

## **Chapter 1 Introduction**

### **1-1. Purpose**

This manual provides guidance on performing detailed site surveys of military installation facilities and civil works projects. Technical specifications, procedural guidance, and quality control criteria are outlined for developing large-scale site plans used for engineering drawings of planned projects, or detailed as-built feature mapping of completed facilities.

### **1-2. Applicability**

This manual applies to all USACE commands having responsibility for the planning, engineering and design, operation, maintenance, construction, and related real estate and regulatory functions of military construction, civil works, and environmental restoration projects. It is intended for use by hired-labor personnel, construction contractors, and Architect-Engineer (A-E) contractors. It is also applicable to surveys performed or procured by local interest groups under various cooperative or cost-sharing agreements.

### **1-3. Distribution**

This publication is approved for public release; distribution is unlimited.

### **1-4. References**

Referenced USACE publications and related bibliographic information are listed in Appendix A. Where applicable, primary source material for individual chapters may also be noted within that chapter.

### **1-5. Discussion**

Control and topographic surveys are performed to determine the planimetric location and/or elevation of surface or subsurface features, facilities, or utilities. These surveys are normally used to prepare highly detailed site plan maps (and digital databases) of a project site, facilities, or utility infrastructure; for future design, on going construction, or as-built condition. Engineering drawing scales are typically large--ranging between 1 inch = 30 ft and 1 inch = 100 ft. These surveys are performed over relatively small project sites using tripod-mounted, manually operated, terrestrial survey equipment, such as transits, tapes, levels, plane tables, electronic total stations, and GPS receivers. This manual covers the field survey techniques, instrumentation, and electronic data collection systems that are used in performing these ground-based field surveys, and transferring observed data into facility management or design databases. Also included are methods for extending geodetic control needed for supplemental topographic mapping work on a military installation or civil works project site. This manual also includes procedures for transferring field data to computer-aided drafting and design (CADD) systems or geographic information systems (GIS) used in planning, engineering, construction, and facility management. Aerial topographic mapping techniques are not addressed in this manual-- see EM 1110-1-1003 (*Photogrammetric Mapping*). FM 3-34.331 (*Topographic Surveying*) should be consulted for tactical field surveying operations supporting field artillery (FA), air-defense artillery (ADA), aviation (e.g., airfield NAVAID and obstruction surveys), intelligence, communications, or construction.

## 1-6. Use of Manual

This manual is intended to be a USACE reference guide for control surveying, site plan mapping, and infrastructure utility feature mapping. These activities may be performed by hired-labor forces, contracted forces, or combinations thereof. This manual will also be used as the primary reference manual for Proponent Sponsored Engineer Corps Training (PROSPECT) courses on topographic surveying. Accuracy specifications, procedural criteria, and quality control requirements contained in this manual may be directly referenced in the scopes of work for Architect-Engineer (A-E) survey services or other third-party survey services, including construction contracts. This is intended to assure that uniform and standardized procedures are followed by both hired-labor and contract service sources throughout USACE.



Figure 1-1. PROSPECT topographic survey training course “Surveying III”  
USACE Professional Development Support Center, Huntsville, AL (2003)

## 1-7. Scope of Manual

The overall scope of this manual is limited to ground-based survey methods--specifically, georeferenced observations taken from survey instruments set up on tripods over fixed control points or benchmarks. These methods usually provide the highest accuracy for engineering surveys, and are necessary when surface and subsurface utilities must be definitively located and identified. Therefore, less-accurate and less-detailed remote aerial mapping techniques are excluded. However, ground-based topographic surveys covered in this manual are normally required to supplement generalized aerial topography, and to provide feature details on surface and subsurface infrastructure. Control survey applications are limited to establishing supplemental (or secondary) reference points at a project site from which detailed topographic mapping or construction stake out is performed. Geodetic control survey methods used for high-order densification of the national reference network (i.e., the National Spatial Reference System--NSRS) are not covered in this manual--see EM 1110-1-1003 (*NAVSTAR GPS Surveying*) for performing precise geodetic control surveys.

*a. Technical references.* Technical or procedural guidance is in more general terms where methodologies are described in readily available references or in survey instrumentation and data collector operation manuals. This manual does not duplicate elementary surveying topics that are adequately covered in a number of academic texts, such as those recommended in paragraph A-2 at Appendix A. References to these publications will be provided to avoid unnecessary redundant coverage of elementary topics. It is strongly recommended that a user performing control or topographic surveys acquire one of these textbooks. Topics that will be referenced include instrument set-up and operation, taping and chaining, instrument calibrations, basic surveying theory and accuracy estimates, traditional survey distance, curve and area computations, traverse adjustments, etc. Reference is also made to various survey and CADD manuals published by State Departments of Transportation (DOT). An excellent example is the California Department of Transportation *Surveys Manual* (CALTRANS Surveys Manual 2001-2004), a 14 chapter publication that can be downloaded at the CALTRANS web site [www.dot.ca.gov/hq/esc/geometronics](http://www.dot.ca.gov/hq/esc/geometronics). Chapters in the CALTRANS *Surveys Manual* are periodically updated as new equipment or techniques are developed. Since design and construction surveys performed by many State DOTs are nearly identical to Corps of Engineers applications, these DOT manuals represent an excellent up-to-date resource on procedures, instrumentation, standards, and specifications.

