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SUR-116 EXAM PREVIEW

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Exam Preview:

1. The field survey instrument may have an internal or external data collector. Total stations can export internal data directly to a processing software package, without going through an external data collector. GPS/RTK units typically record to an internal data collector.
   a. True
   b. False
2. GIS shapefile stores nontopological geometry and attribute information for the spatial features in a data set. The geometry for a feature is stored as a shape comprising a set of ____. Because shapefiles do not have the processing overhead of a topological data structure, they have advantages over other data sources such as faster drawing speed and edit ability.
   a. vector coordinates
   b. spatial coordinates
   c. shapefiles
   d. GIS shapefiles
3. Field notes will supplement digital data records. Typically all field notes will be recorded in a standard, bound, hardcover surveyor's field book as the measurements are made in the field.
   a. True
   b. False

4. Descriptive project data - Field book records must contain sufficient descriptive notes so that the survey can be easily reconstructed by different personnel or at any later point in time. Thus, it is important to describe the starting horizontal and vertical control points and their coordinate values.
    a. True
    b. False
5. Data collector - If a data collector is used, the basic setup information (station description, HI, sketch, etc.) doesn't need to be recorded in the field book as it would be doubling information entry
    a. True
    b. Fasle
6. Monument Descriptions - If a horizontal control line is used, a sketch of it shall be made and included in the notes. This sketch does not need to drawn to scale, but it should include the relative position of one point to the next and the basic control used.
    a. True
    b. False
7. Sample Submittal of Feature Data Accuracy - Some software will provide estimated accuracies of located features. These accuracies are usually based on a priori estimates, unless connected (redundant) adjustment statistics are available.
    a. True
    b. False
8. In the Federal government, professional architectural, engineering, planning, and related surveying services must be procured under the Brooks Architect-Engineer Act, Public Law 92-582 (10 US Code 541-544).
    a. True
    b. False
9. Types of contracts. Two types of A-E contracts are principally used for surveying services: Firm-Fixed-Price (FFP) contracts and Indefinite Delivery contracts (IDC). these fixed-scope FFP contracts are rarely used, and well over ___% of surveying services are procured using IDC.
    a. 95
    b. 93
    c. 59
    d. 55
10. Professional Land Surveyor. Professional surveyors shall be thoroughly familiar with all phases of surveying as it pertains to control traverses, and establishing and reestablishing of property and/or boundary lines.
    a. True
    b. False

Chapter 11
Final Site Plan or Map Production

11-1. Purpose

This chapter provides general guidance on preparing final site plan maps from topographic survey data acquired in digital format in the field. Different methods of transferring data into CADD and GIS platforms are described.

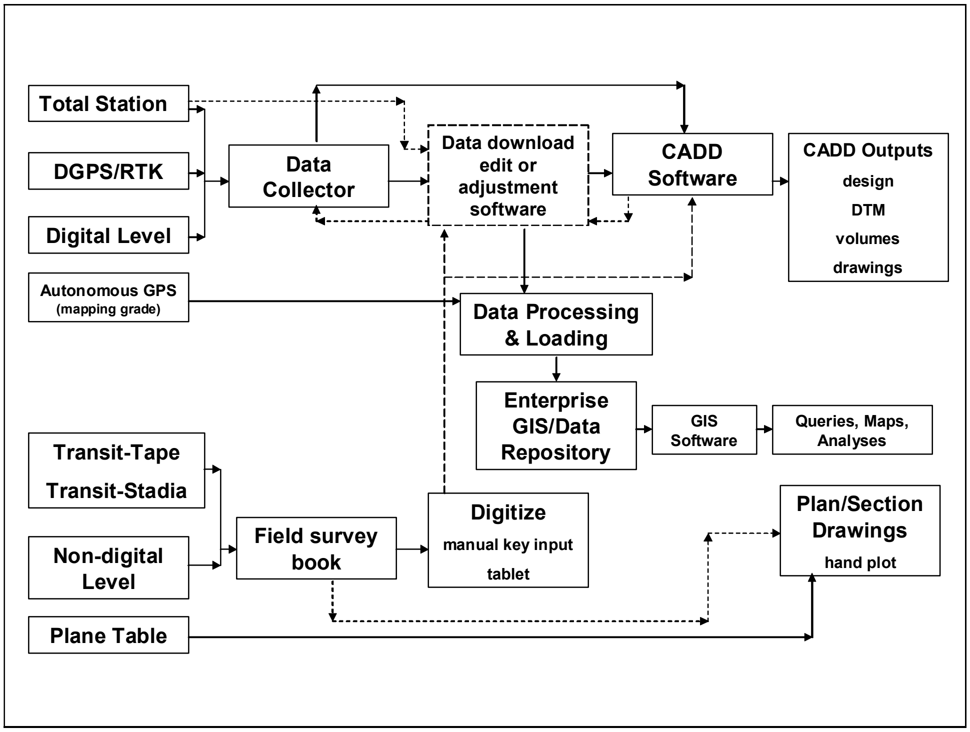


Figure 11-1. Overview of survey data flow

11-2. Overview of Topographic Survey Data Flow

Figure 11-1 above outlines the various routes by which topographic data are processed into a final site plan map format. As indicated in the figure, a number of processing options exist, depending on the software.

a. Field instrument and data collector. The field survey instrument may have an internal or external data collector. Total stations can export internal data directly to a processing software package, without going through an external data collector. GPS/RTK units typically record to an external data collector. Manual data collection is recorded in a field book which must be reduced by hand. If a digital file is desired, field book data must be manually keyed into a software program. A plane table survey obviously is field-finish system in which a final drawing containing planimetric features and contours is generated directly in the field.

b. Data download, editing, and adjustment software. Intermediate data download, edit, and adjustment software may be required for some data collectors. GPS data may require processing at this stage, using software such as Trimble TGO. Total station data is usually downloaded to an office PC using software compatible with that used on the data collector. TDS SurveyPro is an example of this type of software. Depending on the input format of data from the collector (*.raw, *.cr5, etc.), the software may have to create an X-Y-Z coordinate file from the raw data observations. Feature and attribute editing may also be performed at this stage. In addition, feature libraries can be backloaded to the data collector; including processed design files from the CADD software.

c. CADD and GIS software. Numerous software packages are used to process survey data into a final design or map product. All have various options and capabilities. Bentley and AutoDesk are the most common CADD packages used in the Corps. Each CADD vendor has a variety of optional packages which input survey data for use in a final design application. Examples include AutoDesk Land Desktop, AutoDesk Field Survey, Bentley GEOPAC, AutoDesk CAiCE, TDS ForeSight, Trimble Terramodel, Carlsen SurvCadd XML, AutoDesk Land Development, ESRI Survey Analyst, and Bentley InRoads. Some of these packages simply utilize fully processed and edited data to generate final products. Others have survey editing, adjustment, and COGO options built in, along with final drawing capabilities. Each package is generally tailored to a specific engineering discipline--e.g., CAiCE is used for highway design and construction. Many CADD packages will import field data directly from the data collector. Others are restricted to importing data only in certain formats or from specific data collector models. CADD software display capabilities include 2D and 3D models, sheet layout, contours (Figures 11-2 and 11-3), etc.

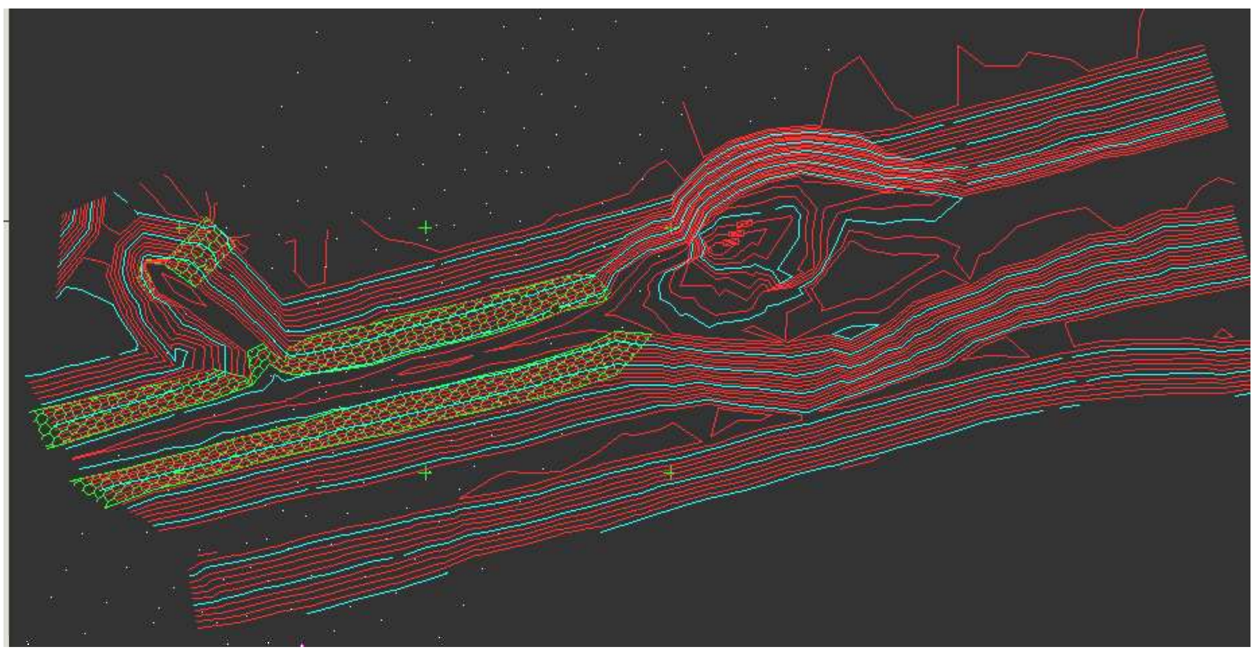


Figure 11-2. MicroStation contour generation from topographic survey of scour erosion site along Sanders Creek, Pat Mayes Lake, Texas (Tulsa District)

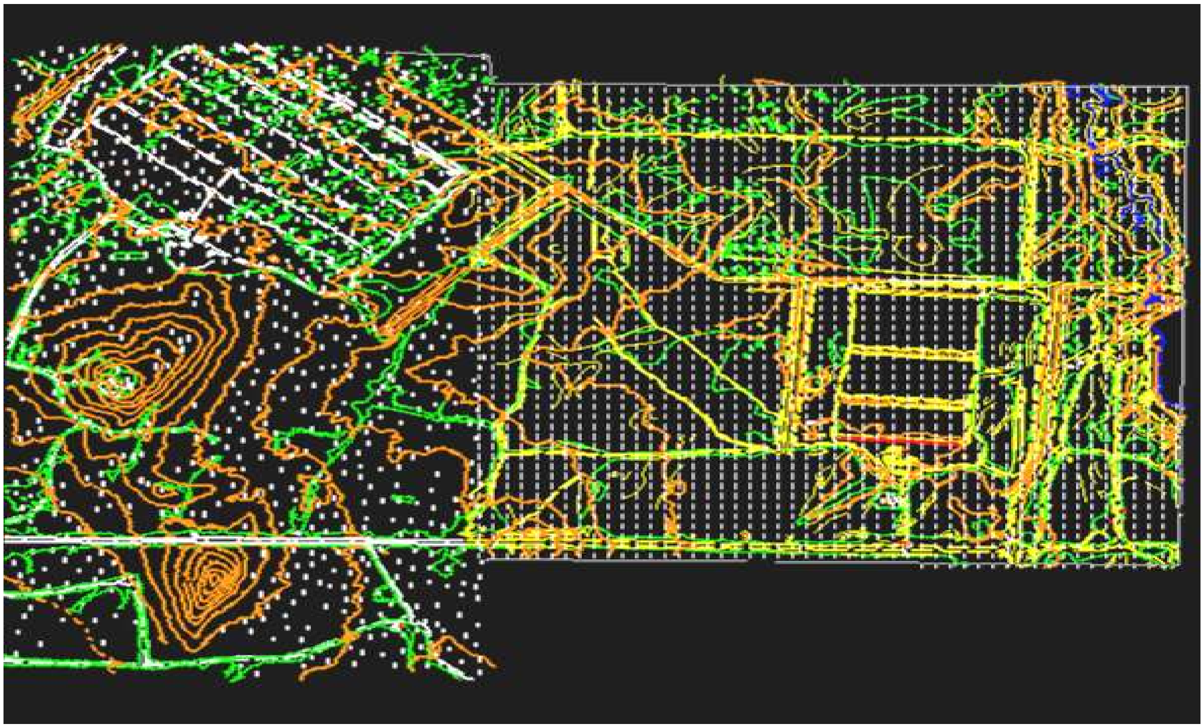


Figure 11-3. MicroStation file Showing Planimetric and Topographic Mapping of 440 acre Range at Fort McCoy (Louisville District)

11-3. Basic Definitions of Geospatial Data used in CADD or GIS Databases

The following subparagraphs detail some of the basic concepts and features required for field-collected topographic data that is exported to a CADD or GIS platform. These include descriptions of data dictionaries, types of feature codes and attributes, methods of feature code collection, and processing features with attributes.

a. Data Dictionary. A Data Dictionary contains the following information:

- Feature and Attribute Library
- Intelligent Features Codes
- Data about Feature Codes

A data dictionary is created using software designed for that purpose. Features and attributes are selected, along with attribute values and expected ranges. The edited data dictionary is uploaded to the data collector. Feature symbols can also be selected for display on the field data collector. The data dictionary software should also have an ability to import a file containing existing GIS table structures or CADD layers and symbols. An example of a Trimble TGO Data Dictionary editor was provided in Chapter 7.

b. Feature Codes. Feature Codes are descriptors identifying some unique property associated with a topographic feature.

c. Cartographic data. Cartographic data are observations (or shots) on spatially distributed features, activities, or events, which are definable as:

- Points
- Lines (Arcs)
- Areas (Polygons)

d. Attributes. Attributes are descriptive information in a database about the cartographic features located on a map. Attributes describe the characteristics of a feature--they are often referred to as non-cartographic data. Attributes can be any numeric or character value that describes the feature. Examples of attributes assigned to a tree might include:

- Height
- Diameter
- Species
- Condition
- Age

e. Attribute Values. Attribute values are sub details given to an attribute. For example, possible values for the attributes of the above Tree feature might include:

- Height = 15m
- Diameter = 0.75m
- Species = Oak
- Condition = Good
- Age = 8 years

When attribute data is collected in the field, the user may be prompted on the data collector when a particular feature is shot. Attribute values can be classified as character, numeric, date, or temporal fields. This prevents the input of an incorrect value into an attribute field; for example, preventing the entry of characters into a numeric field. Attribute range limitations (or domains) are also held in the dictionary to prevent gross blunders in entering attribute data--e.g., a 0.1 ft or 1,500 ft height tree.

f. Point Features. A point feature represents a single geographical location (such as a latitude/longitude and altitude)--see Figure 11-4 below. A point feature type is used to represent a feature that has no length or width. Examples of point features are:

- Tree
- Lamp Post
- Power Pole
- Fire Hydrant
- Manhole

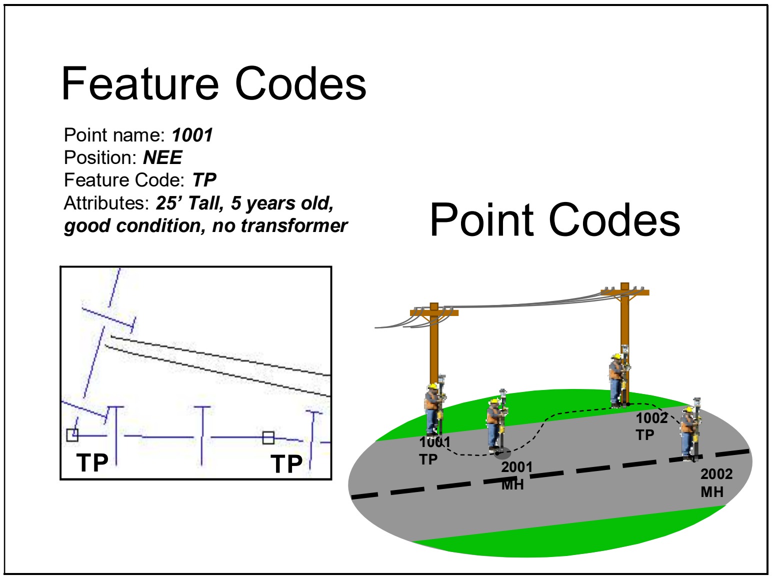


Figure 11-4. Point Codes and Feature Codes (David Evans & Associates)

g. Line Features (breaklines, arcs, strings, or polylines). A GIS line feature type is a series of geographical locations that are connected--so-called "*arc-nodes*." A line feature type is also used to represent a feature which has a length but no width. Some GIS's refer to line features as arcs. CADD software will mathematically define line strings as opposed to connected points in GIS. Breaklines are connected strings, as shown in Figure 11-5 below. Examples of line features are:

- Roads/Railways
- Streams
- Animal trails
- Routes

Line features will have various attributes similar to point features, e.g., storm sewer pipe diameter, type, thickness, date set, etc.

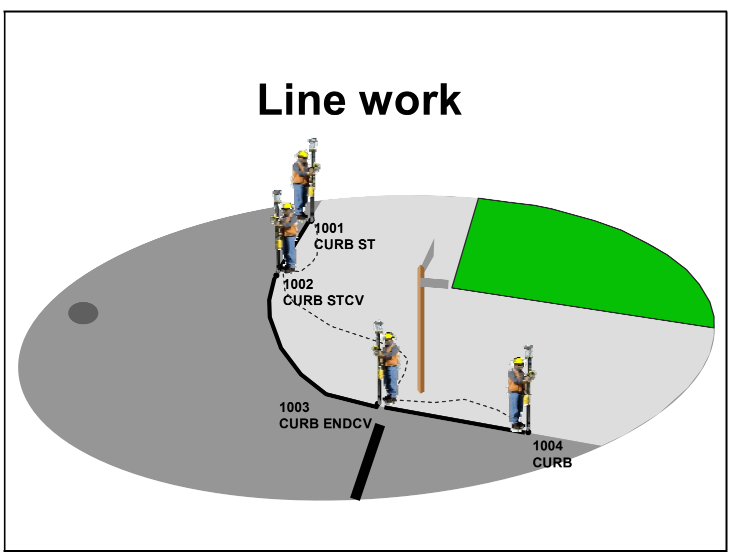


Figure 11-5. Delineating line features (David Evans & Associates)

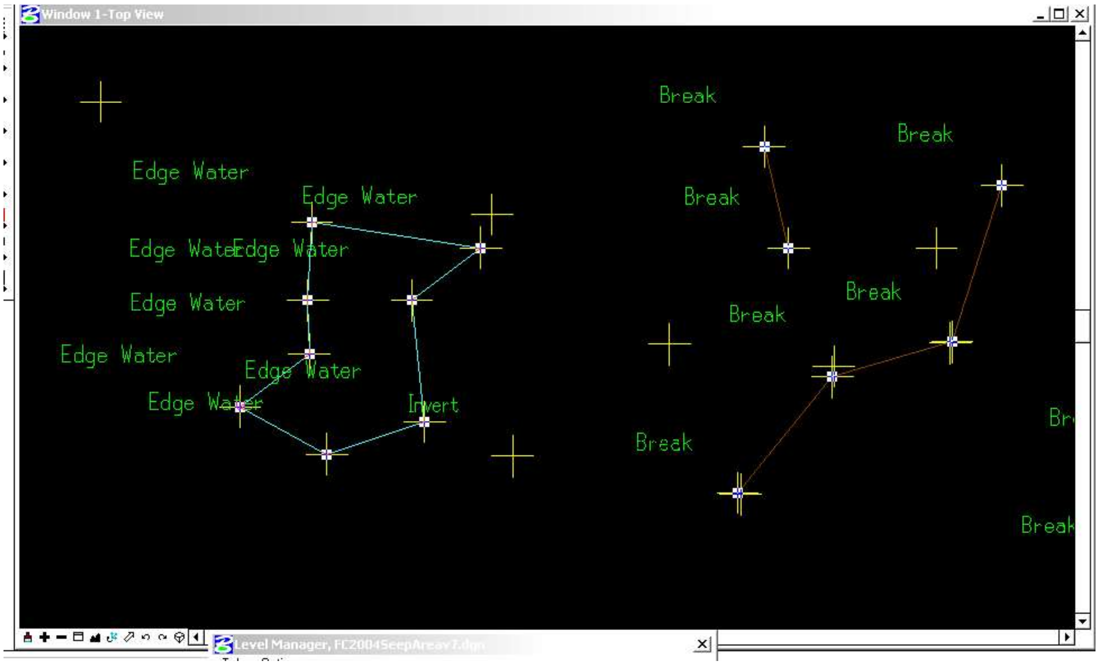


Figure 11-6. Breaklines and connected line features (Portland District 2004 Survey of Fall Creek Seepage Area)

h. Area Features. Areas (polygons) are a series of geographic coordinates joined together to form a boundary. An area feature type is a closed line. An area feature has a length and a width and can have attribute data. In GIS, area features are referred to as polygons. A polygon is a single arc or a series of arcs that are connected together in order to enclose an area. Examples of area features are:

- Soil types
- Wetlands
- Flooded land
- Lakes
- Parking Lot
- Building
- Soil types

i. ESRI Shapefiles. A GIS shapefile stores nontopological geometry and attribute information for the spatial features in a data set. The geometry for a feature is stored as a shape comprising a set of vector coordinates. Because shapefiles do not have the processing overhead of a topological data structure, they have advantages over other data sources such as faster drawing speed and edit ability. Shapefiles handle single features that overlap or that are noncontiguous. They also typically require less disk space and are easier to read and write. Shapefiles can support point, line, and area features. Area features are represented as closed loop, double-digitized polygons. Attributes are held in a dBASE® format file. Each attribute record has a one-to-one relationship with the associated shape record. Shapefiles are created using various ESRI products (e.g., ArcGIS).

11-4. SDSFIE Data Model

The SDSFIE data model described back in Chapter 2 contains the following element definitions taken from Release 2.300. (See also ERDC/ITL 2002b "*SDSFIE/FMSFIE Data Model and Structure*").

- Entity Sets - Broad grouping for data management
  - *Entity Sets* are the highest level of the SDSFIE data model structure and represent data organized at the project level.
  - *Entity Sets* are broad, generalized themes containing groupings (called Entity Classes) of features (i.e., graphic objects (called Entity Types) which can be depicted at their actual geographic locations on a map) and related "graphic" attribute data (i.e., data (information) about the feature which is stored in a database table).
  - The SDSFIE Release 2.40 structure contains the following twenty-six Entity Sets: (1) Auditory, (2) Boundary, (3) Buildings, (4) Cadastre, (5) Climate, (6) Common, (7) Communications, (8) Cultural, (9) Demographics, (10) Environmental Hazards, (11) Ecology, (12) Fauna, (13) Flora, (14) Future Projects, (15) Geodesy, (16) Geology, (17) Hydrography, (18) Improvements, (19) Landform, (20) Land Status, (21) Military Operations, (22) Olfactory, (23) Soil, (24) Transportation, (25) Utilities, (26) and Visual.

