you want to remove any requirements errors you can find by looking for ambiguities, inconsistencies, and any of the other seven requirements errors previously mentioned. You also want to remove any requirements which are duplicates. The main goal here is to build an organized set of requirements that clearly state the system and its behavior with as few requirements as possible. If additional information is required, you should go back to the elicitation stage before continuing, because you will need the final requirements set before determining feasibility.

c. Feasibility. It may or may not be possible to procure a system with all the capabilities requested by users, so you must next perform a feasibility analysis. During this phase, it is a good idea to conceptually plan the system without getting into too much detailed design. You should also speak to representatives of commercial GDS vendors to discuss your requirements and how their systems could be used to meet them. System modeling through data flow diagrams, decision tables and trees, and control flow diagrams is a good way to visualize the system from the given requirements set. Matching the capabilities of possible GDS solutions against these models will give you an understanding of what will be required to build the necessary GDS, either as a custom software development or as a customization of a commercial GDS. If specific requirements are making the GDS too expensive or risky to build, you must decide whether or not to write the SRS and have the system developed as-is or to eliminate the infeasible requirements.

d. Specification. Without an SRS, the contractor/in-house development team would have no idea of what was to be built, your users would be left with false expectations of the GDS, and there would be no way to test if the solution meets all the needs captured during the elicitation and analysis phases. Therefore, you must document the external behavior and qualities of the system while excluding any internal information concerning how the software and hardware operates and the algorithms it uses. The SRS has four roles in the development life cycle: (1) it is the primary input to the design team; (2) it is the primary input to the system test planners; (3) it controls the evolution of the system; and (4) it communicates an understanding of the system requirements. The SRS should be understandable to anyone who reads it regardless of their background, and should contain the following qualities:

- An SRS is correct if every requirement stated therein helps to satisfy a user need.
- An SRS is complete if every user need is satisfied by a system that satisfies every requirement in the SRS.
- An SRS is unambiguous if every requirement stated therein has only one possible interpretation.
- An SRS is consistent if no subsets of the requirements stated therein conflict.
- An SRS is logically closed if it specifies a response for every conceivable stimulus in every conceivable state.
- An SRS is organized if its readers can easily locate information.
- An SRS is modifiable if it can be easily changed when errors are found, or when it needs to be changed due to changes in requirements.
- An SRS is traced if the origin of each of its requirements is clear.
- An SRS is traceable if other documents can reference its requirements easily.
- An SRS is concise if it cannot be made shorter without jeopardizing other qualities of the SRS.
- An SRS is verifiable if there exists a finite, cost effective technique to check that each requirement in the SRS is satisfied by a system.
- An SRS is annotated by importance if the relative importance of each requirement is indicated.

4-6. Performing a Data Requirements Analysis

For most GD&S, the data are the largest cost component, often eclipsing the cost of the hardware and software combined. It is critical that they be properly managed from initial design to long-term archive. The data requirements analysis is the first step in building or acquiring a geospatial database. It is used to both define the content and format of the data as well as to inform potential users of the intent to acquire/produce the database. It is conducted similarly to the system requirements analysis, with the objective of establishing the minimum set of requirements that will meet the near- and long-term needs of the users. It should establish the database:

- Structure.
- Content.
- Scale/resolution.
- Accuracy.
- Currency.
- Any special user requirements.

a. Structure. The structure of the database defines its basic makeup. The two most common geospatial database structures are vector, such as road networks or engineering drawings, and raster, such as gridded elevation matrices or digital imagery.

The database structure is established by the application(s) of the database and the systems that will be used. Applications that involve detailed analysis of lineated features, such as road or stream networks, require attributed vector databases. Raster databases are ideally suited to applications that involve the boolean combination of areal, layered information. The computation of cross-country mobility, which is a function of ground slope, surface roughness, vegetation coverage, and other terrain characteristics, is an example of a query that is often performed using raster databases. The structure of the database should be determined very early in the requirements analysis.

b. Content. The content of the database is determined by the applications for which it will be used. If the database has a vector structure, then it is necessary to determine the specific inclusion criteria for features and attributes. For example, if roads are required, to what level (highway versus dirt cart path), and how richly must they be attributed (e.g., surface material, number of lanes, whether the road has a median, whether the road access is controlled, whether the road is one-way or two-way, etc.)? Collecting unnecessary features and attributes adds to the cost of the database, so it is important to establish the minimum set of features and attributes that satisfy all user requirements.

If the database has a raster structure, then the thematic layers must be determined. Raster databases may have only one layer, such as a digital image, or it may have many layers, such as those needed for the cross-country example discussed above. As with vector databases, increasing the information carried in a raster database increases the cost of production, distribution, and archive, so it is important to establish the user requirements early in the design.

c. Scale/Resolution. Scale refers to the collection scale of vector databases. A collection scale of 1:24,000, for example, implies that the vector database has a feature content that is roughly equivalent to a hardcopy USGS 7.5-minute Quadrangle. Resolution refers to the size of the pixels in the layer(s). Resolution may be expressed as a distance on the ground (e.g., 10 meters) or as is common for raster databases produced by scanning hardcopy products, pixels per inch (e.g., 300 dpi). The scale/resolution has a significant effect on the ability to perform certain types of queries; a database with insufficient scale/resolution may preclude analysis at the level of detail required, but a database with an excessive scale/resolution is more expensive to build and has a negative impact on storage volume and processing times.

d. Accuracy. The accuracy of a database refers to several factors, including coordinate accuracy, attribute accuracy, logical consistency, and completeness.

(1) Coordinate accuracy. Coordinate accuracy refers to the accuracy, expressed as a distance and a confidence factor, of the geographic positions in a database. The coordinate accuracy of a database is influenced by, but not controlled by, the scale/resolution.

(2) Attribute accuracy. The attribute accuracy reflects the confidence in the codes and attribute values assigned to features in a vector database.

(3) Logical consistency. Logical consistency is a measure of the relative positioning of features in a vector database. An example of a break in logical consistency is a building captured on the wrong side of a road. While both the road and the building may be within their allowed coordinate accuracies, their relative positioning is not consistent. Logical consistency is most often expressed as the percentage of features that are consistent with all surrounding features. SDTS expands this definition to include the general fidelity of the data capture, considering such factors as the presence of overshoots and undershoots, topological integrity, and graphic presentation.

(4) Completeness. Completeness refers to the percentage of features in the real world that are captured in the database, within the capture rules of the particular database. Completeness, which deteriorates over time as new features are added to the real world, is measured at the time of database construction.

e. Currency. The currency of the database refers to the elapsed time since collection of the source material. Areas change at different rates, e.g., cultural features in suburban areas change much more rapidly than in sparsely populated regions, so currency requirements for databases often vary according to the area being captured.

f. Special user requirements. This section of the requirements analysis captures any unique needs for the database. These might include: on-line access to the database by the users, unique archive requirements, or special services such as on-demand datum or coordinate transformations.

Chapter 5
Implementation Plan

5-1. Introduction

a. It is a requirement that all USACE Commands develop and maintain an individual multi-year GD&S Implementation Plan (IP) for purchases of dedicated GD&S hardware and software systems. Some USACE Commands have developed and maintain implementation plans. One example is available on the Internet at Universal Resource Locator (URL) http://corps_geo1.usace.army.mil. Some of the considerations used by the Commands in developing their IP's includes: resolution, format and use of presently encoded data; anticipated needs for future data and a GD&S model; compatibility of systems division-wide; Information Management support needed; coordination of GD&S needs and uses across disciplines (e.g., Real Estate, Engineering, Planning and Construction, Operations); and costs.

b. Development and execution of a GD&S Implementation Plan is necessary in order to guarantee the successful and effective installation of a GD&S. In order to reduce risks and minimize excessive costs and redundancy, a comprehensive design and timeline must be created in order to reduce the likelihood of failure. A three to five year timeline driven by specific performance milestones and pilot projects assures progress and manageability. Even if the IP is not acted upon, the document will serve as an informative report on user needs and may benefit other agencies interested in implementing a GD&S.

c. Figure 5-1, taken from an Environmental Protection Agency (EPA) system design (EPA 1993), illustrates the time and resource savings that can be achieved if a system has been properly engineered, such as with an implementation plan. Long-term maintenance costs will be reduced and system implementation will require fewer resources and cost less. The development of an IP will increase costs in the short run, but during a three to five year life cycle, the cost savings during implementation and maintenance will be significant.

5-2. GD&S Implementation Plan Contents

The following sections describe the required content and recommended format of a GD&S Implementation Plan (IP). USACE commands may reformat the IP at their discretion but must include the required information.

a. Background. The background section of the IP summarizes the objectives of the GD&S Implementation Plan and explicitly states the need to execute this IP consistently and comprehensively. This section should also provide examples of the positive impacts of implementing this IP.

b. Scope.

(1) General.

This section of the IP provides some general information of GD&S technology and its application. The following is adapted from existing USACE GIS Implementation Plans:

GD&S is a powerful tool for combining a variety of data types into a common format. The system will speed any analyses that use spatially referenced data by automating processes that were often done by hand. Due to improved technology more information can be managed and manipulated. The sophistication of the analyses that now can be performed is enhanced over what can be achieved using only printed maps. Immediate updating of map files, viewing of multiple classes of information, and iterative “what if” analyses are a small sampling of the available capabilities.

All disciplines in the District must work cooperatively to share geospatial data whenever possible. Increased awareness of data availability and greater sharing of data between disciplines reduces the potential for loss of valuable data (e.g., “old” aerial photos or maps) and reduces costly replication of data collection. The most cost- effective approach to the development and use of a District-wide geospatial data inventory involves consideration of uses for each geospatial data set by the community of potential users, avoiding a limited purview engendered by looking at single applications. Data created by one corporate entity should be available for sharing with all spatial data users within the District or by District customers. Use should not be restricted or precluded by file format, operating system, object description incompatibilities, and so forth.

(2) Existing uses.

This section of the IP will list and describe current GD&S systems implemented and will discuss their individual strengths and weaknesses. Each GD&S description will include whether the data is raster or vector based, what the data sources are, what analyses are exercised, and what modeling is done. In addition, report on the current status of the GD&S in regard to its implementation plan and whether the GD&S has been effective.

(3) Future uses.

This section of the IP provides examples of current projects that could profit from the technologies of a GD&S. Include projects that handle large amounts of data that could be analyzed more effectively in a geographical environment. Describe the needs or potential needs of the project and then show how GD&S technology could simplify and enhance the capabilities of the project.

(4) Needs assessment.

The needs assessment section of the IP lists and prioritizes the requirements presented in Sections 5-2.b (2) and (3) and describes what GD&S solutions would meet the requirements. Assess the requirements and describe the potential benefits of implementing a GD&S in these environments. Multiple sites can find great benefit in sharing data across networks and therefore reducing overall cost.

(5) Communication.

This section of the IP discusses how the GD&S technology and capabilities will be brought to the field through communication. Modes of communication will be compared based on availability and ease of use and may include newsletters, electronic mail, etc.

(6) Awareness of technology.

This section of the IP discusses the importance of the awareness and education of decision-makers of the technology and benefits of GD&S. Awareness may be spread through the use of video tapes, demonstrations and seminars.

c. Design guidance.

(1) Hardware.

The hardware section of the IP presents standards and requirements that restrict the selection of GD&S hardware. Describe the federal and industry-wide standards (GOSIP, POSIX, etc.) that may be relevant. Make sure the standards that are imposed on the GD&S hardware are necessary and appropriate in the light of standards being modified regularly. The major aspect of a GD&S system that must be standardized is the protocols and transports it uses to communicate with other systems or networks. Attention should be given to how well the hardware will fit with existing systems and how well the hardware can be maintained and upgraded. HQUSACE can provide numerous examples of GDS that became dependent on hardware platforms that were obsolete before the system was fully operational.

The decision to implement a multiple system (networked, redundant CPUs) solution or a single (stand-alone) system solution will be made based on the system's user load, throughput, and the requirements for reliability. Multiple system implementations allow more users to be online simultaneously and still perform complex spatial analyses. If a single CPU fails, the multiple system solution will allow continued operation with low to medium effect on processing times. Multiple systems can also effectively share hard disks for storing large databases. However, successfully maintaining multiple systems require additional labor for administration, which can be costly and will demand more strict system resource procedures.

The single system is a simple and cost-effective solution, but it has many drawbacks. On the plus side, the single system features lower maintenance requirements. However, the dependence on a single machine can be disastrous if a system failure corrupts data or delays time-critical projects. The single system limits the number of users that may use the GD&S drastically; in many cases only one user may effectively use the system at one time.

The specific hardware platform that is chosen will depend on the system requirements. A single-user single machine system should use a low-cost solution, such as a 586-based PC configured with at least 16MB RAM and a 500MB hard drive. This system may run using either DOS/Windows or OS/2 and will provide impressive performance for the price. However, if user requirements specify the need to access information from other Districts or from other sources on the Internet and require multiple users, then a UNIX based hardware platform is the best solution. A minimum configuration would be a Sparcstation 20 with 32MB RAM and a 1 GB hard drive. Additional peripherals should be added to each system, such as backup drives, CD-ROM drives, digitizers, scanners and printers.

(2) Software.

The software section of the IP presents standards and requirements that restrict the selection of GD&S software. Describe important capabilities that are required for the proposed GD&S. Issues involving raster and vector compatibility, interoperability with CADD systems, data exchange with cooperating agencies, and importing important nationwide databases should be addressed.

(3) Data formats.

The data format section presents standards and requirements that restrict the selection of GD&S data formats. Discuss data format conversion for importing and exporting data with cooperating agencies and potential users. Describe the different formats that the GD&S will be able to input and output.

(4) Connectivity.

This section of the IP presents standards and requirements that restrict the selection of GD&S networking protocols and transports. This may be done by standardizing on a particular operating system and networking protocol, such as Unix/NFS/Ethernet. This section will also mention the importance to be able to share data with important data sources or other systems that may not be GD&S. An important example would be the capability to connect a raster-based GIS to a vector-based CADD system.

d. Data management.

(1) Data access and exchange.

This section of the IP discusses how data will be accessed and exchanged within the GD&S and with outside organizations.

(2) Data exchange formats.

This section of the IP discusses what formats will be used for data exchange with an emphasis on compatibility and minimizing data loss. The implementation of the Spatial Data Transfer Standard (SDTS) will be addressed also.

(3) Data stewardship.

The data stewardship section of the IP discusses the importance of the centralized database stewardship and how that improves security and minimizes data misuse.

(4) Data maintenance.

This section of the IP discusses who will be responsible for data security, data backups and data updates for each database. Specific procedures and equipment for data backup shall be addressed.

(5) Data archiving.

In this section the IP will discuss the standard operating procedure for performing routine daily and weekly data and system backups.

(6) Data quality.

This section of the IP discusses how quality assurance and quality control will be maintained for each database. Data acquisition standards and procedures will be addressed. Data sources may provide data in non-standard formats which will require that a standard format will be defined along with a procedure to convert all incoming data to the standard format. The standard format for data exchange is the SDTS. It specifies exchange constructs, addressing formats, structure, and content for spatially-referenced vector and raster (including gridded) data.[1]

e. Scope of existing and proposed systems.

(1) Existing systems.

This section of the IP will give detailed system configurations of each currently existing GD&S or related system. The list of system hardware should include workstation name and type, memory installed (RAM), secondary storage devices, tape backup devices, input devices (mouse, tablet, digitizer, scanner), and printers. Describe the operating environment and the networking protocols be used. List all the GD&S related software installed on the computer, including databases.

(2) Pilot projects.

This section of the IP will discuss all pilot projects that have been done or are being planned. The projects will be used to generate a list of lessons learned and a list of additional requirements for the proposed GD&S. Describe what GD&S was used and evaluate the system for its effectiveness.

(3) Proposed systems.

This section of the IP will describe what the proposed system hardware and software configurations will be for the GD&S and how these decisions were made. Pilot Project evaluation is an important step in formulating a wise system configuration.

f. Life cycle costs and justification.

(1) Hardware costs.

This section of the IP will discuss the costs involved in acquiring the hardware for the proposed systems. Hardware costs include the cost of the central processing units, monitors, keyboards, input devices, digitizers, modems, network connections, secondary storage devices, tape backup systems, printers, scanners and other non-standard hardware peripherals.

(2) Software costs.

This section of the IP will discuss the costs involved in acquiring the software for the proposed systems. Software

[1] Paraphrased from the Spatial Data Transfer Standard (FIPS 173) Fact Sheet, July 1994.

costs include operating system support, GD&S software (i.e., Microstation, ERDAS, ARC/INFO, GRASS), database server software (i.e., ORACLE, Informix) and software maintenance packages.

(3) Data acquisition.

This section of the IP will discuss the acquisition of data for the proposed system. Sources and costs for each database will be listed as well as sources for optional data sets.

(4) Database development costs.

This section of the IP will describe how the GD&S database will be designed. Efforts should conclude with the identification of the data dictionary used.

(5) System benefits.

(a) Tangible benefits.

This section of the IP will discuss the benefits of using a GD&S over a manual method which may include the following issues: easier data entry, efficient data manipulation, credible data analysis, faster data output, improved access to current data, ability to perform complex analyses not possible with manual methods, and manpower savings.

(b) Intangible benefits.

This section of the IP will discuss the intangible benefits of using a GD&S which may include the following issues: extended use/reuse of mapping data, ability to analyze more alternatives, common framework for analysis and data sharing, credibility and repeatability of analysis, interdependence of organizations, modeling, and morale and prestige.

g. System implementation.

(1) Personnel requirements and costs.

This section of the IP describes the staffing requirements of the GD&S with emphasis on the source of staffing and the day-to-day activities. GD&S is a shared resource that should be manned and funded as a cooperative basis through all interested parties. Staffing can best be analyzed by reviewing the day-to-day activities that will be required (paragraph 3-10 provides some example position descriptions that may be needed).

(2) Training requirements and costs.

This section of the IP discusses the issues involved with acquiring or developing skilled personnel for the operation
(c) Document lessons learned.

and maintenance of the GD&S. The GD&S industry is growing both in number and in technology, so there will be a continuing need for advanced training. GD&S education can be pursued through contractor seminars/classes or through college course work. Having highly-skilled staff must be a high priority in order to maintain a complicated system such as a GD&S.

This section will discuss the training program that will be used to maintain a highly skilled and educated staff. Multiple disciplines must be supported to ensure that a properly prepared staff is available. This may include scheduling contractor based or college course base GD&S training since there is a lack of GD&S dedicated seminars.

(3) Acquisition strategy.

This section of the IP details the sources of funding and contract vehicles for the acquisition of the proposed systems. System acquisition may be fragmented over many years, so be sure to provide a complete timeline for all procurements.
This section will discuss the issues involved in hardware and software acquisition after the systems arrive. Describe the ramp-up time required for staff to learn how to use the systems appropriately. An orderly ramp-up can be achieved through an active system administrator who maintains standard operating procedures for the system. In addition, describe who will be in charge of allocating GD&S resources to competing projects.

This section will also include tabular timelines detailing the time and cost of system acquisition, training, user group activities, database development and pilot projects. Milestones shall be established so that the timeline may be followed accurately and with performance evaluations. Provide sources of funding for all acquisitions. Create system configuration schematics. Describe the procedure by which ongoing evaluation of the implementation can be made with meetings at least annually.

(4) Time frame.

(a) Mission assignments.

This section of the IP can establish mission assignments with specific staffing requirements and goal-oriented projects.

(b) Milestones.

This section of the IP will establish short- and long- term milestones so that evaluations can be performed and progress can be reviewed regularly.

(c) Document lessons learned.

This section of the IP may describe how a separate "Lessons Learned" document will be created and updated throughout the term of the Implementation Plan. This document will provide useful insight into the implementation of a GD&S and offer advice for future revisions of the IP.

h. Evaluation plan.

(1) Geospatial data and systems technical committee.

This section of the IP assigns the responsibility of performing IP evaluations to the Geospatial Data Technical Committee.

(2) Time table.

This section of the IP describes when, where and how often specific evaluations will occur. The time table for these evaluations will conform to Paragraph 7 of Engineer Regulation 1110-1-8156.

i. Conclusions and recommendations.

This section of the IP discusses the reasons why a GD&S is needed. It should state that the IP presents the justifications, the means and a plan of action for the implementation of a GD&S. It should also state that as technology and the GD&S industry continues to advance, the plan must be reviewed annually and updated as necessary. This section will provide a list of recommendations that summarizes the solutions to the requirements elicited during the requirements analysis.

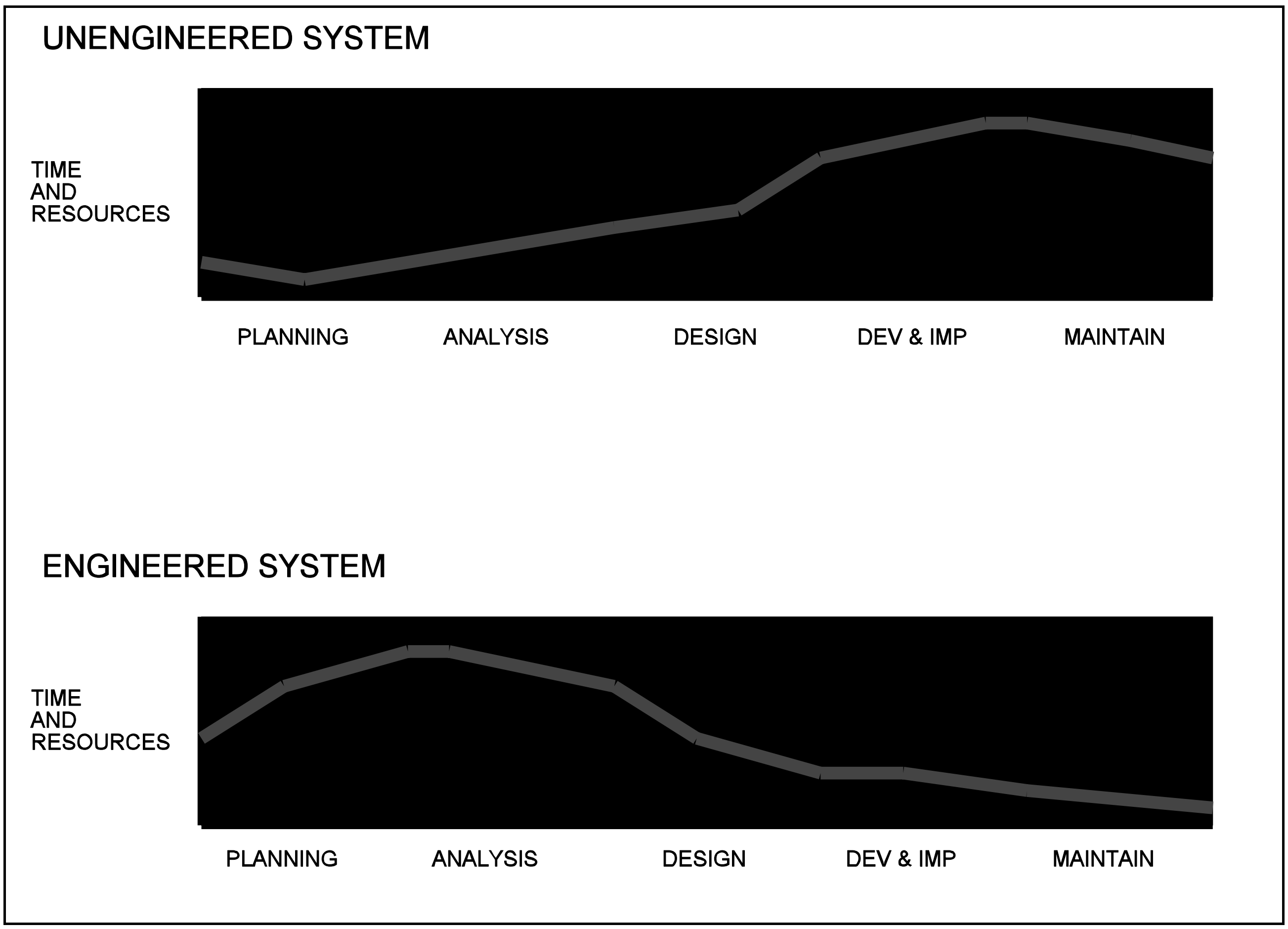

Figure 5-1. System development life cycle comparison

Chapter 6
GD&S Performance Evaluation Criteria

6-1. Introduction

The objective of developing performance evaluation criteria is to establish a protocol for assessing the periodic status of progress toward the goals set in the Implementation Plan by the USACE Command. The key aspect in evaluating the performance of a GD&S implementation is determining whether the system is satisfying user needs, both inside and outside USACE. Selden (1987) proposed a definition of GD&S success which provides an overall framework to construct specific performance evaluation criteria. This definition is as follows:

> *[GD&S] success is defined as the meeting of organizational requirements for the collection, management, analysis, display, and distribution of geographic/ geographically-defined information commensurate with the level of investment over time. Furthermore, [GD&S] success is measured by the degree to which it becomes integrated into, and a part of, an organization's overall information resources infrastructure over the long term.*

6-2. Benefits of GD&S

The documented results of a GD&S implementation performance evaluation can have a beneficial impact in several critical areas including: the preparation of budget requests, the creation of information management plans and assisting Headquarters in responding to a variety of data requests.

6-3. Schedule of Evaluation

The evaluation must initially be performed one year after the approval of the Implementation Plan. This will provide a first impression of how the plan is being carried out. After this initial evaluation, re-evaluations of progress must be made on an annual basis. An information copy of evaluations is to be sent to HQUSACE (CECW-EP-S).

6-4. Issues Associated with the Development of Evaluation Criteria

The evaluation criteria listed in this section cover four major areas: technical, financial, organizational, and personnel. Technical evaluation criteria include software, hardware, data, interfaces, and standards. A good starting point in the development of criteria are the five basic objectives, outlined by the General Accounting Office (GAO, Evaluating the Acquisition and Operation of Information Systems, 1986) for the acquisition and operation of information systems:

a. Ensure system effectiveness. As stated in the implementation plan and requirements analysis, system effectiveness is measured by determining whether the system performs the intended functions and whether users get the information they need, in the right form, in a timely fashion. The following basic questions should be answered and explained with examples:

- Did you accomplish the goals of using the GD&S that you stated in your implementation plan/requirements analysis?

- Does the GD&S implementation produce real products which meet operational needs?

- Does the GD&S implementation provide meaningful support to senior decision-makers?

- Does the use of GD&S implementation promote inter-disciplinary, inter-departmental, intra-organizational, and inter-organizational coordination and cooperation?

To answer these questions, analysts should develop a table which lists the goals and requirements from the Implementation Plan in one column and GD&S implementations in the other. An example is provided at Table 6-1.