*b. Manual coverage and appendices.* The first few chapters in this manual are intended to provide a general overview of control and topographic survey procedures, equipment, and standards. Reference systems and datums used on Corps civil projects and military installations are described in Chapter 5. Subsequent chapters cover survey planning, data collection, data processing, and generation of digital or hard copy site plans. Examples of different topographic survey methods are included--e.g., total station, LIDAR, GPS. Sample topographic survey projects are included within chapters or appendices. Examples include those surveys typically performed on Corps civil works or military construction projects, such as navigation, flood control, real estate, facility design and maintenance, lock and dam surveys, and utility surveys. The final chapter on estimating costs for topographic surveys is intended to assist those USACE commands that contract out these services. Sample scopes of works to contracted and hired-labor field personnel are provided, including data deliverable requirements, are provided in this chapter and in the appendices. The appendices also include a number of Corps project applications where topographic surveys were performed in support of civil and military design and construction.

*c. Evolving technology and procedures.* Survey equipment operation, calibration, and procedural methods for acquiring, logging, processing, and plotting topographic survey data are adequately detailed in operation manuals provided by the various instrument manufacturers and software vendors. Since instrument and data collector operations (and data processing methods) are unique to each vendor, and are being constantly updated, this manual can only provide a general overview of some of the more common techniques used by the Corps or its contractors. As new survey instruments, technology, and machine control integration procedures are developed, Districts are strongly encouraged to use those innovations and recommend modifications to any criteria or technical guidance contained in this manual--see Proponency and Waivers section at the end of this chapter. Other Corps regulations may dictate mandatory requirements for processing, displaying, transferring, and archiving survey data--e.g., metadata archiving. These regulations will be referenced where applicable.

*d. Manual development.* Technical development and compilation of this manual was coordinated in 2004-2005 by the US Army Engineer Research and Development Center--Topographic Engineering Center (CEERD-TR-A). The following USACE Districts provided project examples and/or performed technical reviews on various drafts of the manual: Jacksonville, Louisville, New Orleans, Pittsburgh, Philadelphia, Portland, Rock Island, St. Louis, Tulsa, and Walla Walla. The original version of this manual (*Topographic Surveying*) was developed in the early 1990s by the USACE Topographic Engineering Center at Fort Belvoir, and published on 31 August 1994. This latest update consolidates control

surveying topics from EM 1110-1-1004 (*Geodetic and Control Surveying*), dated 1 Jun 02. EM 1110-1-1004 is superseded by this consolidation into EM 1110-1-1005.

### **1-8. Life Cycle Project Management Applicability**

Project control established during the planning phase of a project may be used through the entire life cycle of the project, spanning decades in many cases. During initial reconnaissance surveys of a project, primary control should be permanently monumented and situated in areas that are conducive to the performance or densification of subsequent surveys for contract site plans, construction, and maintenance. During the early planning phases of a project, a comprehensive survey control plan should be developed which considers survey requirements over a project's life cycle, with a goal of eliminating duplicative or redundant surveys to the maximum extent possible.

### **1-9. Metrics and Accuracy Definitions**

Both English and metric units are used in this manual. Metric units are commonly used in survey instrumentation, such as electronic distance measurement and in GPS surveys. Metric-derived geographical or metric Cartesian coordinates are transformed to English units of measurements for use in local project reference and design systems, such as State Plane Coordinate System (SPCS) grids. In all cases, the use of metric units shall follow local engineering and construction practices. English/metric equivalencies are noted where applicable, including the critical--and often statutory--distinction between the US Survey Foot (1,200/3,937 meters (m) exactly) and International Foot (30.48/100 m exactly) conversions. One-dimensional (1D), two-dimensional (2D), and three-dimensional (3D) accuracy statistics, standards, and tolerances specified in this manual are defined at the 95% RMS confidence level. Unless otherwise stated, "positional accuracies" imply horizontal (2D) RMS measures.

### **1-10. Trade Name Exclusions**

The citation or illustration in this manual of trade names of commercially available products, including supporting surveying equipment, instrumentation, and software, does not constitute official endorsement or approval of the use of such products.

### **1-11. Abbreviations and Terms**

Abbreviations, acronyms, and engineering surveying terms used in this manual are explained in the Glossary at the end of this manual.

### **1-12. Mandatory Requirements**

ER 1110-2-1150 (*Engineering and Design for Civil Works Projects*) prescribes that mandatory requirements be identified in engineer manuals. Mandatory accuracy standards, quality control, and quality assurance criteria are normally contained in tables within each chapter, and these requirements are summarized at the end of the chapter. If no mandatory requirements are listed, then the material in a particular chapter is considered recommended guidance. Any mandatory criteria contained in this manual are based on the following considerations: (1) project safety assurance, (2) overall project function, (3) previous Corps experience and practice, (4) Corps-wide geospatial data standardization requirements, (5) adverse economic impacts if criteria are not followed, and (6) HQUSACE commitments to industry standards.

### **1-13. Governing Engineer Regulations and Related Standards**

Spatial coordinates established using topographic survey techniques fall under the definition of geospatial data contained in ER 1110-1-8156 (*Policies, Guidance, and Requirements for Geospatial Data and Systems*). Accordingly, the guidance in ER 1110-1-8156, and its implementing manual EM 1110-1-2909 (*Geospatial Data and Systems*), must be followed for disseminating and archiving survey data. This would include preparing appropriate metadata files in accordance with the guidance in EM 1110-1-2909. Detailed CADD and GIS standards are promulgated by the CADD/GIS Technology Center in Vicksburg, MS. Federal standards for reporting survey accuracy, geodetic control survey standards, and topographic survey standards are also published by the Federal Geographic Data Committee (FGDC). These FGDC "*Geospatial Positioning Accuracy Standards*" are listed in Appendix A.

### **1-14. Proponency and Waivers**

The HQUSACE proponent for this manual is the Engineering and Construction Division, Directorate of Civil Works. Comments, recommended changes, or waivers to this manual should be forwarded through MSC to HQUSACE (ATTN: CECW-CE).