- Entity Classes - Grouping of data within each Entity Set
  - Corresponds to a map file, so it contains CADD layers or levels.
  - The SDSFIE is designed to be CADD/GIS platform independent, which means the standards are designed to work with the *most limiting* of the predominant commercially available CADD/GIS platforms which will be used.

- Entity Types - Grouping of Items that appear graphically on a map or drawing.
  - The logical name of a type or object that can be graphically depicted on a map or drawing.
  - Grouping or collection of like Items (entities) that appear graphically on a map or drawing.
  - Has a corresponding attribute table (database table containing information concerning the entity type).

- Attribute Tables - A relational database table containing non-graphic information, or attribute data.
  - A relational database table containing attribute data.
  - "Graphic" attribute table - linked to a graphic entity, and contains data describing the graphic entity, along with other data and relationships required for geospatial and relational analysis.
  - "Nongraphic" attribute table - contains data and relationships which may be queried for geospatial and relational analysis.

- Domain Tables - Contains lists of "valid" or "permissible" values for specific attributes in an Attribute Table.
  - A relational database table containing lists of permissible values for specific attributes.
  - Provides a finite set of "valid" or "allowable" values, and may be enlarged as necessary.
  - Includes units of measure, materials, methods, dispositions, classes, status, phase, etc.
  - May be either "LIST" or "RANGE"

For additional information on the SDSFIE Model see: https://tsc.wes.army.mil/products/tssds-tsfms/tssds/html/sdsdocin.asp

11-5. Data Collection and Processing Procedures for Topographic Surveys

There is no standard process for moving digital field observations into a CADD platform. The steps taken vary with the type of total station used, including its internal or external data collector. Field data collection procedures can vary from simple single shot points to fully attributed polyline strings. A variety of data formats can be output from the different data collectors on the market. The field data may be imported directly into a CADD package or processed through intermediate survey software before being uploaded into the CADD package, as was illustrated in Figure 11-1 at the beginning of this chapter. Over 50 different survey software and CADD systems are listed in the most recent compilation by POB Magazine (POB 2004c). Given this variety of CADD/survey software, there are numerous methods used to process data from the field to finished CADD or GIS product. Corps districts primarily use either MicroStation or AutoCAD, with MicroStation being more predominant. However, most data collector software is geared more towards export to AutoCAD than MicroStation. The following steps highlight a general process used in most systems. However, the trend today on some total station systems is to develop data on the data collector that imports directly into the CADD platform without all the intervening steps and varied format conversions described below.

Step 1--Observations. In the first step of the process, the field survey vertical and horizontal angles are measured along with slope distances using the total station. The angles and distances are stored with a point number and description in the data collector. Optionally, attribute data may also be stored with each point, including line/area string codes. COGO routines in the data collector may be employed to convert raw observed data to local grid X-Y-Z coordinates; optionally, these conversions may be made on a PC after the data are downloaded. If a RTK system is used, radial X-Y-Z coordinate data for each observed point is attached with a descriptor identifier code and saved in the data collector.

Step 2--Transfer data from data collector to PC. After completing the survey, the data are then transferred to a field or office computer via telephone, cable, or infrared modem for data processing and editing. The computer is either an in-office desktop system or a laptop model that can be used on site. A number of software systems contain modules for performing this data transfer process. Data transfer programs were described back in Chapter 7. One or more files may be downloaded from the data collector. Depending on the data collector software, these downloaded datasets might include:

- Raw data files in ASCII format containing all original survey, project, and attribute observations keyed or processed in the data collector.

- Native binary format of the above file

- Coordinate file containing reduced X-Y-Z-attribute data for each observed point

- Other types of field recorded data may also be downloaded, e.g., pen tablet field sketches and notes, digital photo images, etc.

Step 3--Reformatting. If a coordinate file was not directly generated in the field, then the raw data files must be processed in the computer to produce a coordinate file that contains point number, point code, X-Y-Z coordinate values, and a point descriptor. Survey software packages provide review and edit capabilities at this stage of the processing, checking point codes and descriptors before they are imported into the CADD platform. These software packages are also useful in generating standardized feature and attribute codes which can be uploaded to the data collector to ensure consistent observing methods.

Step 4--Convert data into a graphics design file for use in a CADD program such as MicroStation or AutoCAD. A number of software conversion programs are available to convert raw data collector files into a CADD file. The program CVTPC, available from ERDC, is an example of a program commonly used to convert the ASCII files into 2D or 3D MicroStation design files. Level, label, symbol, and line definitions are assigned to each point based upon a point code. CVTPC can be obtained by linking to ERDC from the USACE home page at http://www.usace.army.mil.

Step 5--CADD specific applications. Once data are contained in the CADD platform, the basic topographic data can be plotted for review and edit. Digital terrain models (DTM) can be generated that can be used to generate contours, quantity take-offs, etc. Final editing and addition of notes are completed, yielding topographic data in a digital format or as a plotted map. Sheet layouts are assigned and the topographic data are ready to be used for their intended engineering, design, planning, or construction function.

As stated previously, many of the above steps can be skipped if field data are collected using procedures, software, and coding that is directly compatible with the final CADD platform. Thus, uniform operating procedures are needed when collecting and processing survey data. The use of proper field procedures is also essential to prevent errors or omissions in generating the final site plan or map products. Collection of survey points in a systematic and meaningful pattern aids in this process. If consistent field procedures are employed, then a minimal amount of post-processing or editing on the CADD platform will be required.

a. Various software/ hardware packages are available to collect and process survey data. Some data collectors are actually PC-based processors that can log total station data and run various survey adjustment software packages. Field PC-based software can perform post-processing and adjustments, and import the data directly into a CADD workstation.

b. When procuring components of a data collection and processing system, compatibility between components and a minimum capability must be assured. Survey coordinates with a descriptor or code to indicate the surveyed feature should be input, as a minimum, to the CADD system. ASCII X-Y-Z or latitude-longitude-height data, along with alphanumeric descriptor data, are usually accepted by CADD software and are commonly output by data collectors or survey processing programs. The CADD program should have some flexibility in the order the coordinates are received (X-Y-Z, Z-X-Y, etc.) and the length of the data records.

c. More complex and sophisticated information, such as contour lines and symbols, can sometimes be passed from survey to CADD programs through common graphic formats, such as DXF. However, note that a 100% reliable transfer of graphic data is not always possible. For example, contour lines passed to a CADD program in DXF format may have isolated breaks or overlap. Transfer of graphic data using proprietary formats is usually most reliable.

d. Transferring data to a field or office PC is a fairly straightforward process and is usually detailed in the operating manuals associated with the data collector software or CADD/GIS software. Field data are often transferred directly into a CADD or GIS software program using import features on that program. Optionally, an ASCII file may be created on the PC that is generic to any CADD/GIS program. These CADD programs can usually import data from a variety of survey systems and data collectors, including generic datafiles.

11-6. Field Computers and Software for Viewing and Processing Data

Many districts perform much of the survey reduction, processing, editing, and adjustment in the field, and are transferring files directly into a CADD package. The greatest advantage of this procedure is uncovering a mistake which can be easily corrected if the crew and equipment are on the site. Laptop and notebook computers are normally used to download GPS and total station data. Once the files are stored in the computer, data processing and plotting in a CADD package can be performed. Data can be viewed and edited in the field before it is sent on to a CADD platform--see Figure 11-7 below.

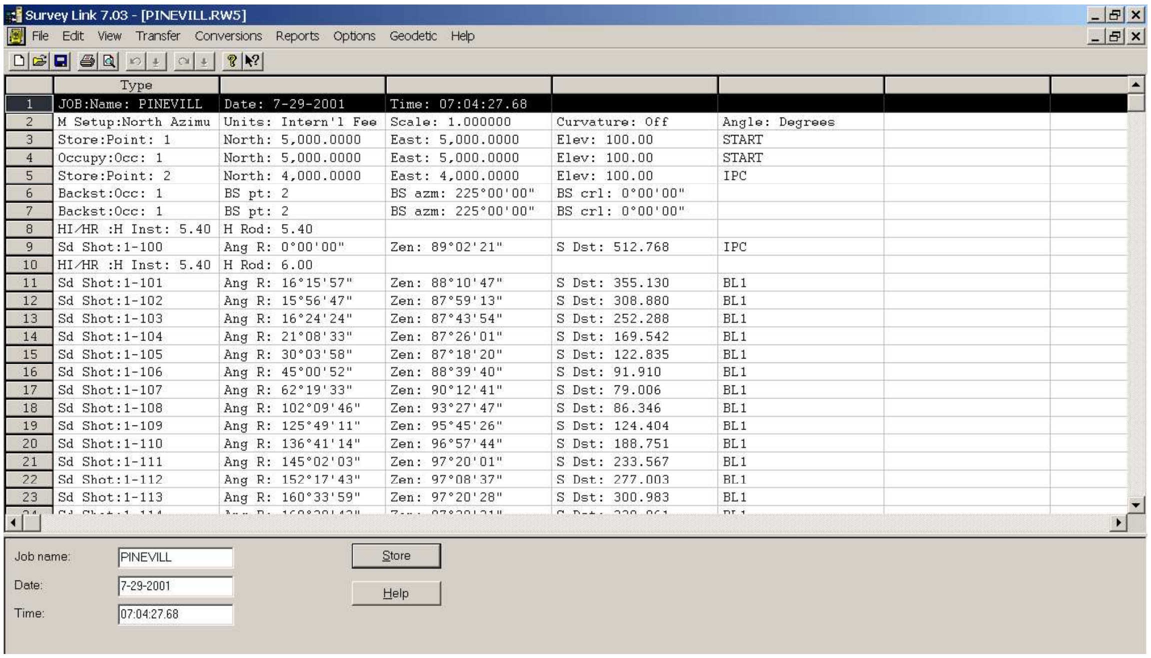


Figure 11-7. Editing total station raw data file in TDS Survey Link 7.03

Listed below are some software considerations to install on field computer systems. Some of these features may also be available on the data collector.

- Interface with field data collector.
- A system of predefined codes for most common objects and operations in a database.
- User-defined codes for site-specific requirements in a database.
- Survey adjustment programs such as:

  Compass rule adjustment
  Transit rule adjustment
  Crandall method
  Least squares
  Angle adjustment
  Distance adjustment

- Include a program which can assign an alphanumeric descriptor field for each survey point.
- Include a full-screen editor to examine and edit ASCII data files.
- Have an interface program to convert files to common graphic interchange formats such as IGES or DXF.
- A program to connect features which were not recorded in order such as fence, curb and gutter, edge of pavement, waterline etc.
- Provide an operating system which will be compatible with post-processing machines with CADD programs such as MicroStation or AutoCAD.
- Custom programs which can use all the features available to the total station or the data collector.
- Select software which provides training if possible.

11-7. Field Quality Control and Quality Assurance Checks

a. Backups. Upon the completion of the file transfer, make a backup copy of the raw data. Once this transfer is complete, and only after this transfer is complete, then the data in the data collector can be deleted.

b. Hard copy prints. Print a copy of the formatted data and check it against the field notes. Check the field input of data against the field notes. Specifically, check the instrument locations, azimuths to backsights, and the elevation of benchmarks. Also scan the data for any information that seems to be out of order. Check rod heights.

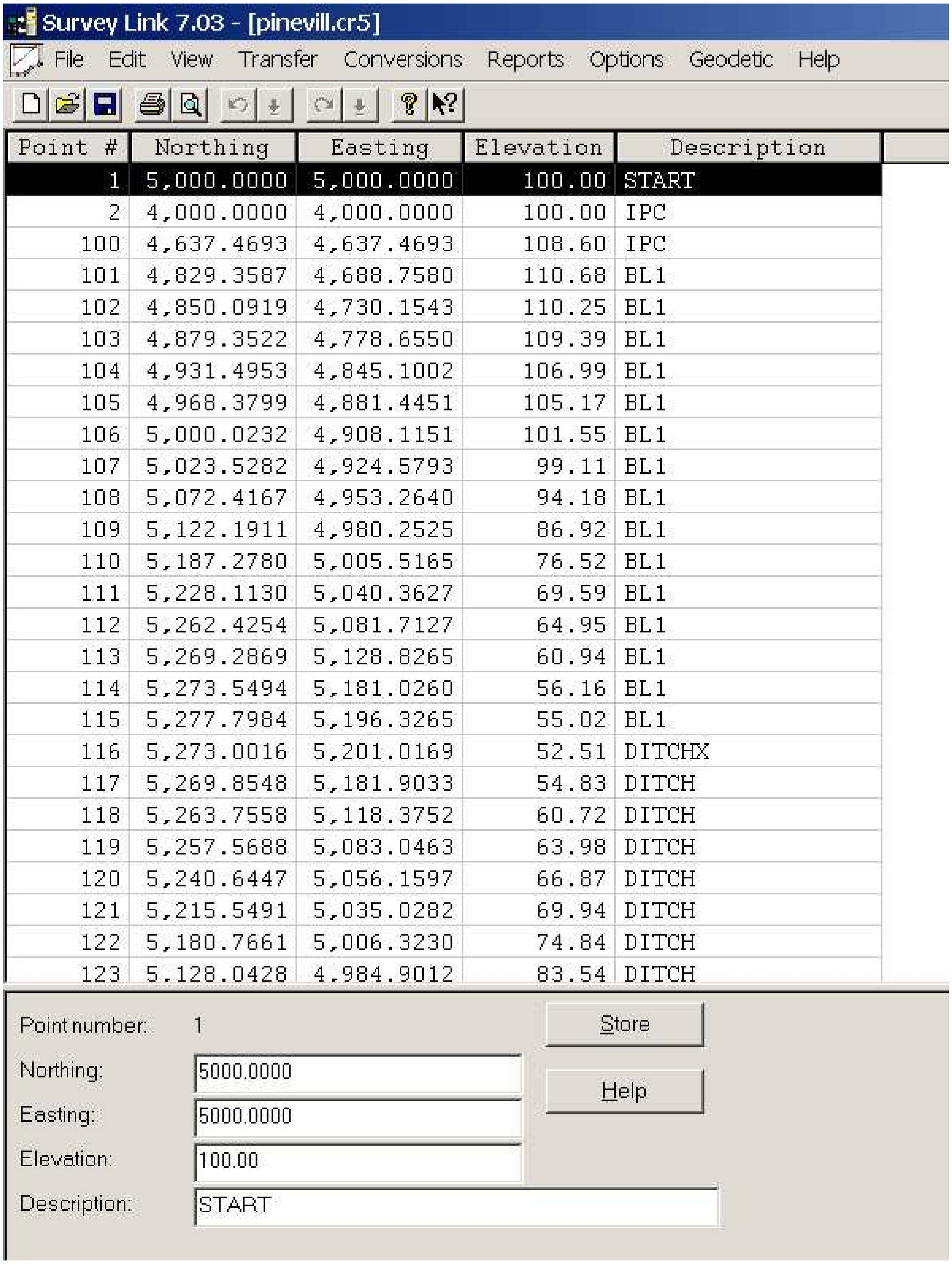
c. Edit the data. Eliminate any information that was flagged in the field as being in error. In the system, make a record of any edits, insertions, deletions, who made them, and when they were made.

d. Process the control data. Produce a short report of the data that were collected in the field. Check the benchmark elevation to be certain that the given elevation is the calculated elevation and that the coordinates of the backsights and foresights are correct.

e. Data quality. To assure that complete data are being supplied by the field, make certain that the field crew fully understands the automated processes that are being used and that they take care to gather data appropriately. It is much easier and more productive for the field crew to get a few extra shots where they know there will be difficulty in generating a good contour map than it will be for those in the office to determine where certain shots should have been made and add them to the database. The field crew must also make sure they pick up all breaklines necessary to produce the final map.

f. Terrain contouring. The field crew will need to become educated about the contouring package used by the District Office. As the data are brought in from the first few projects, and periodically thereafter, the crew should observe the product produced by the contouring program. This will help them to understand where and what amount of data may be needed to get the best results. The District Office staff needs to be aware that in some circumstances the field crew may have difficulty in getting some information (terrain restrictions, traffic, etc.).

g. Field edit. The person responsible for the field work should be involved in the initial phase of editing because he or she will most likely remember what took place. Preferably, the editing should be done the same day the data are gathered, while the field person's memory is still fresh. If it is not possible for someone to walk the site to ensure that the final map matches the actual conditions, then the field person should be the one to review the map. Figure 11-8 shows one example by which processed data can be checked for quality.



Point #	Northing	Easting	Elevation	Description
1	5,000.0000	5,000.0000	100.00	START
2	4,000.0000	4,000.0000	100.00	IPC
100	4,637.4693	4,637.4693	108.60	IPC
101	4,829.3587	4,688.7580	110.68	BL1
102	4,850.0919	4,730.1543	110.25	BL1
103	4,879.3522	4,778.6550	109.39	BL1
104	4,931.4953	4,845.1002	106.99	BL1
105	4,968.3799	4,881.4451	105.17	BL1
106	5,000.0232	4,908.1151	101.55	BL1
107	5,023.5282	4,924.5793	99.11	BL1
108	5,072.4167	4,953.2640	94.18	BL1
109	5,122.1911	4,980.2525	86.92	BL1
110	5,187.2780	5,005.5165	76.52	BL1
111	5,228.1130	5,040.3627	69.59	BL1
112	5,262.4254	5,081.7127	64.95	BL1
113	5,269.2869	5,128.8265	60.94	BL1
114	5,273.5494	5,181.0260	56.16	BL1
115	5,277.7984	5,196.3265	55.02	BL1
116	5,273.0016	5,201.0169	52.51	DITCHX
117	5,269.8548	5,181.9033	54.83	DITCH
118	5,263.7558	5,118.3752	60.72	DITCH
119	5,257.5688	5,083.0463	63.98	DITCH
120	5,240.6447	5,056.1597	66.87	DITCH
121	5,215.5491	5,035.0282	69.94	DITCH
122	5,180.7661	5,006.3230	74.84	DITCH
123	5,128.0428	4,984.9012	83.54	DITCH

Figure 11-8. Reviewing final X-Y-Z coordinate files (Survey Link 7.03)

Figure 11-9 below depicts feature and attribute assignments on one of the objects ("FH" -- fire hydrant) that were imported into a Trimble Geomatics Office (TGO) software display.

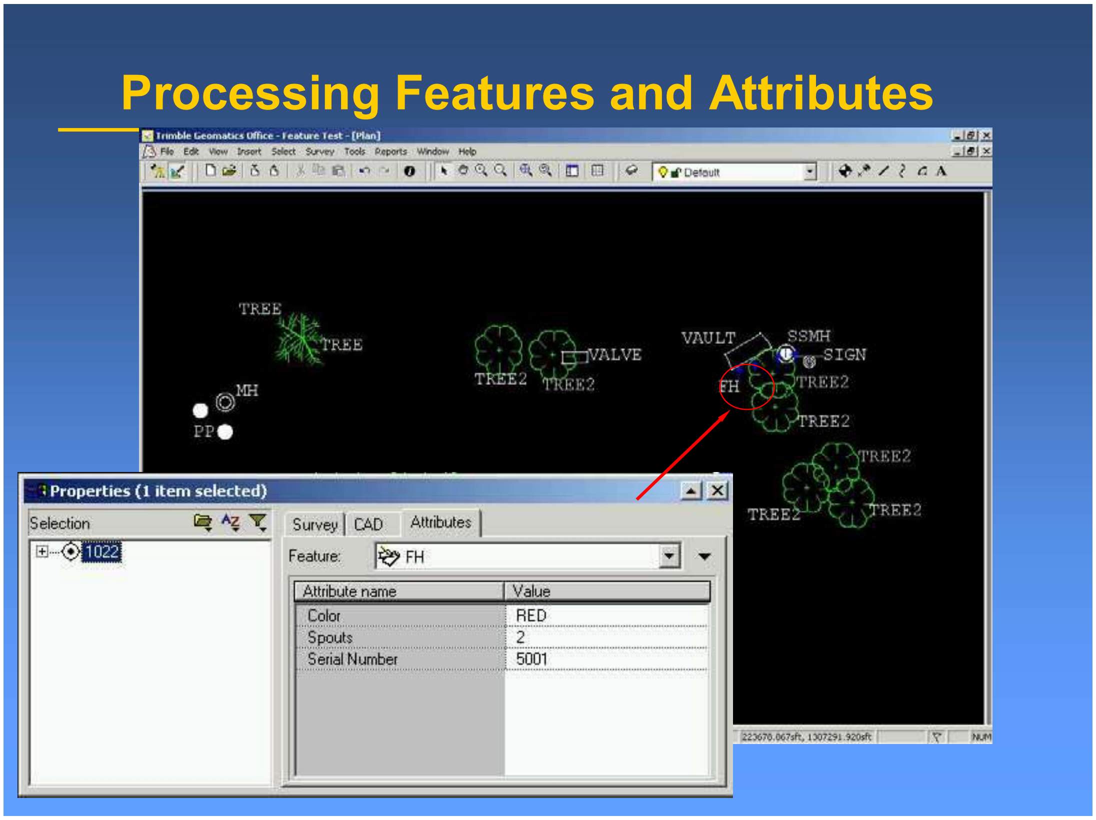


Figure 11-9. Feature and attribute coding--Trimble Geomatics Office (David Evans & Associates)

11-8. Cell Libraries Containing Corps of Engineers Standardized Symbology

A "cell" in MicroStation and a "block" in AutoCAD are groups of graphical elements that can be manipulated as a single entity. Examples of cells/blocks are hydrants, poles, benchmarks, etc. The use of such symbology enhances CADD productivity and provides an excellent opportunity for CADD standardization. MicroStation cells are contained in cell libraries (.cel) and custom line styles contained in resource files (.rsc). AutoCAD blocks are in an individual drawing (.dwg) file, patterns in a pattern library file (.pat), multilines in a multiline library file (.mln), and custom line styles in a line type library file (.lin).

a. Graphical presentations of the entire symbology library are shown in Appendix D of the A/E/C CADD Standard. The symbology library contains four types of elements: Lines, Patterns, Symbols, and Objects. Lines are defined as a graphical representation of linear drawing features (e.g., utility lines, fence lines, contours). Patterns are defined as repeated drawing elements (e.g., lines, dots, circles) within a defined area. Symbols are defined as MicroStation cells or AutoCAD blocks that are representative of objects (e.g., electrical outlets, smoke detectors). Objects are defined as MicroStation cells or AutoCAD blocks that retain their actual size no matter the scale of the drawing.

b. Figure 11-10 below depicts a portion of the surveying and mapping symbols published in the CADD/GIS Technology Center "*A/E/C CADD Standard*"--ERDC/ITL TR-01-6 (Appendix D--Symbology).