Table 6-1
Example Goals/Implementations

Goals/Requirements	GD&S Implementation
Develop a comprehensive inventory and tracking system for all spatial data holdings.	Using GD&S to convert all spatial data into a common format or projection and developing on-line system to display current data holdings.
Educate staff in the operation of an GD&S.	Setting up and conducting a GD&S training course; developed an GD&S; in-house GD&S training manual.

b. Promote system economy and efficiency. An economical and efficient GD&S implementation uses the minimum number of information resources to achieve the output level the system's users require. Under this category, a measure of GD&S implementation success would be the answers to the following questions:

- Can you describe instances where you saved time or money by using a GD&S, had fewer errors in products, were able to locate data to share?

- Are you a successful participant in the Clearinghouse for provision of data? Do you provide metadata to the Clearinghouse? Have you received data through the Clearinghouse?

To quantify the answer to these questions, a comparison could be made of the cost (money and time) of doing business before and after the implementation of GD&S. For example, another table could be developed which lists applications/projects and resources (time, money, labor) to complete. This assumes that adequate data exists on the costs associated with projects before GD&S was implemented, a form of information that should be gathered with the requirements analysis. An example of such a table is shown at Table 6-2.

c. Protect data integrity. Data integrity requires that systems have adequate controls over how data are entered, communicated, processed, stored and reported. Under this category, consider how the GD&S implementation has affected the organization and management of your data. Consider such items as:

- Data redundancy -- Have multiple copies of the same data set been eliminated?

- Clarity of presentation -- Is the data being presented in a more meaningful way?

- Time and costs associated with data entry -- Is data converted and stored in a common GD&S format?

- Data stewardship -- Has responsibility for maintenance of data and preparation of metadata been established?

- Data exchange formats -- Can data be easily transferred into and out of the system?

d. Safeguard information resources. Information resources, which include hardware, software, data, and people, need to be protected against waste, loss, unauthorized use and/or fraud. This category basically deals with data security and system access. Some of the implementation evaluation criteria in this section include:

- Are there standard practices and procedures in place to process sensitive or classified data within the GD&S?

- Is there a system configuration plan in place?

- Are proper file access privileges in place to control unauthorized access to system files, the operating system, common data directories, and user directories?

e. Comply with laws and regulations. Compliance with laws, regulations, policies, and procedures that govern the acquisition, development, operation, and maintenance of information systems must be ensured. A question like the following evaluates this:

- Has the implementation of a GD&S put your organization in a better position to comply with government regulations and reporting requirements not only with system operation and maintenance issues but also with respect to projects associated with litigation support which are related to government regulations?

f. Additional evaluation criteria. Other questions to consider in the implementation evaluation are:

- Are you growing in your use of GD&S technology, i.e., are you using it in new ways?

- Is the GD&S allowing you to do more work, new work, and has it increased your customer base?

- Are more people interested in the GD&S? Is your success attracting new customers?

Table 6-2
GD&S Effectiveness Evaluation

Application/Project Name: ____

Project statistics	Before GD&S	After GD&S
Dollar cost		
Labor hours		
Time to complete		

Additional project statistics could be developed as necessary. To fill in the project statistics, break down the project into tasks and determine the time and cost associated with each task. For example, consider a project which requires the determination of chemical plume spreading in groundwater. A detailed table listing tasks and costs could be developed as follows:

Labor requirements with and without GD&S

Task/Product (Hours)	Technician Labor (Hours)	Engineer/Scientist ($)	Cost
	Before/After	Before/After	Before/After
Data Entry			
Well Logs			
Contour Maps			
Cross Sections			
Time-Series Plots			

Chapter 7
Geospatial Data Issues And Standards

7-1. General

The database itself is normally the most expensive component of a GDS and represents a valuable resource to the Command. The design, development and long term maintenance of a comprehensive geospatial database is a sizable investment. Many issues must be considered to obtain maximum benefit from the database investment.

7-2. Database Development

Following a complete requirements analysis, it is possible to determine the optimum strategy for obtaining the database. Two basic methods are available - acquiring an existing government or commercial database or building a new database.

a. Acquiring an existing database. The least expensive method of obtaining a database is nearly always to acquire an existing database, if one exists that will satisfy the users' needs. Potential data sources of information of available databases include:

- Federal Geographic Data Committee (FGDC) Manual of Federal Geographic Data Products - a compendium of databases available from 21 U.S. Government agencies, including Forest Service, Bureau of the Census, Defense Mapping Agency (DMA), National Park Service, U.S. Geological Survey (USGS), Federal Highway Administration, and National Aeronautics and Space Administration (NASA).

- National Geospatial Data Clearinghouse - an electronic clearinghouse for the NSDI, under development by the FGDC.

- State Geographic Information Activities Compendium - a hardcopy summary of GIS efforts by the State governments.

- Other USACE districts - other districts may have developed a database that would satisfy users' needs.

- Local governments - county and city governments maintain geospatial databases for planning and assessments.

- Commercial sources - many commercial companies offer digital geospatial data for sale.

If an existing database can be found that meets a portion of the requirements, consideration should be given to acquire and build upon it. This technique, while not always practical, can often yield substantial savings.

b. Building a New Database. If an acceptable database is not available from any known source, it is necessary to build a new database. If possible, the cost should be shared by another organization with similar data needs. In any case, the database must be designed in detail to meet all user's needs and meet all applicable standards.

(1) Database standards. The following standards must be used in the database design:

Data Format	FIPSPUB 173 Spatial Data Transfer Standard
Metadata	FGDC Content Standard for Digital Geospatial Metadata
Data Collection	USACE Interim Standards and Specifications for Surveys, Maps, Engineering Drawings, and Related Spatial Data Products
Data Accuracy	USACE Interim Standards and Specifications for Surveys, Maps, Engineering Drawings, and Related Spatial Data Products
Data Content	Tri-Service GIS/Spatial Data Standards
Data Symbology	Tri-Service GIS/Spatial Data Standards

(2) Database specification. A specification serves two purposes: (1) it provides a firm set of rules for data collection and database construction, and (2) it describes the database in sufficient detail to permit application development. This document will permit use of the database inside and outside of the producing organization and result in a substantial cost savings to users. The specification may take several forms, but at a minimum should include the following sections:

- Scope - a concise abstract of the coverage of the specification.

- Applicable Documents - a bibliographic listing of the standards and references used in developing the specification.

- Database Description - a summary of the information contained in and the structure/format of the database and the intended use of the data.

- Metadata - a listing of the static metadata elements, including accuracy, datum, scale/resolution, source, and projection (if applicable).

- Data Format - a detailed description of the data format.

- Data Dictionary - a dictionary of the feature and attribute codes used in the database.

(3) Database construction. The database is built to the meet the requirements of the Database Specification. It is advisable to prototype a database and distribute the prototype to potential users, along with a copy of the draft specification, prior to finalizing the design. This procedure is easier if the database is only for internal use, but no less valuable.

7-3. Data Documentation

Consistent, complete, current documentation of geospatial data is essential to maintaining the data investment and to reduce data duplication. Geospatial data should be documented using standard metadata formats as required by ER 1110-1-8156 and described in Chapter 8 of this manual. Metadata shall be developed using the "Content Standards for Geospatial Metadata." The following are general data documentation guidelines:

- Consider the value of the data set and develop metadata accordingly. For example, do not spend $2,000 to develop a metadata file for a $100 data set and do not spend $100 on metadata for a unique, expensive, and often used data set.

- At a minimum, data providers must make metadata files at the end of a project or data collection effort. This is the most logical approach for data collection efforts that are relatively brief from start to finish. For lengthier data collection efforts and projects, data providers should consider developing metadata files at the beginning of the effort as well, to ensure optimal data sharing and partnering.

- When deciding to develop metadata files for an entire data set vs. making metadata files per coverage or themes within a data set consider cost to develop the metadata, value of the data set, frequency of use of the data set, diversity of data characteristics between themes, etc.

- Find the appropriate metadata element to record important information about a data set. For example, the Metadata Standard does not include elements that are specifically labeled, "Modeling parameters" but there are many opportunities for the modeling community to accurately describe what parameters were used to develop the data set.

7-4. Quality Assurance

a. The primary goal of data quality assurance (QA) is to ensure a consistent and measurable accuracy throughout the database. Consistency is achieved through the use of documented, approved production procedures. Following production, an assessment of the quality of the data set should be made to ensure that the expected result was achieved.

b. The level of production control and the rigor with which the assessments must be made will vary among databases, and should be consistent with the requirements for the database. For example, a cadastral database will generally have exacting accuracy requirements and equally stringent requirements for consistency. This type of database will need to have detailed procedural documentation, a completion signature for each production step, and a comprehensive assessment of accuracy - significantly increasing the cost of production. Conversely, a small-scale database intended only as a background map for geographic orientation (e.g., Digital Chart of the World from DMA) will have much less stringent production documentation requirements and only a cursory accuracy assessment. The method used to measure accuracy can have an impact on the result, so this quality assessment should be made using standard measurement techniques, such as those described in the National Map Accuracy Standard, or local techniques that are well documented.

7-5. Data Access

a. Data and metadata produced by USACE, including those produced by commercial firms under contract to USACE, shall be made available to the public to the extent permitted by law, current policies, and relevant OMB policies, including OMB Circular No. A-130, "Management of Federal Information Resources." HQUSACE, with the assistance of the GD&S Field Advisory Group, has imple mented a procedure to provide public access to USACE geospatial metadata through the National Geospatial Data Clearinghouse. This procedure is described in ER 1110-1-8156 and in Chapter 8 of this manual.

b. Each Command is responsible for establishing procedures for responding to requests from the public for geospatial data. The mechanics of ensuring public access to data holdings should be optimized for the existing organization and unique missions of each USACE Command. Commands may choose to have all requests for geospatial managed through a single office. Others may choose to have internal divisions respond to requests for the data they collect or produce.

7-6. Data Archive

a. Geospatial data represents a significant national asset. USACE Commands shall protect against the permanent loss of data by establishing an effective data archive. The archive shall contain a copy of all data sets produced within USACE, either in-house or on contract, and have an effective cataloging system such that data sets may be retrieved in reasonable time. The data archiving process (manual, automatic, or a combination) and frequency shall be appropriate for the application and sensitivity of the data.

b. The FGDC Historical Data Working Group has developed a draft brochure that provides guidance on the responsibilities of geospatial data developers and custodians. It lists 12 circumstances under which geospatial data sets should be archived. Any geospatial database that has current or potential future value to your Command or another Government agency that cannot be easily replicated must be considered for archive. This guidance has the effect of including nearly all geospatial data.

7-7. Data Maintenance

a. Data shall be maintained as needed to support USACE applications. As a data set is updated, its metadata shall also be updated and made available to the Clearinghouse.

b. It is recommended that the update cycle be determined during the requirements analysis based on currency requirements and budgetary constraints. Data maintenance can be a costly - but necessary - on going GD&S expense. Data maintenance is a cost multiplier that must be considered as part of the overall GD&S expense.

7-8. Data Liability

Data liability is an issue that requires more attention by legal experts. Liability for the data produced by USACE can come in two forms: (1) liability for data that does not meet its stated accuracy, and (2) liability for the unintended usage of the data [Aronoff, 1989].

a. Liability for Incorrect Data. The Federal Government is protected from being sued for providing "misinformation" under the Federal Tort Claims Acts. However, the government is not protected from "malpractice." There are few precedents in this area, but the best solution for USACE Commands is to develop sound procedures for data collection, handling, and processing and to adhere to the procedures. No USACE Command shall knowingly provide data that does not meet its stated accuracy nor which has undocumented or incorrect lineage. Every effort must be made to ensure that users understand the capabilities and limits of the data set they are using.

b. Liability for misuse. In "Geographic Information Systems: A Management Perspective," Stan Aronoff provides examples of how advanced GD&S can be employed to misuse public data in a manner that would be not be possible using hardcopy. There are no standing legal precedents in this area, so a USACE-wide policy on restricting access to certain types of data cannot yet be developed. It is important that all data provided through the Clearinghouse be properly documented as to its intended use, as required by the metadata standard.

7-9. Data Policies and Coordination

a. Policies. Each USACE Command may develop tailored GD&S policies to supplement and implement this guidance document. Tailored policies regarding GD&S technologies shall be drafted by the GD&S Technical Committee and approved by the GD&S Oversight Committee. Tailored policies shall adhere to the requirements of this document and all applicable standards, orders, and OMB circulars, and they shall support the goals of the NSDI.

b. Coordination of GD&S efforts. Coordination and prioritization of geospatial data acquisition and GD&S development efforts within a USACE Command shall be the function of the GD&S Technical Committee.

c. Coordination with authorities. The GD&S Technical Committee shall appoint a representative to coordinate USACE geospatial data acquisition and GD&S development efforts with local and state governments and national GIS coordinating committees. This representative may be the Command POC or another member of the Technical Committee. If it is necessary, multiple members of this committee can liaise outside of the Command; however, information exchange then becomes critical. The purpose of the coordination is to reduce duplicative data collection efforts and identify cost sharing opportunities.

7-10. Importance of Geospatial Data Standards

Technical progress in GD&S has resulted in wide use by many organizations of geospatial data. GD&S users need geospatial data standards to better manage this data. Users should recognize that standards are supportive of efforts to reduce redundant data, make systems more efficient and lower project costs. To this end most standards provide flexibility which allows users to adapt the standards to their specific environment. This flexibility should be used with caution, however, to avoid distortion of the standards intent.

a. Benefits of geospatial data standards. The benefits of geospatial data standards come from making the activities which the geospatial data standards support more successful. As a suite of geospatial data standards is adopted the following benefits should accrue to the activities in an organization:

- There is a removal of barriers to geospatial data exchange and a more ordered and cost-effective data sharing as standards provide exchange mechanisms for the transfer of geospatial data between dissimilar systems.

- Geospatial data quality improves and configuration management of data increases as standards provide metadata to help organize and maintain the organizations internal spatial data.

- User confidence increases that geospatial data products are as advertised and providers of data can offer a warranty for data provided as products produced to a standard give users knowledge about the structure and content of data before acquiring it.

- Standards allow increased access to geospatial data. As a result new uses are found for the data as there is an increase in the number of geospatial data product choices available to the user community.

- Integration of systems is encouraged as geospatial data can flow between them, thus maximizing effective use of systems.

- Data collection duplication is reduced and investments in those geospatial data collected provide more return on the investment in them.

- Public access to geospatial data is improved and there is an increase in the GD&S user base due to data availability with an attendant diffusion of knowledge.

b. Types of geospatial data standards. Standards may be catalogued in several ways. One is by source of authority. Standards can be de facto, such as AutoCAD DXF, where the user community, through constant use adopts a practice without any formal certification. Standards may also be certified by a government body or a professional organization. Among these are the International Standards Organization (ISO), American National Standards Institute (ANSI), National Institute of Standards and Technology (NIST), the Federal Geographic Data Committee (FGDC) and the Tri-Service CADD/GIS Technology Center or those promulgated by professional organizations such as the American Congress on Surveying and Mapping (ACSM).

Another way to catalog standards is by the functionality the standard addresses. For the GD&S area these form a framework of standards as seen below:

- Hardware and Physical Connection Standards.

  These are standards that pertain to the physical connection and cabling of hardware devices.

- Application Standards.

  These are standards that impact the actual presentation and display of data in a GD&S, such as map design criteria.

- Software Standards.

  These are standards that address the development of software and software documentation including macros.

- Professional Standards.

  These are standards that establish levels of competency and training.

- Network Communication Standards.

  These are standards that address the protocols for the transfer of data and information from one computer system to another

` Data Standards.

These are standards that address geospatial data transfer formats, accuracy, documentation, structure, content and management. It is these standards which are discussed below.

7-11. Authority for Geospatial Data Standards

Standards for geospatial data in USACE are governed by the following organizations.

a. Federal Geographic Data Committee. OMB Circular A-16 (Coordination of Surveying, Mapping and Related Spatial Data Activities) establishes a process to foster the development of a national spatial data framework for an information-based society with the participation of Federal, state, and local governments, and the private sector, and to reduce duplication of effort. It addresses the responsibilities of Federal agencies in the coordination of surveying, mapping, and related spatial data. It also establishes an interagency coordinating committee known as the Federal Geographic Data Committee (FGDC). The objective of the FGDC is to promote the coordinated development, use, sharing, and dissemination of surveying, mapping, and related geospatial data.

Executive Order 12906 Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure (NSDI) states, among other things, that Federal agencies collecting or producing geospatial data shall ensure that data will be collected in a manner that meets all relevant standards adopted through the FGDC process. It also establishes the FGDC's authority over the NSDI and the National Geospatial Data Clearinghouse(Clearinghouse).

The FGDC can be contacted at:

U.S. Geological Survey
590 National Center
Reston, Virginia 22092
Telephone: (703) 648-4533
Fax: (703) 648-5755
Internet: gdc@usgs.gov

b. National Institute of Standards and Technology. The Computer Systems Laboratory at the National Institute of Standards and Technology (NIST) is responsible for developing technical, management, physical and administrative standards and guidelines for computer and related telecommunication systems. These standards are known as Federal Information Processing Standards (FIPS) Publications (FIPSPUBS). Many of these are of importance to GD&S and are discussed in the section on mandatory standards. FIPSPUBS are available from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: (703) 487-4650

c. Tri-Service CADD/GIS Technology Center. The Tri-Service CADD/GIS Technology Center is a multi-service vehicle to set standards and coordinate facilities CADD and GIS within the Department of Defense. It also promotes system integration and standards including naming conventions, common GIS layers, standard symbology, databases and analysis tools. The Tri-Service Center can be reached at:

Tri-Service CADD/GIS Technology Center
Information Technology Laboratory
(CEWES-ID-C)
U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
Telephone: (601) 634-4582
Fax: (601) 634-4584
Internet: wesimda@ex1.wes.army.mil

7-12. Applicable Standards

Some standards are going to impact all USACE organizations. Others will only be of concern to USACE organizations with special circumstances. Mandatory standards are those that are sufficiently mature that all USACE components must follow them. ER 1110-1-8156, paragraph 6 requires that anyone who believes these standards are inappropriate for their use must apply to CECW-EP-S for a waiver. The waiver must explain why the standards are inappropriate and what will be used instead. Recommended standards are those where compliance is encouraged but the maturity of the standard is not sufficient for them to be mandatory.

a. Mandatory geospatial data standards.

(1) Federal Information Processing Standards Publications.

Use of Federal Information Processing Standards (FIPS) are mandatory for USACE GD&S. The USGS Open-file Report 88-105, *A Process for Evaluating GIS,* provides a 63 page annotated list of Federal Information Processing Standards (FIPS) and National Bureau of Standards GD&S related standards, guidelines and references. The report can be acquired from:

USGS Earth Science Information Center
507 National Center
Reston, VA 22092
Toll Free Number: 1-800-USA-MAPS
Telephone: (703) 648-5920
FAX: (703) 648-5548

The FIPS Publications are available from:

National Technical Information Service
Computer Products Office
5285 Port Royal Road
Springfield, VA 22161
Telephone: (703) 487-4600

(2) FIPS 173 Spatial Data Transfer Standard.

The Spatial Data Transfer Standard (SDTS) provides specifications for the organization and structure of digital spatial data transfer, definition of spatial features and attributes, and data transfer encoding. The purpose of the standard is to promote and facilitate the transfer of digital spatial data between dissimilar computer systems. This standard is for use in the acquisition and development of government applications and programs involving the transfer of digital spatial data between dissimilar computer systems. The use applies when the transfer of digital spatial data occurs or is likely to occur within and/or outside of the Federal Government. It is likely that vendors/producers of leading GD&S will introduce SDTS import/export capability in the future. The SDTS is a key element of the NSDI and is the result of FGDC efforts.

(3) Content Standards for Digital Geospatial Metadata.

This standard specifies the information content of metadata for a set of digital geospatial data. The purpose of the standard is to provide a common set of terminology and definitions for concepts related to these metadata. This standard is the data documentation standard referenced in Executive Order 12906 which mandates the documentation of all new geospatial data starting 11 January 1995 and the development of a plan to document geospatial data previously collected or produced, by 11 April 1995.

The metadata standard is the product of the FGDC. Executive Order 12906 instructs Federal agencies to use the metadata standard to document new geospatial data beginning in 1995 and to provide these metadata to the public through the National Geospatial Data Clearinghouse. The GD&S vendor community may provide metadata software in the future. Several pieces of public domain metadata software are available. Document.aml is a public domain metadata macro for use with ARC/INFO. CORPSMET is a DOS-based public domain metadata software developed by USACE. CORPSMET can be used to document any geospatial data independently of the geospatial data system in use.

(4) USACE Interim Standards and Specifications for Surveys, Maps, Engineering Drawings, and Related Spatial Data Products.

This is to be used for prescribing standards and specifications for USACE field surveys, maps, engineering drawings, and related spatial data products. It is applicable to all HQUSACE elements, major subordinate commands, districts, laboratories, and field operating activities having civil works, military programs, and environmental restoration responsibilities. It also applies to functional areas having responsibilities for regulatory investigations and studies, real estate, and support to Army installation master planning, and other functions involving surveying, mapping, or spatial database development.

(5) Tri-Service GIS/Spatial Data Standards (TSSDS).

These standards are applicable to all Department of Defense activities having civil works or public works, military programs, and environmental programs or that are responsible for facilities/installation management. They prescribe standards and specifications for GIS and related spatial data. The intent is to create standards that will satisfy the project life-cycle concept for digital data. The TSSDS are intended to contain requirements for standard data entry, storage and retrieval, using predefined screen displays and plotting routines. There are many subcommittees and working groups of the FGDC that are development of content standards and the work is at various levels of maturity. The final versions of these standards will be incorporated into the TSSDS for distribution and use throughout USACE therefore by using the most recent version of the TSSDS one will also be using the most recent FGDC content standards. The proponent for this standard is the Tri-Service CADD/GIS Technology Center.

b. Military standards. Those elements of USACE working with Defense Mapping Agency (DMA) geospatial data may find it necessary to use Military Standards (MIL-STD). As of 27 December 1994 DoD agencies may not require vendors to support Military Standards unless the agency obtains a waiver to do so. USACE employees should check with Procurement or Engineering Chiefs for the most current guidance related to this requirement. The DMA standards and specifications program is described in Digitizing the Future. It is available from the DMA Headquarters Plans and Requirements Directorate in care of:

Director, Defense Mapping Agency
ATTN: PR (MS A-13)
8613 Lee Highway
Fairfax, Virginia 22031-2137
Telephone: (703) 285-9339 or 9333

c. Recommended geospatial data standards. These are standards that are in various stages of development and which may become USACE standards in the future.

(1) Open Geodata Interoperability Standard/ Specification (OGIS).

The OGIS is a public domain software specification designed to promote true interchange among varied software and data structures. The OGIS is motivated by the costs of data conversion and sees independence from proprietary data structures. The OGIS project delivered a draft standards specification document in February 1994.

The proponent of the OGIS is the Open GIS Foundation (OGF) which may be reached at:

1 Kendall Square
Building 200, Suite 2200
Cambridge, MA 02139
Telephone: (617) 621-7025
FAX: (617) 621-7174

d. Guidelines.

(1) Guidelines for Implementing the National Geospatial Data Clearinghouse.

As defined in Executive Order 12906 the National Geospatial Data Clearinghouse is “a distributed network of geospatial data producers, managers and users linked electronically.” Initially the clearinghouse functions are to publicize what geospatial data exists, the condition of these data and instructions on accessing the data. Later functions will provide direct access to the data, allow producers to publicize data that are prepared and planned and let users advertise their data needs. The clearinghouse will build on the Metadata Standard and the SDTS and will exploit the Wide Area Information Servers (WAIS).

The FGDC Clearinghouse Working Group developed the Clearinghouse and conducted a prototype test in the Fall of 1993. The EO 12906 requires the FGDC to establish a Clearinghouse within six months of the date of the order. The Clearinghouse is established and the Working Group is pursuing development of user guides, software enhancements and related support materials.

Chapter 8
USACE and Executive Order 12906

8-1. General

a. GD&S requirements at the Federal level revolve around the geospatial data itself. The unique character of geospatial data is recognized at the Federal level in Executive Order 12906, “Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure.” All of the actions Commands must take related to geospatial data have their regulatory basis in EO 12906. In this EO, several requirements related to the handling of geospatial data are instituted at the Federal level with the intent of reducing data duplication and protecting the nation's large investment in this class of information.

b. The EO places five (5) requirements on Federal agencies regarding the acquisition and access of geospatial data. These are: (1) document new geospatial data using the FGDC Content Standard for Digital Geospatial Metadata. (Data are considered new if produced or collected since January 1995.); (2) document existing geospatial data to the extent practicable. (Data are considered existing if collected or produced prior to January 1995.); (3) make documentation accessible to the Clearinghouse; (4) utilize the Clearinghouse prior to the collection or production of new geospatial data; (5) establish procedures to make geospatial data available to the public.

c. In ER 1110-1-8156, HQUSACE has developed a method for meeting these requirements. This method will promote consistency in the way USACE geospatial data holdings are documented and publicized and provide a practical method of meeting the requirements.

8-2. Document New Geospatial Data

a. EO 12906 SEC 3(b) requires agencies to thoroughly document the origins and characteristics of geospatial they collect or produce. The term “metadata” has been adopted to refer to this documentation. The first standard adopted by the FGDC describes the information that must be included in metadata.

b. Data documentation requirements depend on the age of the data. The EO states, “... Beginning 9 months from the date of this order [April, 1994], each agency shall document all new geospatial data ....” Thus data are considered new if produced or collected since January 1995. FGDC compliant metadata are required for all new data. Fully compliant metadata includes all of the mandatory and mandatory if applicable elements. As discussed in paragraph 7-3 of this EM, several considerations guide Commands in documenting new geospatial data.

c. Often, several simultaneous data collection efforts are launched at the beginning of a project in order to assemble background data or to populate a carefully designed database. The database may be composed of multiple files each containing a specific data theme or covering a specified geographic area of the same theme. Metadata for reach of these individual files will contain a lot of repetitive information. It may be appropriate to document groups of files that form a well defined dataset with a single metadata file.

d. The full text of “Content Standards for Digital Geospatial Metadata,” (FGDC, 1994) is available via the Internet at ftp://waisqvarsa.er.usgs.gov/wais/docs. This standard is referred to here as the “metadata standard.” Metadata normally reside in a text file distinct from the data they describe and can be consulted and shared easily. By examining metadata, potential users determine if existing geospatial data held by USACE meet their needs and decide if they wish to obtain a copy of the data. The characteristics of geospatial data that must be documented are established by the metadata standard. Using commercial and public domain software tools, FGDC compliant metadata can be developed in a straight forward manner.