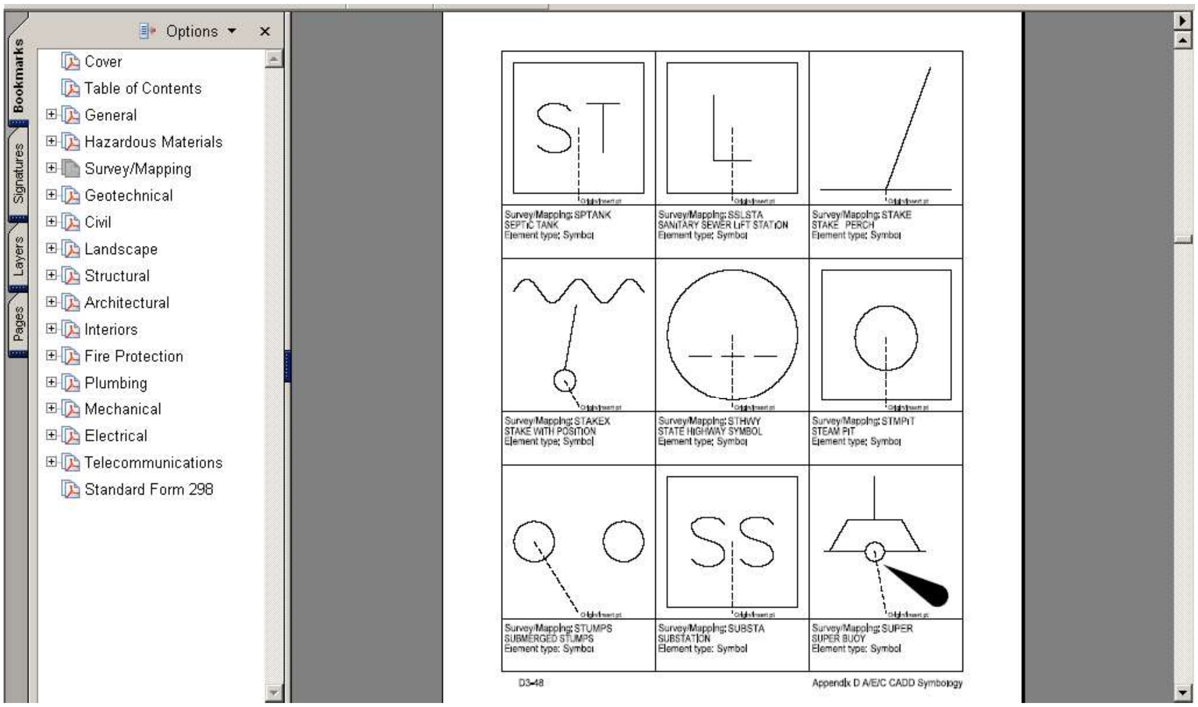


Figure 11-10. Portion of A/E/C CADD Standard surveying and mapping symbology listing

11-9. Sheet and Model Files

A model file contains the physical components of a building (e.g., columns, walls, windows, ductwork, piping, etc.). Model files are drawn at full scale and typically represent plans, elevations, sections, etc. A sheet file is synonymous with a plotted CADD drawing file. A sheet file is a selected view or portion of the model file(s) within a border sheet. A sheet file is a view or portion of an assembly of referenced model files plus additional sheet-specific information (e.g., north arrows, scales, section cuts, title block information). A sheet file is the final project sheet, which is a “ready-to-plot” CADD file within a border sheet and is usually plotted at a particular scale, since the border sheet is scaled up to fit around the full-scale model files.

11-10. Reference Files

Reference files (external references or XREFs) enable designers to share drawing information electronically, eliminating the need to exchange hard copy drawings between the design disciplines. With the use of reference files, the structural engineer need not wait for the architect to complete the architectural floor plans before beginning the structural framing plan model file. Nor does the engineer have to redraw the architect’s structural walls on the structural framing plan model file. Referencing electronic drawing information makes any future changes made by the architect apparent to the structural designer. This real-time access to the work of others ensures accuracy and consistency within a set of drawings and helps promote concurrent design efforts. No longer does one discipline have to wait until another discipline is nearly finished before they begin their drawings. The use of reference files is a key component in the successful use of the level/layer assignments. To create either a model file or a final sheet file, multiple referenced model files may be required.

11-11. Level Assignments for Surveying and Mapping

The following table depicts the “standard” 63 level assignments used for surveying & mapping features in many Districts of the Corps of Engineers.

Level	Description	Color	Weight	Line Code
1	Sheet Dependant Information			
2	Coordinate Grid/ Neat Box / N. Arrow	2	0	0
3	Coordinate Grid / Annotation	2	0	0
4	Buildings	4	2	0
5	Building Annotation	4	0	0
6	Centerline	3	0	4
7	Road, Railroad and Centerline Annotation	4	0	0
8	Roads, Parking Lots, Walks, Railroads, and Trails	4	1	
9	Concrete Joint Layout	4	0	0
10	Concrete Joint Elevations	4	0	0
11	Runway, Taxiway, and Aprons	5	1	0
12	Runway Annotation	5	0	0
13	Pavement Markings and Signs	5	0	0
14	Structures and Headwalls	6	1	0
15	Structure Annotation	6	0	0
16	Culverts	6	1	0
17	Culvert Annotation	4	0	0
18	Riprap	2	1	0
19	Water Features	1	0	0
20	Water Feature Annotation	1	5	0
21	Vegetation	2	0	0
22	Vegetation Annotation	2	0	0
23	Fences, Guard Rails	1	0	0
24	Fence Annotation	1	0	0
25	Boundary Lines / Cadastral-R/W	6	2	0
26	Boundary Lines / Cadastral / Annotation	6	0	0
27	Survey Control Points, Baselines	5	1	0
28	Survey Control Points / Azimuths	5	0	0
29	Breaklines	4	0	0
30	Spot Elevation	4	0	0
31	Major Contours	6	2	0
32	Contour Annotation	6	0	0
33	Minor Contours	3	0	0
34	Bores, Holes, and Text	6	0	0
35	Storm Sewerlines and Manholes	2	0	0
36	Storm Sewer Annotation	2	0	0
37	Sanitary Sewerlines, and Manholes	4	0	0
38	Sanitary Annotation	4	0	0
39	Water Lines, Fire Hydrants, and Water Tanks	1	0	0
40	Waterline Annotation	1	0	0
41	Gaslines, Features, and Valves	3	0	0
42	Gasline Annotation	3	0	0
43	Powerlines, Lights, and Telephone Poles	5	0	2
44	Powerline Annotation	5	0	0
45	Steamlines, Features, and Valves	6	0	0
46	Steamline Annotation	6	0	0
47	Cross Sections and Profiles	4	0	0
48	Details, Inserts		0	0
49	Soundings	1	0	0
50	Channel Lines, Disposal Areas	3	5	3
51	Channel Line Annotation		5	0
52	Navigation Aides and Annotation	6	1	0
53	Levees, Dikes, and Annotation	4	1	0
54	Pipe Lines, Structures, and Bridges	6	1	0
55	Pipe Line Annotation	6	0	0
56	Stationing and Ranges	5	1	0
57	Revetments and Annotation	2	0	0
58	Match Lines	3	1	0
59	Match Line Annotation	3	5	0
60	Unassigned			
61	Unassigned	3	2	0
62	Unassigned			
63	Unassigned			

Chapter 12
Survey Documentation and Submittals

12-1. General

This chapter provides guidance on survey documentation, such as field notes, deliverables, metadata, and final submittal reports generated for a topographic survey project, such as a site survey, control survey, hydrographic survey, or construction measurement and payment survey. Generally, a project report is prepared for every major surveying project; in particular, those projects involving new work. Less formal letter reports will usually suffice for routine or repetitive construction surveys. Contract survey specifications will indicate when a formal report is required. This narrative report should describe all salient events and procedures involved in the project. The report will outline all submittals or deliverables attached with the report, to include: raw data files (GPS, data collector), coordinate files, design files (*.dgn), ESRI shape files, sheet index files, hard-copy drawings, quantity take-off computations, etc. In addition, any QC and/or QA procedures should be described. If real property surveys are involved requiring filing in local jurisdictions, then appropriate licensing certifications must be made on the submitted drawings. FEMA or FAA certifications will require survey reports to be submitted in that agency's format.

12-2. Final Survey Report Format--Civil Works

A standardized report format should be used for all major survey projects--especially those for planned design and construction. A project report submitted in a consistent format provides essential background information to the design engineer. The following outline may be used for guidance in preparing a survey report on a topographic survey.

Outline for Survey Report Submittals

Section 1: General Project Description
Overview of the project including location, purpose, and parties involved.

Section 2: Background
Reason for project (more detailed description) and more specific location description including a map. Accuracy and deliverables should be discussed in this section. Attach or include a copy of the original Scope of Work prepared by the originator. Add funding information if applicable.

Section 3: Project Planning
How the project was planned including but not limited to: reconnaissance results; control establishment; datums; DGPS method(s) selected; topographic survey techniques; feature and attribute standards selected.

Section 4: Data Collection
Overview of how data was collected including but not limited to: Equipment used (make and model); data collection method(s) and/or techniques used; control points used; amount of data collected; number of crews and personnel per crew; how long the data collection took; data processing/error checking performed in field.

Section 5: Primary Control Data Processing
How the control data processing was performed including but not limited to process followed.

Subsection 5-1: Total station Traversing--adjustment software, results, closures, final adjustment results and coordinate listings.

Subsection 5.2: GPS Control Surveys & Baseline Processing--Software used; baseline processing results (summary); reprocessed baselines and reason for; parameters for baseline processing (elevation mask, type of ephemeris used); summary results or loop closures (if applicable).

Subsection 5.3: Combined GPS, Total Station, Differential Leveling Network Adjustments---Software used; results of unconstrained adjustment, minimal constrained adjustment, and fully constrained adjustment; summary of weights used, general statistics.

Section 6: Project Summary and Conclusion
This section shall include overall results of the processing, products produced, listing of deliverables being submitted, list of metadata files submitted, overall accuracy of the data collection (based on results from data processing section), problems encountered during data collection and data processing, recommendations for future data collection efforts of this type or in this area (lessons learned).

Section 7: Output and Reports from Software
This section shall include the detailed reports and output from software packages used during the data processing. This section might have multiple subsections--e.g., one for each step in the processing that has output that is critical in evaluating results.

12-3. Final Survey Report Format--Military

FM 3-34.331 recommends the following format be utilized for final project reports involving military facilities. The guidance and report outline is excerpted from FM 3-34.331.

An end-of-project report is used to inform the commander and the customer that the project has been completed. The results of the project will generally be listed on DA Form 1962. Copies of DA Form 1959, map overlays, and other graphics may be included. The report should be broken down into readily identifiable numbered and titled paragraphs, as follows:

- Paragraph 1. References. A complete listing of all orders, letters, project directives, and memorandums for record (MFRs) concerning the project. Normally, the other reports will not be listed as references.

- Paragraph 2. Personnel. The name and rank of all personnel participating in the project. The inclusive dates of their involvement should also be listed. This paragraph can be further broken down as follows:

  - Field-crew personnel from the parent unit.
  - Visiting or inspecting personnel (the unit or office should also be included).
  - Local officials directly involved in the project.

- Paragraph 3. Objective. The specific mission statement.

- Paragraph 4. Discussion. A detailed discussion of exactly what transpired during the conduct of the project. Specific dates and details should be included. The milestone objectives outlined in the recon report should be discussed. Indicate whether the project was kept on schedule, or fully explain the reasons for falling behind schedule.

- Paragraph 5. Problem Areas. Specific problem areas and the solutions to the problems. This information becomes a historical record to be used for future planning purposes. Technical information will be included in the narrative and graphic sections of the recon report.

- Paragraph 6. Funding. All fund citations and a total of all funds expended. The ISVT and recon reports are the sources for this information. Copies of all travel vouchers and other expenses should be included.

- Paragraph 7. Work Hours. The total number of expended work hours (broken down by rank). A composite of all progress reports should be included.

- Paragraph 8. Conclusions and Recommendations. Cite specific conclusions and recommendations.

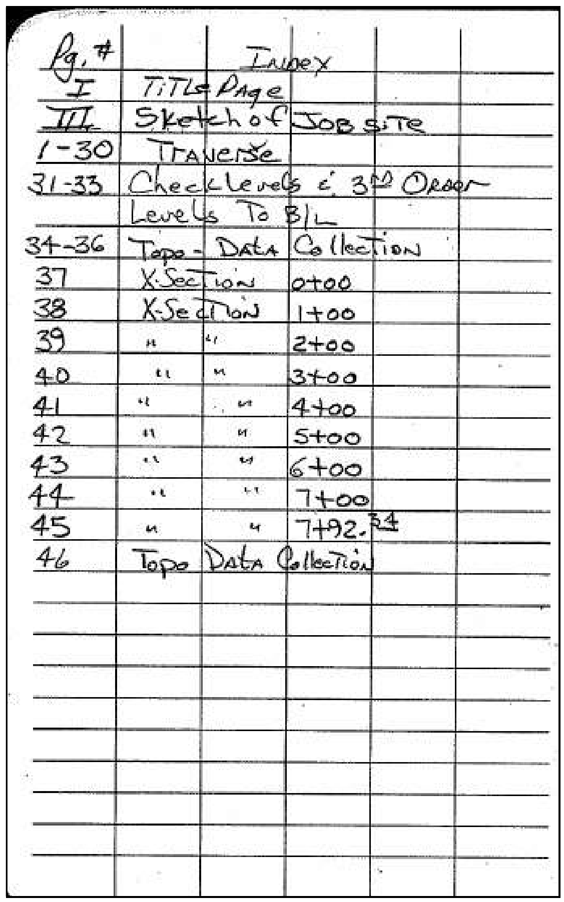
Examples of final survey reports submitted by an AE contractor and Corps in-house staff are included in the application projects in some of the appendices to this manual. Although these reports do not conform to the above formats, they do include the same general information.

12-4. Field Note Keeping Procedures and Formats

Field notes will supplement digital data records. Typically all field notes will be recorded in a standard, bound, hardcover surveyor's field book as the measurements are made in the field.

a. Entries. All field note entries shall be made with a black lead pencil or ink. Notations made by other than the original surveyor shall be made with a colored pencil so a clear distinction exists between the field observations and subsequent corrections, adjustments, comments or supplemental data.

b. Index. The first two (or more) pages of each field book shall be reserved for the index and shall be annotated with Roman numerals. An index entry shall be made for each day. The index should contain the date and description of the survey, Project or Contract number, the type of survey, and the page numbers containing the survey data. The remainder of the field book shall contain the actual field data and shall be numbered beginning at page one. A sample field book index is shown in Figure 12-1 below.



Pg. #	Index	
I	Title Page	
III	Sketch of Job Site	
1-30	Traverse	
31-33	Check Levels & 3rd Order Levels To B/L	
34-36	Topo - Data Collection	
37	X-Section	0+00
38	X-Section	1+00
39	" "	2+00
40	" "	3+00
41	" "	4+00
42	" "	5+00
43	" "	6+00
44	" "	7+00
45	" "	7+92.34
46	Topo Data Collection	

Figure 12-1. Sample index page in a field survey book (Vicksburg District)

c. Title page. A separate Title Page shall be prepared for each day's work, or partial days work if applicable. The Title Page shall be referenced in the field book Index. The Title Page shall contain all pertinent information about the survey--project, contract number, personnel, weather, instruments used, etc. An example of a comprehensively detailed title page is shown in Figure 12-2 below.


(1)

PARTY: C&C TECHNOLOGIES, INC JOB# 7322 9-23-04

KEN CORMIER P.C, NOTES, ⊼ P.C. & WARM

PAIGE MCLENDON – PROJECT MANAGER

ERIC QUIRK – CAD / INST / ROD

SAM ALLEMAN – MULTIBEAM OPERATOR

BILL BERGEN – USACE CONSULTANT

DAVID ROBAR – USACE ASST CHIEF OF SURVEY

KEY WEST, FLORIDA

US ARMY CORPS OF ENGINEERS

JACKSONVILLE DISTRICT

DREDGING 34-FOOT PROJECT

MAIN SHIP CHANNEL, CUT-A, CUT-B, CUT-C

& TRUMAN HARBOR

CONST. CONTRACT NO DACW17-03-C-0001

DREDGE CONTRACTOR - BEAN-STY.

SUB-CONTRACT TO JOHNSON-MCADAMS

CONTRACT NO DACW17-01-D-0003

TASK ORDER 20 SURVEY NO 04-030

⊼: SOKKIA B20 AUTOMATIC LEVEL, LEICA 500 GPS RTK SYSTEM w/ CARLSON DATA COLLECTOR

HORIZ DATUM: NAD '83 ZONE: FLORIDA EAST

VERTICAL DATUM: MLLW UNITS: FEET US

– EPOCH 1960 – 1978 (LEVELS)

RTK = NAVD '88

238

Figure 12-2. Sample Title Page in a field survey book (Jacksonville District)

d. Page setup. The first page of each entry should contain (at the top left side of the page) the name of the installation or project location, a specific project title, and the type of work being done. At the top of the right side of the right half of the page, record the actual date of the survey, weather conditions, type and serial number of instruments used, members of the crew and their assignment, map or field book references, and other remarks as necessary for a complete understanding of the survey. Pages are numbered on the right hand page only.

e. Corrections. No erasures should be made in the field book. If errors are made, they will be crossed through and the corrections will be entered ensuring that the original data remains legible. No figure should be written over the top of another-- nor should any figure be erased. If a whole page is in error, the complete page will be lined or crossed through and the word "VOID" will be written in large letters diagonally across the page. An explanation of the error, and a cross-reference will be entered on the voided page showing the book and page number where the correct information may be found. At the end of each day of work, the field notes shall be signed and dated by the individual responsible for the work.

f. Data collector. If a data collector is used, the basic setup information (station description, HI, sketch, etc.) needs to be recorded in the field book. This information is used to document the sequence of the survey. Sketches are added in the field book as needed to supplement the data collector and aid the CADD technician with the planimetric features. On some critical projects (e.g., boundary location, construction payment surveys, etc.) it may be prudent to duplicate digitally recorded data in the field book as it is observed. The requirement for such duplicative recording will depend on the nature of the project, including factors such as potential contract disputes and claims, boundary encroachments, etc.

g. References. When it is necessary to copy information from another field book or other source, a note will be made which clearly states that the information was copied and the source from which it came. If the notes are a continuation from another field book, a description will be written in the field book to the effect "NOTES CONTINUED FROM BK XXXX PAGE XX." A similar description (e.g., CONTINUED IN BOOK XXXX FROM PAGE XX) will be written on the last page of each section of notes if those notes are to be continued either in another book or on another page that is not adjacent to the current page.

h. Sketches. Sketches are absolutely essential on many site plan surveys, especially if complex utility details are involved. The sketch should show all the details, dimensions, and explanatory notes required. The sketch should be written on a whole page whenever possible. If necessary, multiple pages with the sketch divided equally among the pages should be used if the sketch has too many details to be shown on one page.

i. Digital photos. Sketches and other data may be supplemented by digital photos taken in the field. Photos are often useful of permanent control monuments occupied, utility access covers/boxes, utility identification signs, sample vegetation and tree cover, culverts, bridges, towers, etc. References to digital photos should be made in the field book or data collector.

j. Descriptive project data. Field book records must contain sufficient descriptive notes so that the survey can be easily reconstructed by different personnel or at any later point in time. Thus, it is important to describe the starting horizontal and vertical control points and their coordinate values. Problems or control discrepancies should be clearly noted in the field book. Sketches of traverse or level routes should be drawn in the field book. Instruments used should be identified. All the forgoing applies whether or not a data collector system is used. Figure 12-3 below depicts a portion of a field book that describes the initial base station set up parameters for a RTK survey. Such basic information is critical in the event the subsequent RTK survey data is questioned.

k. Project archives. In general, a separate field book should be initiated for each design or construction project. Field books should be copied or scanned as soon as possible after the field work is completed. The original book should be submitted with the deliverables for permanent retention by the District office.

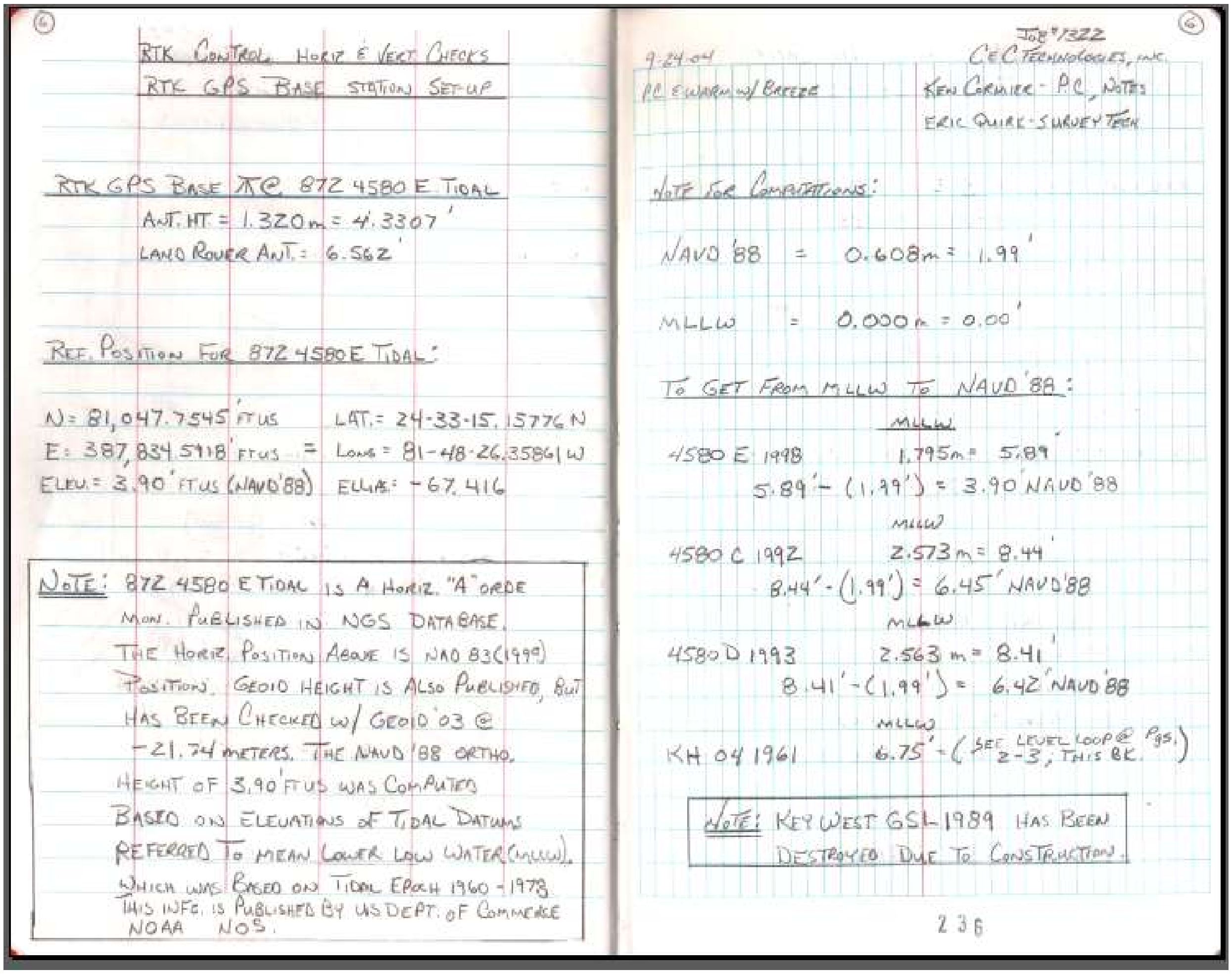
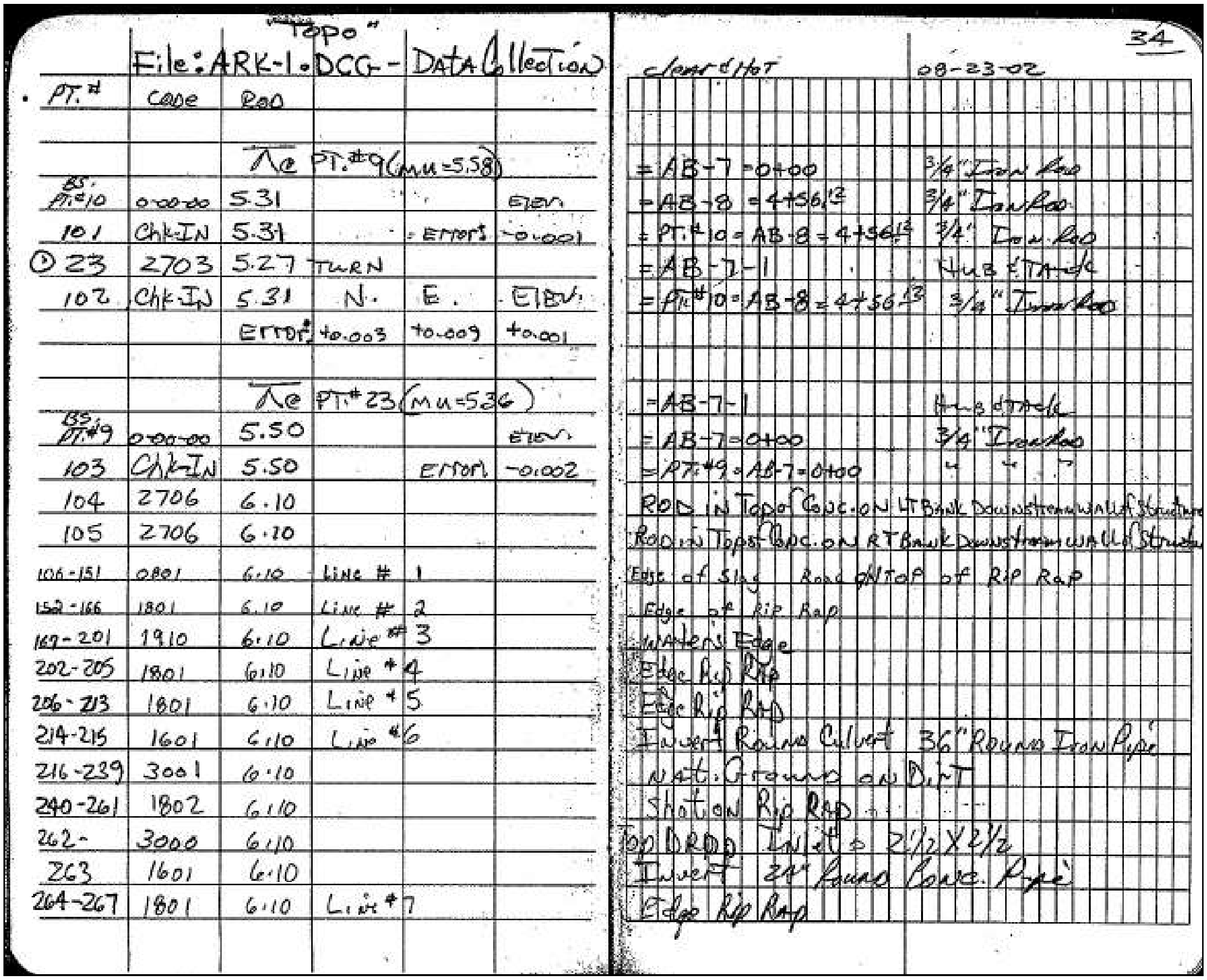


Figure 12-3. RTK reference notes in a field survey book (Jacksonville District--C&C Technologies, Inc.)

12-5. Sample Topographic Survey Field Book Notes

There is no set format for topographic field notes. The amount of detail required in the field book will depend on the nature of the project. When a data collector is used with a total station or RTK, then only minimal file referencing data is needed in the field book, as illustrated in Figure 12-4 below.



"Topo" File: ARK-1.DCG - Data Collection

PT.#	Code	Rod			
		∧@ PT.#9 (MU=5.58)			
BS. PT.#10	0-00-00	5.31			Elev
101	Chk-IN	5.31		Error	-0.001
① 23	2703	5.27	TURN		
102	Chk-IN	5.31	N.	E.	Elev.
		Error:	+0.003	+0.009	+0.001
		∧@ PT.#23 (MU=5.36)			
BS. PT.#9	0-00-00	5.50			Elev
103	Chk-IN	5.50		Error	-0.002
104	2706	6.10			
105	2706	6.10			
106-151	0801	6.10	Line # 1		
152-166	1801	6.10	Line # 2		
167-201	1910	6.10	Line # 3		
202-205	1801	6.10	Line # 4		
206-213	1801	6.10	Line # 5		
214-215	1601	6.10	Line # 6		
216-239	3001	6.10			
240-261	1802	6.10			
262-	3000	6.10			
263	1601	6.10			
264-267	1801	6.10	Line # 7		

clear & Hot 08-23-02 34

=AB-7-0+00	3/4" Iron Rod
=AB-8 = 4+56.13	3/4" Iron Rod
=PT.#10 = AB-8 = 4+56.13	3/4" Iron Rod
=AB-7-1	Hub & Tack
=PT.#10 = AB-8 = 4+56.13	3/4" Iron Rod
=AB-7-1	Hub & Tack
=AB-7=0+00	3/4" Iron Rod
=PT.#9 = AB-7 = 0+00	" " "
Rod in Top of Conc. on LT Bank Downstream Wall of Structure	
Rod in Top of Conc. on RT Bank Downstream Wall of Structure	
Edge of Slag Road on Top of Rip Rap	
Edge of Rip Rap	
Waters Edge	
Edge Rip Rap	
Edge Rip Rap	
Invert Round Culvert 36" Round Iron Pipe	
Nat. Ground on Dirt	
Shot on Rip Rap	
Top Drop Inlet 2 1/2 X 2 1/2	
Invert 24" Round Conc. Pipe	
Edge Rip Rap	

Figure 12-4. Topographic survey notes referencing data collector shots (Vicksburg District)

When topographic observations are manually recorded, a variety of field book formats may be used. The particular format selected will depend on the note keeper's preferences, the type of project, densification method (radial, cross-sections, or linear profiles), type of instrument, and amount of descriptor data required for individual shots. The surveying texts listed in Appendix A provide examples of topographic survey notes--particularly Kavanagh 1997 and many of the state DOT manuals. Some representative examples of topographic field notes are shown on the following Figures 12-5 through 12-8.

℄ Profile – Road A — 10/20/85 — (27)

Sta.	+	HI	−	Elev.	Adj. Elev.	
TBM#3	11.80	183.68			171.88	TBM#3 is nail in root of 24" water oak,
13+00			9.40			set in June 1975- Book 42-12
13+89			4.96			
13+96			4.60			
14+00			4.40			X-SEC. # 3B
14+49			2.11			
TP			1.03	182.65	[+.01] 182.66	
	9.94	[.60] 192.59				
15+00			8.61			X-SEC. # 4
15+19			7.66			
16+00			3.38			X-SEC. # 5
16+47			0.88			
TBM#4			0.81	191.78	191.80	TBM#4 is RR spike set in ℄ pavement.
						Set June 1975 - Book 42-12
	11.45	203.25				
17+00			8.87			SAMPLE NOTES-PROFILE
18+00			3.80			ON EXISTING PAVEMENT

Figure 12-5. Sample notes from a road profile survey--setting elevations on intermediate stations

X-SECTION STA 0+00 L-8 — 10 — 13 SEPT 87

RANGE	+	HI	−	ROD	ELEV	
					10.00	"FCSJ-2120" (PUBLISHED NGVD 1929)
	4.00	14.00				
200				3.9		B/L AND TOP OF LEVEE
25				6.0		SLOPE
30				8.0		BREAK
34				9.9		SLOPE
50				10.0		SLOPE
75				12.5		SLOPE
300				14.5		SLOPE
			13.55		0.45	T. P. (2x2 HUB)
	3.55	4.00				
175				3.6		TOE of LEVEE
150				3.6		MARSH (GRASS + Water)
125				3.6		MARSH (GRASS + Water)
			2.25		1.75	"FCSJ-2119" (Published ELEV 1.74)

Figure 12-6. Sample notes from a levee cross-section survey

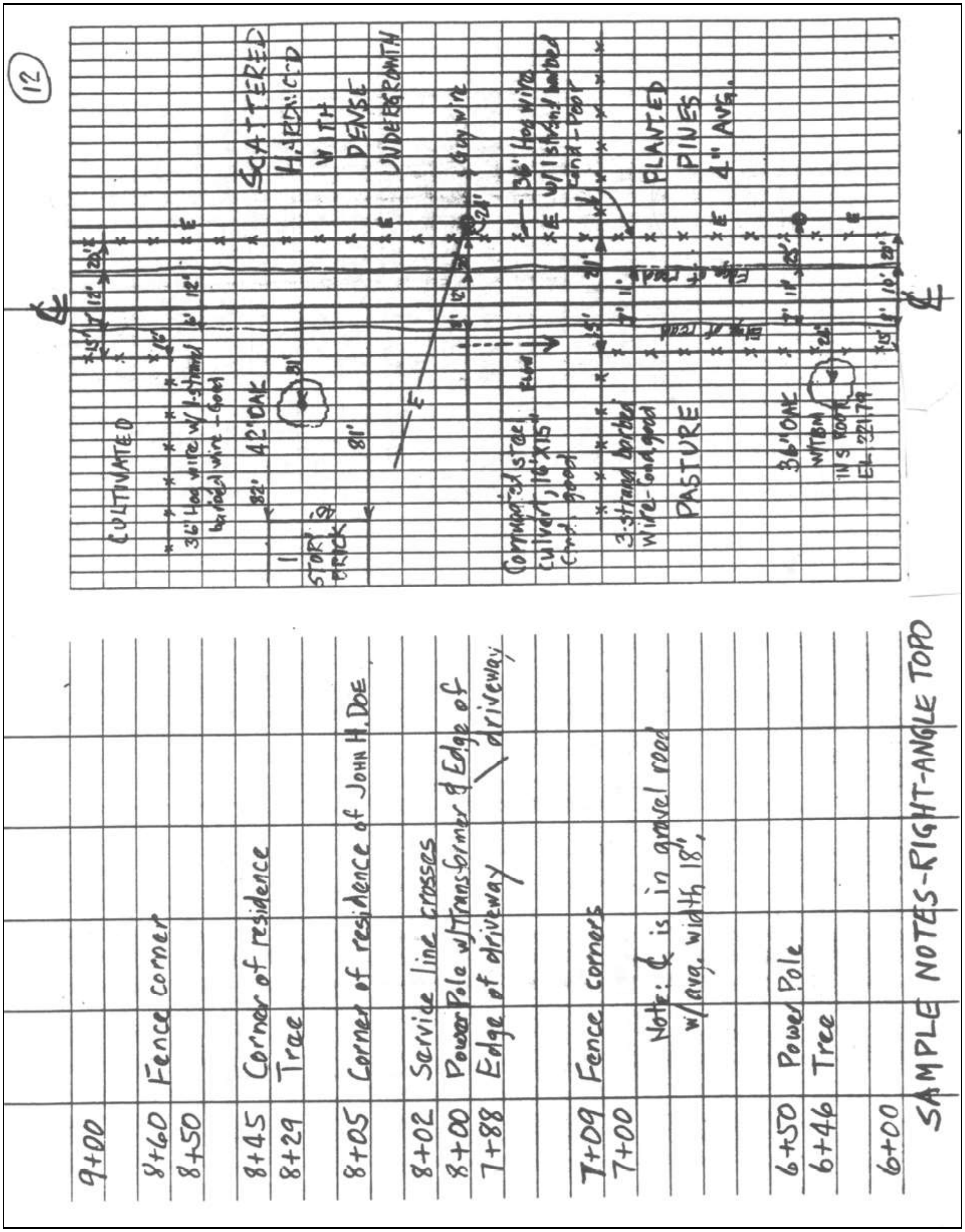


Figure 12-7. Notes from a right-angle topographic survey along a road centerline

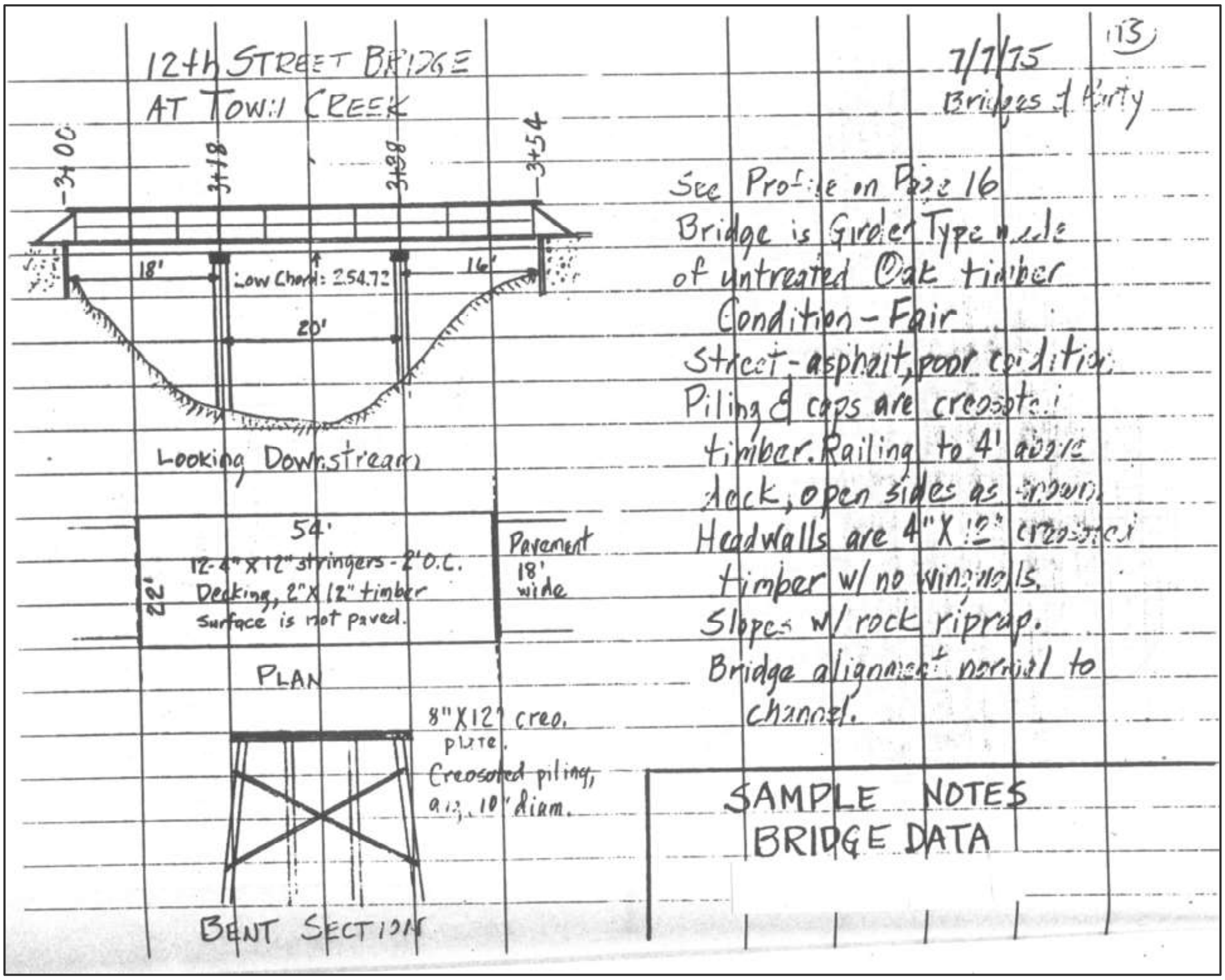


Figure 12-8. Sample notes from a bridge survey

12-6. Monument Descriptions

A description of the point occupied shall be made in the field notes. This description shall include the type of monument, its general location, and the type of material the point is set in. A sketch of the location of the point relative to existing physical features and reference ties shall be made and included in the notes. If a horizontal control line is used, a sketch of it shall be made and included in the notes. This sketch does not need to drawn to scale, but it should include the relative position of one point to the next and the basic control used. Alternatively, DA Form 1959 (Description and Recovery of Horizontal Control Station) may be used to record descriptions of permanent control monuments. A sample DA Form 1959 is shown at Figure 3-1 in Chapter 3. Optionally, a digital photo or "rubbing" of a monument may be obtained and submitted.

12-7. Standardized Coordinate File Coding (New Orleans District)

This section describes a coding scheme used by New Orleans District that is intended to define the general parameters associated with a survey project. This coding format is a mandatory submittal item for AE contractors performing surveys in New Orleans District. These code records are inserted into the ASCII coordinate file produced by the data collector and were developed for general USACE topo survey requirements. These records are used when importing the data into a GIS to create the required Metadata file. Additional codes may need to be developed to suit particular applications. All code records will begin with a " # " in column 1, and are limited to 80 characters (4 for the code, 1 space, and 75 for text). All comment records will begin with a ";" in column 1, and are also limited to 80 characters. The submitted file is in chronological order thus the code records will define the attributes of the records that follow. If the field data collection was completed in 7 days, the file would contain 7 #H02 records. Each would be placed at the beginning of the data collected on that day in indicate that the following records were collected on that date.

INDEX OF RECORD CODES

#B01 - Coordinates and station of baseline PI.
#B00 - Name of ASCII coordinate file that contains the survey data.
#BC1 - Coordinates and station of point of curve for curve #1.
#BT1 - Coordinates and station of point of tangent for curve #1.
#BI2 - Coordinates of point of intersection for curve #2.

#C01 - Party Chief.
#C02 - Instrument Man.
#C03 - Rodman.

#G01 - Staff gage code number supplied by USCOE.
#G02 - Name of gage.
#G03 - Water surface elevation as read on gage.
#G04 - Time (1423) of gage reading based on 24 hr clock.
#G10-G99 - Descriptions and or comments are limited to 75 characters per record.

#H01 - Standard DOS file name of ASCII file which contains the survey data. More than one file is allowed per survey job.
#H02 - Date (MM/DD/YY) on which the following information was obtained.
#H03 - Order (accuracy) of survey. (1,2,3..AA).
#H04 - Horizontal datum on which the survey is referenced. (NAD-1927, NAD-1983, WGS-84,...).
#H05 - Job number of survey. (YY-JJJ).
#H06 - Unit of linear measure (FT, MT, MI, ...).
#H07 - Map projection. Use standard list of projection codes (1702, 1703, ...).
#H08 - Location of survey such as nearest town, river, channel, basin. More than one location is allowed per survey.
#H09 - Survey firm or organization.
#H10 - Index number of survey field book in which the following information is recorded.
#H11 - Page number of field book specified by previous #H10 code on which the following information is recorded.
#H12 - Combined scale factor.
#H20 - Title of survey job. The survey title is limited to 75 characters per record.
#H21-H29 - Continuation of survey job title.
#H30 - Reserved for any comments about the survey job. The comments are limited to 75 characters per record.
#H31-H99 - Continuation of comments about the survey job.

#I01 - Instrument.
#I02 - Serial number.

#M01-M99 - Description of miscellaneous survey points that follow.

#P01 - The profile segment's beginning x-y coordinates and stationing.
#P03 - Time of profile. Only needed if elevations of points are relative to prorated water surface.
#P04 - Prorated water surface elevation used for elevation of points in profile.

#T01 - Name of temporary benchmark (TBM).
#T02 - Given elevation of TBM.
#T05 - Condition of TBM.
#T06 - Found elevation of TBM.
#T10-T99 - Description of TBM.

#X01 - The range line definition which contains the end point coordinates, station, and name of the range.
#X02 - Range code or index number.
#X03 - Time of cross-section. Only needed if elevations of points are relative to prorated water surface.
#X04 - Prorated water surface elevation used for elevation of points in cross-section.

#W01 - Temperature.

#W02 - Pressure.
#W03 - Humidity.
#W04 - Cloud conditions
(0-10%: clear
10-50%: scattered
50-90%: broken
90-100%: obscured)
#W05 - Wind speed.
#W06 - Wind direction
(N,S,E,W,NE,NW,SE,SW)

---

a. Survey job parameters. Header records are required to describe the survey job parameters such as Horizontal Datum, Units of Measure, Survey Date, Job Location, Survey Firm, etc. #H20 thru #H29 are reserved for job title. #H30 to #H99 are reserved for any comments about the survey job. Survey field book and page numbers shall be indicated on the #H12 and #H13 records. This allows for an easy reference to original field data.