8-3. Document Existing Geospatial Data

a. Eo 12906 calls for each agency to document older geospatial data to the extent practicable. The volume and diversity of existing geospatial data held by USACE Commands represents, without some consolidation, an insurmountable number of metadata files to be generated and subsequently managed. More importantly, much of the information about the origins, characteristics, and previous processing of these older data may be lost or difficult to find.

b. HQUSACE has developed a practical approach to consolidating and documenting older data. This approach employs the concept of geospatial data “collections” and the use of “minimum required metadata.”

c. A data collection is a logically consistent grouping of geospatial data that can be documented in a uniform manner. Collections may be established based on a consistent theme or on a consistent spatial domain. Each collection can then be documented by a single “collection metadata” file containing only the mandatory elements of the metadata standard (primarily Sections 1 and 7 of the Metadata Standard). These minimum collection metadata are only to be used for existing (pre-1995) geospatial data.

d. For some collections of older data it may be possible to include other elements of the metadata standard as well (e.g., all the items in a collection have the same spatial data organization or the same spatial reference parameters). Collection metadata of older data rely heavily on a strongly descriptive abstract and a complete set of theme and place keywords to convey to the reader the origin and characteristics of the items included in the collection.

e. An example of a geospatial data collection based on theme is hydrographic survey data. A single Command may hold thousands of individual pre-1995 digital files containing hydrographic survey data. For documentation purposes, it is advantageous to consider the entire holding of older hydrographic survey data, regardless of age, format, or project location as a "data collection" and to document this collection with a single "collection metadata" file. Other examples of theme based collections are geodetic/survey control, geophysical logs, aerial photographs, and water control data. An example of a collection metadata file for hydrographic survey data is given in Table 8-1.

f. HQUSACE has developed collection metadata templates for data themes commonly held by Commands. These templates are available electronically via the USACE Node. Commands may define additional geospatial data collections as needed when documenting large holdings of existing (pre-1995) geospatial data. The usefulness of collection metadata is enhanced if Commands maintain an inventory of the individual items (files) represented by the collection if this can be accomplished with reasonable resources.

g. Data collections based on spatial domain generally pertain to a specific project or installation. These "project collections" may contain a variety of engineering, environmental and operations data in various formats generated during planning, construction and operation of the project. A project collection metadata file is given in Table 8-2.

h. Not all existing data can be included in a collection. Geospatial data produced prior to January 1995, if not included in a collection, can be documented as resources become available or as necessary for purposes of data exchange.

8-4. Make Documentation Accessible to the National Geospatial Data Clearinghouse

a. The third requirement of EO 12906 is for Federal Agencies to make geospatial data documentation electronically accessible. The National Geospatial Data Clearinghouse (Clearinghouse) was established for this purpose. The Clearinghouse is a distributed, electronically connected network of geospatial data producers, managers, and users. The Clearinghouse allows its users to determine what geospatial data exist, find the data they need, evaluate the usefulness of the data for their applications, and obtain or order the data as economically as possible. The Clearinghouse is functioning as an electronic geospatial data locator and access service operating on the Internet and is a key element of EO 12906.

b. As the overall agency response to this requirement, HQUSACE has established and maintains a centralized Clearinghouse Node (USACE Node) (electronic address) for all USACE Commands. The USACE Node functions as the primary point of public access to documentation about the USACE geospatial data holdings. A separate electronic data page for each USACE activity is maintained by HQUSACE on this server. The Internet URL is http://corps_geo1.usace.army.mil. This electronic site is for Clearinghouse and related purposes.

c. Commands have two actions related to making their metadata documentation accessible to the Clearinghouse. Commands must complete and submit collection metadata for older data as discussed in paragraph 8-3 above. The templates available on the server may be used for this purpose. Commands must submit the completed metadata for new geospatial data as discussed in paragraph 8-2 above.

d. Commands will utilize the USACE node for the purpose of presenting their geospatial data holdings to the public and will update their data pages not less than once a year. Commands will prepare and submit to the USACE node, all metadata as discussed in paragraphs 7.g(1), 7.g(2), and 7.g(3) of ER 1110-1-8156 and in paragraphs 8-2 and 8-3 of this manual. Commands will use the USACE Clearinghouse node for submission of all collection and full metadata. The node may also be utilized as a location for electronic data delivery if desired. Frequently requested geospatial data may be placed on the node for unrestricted direct public access as appropriate. The INTERNET URL address for the Corps Clearinghouse node is http://corps_geo1.usace.army.mil.

e. Commands may establish supplemental Clearinghouse nodes in accordance with CEIM guidance on requirements for computer network security. Commands must assure a link is maintained from the USACE node to any supplemental nodes established by the Command. Use of a supplemental node does not remove the requirement to provide and maintain all metadata on the USACE node.

f. The USACE node as established and maintained by HQUSACE serves several purposes: (1) The node establishes a single electronic site with specified formats and protocols for USACE Commands to list their data holdings; (2) The node provides a starting point and search engine for Commands to use when checking the Clearinghouse for existing data; (3) By completing the collection metadata examples for existing data Commands may fulfill the requirement to document existing geospatial data; (4) The node provides a location for public distribution of geospatial data for use by Commands if desired; (5) The node provides a focal point for distribution of information regarding GD&S issues in USACE.

8-5. Search the Clearinghouse

The fourth requirement of EO 12906 is for each agency to check the Clearinghouse for usable, available geospatial data before expending funds to collect new data. HQUSACE has chosen to enforce this requirement at the Command level. As set forth in ER 1110-1-8156, each Command must certify it has searched the Clearinghouse for available data as part of the budget submission process. The USACE node provides a form-tool to assist in searching the Clearinghouse.

8-6. Establish Procedures to Make Geospatial Data Available to the Public

Commands should establish internal procedures for responding to legitimate requests from the public for copies of geospatial data in the Command's holdings.

Table 8-1
Collection Metadata Describing New Orleans District Hydrographic Survey Data Collection

Identification_Information:
Citation:
Citation_Information:
Originator: U.S. Army Corps of Engineers, New Orleans District, New Orleans, Louisiana

Publication_Date: 19951031
Title: Hydrographic Survey Data Collection

Description:
Abstract: The U.S. Army Corps of Engineers (USACE) maintains a collection of hydrographic surveys that have been obtained in accordance with USACE Engineer Manual (EM) 1110-2-1003, "Hydrographic Surveying." USACE in-house crews and contractors collect this data using the traditional hydrographic surveying echo sounding equipment, as well as, airborne laser platforms. Hydrographic surveys are performed of navigation lock approach channels, in river and harbor navigation projects, and within the major inland waterway tributaries, such as the Mississippi River. Surveys may include revetment locations, project, river structures, and comprehensive river surveys. Some surveys are point-on-range surveys along range lines established at regular intervals in rivers and channels. The hydrographic survey collection is composed of digital data files that contain 3-dimensional coordinates defining river and harbor bottoms. These files contain real world coordinates and can be related to absolute positions on the earth. Sometimes the hydrographic surveys are merged with overbank topographic surveys to create a full model of the channel cross sections. Recently, hydrographic surveys have been conducted with sweep and multi-beam sonar survey equipment, rather than via conventional data collection. This technology will become increasingly common on future surveys. The New Orleans District began collecting hydrographic survey data in 1880 and began maintaining the data in digital form in 1980. The digital holdings represent over 1500 hydrographic survey jobs. The New Orleans District hydrographic survey data is collected along the major tributaries, waterways, coastal harbors, and engineering projects within the district such as the Mississippi River, Atchafaylaya River, the Gulf Intracoastal Waterway, and major streams, tributaries, and passes to the Gulf of Mexico and coastal Louisiana.

Purpose: Hydrographic surveys are conducted in support of planning, engineering, and design, construction, operation, maintenance, and regulation of civil works navigation and flood control projects. Specific example uses of the survey data include performing channel and levee slope stability analyses and construction of USACE structures, such as locks and dams, levees, and flood walls. Hydrographic surveys are also taken to monitor channel shoaling and scour to maintain channels at navigable project depths.

Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 1880
Ending_Date: 1995
Currentness_Reference: ground condition
Status:
Progress: In work
Maintenance_and_Update_Frequency: Continually
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate:-94.25
East_Bounding_Coordinate:-88.67
North_Bounding_Coordinate:33.76
South_Bounding_Coordinate:28.28
Keywords:
Theme:
Theme_Keyword_Thesaurus: none
Theme_Keyword: hydrographic
Theme_Keyword_Thesaurus: none
Theme_Keyword: survey
Theme_Keyword_Thesaurus: none
Theme_Keyword: bathymetry
Place_Keyword_Thesaurus: Geographic Names Information System
Place_Keyword: Arkansas
Place_Keyword: Mississippi
Place_Keyword: Louisiana
Access_Constraints: None
Use_Constraints: These data were compiled for government use and represents the results of data collection/processing for a specific U.S. Army Corps of Engineers (USACE) activity. The USACE makes no representation as to the suitability or accuracy of these data for any other purpose and disclaims any liability for errors that the data may contain. As such, it is only valid for it is intended use, content, time, and accuracy specifications. While there are no explicit constraints on the use of the data, please exercise appropriate and professional judgment in the use and interpretation of these data.

(Continued)

Table 8-1 (Concluded)

Metadata_Reference_Information:
Metadata_Date: 19951031
Metadata_Contact: Chief, Surveys Section, Engineering Division
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: U. S. Army Corps of Engineers, New Orleans District,

Contact_Address:
Address_Type: mailing address
Address:P.O. Box 60267
City: New Orleans
State_or_Province:LA>
Postal_Code: 70160-0267
Contact_Voice_Telephone: 504-865-1121

Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: 19940608

Table 8-2
Collection Metadata Describing the Kissimmee River Restoration Project Data Collection at the Jacksonville District

Identification_Information:

Citation:

Citation_Information:

Originator:

US Army Corps of Engineers
Jacksonville District
Jacksonville, Florida

Publication_Date: 19950901

Title: Kissimmee River Restoration Surveys

Description:

Abstract:

Digital orthophotography covering the Kissimmee River flood plain between Lake Kissimmee and Lake Okeechobee, was collected in support of the Kissimmee River Restoration (KRR). This collection consists of the orthoimagery, contours, spot elevations, cross sections, bathymetry and digital terrain models (DTMs). Some data is in ARC/INFO coverages and Grids, some in Intergraph design files, some in both. The flood plain of the Kissimmee is considered as divided into four pools along its length which correspond to structures along Canal 38. Each pool is further divided into blocks which serve to keep the file size of the data manageable. The grids, the contours, spot elevations, and other vector coverages are tiled to correspond to these blocks. The orthoimages are tiled to provide a standard engineering drawing at a scale of 1" = 100', and there are typically 7-10 of them per block. The surveys and photogrammetry were performed by private architectural and engineering (A&E) contractors for the Corps of Engineers. Each pool was awarded to a different contractor. As a result, there are inconsistencies in the data provided when one pool is compared to another.

Contours, spot elevations and a DTM in ARC/INFO and Intergraph format were provided for all pools. Additional coverages such as cross sections and design files of other features, such as utilities and building footprints were provided at the discretion of the individual contractors. The orthoimages are 8-bitgreyscale TIFF; pixel size is 1x1 foot. Individual images are 3000 x 2500 pixels, and 375 of these 7.5 Mb files are required to cover the flood plain: 146 for Pool A, ?? for Pool B, 114 for Pool C and ?? for Pool D.

Index contours occur at five foot intervals with supplemental contours at one foot intervals.

Photogrammetrically derived spot elevations are at approximate 60 foot grid spacing where the ground was not obscured.

Digital terrain models are in the form of ARC/INFO floating point Grids, Intergraph DTMs and TTNs with a 60 foot cell size.

Purpose:

The data were collected to support and monitor the progress of the KRR, an environmental restoration project designed to return hydrology in the flood plain to a state more closely resembling that which preceded the construction of C-38. The data are suitable for applications that require detailed elevation data and high resolution aerial orthoimagery of this area. Some examples of these are inundated area mapping, land use determination, and existence of structures, roads and drainage features on lands subject to inundation.

Time_Period_of_Content:

Time_Period_Information:

Single_Date/Time:

Calendar_Date: 19950401

Currentness_Reference: Publication date of sources

Status:

Progress: In work

Maintenance_and_Update_Frequency: None

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: -81.2590

East_Bounding_Coordinate: -80.8370

North_Bounding_Coordinate: 27.8250

South_Bounding_Coordinate: 27.1090

Keywords:

Theme:

(Continued)

Table 8-2 (Concluded)

Theme_Keyword_Thesaurus: none
Theme_Keyword: Aerial photography
Theme_Keyword: Topography
Theme_Keyword: Orthoimagery
Theme_Keyword: DTM
Place_Keyword_Thesaurus: Geographic Names Information System
Place_Keyword: Florida
Place_Keyword: Kissimmee
Place_Keyword: C-38
Place_Keyword: Osceola County
Place_Keyword: Polk County
Place_Keyword: Okeechobee County
Place_Keyword: Highlands County
Access_Constraints: none
Use_Constraints:
These data were collected and processed for government use in a specific US Army Corps of Engineers (USACE) activity. The Jacksonville District makes no representation as to the suitability or accuracy of these data for any other purpose and disclaims any liability for errors that the data may contain. As such, it is only valid for its intended use within its content, time and accuracy specifications. While no explicit constraints are placed on the use of this data, please exercise appropriate and professional judgement in it's use and interpretation.
Metadata_Reference_Information:
Metadata_Date: 19950824
Metadata_Contact:
Chief, Survey Section, Engineering Division

Contact_Information:
Contact_Organization_Primary:
Contact_Organization:
US Army Corps of Engineers
Jacksonville District
Survey Section, CESAJ-EN-DT

Contact_Address:
Address_Type: mailing address
Address: PO Box 4970
City: Jacksonville
State_or_Province: FL
Postal_Code: 32232-0019
Contact_Voice_Telephone: 904-232-1606
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: 19940608

Chapter 9
Hardware, Software and Network Issues and Standards

9-1. General

Configuring and procuring the GD&S is a challenge, considering all the combinations of hardware, software and connectivity options available, but a solid set of requirements will allow purchases to be made with confidence. These requirements include the user needs, as defined in the systems requirements analysis, and non-user needs, the rules and regulations that must be followed during a system procurement, which may affect system design. GD&S design can be divided into hardware, software and network configuration.

9-2. Hardware

a. Compliance with standards. GD&S design must be done in phases and certain subjects must be dealt with in the early stages of system configuration. For instance, there are Federal standards that impose various standards on internetworking and interoperability among computer systems.

The United States Government has adopted the International Standard ISO/IEC 9945-1:1990, Information Technology - Portable Operating System Interface (POSIX) - Part 1: System Application Program Interface (API) [C Language}, as a Federal Information Processing Standard (FIPS 151-2, May 12, 1993). This standard defines a C programming language source interface to an operating system environment for scientific workstations, multi- user, and multi-tasking systems. This standard does not apply to the desktop or single user environment. This standard is for use by computing professionals involved in system and application software development and implementation. An objective of this standard is to promote portability of useful computer application programs at the source code level. FIPS 151-2 supersedes FIPS 151-1 and FIPS 151.

FIPS 146-2 (May 15, 1995), Profiles for Open Systems Internetworking Technologies (POSIT), removed the requirement that federal agencies specify Government Open Systems Interconnection Profile (GOSIP) protocols when acquiring computer networking products and services and communications systems or services.

b. Architecture. There are two basic system architectures in use, the client/server model and the stand-alone workstation model.

The client/server architecture allows all the large datasets and software packages to be stored on one central server system, freeing the other client machines to use their resources for other needs. This model provides better data management, allows for greater expansion due to the lower cost of typical client machines, which could be a simple X terminal, and provides single-point control of the databases and software used in the system. The server machine must have sufficient computing muscle and storage capacity to satisfy the needs of multiple users. This will drive up the cost of the initial server machine beyond what a typical stand-alone workstation would cost, but additional client machines will cost substantially less, particularly if that client machine is just an X terminal. The server can act solely as a file server for data storage and retrieval, or it can also provide computation services due to its fast CPU. In this aspect, the server could be viewed as a powerful standalone workstation with the capability to share its resources through a network.

The stand-alone system does not have shared resource requirements, so the performance of the CPU is not as important, but the system does require that every peripheral and upgrade path will be available during the lifetime of the GD&S. The purpose of a stand-alone GD&S could be to ensure strict security on the data since there are no channels for outside accesses. In addition, a stand-alone design can place networking as a low priority since it is rarely if ever used. This will severely limit the amount of data shared among GD&S and reduces the available resources the GD&S can use for scientific analysis.

c. Operating system (OS). The OS that is used must be compatible with the GD&S software and provide services to satisfy user needs and networking needs. In addition, consideration must be given to optional software and peripheral interfaces. The choice may be very simple if existing hardware has already been standardized on one OS; otherwise, the choices that are available are increasing and within three years the situation could change dramatically. The major OS choices available are UNIX (most are POSIX compliant), Windows, Windows NT (POSIX compliant), Windows95, DOS, VMS, and OS/2. Since the availability of these operating systems has grown over the past few years, the system designers choice of OS could be based on preference, but a shrewd choice can substantially benefit the GD&S and can prevent unnecessary costs when changes must be made. When choosing an OS for a time-critical GD&S, consider track record and dependability to be very important and avoid recent upgrades and opt for the older, more secure versions.

UNIX has been the overall standard in scientific computing over the last 15 years, mostly because of its wide availability over varying platforms and its close relationship with developers. UNIX offers standard networking based on TCP/IP protocol which is available with every version of UNIX. In addition, multiple users and multiple concurrent processes are supported, which makes it a likely choice for multiple user systems. Each user on a UNIX based system has a user account and password, which allows the system to maintain security and generate accounting information for billing or resource management. Recently, UNIX has undergone a graphical facelift much like Windows for DOS, which may come from different vendors. Through the X Consortium's graphical server standard many graphical environments are offered to provide a graphical user interface to UNIX, including HP-VUE, Motif, OpenWindows and SunView. This OS has been around for many years and has a very respectable track record and offers many services that other operating systems do not.

VMS is the proprietary OS developed by Digital Equipment Corporation (DEC) to operate on their line of VAX machines and has the same basic capabilities as UNIX minus the wide availability with different hardware and platforms. OS/2 is developed by International Business Machines (IBM) and offers a fully 32 bit operating system architecture for PC class machines. In addition, it provides compatibility with Microsoft Windows and DOS. Microsoft offers Windows NT, a 32-bit operating system with advanced networking and security features and maintains the standard Windows interface. Microsoft also offers Windows and DOS operating systems for PC class machines, which provides access to thousands of commercial software packages with substantially lower cost than a typical UNIX based software package. Apple's proprietary OS for the Macintosh line of computers maintains a simple plug-and-play peripheral interface.

d. Compatibility with existing hardware. Integration of a new GD&S into an existing system must be done with care and foresight in order to reduce incompatibility problems. If the existing systems are linked via a network and the new GD&S is proposed to be integrated into the existing network, then make sure the networking protocols and transports are supported on all machines. Some systems allow multiple protocols and transports to be used, however it is much more stable and safe to use the same network protocols (e.g., TCP/IP) and transports (e.g., 10BaseT). Additional cost can be saved if peripherals can be shared or used on all machines within the GD&S, consequently, verify that the existing peripherals can be used by the new GD&S hardware and software. It is generally a good idea to limit the number of different vendors and manufacturers to as few as possible in order to reduce maintenance contract costs and hardware/ software conflicts that arise between products from different manufacturers. This is especially true with software since developers rarely have the time and resources to test their products on every hardware configuration.

e. Upgradeability. Considering the pace that technology increases - a hardware generation is approximately seventeen months - it is inevitable that hardware and software upgrades will be desirable to increase performance and offer more complex analytical functions. It is very important to choose hardware and software that can be upgraded in as many ways as possible. Determine if CPU upgrades, RAM expansions, video expansions and storage expansions are available immediately or in the near future. Currently, the more flexible mode of upgrade is to offer a few hardware “slots” that are connected to the CPU bus architecture so that upgrade boards can be added to the system, such as to provide accelerated video and faster networking throughput.

f. Peripheral support. A GD&S is composed of a CPU, GD&S software, georeferenced datasets and additional peripherals that provide input and output to the system. There are many peripherals that should be accessible through the GD&S, such as scanners, digitizers, backup devices, GPS post processing, printers and plotters. Peripherals are an integral part of a GD&S and must be supported.

g. Maintenance and Management. Hardware maintenance is a very important job that generally requires a staff devoted to this task. Large computer systems of the past require expensive maintenance contracts and require constant attention. The purchaser has either the option to purchase a maintenance contract from the vendor or develop a trained staff for maintaining the computer equipment. Both options are costly, but system health must be maintained in order to have a working GD&S. This is especially true in a network, where if the network was corrupted or failed, then GD&S work would come to a halt until the problem could be fixed. In these situations, having service staff available may save a project from failure.

A System Administrator position should be created to manage the GD&S hardware and network products. The System Administrator shall maintain the system and develop standard operating procedures for the GD&S, such as user accounts, project schedules, scheduled downtimes for maintenance and CPU utilization reports.

h. Example configurations.

(1) SUN Sparcstation 10.

(a) 40 MB RAM.

(b) (2) 1.2 GB hard drives.

(c) Keyboard.

(d) Mouse.

(e) Wacom digitizing tablet.

(f) CD-ROM drive.

(g) Exabyte backup drive.

(h) 17' 256 color monitor.

(2) Intergraph Microstation.

(a) Keyboard.

(b) CD-ROM drive.

(c) 20' color monitor.

(d) Digitizing tablet.

(3) 486 33Mhz PC-compatible.

(a) 8 MB RAM

(b) 500 MB hard drive.

(c) Mouse.

(d) Keyboard.

(e) Syquest 88MB removable hard drive.

(f) CD-ROM drive.

(g) 14' color monitor.

(h) Ethernet networking card.

(i) 256 color Super-VGA video card.

(j) 600 dpi monochrome laser printer.

9-3. Software

a. Compliance with standards. In order for a GD&S to operate efficiently, a dependable strategy must be designed to handle importing and exporting datasets of differing formats and platforms. The Spatial Data Transfer Standard (SDTS), FIPS 173, is a mechanism for the transfer of spatial data between dissimilar computer systems. The SDTS specifies exchange constructs, addressing formats, structure, and content for spatially referenced vector and raster data. The SDTS Fact Sheet by the U.S. Geological Survey states that the advantages of SDTS include data and cost sharing, flexibility, and improved quality, all with no loss of information. This standard is mandatory for Federal agencies and will serve as the spatial data transfer mechanism for all Federal agencies. The U.S. Geological Survey (USGS) has been designated as the maintenance authority and will be producing software tools and guidelines for SDTS data encoding and decoding. They will also offer SDTS workshops and training in order to educate the spatial data community. The GDS software chosen must support SDTS as one of its data import/export format options.

For further information regarding the SDTS (FIPS 173), contact:

U.S. Geological Survey
SDTS Task Force
526 National Center
Reston, VA 22092
FAX: (703) 648-4270
E-mail: sdts@usgs.gov

b. Export/import raster and vector data. The GDS software must have the capability to import a variety of commonly available data formats without loss of information. This includes vector and raster data and associated descriptive attribute (tabular) data. At a minimum, the GDS software should have routines for importing commonly available data from government and commercial sources. These formats include DEM and DLG (USGS), TIGER-Line (Census Bureau), DTED and VPF (DMA) and standard commercial image formats from SPOT and EOSAT. In addition, the software should accept the widely used DXF exchange format, SDTS formats and ascii data.

Data export formats supported by the GDS software can be more limited. Data exchange between GDS using the same software is generally easy. The SDTS governs the exchange of spatial data between dissimilar systems among Federal agencies.

DMA has developed several data formats as military standards. However, these military standards are not FIPS and the GDS software chosen is not required to read or write data in these formats. The Vector Product Format (VPF), MIL-STD-2407 is a standard vector data format used by the Defense Mapping Agency and many of their map products are distributed in that format. DMA has also developed the Raster Product Format, MIL-STD-2411, for image and scanned data in compressed or uncompressed form.

c. Visual environment. There are certain minimum visual requirements that the GD&S environment must fulfill so that data analysis can be properly done. The GD&S must be able to display the datasets in a georeferenced environment and preferably allow the user to zoom into and away from the dataset based on certain spatial characteristics. Secondly, the user must be able to query the dataset either spatially or topically. Otherwise, the data remains strictly graphical and detailed analyses and reports can not be accurately performed. Third, the GD&S must provide the user with the capability to manipulate the dataset in some intelligent manner. Suppose the user must create a demonstration and the project calls for particular locations passing certain qualifications to be set to the color blue. The user will need to be able to manipulate the dataset as it is displayed to reflect these requirements. Data integrity should not be violated, but a certain latitude must be given to the user so that the environment can be as flexible and usable as possible.

d. Maintenance and management. GD&S maintenance requires a standard operating procedure for data archiving, data security and data modification. A typical data archiving schedule consists of daily data backups and weekly full system backups. Archiving data will ensure that any corruption or system failure will not destroy important data or software. Data security measures such as user and project login with password entry to the GD&S are standard. In a distributed GD&S network, data stewardship can be allocated such that data management and security can be centralized in one organization. However, a stand-alone GD&S workstation will require more control and might require strict passwords and possibly even read-only access to critical datasets. Computer systems are not fail safe and as many provisions that can be taken to prevent data loss or data corruption must be made. If datasets must be edited or updated, then a standard operating procedure should be drawn up for such an occasion, and a version control procedure should be implemented. Full backups of each successive data state should be kept in case the decision is made to reverse the changes.

9-4. Networking

a. Overview. In the early days of the personal computer revolution, people were content to use their computers for personal finance and possibly a little word processing. However, as hardware and software capabilities grew, they realized that these computers could offer them much more. Today's high-powered systems are used in all facets of business, including the quickly- growing GDS market. A computer is simply much better at GDS activities than people performing them by hand because it can analyze multiple multi-record databases and correlate an information base into useful results quick enough for them to be utilized in the real world. For example, the Federal Emergency Management Agency (FEMA) now uses a GDS to manage natural and man- made disasters. This GDS allows the agency to track hurricanes, estimate damage through simulations, and plan relief efforts in a matter of minutes; FEMA can now better manage relief aid for such disasters and then use the data gathered during one hurricane to plan for the next. Applications of GDS like this save time and lives, but are dependent upon the availability of large and often costly databases. Databases can quickly surpass your system's on-line storage capacity, requiring access to (and storage on) other machines, both local and remote. You may also have a need to send output from your GDS system to customers through quicker means than the postal service. Networking was born some twenty years ago to solve such problems. At that time, visionaries had an idea of computers becoming information resources for any number of different subjects. This idea has become a reality with the advent of the Internet. Once you are connected to the Internet, you have instant access to a wealth of information. Through electronic mail and bulletin boards (called “news groups” in Internet lingo), you can use a different kind of resource: a worldwide supply of knowledgeable people, their software, and their hardware.