#H01 - Standard DOS file name of ASCII file which contains the survey data. More than one file is allowed per survey job.
#H02 - Date (MM/DD/YY) on which the following information was obtained.
#H03 - Order (accuracy) of survey. (1,2,3..AA).
#H04 - Horizontal datum on which the survey is referenced. (NAD-1927, NAD-1983, WGS-84,...).
#H05 - Job number of survey. (YY-JJJ).
#H06 - Unit of linear measure (FT, MT, MI, ...).
#H07 - Map projection. Use standard list of projection codes (1702, 1703, ...).
#H08 - Location of survey such as nearest town, river, channel, basin. More than one location is allowed per survey.
#H09 - Survey firm or organization.
#H10 - Index number of survey field book in which the following information is recorded.
#H11 - Page number of field book specified by previous #H10 code on which the following information is recorded.
#H12 - Combined scale factor.
#H20 - Title of survey job. The survey title is limited to 75 characters per record.
#H21-#H29 - Continuation of survey job title.
#H30 - Reserved for any comments about the survey job. The comments are limited to 75 characters per record.
#H31-#H99 - Continuation of comments about the survey job.

b. Vertical control. All control points whether found or established must be described by control code records. Vertical control records are required to define the parameters such as Vertical Datum, Benchmark Name, Epoch, etc., used to determine the survey point elevations. These records are required at the beginning of a file and where the vertical parameters change such as when a different benchmark is used, a code is inserted to describe the mark.

#V01 - Name of permanent benchmark (PBM).
#V02 - Given elevation of PBM.
#V03 - Epoch (date of adjustment).
#V05 - Condition of PBM.
#V06 - Found elevation of PBM.
#V07 - Horizontal Position of PBM. (Northing, Easting or DDMMSS.SSSSS, DDDMMSS.SSSSS)
#V09 - Vertical adjustment (adjustment value to apply to following records).
#V10-#V99 - Description of PBM.

c. Temporary benchmarks (TBM). All TBMs used whether established or found must be defined with TBM records. The primary benchmark used to set the TBM will be assumed to be the previous #V01 record (V-Records). The date set will come from the last "H02" record. #T10 through #T99 are used for description of mark.

#T01 - Name of temporary benchmark (TBM).
#T02 - Given elevation of TBM.

#T05 - Condition of TBM.
#T06 - Found elevation of TBM.
#T10-#T99 - Description of TBM.

d. Baseline parameters. These records describe the reference baseline. If a baseline listing is available, the user may include the file name in the #B00 record. Each baseline PI is defined by its coordinates, station number, and PI name. Curve data are defined by #BC, #BI, and #BT records. These records define the coordinates, and station number of the Point of Curve, Point of Intersection, and Point of Tangent respectively.

#B00 - Name of ASCII coordinate file that contains the baseline data.
#B01 - Coordinates and station of baseline PI. (Northing, Easting, Station, PI)
#BC1 - Coordinates and station of point of curve for curve #1.
#BT1 - Coordinates and station of point of tangent for curve #1.
#BI1 - Coordinates of point of intersection for curve #1.

e. Survey crew members. Gage records are required each time a gage is read.

#C01 - Party Chief.
#C02 - Instrument Man.
#C03 - Rodman.

f. Water surface elevation. Gage records are required each time a gage is read.

#G01 - Staff gage code number supplied by USACE.
#G02 - Name of gage.
#G03 - Water surface elevation as read on gage.
#G04 - Time (1423) of gage reading based on 24 hr clock.
#G10-#G99 – Gage descriptions and or comments

g. Instrument records. These records are required to document the equipment used--Total Station, GPS Receiver, Level, etc.

#I01 - Instrument.
#I02 - Serial number.

h. Miscellaneous records. These records are required on miscellaneous shots. The record will contain a general description of the points that follow.

(M-RECORDS -- example)
#M01 Borehole locations at the south end of the ammo
#M02 plant located in the U.S. Army Reserve Complex
#M03 in Corn Bayou, La., near the WABPL.
#M01-M99 - Description of miscellaneous survey points that follow.

i. Profile parameters. Each reach of profile must be preceded by a #P01 record. If the profile contains sounding data controlled by a gage, a #P03 (time) and #P04 (elevation) record must be included showing the interpolated water surface elevation.

#P01 - The profile segment's beginning x-y coordinates and stationing.
#P03 - Time of profile. Only needed if elevations of points are relative to prorated water surface.
#P04 - Prorated water surface elevation used for elevation of points in profile.

j. Cross-section parameters. Each cross-section must be preceded by a #X01 record. If the section contains sounding data controlled by a gage, a #X03 (time) and #X04 (elevation) record must be included showing the interpolated water surface elevation.

#X01 - The range line definition which contains the end point coordinates, station, and name of the range.
#X02 - Range code or index number.
#X03 - Time of cross-section. Only needed if elevations of points are relative to prorated water surface.
#X04 - Prorated water surface elevation used for elevation of points in cross-section.

k. Weather parameters. Observed weather conditions as directed in scope of work.

#W01 - Temperature.
#W02 - Pressure.
#W03 - Humidity.
#W04 - Cloud conditions
(0-10%: clear
10-50%: scattered
50-90%: broken
90-100%: obscured)
#W05 - Wind speed.
#W06 - Wind direction (N,S,E,W,NE,NW,SE,SW)

l. Standardized Coding of Data Set Records (New Orleans District). A data set is defined as a cross section, a profile, or a group of topo shots. A data set begins with the #M, #P, or #X code records. For example a cross section data set begins with the #X records and is terminated by any #M, #P, or #X record. In the following example, the section at station 740+60.00 includes points 14 through 36.

```
#X013662575.472 513846.972 3663420.478 514783.249 74068.00 U-038
14,513846.972800,3662575.472400,25.177800,CLL
15,513851.730690,3662579.729793,24.790555,FSC
16,513854.771424,3662582.450114,23.607343,CON
17,513861.896190,3662588.617533,20.473465,CON
18,513869.537809,3662595.353421,17.172052,CON
19,513870.695011,3662596.667041,16.935937,FST
20,513885.651015,3662609.886094,17.604381,GRN
21,513897.436845,3662620.505040,17.054901,FL
22,513908.146804,3662629.967624,17.636607,GRN
28,514012.307919,3662723.237411,18.174412,GRN
29,514030.276254,3662739.133536,18.048303,GRN
30,514045.890994,3662753.505709,17.817666,GRN
31,514053.518645,3662760.498189,17.489915,TBK
32,514056.229181,3662763.379132,15.895516,RAP
33,514062.253261,3662768.735739,12.501015,RAP
34,514068.531708,3662774.720419,8.722339,RAP
35,514073.817554,3662777.983519,4.021107,RAP
36,514076.573300,3662782.391800,2.350900,WE
#X01 3662546.513 513869.121 3663402.044 514818.226 74032.00 U-038A
37,513869.121300,3662546.513300,24.810400,CLL
38,513874.846108,3662551.522557,24.355463,FSC
39,513877.284808,3662553.713072,23.223493,CON
40,513884.216098,3662559.999895,20.291534,CON
41,513891.230399,3662566.338795,17.194674,CON
42,513892.695782,3662567.524053,16.967491,FST
43,513908.060337,3662581.755554,17.467846,GRN
44,513918.193497,3662590.318394,17.270104,FL
45,513931.191766,3662602.314157,17.485274,GRN
```

m. Sample Set of Encoded Records from a Topographic Survey (New Orleans District). The following archival data was created for a survey of a power line near Algiers, LA. This dataset was generated by the AE contractor as part of his survey deliverable. The same dataset is then used to create a metadata file shown in a subsequent section.

```
#H01 04024LRP.EM
#H02 01-07-04
#H03 3
#H04 NAD83
#H05 04024
#H06 USFEET
#H07 1702
#H08 NEAR ALGIERS, LA.
#H09 CHUSTZ SURVEYING INC.
#H10 040012
#H11 1-75
#H12 1.0
#H20 FIELD DATA RE-COLLECTION OF CHALMETTE POWERLINE
#H30 W912P8-04-D-0001
#H31 Task Order 7
;
;
;------------------VERTICAL CONTROL INFORMATION ----------
;
#V01 Q 196
#V02 6.77
#V03 1996
#V04 LWRP 1993
#V05 Good
#V06 N/A
#V07 29-55-31 89-59-06
#V10 THE PID FOR THIS PBM IS AT0483
#V11 AS PER THE SCOPE OF WORK FOR THIS PROJECT, PBM Q 196
#V12 WAS TO BE USED FOR THE VERTICAL CONTROL ON THIS PROJECT
#V13 NOTE: THIS FILE HAS BEEN CORRECTED TO THE LWRP 1993 VALUES
#V14 BY ADDING 0.15 FT TO THE NAVD88 ELEVATION TO BRING IT TO
#V15 NGVD29, THEN SUBTRACTING THE LWRP 1993 VALUE OF 0.9 AS
#V16 PROVIDED IN THE SCOPE OF WORK TOTAL CORRECTION TO NAVD88
#V17 WIRE ELEVATION IS (-) 0.65 FT
;
;
;--------------------TEMPORARY BENCK MARKS-----------------------
;
;
; ELEVATIONS WERE ESTABLISHED ON SEVERAL CONTROL POINTS
; BUT NO ACTUAL TBMS WERE ESTABLISHED ON THE PROJECT
;
;-----------------------FIELD PERSONNEL----------------------------
;
#C01 LEE HINES
#C01 MATHEW DELHOMME
#C02 JOHN TEMPLETON
#C03 ROGER GROS
#C03 GREGERY GROS
;
;--------------------------EQUIPMENT-------------------------------
```

```
#E01 TOTAL STATION
#E02 LEICA T-1010
#E03 370556
;
#E01 LEVEL
#E02 TOPCON ATG3
#E03 5F6344
;
;
;---------------------------WEATHER--------------------------------
;
#W01 64 F
#W02 30.5 inHg
#W03 40%
#W04 PARTLY CLOUDY
#W05 10-15 MPH
#W06 WNW
;
; NOTE:  ADDITIONAL WEATHER RECORDS ARE IN THE FIELD BOOKS
```

12-8. Creating Metadata for Topographic Surveys

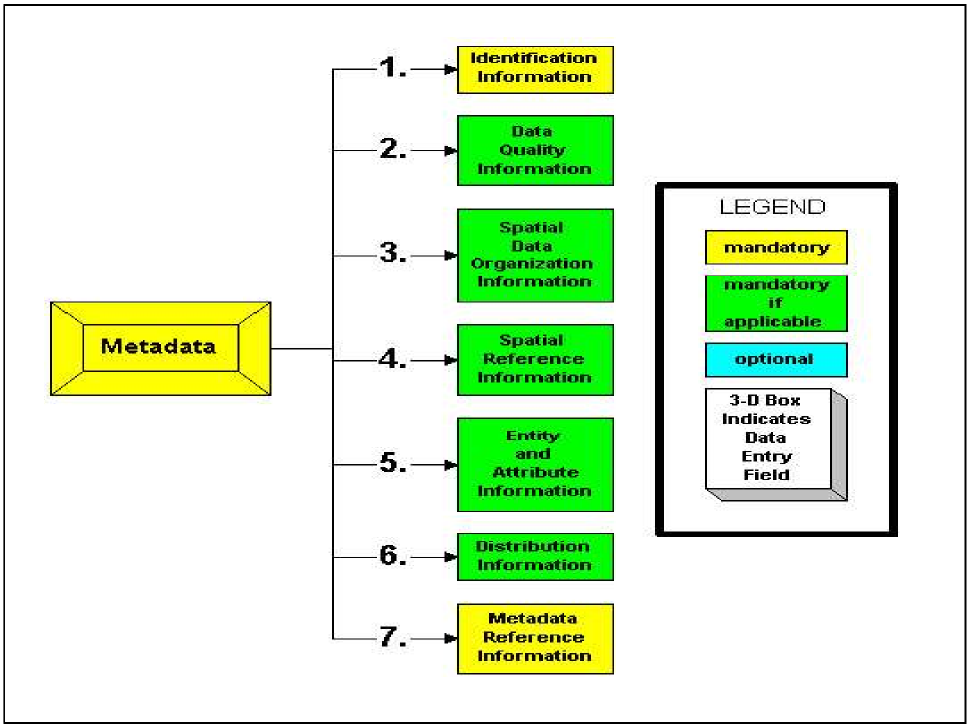


Figure 12-9. Mandatory and optional metadata fields

Metadata records should be created for topographic survey projects. The file structure is outlined in Figure 12-9 above. Only fields 1 and 7 are mandatory--2 through 6 are optional. Corps metadata policy and procedural references are contained in ER 1110-1-8156 (Policies, Guidance, and Requirements for Geospatial Data and Systems) and EM 1110-1-2909 (*Geospatial Data and Systems*). The following is a sample metadata file generated from the previously described New Orleans District power line survey.

Identification_Information:
Citation:
Citation_Information:
Originator: New Orleans District, U.S. Army Corps of Engineers
Publication_Date: JANUARY 6, 7, 15 and 16, 2004
Title: FIELD DATA RE-COLLECTION OF CHALMETTE POWERLINE
Publication_Information
Publication_Place: New Orleans, LA
Publisher: New Orleans District, U.S. Army Corps of Engineers
Online_Linkage:
<NONE>
Online_Linkage:
<NONE>
Description:
Abstract:
Resurvey of the Entergy power line crossing located at Mississippi River mile 89.2 AHP. The power lines were raised to facilitate the navigation of large cruse liners to the Port of New Orleans. The power lines were surveyed at a 75-foot interval and referenced to PBM Q-196 (AT0483). Note: this file has been corrected to the LWRP 1993 values by adding 0.15 ft to the NAVD88 elevation to bring it to NGVD29, then subtracting the LWRP 1993 value of 0.9 as provided in the scope of work.
Total correction to NAVD88 wire elevation is (-) 0.65 ft
Horizontal positions were relative to the levee marker survey traverse on the NAD83 datum.
Surveys were performed to document the elevations of the high tension

Purpose:
The power lines were hanging too low for the new cruise ship to safely cross under without striking. Documentation was required by the utility company and the cruse lines to determine the margin of safety under the raised wires.

Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: JANUARY 6, 7, 15 and 16, 2004
Currentness_Reference: publication date
Status:
Progress: Complete
Maintenance_and_Update_Frequency: Daily.
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: 3709150.07
East_Bounding_Coordinate: 3709460.65
North_Bounding_Coordinate: 523258.07
South_Bounding_Coordinate: 520243.34
Keywords:
Theme:
Theme_Keyword_Thesaurus: none
Theme_Keyword: Boundaries
Theme_Keyword: Hydrography
Theme_Keyword: Topography
Place:
Place_Keyword_Thesaurus: none
Place_Keyword: New Orleans
Place_Keyword: Louisiana

Place_Keyword: NEAR ALGIERS, LA.
Temporal:
Temporal_Keyword_Thesaurus: None
Temporal_Keyword: JANUARY 6, 7, 15 and 16, 2004

Access_Constraints:
None.
Use_Constraints:
This survey information is accurate as of the date of publication. Topographic-Hydrographic survey data is subject to change rapidly due to several factors including but not limited to dredging activity and natural shoaling scouring processes. The U. S. Army Corps of Engineers accepts no responsibility for changes in the conditions which develop after the date of publication. This information is intended for the internal use of the U. S. Army Corps of Engineers and it is being provided for external use as a public service. This agency accepts no responsibility for errors or omissions contained in this data. The accuracy of this data is therefore not guaranteed, and prudent surveyors or mariners should not rely solely upon it.

Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Mark W. Huber
Contact_Address:
Address_Type: mailing address
Address:
U.S. Army Corps of Engineers
New Orleans District
Survey Section
CEMVN-ED-SS
P.O. Box 60267
City: New Orleans
State_or_Province: LA
Postal_Code: 70160-0267
Country: USA
Contact_Voice_Telephone: (504) 862-1852
Contact_Facsimile_Telephone: (504) 862-1850
Contact_Electronic_Mail_Address: mark.w.huber@MVN02.usace.army.mil

Data_Quality_Information:
Logical_Consistency_Report:
The quality of data collected is consistent between dates and vessels collection information.

Completeness_Report:
The listed surveys represent complete collection for this date.
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report:
Hydrographic Survey Data collected via DGPS and XY accuracy is +- 3 feet.
Topographic Data is Third Order Class II
Lineage:
Source_Information
Source_Citation:

Citation_Information:
Originator: New Orleans District.
Publication_Date: Unpublished material
Title: No title, data not formally published,
hard copy is avail
Geospatial_Data_Presentation_Form: ASCII File
Publication_Information:
Publication_Place: n/a
Publisher: n/a
Other_Citation_Details: n/a
Type_of_Source_Media: paper
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: JANUARY 6, 7, 15 and 16, 2004
Source_Currentness_Reference: ground condition
Source_Citation_Abbreviation:
Not avail.
Source_Contribution:
Not avail.
Process_Step:
Process_Description:
Hydrosurveys are collected via DGPS. Topographic
surveys are typically collected with total stations.
Source_Used_Citation_Abbreviation: N/A
Source_Used_Citation_Abbreviation: N/A
Process_Date: JANUARY 6, 7, 15 and 16, 2004
Source_Produced_Citation_Abbreviation:
N/A
Process_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Ronald W. King
Contact_Address:
Address_Type: mailing address
Address:
U.S. Army Corps of Engineers
New Orleans District
Survey Section
CEMVN-ED-SS
P.O. Box 60267
City: New Orleans
State_or_Province: LA
Postal_Code: 70160-0267
Country: USA
Contact_Voice_Telephone: (504) 862-1853
Contact_Facsimile_Telephone: (504) 862-1850
Contact_Electronic_Mail_Address:
ronald.w.king@MVN02.usace.army.mil

Spatial_Data_Organization_Information:
Indirect_Spatial_Reference:
Filename: 04024LRP.em
This survey data is presented in an ASCII XYZ coordinate file.

Direct_Spatial_Reference_Method: Vector

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
State Plane:
Zone: 1702
Unit_of_Measure: USFEET

Entity_and_Attribute_Information:
Overview_Description:
Entity_and_Attribute_Overview:
The data attributes consist of soundings, depth curves (soundings), and obstructions.
Entity_and_Attribute_Detail_Citation:
not req'd.

Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Ronald W. King
Contact_Address:
Address_Type: mailing address
Address:
U.S. Army Corps of Engineers
New Orleans District
Survey Section
CEMVN-ED-SS
P.O. Box 60267
City: New Orleans
State_or_Province: LA
Postal_Code: 70160-0267
Country: USA
Contact_Voice_Telephone: (504) 862-1853
Contact_Facsimile_Telephone: (504) 862-1850
Contact_Electronic_Mail_Address: ronald.w.king@MVN02.usace.army.mil
Resource_Description: not applicable
Distribution_Liability:
The Government furnishes this data and the recipient accepts and uses it with the express understanding that the United States Government makes no warranties, expressed, or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data furnished. The United States shall be under no liability whatsoever to any person by reason of any use made thereof. This data belongs to the Government. Therefore, the recipient further agrees not to represent this data to anyone as other than Government provided data. The recipient may not transfer this data to others without also transferring this disclaimer.
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: EM
Format_Information_Content: ASCII XYZ Format
Transfer_Size: 0.500 megabytes
Digital_Transfer_Option:

Online_Option:
Computer_Contact_Information:
Network_Address:
Network_Resource_Name:
<NONE>
Online_Computer_and_Operating_System:
Windows NT Server running Netscape WWW Server
Offline_Option:
Offline_Media: 3.5 inch diskette
Recording_Format: DOS for diskette
Fees: Labor and media fees will be charged for requests for off-line data

Metadata_Reference_Information:
Metadata_Date: JANUARY 6, 7, 15 and 16, 2004
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Mark W. Huber
Contact_Address:
Address_Type: mailing address
Address:
U.S. Army Corps of Engineers
New Orleans District
Survey Section
CEMVN-ED-SS
P.O. Box 60267
City: New Orleans
State_or_Province: LA
Postal_Code: 70160-0267
Country: USA
Contact_Voice_Telephone: (504) 862-1852
Contact_Facsimile_Telephone: (504) 862-1850
Contact_Electronic_Mail_Address: mark.w.huber@MVN02.usace.army.mil
Metadata_Standard_Name:
FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: 19940608

12-9. Sample Submittal of Feature Data Accuracy

Some software will provide estimated accuracies of located features. These accuracies are usually based on a priori estimates, unless connected (redundant) adjustment statistics are available. Figure 12-10 below depicts a topographic survey with estimated feature accuracies indicated by error ellipses.

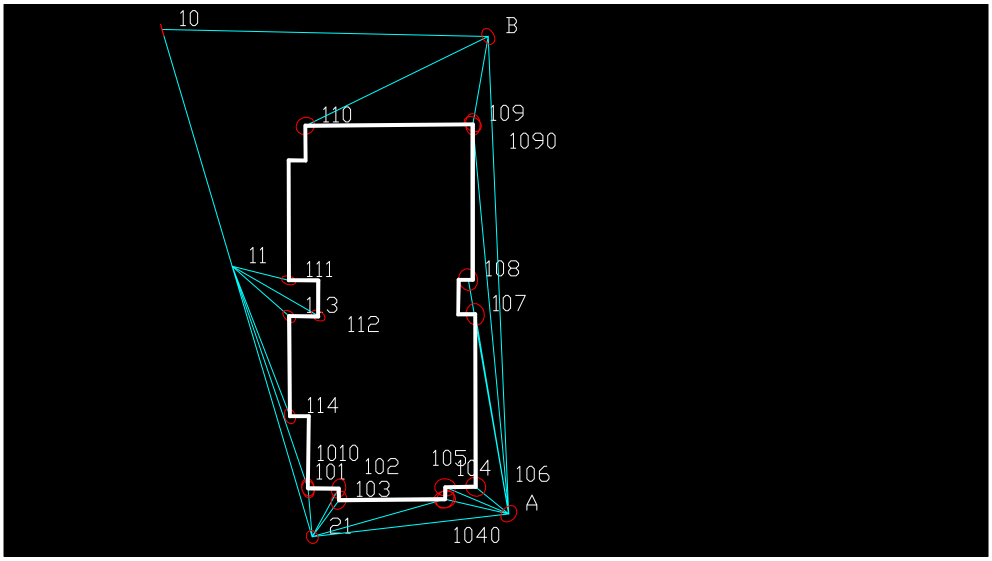


Figure 12-10. Error ellipses indicating horizontal feature accuracy on shots to building corners. Error estimates are relative to closed traverse from Point "10" which was constrained. Errors logically increase with distance from Point "10."

12-10. Deliverable QA Checklist

The following list may be used for verifying receipt of deliverables and as a QA check on submitted data.