This section provides a *brief* introduction to the subject of networking. This information could easily fill a book in its own right. The Internet, as described in this document, is still evolving along with the means of accessing it. Therefore, it should be known that the information presented in this document is current as of early August 1994 and may change within the next several years.

b. Introduction to networking and related concepts. Networking, simply put, is connecting your computers together so they can share information. Effective networking increases productivity by using computer resources, such as files, printers, and memory, more efficiently. A network puts the power of all your system's hardware and software at your fingertips.

Although there are many different types of networks, they fall into two general categories. Local area networks (LAN) are small groups of computers in close proximity connected together on a single line. Wide area networks (WAN), such as the Internet (although the Internet is really a collection of WAN, it can be viewed here as one large network) connect computers that can be as close as several hundred feet to as far as across the globe and typically include connections via cable, telephone lines, and satellites.

A network, in the physical sense, consists of cables or phone lines which directly connect computers, and special hardware installed in each computer which provide the means for communication. Computers on a network have established ways of communicating, called protocols. Protocols dictate which signals computers use across cables, how they tell one another that they have received information, and how they exchange information. These protocols are broken down into layers of service which specify the hardware/software interactions taking place on the network. Each layer is responsible for one piece of the communication and interacts only with the layers above and below it. For example, the International Organization for Standards (ISO) has a seven-layer protocol called the Reference Model for Open Systems Interconnection (OSI), as shown in Table 9-1 (lower layers are closer to hardware and higher layers are closer to the user).

A basic networking package consists of several services that allow your computer to connect to both local and wide area networks.

TCP/IP provides various protocols for networking communications that other networking packages, such as NFS, use. The TCP/IP package also provides end-user programs such as telnet and ftp that enable remote login and file transfer between systems running TCP/IP.

NFS allows you to export file systems to the network so that users on other computers can use them as if they were local, and to import file systems from remote systems to your own.

The Multichannel Memorandum Distribution Facility (MMDF) controls electronic mail communications between machines. MMDF is a service that provides users with transparent access to different networks and related mail transport protocols.

c. Local area networks.

(1) Description of a LAN. A local area network is a direct connection of computers in the same office or in adjacent buildings on a single cable. Within this small circle, each computer can communicate with every other computer on the LAN and share resources such as hard drives, printers, and any other peripherals. A LAN typically has one or more machines which perform services on behalf of the other computers in the LAN. These servers usually perform printing and file storage services. In addition, a server is also used to route connections to the Internet and other LANs around the world. The USACE policy on LANs is stated in IM Policy Memo 25-1-8, “Local Area Network (LAN) Design and Interoperability.”

(2) NFS/NIS. When the TCP/IP protocol was first developed and implemented on UNIX workstations, it was wonderful to be able to retrieve specific data from other machines on your LAN through such programs as ftp. However, with larger programs being developed, this became impractical. For example, most GDS systems require a large amount of online data which can quickly consume computer disk space. Instead of requiring each machine on the LAN to have its own copy of such data, it would be better to have one central copy on a server which everyone can access without having to transfer it to their machine. FTP does not provide the capabilities necessary to perform this task. In the early 80's Sun Microsystems developed a service called NFS (Network File System) which revolutionized the computer industry. NFS is a set of protocols which allow your computer to use files on other systems as if they were local. So, instead of obtaining files via ftp, you can read, write and edit files on remote machines. NIS is the service which manages all NFS activities. Its primary purpose is to ensure network consistency and maintain file access security in a LAN. NIS accomplishes this task by maintaining lists of users, passwords, and system access availability, and distributing the lists throughout the LAN. Each machine then knows who has access to specific files.

(3) Hardware and software issues. When the only computers you could buy included the UNIX operating system, building a LAN was not a problem because the basic architecture of each system's UNIX was the same. So, even if you had UNIX computers from two different vendors, you could be certain that the two machines would communicate without any problems on your LAN. Times have changed, and there are now many different operating systems available for every computer you can buy. Not all of them come with TCP/IP software. For example, while UNIX comes with such a package, MSDOS requires extra add-on software. Even with TCP/IP installed on both platforms, you still might not be able to share data due to physical differences between the machines such as the way one computer stores binary information as opposed to the other. The point is that you must put some thought into building your LAN. Make sure that all the different types of computers you wish to include will work cooperatively together or that you can purchase software to make them work together. Sun sells software which allows PCs to communicate with UNIX machines as do other vendors. Macintosh computers come ready with TCP/IP, but do not automatically support NFS. In addition, you should thoroughly investigate any hardware limitations you might encounter. If you plan out a strategy for purchasing equipment and computers for your LAN ahead of time, it will save you a world of data access and transfer nightmares.

d. The Internet. The Internet is a worldwide collection of WANs linking computers from government, academia, and industry. It allows easy access for computer users, and so is being used by the FGDC for the establishment of the National Geospatial Data Clearinghouse.

(1) History of the Internet. The Internet began as a Department of Defense experiment to develop a computer network which could operate without data loss in a battle during wartime when partial outages are likely. Because of

the premise on which it was developed, the ARPAnet (as the Internet was originally called), placed all the demands of data transmission and decoding on the network computers rather then the actual network links. This meant that the network did not have a vulnerable main transmission path or decoding hub. If one link vanished, the network computers determined this and rerouted their data through another path.

While this experiment was taking place, universities and other government agencies, who had most of the computing power in the United States, were looking for ways to link their systems together for research and educational purposes. However, since these organizations had no policies regarding computer purchasing, they found it difficult to successfully link computers from different manufacturers. The ARPAnet development solved this problem because of its basis on computers transmitting and decoding data themselves. If you wanted your computer to have access to other types of computers, you only had to write a piece of software for your computer which could send and receive data using the Internet Protocol (the method by which data is transmitted on the Internet). Demand to connect university and government mainframes grew, and Internet developers, responding to pressures, began to develop their Internet Protocol software on every possible type of computer. It quickly became the only practical way for computers from different manufacturers to communicate.

Roughly 10 years later, Ethernet local area networks (LAN) and workstations appeared on the scene. Most of them came with Berkeley UNIX, which came with the necessary Internet Protocol software built-in (this is where the fallacy that the Internet is UNIX started - although most of the Internet Protocol software originated on UNIX platforms, it is not part of the UNIX operating system itself). A new demand was created not only to connect large time-sharing mainframes to the ARPAnet but also to connect the entire LAN. Many different organizations started to build their own networks based on the Internet protocols because they found the existing ARPAnet communications too limiting due to its bureaucracy and staffing problems. Probably the most important of these new networks was the National Science Foundation's (NSF) NSFNET. In the 80's, the NSF established five centers for supercomputing activities. The fastest computers had previously been available only to the military and researchers from the government and universities. The NSF was now making such resources available to any world-wide researcher. Only five centers were established because of costs. To connect each center they needed dedicated, high-speed phone lines which were paid for by the mile. They realized that connecting each university to a center would bankrupt the agency, so they established regional networks with links to the supercomputing centers. Each university was connected to its nearest neighbor, and each computer in the network chain would forward requests between computers in the chain. This solution was very successful and has been adopted for modeling current networking activities.

In the late 80's, with network traffic increasing by about 15 percent per year, the Internet had grown to the point that its routing computers and the telephone lines connecting them were overloaded. The Federal government invested large sums of money into upgrading the entire network, and it continues to be the driving force behind supporting the Internet. These upgrades included new telephone lines with higher data transfer rates and more powerful data routing systems. With these enhancements to the Internet, it has become possible for more people to use the Internet not only in government, universities, and corporations, but also in their own homes. Various national companies, such as DELPHI, now offer Internet connections through standard modems. This type of connection may be slower than those available to organizations, but it is much more reliable than earlier bulletin board services to which the average home user had access. In addition, through such a connection, you have access to any computer on the Internet and a multitude of data and services.

(2) Internet security issues. Since the Internet is a global community of networks, anyone can have access to your system at any time. USACE Commands must control the types of access by establishing some basic security procedures before placing systems on the network. Each system administrator must be aware of the risks and take appropriate action to protect USACE systems without limiting access to the services available in Internet. USACE requirements for Internet Security are described in EP 25-1-97, Internet Implementing Procedures.

e. Obtaining Information from the Internet. This section will give a brief overview of services and applications which are used to access the Internet. Appendix C lists specific Internet sites that provide GD&S information.

(1) Telnet. Telnet is used for logging into other computers on the Internet or even to other computers on your LAN. Once you have established a connection, your machine is operating as a dummy terminal to display messages from the remote machine. It is used primarily for text-based purposes such as searching library card catalogs and other kinds of databases. Telnet generally does not offer file transfer capabilities between connected machines other than simple ASCII text.

Table 9-1
Reference Model for Open Systems Interconnection

Layer	Name	Description
7	Application	Defines how programs can communicate with each other.
6	Presentation	Performs any necessary data conversion.
5	Session	Establishes an enhanced connection (session) with other machines.
4	Transport	Makes sure information exchanged between computers arrives intact and without errors.
3	Network	Makes sure information coming from one computer arrives at the correct destination.
2	Data Link	Makes sure information gets from one end of the cable to the other intact.
1	Physical	Defines the way information travels on a cable. A common physical-level protocol is the IEEE 802.3 protocol, of which Ethernet is a subset.

(2) FTP. FTP (File Transfer Protocol) allows you to move files between machines. Once a connection is established, you may view the directory structure of the remote machine and move files to/from that computer, but you may not run any applications on that system. FTP is most useful for retrieving files from public archives that are scattered on the Internet. This is called an "anonymous FTP" because you do not need an account to access the remote computer.

(3) Electronic mail. Electronic mail, or e-mail, lets you send and receive messages to/from a person at a remote location on the Internet. E-mail is usually used for quick informal conversing over the Internet and as a means to quickly distribute textual information to multiple parties. Present E-mail software can even distribute embedded documents from popular word processors and other files.

(4) Network news. USENET is a system that lets you read (and post) messages that have been sent to public "news groups" (news groups are the equivalent of bulletin boards in the Internet community.) It is used primarily to converse with other people on any subject. For example, if you had a question about a problem with your laser printer, you could post a message to this service asking if anyone has a solution. USENET is the world's largest bulletin board service.

(5) Gopher clients. Gopher is a tool for browsing the Internet by selecting resources from a menu. Most often you will view the resources available in a directory tree structure. Gopher client software is designed to be user friendly so that it can help you get access to a particular item of interest. You do not have to worry about Internet addresses and once it has established a connection for you, the software can even retrieve files. Because of this, gopher clients are like ftp software packages with a user-friendly front-end. To use this type of package, the remote machine must be configured as a gopher server. This service is relatively new in the Internet community, so you will mainly find gopher servers at universities.

(6) WAIS. Wide Area Information Servers (WAIS) is another new service available on the Internet and is being used by FGDC. It is good for searching through indexed material and finding articles based on what they contain. WAIS is really a tool for working with large collections of data and databases. Almost any type of information can be indexed, and the retrieval software allows natural language string searches. For example, you could use WAIS to search indexed GDS databases for all references to Lake Michigan. In addition to searching for information in documents and databases, WAIS also has the capability to show you the information itself.

(7) The World Wide Web. The World Wide Web (WWW) is the newest information service to arrive on the Internet. This service is based on a technology called hyperlinking. Hyperlinking is a means of providing point-and-click access to other document sources - text, image, or sound - which relate to what you are currently viewing. Anyone who has used the Microsoft Windows Help program has seen this technology at work. Sections of text can have links to other sections through keywords. These keywords are highlighted via underlining, italics, etc. When you click on one of these keywords with a mouse, the software "fetches" the document corresponding to that link. The Web operates in the same way, but it goes much further. The links in the Web can be either text-based, pointing to other Internet sites and particular files which you may download to your machine, or multimedia pictures and audio which may be played on your computer. The purpose of the Web is to provide a subject-oriented means of browsing the Internet, which makes finding particular files and information much easier. Instead of locating files through text based searches with ftp and telnet, you are presented

with a paragraph on a particular file with a direct link to that file somewhere on the Internet.

Since the Web is relatively new, not many hyperlink Internet sites exist. These sites are identified by the letters “http” at the beginning of their address. In addition, it is up to the owners of each Internet site to determine whether or not to build hyperlink pages for their computers. If you are planning to let the public use your computer, it is a much more user friendly way to provide access to your services and resources. From a user's point of view, these hyperlink documents would be useless if there were no way to view them. Fortunately, the Web has been strongly endorsed by the Internet community, and there is an effort under way to develop such applications. Mosaic, which is being developed by the National Center for Supercomputing Applications, is the most popular of these hyperlink Internet browsing tools. This software offers all the features of the Web plus capabilities for WAIS, ftp, telnet, and gopher in one package, and is being developed for UNIX workstations running X-Windows, Macintoshes, and PCs with Microsoft Windows. The latest version of Mosaic is available free on the Internet with new alpha releases being distributed for all three environments about once every month. For further information on Mosaic, contact:

NCSA Documentation Orders
152 Computing Applications Building
605 East Springfield Avenue
Champaign, IL 61820-5518
(217) 244-4130
orders@ncsa.uiuc.edu

Chapter 10
System Procurement

10-1. General

a. The term "Information Technology (IT)" is defined in Public Law (PL) 104-106, Section 5002 Definitions, (3) (b). IT includes computers, ancillary equipment, software, firmware and similar procedures, services (including support services) and related resources.

b. The passage of PL 104-106 has shifted the responsibility for management and oversight of IT from the General Services Administration (GSA) to the Office of Management and Budget (OMB). GSA abolished the FIRMR effective 8 Aug 96. OMB is required to issue guidance in conducting IT acquisitions. Your local Director or Chief of Information Management will be able to provide you with the latest guidance and direction in defining and developing the appropriate documentation to justify initiating the acquisition process. As a minimum, requirements should have been identified in your organization's IMA Mod Plan and the IT assets captured in the Requirement Statements Management System (RSMS). If solicitation or contract does not require IT then a brief statement must accompany the request that states, the specification for this contract do not contain any requirement for IT."

c. The documentation required to justify initiating the acquisition process is, generally: stating a specific mission that needs IT resources to satisfy that mission, with measurable benefits derived from the investment. All of these must be consistent with common sense and sound business practices.

(1) The planning for IT resource requirements starts with establishing the mission need. The needs identified at program initiation must be reexamined at each milestone to assure that they reflect the most current program conditions and IT. The following are major elements in the acquisition process: mission needs, structuring an acquisition strategy, developing producible and affordable designs, making decisions, and assessing program status as it applies to Life Cycle Management of Information System (LCMIS).

(2) A part of the requirement justification must identify the IT resource being requested, in order that the Director or Chief of Information Management can certify compliance that it is consistent with Army Technical Architecture. A statement justifying the requirement is required, and a financial analysis under LCMIS may be required. You need to assure that requirement statement has been updated and still conveys the justification for the IT resource.

10-2. Contract Vehicles

This section lists the points of contact for some existing contract vehicles that can be used by USACE Commands to procure GDS hardware and/or software. These contracts are applicable to GDS procurements but are by no means the only vehicles available. Using an existing contract vehicle eliminates some of the procurement steps. However, all hardware procurements must have approved Life Cycle Management documentation, a Requirements Analysis and Analysis of Alternatives.

The most important contract for acquisition of GDS hardware and software is the "Facilities CAD2" contract. The CAD2 contract was awarded to two vendors, Intergraph (Contract N66032-93-D-0021) and Cordant, Inc. (Contract N66032-93-D-0022). Both vendors offer a wide variety of software and hardware products and support services for GD&S applications.

The USACE point of contact for the Facilities CAD2 contract is:

Mr. C. W. "Rusty" Brasfeild, Jr.
Facilities CAD2 COR
NAVFAC DET WES, Bldg 8000
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
Telephone: (800) 700-2232 or (601) 634-4474
FAX: (601) 634-2947

GDS software and hardware are also available from the CEAP-IA. This contract supports the Corps of Engineers Automation Plan (CEAP) and is an indefinite delivery, indefinite quantity contract. The ESRI line of ARC/Info GDS software products are available from this contract. It also provides multiuser SUN and Control Data 4000 workstations, SUN and Control Data 4000 UNIX mini-computers, Control Data CYBER mainframes, local (LAN) and wide area network (WAN) hardware and software, the ORACLE database management system with associated products, and professional support services.

The USACE Point of Contact for the CEAP-IA is:
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The Small Multi-user Computer-II (SMC-II) contract was awarded to Telos and supplies peripherals, software, networking components, maintenance, and engineering services. The USACE Point of Contact for the SMC-II contract:

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Chapter 11
ACCURACY STANDARDS FOR ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT SURVEYING AND MAPPING

11-1. Scope. This chapter provides technical guidance on engineering surveying and mapping accuracy standards used in engineering and construction. It is intended for use in developing specifications for geospatial data used in various project documents, such as architectural and engineering drawings, master planning maps, construction plans, navigation project condition charts and reports, and related GIS, CADD, and AM/FM products. Guidance is provided for preparing specifications for surveying and mapping services.

11-2. General Surveying and Mapping Specifications. Construction plans, maps, facility plans, and CADD/GIS data bases are created by a variety of terrestrial, satellite, acoustic, or aerial mapping techniques that acquire planimetric, topographic, hydrographic, or feature attribute data. Specifications for obtaining these data should be "performance-based" and not overly prescriptive or process oriented. They should be derived from the functional project requirements and use recognized industry accuracy standards where available.

a. Industry standards. Maximum use should be made of industry standards and consensus standards established by private voluntary standards bodies; in lieu of Government-developed standards. Therefore, industry-developed accuracy standards should be given preference over Government standards. A number of professional associations have published surveying and mapping accuracy standards, such as the American Society for Photogrammetry and Remote Sensing (ASPRS), the American Society of Civil Engineers (ASCE), the American Congress on Surveying and Mapping (ACSM), and the American Land Title Association (ALTA). When industry standards are non-existent, inappropriate, or do not meet a project's functional requirement, FGDC, DoD, Tri-Service, DA, or USACE standards may be specified as criteria sources. Minimum technical standards established by state boards of registration, especially on projects requiring licensed surveyors or mappers, should be followed when legally applicable. Local surveying and mapping standards should not be developed where consensus industry standards or DoD/DA standards exist.

b. Performance specifications. Performance-oriented (i.e., outcome based) specifications are recommended in procuring surveying and mapping services. Performance specifications set forth the end results to be achieved (i.e., final map format, data content, and/or accuracy standard) and not the means, or technical procedures, used to achieve those results. Performance-oriented specifications typically provide the most flexibility and use of state-of-the-art instrumentation and techniques. Performance specifications should succinctly define only the basic mapping requirements that will be used to verify conformance with the specified criteria, e.g., mapping limits, feature location and attribute requirements, scale, contour interval, map format, sheet layout, and final data transmittal, archiving or storage requirements, required accuracy criteria standards for topographic and planimetric features that are to be depicted, and quality assurance procedures. Performance-oriented specifications should be free from unnecessary equipment, personnel, instrumentation, procedural, or material limitations; except as needed to establish comparative cost estimates for negotiated services.

c. Prescriptive (procedural) specifications. Use of prescriptive specifications should be kept to a minimum, and called for only on highly specialized or critical projects where only one prescribed technical method is appropriate or practical to perform the work. Prescriptive specifications typically require specific field instrumentation, equipment, personnel, office technical production procedures, or rigid project phasing with on-going design or construction. Prescriptive specifications may, depending on the expertise of the writer, reduce flexibility, efficiency, and risk, and can adversely impact project costs if antiquated methods or instrumentation are required. Prescriptive specifications also tend to shift most liability to the Government. Occasionally, prescriptive specifications may be applicable to Corps projects involving specialized work not routinely performed by private surveying and mapping firms, e.g., mapping tactical operation sites, mapping hazardous, toxic, and radioactive waste (HTRW) clean-up sites, military/tactical surveying, or structural deformation monitoring of locks, dams, and other flood control structures.

d. Tri-Service CADD/GIS Technology Center standards. Tri-Service standards should be specified for in-house or A-E services requiring delivery of CADD, GIS, and other spatial and geospatial data covered by this chapter--see Chapter 7 for detailed reference requirements.

e. Quality control. Quality control (QC) of contracted surveying and mapping work should generally be performed by the contractor. Therefore, USACE quality assurance (QA) and testing functions should be focused on whether the contractor meets the required performance specification (e.g., accuracy standard), and not the intermediate surveying, mapping, and compilation steps performed by the contractor. The contractor's internal QC will normally include independent tests which may be periodically reviewed by the Government. Government-performed (or monitored) field testing of map accuracies is an optional QA requirement, and should be performed when technically and economically justified, as determined by the ultimate project function.

f. Metrication. Surveying and mapping performed for design and construction should be recorded and plotted in the units prescribed for the project by the requesting Command or project sponsor. During transition to the metric system, inch-pound (IP) units or soft conversions may be required for some geospatial data.

g. Spatial coordinate reference systems. Where practical and feasible, civil and military projects should be adequately referenced to nationwide or worldwide coordinate systems directly derived from, or indirectly connected to, Global Positioning System (GPS) satellite observations. In addition, navigation and flood control projects in tidal areas should be vertically referenced to the latest datum epoch established by the Department of Commerce.

11-3. Accuracy Standards for Engineering and Construction Surveying. Engineering and construction surveys are performed to locate, align, and stake out construction for civil and military projects, e.g., buildings, utilities, roadways, runways, flood control and navigation projects, training ranges, etc. Engineering surveys are performed to provide the base horizontal and vertical control used for area mapping, GIS development, preliminary planning studies, detailed site plan drawings for construction plans, construction measurement and payment, preparing as-built drawings, installation master planning mapping, and future maintenance and repair activities. Most engineering surveying standards currently used are based on local practice, or may be contained in State minimum technical standards.

a. Accuracy standards. Engineering and construction surveys are normally specified and classified based on the horizontal (linear) point closure ratio or a vertical elevation difference closure standard. This type of performance criteria is most commonly specified in Federal agency, state, and local surveying standards, and should be followed and specified by USACE commands. These standards are applicable to most types of engineering and construction survey equipment and practices (e.g., total station traverses, differential GPS, differential spirit leveling). These accuracy standards are summarized in the following tables.

Table 11-1
Minimum Closure Accuracy Standards for Engineering and Construction Surveys

USACE Classification	Closure Standard	
Engr & Const Control	Distance (Ratio)	Angle (Secs)
First-Order	1:100,000	$2\sqrt{N}$[1]
Second-Order, Class I	1:50,000	$3\sqrt{N}$
Second-Order, Class II	1:20,000	$5\sqrt{N}$
Third-Order, Class I	1:10,000	$10\sqrt{N}$
Third-Order, Class II	1: 5,000	$20\sqrt{N}$
Engineering Construction (Fourth-Order)	1: 2,500	$60\sqrt{N}$

[1] N = Number of angle stations

 *

Table 11-2
Minimum Elevation Closure Accuracy Standards for Engineering and Construction Surveys

USACE Classification	Elevation Closure Standard (ft)[1]	(mm)
First-Order, Class I	$0.013\sqrt{M}$	$3\sqrt{K}$
First-Order, Class II	$0.017\sqrt{M}$	$4\sqrt{K}$
Second-Order, Class I	$0.025\sqrt{M}$	$6\sqrt{K}$
Second-Order, Class II	$0.035\sqrt{M}$	$8\sqrt{K}$
Third-Order	$0.050\sqrt{M}$	$12\sqrt{K}$
Construction Layout	$0.100\sqrt{M}$	$24\sqrt{K}$

[1] $\sqrt{M}$ or $\sqrt{K}$ = square root of distance in Miles or Kilometers

b. Survey closure standards. Survey closure standards listed in Tables 11-1 and 11-2 should be used as a basis for classifying, standardizing, and evaluating survey work. The point and angular closures (i.e., traverse misclosures) relate to the relative accuracy derived from a particular survey. This relative accuracy (or, more correctly, precision) is estimated based on internal closure checks of a traverse survey run through the local project, map, land tract, or construction site. Relative survey accuracy estimates are always expressed as ratios of the traverse/loop closure to the total length of the survey (e.g., 1:10,000).

(1) Horizontal closure standard. The horizontal point closure ratio is determined by dividing the linear distance misclosure of the survey into the overall circuit length of a traverse, loop, or network line/circuit. When independent directions or angles are observed, as on a conventional traverse or closed loop survey, these angular misclosures should be distributed (balanced) before assessing positional misclosure. In cases where differential GPS vectors are measured in three-dimensional geocentric coordinates, then the horizontal component of position misclosure is assessed relative to Table 11-1.

(2) Vertical control standards. The vertical accuracy of a survey is determined by the elevation misclosure within a level

section or level loop. For conventional differential or trigonometric leveling, section or loop misclosures (in millimeters or feet) should not exceed the limits shown in Table 11-2, where the line or circuit length is measured in the applicable units. Fourth-Order accuracies are intended for construction layout grading work.

c. Geospatial Positioning Accuracy Standards. Many control surveys are now being efficiently and accurately performed using radial (spur) techniques--e.g., single line vectors from electronic total stations or kinematic differential GPS to monumented control points, topographic feature points, property corners, etc. Since these surveys may not always result in loop closures (i.e., closed traverse) alternative specifications for these techniques must be allowed. This is usually done by specifying a radial positional accuracy requirement. The required positional accuracy may be estimated based on the accuracy of the fixed reference point, instrument, and techniques used. Ratio closure standards in Tables 11-1 and 11-2 may slowly decline as more use is made of nation-wide augmented differential GPS positioning and electronic total station survey methods. The FGDC is currently (1998) proposing use of positional accuracy tolerances in order to more easily correlate surveying standards with mapping or geospatial positional accuracy standards--e.g., NSSDA.

(1) GPS satellite positioning technology allows development of map features to varying levels of accuracy, depending on the type of equipment and procedures employed. Given this rapidly developing technology, GPS surveying specifications rapidly become obsolete; therefore, it is best to follow GPS manufacturer's recommended procedures. The advent of Government and commercial augmented GPS systems allows direct, near real-time positioning of static AM/FM type features and dynamic platforms (survey vessels, aircraft, etc.). Site plan drawings, photogrammetric control, and related GIS features can be directly constructed from GPS or differential GPS observations, at accuracies ranging from 1 cm to 100 meters (95%).

(2) Accuracy classifications of maps and related GIS data developed by GPS methods can be estimated based on the GPS positioning technique employed. Permanent GPS reference stations (Continuously Operating Reference Stations or CORS) can provide decimeter and even centimeter-level point positioning accuracies

over wide ranges; thus providing direct map/feature point positioning without need for preliminary control surveys.

d. Higher-order surveys. Requirements for relative line accuracies exceeding 1:50,000 are rare for most facility engineering, construction, or mapping applications. Surveys requiring accuracies of First-Order (1:100,000) or better should be performed using FGDC geodetic standards and specifications. These surveys must be adjusted and/or evaluated by the National Geodetic Survey (NGS) if official certification relative to the national network is required.

e. Instrumentation and field observing criteria. In accordance with the policy to use performance-based standards, rigid prescriptive requirements for survey equipment, instruments, or operating procedures are discouraged. Survey alignment, orientation, and observing criteria should rarely be rigidly specified; however, general guidance regarding limits on numbers of traverse stations, minimum traverse course lengths, auxiliary azimuth connections, etc., may be provided for information. For some highly specialized work, such as dam monitoring surveys, technical specifications may prescribe that a general type of instrument system be employed, along with any unique operating, calibration, or recordation requirements.

f. Connections to existing control. Surveys should normally be connected to existing local control or project control monuments/benchmarks. These existing points may be those of any Federal (including Corps project control), State, local, or private agency. Ties to local Corps or installation project control and boundary monuments are absolutely essential and critical to design, construction, and real estate. In order to minimize scale or orientation errors, at least two existing monuments should be connected. It is recommended that Corps surveys be connected with one or more stations on the National Spatial Reference System (NSRS), when practicable and feasible. Connections with local project control that has previously been connected to the NSRS is normally adequate in most cases. Connections with the NSRS shall be subordinate to the requirements for connections with local/project control.

g. Survey computations, adjustments and quality control/assurance. Survey computations, adjustments, and quality control should be performed by the organization responsible for the actual field survey. Contract compliance assessment of a survey should be based on the prescribed point closure standards of internal loops, not on closures with external networks of unknown accuracy. In cases where internal loops are not observed, then assessment must be based on external closures. Specifications should not require closure accuracy standards in excess of those required for the project, regardless of the accuracy capabilities of the survey equipment. Least squares adjustment methods should be optional for 2nd or lower order survey work. Professional contractors should not be restricted to rigid computational methods, software, or recording forms. Use of commercial software adjustment packages is strongly recommended.

h. Data recording and archiving. Field survey data may be recorded and submitted either manually or electronically. Manual recordation should follow standard industry practice, using field book formats outlined in various technical manuals.

11-4. Accuracy Standards for Maps and Related Geospatial Products. Map accuracies are defined by the positional accuracy of a particular graphical or spatial features depicted. A map accuracy standard classifies a map as statistically meeting a certain level of accuracy. For most engineering projects, the desired accuracy is stated in the specifications, usually based on the final development scale of the map--both the horizontal "target" scale and vertical relief (specified contour interval or digital elevation model). Often, however, in developing engineering plans, spatial data bases may be developed from a variety of existing source data products, each with differing accuracies--e.g., mixing 1 in = 60 ft topo plans with 1 in = 400 ft reconnaissance topo mapping. Defining an "accuracy standard" for such a mixed data bases is difficult and requires retention of the source of each data feature in the base. In such cases the developer must estimate the accuracy of the mapped features.

a. ASPRS Standard. For site mapping of new engineering or planning projects, there are a number of industry and Federal mapping standards that may be referenced in contract specifications. The recommended standard for facility engineering is the ASPRS "Accuracy Standards for Large-Scale Maps" (ASPRS 1990). This standard, like most other mapping standards, defines map accuracy by comparing the mapped location of selected well-defined points to their "true" location, as determined by a more accurate, independent field survey. Alternately, when no independent check is feasible or practicable, a map's accuracy may be estimated based on the accuracy of the technique used to locate mapped features--e.g., photogrammetry, GPS, total station, plane table, The ASPRS standard has application to different types of mapping, ranging from wide-area, small-scale, GIS mapping to large-scale construction site plans. It is applicable to all types of horizontal and vertical geospatial mapping derived from conventional topographic surveying or photogrammetric surveys. This standard may be specified for detailed construction site plans that are developed using conventional ground topographic surveying techniques (i.e., electronic total stations, plane tables, kinematic GPS). The ASPRS standard is especially applicable to site plan development work involving mapping scales larger than 1:20,000 (1 in. = 1,667 ft); it therefore applies to the more typical engineering map scales in the 1:240 (1 in. = 20 ft) to 1:4,8000 (1 in. = 400 ft) range. Its primary advantage over other standards is that it contains more definitive statistical map testing criteria, which, from a contract administration standpoint, is desirable. Using the guidance in Tables 11-3 and 11-4, specifications for site plans need only indicate the ASPRS map class, target scale, and contour interval.

b. Horizontal (planimetric) accuracy criteria. The ASPRS planimetric standard compares the root mean square error (RMSE) of the average of the squared discrepancies, or differences in coordinate values between the map and an independent topographic ground survey of higher accuracy (i.e., check survey). The "limiting RMSE" is defined in terms of meters (feet) at the ground scale rather than in millimeters (inches) at the target map scale. This results in a linear relationship between RMSE and target map scale; as map scale decreases, the RMSE increases linearly. The RMSE is the cumulative result of all errors including those introduced by the processes of ground control surveys, map compilation, and final extraction of ground dimensions from the target map. The limiting RMSE's shown in Table 11-3 are the maximum permissible RMSE's established by the ASPRS standard. These ASPRS limits of accuracy apply to well-defined map test points only--and only at the specified map scale.

c. Vertical (topographic) accuracy criteria. Vertical accuracy has traditionally been, and currently still is, defined relative to the required contour interval for a map. In cases where digital elevation models (DEM) or digital terrain models (DTM) are being generated, an equivalent contour interval can be specified, based on the required digital point/spot elevation accuracy. The contours themselves may be later generated from a DEM using computer software routines. The ASPRS vertical standard also uses the RMSE statistic, but only for well-defined features between contours containing interpretative elevations, or spot elevation points. The limiting RMSE for Class 1 contours is one-third of the contour interval. Testing for vertical map compliance is also performed by independent, equal, or higher accuracy ground survey methods, such as differential leveling. Table 11-4 summarizes the limiting vertical RMSE for well-defined points, as checked by independent surveys at the full (ground) scale of the map.

Table 11-3a. ASPRS Planimetric Feature Coordinate Accuracy Requirement (Ground X or Y in Meters) for Well-Defined Points

Target Map Scale	ASPRS Limiting RMSE in X or Y (Meters)		
Ratio m/m	Class 1	Class 2	Class 3
1:50	0.0125	0.025	0.038
1:100	0.025	0.05	0.075
1:200	0.050	0.10	0.15
1:500	0.125	0.25	0.375
1:1,000	0.25	0.50	0.75
1:2,000	0.50	1.00	1.5
1:2,500	0.63	1.25	1.9
1:4,000	1.0	2.0	3.0
1:5,000	1.25	2.5	3.75
1:8,000	2.0	4.0	6.0
1:10,000	2.5	5.0	7.5
1:16,000	4.0	8.0	12.0
1:20,000	5.0	10.0	15.0
1:25,000	6.25	12.5	18.75
1:50,000	12.5	25.0	37.5
1:100,000	25.0	50.0	75.0
1:250,000	62.5	125.0	187.5

Table 11-3b. ASPRS Planimetric Feature Coordinate Accuracy Requirement (Ground X or Y in Feet) for Well-Defined Points

Target Map Scale		ASPRS Limiting RMSE in X or Y (Feet)		
1"= x ft	Ratio ft/ft	Class 1	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
1,000	1:12,000	10.0	20.0	30.0
1,667	1:20,000	16.7	33.3	50.0

Table 11-4a. ASPRS Topographic Elevation Accuracy Requirement for Well-Defined Points (Meters)

ASPRS Limiting RMSE in Meters

Target Contour Interval	Spot or Digital Topographic Feature Points			Terrain Model Elevation Points		
Meters	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
0.10	0.03	0.07	0.10	0.02	0.03	0.05
0.20	0.07	0.13	0.2	0.03	0.07	0.10
0.25	0.08	0.17	0.25	0.04	0.08	0.12
0.5	0.17	0.33	0.50	0.08	0.16	0.25
1	0.33	0.66	1.0	0.17	0.33	0.5
2	0.67	1.33	2.0	0.33	0.67	1.0
4	1.33	2.67	4.0	0.67	1.33	2.0
5	1.67	3.33	5.0	0.83	1.67	2.5
10	3.33	6.67	10.0	1.67	3.33	5.0

Table 11-4b. ASPRS Topographic Elevation Accuracy Requirement for Well-Defined Points (Feet)

ASPRS Limiting RMSE in Feet						
Target Contour Interval	Topographic Feature Points			Spot or Digital Terrain Model Elevation Points		
ft	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
0.5	0.17	0.33	0.50	0.08	0.16	0.2
1	0.33	0.66	1.0	0.17	0.33	0.5
2	0.67	1.33	2.0	0.33	0.67	1.0
4	1.33	2.67	4.0	0.67	1.33	2.0
5	1.67	3.33	5.0	0.83	1.67	2.5

d. Map accuracy quality assurance testing and certification. Independent map testing is a quality assurance function that is performed independent of normal quality control during the mapping process. Specifications and/or contract provisions should indicate the requirement (or option) to perform independent map testing. Independent map testing is rarely performed for engineering and construction surveys. If performed, map testing should be completed within a fixed time period after delivery, and if performed by contract, after proper notification to the contractor. In accordance with the ASPRS standard, the horizontal and vertical accuracy of a map is checked by comparing measured coordinates or elevations from the map (at its intended target scale) with spatial values determined by a check survey of higher accuracy. The check survey should be at least twice (preferably three times) as accurate as the map feature tolerance given in the ASPRS tables, and a minimum of 20 points tested. Maps and related geospatial databases found to comply with a particular ASPRS standard should have a statement indicating that standard. The compliance statement should refer to the data of lowest accuracy depicted on the map, or, in some instances, to specific data layers or levels. The statement should clearly indicate the target map scale at which the map or feature layer was developed. When independent testing is not performed, the compliance statement should clearly indicate that the procedural mapping specifications were designed and performed to meet a certain ASPRS map classification, but that a rigid compliance test was not performed. Published maps and geospatial databases whose errors exceed those given in a standard should indicate in their legends or metadata files that the map is not controlled and that dimensions are not to scale. This accuracy statement requirement is especially applicable to GIS databases that may be compiled from a variety of sources containing known or unknown accuracy reliability.

e. National Standard for Spatial Data Accuracy (NSSDA). The traditional small-scale "United States National Map Accuracy Standard" (Bureau of the Budget 1947) is currently (1998) being revised by the FGDC as the NSSDA. The latest draft of the NSSDA indicates it is directly based on the ASPRS standard; however, the ASPRS coordinate-based standard is converted to a 95% radial error statistic and the vertical standard is likewise converted from a one-sigma (68%) to 95% standard. The draft NSSDA defines positional accuracy of spatial data, in both digital and graphic form, as derived from sources such as aerial photographs, satellite imagery, or other maps. Its purpose is to facilitate the identification and application of spatial data by implementing a well-defined statistic (i.e., 95% confidence level) and testing methodology. As in the ASPRS standard, accuracy is assessed by comparing the positions of well defined data points with positions determined by higher accuracy methods, such as ground surveys. Unlike the above ASPRS tables, the draft NSSDA standard does not define pass-fail criteria--data and map producers must determine what accuracy exists for their data. Users of that data determine what constitutes acceptable accuracies for their applications. Unlike the ASPRS standard which uses the RMSE statistic in the X, Y, and Z planes, the NSSDA defines horizontal spatial accuracy by circular error of a data set's horizontal (X & Y) coordinates at the 95% confidence level. Vertical spatial data is defined by linear error of a data set's vertical (Z) coordinates at the 95% confidence level. ASPRS lineal horizontal accuracies in X and Y can be converted to NSSDA radial accuracy by multiplying the limiting RMSE values in Table 3 by 2.447, e.g.,

$$\text{Radial Accuracy}_{NSSDA} = 2.447 * \text{RMSE}_{ASPRS\text{-- } X \text{ or } Y} \qquad \text{Eq. 11-1}$$

ASPRS 1-sigma (68%) vertical accuracies can be converted to NSSDA 95% lineal accuracy by multiplying the limiting RMSE values in Table 4 by 1.96, e.g.,

$$\text{Vertical Accuracy}_{NSSDA} = 1.96 * \text{RMSE}_{ASPRS\text{ -- }Z} \qquad \text{Eq. 11-2}$$

In time, it is expected that the NSSDA will be the recognized standard for specifying the accuracy of all mapping and spatial data products, and the ASPRS standard will be modified to 95% confidence level specifications.

f. Other mapping standards. When work is performed for DoD tactical elements or other Federal agencies or overseas, mapping standards other than ASPRS may be required.

11-5. Topographic and Site Plan Survey Standards. Topographic surveys and construction site plan surveys are performed for the master planning, design, and construction of installations, buildings, housing complexes, roadways, airport facilities, flood control structures, navigation locks, etc. Construction plans are performed at relatively large scales (typically ranging between 1" = 20 ft to 1" = 400 ft (1:240 to 1:4,800)) using electronic total stations, plane tables, or other terrestrial survey techniques. The ASPRS large scale mapping accuracy standards may be used for all types of ground topographic surveying methods. Guidance for performing topographic surveys is contained in a variety of commercial and government publications. Recognized industry procedural specifications, manuals, or surveying textbooks should be used for guidance in performing plane table surveys, total station surveys, and radial topographic mapping methods using kinematic GPS. For all types of topographic surveys or site plan surveys, the mapping specifications must clearly indicate the level of surface and underground feature detail to be mapped. Recommended detail scales for common types of engineering plans and topographic maps are outlined below and at the end of this chapter. Refer also to EM 1110-1-1005, Topographic Mapping.

a. Reconnaissance topographic surveys. These surveys are performed at relatively small scales--from 1" = 400 ft (1:4,800) to 1" = 1,000 ft (1:12,000). They provide a basis for general studies, site suitability decisions, or preliminary site layouts. General location of existing roads and facilities are depicted, and only limited feature and rough elevation detail is shown--5 to 10 foot contour intervals usually being adequate. Enlarged USGS 1:24,000 maps may be substituted in many cases.

b. General/Preliminary site plans. Scales from 1" = 200 ft to 1" = 400 ft (1:2,400-1:4,800). Depicts general layout arrangement of areas where construction will take place, proposed transportation systems, training areas, and existing facilities.

c. Detailed topographic surveys for construction site plan drawings. Scales from 1" = 20 ft to 1" = 200 ft--and 1 or 2-foot contour intervals. Detailed ground topographic surveys are performed to prepare base map for detailed site plans (general site layout plan, utility plan, grading plan, paving plan, airfield plan, demolition plan, etc.). Scope of mapping confined to existing/proposed building area. Used as base for subsequent as-built drawings of facilities and utility layout maps (i.e., AM/FM data bases).

d. As-Built surveys and AM/FM mapping. As-built drawings may require topographic surveys of constructed features, especially when field modifications are made to original designs. These surveys, along with original construction site plans, should be used as a base framework for an installation's AM/FM data base. Periodic topographic surveys may also be required during maintenance and repair projects in order to update the AM/FM data base.

11-6. Photogrammetric Mapping Standards and Specifications. Most smaller scale (i.e., less than 1 in = 100 ft, or 1:1,200) engineering topographic mapping and GIS data base development is accomplished by aerial mapping techniques. The ASPRS standards should be used in specifying photogrammetric mapping accuracy requirements. Procedures for developing photogrammetric mapping specifications are contained in EM 1110-1-1000, "Photogrammetric Mapping." This manual contains guidance on specifying flight altitudes, determining target scales, and photogrammetric mapping cost estimating techniques. A full contract guide specification is also contained in an appendix to the manual. More comprehensive technical guidance may be obtained from various academic publications. Currently, few aerial mapping references reflect the latest uses and potential efficiencies of GPS-controlled photogrammetry or soft copy compilation processes. In specifying photogrammetric mapping services, it is essential that feature accuracy tolerances (horizontal and vertical) be clearly identified relative to the project target mapping scale, and that this scale be correlated with an appropriate flight altitude and the type of photogrammetric mensuration instruments used.

11-7. Construction Survey Accuracy Standards. Construction survey procedural and accuracy specifications should follow recognized industry and local practices. General procedural guidance is contained in a number of standard commercial texts. Accuracy standards for construction surveys will vary with the type of construction, and may range from a minimum of 1:2,500 up to 1:20,000. A 1:2,500 "4th Order Construction" classification is intended to cover temporary control used for alignment, grading, and measurement of various types of construction, and some local site plan topographic mapping or photo mapping control work. Lower accuracies (1:2,500-1:5,000) are acceptable for earthwork, dredging, embankment, beach fill, and levee alignment stakeout and grading, and some site plan, curb and gutter, utility building foundation, sidewalk, and small roadway stakeout. Moderate accuracies (1:5,000) are used in most pipeline, sewer, culvert, catch basin, and manhole stakeouts, and for general residential building foundation and footing construction, major highway pavement, and concrete runway stakeout work. Somewhat higher accuracies (1:10,000-1:20,000) are used for aligning longer bridge spans, tunnels, and large commercial structures. For extensive bridge or tunnel projects, 1:50,000 or even 1:100,000 relative accuracy alignment work may be required. Grade elevations are usually observed to the nearest 0.01 foot for most construction work, although 0.1 ft accuracy is sufficient for riprap placement, earthwork grading, and small-diameter pipe placement. Construction control points are typically marked by semi-permanent or temporary monuments (e.g., plastic hubs, P-K nails, iron pipes, wooden grade stakes).

11-8. Cadastral or Real Property Survey Accuracy Standards.

a. General. Many State codes, rules, statutes or general professional practices prescribe minimum technical standards for real property surveys. Corps in-house surveyors or contractors should follow applicable State technical standards for real property surveys involving the determination of the perimeters of a parcel or tract of land by establishing or reestablishing corners, monuments, and boundary lines, for the purpose of describing, locating fixed improvements, or platting or dividing parcels. Although some State standards relate primarily to accuracies of land and boundary surveys, other types of survey work may also be covered in some areas. Refer to ER 405-1-12, Real Estate Handbook and the "Manual of Instructions for the Survey of the Public Lands of the United States" (US Bureau of Land Management 1973) for additional technical guidance on performing cadastral surveys, or surveys of private lands abutting or adjoining Government lands.

b. ALTA/ACSM standards. Real property survey accuracy standards recommended by ALTA/ACSM are contained in "Minimum Standard Detail Requirements for ALTA/ACSM Land Title Surveys," 1992. This standard was developed to provide a consistent national standard for land title surveys and may be used as a guide in specifying accuracy closure requirements for USACE real property surveys. However, it should be noted that the ALTA/ACSM standard itself not only prescribes closure accuracies for land use classifications but also addresses specific needs peculiar to land title insurance matters. The standards contain requirements for detailed information and certification pertaining to land title insurance, including information discoverable from the survey and inspection that may not be evidenced by the public records. The standard also contains a table as to optional survey responsibilities and specifications which the title insurer may require. USACE cadastral surveys not involving title insurance should follow State minimum standards; not ALTA/ACSM standards. On land acquisition surveys which may require title insurance, the decision to perform an ALTA/ACSM standard survey, including all optional survey responsibilities and specifications, should come from the project sponsor. Meeting ALTA/ACSM Urban Class accuracy standards is considered impractical for small tracts or parcels less than 1 acre in size.

11-9. Hydrographic Surveying Accuracy Standards. Hydrographic surveys are performed for a variety of engineering, construction, and dredging applications in USACE. Accuracy standards, procedural specifications, and related technical guidance are contained in EM 1110-2-1003, Hydrographic Surveying. This manual should be attached to any A-E contract containing hydrographic surveying work, and must be referenced in construction dredging contracts involving in-place measurement and payment. Standards in this manual apply to Corps river and harbor navigation project surveys, such as dredge measurement and payment surveys, channel condition surveys of inland and coastal Federal navigation projects, beach renourishment surveys, and surveys of other types of marine structures. Accuracy standards for three distinct classes of surveys are specified: (1) Contract Payment, (2) Project Condition, and (3) Reconnaissance Surveys. Standards for nautical charting surveys or deep-water bathymetric charting surveys should conform with applicable Defense Mapping Agency (DMA), National Ocean Survey (NOS), or U.S. Naval Oceanographic Office (USNAVOCEANO) accuracy and chart symbolization criteria.

11-10. Structural Deformation Survey Standards. Deformation monitoring surveys of Corps structures require high line vector and/or positional accuracies to monitor the relative movement of monoliths, walls, embankments, etc. Deformation monitoring survey accuracy standards vary with the type of construction, structural stability, failure probability and impact, etc. Since many periodic surveys are intended to measure "long-term" (i.e., monthly or yearly changes) deformations relative to a stable network, lesser survey precisions are required than those needed for short-term structural deflection type measurements. Long-term structural movements measured from points external to the structure may be tabulated or plotted in either X-Y-Z or by single vector movement normal to a potential failure plane. Accuracy standards and procedures for structural deformation surveys are contained in EM 1110-1-1004. Horizontal and vertical deformation monitoring survey procedures are performed relative to a control network established for the structure. Ties to the National Spatial Reference System are not necessary other than for general reference, and then need only USACE Third-Order connection.

11-11. Geodetic Control Survey Standards. Geodetic control surveys are usually performed for the purpose of establishing a basic framework of the National Spatial Reference System (NSRS). These geodetic network densification survey functions are clearly distinct from the traditional engineering and construction surveying and mapping standards covered in this chapter. Geodetic control surveys of permanently monumented control points that are incorporated in the NSRS must be performed to far more rigorous standards and specifications than are control surveys used for general engineering, construction, mapping, or cadastral purposes. When a project requires NSRS densification, or such densification is a desirable by-product and is economically justified, USACE Commands should conform with published FGDC survey standards and specifications. This includes related automated data recording, submittal, project review, and adjustment requirements mandated by FGDC and the National Geodetic Survey.

11-12. Determining Surveying and Mapping Requirements for Engineering Projects. General guidance for determining project-specific mapping requirements is contained in Table 11-5 at the end of this chapter. This table may be used to develop specifications for map scales, feature location tolerances, and contour intervals for typical engineering and construction projects. It is absolutely essential that surveying and mapping specifications originate from the functional requirements of the project, and that these requirements be realistic and economical. Specifying map scales or accuracies in excess of those required for project planning, design, or construction results in increased costs to USACE, local sponsors, or installations, and may delay project completion. However, the recommended standards and accuracy tolerances shown in Table 11-5 should be considered as general guidance for typical projects--variance from these norms is expected.

a. Mapping scope/limits. Mapping limits should be delineated so only areas critical to the project are covered by detailed ground or aerial surveying. The areal extent of detailed (i.e., large-scale) site plan surveys should be kept to a minimum and confined to the actual building, utility corridor, or structure area. Outside critical construction perimeters, more economical smaller scale plans should be used, along with more relaxed feature location accuracies, larger contour intervals, etc.

b. Target scale and contour interval specifications. Table 11-5 provides recommended map scales and contour intervals for a variety of engineering applications. The selected target scale for a map or construction plan should be based on the detail necessary to portray the project site. Surveying and mapping costs typically increase exponentially with larger mapping scales; therefore, specifying too large a site plan scale or too small a contour interval than needed to adequately depict the site can significantly increase project costs. Topographic elevation density or related contour intervals must be specified consistent with existing site gradients and the accuracy needed to define site layout, drainage, grading, etc., or perform quantity take offs. Photogrammetric mapping flight altitudes or ground topographic survey accuracy and density requirements are determined from the design map target scale and contour interval provided in the contract specifications.

c. Feature location tolerances. This requirement establishes the primary surveying effort necessary to delineate physical features on the ground. In most instances, a construction feature may need to be located to an accuracy well in excess of its plotted/scaled accuracy on a construction site plan; therefore, feature location tolerances should not be used to determine the required scale of a drawing or determine photogrammetric mapping requirements. In such instances, surveyed coordinates, internal CADD grid coordinates, or rigid relative dimensions are used. Table 11-5 indicates recommended positional tolerances (or precisions) of planimetric features. These feature tolerances are defined relative to adjacent points within the confines of a specific area, map sheet, or structure--not to the overall project or installation boundaries. Relative accuracies are determined between two points that must functionally maintain a given accuracy tolerance between themselves, such as adjacent property corners; adjacent utility lines; adjoining buildings, bridge piers, approaches, or abutments; overall building or structure site construction limits; runway ends; catch basins; levee baseline sections; etc. Feature tolerances should be determined from the functional requirements of the project/structure (e.g., field construction/fabrication, field stakeout or layout, alignment, locationing, etc.). Few engineering, construction, or real estate projects require that relative accuracies be rigidly maintained beyond a 1500m (5,000-ft) range, and usually only within the range of the detailed design drawing for a project/structure (or its equivalent CADD design file limit). For example, two catch basins 60 m (200 ft) apart might need to be located to 25mm (0.1 ft) relative to each other, but need only be known to ±30m (±100 ft) relative to another catch basin 10 km (6 miles) away. Likewise, relative accuracy tolerances are far less critical for small-scale GIS data elements. Actual construction alignment and grade stakeout will generally be performed to the 30mm (0.1 ft) or 3mm (0.01 ft) levels, depending on the type of construction.

d. CADD level/layer descriptors. The use of CADD or GIS equipment allows planimetric features and topographic elevations to be readily separated onto various levels or layers and depicted at any scale. Problems may arise when scales are increased beyond their originally specified values, or when so-called "rubber sheeting" is performed. It is therefore critical that these geospatial data layers, and related metadata files, contain descriptor information identifying the original source target scale and designed accuracy.

e. Map control survey specifications. The control survey used to provide primary reference for a map or GIS product is normally performed at a higher accuracy than that required for features shown on the map. Most maps warranting an accuracy classification should be referenced to, or controlled by, conventional field surveys of Third-order accuracy. Control survey accuracies are usually measured in different units--relative distance ratios--rather than positional tolerance. Base- or area-wide mapping control procedures should be designed and specified to meet functional accuracy tolerances within the limits of the structure, building, or utility distance involved for design, construction, or real estate surveys. Higher order (i.e., First or Second-order) control surveys should not be specified for area-wide mapping or GIS definition unless a definitive functional requirement exists (e.g., military operational targeting or some low-gradient flood control projects).

f. Reference datum and coordinate system specifications. A variety of reference datums and coordinate references are used throughout Corps projects. Wide-area mapping projects should be referenced to spatial datums, plane coordinate grids, and vertical reference planes that are commonly used in the area, where practical and feasible. Small, local construction projects and cadastral surveys are usually locally referenced and need not be connected to external datums.