- GPS network sketch
- Control diagram
- GPS raw data along with field observation log sheets filled out in field with all information and sketches
- Traverse sketches
- Level line sketches
- Raw data and computation files with horizontal and vertical abstracts
- GPS baseline reduction reports
- Traverse adjustments
- Level line adjustments
- Free and constrained adjustment reports (combined observations)
- Field survey books (original) containing daily record of survey observations
- Scanned field survey books (in Adobe Acrobat PDF format, one field book per file)
- Detail sketches of utilities and other planimetric features
- ASCII file containing all reduced coordinate data in X-Y-Z format
- DGN, DTM, and ESRI files
- Advance hard-copy plots (2 sets)
- Metadata files (*.gen and *.met files)
- Final Survey Report (narrative format following outline earlier in this chapter)

12-11. Mandatory Criteria

Preparation and submittal of metadata, as described in paragraph 12-10, is mandatory.

Chapter 13
Topographic Survey Contracting and Cost Estimating

13-1. General Contracting Policies and Procedures

The following sections describe the process for contracting topographic and control surveying services, including related cost estimates. It covers development of survey scopes of work, performance specifications, and cost estimates for Architect-Engineer (A-E) contracts. Although this chapter is intended to provide guidance for estimating costs for surveying services, the explanations herein regarding procurement policies and practices describe only the framework within which cost estimates are used. For detailed guidance on procurement policies and practices, refer to the appropriate procurement regulations: FAR, DFARS, AFARS, EFARS, EP 715-1-7 (*Architect-Engineer Contracting*), and the PROSPECT course specific to A-E contracting.

a. Brooks Architect-Engineer Act. In the Federal government, professional architectural, engineering, planning, and related surveying services must be procured under the Brooks Architect-Engineer Act, Public Law 92-582 (10 US Code 541-544). The Brooks A-E Act requires the public announcement of requirements for surveying services, and selection of the most highly qualified firms based on demonstrated competence and professional qualifications. Cost or pricing is not considered during the selection process. After selection, negotiation of fair and reasonable contract rates for the work is conducted with the highest qualified firm. Topographic surveying supporting the Corps' research, planning, development, design, construction, or alteration of real property is considered to be a related or supporting architectural or engineering service, and must therefore be procured using Brooks A-E Act qualifications-based selection, and not by bid price competition.

b. Contracting processes and procedures. Corps procedures for obtaining A-E services are based on a variety of Federal and DOD acquisition regulations. The following paragraphs synopsize the overall A-E process used in the Corps.

(1) Types of contracts. Two types of A-E contracts are principally used for surveying services: Firm-Fixed-Price (FFP) contracts and Indefinite Delivery contracts (IDC). FFP contracts are used for moderate to large mapping projects (e.g., > $1 million) where the scope of work is known prior to advertisement and can be accurately defined during negotiations--typically for a large new project site. Due to variable and changing engineering and construction schedules (and funding), most mapping work involving surveying services cannot be accurately defined in advance; thus, these fixed-scope FFP contracts are rarely used, and well over 95% of surveying services are procured using IDC.

(2) Announcements for surveying services. Requirements for surveying services are publicly announced and firms are given at least 30 days to respond to the announcement. The public announcement contains a brief description of the project, the scope of the required services, the selection criteria in order of importance, submission instructions, and a point-of-contact. This public announcement is not a request for price proposal, and firms are directed not to submit any price-related information.

(3) Selection criteria. Federal and DOD regulations set the criteria for evaluating prospective surveying contractors as listed below. These criteria are listed in the public announcement in their order of importance. (The order listed below may be modified based on specific project requirements.)

- Specialized experience and technical competence in the type of work required.

- Professional qualifications necessary for satisfactory performance.
- Past performance on contracts with Government agencies and private industry in terms of cost control, quality of work, and compliance with performance schedules.
- Capacity to perform the work in the required time.
- Knowledge of the locality of the project.
- Utilization of small or disadvantaged businesses.
- Geographic proximity.
- Volume of DOD contract awards.

[Note: the last three items are secondary selection criteria--see EP 715-1-7 (*Architect-Engineer Contracting*) for latest policy on A-E selection procedures and evaluation criteria]

(4) Selection process. The evaluation of firms is conducted by a formally constituted Selection Board in the Corps district seeking the services. This board is made up of highly qualified professional employees having experience in architecture, engineering, surveying, etc. The board evaluates each of the firm's qualifications based on the advertised selection criteria and develops a list of the three most highly qualified firms for a single award (multiple awards have slightly different requirements). As part of the evaluation process, the board conducts interviews with these top firms prior to ranking them. The firms are asked questions about their experience, capabilities, organization, equipment, quality management procedures, and approach to the project. These interviews are normally conducted by telephone. The top three firms are ranked and the selection is approved by the designated selection authority. The top ranked firm is notified they are under consideration for the contract. Unsuccessful firms are also notified, and are afforded a debriefing as to why they were not selected, if they so request.

(5) Negotiations and award. The highest qualified firm ranked by the selection board is provided with a detailed scope of work (SOW) for the project, project information, and other related technical criteria, and is requested to submit a price proposal for performing the work. A guide specification for developing the basic contract SOW is at Appendix D (*Sample Scopes of Work and Guide Specifications for Topographic Surveying Services*). In the case of IDC, price proposals consist simply of unit rates for various disciplines, services, and equipment. This list becomes the contract "Schedule" of prices, and the schedule will also include provisions for overhead, profit, and incidental supplies. Once a fair and reasonable price (to the government) is negotiated, the contract is awarded. The Government Contracting Officer is obligated to strive to obtain a negotiated price that is "fair and reasonable" to both the Government and the contractor.

c. Survey personnel requirements and qualifications. The general personnel requirements that would be found on a topographic or control survey services contract are as follows:

- Contractor's Project Manager (PM). PMs shall be thoroughly familiar with all phases of surveys and their relationship to the design, construction, and development of major engineering projects, in addition to the contract supervision and administration aspects related thereto. As PM, this official shall exercise the full managerial control required to efficiently, economically, and technically administer all contract forces assigned to perform work under the contract.

- Professional Land Surveyor. Professional surveyors shall be thoroughly familiar with all phases of surveying as it pertains to control traverses, and establishing and reestablishing of property and/or boundary lines. They shall be qualified to perform supervisory and administrative duties in connection with economical and efficient operation; planning the work and making assignments; and in performing any other duties necessary for accomplishment of assigned work. Proof of registration will be furnished upon request. Land surveyors shall be licensed in the State where the work is performed. (Since many topographic surveys involve ties to property corners, this work should be done under the supervision of a Professional Land Surveyor).

- Supervisory Surveying Technician (Party Chief). The Party Chief shall be thoroughly familiar with all phases of surveys for design and construction projects. These surveys will include design data, horizontal and vertical control surveys, geodetic surveys, cadastral, topographic and construction layout, profiles, cross sections, quantity, and measurement surveys. They shall also be qualified to make field computations for accomplishment of work assigned. Each field Party Chief shall be capable of planning the work for his party to obtain work efficiency and to gainfully utilize all of the members of his party.

- Survey Technician (Instrumentperson/Recorder). Instrumentperson/Recorders shall be capable of operating under supervision, survey instruments, including theodolite, transit, level, alidade, and electronic distance meters. They shall be experienced in keeping all forms of notes in a firm and legible hand, and operating data collectors.

- Survey Technician (Rodperson/Chainperson). Rodpersons/Chainpersons shall be assigned to perform a limited variety of simple repetitive tasks, such as but not limited to, holding rod or range pole for observation and measuring distances by steel tape.

- Engineering Technician (Drafter/Mapper/CADD Operator). A drafter shall be capable of preparing neat and legible drawings of topographic and property surveys; they shall have substantial experience in the drafting field including proficiency with CADD and be capable of performing assignments of originality or complexity. They shall be capable of applying initiative and resourcefulness in independent planning of methods.

- Civil Engineering Technician (Office Survey Computer). The survey Computer Person shall be capable of making all computations and adjustments required for all surveying, mapping, and geodesy requirements performed under the contract. The Computer Person shall have had extensive field experience in addition to a comprehensive mathematical computing ability. The Computer Person shall be designated with the authority to recommend re-observations when the data does not meet the accuracy specifications required under the contract. The Computer Person shall be thoroughly familiar with all computational techniques and procedures covered under the referenced technical specifications, e.g., COGO, GPS baseline reduction, network adjustments, coordinate transformations, etc.

13-2. Indefinite Delivery Contracts

The vast majority of the Corps surveying services are procured using Indefinite Delivery Contracts (IDC). These IDCs are procured using the selection and negotiation process described above. IDC (once termed "Open-End" or “Delivery Order” contracts) have only a general scope of work--e.g., "Topographic Surveying Services in Southeastern United States.” When work arises during the term of the contract, task orders are written for performing that specific work. Task orders are negotiated using the unit rate "Schedule" developed for the main contract. Thus, negotiations are focused on the level of effort and performance period. Task orders typically have short scopes of work--a few pages. The scope is sent to a contractor who responds with a proposal incorporating the scheduled rates, from which negotiations are initiated. Under emergency conditions (e.g., flood fights, hurricanes) contractors can be issued task orders verbally by the Contracting Officer, with the scope of work simply defined as a limiting number of days for survey crew at the contract schedule rate. The entire process--from survey need to task order award--should routinely take only 2 to 4 weeks. From the IDC Schedule, a survey crew and equipment is pieced together using the various line items--adding or deducting personnel or equipment as needed for a particular project.

a. Unit price basis. A number of methods are used by Districts for estimating and scheduling topographic surveying services in a fixed-price or IDC contract. The most common method is a "daily rate" basis, although hourly rates for personnel labor are used by some Districts. A daily rate basis is the cost for personnel or equipment over a nominal 8-hour day. In some cases, a composite daily rate may be estimated and negotiated for a full field crew (including all personnel, instrumentation, transport, travel, and overhead). A daily (or hourly) crew rate is the preferred unit price basis for estimating contracted survey services for IDC contracts and their task orders. It provides the most flexibility for IDC contracts, especially when individual project scopes are expected to vary widely. The crew personnel size, total stations, RTK systems deployed, vehicles, etc., must be explicitly indicated in the contract specifications, with differences resolved during negotiations. Options to add additional personnel and/or transport must be accounted for in the estimate and unit price schedule. Cost estimates for surveying services are usually broken down using the following detailed analysis method.

Table 13-1. Factors for Estimating A-E Costs

Item	Description
I	Direct labor or salary costs of survey technicians: includes applicable overtime or other differentials necessitated by the observing schedule
II	Overhead on Direct Labor *
III	G&A Overhead Costs (on Direct Labor) *
IV	Direct Material and Supply Costs
V	Travel and Transportation Costs: crew travel, per diem, airfare, mileage, tolls, etc. Includes all associated costs of vehicles used to transport personnel & equipment
VI	Other Direct Costs (not included in G&A): includes survey equipment and instrumentation, such as total stations. Instrument costs should be amortized down to a daily rate, based on average utilization rates, expected life, etc. Some of these costs may have been included under G&A. Exclude all instrumentation and plant costs covered under G&A, such as interest
VII	Profit on all of the above (Computed/ negotiated on individual task order or developed for all task orders in contract)

* these may be combined into a single overhead rate

b. Contract Price Schedule. The various personnel, plant and equipment cost items like those shown in Table 13-1 above are used as a basis for negotiating fees for individual line items in the basic IDC contract. During negotiations with the A-E contractor, individual components of the contractor's price proposal may be compared and discussed. Differences will be resolved in order to arrive at a fair and reasonable price for each line item. The contract may also schedule unit prices based on variable crew sizes and/or equipment. A typical negotiated IDC price schedule (Section B - Supplies or Services and Prices/Costs) is shown below in Table 13-2. The contract specifications would contain the personnel and equipment requirements for each line item. Each Corps district has its unique requirements and therefore line items used in schedules will vary considerably. For instance, some districts may elect to apply overhead as a separate line item. Others may compute profit separately for each task order and others may not include travel costs with crew rates. The following sample price schedule included 150% overhead on the labor rates. Profit is assumed to be a separate (but constant) line item (10.5%) that will be added to each Task Order.

(Technically, a formal IGE is not prepared for a basic Indefinite Delivery Contract since there is no scope of work; however, the same IGE preparation principles are used in estimating line items in an IDC schedule. An informal IGE can be prepared for Task Orders less than $100,000. An IGE for a Task Order will be prepared using the contract rates for labor, overhead, supplies, travel, etc.).

Table 13-2. Sample Contract Schedule of Services for an Indefinite Delivery Contract used for Topographic Surveying Services

LINE ITEM	UNITS	DAILY RATE
SUPV PROF CIVIL ENGINEER	daily	$795.60
SUPV PROF LAND SURVEYOR	daily	$681.20
REGISTERED LAND SURVEYOR	daily	$572.00
CIVIL ENGR TECH	daily	$364.00
CARTOGRAPHIC TECH (Includes CADD WorkStation Operator)	daily	$332.80
STEREO PLOTTER OPERATOR (Includes Photogrammetric Softcopy WorkStation)	daily	$455.52
ENGINEERING/CARTOGRAPHIC AID	daily	$309.92
G.I.S. SYSTEMS ANALYST (Includes CADD WorkStation)	daily	$582.40
G.I.S. DATABASE MANAGER (Includes CADD WorkStation)	daily	$542.88
G.I.S. TECHNICIAN (Includes CADD WorkStation)	daily	$343.20
PARTY CHIEF	daily	$384.80
PARTY CHIEF (OVERTIME)	hour	$28.86
INSTRUMENTPERSON	daily	$291.20
RODMAN-CHAINMAN-LABORER	daily	$234.00
4-PERSON TOPOGRAPHIC SURVEY PARTY	daily	$1,196.00
3-PERSON TOPOGRAPHIC SURVEY PARTY	daily	$904.80
2-PERSON TOPOGRAPHIC SURVEY PARTY	daily	$665.60
1-PERSON TOPOGRAPHIC SURVEY PARTY	daily	$502.98
MOB & DEMOB OF SURVEY PARTY	per project	$988.00
TOTAL STATION EQUIPMENT COST cost per instrument & data collector, per day	daily	$50.00
GPS EQUIPMENT COST cost per receiver, per day	daily	$75.00
FIELD COMPUTING PCS & SOFTWARE	daily	$50.00
MISC. ITEMS		
ATV	daily	$104.00
Milage-4 Wheel Truck	per mile	$0.60
SMALL SURVEY SKIFF BASIC RATE	daily	$93.60
W/Fathometer	daily	$107.12
Materials (PVC, steel fence posts, rebar, misc.)	daily	$10.00
PER DIEM (estimate actual costs on each Task Order--use JTR per diem rates)	daily	
PROFIT (use 10.5% for all task orders issued under contract)		

c. Personnel and crew line items. Individual line items in the above schedule need to be explicitly defined in the IDC specifications. For example, the specifications must define what instrumentation and plant, if any, is included on a “2-PERSON SURVEY PARTY.”

d. Overtime rates. Overtime rates should rarely be used--generally only during emergency operations. Task Orders issued under an IDC will be estimated based on nominal 40-hour weeks (8-hour or 10-hour workdays). Options to work overtime are the prerogative of the A-E contractor--it is not the Government's mission to tell a contractor how to schedule his forces. Overtime rates do not include overhead. Thus, in the above example, the $28.86 overtime rate for the "Party Chief" is based on 1.5 times a base hourly rate of $19.24. The daily rate of $384.80 is determined from $19.24/hr x 8 hr/day x 150% overhead rate.

e. Mob/Demob. This sample schedule shows a fixed mob/demob rate, which is used by some Districts. This is a carryover from traditional construction contracting where mob/demob is a bid line item. Generally, surveying services would not use a constant mob/demob rate as shown here--mainly because under an IDC the job location for the Task Orders is normally unknown. Mob/demob times would be applied to the time estimates for personnel and equipment in individual Task Orders. (There might be cases where the work site is the same installation for the entire contract period--then a fixed mob/demob rate would be applicable).

f. Excessive mob/demob costs. In the above sample schedule, the mob/demob rate of $988.00 exceeds the $665.60 daily rate for a 2-man survey crew. If a Task Order issued under this contract entails only one day of effort, then this not a cost effective contract for surveying services. An alternate A-E procurement mechanism should be used for a small amount of work--e.g., credit card issuance to a firm located near to the job site.

g. Miscellaneous items in Schedule. Generally, it is preferred to lump miscellaneous supplies into a crew rate or include it in overhead. The $10.00 line item in the above Schedule for "Materials" could have been included in the contract overhead. If there is a major requirement for supplies on a Task order, then this can be negotiated during the order--e.g., "200 monuments with bronze discs." The fewer the number of line items in the contract schedule, the easier it is to estimate individual task orders.

13-3. Cost Estimates for Contracted Topographic Mapping IDCs

Cost estimates are required for each line item in an IDC schedule. These estimates must be sufficiently detailed such that the Government negotiator can reach a "fair and reasonable" price with the selected A-E firm. Details on performing government cost estimates for A-E contracts are covered in EP 715-1-7 and the PROSPECT course "*A-E Contracting*." The following cost computations are representative of the procedures used in preparing the IGE for an A-E contract and/or an IDC contract price schedule. Costs and overhead percentages are shown for illustration only--they are subject to considerable geographic-, project-, and contractor-dependent variation (e.g., audited G&A rates could range from 50 to 200 percent).

a. Labor. Labor rates are direct costs and are estimated for each personnel line item required in the basic IDC contract. The estimated labor rate is obtained from a number of sources, such as:

- Prior contract rates
- Trade publications
- Equivalent GS rates
- Department of Labor published rates (including Service Contract Act minimum rates)
- Labor rates in other District IDCs

b. Indirect overhead costs. Overhead is an indirect cost--a cost that cannot be directly identified with the performance of a contract but is necessary for the normal operation of a business. Overhead is normally broken into two parts: Direct and General & Administrative (G&A). Direct overhead includes items such as benefits, health plans, retirement plans, life insurance, etc. G&A includes office supervision staff, marketing, training, depreciation, taxes, insurance, utilities, communications, accounting, downtime, etc. (Care must be taken to ensure there is no duplication between G&A overhead and direct costs. An example of duplication might be a maintenance contract for a total station being included in both G&A and directly on the equipment cost). Usually direct and G&A overheads are combined into one amount and applied as a percentage against the base labor cost. Overhead rates are estimated using similar resources listed above for labor rates. Arbitrary limits on overhead rates should never be set. Overhead rates are negotiable and may optionally be audited before contract award.

The following is a sample IGE labor rate computation for two selected line items in a schedule: a party Chief and a Survey Aid. (2,087 hours per year assumed). Direct and G&A overheads are broken out for the Party Chief but are shown combined for the Survey Aid. A daily rate, hourly rate, and overtime rate is shown.

SAMPLE IGE LABOR RATE COMPUTATIONS

Supervisory Survey Tech (Party Chief)	$42,776.00/yr	*(based on GS pay schedule)*
Overhead on Direct Labor (36%)	$15,399.36/yr	*(based on historical rates)*
G&A Overhead (115%)	<u>$49,192.40/yr</u>	*(based on historical rates)*
Total:	$107,367.76/yr or $411.57/day or $51.44/hr	
	[Overtime rate: $42,776 / 2087 x 1.5 = $30.74]	
Survey Aid	$23,332/yr	*(based on GS pay schedule)*
@ 151 % O/H (36%+115%)	$58,563.32/yr or $224.49/day or $28.06/hr	
	[Overtime rate: $23,332 / 2087 x 1.5 = $ 16.77]	

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c. Estimating equipment and instrumentation costs. The following is an example of instrumentation cost estimates in an IGE. Total station and RTK instrumentation rates used are approximate (2004) costs. The monthly "rental rates" are approximate long-term purchase agreement payments--daily cost must factor in estimated chargeable utilization each month--this can vary greatly. Associated costs for instrumentation, such as insurance, maintenance contracts, interest, etc., are presumed to be indirectly factored into a firm's G&A overhead account. If not, then such costs must be directly added to the basic equipment depreciation rates. Other equally acceptable accounting methods for developing daily costs of equipment may be used. Equipment utilization estimates in an IGE may be subsequently revised (during negotiations) based on actual rates as determined from a detailed cost analysis and field price support audits. The major variables in estimating costs are:

- Utilization rates. A particular survey instrument may be used (charged) only a limited number of days in a year. A total station or vehicle may be utilized well over 200 days a year whereas other instruments are not used on every project. For example, a $150,000 terrestrial scanner may be actually used only 20 days a year. If the annual operating cost of this instrument (without operator) is say $40,000, then the daily rate is $2,000/day. This is the amount that the contractor must charge to recoup his purchase or lease expenses (not including profit). A two-man survey crew may carry both a total station and RTK system with them in the field. Even though only one of these systems can be used on a given day, both systems are chargeable for utilization. Utilization rates are difficult to estimate given they can vary widely from contractor to contractor, and with the type of equipment. Thus, the government estimator must have some knowledge of equipment utilization by a typical survey firm.

• Equipment cost basis. There are a number of methods to estimate the cost basis of a particular instrument. Trade publications (e.g., *POB*, *Professional Surveyor*, and *American Surveyor*) contain tabulations and advertisements with purchase costs, loan costs, rental costs, or lease costs. If an item is purchased, then an estimated life must be established--usually varying between 3 to 7 years for most electronic equipment and computers. Assuming the instrument is purchased on a loan basis, the annual/monthly cost can be estimated--e.g., a $40,000 instrument purchased over 5 years at 5% is $755/month. At 15 days/month estimated utilization, the daily rate would be $50/day. Lease rates published in trade publication also provide estimates for costs. Rental rates are applicable to obtaining IGE estimates. In general, rental rates will run between 5% and 15% of the original purchase cost, per month. Thus, a $40,000 instrument could be rented for $4,000 per month, assuming a 10% rate. If it is utilized 15 days a month, then the daily rental rate would be $266/day. Obviously, in the above examples, rental rates far exceed purchase rates. The IDC contract solicitation should have specified the desirability for ownership versus rental of instruments and equipment.

The following are selected example computations of equipment costs rates that would be used in preparing an IGE for an indefinite delivery contract schedule. The daily costs can be computed based on purchase (loan) costs or lease costs. A rental rate is another option.

ESTIMATING SURVEY INSTRUMENTATION & EQUIPMENT COSTS

Total Station: data collector, prisms, etc. $32,000 purchase cost @ 5 yrs life @ 120 d/yr utilization		$ 53/day
At a typical lease rate of $600/mo and 10 days utilization/mo		*$60/day*
RTK topographic system --2 geodetic quality GPS receivers, batteries, tripods, data collectors, etc. $30,000 purchase cost @ 4 yrs @ 100 d/yr		$ 75/day
Laptop, field--with COGO, GPS, and CADD software $15,000 purchase cost @ 3 yrs @ 200 d/yr		$ 25/day
Survey Vehicle $50,000 @ 4 yrs @ 225 d/yr	$ 55/day	
plus O&M, fuel, etc.	$ 25/day	$ 80/day

(A purchase or lease rate may be used. Optionally, a daily rental rate.
The contract may be structured to pay actual mileage rates (e.g., $0.50/mile).
Vehicle costs should not include those items covered under G&A, such as liability insurance, etc.)