(1) Horizontal reference. In CONUS, maps should be horizontally referenced to either the North American Datum of 1983 (NAD 83) or 1927 (NAD 27) systems. Commands should develop plans to eventually reference all civil and military projects to the NAD 83, with connection to the GPS-based, nationwide National Spatial Reference System (NSRS) if practicable and feasible. These spatial datum coordinates should be transformed to a recognized plane coordinate system that is used in the project or installation area, such as the State Plane Coordinate System (SPCS) or Universal Transverse Mercator (UTM) grid system. The UTM grid system may be used for military operational or tactical uses in locales within and outside the continental United States (OCONUS), or on some civil projects encompassing or crossing multiple SPCS zones. Grid systems (and north arrow references) shown on maps or plans must clearly indicate the reference datum and orientation origin. When local grid systems (e.g., station-offset) are developed for detailed construction, they should be clearly distinguished from the SPCS grid.

(2) Vertical reference. In CONUS, vertical map control should be referenced to either the National Geodetic Vertical Datum, 1929 Adjustment (NGVD 29), or the North American Vertical Datum, 1988 Adjustment (NAVD 88). Independent or local survey datums and reference systems should be avoided unless required by local code, statute, or practice. Coastal navigation projects should be referenced to Mean Lower Low Water (MLLW) datum. Inland low water reference planes should be referenced to NGVD 29 or NAVD 88.

g. Plan drawing feature specifications. Mapping specifications must clearly and explicitly define the types, areal extent, and locational accuracy of features to be surveyed. The type and purpose of the map (e.g., paving plan, landscape plan, irrigation plan, etc.) should be clearly defined in the specifications in order for the field surveyor to determine which features are critical to the project. Especially critical areas, structures, or utilities should be highlighted in the technical requirements, including special accuracy tolerances for these features that may necessitate specialized ground surveying procedures. In addition, the specifications should indicate the symbology, detailing, and attributing required for recurring features, such as manholes, curbs, pavements, valves, etc. Feature symbology/delineation is specified as a function of scale--e.g., depiction of structure perimeters, centerlines, elevations, etc. For each map product, feature depiction, delineation, layering, and attributing requirements should be broken out and specified, generally following the Tri-Service discipline/drawing-based level/layer assignments or, for GIS applications, the entity set, class, attribute and domain relationships. Not all CADD levels/layers will require topographic mapping support--e.g., Interior Design. Within each level/layer, a few of the construction plans are listed below that may require field or aerial topographic mapping to delineate the features or systems on that plan. Typical features or systems within a CADD level/layer construction plan are also listed; however, this listing is not comprehensive and must be adjusted and supplemented for unique project-specific requirements, and to insure features are mapped into appropriate layers with sufficient attribute detail, as explained above.

11-13. References.

ER 405-1-12
Real Estate Handbook

EM 1110-1-1000
Photogrammetric Mapping

EM 1110-1-1004
Deformation Monitoring and Control Surveying

EM 1110-1-1005
Topographic Surveying

EM 1110-2-1003
Hydrographic Surveying

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**Table 11-5. RECOMMENDED ACCURACIES AND TOLERANCES:
ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT PROJECTS**

Project or Activity	Target Map Scale SI/IP	Feature Position Tolerance Horizontal SI/IP	Feature Position Tolerance Vertical SI/IP	Contour Interval SI/IP	Survey Accuracy Hor/Vert
<u>**DESIGN, CONSTRUCTION, OPERATION & MAINTENANCE OF MILITARY FACILITIES**</u>					
Maintenance and Repair (M&R)/Renovation of Existing Installation Structures, Roadways, Utilities, Etc					
General Construction Site Plans & Specs:	1:500	100 mm	50 mm	250 mm	3rd-I
Feature & Topographic Detail Plans	40 ft/in	0.1-0.5 ft	0.1-0.3 ft	1 ft	3rd
Surface/subsurface Utility Detail Design Plans	1:500	100 mm	50 mm	N/A	3rd-I
Elec, Mech, Sewer, Storm, etc	40 ft/in	0.2-0.5 ft	0.1-0.2 ft		3rd
Field construction layout		0.1 ft	0.01-0.1 ft		
Building or Structure Design Drawings	1:500	25 mm	50 mm	250 mm	3rd-I
	40 ft/in	0.05-0.2 ft	0.1-0.3 ft	1 ft	3rd
Field construction layout		0.01 ft	0.01 ft		
Airfield Pavement Design Detail Drawings	1:500	25 mm	25 mm	250 mm	3rd-I
	40 ft/in	0.05-0.1 ft	0.05-0.1 ft	0.5-1 ft	2nd
Field construction layout		0.01 ft	0.01 ft		
Grading and Excavation Plans	1:500	250 mm	100 mm	500 mm	3rd-II
Roads, Drainage, Curb, Gutter etc.	30-100 ft/in	0.5-2 ft	0.2-1 ft	1-2 ft	3rd
Field construction layout		1 ft	0.1 ft		
Recreational Site Plans	1:1000	500 mm	100 mm	500 mm	3rd-II
Golf courses, athletic fields, etc.	100 ft/in	1-2 ft	0.2-2 ft	2-5 ft	3rd
Training Sites, Ranges, and Cantonment Area Plans	1:2500	500 mm	1000 mm	500 mm	3rd-II
	100-200 ft/in	1-5 ft	1-5 ft	2 ft	3rd
General Location Maps for Master Planning	1:5000	1000 mm	1000 mm	1000 mm	3rd-II
AM/FM and GIS Features	100-400 ft/in	2-10 ft	1-10 ft	2-10 ft	3rd
Space Management Plans	1:250	50 mm	N/A	N/A	N/A
Interior Design/Layout	10-50 ft/in	0.05-1 ft			
As-Built Maps: Military Installation Surface/Subsurface Utilities (Fuel, Gas, Electricity, Communications, Cable, Storm Water, Sanitary, Water Supply, Treatment Facilities, Meters, etc.)	1:1000 or 50-100 ft/in (Army); 1:500 or 50 ft/in (USAF)	100 mm / 0.2-1 ft	100 mm / 0.2 ft	250 mm / 1 ft	3rd-I / 3rd

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Table 11-5 (Contd). RECOMMENDED ACCURACIES AND TOLERANCES: ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT PROJECTS

Project or Activity	Target Map Scale SI/IP	Feature Position Tolerance Horizontal SI/IP	Vertical SI/IP	Contour Interval SI/IP	Survey Accuracy Hor/Vert
Housing Management GIS (Family Housing, Schools, Boundaries, and Other Installation Community Services)	1:5000 100-400 ft/in	10000 mm 10-15 ft	N/A	N/A	4th 4th
Environmental Mapping and Assessment Drawings/Plans/GIS	1:5000 200-400 ft/in	10000 mm 10-50 ft	N/A	N/A	4th 4th
Emergency Services Maps/GIS Military Police, Crime/Accident Locations, Post Security Zoning, etc.	1:10000 400-2000 ft/in	25000 mm 50-100 ft	N/A	N/A	4th 4th
Cultural, Social, Historical Plans/GIS	1:5000 400 ft/in	10000 mm 20-100 ft	N/A	N/A	4th 4th
Runway Approach and Transition Zones: General Plans/Section	1:2500 100-200 ft/in	2500 mm 5-10 ft	2500 mm 2-5 ft	1000 mm 5 ft	3rd-II 3rd
Approach maps	1:5000 (H) 1:1000 (V)				
Approach detail	1:5000 (H) 1:250 (V)				
<u>DESIGN, CONSTRUCTION, OPERATIONS AND MAINTENANCE OF CIVIL TRANSPORTATION & WATER RESOURCE PROJECTS</u> Site Plans, Maps & Drawings for Design Studies, Reports, Memoranda, and Contract Plans and Specifications, Construction plans & payment					
General Planning and Feasibility Studies, Reconnaissance Reports	1:2500 100-400 ft/in	1000 mm 2-10 ft	500 mm 0.5-2 ft	1000 mm 2-10 ft	3rd-II 3rd
Flood Control and Multipurpose Project Planning, Floodplain Mapping, Water Quality Analysis, and Flood Control Studies	1:5000 400-1000 ft/in	10000 mm 20-100 ft	100 mm 0.2-2 ft	1000 mm 2-5 ft	3rd-II 3rd
Soil and Geological Classification Maps	1:5000 400 ft/in	10000 mm 20-100 ft	N/A	N/A	4th 4th
Land Cover Classification Maps	1:5000 400-1000 ft/in	10000 mm 50-200 ft	N/A	N/A	4th 4th

Table 11-5 (Contd). RECOMMENDED ACCURACIES AND TOLERANCES: ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT PROJECTS

Project or Activity	Target Map Scale SI/IP	Feature Position Tolerance Horizontal SI/IP	Vertical SI/IP	Contour Interval SI/IP	Survey Accuracy Hor/Vert
Archeological or Structure Site Plans & Details					
(Including Non-topographic, Close Range,	1:10	5 mm	5 mm	100 mm	2nd-I/II
Photogrammetric Mapping)	0.5-10 ft/in	0.01-0.5 ft	0.01-0.5 ft	0.1-1 ft	2nd
Cultural and Economic Resource Mapping	1:10000	10000	N/A	N/A	4th
Historic Preservation Projects	1000 ft/in	50-100 ft			4th
Land Utilization GIS Classifications	1:5000	10000 mm	N/A	N/A	4th
Regulatory Permit Locations	400-1000 ft/in	50-100 ft			4th
Socio-Economic GIS Classifications	1:10000	20000 mm	N/A	N/A	4th
	1000 ft/in	100 ft			4th
Grading & Excavation Plans	1:1000	1000 mm	100 mm	1000 mm	3rd-I
	100 ft/in	0.5-2 ft	0.2-1 ft	1-5 ft	3rd
Flood Control Structure Clearing & Grading	1:5000	2500 mm	250 mm	500 mm	3rd-II
Plans (e.g., revetments)	100-400 ft/in	2-10 ft	0.5 ft	1-2 ft	3rd
Federal Emergency Management	1:5000	1000 mm	250 mm	1000 mm	3rd-I
Agency Flood Insurance Studies	400 ft/in	20 ft	0.5 ft	4 ft	3rd
Locks, Dams, & Control Structures	1:500	25 mm	10 mm	250 mm	2nd-II
Detail Design Drawings	20-50 ft/in	0.05-1 ft	0.01-0.5 ft	0.5-1 ft	2nd/3rd
Spillways & Concrete Channels	1:1000	100 mm	100 mm	1000 mm	2nd-II
Design Plans	50-100 ft/in	0.1-2 ft	0.2-2 ft	1-5 ft	3rd
Levees and Groins: New Construction or	1:1000	500 mm	250 mm	500 mm	3rd-II
Maintenance Design Drawings	100 ft/in	1-2 ft	0.5-1 ft	1-2 ft	3rd
Construction In-Place Volume Measurement	1:1000	500 mm	250 mm	N/A	3rd-II
Granular cut/fill, dredging, etc.	40-100 ft/in	0.5-2 ft	0.5-1 ft		3rd
Beach Renourishment/Hurricane	1:1000	1000 mm	250 mm	250 mm	3rd-II
Protection Project Plans	100-200 ft/in	2 ft	0.5 ft	1 ft	3rd

Table 11-5 (Contd). RECOMMENDED ACCURACIES AND TOLERANCES: ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT PROJECTS

Project or Activity	Target Map Scale SI/IP	Feature Position Tolerance Horizontal SI/IP	Vertical SI/IP	Contour Interval SI/IP	Survey Accuracy Hor/Vert
Project Condition Survey Reports					
Base Mapping for Plotting Hydrographic	1:2500	10000 mm	250 mm	500 mm	N/A
Surveys: line maps or aerial plans	200-1000 ft/in	5-50 ft	0.5-1 ft	1-2 ft	N/A
Dredging & Marine Construction Surveys	1:1000	2000 mm	250 mm	250 mm	N/A
New Construction Plans	100 ft/in	6 ft	1 ft	1 ft	N/A
Maintenance Dredging Drawings	1:2500	5000 mm	500 mm	500 mm	N/A
	200 ft/in	15 ft	2 ft	2 ft	N/A
Hydrographic Project Condition Surveys	1:2500	5000 mm	500 mm	500 mm	N/A
	200 ft/in	16 ft	2 ft	2 ft	N/A
Hydrographic Reconnaissce Surveys	-	5000 m	500 mm	250 mm	N/A
		15 ft	2 ft	2 ft	N/A
Offshore Geotechnical Investigations	-	5000 mm	50 mm	N/A	N/A
Core Borings /Probings/etc.		5-15 ft	0.1-0.5 ft		4th
Structural Deformation Monitoring Studies/Surveys					
Reinforced Concrete Structures:	Large-scale	10 mm	2 mm	N/A	N/A
Locks, Dams, Gates, Intake Structures,	vector	0.03 ft	0.01 ft		N/A
Tunnels, Penstocks, Spillways, Bridges	movement diagrams or tabulations	(long-term)			
Earth/Rock Fill Structures: Dams, Floodwalls,	(same as	30 mm	15 mm	N/A	N/A
Levees, etc--slope/crest stability & alignment	above)	0.1 ft (long term)	0.05 ft		N/A
Crack/Joint & Deflection Measurements:	tabulations	0.2 mm	N/A	N/A	N/A
piers/monoliths--precision micrometer		0.01 inch			N/A

Table 11-5 (Contd). RECOMMENDED ACCURACIES AND TOLERANCES: ENGINEERING, CONSTRUCTION, AND FACILITY MANAGEMENT PROJECTS

Project or Activity	Target Map Scale SI/IP	Feature Position Tolerance Horizontal SI/IP	Vertical SI/IP	Contour Interval SI/IP	Survey Accuracy Hor/Vert
REAL ESTATE ACTIVITIES: ACQUISITION, DISPOSAL, MANAGEMENT, AUDIT					
Maps, Plans, & Drawings Associated with Military and Civil Projects					
Tract Maps, Individual, Detailing					
Installation or Reservation Boundaries,	1:1000	10 mm	100 mm	1000 mm	3rd-I/II
Lots, Parcels, Adjoining Parcels, and	1:1200 (Army)				3rd
Record Plats, Utilities, etc.	50-400 ft/in	0.05-2 ft	0.1-2 ft	1-5 ft	
Condemnation Exhibit Maps	1:1000	10 mm	100 mm	1000 mm	3rd-I/II
	50-400 ft/in	0.05-2 ft	0.1-2 ft	1-5 ft	3rd
Guide Taking Lines/Boundary Encroachment	1:500	50 mm	50 mm	250 mm	3rd-I/II
Maps: Fee and Easement Acquisition	20-100 ft/in	0.1-1 ft	0.1-1 ft	1 ft	3rd
General Location or Planning Maps	1:24000	10000 mm	5000 mm	2000 mm	N/A
	2000 ft/in	50-100 ft	5-10 ft	5-10 ft	4th
GIS or Land Information System (LIS) Mapping, General					
Land Utilization and Management, Forestry	1:5000	10000 mm	N/A	N/A	3rd
Management, Mineral Acquisition	200-1000 ft/in	50-100 ft			3rd
Easement Areas and Easement	1:1000	50 mm	50 mm	N/A	3rd
Delineation Lines	100 ft/in	0.1-0.5 ft	0.1-0.5 ft		3rd
HAZARDOUS, TOXIC, RADIOACTIVE WASTE (HTRW) SITE INVESTIGATION, MODELING, AND CLEANUP					
General Detailed Site Plans	1:500	100 mm	50 mm	100 mm	2nd-I/II
HTRW Sites, Asbestos, etc.	5-50 ft/in	0.2-1 ft	0.1-0.5 ft	0.5-1 ft	2nd/3rd
Subsurface Geotoxic Data Mapping	1:500	100 mm	500 mm	500 mm	3-II
and Modeling	20-100 ft/in	1-5 ft	1-2 ft	1-2 ft	3rd
Contaminated Ground Water	1:500	1000 mm	500 mm	500 mm	3rd-II
Plume Mapping/Modeling	20-100 ft/in	2-10 ft	1-5 ft	1-2 ft	3rd
General HTRW Site Plans &	1:2500	5000 mm	1000 mm	1000 mm	3rd-II
Reconnaissance Mapping	50-400 ft/in	2-20 ft	2-20 ft	2-5 ft	3rd

EXPLANATORY NOTES FOR COLUMNS IN TABLE 11-5:

1. Target map scale is that contained in CADD, GIS, and/or AM/FM layer, and/or to which ground topo or aerial photography accuracy specifications are developed. This scale may not always be compatible with the feature location/elevation tolerances required. In many instances, design or real property features are located to a far greater relative accuracy than that which can be scaled at the target (plot) scale, such as property corners, utility alignments, first-floor or invert elevations, etc. Coordinates/elevations for such items are usually directly input into a CADD or AM/FM data base.

2. The feature position or elevation tolerance of a planimetric feature is defined at the 95% confidence level. The positional accuracy is relative to two adjacent points within the confines of a structure or map sheet, not to the overall project or installation boundaries. Relative accuracies are determined between two points that must functionally maintain a given accuracy tolerance between themselves, such as adjacent property corners; adjacent utility lines; adjoining buildings, bridge piers, approaches, or abutments; overall building or structure site construction limits; runway ends; catch basins; levee baseline sections; etc. The tolerances between the two points are determined from the end functional requirements of the project/structure (e.g., field construction/fabrication, field stakeout or layout, alignment, locationing, etc.).

3. Horizontal and vertical control survey accuracy refers to the procedural and closure specifications needed to obtain/maintain the relative accuracy tolerances needed between two functionally adjacent points on the map or structure, for design, stakeout, or construction. Usually 1:10,000 Third-Order (I) control procedures (horizontal and vertical) will provide sufficient accuracy for most engineering work, and in many instances of small-scale mapping or GIS rasters, Third-Order, Class II methods and Fourth-Order topo/construction control methods may be used. Base- or area-wide mapping control procedures shall be specified to meet functional accuracy tolerances within the limits of the structure, building, or utility distance involved for design or construction surveys. Higher order control surveys shall not be specified for area-wide mapping or GIS definition unless a definitive functional requirement exists (e.g., military operational targeting or some low-gradient flood control projects).

Appendix A
References

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Spatial Data Transfer Standard (FIPS 173) Factsheet.

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Geographic Information System Implementation Plan, St. Paul District.

U.S. Army Corps of Engineers 1990
Geographic Information System Implementation Plan, Vicksburg District.

U.S. Army Corps of Engineers 1992
Buffalo District Geographic Information System FY 93-FY 95 Implementation Plan.

U.S. Army Corps of Engineers 1989
North Central Division Implementation Plan for Geographic Information Systems.

U.S. Department of the Army 1996
Director of Information Systems for Command, Control, Communications, and Computers. *Army Technical Architecture*, Washington, DC.

Appendix B
Abbreviations and Acronyms List

AA	Analysis of Alternatives
AAG	Association of American Geographers
ACSM	American Congress on Surveying and Mapping
ADPE	Automatic Data Processing Equipment
AM/FM	Automated Mapping/Facilities Management
ANSI	American National Standards Institute
APR	Agency Procurement Request
ARPA	Advanced Research Projects Agency
ASPRS	American Society for Photogrammetry and Remote Sensing
CAD	Computer Aided Design
CAD2	Computer Aided Design 2 Contract
CADD	Computer-aided Design and Drafting
CD-ROM	Compact Disk-Read Only Memory
CEAP	Corps of Engineers Automation Plan
CLIN	Contract Line Item Number
CPU	Central Processing Unit
CRREL	Cold Regions Research and Engineering Laboratory
DAT	Digital Audio Tape
DLG	Digital Line Graph
DMA	Defense Mapping Agency
DPA	Delegation of Procurement Authority
EO	Executive Order
EAB	Environmental Advisory Panel
EC	Engineer Circular
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FEMA	Federal Emergency Management Agency
FGDC	Federal Geographic Data Committee
FIPS	Federal Information Processing Standards
FIPSPUB	Federal Information Processing Standards Publication
FIRMR	Federal Information Resources Management Regulation
FTP	File Transport Protocol
FY	Fiscal Year
GAO	Government Accounting Office
GB	gigabytes (1024 MB)
GD/S	Geospatial Data/Systems
GDS	Geospatial Data System
GIS	Geographic Information System
GOSIP	Government Open Systems Interconnection Profile (FIPS 146-1)
GRASS	Geographic Resources Analysis Support System
HQUSACE	Headquarters United States Army Corps of Engineers
HTRW	Hazardous, Toxic, and Radioactive Waste
IAW	In Accordance With
IBM	International Business Machines
IEEE	Institute of Electrical and Electronic Engineers

IP	Implementation Plan
ISO	International Standards Organization
ITU	International Telecommunications Union
KB	kilobytes (1024 bytes)
LAN	Local Area Network
LCMIS	Life Cycle Management of Information Systems
LIS	Land Information System
LMV	Lower Mississippi Valley Division
MB	megabytes (1024 KB)
MIL-STD	Military Standard
MMDF	Multichannel Memorandum Distribution Facility
MSDOS	Microsoft Disk Operating System
NASA	National Aeronautics and Space Administration
NAVFAC	Naval Facilities
NFS	Network File System
NIST	National Institute of Standards and Technology
NSDC	National Spatial Data Clearinghouse
NSDI	Natinal Spatial Data Infrastructure
NSGIC	National States Geographic Information Council
O&M	Operation and Maintenance
OGF	Open GIS Foundation
OGIS	Open Geodata Interoperability Standard/Specification
OMB	Office of Management and Budget
OS	Operating System

OSI	Open Systems Interconnection
PC	Personal Computer (IBM PC-compatible)
POC	Point of Contact
PROSPECT	Proponent Sponsored Engineer Corps Training
QA	Quality Assurance
RA	Requirements Analysis
RAM	Random Access Memory
SDTS	Spatial Data Transfer Standard
SMC	Small Multi-user Computer
SRS	Systems Requirements Specification
TAC	Transatlantic Center
TBD	To Be Decided
TCP/IP	Transmission Control Protocol/Internet Protocol
TEC	Topographic Engineering Center
URISA	Urban and Regional Information Systems Association
URL	Universal Resource Locator
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
VPF	Vector Product Format
WAIS	Wide Area Information Servers
WAN	Wide Area Network
WES	Waterways Experiment Station
WRSC	Water Resources Support Center
WWW	World WideWeb

Appendix C
Internet Information Sites

C-1. USACE Resources Available on the Internet

The primary resource for information regarding GD&S issues in the Corps of Engineers is the USACE Clearinghouse Node. The Internet URL for this site is:

U.S. Army Corps of Engineers National Geospatial Data Clearinghouse Node.

http://corps_geo1.usace.army.mil

Additional Internet sites with GD&S information within the Corps are:

Tri-Services CADD/GIS Technology Center.

http://mr2.wes.army.mil

Headquarters, U.S. Army Corps of Engineers.

http://www.usace.army.mil

U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory

http://www.usace.army.mil/crrel

U.S. Army Corps of Engineers Waterways Experiment Station

http://www.wes.army.mil/Welcome.html

U.S. Army Corps of Engineers Construction Engineering Research Laboratory

http://www.cecer.army.mil:80/welcome.html

U.S. Army Corps of Engineers Topographic Engineering Center

http://www.tec.army.mil

GRASS GIS home page

http://www.cecer.army.mil:80/grass/GRASS/main.html

GRASS GIS source code

ftp://moon.cecer.army.mil/grass

C-2. GD&S Information Sites on the Internet

An up-to-date listing of Internet resources for GD&S materials including databases, software, source code, etc. is maintained by Queens University in Canada. This list is complied from user submissions and other net resources. It has not been verified, so do not be surprised if one of the sites refuses access or does not exist. The list is periodically updated and is available at:

ftp://gis.queensu.ca/pub/gis/docs/gissites.txt and as a WWW document at:

ftp://gis.queensu.ca/pub/gis/docs/gissites.html

The 9 December 1995 list is provided below:

Last Update: December 9, 1995.

Compiled from user submissions and various net resources.

E-mail additions to Michael McDermott:

mcdermom@gisdog.gis.queensu.ca

AGU - American Geophysical Union home page.

http://earth.agu.org/kosmos/homepage.html

AIDS Epidemic animations of the U.S., 1981-1993 - CIESEN.

http://www.ciesin.org/datasets/cdc-nci/cdc-nci.html

Analytical Spectral Devices - makers of field portable spectroradiometers.

http://www.asdi.com/asd/

Arc/Info AML FTP site.

ftp://wigeo.wu-wien.ac.at/pub/acdgis-l/aml

Arc/Info to IDRISI AML conversion routines.

ftp://mars.uoregon.edu/pub

Arc/Info tutorial (requires UNIX).

http://boris.qub.ac.uk/shane/arc/archome.html

ARGUS Census Map USA Page.

http://www.tcel.com/~argus

Arizona Geographic Information Council.

http://www.state.az.us/gis3/agic/agichome.html

Atlantis Scientific home page, includes info on ERGOvista (RS program).

http://www.atlsci.com

Atlas GIS mailing list and FAQ home page.

http://www.csn.net:80/~rdandrea

Australian National University - Bioinformatics.

http://life.anu.edu.au:80/

Australian National University - Landscape Ecology Services.

http://life.anu.edu.au/landscape_ecology/landscape.html

BADGER, NASA's Bay Area Digital Geo-Resource Project home page.

http://www.svi.org/badger.html

Bibliographic search page on the environment from the USGS.

http://waisqvarsa.er.usgs.gov/public/biblio.html

Blackwell Publishing's catalogue of Geography books.

http://www.cityscape.co.uk/bookshop/bwcat.html

BLM (US) - Various conversion programs and datasets.

ftp://ftp.blm.gov/pub/gis/index.html

Boulder County, Colorado GIS landuse department.

http://www.boco.co.gov/gislu

British Ordnance Survey home page.

http://www.open.gov.uk/ordsurv/oshome.html

California - Teale Data Center GIS data library (Arc/Info format).

http://gis.gislab.teale.ca.gov

CALMIT - Center for Advanced Land Management Information Technologies, University of Nebraska

http://ianrwww.unl.edu/ianr/calmit/calmit.htm

CalTech (US) - Earth Viewer.

http://www.ugcs.caltech.edu/htbin/earth

Canada Centre for Remote Sensing.

http://www.ccrs.nrcan.gc.ca

Canadian WWW servers top level list and virtual map.

http://www.sal.ists.ca/services/w3_can/www_index.html

CANSPACE - Canadian Space Geodesy Forum archive (lots of GPS info).

gopher://unbmvs1.csd.unb.ca:1570/1EXEC%3aCANSPACE

CARIS GIS/Universal Systems Ltd. home page.

http://www.universal.ca

Cartography Resources on the Web - maintained by Jeremy Crampton.

http://geog.gmu.edu/gess/jwc/cartogrefs.html

CAST - The Center for Advanced Spatial Technologies, University of Arkansas

http://www.cast.uark.edu/

Catalogue of Digital Elevation Data (maintained by Bruce Gittings).

http://www.geo.ed.ac.uk/home/ded.html

CCM - Canada Centre for Mapping.

http://ccm-10.ccm.emr.ca/

CCM - Selected bibliography including hypermedia and geographic data.

http://ccm-10.ccm.emr.ca/publications/ccmpubs.html

CDIAC - Carbon Dioxide Information Analysis Center. Contains climate datasets.

ftp://suns01.esd.ornl.gov/pub

Census Data archive (US) at the Lawrence Berkley Laboratory.

ftp://cedrcd.lbl.gov/data1/merrill/docs/LBL_census.html

Center for Remote Sensing and Spatial Analysis - Rutgers University.

http://deathstar.rutgers.edu/

Centre for Earth Observation (CEO) of the European Community home page.

http://www.ceo.org

Centre for Earth Observation (CEO) European-Wide Service Exchange (EWSE).

http://ewse.ceo.org

CERL/GRASS welcome file.

http://www.cecer.army.mil:80/welcome.html

CERN - WWW Virtual Library on the subject of Geography.

http://info.cern.ch/hypertext/DataSources/bySubject / Geography/Overview.html

Chartwrite AB's Data-on-the-Map - an easy to use mapping/GIS program.

http://www.chartwrite.se

CIESIN - The Consortium for International Earth Science Information Network.

http://infoserver.ciesin.org

CIA World Databank.

ftp://gatekeeper.dec.com/pub/graphics/data/cia-wdb

CIA World Fact Book.

http://www.ncsa.uiuc.edu:8001/cmns-moon.think.com:201/CIA?