Misc Materials (field books, survey supplies, etc)	$ 15/day

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d. Travel and per diem. Travel and per diem costs are usually negotiated on individual task orders, based on the geographical location, transport vehicles (air, land, or floating plant), mob/demob times, etc. Maximum per diem is based on current JTR/GSA rates.

e. Material costs. The material cost estimate above could have been easily included in G&A overhead, given these are usually small amounts relative to the other labor and equipment line items. Unusual material costs on an individual Task Order can be negotiated as a lump sum item on the order--e.g., custom monuments.

f. Combined Crew Rates. The labor and equipment line items described above can be combined to obtain a single rate for a one or two man topographic crew. For example, a one-man crew would include a Party Chief, total station, computer, vehicle, and miscellaneous supplies. Using the above rates the daily cost of a one-man crew would be computed as follows:

Supervisory Survey Tech (Party Chief) [includes 151% O/H]		$411.57/day
Total Station (robotic): data collector, prisms, etc.		$53.00/day
Vehicle		$80.00/day
Miscellaneous expenses		$15.00/day
	Subtotal	$559.57/day
	Profit at 10%	$55.96/day
	Total Crew Rate	$615.53/day

[Travel and per diem expenses would be added separately on a task Order]

g. Verification of Contractor Cost or Pricing. Regardless of the contract price method used, it is essential (but not always required) that a cost analysis and price analysis be employed to verify all cost or pricing data submitted by a contractor, particularly major cost items such as equipment and plant. Some operation and maintenance costs may be directly charged, or portions may be indirectly included in a firm's G&A overhead account. In some instances, a firm may lease/rent survey instrumentation or plant equipment in lieu of purchase. Rental would be economically justified only on limited scope projects and if the equipment is deployed on a full time basis. Whether the equipment is rented or purchased, the primary (and most variable) factor is the equipment's actual utilization rate, or number of actual billing days to clients over a year. Only a detailed audit and cost analysis can establish such rates and justify modifications to the usually rough assumptions used in the IGE. In addition, an audit will establish any nonproductive labor/costs, which are transferred to a contractor's G&A. Given the variable equipment costs and utilization rates in surveying (particularly in specialized instrumentation such terrestrial lasers), failure to perform a detailed cost analysis and field pricing support audit on contracted surveying services will make the IGE difficult to substantiate.

13-4. Task Order Time and Cost Estimates

Once unit prices have been negotiated and established in the basic IDC schedule as illustrated in the above sections, each IDC task order is negotiated primarily for effort. The process for estimating the time to perform any particular survey function in a given project is highly dependent on the knowledge and personal field experience of the government and contractor estimators. The negotiated fee on a task order is then a straight mathematical procedure of multiplying the agreed-upon effort against the established unit prices in Schedule B, plus an allowance for profit if not included in the unit rates. A formal IGE is currently (2005) only required for task orders over $100,000, along with a detailed profit computation, documented records of negotiations, etc. The scope is attached to a DD 1155 order placed against the basic contract. If a preliminary site investigation is scheduled for this project, any such adjustments should be investigated and resolved prior to negotiating subsequent task orders for the various phases of the work, to the maximum extent possible. As such, the negotiated costs for the subsequent work phases would be considered fixed price agreements. Any later adjustments to these agreed to prices would be issued in the form of modifications to task orders (change orders), and would have to be rigorously defended as significant, unforeseen changes in the scope. The contractor would be expected to immediately notify the contracting officer (KO) or Contracting Officer's Representative (COR) of the need for cost adjustments. The following process (excerpted from Louisville District) is representative of the steps taken to initiate a Task Order in a District. Note that these procedures will vary from District to District.

- Request for survey/mapping information. Make sure proposed work is within the scope of services in the basic Indefinite Delivery contract. You may need to use another contract available through others in your district. You may also request contract capacity from another district. If you have in-house capability you may also propose to do this work using government resources. The schedule of the work request may also determine how you proceed. The contracting process takes time (up to 2 to 4 weeks or more) and in-house forces may be more readily available for projects requiring quick turn around.

- Develop Scope of Work (SOW). Request funding for your labor to develop SOW. You may develop the SOW with the help of your co-workers and you may also ask project related questions of the contractor. You may not discuss cost with the contractor at this time. Include a description of the work required, a schedule, quality control, and safety plan (if required). You may also reference the required engineering manuals which are available on-line.

- Review SOW with project manager (PM) and make necessary changes.

- Develop Independent Government Estimate (IGE) or Informal Working Estimate for small orders. Determine if original SOW matches project budget and verify availability of funds. If original request exceeds available budget, offer cost saving alternatives; e.g., aerial photography flown at a higher altitude or less detailed mapping and contours etc.

- Get money set up and moved in appropriate funding systems (P2/CEFMS) so you may create a Purchase Request & Commitment (PR&C).

- Get a labor code set up for Contracting personnel to process PR&C.

- Write labor PR&C.

- Write request for proposal (RFP) letter.

- Get PR&C reviewed and approved. Notify contracting office that the labor PR&C has been written and forward the SOW, IGE, and RFP. The contracting office will send RFP and SOW to the contractor. The contractor will normally have 10 days to submit their proposal. When contracting receives the proposal they will forward it to you for technical analysis. If the proposal is acceptable notify contracting and they will award the task order and send the notice to proceed to the contractor. If the proposal is not acceptable, identify items that are out of compliance and forward a list of these items to contracting as points of negotiation. Contracting will schedule a negotiation date. During the negotiation you will discuss the points of negotiation and come to an acceptable compromise with the contractor. You may need to modify your SOW and IGE based on the negotiations. Forward the updated contract documents and contracting will award the task order and send the notice to proceed.

13-5. Task Order Request for Proposal

Following is an example of a letter request for proposal for topographic surveying services. This proposed task order from Louisville District supports topographic and boundary surveys of a US Army Reserve Center. The Scope of Work (SOW) attachment to this letter is included here. Sample SOWs for other military and civil works topographic mapping surveys are provided at Appendix D in the other Application Project appendices to this manual.

SAMPLE LETTER REQUEST FOR PROPOSAL

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26 March 2002

Survey and Mapping Section

EarthData International
45 West Watkins Mill Road
Gaithersburg, MD 20878

Gentlemen:

Reference is made to Indefinite Delivery Contract No. DACW27-00-D-0017 for survey and mapping services for the Louisville District Corps of Engineers.

Enclosed is a scope of work dated 25 March 2002 for topographic mapping and boundary survey of a proposed USARC site in the vicinity of Cleveland, OH. This work is for a delivery order under the above-referenced contract. Please submit your proposal no later than ten (10) calendar days after receipt of this letter. Return your proposal by mail to the U.S. Army Corps of Engineers 600 Dr. Martin Luther King, Jr., Place, Room 821, Louisville, KY 40202-2230, or by fax to 502/ 315-6194. Mark your proposal to the ATTENTION OF **CELRL-CT (PR&C W22W9K 20949148).**

The "Release of Claims" form should be submitted after completion of the project along with your Final Pay Estimate.

If you have contractual questions, please call Robin Woodruff at 502/ 315-6189. For technical questions concerning the scope of work contact Chris Heintz at 502-315-6408.

Sincerely,

Robin Woodruff
Contract Specialist

Enclosure

CF:
CELRL-ED-M-SM (C. Heintz)

The following is the Scope of Work that was attached to the above letter request for proposal:

SCOPE OF WORK
Contract No. DACW27-00-D-0017
EarthData, International

Date: 25 March 2002

Project: United States Army Reserve Center-Boston Heights, OH

GENERAL
The contractor, operating as an independent contractor and not as an agent of the government, shall provide all labor, material, and equipment necessary to perform professional surveying & mapping for the Louisville District Corps of Engineers. The work required consists of gathering field data, compiling this data into a three-dimensional digital topographic map of the proposed site for a United States Army Reserve Center in the vicinity of Boston Heights, OH.

This project also requires performing a boundary survey of the site. The details of the boundary survey are described in the attached scope of work.

The contractor shall furnish the required personnel, equipment, instrumentation, and transportation as necessary to accomplish the required services and furnish to the government digital terrain data, control data forms, office computations, reports, and other data with supporting material developed during the field data acquisition and compilation process. During the prosecution of the work, the contractor shall provide adequate professional supervision and quality control to assure the accuracy, quality, completeness, and progress of the work.

TECHNICAL CRITERIA AND STANDARDS
The following standards are referenced in specification and shall apply to this contract:

USACE EM 1110-1-1005, Topographic Surveying: This reference is attached to and made part of this contract. This reference is available at the following Internet Address http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-1-1005/toc.htm and made part of this contract.

USACE EM 1110-1-1002, Survey Markers and Monumentation: This reference is available at the following Internet address http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-1-1002/toc.htm.

Spatial Data Standards (SDS): This reference is available at the following Internet address http://tsc.wes.army.mil/.

ASPRS: American Society for Photogrammetry and Remote Sensing accuracy standards for large-scale maps. Digital Elevation Model Technologies and Applications: The DEM Users Manual.

SCOPE OF WORK
Professional surveying, mapping and related services to be performed under this contract are defined below. Unless otherwise indicated in this contract, each required service shall include field-to-finish effort. All mapping work will be performed using appropriate instrumentation and procedures to establishing control, field data acquisition, and compilation in accordance with the functional accuracy requirements to include all quality control associated with these functions. The work will be accomplished in accordance with surveying and mapping criteria contained in the technical references, except as modified or amplified herein.

The three-dimensional digital topographic map will be compiled in meters at a scale of 1:600, with ¼-meter (25 cm) contours. The mapping area is outlined on the attached map. All planimetric features will be shown. This includes, but is not limited to buildings, sidewalks, roadways, parking areas (including type such as gravel, paved, concrete, etc.), visible utilities, trees, road culverts (including type, size and inverts). Rim, ground surface and invert elevations and pipe sizes at sanitary manholes, cleanouts, storm manholes, inlets and catch basins, location of fire hydrants and water valves, location and type of fences and walls will be shown.

A referenced baseline with a minimum of two points will be established adjacent to each site. The location of the baseline will be set in an area that will not be disturbed. At least two benchmarks will be set within the map area. The baseline stations and benchmarks will be referenced and described. The Corps will supply survey disks on 30" aluminum rods and witness posts for the baselines. A spike in a pole, or chiseled square in a headwall, etc. will suffice for benchmarks. Real estate boundary monuments may be used as baseline monuments and TBMs. The descriptions of the baselines and benchmarks will be shown in the digital file on a separate level. In addition to showing the descriptions in the digital file, a hard copy of the descriptions will be submitted with the project report.

The coordinates of the mapping projects will be tied to the Ohio (North Zone) State Plane Coordinate System NAD83 and vertically tied to NAVD 1988.

PROJECT DELIVERABLES

The contractor will submit the final topographic map in digital format. The digital map will be submitted in MicroStation format, (*.dgn) on 3 ½" diskette or CD-ROM. The file will be created in MicroStation and not translated from other CADD software. The digital file will be created in 3-D with the topographic and planimetric elements placed at their actual X & Y coordinate locations. The global origin will be 0,0 and the working units will be 1000:1.The Louisville District Corps of Engineers CADD standards will be used. These standards contain the correct cell libraries, symbology and level assignments, colors, line weights, etc.

A project report will be compiled. This report will contain a general statement of the project, existing geodetic control used to establish new monumentation, condition of existing monuments, baseline and TBM descriptions and references, amount of adjustments, procedures and equipment used, all file names, any special features unique to this particular project, and personnel performing the surveying and mapping.

All field notes will be submitted in a standard bound survey field book or if electronic data collection methods were employed, all digital raw data files, in ASCII format will be submitted. If electronic data collection was the method of choice for capturing the information, the final X, Y & Z coordinate file, in ASCII format, will be submitted with the raw data file.

A metadata file describing the project. If necessary, the Government will supply Corpsmet software. Corpsmet is a program that puts metadata information into the proper format so it may be submitted to the national spatial data clearinghouse.

QUALITY CONTROL

A quality control plan will be developed and submitted. The quality control plan will describe activities taken to ensure the overall quality of the project.

The accuracy of the mapping will meet or exceed ASPRS map accuracy class 2.

Map verification will be performed at each site. The verification will be accomplished by collecting coordinates for 10 random points at each site and comparing them with the coordinates of the same points on the finished map. The random points will not be used to compile the finished map. Differences between the field-test information and the finished map will be compared with differences allowed by ASPRS map accuracy class 2 standards. Any areas found to be out of compliance must be corrected before submittal. A summary of the actual vs. allowable differences along with a statement that mapping meets ASPRS map accuracy class 2 standards will be provided with the data.

SAFETY
Every safety measure feasible will be taken to insure the safety of the field personnel involved in this survey. All requirements of the U.S. Army Corps of Engineers EM 385-1-1, titled SAFETY AND HEALTH REQUIREMENTS MANUAL will be maintained.

SCHEDULE
All work will be completed and submitted by 15 May 2002. All information developed by the contractor during the course of this work will be the property of the United States Government, acting through the U.S. Army Corps of Engineers, Louisville District. Such information will not be released to others without the express written permission of the Corps of Engineers.

13-6. Government Cost Estimate for a Task Order

The following is an example of a cost estimate prepared for a small (4 day) topographic surveying project in Tulsa District. A more formal IGE is not required; however, the format shown on this informal estimate would be similar to that followed for an IGE. Labor and overhead rates are taken from the price schedule in the basic IDC contract. The 12% profit was computed for this task order using a weighted guideline method described in the next paragraph.

CONTRACT NO. DACW56-01-D-0000
TASK ORDER NO. 16

PAT MAYSE LAKE SCOUR AREA ALONG RIVER
TOPOGRAPHIC SURVEY
COST ESTIMATE
08JAN03

1. ESTIMATED FIELD TIME				
	PERSONNEL IN FIELD CREW		2	Crew
	RECON AND ACCESS TO SITE		0.5	DAYS
	ACCOMPLISH REQUIRED SURVEY		2.5	DAYS
	TRAVEL		1	DAYS
	TOTAL DAYS		**4**	
2. DIRECT LABOR COSTS:				
A).	Project Manager			
2	Hrs x Rate	$26.00	$52.00	
B).	Project Field Supervisor			
32	Hrs x Rate	$25.00	$800.00	
C).	Instrument Man			
32	Hrs x Rate	$16.00	$512.00	
D).	Cad Technician			
20	Hrs x Rate	$17.00	$340.00	
Total Direct Labor Costs			**$1,704.00**	
3. OVERHEAD (Direct + G&A)				
115.00%	Direct Labor	$1,704.00	**$1,959.60**	
4. PROFIT (Direct Labor + Overhead)				
12.00%	of L + O.H.	$3,663.60	**$439.63**	
5. INDIRECT COSTS				
A). Survey Vehicle				
4	Days x Rate	$120.00	$480.00	
B). Per Diem				
4	Days x Rate x $103.00 x	2Men	$824.00	
	Total In-Direct Cost----------------------		**$1,304.00**	
6. TOTAL COST ESTIMATE--			**$5,407.23**	

The above time estimate allows 1 day for travel to/from the job site. This is paid at the crew rates instead of a separate mob/demob line item. The hourly rates from the basic IDC schedule do not include overheads--these are applied on the task order estimate as shown above. There is no separate estimate for survey instruments--this equipment is assumed to be included in the overhead. The 12% profit on this task order was computed and documented as shown on the following memorandum. Note that many Districts do not compute a profit for each task order as shown here. A profit is computed and negotiated when the initial IDC is set up. This constant profit will be used to cover the entire basic IDC--under the assumption that all the task orders that will be performed over the entire (3-year) contract period is of similar complexity, length, etc. Note also that profit was not computed on the "indirect costs" shown in the above Tulsa District cost estimate. Normally, profit is computed on the total estimated cost of a work order, including travel and transportation costs.

ALTERNATE STRUCTURED APPROACH CALCULATIONS
ARCHITECT-ENGINEER CONTRACTS
(Reference EFARS 15.404-73-101)

Project Description: Pat Mayse Lake Scour Erosion Area Topographic Survey

Project Schedule: The contractor is to commence with the project within one week (7 days) of award and final delivery made to the Government within 14 calendar days from date of award.

Element	**Range**	**Weight**		
Technical Complexity	0.05 - 0.10	0.090		
Length	0.02 - 0.04	0.030		
Socioeconomic Factors	0.00 - 0.02	0.000		
TOTAL		0.120	=	**12.00%**

For another example of a cost estimate on an IDC task order, see Appendix G (*Application: Topographic Survey of Hannibal Lock & Dam--Proposed Nationwide DGPS Antenna Site (Pittsburgh District)*).

13-7. A-E Services Request for Task Order Issuance

The following is an example of an internal action request to initiate contracting action to finalize the task order award. If the A-Es price proposal has been received, it would be attached to this memorandum along with the sample Technical Analysis memorandum shown below. Appropriate District elements responsible for negotiation and award would take action on this request.

ARCHITECT-ENGINEER SERVICES REQUEST

1. Negotiation and award of Architect-Engineer services is required for the following contract action:

   Location: Pat Mayse Lake Scour Erosion Sanders Creek

   Project: Topographic Survey

   Contract Number: DACW56-01-D-0000

   Task Order/Modification Number: 00-16

   Architect-Engineer Firm: ************* Surveyors, Inc.

   A-E Phone: (800) 123-4567 A-E Fax: (888) 123-4567

   A-E Point of Contact (if known): ****************, PLS

2. The "DRAFT" Scope of Work is attached.

3. An appropriate Site History is attached.

4. The Approved Government Estimate is attached (~~or will be provided no later than ________~~).

5. The Project Execution Plan (PEP) Board Memorandum or waiver is attached for HTRW contract actions.

6. This contract action must be awarded absolutely no later than 24Jan03
   for the following reason/s: ____

7. Purchase Request and Commitment Number _______________ has been approved and certified for this action and is attached. It will be amended for the total award amount following negotiations.

8. The Estimated Construction Cost (if applicable) is $____________.

9. The Project Manager is Marjorie Courtright, PLS at extension 7574.

10. Additional Remarks:

   Project Engineer: Bob Goranson
   Section: CESWT-EC-CD
   Extension: (918) 669-7
   Requesting Org: CESWT-EC-DD
   Date: 08Jan03

NOTE: Attachments should be via printed and electronic copies.

Pat Mayse Lake Scour Erosion Area Sanders Creek Topographic Survey
DACW56-01-D-1005
Task Order 16
Technical Analysis
Request for Proposal Results
14 Jan 03

Please note the following concerning the above referenced:

The lump sum cost estimate provided by *********, Inc. was more than the Corps projected cost by $ 96.32. This difference was a result of their firm estimating per diem time for the CADD Technician field crew time (this is acceptable since they considered no time for a Project Manager and less percent profit). The contractor has a clear understanding of what is required to perform the requested duties and the rates presented are correct as per contract DACW56-01-D-1005. It is therefore my opinion that we award *********, Inc. this task order #16.

PR & C #30130313 has been amended and certified for the final amount of $ 5,504.00.

Marjorie Ellenberg Courtright, PLS

13-8. Labor Hour Task Orders for Construction Surveying Services

Fixed-price task orders under IDC are effectively used to provide a substantial amount of surveying and mapping services in USACE. However, fixed-price task orders are not usually appropriate for quality assurance and payment surveys of ongoing construction projects since the duration of the survey work is not within the control of the survey contractor. The surveyor contractor's progress is dependent on the progress of the construction contractor, which in turn, depends on weather, equipment malfunctions, unforeseen site conditions, material availability, labor problems, and many other factors. In such cases, a labor-hour task order is a very useful contracting mechanism. Labor-hour contracts (guidance also applicable to task orders) are covered in Federal Acquisition Regulation (FAR) Subpart 16.6. Labor-hour task orders are appropriate when the uncertainties involved in contract performance do not permit costs to be anticipated with sufficient accuracy or confidence to use a fixed-price task order. The contractor is required to apply its best efforts, but is not obligated to complete the assigned work within the task order ceiling price. Hence, a higher level of surveillance is required by the Government to ensure the contractor is performing as efficiently as possible and cost controls are being used. No special approvals are required to use labor-hour task orders, but the contracting officer must execute a determination and findings for the contract file explaining why no other contract type is suitable. There is no true negotiation, but rather an agreement on a realistic ceiling price considering the most likely conditions. All hourly costs for personnel and equipment (including direct overhead, G&A, and profit) are already established in the contract. The Government buys a certain amount of effort and has considerable control over how that effort is expended toward completion of the specified task. The Government can direct the contractor to start, pause, and stop work, within reasonable limitations. However, the Government bears the cost for disruptions in work. A labor-hour task order has the flexibility to follow the progress of the construction, without unfairly holding the survey contractor to a fixed price. The most cost-effective situation is where there is more than one project in the same area that can be surveyed using one task order. If there is a delay on one project, the survey crew can relocate to another project and resume work with minimal lost time. The following is an example of a Labor Hour task order scope.

LABOR HOUR TASK ORDER

Furnish all personnel, plant, equipment, transportation and materials necessary to perform, process and deliver the survey data described herein for construction stakeout and payment surveys in the following work areas in accordance with the general instructions and conditions set forth in Contract DACWXX-XX-D-XXXX:

- [List projects or work areas. Attach marked-up maps if needed. Describe work.]

Since it is not possible to accurately estimate the extent or duration of this work, this order will be issued on an estimated, not-to-exceed basis. The estimated quantities and ceiling price in accordance with the established contract rate schedule are as follows:

3-Person survey crew @ $---/hour x [___] hours = $ __________
Project manager @ $---/hour x [___] hours = $__________

Ceiling price $ __________

It is estimated that this work will begin about [__(date)__] and be completed about [__(date)__]. The contracting officer's representative (COR) at the [______] Project Office will advise the contractor at least [___] hours in advance of when work must begin. The contractor may be directed to stop work at any time due to circumstances beyond the Government's control. If work is stopped at a work area, the contractor may be directed to relocate and start (or continue) work at one of the other work areas covered by this order, or to demobilize and return to the contractor's office. The contractor will be compensated at the hourly contract crew rate while stopped, relocating to another work area, demobilizing, or remobilizing (if required). There will be no compensation while the contractor is demobilized. The COR will advise the contractor at least [___] hours in advance of when the contractor must remobilize and resume work.

The contractor will prosecute the work diligently and efficiently under the general direction and oversight of the COR. The contractor will provide a daily report, describing the work performed and hours worked, to the COR for certification. The daily reports will be used by the contractor to prepare monthly payment vouchers. With each monthly payment voucher, the contractor will estimate monthly and total earnings in the succeeding month, expressed both as total dollars and a percentage of the ceiling price.