CIA World Map database and lat/long coord. of major U.S. cities.

ftp://ftp.cs.toronto.edu/doc/geography

comp.infosystems.gis Usenet newsgroup.

news://comp.infosystems.gis

CMU Maps home page (US).

http://www.cs.cmu.edu/afs/cs.cmu.edu/user/maps / www/home.html

DCW - Digital Chart of the World (US data).

http://waisqvarsa.er.usgs.gov/public/dcwindex.html

DCW - Digital Chart of the World - documentation.

http://waisqvarsa.er.usgs.gov/public/dcw/dcwinfo.html

Delorme Mapping Corporation.

http://www.delorme.com

Deutsches Klimarechenzentrum (German Climate Computer Centre).

http://www.dkrz.de

Digital Map Library, Queen's University (restricted to Queens users only).

ftp://ftp.ccs.queensu.ca/pub/gismaps

Digitized Outline of the U.S./world and 1980 Census Country Boundaries.

ftp://ftp.uu.net/graphics/maps

DLG, DEM, GBF-DIME, DTM and TIGER files (US).

ftp://spectrum.xerox.com/pub/map

DLG-E Information.

ftp://sdts.er.usgs.gov/pub/dlge

Earth Observatorium - a CD-ROM on NASA's “Mission to Planet Earth” (STS-59).

http://www.csn.net/malls/rmdp/ee.html

Earth Observations Lab, Institute for Space and Terrestrial Science (CAN).

http://eol.ists.ca/Welcome.html

Earthquake info from the USGS in Menlo Park, CA

http://quake.wr.usgs.gov/

EINet Galaxy's Pointers to Geography Resources.

http://galaxy.einet.net/galaxy/Science/Geography.html

Environmental Info Resources Top Level List (maintained by David Crossley).

http://kaos.erin.gov.au/other_servers/other_servers.html

EPA - Environmental Protection Agency home page (US).

http://www.epa.gov/

EPA - National GIS Program.

http://www.epa.gov/docs/ngispr/natgispr.html

EPA - National library database (US).

telnet://epaibm.rtpnc.epa.gov

EPA - Office of Policy, Planning and Evaluation, GIS resources page.

http://www.epa.gov/docs/oppe/spatial.html

EPA - Region 10: AK, ID, OR, and WA - includes map and data library.

http://www.epa.gov/region10/www/r10.html

EPI-MAP-US Center for Disease Control GIS source and data.

ftp://oak.oakland.edu/pub/msdos/mapping

ERIN - Australian Environmental Resources Information Network.

http://kaos.erin.gov.au/erin.html

EROS - US Earth Resources Observation Systems Remote Sensing Data Center.

http://sun1.cr.usgs.gov/eros-home.html

ETOPO5 Sample colour shaded relief maps of the U.S.

ftp://src.doc.ic.ac.uk/geology/maps/gifmaps

ESIS - European Space Information System.

http://mesis.esrin.esa.it/html/esis.html

Faculty of Regional Science and Architecture, University of Vienna.

http://info.archlab.tuwien.ac.at

Fed. Institute of Technology GERMINAL Project - GIS/ Environment Management and Planning.

http://dgrwww.epf1.ch/GERMINAL/Germinal.html

FGDC (US) - Spatial Metadata Standard text source.

ftp://waisqvarsa.er.usgs.gov/wais/docs

FGDC - US Manual of Federal Geographic Data Products.

http://info.er.usgs.gov/fgdc-catalog/title.html

Finland National Land Survey Geographic Information Centre.

http://www.mmh.fi/

Fish and Wildlife Service (US) National Wetlands Inventory FTP site.

ftp://192.189.43.33/

Forestland data for the US (Arc/Info format).

http://www.epa.gov/docs/grd/forest_inventory/

Gazetteer for the U.S.

http://wings.buffalo.edu/geogw

GCMD - Global Change Master Directory.

telnet://GCNET@132.156.47.218

GCTP - USGS General Cartographic Transformation Package.

ftp://isdres.er.usgs.gov/.USGS.GCTP

GDE Systems Inc. - Photogrammetric, cartographic and image processing systems.

http://www.gdesystems.com

GeoData Institute at the University of Southampton.

http://www.geodata.soton.ac.uk/

Geodetic Survey of Canada.

http://www.geod.emr.ca/

GeoEAS - EPA (US) geostatistical library source.

ftp://math.arizona.edu/pub/geostat

Geographic Designs Inc. - Software, research and consulting services.

http://www.geodesigns.com

Geographic name server for USA (enter name to search).

telnet://martini.eecs.umich.edu:3000

Geography and GIS Servers Listing - maintained at Utrecht University.

http://www.frw.ruu.nl/nicegeo.html

Geologic fault database for the U.S.

ftp://alum.wr.usgs.gov/pub/map

Geologic Map of U.S. Pacific Northwest Continental Margin.

http://mustang.oce.orst.edu

Geological Survey of Canada On-Line Library.

telnet://opac@geoinfo.gsc.emr.ca

Geological Survey Bureau of the Iowa Department of Natural Resources GIS page.

http://samuel.igsb.uiowa.edu

Geological Survey of Japan home page.

http://www.aist.go.jp:7128/

Geomatics International (Canada) home page.

http://www.geomatics.com/

GEOname Digital Gazetteer - CD with four million non-US placenames.

http://www.gdesystems.com/IIS/SlipSheets/GEONAME.html

GeoVu - NGDC MS-Windows GIS/RS data visualization program.

ftp://ftp.ngdc.noaa.gov/Acess_Tools

GIAL - Geographic Information and Analysis Laboratory: NCGIA Buffalo.

http://zia.geog.buffalo.edu/GIAL/netgeog.html

GIF Images of Israel and Surrounding Countries.

gopher://israel-info.gov.il:70/11/gifs

GIS Job Clearinghouse.

http://walleye.forestry.umn.edu:70/0/www/main.html

GIS Job Announcement Gopher Server.

gopher://nero.aa.msen.com:70

GIS Master Bibliography Project (maintained by Duane Marble).

http://thoth.sbs.ohio-state.edu/

GIS Resource Pointers on the Internet (maintained by Matthias Werner).

http://www.laum.uni-hannover.de/gis/gisnet / gisnet.html

GIS Software Listing (maintained by Oliver Weatherbe).

http://triton.cms.udel.edu/~oliver/gislist.html

GIS User's Guide to Internet Tools (maintained by S. Murnion and G. Munroe).

file://jupiter.qub.ac.uk/pub/GIS/GIS.html

GIS-L and comp.infosystems.gis FAQ listing (maintained by Lisa Nyman).

ftp://abraxas.adelphi.edu/pub/gis/FAQ

GIS-L and comp.infosystems.gis FAQ listing alternate site.

ftp://ftp.census.gov/pub/geo/gis-faq.txt

GIS/Remote Sensing/GPS/Geosciences top level page at Texas A&M (very good).

http://ageninfo.tamu.edu/geoscience.html

GLIS - EROS Data Center Global Land Information System (X Windows only).

telnet://xglis.cr.usgs.gov:5060/

GLIS - Global Land Information System.

http://edcwww.cr.usgs.gov/glis/glis.html

GMT - Generic Mapping Tools software source.

ftp://kiawe.soest.hawaii.edu/pub/gmt

GPS Information Center, U.S. Coast Guard (login: select database 34).

telnet://fedworld.gov

GPS Information Sources (maintained by Richard Langley).

ftp://unbmvs1.csd.unb.ca/PUB.CANSPACE.GPS . INFO.SOURCES

GPS satellite current constellation status.

finger gps@geomac.se.unb.ca

GRASS GIS home page.

http://www.cecer.army.mil/grass/GRASS.main.html

GRASS GIS source code for UNIX platforms including LINUX.

ftp://moon.cecer.army.mil/grass

GSLIB - Stanford U. Geostatistical Library source (FORTRAN).

ftp://wiener.stanford.edu/gslib1.31

HOLIT - Israel Ecological & Environmental Information System.

http://vms.huji.ac.il/www_teva/db000.html

IDMSP - Raster image display/manipulation software.

ftp://hypatia.gsfc.nasa.gov/pub/software/imdisp

IDRISI-L FTP site (donated data, modules and more).

ftp://midget.towson.edu/idrisi

Illinois Natural History Survey GIS.

http://www.inhs.uiuc.edu:70/0h/igis/igismain

ImageNet - Landsat, SPOT and Russain RS Imagery archive/browser.

http://www.coresw.com/

Infotech Enterprises - GIS data conversion and programming home page.

http://infotech.stph.net

INGIS - The Indiana Geographic Information System Server.

http://ingis.acn.purdue.edu/

Institute for Photogrammetry and Remote Sensing, University of Karlsruhe (GER).

http://www.laum.uni-hannover.de/uis/uis.html

Institute for Photogrammetry, University. of Stuttgart (GER).

http://hpux.bauingenieure.uni-stuttgart.de

Institute for Regional Planing and Regional Science, University of Hannover (GER).

http://www.laum.uni-hannover.de/gis/gisnet / wwwgis.html

Institute for Space and Terrestrial Science (CAN).

http://www.ists.ca/Welcome.html

Institute of Geography, University of Salzburg (restricted access).

http://www.edvz.sbg.ac.at/geo/home.html

Intergraph Corporation.

http://www.intergraph.com

IOWA Department of Natural Resources FTP site (US).

ftp://gsb.igsb.uiowa.edu/

ISL - Information Systems Workgroup search page (several search engines).

http://www_is.cs.utwente.nl:8080/cgi-bin/local / nph-susi1.pl

Japan Virtual Map.

http://www.ntt.jp/japan/map

JHU/APL Digital relief maps of U.S image browser.

http://ageninfo.tamu.edu/apl-us/

JHU/APL ETOPO5 Digital relief maps of U.S.

http://www.doc.ic.ac.uk/public/geology/maps/gifmaps/

KHOROS - visualizaion software development environment source (working?).

ftp://pprg.eece.unm.edu/pub/khoros/release

Laboratory for Telecommunication and Remote Sensing Technology - TUDelft, NL.

http://tudedv.et.tudelft.nl/www/ttt/rs/rs_home.html

Lat/Long file of major world cities (coarse).

ftp://gis.queensu.ca/pub/gis/city/geocity.zip

Library of Congress (US) country information.

http://lcweb.loc.gov/homepage/country.html

Linnet Geomatics International (Canada) - includes LIS/GIS data repository.

http://www.linnet.ca/linnet/

macGIS gopher server.

gopher://dslmac.uoregon.edu:70

MapInfo FAQ (maintained by John McCombs).

ftp://ftp.csn.org/mapinfo/mi_faq.zip

MapInfo “maplication” programs.

ftp://ftp.csn.org/mapinfo

McGill University Department of Earth Sciences (CAN).

http://stoner.eps.mcgill.ca

Meta-Index of GIS related material on the Web (very comprehensive).

http://abacus.bates.edu/~nsmith/General / Resources-GIS.html

Meteorological, Geophysical and Oceanographic top level data list.

http://www.cis.ohio-state.edu/hypertext/faq/usenet / weather/top.html

MIT - Earth Resources Laboratory.

http://www-erl.mit.edu

Montana Natural Resource GIS data library (Arc/Info format).

http://nris.msl.mt.gov/gis/mtmaps.html

MOSS - PC GIS source.

ftp://ftp.csn.org/COGS/MOSS

NAISMap - National Atlas Information Service (Canada) WWW-based GIS (very impressive).

http://ellesmere.ccm.emr.ca/naismap/naismap.html

NASA - home page.

http://hypatia.gsfc.nasa.gov/NASA_homepage.html

NASA - Images from the Voyager and Magellan missions.

ftp://explorer.arc.nasa.gov/pub/SPACE

NASA - NASA Internet connections top level list.

http://krakatoa.jsc.nasa.gov/NASAInternetConnection.html

Naval Observatory Automated Data Service.

telnet://ads@tycho.usno.navy.mil

NCAR - National Center for Atomospheric Research data support archive.

ftp://ncardata.ucar.edu/

NCAR - US National Center for Atmospheric Research home page.

http://www.ucar.edu

NCEER - Seismic Activity Server.

telnet://strongmo:nceer@duke.ldgo.columbia.edu:23/8

NCGIA FTP server at U. of Maine.

ftp://grouse.umesve.maine.edu/pub/NCGIA/

NCGIA WWW server as U. of Maine.

http://blackbird.umesve.maine.edu/home_page.html

NCGIA FTP server at U.C. Santa Barbara (UCSB).

ftp://ncgia.ucsb.edu/pub

NCGIA WWW server at U.C. Santa Barbara (UCSB).

http://www.ncgia.ucsb.edu/

NCGIA WWW server SUNY Buffalo.

http://zia.geog.buffalo.edu/

NCSU - NCSU library gopher: GIS.

gopher://dewey.lib.ncsu.edu:70/11/library/disciplines/geogrphy/gis

NGDC - National Geophysical Data Center (US) home page.

http://www.ngdc.noaa.gov/ngdc.html

Norwegian Institute of Technology GIS pointer page.

http://www.iko.unit.no/gis/gisen.html

NRC - Natural Resources Canada (Energy, Mines and Resources Canada).

http://www.emr.ca/

NRC - Natural Resources Canada On-line Library.

telnet://opac@canlib.emr.ca

NSCA - WWW search engine meta-index (very useful).

http://www.ncsa.uiuc.edu/SDG/Software/Mosaic/Demo/metaindex.html

NSSDC On-line Data and Information Server (including NASA master dir).

telnet://nodis@nssdca.gsfc.nasa.gov

Ocean Mapping Group, U. of New Brunswick (includes sea-floor fly-over MPEGs).

http://www.omg.unb.ca/omg/

Online Career Center (useful for both GIS job searchers and GIS employers).

gopher://gopher.msen.com

On-line Resources for Earth Scientists FAQ (maintained by Bill Thoen).

ftp://ftp.csn.net/COGS/ores.txt

Oregon's State Service Center for Geographic Information Systems.

http://www.sscgis.state.or.us

ORNL - Oak Ridge Nat. Laboratory (US) fire simulation program EMBYR.

http://jupiter.esd.ornl.gov/ern/embyr/embyr.html

OSU - Ohio State University (US).

http://www.cis.ohio-state.edu

OZGis - OZ GIS source (msdos and windows).

ftp://oak.oakland.edu/pub/msdos/mapping

Pacific GIS - A non-profit organization devoted to public access GIS.

http://www.ptialaska.net/~pacgisak

Paleomagnetic database for the world. Includes DTM images.

ftp://earth.eps.pitt.edu/pub

PARC - Xerox Palo Alto Research Center map viewer.

http://pubweb.parc.xerox.com/map

PCI home page.

http://www.pci.on.ca/

PHARUS - Phased Array Universal SAR project, TUDelft, FEL, & NLR, Netherlands.

http://tudedv.et.tudelft.nl/www/ttt/rs/pharus / pharus_home.html

Planet Earth Home Page (a very good top level WWW server).

http://white.nosc.mil/info.html

PROJ - projection conversion program source.

ftp://charon.er.usgs.gov/pub/PROJ.4

Project GeoSim - Geography education software.

http://geosim.cs.vt.edu/index.html

REGIS - UC Berkeley Research Program in Environmental Planning and GIS.

http://www.ced.berkeley.edu

Remote Sensing Catalogue of the WWW Virtual Library (maint. by VTT-RS Group).

http://www.vtt.fi/aut/ava/rs/virtual/

Resources for Cartorgraphy, GIS and Remote Sensing (maint. by Michael Ritter).

http://www.uwsp.edu/acaddept/geog/cart.htm

Rice University (US) - Geography, software, GIS info and more.

gopher://riceinfo.rice.edu/11/Subject/Geography

RSD - NASA's Public Use of Remote Sensing Data home page.

http://camille.gsfc.nasa.gov/rsd/

Ryerson University GIS and Geography home page.

http://www.acs.ryerson.ca/~gta

SAIF - Canadian Spatial Archive Interchange Format specifications.

http://www.wimsey.com/~infosafe/saif/saifHome.html

Satellite images of Japan and the Pacific.

http://www.ntt.jp/japan/GMS

Satellite images, various.

http://web.nexor.co.uk/places/satelite.html

SDTS - US Spatial Data Transfer Standard (FIPS 173).

ftp://sdts.er.usgs.gov/pub/sdts/

Sea-surface temperature data (near real-time).

ftp://satftp.soest.hawaii.edu/pub/avhrr/images

SOEST - Generic Mapping Tool (GMT).

http://www.soest.hawaii.edu/soest/about.ftp.html

Software Support Laboratory: Space and Earth Scientists Software Tools.

http://sslab.colorado.edu:2222/ssl_homepage.html

Space and Astronomy related FAQs.

http://www.cis.ohio-state.edu/hypertext/faq/usenet / spae/top.html

SRSC - Space Remote Sensing Center, Inst. for Technology Development (US).

http://www.itd.com

STIS - US NSF Science and Technology Information Service.

telnet://public@stis.nsf.gov

Strategic Mapping Inc. home page.

http://www.stratmap.com

Synmap Information Technologies, NS, Canada - inc. geogdata for South America.

http://www.isisnet.com/synmap/index.html

TAMU - Sample ETOP5 dataset relief images (working?).

ftp://ageninfo.tamu.edu/11/apl-us

TAMU - Texas A&M U. version of LINUX (access?).

ftp://sc.tamu.edu

Thomas Bros. Maps home page.

http://www.thomas.com/

TIGER - US Census TIGER files mapping service.

http://tiger.census.gov

Texas GIS Planning Council home page (inc. Texas GIS data).

file://sun.stac.dir.texas.gov/DIR/gis.html

UNC - U of North Carolina Inst. for Transportation Research and Education.

http://itre.uncecs.edu

UNEP GRID database listing (GRIDLIST.DOS, GRIDLIST.WP5).

ftp://camelot.es.anl.gov/pub

UNIDATA gopher server with weather summary maps for the U.S. and world.

gopher://groucho.unidata.ucar.edu:70/11/Images

University of Washington Geophysics program home page.

http://www.geophys.washington.edu/

US Bureau of the Census home page.

http://www.census.gov/

US Fish and Wildlife service - National Wetlands Inventory FTP site.

ftp://192.189.43.33/

US Fish and Wildlife service - National Wildlife Refuge System WWW server.

http://bluegoose.arw.r9.fws.gov/

US GeoData index files.

ftp://greenwood.cr.usgs.gov/pub/esic

USGS - United States Geological Survey home page.

http://info.er.usgs.gov

USGS - United States Geological Survey WAIS.

wais://info.er.usgs.gov/USGS-Server

USGS beginners tutorial on GIS.

http://info.er.usgs.gov/research/gis/title.html

USGS Distributed Spatial Data Library.

file://waisqvarsa.er.usgs.gov/wais/home.html

USGS federal government data products catalog.

http://info.er.usgs.gov/fgdc-catalog/title.html

USGS geologic mapping and volcanic hazards assessment home page.

http://vulcan.wr.usgs.gov/Projects/Mapping+hazards/framework.html

USGS GIS home page.

http://info.er.usgs.gov/research/gis/title.html

USGS GISLab FTP site - 1:250000 DEM depot.

ftp://edcftp.cr.usgs.gov/pub/data/DEM/250

USGS Global Land Information System (GLIS) - LANDSAT Archive.

telnet://glis.cr.usgs.gov:guest

USGS - National Geospatial Data Clearinghouse.

http://nsdi.usgs.gov/nsdi/index.html

USGS/EROS FTP site - DEM and DLG file depot.

ftp://edcftp.cr.usgs.gov/pub/data

USGS - Technical Standards and Cartographic Software.

ftp://nmdpow9.er.usgs.gov/public

US National Biological Service, Environmental Management Technical Center.

http://www.emtc.nbs.gov/

US National Parks Service - digital data archive (Arc/Info format).

ftp://ftp.its.nps.gov/pub/park_boundaries

U.S. Weather Service Hydrologic RS Center - AVHRR sample images and viewers.

ftp://snow.nohrsc.nws.gov/AVHRR_sample

Virtual Tourist Map of WWW information services around the world.

http://wings.buffalo.edu/world

VPFVIEW (DCW) program for UNIX (Sun workstations) - DND Canada.

ftp://jupiter.drev.dnd.ca/pub/gis/vpfview

VTT Automation, Space Technology and Remote Sensing Services.

http://www.vtt.fi/aut/ava/rs/

Weather information, Japan.

gopher://gan.ncc.go.jp:70/11/INFO/weather

Weather map - U.S.

gopher://meteor.atms.purdue.edu:70/1/satellite

Weather satellite and surface analysis images for North America.

ftp://wuarchive.wustl.edu/multimedia/images/wx

WOCE - World Ocean Circulation Experiment and Oceanographic top level list.

http://diu.cms.udel.edu/other/other.html

World Data Bank - Worlds coastlines, countries, rivers, etc.

ftp://sepftp.stanford.edu/pub/World_Map

WWW Database Article Archive, including information on GIS database design.

http://www.lpac.ac.uk/SEL-HPC/Articles/DBArchive.html

WWW Search engines meta-index at Centre Universitaire d'Informatique (CUI).

http://cuiwww.unige.ch/meta-index.html

WWW telnet client (only 10 users allowed at same time).

telnet://info.cern.ch

WWW Virtual Library page on Geography - maintained by Gordon Dewis.

http://hpb1.hwc.ca:10002/WWW_VL_Geography.html

WWWW - World Wide Web Worm search engine.

http://www.cs.colorado.edu/home/mcbryan/WWWW.html

Zentrum flr graphische Datenverarbeitung (ZGDV Graphic Data Centre).

http://www.igd.fhg.de

Appendix D
How to Submit and Access Data and Metadata on the USACE Node of the National Geospatial Data Clearinghouse

D-1. Introduction[1]

a. The U.S. Army Corps of Engineers (USACE) has a server on the Internet on which they store and make available to all interested persons original geospatial data and metadata created and owned by USACE agencies. It is the USACE node of the National Geospatial Data Clearinghouse. Throughout this appendix the server is called the Geospatial Server or the Server. Its network name is corpsgeo1.usace.army.mil and its Internet Protocol (IP) address is 144.3.144.20. It uses anonymous file transfer protocol (ftp), World Wide Web (WWW or Web), and limited-access ftp processes to enable users to submit and access geospatial data and metadata. This appendix is a detailed description of how to use the Server.

b. When metadata are submitted to the USACE node of the National Geospatial Data Clearinghouse, they are added to a national repository of geospatial data that is searchable and available electronically to anyone in the world with Internet access. Use of this database will eliminate duplication of data creation, enable more efficient use of resources, and make more information available for better decision making.

c. The multiple facets of the Server are described in this appendix, including the following:

(1) Process for submitting geospatial metadata to the Server.

(2) Process for submitting geospatial data to the Server.

(3) Processes to find and access data and metadata from the Server on WWW pages at http://corpsgeo1.usace.army.mil.

d. The webmaster of the Server mentioned throughout this appendix may be contacted in the following ways:

E-mail: webmaster@corpsgeo1.usace.army.mil
Phone: 603-646-4320
Fax: 603-646-4658

D-2. Responsibilities of the Geospatial Data and Systems Point of Contact

Engineer Regulation (ER) 1110-1-8156 requires that a Geospatial Data and Systems Point of Contact (GD&S POC) be designated by each Command. The GD&S POC responsibilities are defined in detail in the ER. The POC will act as the liaison between the geospatial data community of the command and Corps Headquarters, and thus will also be the POC between the Command and the Server administrators. In reference to the Server, the ER states that the GD&S POC's responsibilities include the following:

> As new data pages are developed on the USACE Clearinghouse node by HQUSACE for the Commands, GD&S POCs will review the pages and provide corrections to the Webmaster. Annually, the GD&S POC will review the Command's geospatial data pages on the USACE Clearinghouse node and forward any updates to the Webmaster.

In addition, POCs should consider the following areas of concern within their Command's geospatial data community:

a. The system(s) of filenames used to name data and metadata files by persons within their Command.

b. Records of the Server filenames that will extend beyond each employee's time of service.

c. Coordination with their information management group.

D-3. Metadata Submission to the Server

Please note that data and metadata files are currently being accepted from USACE employees who are registered to submit files on the Geospatial Data Clearinghouse Server. If you have questions about anything in this document, you can ask your GD&S POC.

a. Accessing the Server for metadata submission. (This section is the same for metadata and data submission, paragraphs D-3 and D-4.) Users need to register only once to have access to the Geospatial Clearinghouse Server for metadata and data submission. Do the following three things to register:

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[1] Please note that updates to this document will be available at http://corpsgeo1.usace.army.mil/howto/.

(1) Inform the GD&S POC for your organization that you intend to submit metadata and data to the Server. You can search for the name and contact information of the GD&S POC for your organization in the GD&S POC database at URL

http://dbserver.crrel.usace.army.mil:2000/owa_crrel/owa/gds.menu

(2) To put metadata files on the USACE Geospatial Server, you must get a Corps UPASS user ID and password, and register with the UPASS system as a user on the Geospatial Metadata and Data Server. This is the same UPASS user ID and password that are recognized by the Server for data submission. (They are also the same user ID and password used in CEFMS.) The Corps standard UPASS system will be used for issuing and controlling user IDs and passwords. To get a UPASS user ID, ask your UPASS administrator for a "UPASS user ID on the Geospatial and WWW Server." To find out who your UPASS administrator is, contact your information management group.

(3) The corpsgeo1 webmaster must have your e-mail address before the metadata submission process will work for you. You must submit your name, e-mail address, and USACE organization to the Corpsgeo1 webmaster. You can do this one of three ways:

(a) Our web form at
http://corpsgeo1.usace.army.mil/user-id2.html

(b) E-mail
webmaster@corpsgeo1.usace.army.mil

(c) The corpsgeo1 webmaster at (603) 646-4320.

Satisfying these three requirements will enable you to put metadata and data on the Server.

b. Metadata file format: Requirements under Isite software.

(1) What are the file format requirements for metadata submission? There are three requirements for the metadata file format. Why these requirements are in place and suggestions on how to meet them are given in the following discussion. The output from CORPSMET95 conforms to these requirements. The requirements are as follows:

(a) Conformance with the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (the Standard), published 8 June 1994.

(b) Indention of each line in the metadata file according to the rules required by mp, a metadata parser software program which will be explained later (Schweitzer 1997b).

(c) Plain ASCII text file format. Most word processors enable a file to be saved in ASCII text format by saving to "Text Only."

(2) Why is each of these requirements necessary? Knowing why these formats are required could mean the difference between persistence and disillusionment in the future.

(a) The Content Standard. According to Federal Executive Order 12906 and ER 1110-1-8156, metadata must be created and made available to the public for all newly developed geospatial data and for selected older geospatial data created by the agencies of the Federal government. According to the Executive Order, all USACE geospatial metadata must conform to the FGDC Content Standards for Digital Geospatial Metadata, which can be viewed at the URL

http://geochange.er.usgs.gov/pub/tools/metadata/standard/

The Content Standard defines the specific required and optional descriptors (or records) needed to describe a geospatial data set to a data user who has no previous knowledge of the data. The Overview in the Standard says,

> This standard specifies the information content of metadata for a set of digital geospatial data. The purpose of the standard is to provide a common set of terminology and definitions for concepts related to these metadata. Metadata are data about the content, quality, condition, and other characteristics of data.

The purpose for standardizing geospatial metadata is to be a part of the National Geospatial Data Clearinghouse (National Clearinghouse) and thus make the data we create accessible to the nation and the world electronically from a single source for better use of resources and better decision making. A data search initiated at the National Clearinghouse Web site can include a search of the USACE database as well as all other participating Federal agencies. Finally, a standardized format is necessary for the manipulation of the file by software, consistent use of terminology, and consistent presentation.

(b) The indentations. To function as a node of the National Geospatial Data Clearinghouse, the Server must follow the protocol the Clearinghouse requires. The indexing software required on the National Clearinghouse Server and the USACE Server is Isite. Indexing software permits the metadata text and fields to be searchable by keyword. Isite software can index only metadata that is in Standard Generalized Markup Language (SGML) format. SGML tags will be added to your plain ASCII text-only metadata by a processing script when you put it on the Server. The indentations are needed to enable the processing software to add SGML to your file. Figure D1 shows an example of correctly indented metadata. The indentations are automatically generated by the USACE metadata creation software tool, CORPSMET95. When a metadata script is submitted to the USACE Clearinghouse Server, a program called the Sisyphus Program or SP is running to process it. The first thing that SP does is to run the metadata file through a program, mp, created by Peter Schweitzer, U.S. Geological Survey (USGS) (Schweitzer 1997b). Mp checks the metadata syntax according to the Content Standard and will output the file in SGML and Hyper Text Markup Language (HTML) format. SGML is needed for the Isite indexing software. HTML is needed to present metadata on the Web. Mp is the program that requires metadata to be in hierarchically indented format and will send back error messages if the metadata does not follow the Content Standard. Rather than require everyone submitting metadata to encode their metadata in the unfamiliar SGML, it was decided that metadata must have the hierarchical indentations.

(c) Text only. Metadata files must be in ASCII text format or they will be unreadable by SP, mp, and Isite. Word processor proprietary formats cannot be used. Files should not be in HTML or SGML format when they are submitted to the Server. No formatting codes should be embedded in the metadata file.

(3) How can I easily create metadata according to these requirements? The metadata generator software package, CORPSMET95, developed by the Corps, creates metadata in the correct format. It outputs the metadata file in the correct hierarchically indented format. It runs on Windows95 and NT operating systems. It is free of charge and menu driven. CORPSMET95 is highly recommended because of its ease of use and because the output is correctly formatted for the USACE Server. It can be downloaded from the URL

ftp://corpsgeo1.usace.army.mil/pub/corpsmet95/

This file has to be unzipped before it is installed. For more information on this process, ask your information systems group.

c. Filename conventions.

(1) When metadata files are put on the Server, a program runs that uses the filename extension of each file to determine how it will handle the file. Original metadata files should have the extension .met. Other extensions are used for

(a) Files that are to replace files currently on the Server (.rep).

(b) Files to be deleted (.del).

(c) Data files (.dat).

(2) When a file is sent via ftp to the Server, the name can have up to 100 characters, and the extension .met can be added to the file name used on the PC. All file names should consist of a continuous string of characters, which may include numbers, letters, underscore (_), hyphen (-), and dot (.). File names are case sensitive. Other special characters should be avoided, including spaces.

(3) The GD&S POCs and persons submitting metadata are responsible for keeping track of the file names of the Command's metadata. The file name will be needed if the metadata has to be replaced, updated, or deleted in the future. The file names currently in a Command's metadata directory can be seen by using anonymous ftp to view the Command's metadata directory. (See paragraph D-5 for instructions on how to use anonymous ftp.)

(4) In the past, metadata file names were changed as they were moved by SP to the Server metadata storage area. (User ID, date, and time were added to the original name.) This no longer occurs.

d. Submitting metadata to the Server. To put a metadata file on the Geospatial Server after you have registered to access the Server as described in D-3*a*, follow these steps:

(1) Plan your file name. Remember to use the .met extension for metadata file submissions. You can submit multiple files during one ftp session, including metadata and data files.

(2) Use your computer's ftp utility. There are many variations of ftp software. It would be impossible to describe them all. For assistance with the ftp utility on your computer, ask your information management group.

```
Identification_Information:
    Citation:
        Citation_Information:
            Originator: New Orleans District, U.S. Army Corps of Engineers
            Publication_Date: 19941206
            Title: Mississippi River Southwest Pass Hydrographic Surveys of 19941206
            Edition: N/A
            Geospatial_Data_Presentation_Form: map
            Publication_Information:
                Publication_Place: New Orleans, LA
                Publisher: New Orleans District, U.S. Army Corps of Engineers
            Online_Linkage: http://www.lmn.usace.army.mil/ops/odt/nav-cond.htm
    Description:
        Abstract:
            The Mississippi River Southwest Hydrographic
            Surveys are compiled in order to monitor and
            maintain  Mississippi River Channel conditions at
            South and Southwest Passes and Pass A Loutre.
        Purpose:
            The purpose of the Mississippi River
            Southwest Pass Hydrographic Surveys is to
            provide a current survey and map of the Mississippi River
            for the purpose of recording changes in channel
            conditions, secondarily as an aid to navigation,
            and to be used as an engineering and planning tool for
            future Flood Control, Navigation, and Hurricane Protection
            projects.
    Time_Period_of_Content:
        Time_Period_Information:
            Single_Date/Time:
                Calendar_Date: 19941206
        Currentness_Reference: Publication Date
    Status:
        Progress: In work
        Maintenance_and_Update_Frequency: Daily
    Spatial_Domain:
        Bounding_Coordinates:
            West_Bounding_Coordinate: -089.300000
            East_Bounding_Coordinate: -089.070000
            North_Bounding_Coordinate: +29.100000
            South_Bounding_Coordinate: +28.530000
    Keywords:
        Theme:
            Theme_Keyword_Thesaurus: Tri - Service Spatial Data Standard
                Theme_Keyword: Boundaries
                Theme_Keyword: Hydrography
[Note: Metadata file cropped here.]
```

Figure D-1. An example of correctly indented metadata. The original metadata file was created by the New Orleans District using CORPSMET95. Only a portion of the entire metadata file is shown here.

(3) Use the following parameters to ftp to your home directory on corpsgeo1:

Host: corpsgeo1.usace.army.mil
Login ID: *yourUPASSid*
Password: *yourUPASSpassword*

When you have successfully logged on to corpsgeo1, you will be in your home directory. This is the only place on the Server where you can put files.

(4) You are now ready to submit the file to the Server. (The metadata file must be ASCII text, and must be sent in ASCII text mode.) In a command line view on a Windows3.x/Win95/NT or UNIX operating system, the command to send the file to the Server is

put filename.met

(5) When you are done putting metadata on the Server, close the session and exit from the ftp software. If you stop communicating with the ftp site for some period of time during the ftp session, you may be timed out; i.e., you will not be connected to the Server anymore. If this occurs, you will have to ftp to the Server again.

(6) SP will process new files approximately once an hour. If a metadata submission is successfully processed, you will receive an e-mail message within a few hours saying so. If the file is not successfully processed, you will receive an e-mail message within a few hours stating this and explaining why it was not successfully processed.

e. Replacing or deleting metadata files. To replace or delete a metadata file on the Server, you will need to know the exact file name of the file to be replaced or deleted. You can use anonymous ftp or use the World Wide Web and go to the URL ftp://corpsgeo1.usace.army.mil to go to your organization's metadata directory to look for the file name you need. Login procedures and the directory structure for anonymous ftp on the corpsgeo1 site are given in paragraph D-5. If you are trying to replace or delete files that you did not put on the Server, you will have to contact the webmaster with proof that you are now responsible for these files.

(1) To replace (or update) a metadata file.

(a) Have the replacement file ready on your local computer. The file name of the replacement file should be in the format

filename(.met).rep

where filename(.met) is the name of the file to be replaced. The original file name will end with .met so the file name you type here will end with .met.rep. The extension .rep will cause the Server to replace the metadata file currently in your Command's metadata directory having the name filename.met with the file you just put in your home directory.

(b) Ftp to the Server. Use the following parameters to ftp to your home directory on corpsgeo1:

Host: corpsgeo1.usace.army.mil
Login ID: *yourUPASSid*
Password: *yourUPASSpassword*

(c) You are now ready to submit the file to the Server. (The metadata file must be ASCII text, and must be sent in ASCII text mode.) In a command line view on a Windows3.x/Win95/NT or UNIX operating system, the command to send the file to the Server is

put filename.met.rep

(d) When you are done putting metadata on the Server, close the session and exit from the ftp software.

(2) To delete a metadata file.

(a) First create a dummy file on your local computer. It does not matter what is in the dummy file. The file name should be in the format

filename(.met).del

where filename(.met) is the name of the dummy file you created on your local computer and the name of the file to be deleted. The file name of the existing metadata file will end with .met, so the name of the dummy file will end with .met.del. The extension .del will cause the Server to delete the metadata file you have named.

(b) Ftp to the Server. Use the following parameters to ftp to your home directory on corpsgeo1:

Host: corpsgeo1.usace.army.mil
Login ID: *yourUPASSid*
Password: *yourUPASSpassword*

(c) You are now ready to submit the dummy file to the Server. (The metadata file must be ASCII text, and must be sent in ASCII text mode.) In a command line view on a Windows3.x/Win95/NT or UNIX operating system, the command to send the file to the Server is

put filename.met.del

(d) When you are done putting metadata on the Server, close the session and exit from the ftp software.

f. Editing collection metadata files. The USACE geospatial data and metadata available on the Web include *collection metadata* and *detailed metadata*. A collection metadata file is a single metadata file that describes a series of related data files that are routinely collected by an agency. For example, the data may be hydrographic files that have been collected for 20 years. A detailed metadata file describes a unique data file or a collection of data files that are not routinely collected by an agency. The corpsgeo1 team has created a series of templates of collection metadata for USACE Commands to edit or delete, as appropriate. Links to these are found under each Command's data pages. The changes to these pages can be made on a paper copy or electronic copy of the file. Electronic editing is preferred. You can make the changes to the electronic file as described below, then send the resulting file to the webmaster as an e-mail attachment.

(1) Electronic editing

(a) While browsers differ, general instructions for saving an electronic copy of a Web page to your local computer are given here. To download the Web page to your PC, use your browser to view the collection metadata file Web page. Save the file to your PC by using the browser menu options: File/Save as. Choose to save in the format type HTML or text. Note where in your directory structure the file is being saved and its file name. Press enter.

(b) When it is saved, the collection metadata file will have all the HTML tags necessary for viewing it from your Web browser on your local PC. To view the file on your PC using your browser, use the browser menu options File/Open File in Browser or File/Open/Browse to locate and open the electronic copy of the metadata file you just downloaded.

(c) You can then work in your word processor to make needed changes in the file and view the results from your browser. Please remember to open and save file in "Text Only" format in your word processing software. Any images in these files will not appear as you edit and view them on your local computer. This is normal. When the file is placed back on the Server, the images will appear as they should.

(2) Editing a paper copy. Print a hard copy of the page from your web browser while you are viewing it. Edit it and fax the edited version to the corpsgeo1 webmaster at 603-646-4658. Please make your edits clearly. Please let the webmaster know the fax is coming.

D-4. Data Submission to the Server

Please note that data and metadata files are currently being accepted on the Corps Geospatial Server from USACE employees who are registered to use the Server. The producers of geospatial data are responsible for the quality, integrity, and maintenance of the data that they produce.

a. Accessing the Server for data submission. The process for registering to use the Server for metadata and data submission is exactly the same. The three requirements are described in paragraph D-3*a*.

b. Data file formats. Data in any format will be accepted on the Server. This includes output generated by any Computer-Aided Design and Drafting (CADD) system or Geographic Information System (GIS). It includes any data that contain geospatial coordinates. Please be aware of the file name conventions for placing data on the Server as described below. When you are sending binary data, remember to set the mode for binary. This may be done automatically by the ftp software.

c. Filename conventions.

(1) A UNIX script called SP, or the Sisyphus Program, is running on the Server at all times. This program scans the new files in your directory and uses the filename extension of each file to determine how it will handle the file. Original data files should have the extension .dat. Other extensions are used for

(a) Files that are to replace files currently on the Server (.rep).

(b) Files to be deleted (.del).

(c) Metadata files (.met).

(2) When a file is sent to the Server, the name can have up to 100 characters, and the extension.dat can be added to the filename used on the PC. For example, an Arc Info export file could be called white_riverVT19970607.e00.dat. If your local computer does not allow long file names, you

can change the name using your ftp utility when the file is on the Server. All file names should consist of a continuous string of characters that may include numbers, letters, underscore (_), hyphen (-), and dot (.). File names will be case sensitive. Other special characters should be avoided, including spaces.

(3) The filename will be needed if a data file has to be replaced, updated, or deleted in the future. You can look for your Command's data file names using the Web page at URL

http://corpsgeo1.usace.army.mil/cgi-bin/
geodatalookup.pl

d. Submitting data. The producers of geospatial data are responsible for the quality, integrity, and maintenance of the data that they produce.

(1) Data and the referring metadata file. When a data file is submitted to the Server, a metadata file that refers to that data file absolutely must be submitted to the Server at the same time. (A metadata file may be submitted without a data file.)

(a) Section 6 of a metadata file is the "Distribution Information" section. This section contains information about the distribution of and options for obtaining the data to which the metadata refers. Which of the optional data descriptors in this section will be used will depend on where the data are located. There is a section for "Non Digital Data" (6.4.1) as well as for "Digital Data" (6.4.2).

(b) When a data file and the referring metadata file are submitted to the USACE Geospatial Server, the metadata file must contain the following reference to the data:

http://corpsgeo1.usace.army.mil/filename.dat

where filename.dat is the name of the data file to which the metadata refers. This reference has to be under the Distribution Information section of the metadata called “Network Resource Name.” SP, the script that processes the files, takes this text and turns it into a link to the actual data file. (http://corpsgeo1.usace.army.mil is just dummy text to alert SP as to what it needs to do.) When people read the metadata on the Server, they will be able to request a download of the corresponding data immediately, if the data are on the corpsgeo1 Server.

(c) If you are submitting data with metadata, your metadata Distribution Information Section options must look like this (notice the hierarchical indentation of the options):

```
6: Distribution Information:
  Standard Order Process:
    Digital Form:
      Digital Transfer Option:
        Online Option:
          Computer  Contact Info:
            Network Address:
              Network Resource Name:
                http://corpsgeo1.usace.army.mil/filename.dat
```

where filename.dat is the filename of the data file to which the metadata file refers.

(d) For a clear, detailed description of "Distribution Information" of the Content Standard, see Peter Schweitzer’s Web page (Schweitzer 1994) at

http://geochange.er.usgs.gov/pub/tools/metadata/
standard/06.html

(e) The data and referring metadata files must be submitted at the same time to enable SP to process the information in the Distribution Information section of the metadata file.

(f) If there is no corresponding metadata file with a data file when it arrives at the Server, the data file will be put in storage for 2 weeks and you will be notified that you need to submit a metadata file with it. If you submit the metadata file within that 2-week period, you do not have to resubmit the data file; SP will take the data file from the temporary storage directory and process it normally.

(g) If you want to submit a data file that corresponds to a metadata file already on the Server, you will need to delete the old metadata file from the Server and resubmit it with the new data file. This will enable you to include the required text in the Network Resource Name section of the metadata file and allow SP to process the two files correctly.

(h) One metadata file may refer to multiple data files. If this is the situation, the metadata Distribution Information section will have more that one Network Resource Name, for example:

```
Distribution Information
  Standard Order Process
    Digital Form
      Digital Transfer Option
        Online Option
          Computer  Contact Info
            Network Address
```

Network Resource Name
http://corpsgeo1.usace.army.mil/fname1.dat
Network Resource Name
http://corpsgeo1.usace.army.mil/fname2.dat
Network Resource Name
http://corpsgeo1.usace.army.mil/fname3.dat

where fname1.dat, fname2.dat, and fname3.dat are the file names of the data files that correspond to the metadata file.

(i) To summarize,

- You can submit a metadata file without a data file.
- If you submit a data file, you must simultaneously submit a referring metadata file.
- One metadata file can refer to multiple data files.
- Multiple metadata files can refer to one data file.

(2) To ftp a data file to the Geospatial Server.

(a) Plan your file name. Remember to use the .dat extension for data file submissions.

(b) Use your computer's ftp utility. There are many variations of ftp software. It would be impossible to describe them all. If you don't know how to use the ftp utility on your computer, ask your information management team.

(c) Use the following parameters in your ftp software to ftp to your home directory on the Server site:

Host: corpsgeo1.usace.army.mil
Login ID: *yourUPASSid*
Password: *yourUPASSpassword*

When you have successfully sent files via ftp to corpsgeo1, you will be in your home directory on the Server. This is the only place on the Server where you can put files.

(d) You are now ready to transfer the data file to the Server. The file must be sent as a binary file. In a command line view on a Windows3.x/Win95/NT or UNIX operating system, the commands to set the ftp to binary mode and send the file are

```
bi
put filename.dat
```

If you do not send files by ftp using the command line, the binary setting may be chosen automatically by the ftp software.

(e) When you are done putting data on the Server, close the session and exit from the ftp software.

(f) SP will process new files approximately once an hour. If a data submission is successfully processed, you will receive an e-mail message within a few hours saying so. If the file is not successfully processed, you will receive an e-mail message stating this and explaining why it was not successfully processed.

e. Replacing or deleting data files. To replace or delete a data file, you will need to know the exact name of the file to be replaced or deleted. You can look for your Command's data file names using the Web page at URL

http://corpsgeo1.usace.army.mil/cgi-bin/
geodatalookup.pl

Remember also to replace or delete the metadata file that refers to a data file you are removing or deleting. If you are trying to replace or delete files that you did not put on the Server, you will have to contact the webmaster with proof that you are now responsible for these files in order to replace or delete them.

(1) To replace (or update) a data file.

(a) Have the replacement file ready on your local computer. The name of the replacement file should be in the format

filename(.dat).rep

where filename(.dat) is the name of the file to be replaced. The original file name will end with .dat so the file name you type here will end with .dat.rep. The extension .rep will cause the Server to replace the data file currently in your Command's data directory with the file you just put in your home directory. The file name must match exactly for this to work.

(b) Log onto the Server using the following parameters in your ftp software:

Host: corpsgeo1.usace.army.mil
Login ID: *yourUPASSid*
Password: *yourUPASSpassword*

(c) You are now ready to transfer the replacement data file to the Server. The file must be sent as a binary file. In a command line view on a Windows3.x/Win95/NT or UNIX operating system, the commands to set the ftp to binary mode and send the file are

bi
put filename(.dat).rep

If you do not send the files by ftp using the command line, the binary setting may be chosen automatically by the ftp software.

(d) When you are done, close the ftp session and quit the ftp utility.

(2) To delete a data file.

(a) First create a dummy file on your local computer. It does not matter what is in the dummy file. The file name should be in the format

filename(.dat).del

where filename(.dat) is the name of the dummy file you created on your local computer and the name of the file to be deleted. The name of the existing data file will end with .dat so the name of the dummy file will end with .dat.del. The extension .del will cause the Server to delete the data file you have named.

(b) Use the following parameters in your ftp software to log in on the Server:

Host: corpsgeo1.usace.army.mil
Login ID: *yourUPASSid*
Password: *yourUPASSpassword*

(c) You are now ready to transfer the dummy data file to the Server. It does not matter if the file is sent in binary or text mode. In a command line view on a Windows3.x/Win95/NT or UNIX operating system, the command to send the file is

put filename(.dat).del

(d) Close your ftp session and quit the ftp utility.

D-5. Accessing Corps Geospatial Data and Metadata

Notice to data users: The data described in the metadata files produced by the USACE represent the results of data collection and processing for a specific USACE activity and indicate the general existing conditions. As such it is valid only for its intended use, content, time, and accuracy specifications. The user is responsible for the results of any application of the data for other than its intended purpose.

a. USACE geospatial data and metadata. The USACE geospatial data and metadata available on the Web include *collection metadata* and *detailed metadata*. These terms are defined in paragraph D-3*f*. All metadata files name the Point of Contact for the data set described and state how the data can be obtained. When the data reside on this Server, there will be a link in the metadata from the metadata to corresponding data set(s). These links will be in the Distribution Information Section of the metadata file. (See paragraph D-4 for details.) USACE Commands will decide which of their data products to make available on the Server.

b. Accessing data via metadata: keyword search, image maps, USACE Command list, and anonymous ftp. To determine if a data set is appropriate for your use, you can access the corresponding metadata file and read about the specifications of the data. There are four ways to search for data on the USACE Server: National Clearinghouse search form, image maps linked to USACE Command data pages, textual list of USACE Commands, and anonymous ftp.

(1) National Geospatial Data Clearinghouse. The USACE Server had a search form just to search our Server. However, compliance with the National Geospatial Data Clearinghouse policy requires that keyword searches start at the National Clearinghouse search tool. You can limit your search to USACE metadata only, to metadata developed by a particular USACE Command, or to all metadata containing a keyword by entering the appropriate terms in the search form, as described below. A link to the Clearinghouse keyword search form is available on the USACE Server homepage. A direct link to the Clearinghouse search tool is URL

http://130.11.52.178/

(a) To choose to look only at USACE data holdings. Go to the section called *Databases*. In this section, choose the *Army Corps of Engineers* option. You will also need to put a keyword in the *Keyword and Fielded Search* section even if you are not interested in any particular keyword. Using the *FullText* or *Abstract* options in the *Text Search* box and the keyword *the* in the *Text Input* box will get you all the USACE holdings. (To do a keyword search, enter the keyword in the *Text Input* box.)

(b) To choose only to look at the data holdings of a particular USACE Command. Go to the section called *Databases*. In this section, choose the *Army Corps of Engineers* option. In the *Keyword and Fielded Search* section find the *Text Search* box and choose the option *Originator*. Put the name of the Command for which you want to search in the *Text Input* box.

(c) To select a specific geographic area**.** The National Clearinghouse is spatially indexed. This means that you can add geographic coordinates to the search statement, limiting the search to the geographic area in which you are interested. A section titled *Add spatial search?* enables you to do this.

(d) Submit. Click on the *Submit Query* button to start the search engine. The results will be a list of the metadata files from the database that fit the specifications you submitted.

(2) Image maps and textual list. There are links on the Server homepage to the textual USACE Command list at URL http://corpsgeo1.usace.army.mil/org.direct.html and the image maps at URL http://corpsgeo1.usace.army.mil/metadata.html. Both of these links start the data-seeker through a series of pages based on the USACE organizational structure and both lead to the same Command data pages. There is a data page for each USACE Command. On the data pages are links to the Command's collection and detailed metadata pages and GD&S POC contact information.

(3) Accessing Corps metadata using anonymous ftp. You also can get metadata by using anonymous ftp originating from your local computer. This will allow you to transfer metadata files to your computer. You do not need to have a Corps UPASS user id. The difficulty of using anonymous ftp is that if you do not know exactly where to find what you want, you must browse around the directories. When you find the metadata you want, you can copy it to your local computer using your ftp utility. To use anonymous ftp:

(a) Use your computer's ftp software. If you don't know how to use the ftp utility on your computer, ask your information management team.

(b) Use the following parameters to ftp to the anonymous ftp site:

Host: corpsgeo1.usace.army.mil
Login ID: anonymous
Password: *your E-mail address*

(c) When you log on the anonymous ftp site, you are at the top of the Server anonymous ftp directory structure. Look at the directories and files in this directory. In a command line view on a Windows3.x/Win95/NT or UNIX operating system, the command to display the directory and file names is

```
ls
```

Here you will see the acronyms of USACE Command divisions, and the names *labs* and *foa* (field operating activities). Entering these directories will lead you to directories of the subordinate Commands, which in turn contain metadata directories. An example of changing directories, displaying the contents of the directory, and moving down to another directory in a command line mode is given here:

```
cd labs
ls
cd crrel
ls
```

or

```
cd labs/crrel
ls
```

(d) If you find a file that you want to load to your local computer, you can do so. To do this from a command line mode, type

```
get filename.met
```

The metadata file will be in ASCII text format, so it can be moved to your computer in text or binary mode.

(e) When you are done with the ftp session, close it and exit from the ftp software. If you stop communicating with the ftp site for some period of time during the ftp session, you may be timed out; i.e., you will not be connected to the Server anymore. If this occurs, you will have to ftp to the Server again.

D-6. Conclusion

The metadata and data on the USACE Server are developed and submitted to the Server through the hard work and determination of innumerable USACE employees. The USACE Geospatial Data Server is only in its inception. It is hoped that the Server will become a useful tool that will enable USACE, other Federal agencies, and the public to access USACE data. As the USACE Clearinghouse is further developed, there may be changes in software, the National Clearinghouse, and other parts of the process. USACE will maintain Web pages on the Server that report updates to the process of metadata and data submission and accession. These Web pages will be located at the URL

http://corpsgeo1.usace.army.mil/howto

D-7. References

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