The contractor will immediately notify the COR in writing when total estimated earnings reach 85 percent of the ceiling price. Also, if at any time the contractor projects that the total estimated earnings to complete the work will exceed the ceiling price, the contractor will promptly notify the COR and give a revised estimated total price with supporting reasons and documentation. The contracting officer will increase the ceiling price in writing if warranted or limit the work so as to remain within the current ceiling price. Exceeding the ceiling price is at the contractor's own risk.

[Insert technical requirements and deliverables.]

13-9. Hired-Labor Survey Cost Estimates

Cost estimates for USACE field forces engaged in topographic surveys are developed similarly to those for contracted field survey work described above. Normally, an average daily rate of personnel, travel, per diem, and equipment is established. Personnel labor costs are determined identically to those described above for A-E survey force labor--overheads are applied to the base wage rate of the government employee. Field crew personnel costs include direct labor, fringe benefits, technical indirect overhead, and direct overhead costs. Expenses for instrumentation and plant differ from commercial accounting methods since these charges are dependent on the method by which they were expensed at initial purchase. Equipment may be expensed against a single project account, or indirectly expensed against multiple projects. Land plant, floating plant, survey instrumentation, and CADD/computer systems may have established rental rates based on a revolving fund accounting process. Plant rental and survey equipment rental rates are usually developed at the time of purchase (or lease) may be periodically updated based on actual utilization rates as charged against projects. Various Plant Replacement and Improvement Program (PRIP) costs make up the expense. These daily plant rental rates may be recomputed annually, or more often if utilization changes significantly. The survey crew rate should also be periodically recomputed so that accurate and current cost estimates can be provided to requesting elements in a District.

Appendix L
Glossary

L-1. Abbreviations and Acronyms

1D .... One Dimensional
2D .... Two-dimensional
2DRMS .... Twice the distance root mean square
3D .... Three-dimensional
A-E .... Architect-Engineer
A/E/C........................... Architect/Engineer/Construction
ACSM.......................... American Congress on Surveying and Mapping
ADA .... Air Defense Artillery
AFB .... Air Force Base
ALTA .... American Land Title Association
AM/FM........................ Automated Mapping/ Facility Mapping
AOC .... Aircraft Obstruction Surveys
ARP .... Antenna Reference Point
ASCE........................... American Society of Civil Engineers
ASPRS......................... American Society for Photogrammetry and Remote Sensing
BFE.............................. Base Flood Elevation
BLM .... Bureau of Land Management
BS .... Backsight
CADD.......................... Computer Aided Drafting and Design
CAiCE .... Computer Aided Civil Engineering
CALTRANS................ California Department of Transportation
CEFMS........................ Corps of Engineers Financial Management System
COGO.......................... Coordinate Geometry
CONUS. .... CONtinental United States
CORPSCON................ CORPS CONvert
CORS .... Continuously Operating Reference Stations
COR............................. Contracting Officer's Representative
DA .... Department of the Army
DE................................ Difference in Elevation
DEM .... Digital Elevation Model
DOD .... Department of Defense
DOT............................. Department of Transportation
DFARS. .... Defense Federal Acquisition Regulation Supplement
DGPS........................... Differential Global Positioning System
DTM .... Digital Terrain Model
EAC............................. Echelons Above Corps
EDM .... Electronic Distance Measurement
EFARS......................... Engineer Federal Acquisition Regulation Supplement
EM .... Engineer Manual
ERM .... Elevation Reference Mark
ERDC .... Engineer Research and Development Center
E&D. .... Engineering and Design
FA .... Field Artillery
FAA .... Federal Aviation Administration
FAC .... Florida Administrative Code

FAR .... Federal Acquisition Regulations
FAR .... Federal Aviation Regulation
FEMA .... Federal Emergency Management Agency
FFP .... Firm Fixed Price
FGCS .... Federal Geodetic Control Subcommittee
FGDC .... Federal Geographic Data Committee
FIRM .... Flood Insurance Rate Map
FIS .... Flood Insurance Study
FLSA .... Fair Labor Standards Act
FM .... Field Manual
FMSFIE .... Facility Management Standard for Facilities, Infrastructure, and Environment
FOA .... Field Operating Activity
FS.................................. Foresight
G&A .... General and Administrative
GDOP .... Geometric Dilution of Position
GIS................................ Geographic Information System
GPS............................... Global Positioning System
GRS 80 .... Geodetic Reference System of 1980
GS .... General Support
GSA .... General Services Administration
GZD.............................. Grid Zone Designator
HARN .... High Accuracy Regional Networks
HI.................................. Height of Instrument
HDOP .... Horizontal Dilution of Position
HPGN .... High Precision Geodetic Networks
HR .... Height of Reflector
HT................................. Height of Target
HTRW .... Hazardous, Toxic, or radioactive Waste
HQUSACE .... Headquarters, US Army Corps of Engineers
IDC. .... Indefinite Delivery Contract
IERS .... International Earth Rotation Service
IGE .... Independent Government Estimate
IGLD 55 .... International Great Lakes Datum of 1955
IGLD 85 .... International Great Lakes Datum of 1985
ILS .... Instrument Landing System
INT .... Intersection
ITL................................ Information Technology Lab
ITRF .... International Terrestrial Reference Frame
JTR .... Joint Travel Regulation
KO .... Contracting Officer
LCC .... Lambert Conformal Conic
LEC .... Linear Error of Closure
LIDAR.......................... LIght Detection And Ranging
LWRP........................... Low Water Reference Plane
MACOM .... Major Army Command
MDL .... MicroStation Design Language
MGRS........................... Military Grid-Reference System
MHW............................ Mean High Water
MLLW.......................... Mean Lower Low Water
MLRS .... Multiple Launch Rocket System
MLS.............................. Microwave Landing System

MSL.............................. Mean Sea Level
MSL1912...................... Mean Sea Level Datum of 1912
NAD 27 .... North American Datum of 1927
NAD 83 .... North American Datum of 1983
NADCON .... North American Datum Conversion
NAS.............................. National Airspace System
NAVAID .... Navigation Aid
NAVD 88 .... North American Vertical Datum 1988
NDGPS......................... Nationwide Differential GPS
NFIP .... National Flood Insurance Program
NGRS .... National Geodetic Reference System
NGS .... National Geodetic Survey
NGVD 29 .... National Geodetic Vertical Datum 1929
NMAS .... National Map Accuracy Standard
NMP .... National Mapping Program
NOAA .... National Oceanic and Atmospheric Administration
NOS .... National Ocean Service
NSRS........................... National Spatial Reference System
NSSDA......................... National Standard for Spatial Data Accuracy
NVCN.......................... National Vertical Control Network
OCONUS .... Outside the Continental United States
OHWM......................... Ordinary High Water Mark
OPUS........................... On-Line Positioning User Service
OTF .... On-the-Fly
P&S .... Plans and Specifications
PADS........................... Position and Azimuth Determination System
PBM .... Permanent Benchmark
PDOP........................... Position Dilution of Position
PDSC........................... Professional Development Support Center
PI .... Point of Intersection
PLGR........................... Precise Lightweight Geodetic Receiver
PM .... Project Manager or Management
POB .... Point of Beginning
POI .... Point on Line
POT .... Point of Tangency
PPRTK .... Post-Processed Real-Time Kinematic
ppm.............................. Parts per Million
PR&C .... Purchase Request & Commitment
PRIP .... Plant Replacement and Improvement Program
PROSPECT .... Proponent Sponsored Engineer Corps Training
PVT .... Point of Vertical Tangent
QA .... Quality Assurance
QC .... Quality Control
RFP.............................. Request for Proposal
RMS .... Root mean Square
RMSE.......................... Root Mean Square Error
RTK............................. Real Time Kinematic
SCP.............................. Survey Control Point
SDSFIE........................ Spatial Data Standard for Facilities, Infrastructure, and Environment
SDTS .... Spatial Data Transfer Standard
SI .... International System of Units

SOW .... Scope or Statement of Work
SPCE .... Survey Planning and Coordination Element
SPCS .... State Plane Coordinate System
TA................................. Target Acquisition
TBM .... Temporary Benchmark
TDS .... Tripod Data Systems
TDSE............................ Touchdown Zone Elevation
TEC .... Topographic Engineering Center
TIN .... Triangular Irregular Network
TM .... Transverse Mercator
TGO.............................. Trimble Geomatics Office
TP .... Turning Point
TSC............................... Trimble Survey Controller
US .... United States
USACE .... US Army Corps of Engineers
USARC......................... US Army Reserve Center
USC&GS .... US Coast & Geodetic Survey
USCG .... US Coast Guard
USFS .... US Forest Service
USGS............................ US Geological Survey
USNAVOCEANO........ US Navy Oceanographic Office
USNG .... US National Grid
UTM .... Universal Transverse Mercator
VDOP .... Vertical Dilution of Position
VERTCON .... VERTical CONversion
VLBI............................. Very-Long-Baseline-Interferometry
WAAS .... Wide Area Augmentation System
WGS 84 .... World Geodetic System of 1984
WRDA.......................... Water Resources Development Act
XREF............................ External Reference
ZD................................. Zenith Distance

L-2. Terms

Absolute or Autonomous GPS
Operation with a single receiver for a desired position. This receiver may be positioned to be stationary over a point. This mode of positioning is the most common military and civil application.

Accuracy
The degree to which an estimated (mean) value is compatible with an expected value. Accuracy implies the estimated value is unbiased.

Adjustment
Adjustment is the process of estimation and minimization of deviations between measurements and a mathematical model.

Altimeter
An instrument that measures elevation differences usually based on atmospheric pressure measurements.

Altitude
The vertical angle between the horizontal plane of the observer and a directional line to the object.

Angle of Depression
A negative altitude.

Angle of Elevation
A positive altitude.

Angular Misclosure
Difference in the actual and theoretical sum of a series of angles.

Archiving
Storing of documents and information.

Astronomical Latitude
Angle between the plumb line and the plane of celestial equator. Also defined as the angle between the plane of the horizon and the axis of rotation of the earth. Astronomical latitude applies only to positions on the earth and is reckoned from the astronomic equator, north and south through 90E. Astronomical latitude is the latitude that results directly from observations of celestial bodies, uncorrected for deflection of the vertical.

Astronomical Longitude
Arbitrarily chosen angle between the plane of the celestial meridian and the plane of an initial meridian. Astronomical longitude is the longitude that results directly from observations on celestial bodies, uncorrected for deflection of the vertical.

Astronomical Triangle
A spherical triangle formed by arcs of great circles connecting the celestial pole, the zenith and a celestial body. The angles of the astronomical triangles are: at the pole, the hour angle; at the celestial body, the parallactic angle; at the zenith, the azimuth angle. The sides are: pole to zenith, the co-latitude; zenith to celestial body, the zenith distance; and celestial body to pole, the polar distance.

Atmospheric Refraction
Refraction of electromagnetic radiation through the atmosphere causing the line-of-sight to deviate from a straight path. Mainly temperature and pressure conditions determine the magnitude and direction of curvature affecting the path of light from a source. Refraction causes the ray to follow a curved path normal the surface gradient.

Azimuth
The horizontal direction of a line clockwise from a reference plane, usually the meridian. Often called forward azimuth to differentiate from back azimuth.

Azimuth Angle
The angle less than 180° between the plane of the celestial meridian and the vertical plane with the observed object, reckoned from the direction of the elevated pole. In astronomic work, the azimuth angle is the spherical angle at the zenith in the astronomical triangle, which is composed of the pole, the zenith and the star. In geodetic work, it is the horizontal angle between the celestial pole and the observed terrestrial object.

Azimuth Closure
Difference in arc-seconds of the measured or adjusted azimuth value with the true or published azimuth value.

Backsight
A sight on a previously established traverse or triangulation station and not the closing sight on the traverse. A reading on a rod held on a point whose elevation has been previously determined.

Barometric Leveling
Determining differences of elevation from measured differences of atmospheric pressure observed with a barometer. If the elevation of one station above a datum is known, the approximate elevations of other station can be determined by barometric leveling. Barometric leveling is widely used in reconnaissance and exploratory surveys.

Baseline
Resultant three-dimensional vector between any two stations with respect to a given coordinate system. The primary reference line in a construction system.

Base net
The primary baseline used for densification of survey stations to form a network.

Base Points
The beginning points for a traverse that will be used in triangulation or trilateration.

Base Control
The horizontal and vertical control points and coordinates used to establish a base network. Base control is determined by field surveys and permanently marked or monumented for further surveys.

Bearing
The direction of a line with respect to the meridian described by degrees, minutes, and seconds within a quadrant of the circle. Bearings are measured clockwise or counterclockwise from north or south, depending on the quadrant.

Benchmark
A permanent material object, natural or artificial, on a marked point of known elevation.

Best Fit
To represent a given set of points by a smooth function, curve, or surface which minimizes the deviations of the fit.

Bipod
A two-legged support structure for an instrument or survey signal at a height convenient for the observer.

Bluebook
Another term for the "FGCS Input Formats and Specifications of the National Geodetic Data Base".

Blunder
A mistake or gross error.

Bureau International de l'Heure
The Bureau was founded in 1919 and its offices since then have been at the Paris Observatory. By an action of the International Astronomical Union, the BIH ceased to exist on 1 January 1988 and a new organization, the International Earth Rotation Service (IERS) was formed to deal with determination of the Earth's rotation.

Cadastral Survey
Relates to land boundaries and subdivisions, and creates units suitable for transfer or to define the limitations of title. The term cadastral survey is now used to designate the surveys of the public lands of the US, including retracement surveys for identification and resurveys for the restoration of property lines; the term can also be applied properly to corresponding surveys outside the public lands, although such surveys are usually termed land surveys through preference.

Calibration
Determining the systematic errors in an instrument by comparing measurements with correct values. The correct value is established either by definition or by measurement with a device that has itself been calibrated or of much higher precision.

Cartesian Coordinates
A system with its origin at the center of the earth and the x and y and z axes in the plane of the equator. Typically, the x-axis passes through the meridian of Greenwich, and the z-axis coincides with the earth's axis of rotation. The three axes are mutually orthogonal and form a right-handed system.

Cartesian System
A coordinate system consisting of axes intersecting at a common point (origin). The coordinate of a point is the orthogonal distance between that point and the hyperplane determined by all axes. A Cartesian coordinate system has all the axes intersecting at right angles, and the system is called a rectangular.

Celestial Equator
A great circle on the celestial sphere with equidistant points from the celestial poles. The plane of the earth's equator, if extended, would coincide with that of the celestial equator.

Celestial pole
A reference point at the point of intersection of an indefinite extension of the earth's axis of rotation and the apparent celestial sphere.

Celestial sphere
An imaginary sphere of infinite radius with the earth as a center. It rotates from east to west on a prolongation of the earth's axis.

Central Meridian
A line of constant longitude at the center of a graticule. The central meridian is used as a base for constructing the other lines of the graticule. The meridian is used as the y-axis in computing tables for a State Plane Coordinate system. That line, on a graticule, which represents a meridian and which is an axis of symmetry.

Chain
Equal to 66 feet or 100 links. The unit of length prescribed by law for the survey of the US public lands. One acre equals 10 square chains.

Chained Traverse
Observations and measurements performed with tape.

Chaining
Measuring distances on the ground with a graduated tape or with a chain.

Chart Datum
Reference surface for soundings on a nautical chart. It is usually taken to correspond to a low water elevation, and its depression below mean sea level is represented by the symbol Z_o. Since 1989, chart datum has been implemented to mean lower low water for all marine waters of the US its territories, Commonwealth of Puerto Rico and Trust Territory of the Pacific Islands.

Chi-square Testing
Non-parametric statistical test used to classify the shape of the distribution of the data.

Chronometer
A portable timekeeper with compensated balance, capable of showing time with extreme precision and accuracy.

Circle Position
A prescribed setting (reading) of the horizontal circle of a direction theodolite, to be used for the observation on the initial station of a series of stations that are to be observed.

Circuit Closure
Difference between measured or adjusted value and the true or published value.

Clarke 1866 Ellipsoid
The reference ellipsoid used for the NAD 27 horizontal datum. It is a non-geocentric ellipsoid formerly used for mapping in North America.

Closed Traverse
Starts and ends at the same point or at stations whose positions have been determined by other surveys.

Collimation
A physical alignment of a survey target or antenna over a mark or to a reference line.

Collimation Error
The angle between the actual line of sight through an optical instrument and an alignment.

Compass Rule
The correction applied to the departure (or latitude) of any course in a traverse has the same ratio to the total misclosure in departure (or latitude) as the length of the course has to the total length of the traverse.

Confidence Level

Statistical probability (in percent) based on the standard deviation or standard error associated with the normal probability density function. The confidence level is assigned according to an expansion factor multiplied by the magnitude of one standard error. The expansion factor is based on values found in probability tables at a chosen level of significance.

Conformal
Map projection that preserves shape.

Contour
An imaginary line on the ground with all points at the same elevation above or below a specified reference surface.

Control
Data used in geodesy and cartography to determine the positions and elevations of points on the earth's surface or on a cartographic representation of that surface. A collective term for a system of marks or objects on the earth or on a map or a photograph whose positions or elevation are determined.

Control Densification
Addition of control throughout a region or network.

Control Monuments
Existing local control or benchmarks that may consist of any Federal, state, local or private agency points.

Control Point
A point with assigned coordinates is sometimes used as a synonym for control station. However, a control point need not be realized by a marker on the ground.

Control Survey
A survey which provides coordinates (horizontal or vertical) of points to which supplementary surveys are adjusted.

Control Traverse
A survey traverse made to establish control.

Conventional Terrestrial Pole (CTP)
The origin of the WGS 84 Cartesian system is the earth's center of mass. The Z-axis is parallel to the direction of the CTP for polar motion, as defined by the Bureau of International de l'Heure (BIH), and equal to the rotation axis of the WGS 84 ellipsoid. The X-axis is the intersection of the WGS 84 reference meridian plane and the CTP's equator, the reference meridian being parallel to the zero meridian defined by the BIH and equal to the X-axis of the WGS 84 ellipsoid. The Y-axis completes a right-handed, earth-centered, earth-fixed orthogonal coordinate system, measured in the plane of the CTP equator 90 degrees east of the X-axis and equal to the Y-axis of the WGS 84 ellipsoid.

Coordinate Transformation
A mathematical process for obtaining a modified set of coordinates through some combination of rotation of coordinate axes at their point of origin, change of scale along coordinate axes, or translation through space

CORPSCON
(Corps Convert) Software package (based on NADCON) capable of performing coordinate transformations between NAD 83 and NAD 27 datums.

Crandall Method
Traverse misclosure in azimuth or angle is first distributed in equal portions to all the measured angles. The adjusted angles are then held fixed and all remaining coordinate corrections distributed among the distance measurements.

Cross sections
A survey line run perpendicular to the alignment of a project, channel or structure.

Curvature
The rate at which a curve deviates from a straight line. The parametric vector described by dt/ds, where t is the vector tangent to a curve and s is the distance along that curve.

Datum
Any numerical or geometrical quantity or set of such quantities which serve as a reference or base for other quantities.

Declination
The angle, at the center of the celestial sphere, between the plane of the celestial equator and a line from the center to the point of interest (on a celestial body).

Deflection of the Vertical
The spatial angular difference between the upward direction of a plumb line and the normal to the reference ellipsoid. Often expressed in two orthogonal components in the meridian and the prime vertical directions.

Deflection Traverse
Direction of each course measured as an angle from the direction of the preceding course.

Deformation Monitoring
Observing the movement and condition of structures by describing and modeling its change in shape.

Departure
The orthogonal projection of a line onto an east-west axis of reference. The departure of a line is the difference of the meridional distances or longitudes of the ends of the line.

Differential GPS
Process of measuring the differences in coordinates between two receiver points, each of which is simultaneously observing/measuring satellite code ranges and/or carrier phases from the NAVSTAR GPS constellation. Relative positioning with GPS can be performed by a static or kinematic modes.

Differential Leveling
The process of measuring the difference of elevation between any two points by spirit leveling.

Direction
The angle between a line or plane and an arbitrarily chosen reference line or plane. At a triangulation station, observed horizontal angles are referred to a common reference line and termed horizontal direction. A line, real or imaginary, pointing away from some specified point or locality toward another point. Direction has two meanings: that of a numerical value and that of a pointing line.

Direct Leveling
The determination of differences of elevation through a continuous series of short horizontal lines. Vertical distances from these lines to adjacent ground marks are determined by direct observations on graduated rods with a leveling instrument equipped with a spirit level.

Distance Angle
An angle in a triangle opposite a side used as a base in the solution of the triangle, or a side whose length is to be computed.

Dumpy Level
The telescope permanently attached to the leveling base, either rigidly to by a hinge that can be manipulated by a micrometer screw.

Earth-Centered Ellipsoid
Center at the Earth's center of mass and minor semi-axis coincident with the Earth's axis of rotation.

Easting
The distance eastward (positive) or westward (negative) of a point from a particular meridian taken as reference.

Eccentricity
The ratio of the distance from the center of an ellipse to its focus on the major semi-axis.

Electronic Distance Measurement (EDM)
Timing or phase comparison of electro-magnetic signal to determine an interferometric distance.

Elevation
The height of an object above some reference datum.

Ellipsoid
Formed by revolving an ellipse about its minor semi-axis. The most commonly used reference ellipsoids in North America are: Clarke 1866, Geodetic Reference System of 1980 (GRS 80), World Geodetic System of 1972 (WGS 72) and World Geodetic System of 1984 (WGS 84).

Ellipsoid height
The magnitude h of a point above or below the reference ellipsoid measured along the normal to the ellipsoid surface.

Error
The difference between the measured value of a quantity and the theoretical or defined value of that quantity.

Error Ellipse
An elliptically shaped region with dimensions corresponding to a certain probability at a given confidence level.

Error of Closure
Difference in the measured and predicted value of the circuit along the perimeter of a geometric figure.

Finite Element Method
Obtaining an approximate solution to a problem for which the governing differential equations and boundary conditions are known. The method divides the region of interest into numerous, interconnected sub-regions (finite elements) over which simple, approximating functions are used to represent the unknown quantities.

Fixed Elevation
Adopted as a result of tide observations or previous adjustment of spirit leveling, and which is held at its accepted value in any subsequent adjustment.

Foresight
An observation to the next instrument station. The reading on a rod that is held at a point whose elevation is to be determined.

Frequency
The number of complete cycles per second existing in any form of wave motion.
Geodesic Line
Shortest distance between any two points on any mathematically defined surface.

Geodesy
Determination of the time-varying size and figure of the earth by such direct measurements as triangulation, leveling and gravimetric observations.

Geodetic Control
Established and adjusted horizontal and/or vertical control in which the shape and size of the earth have been considered in position computations.

Geodetic Coordinates
Angular latitudinal and longitudinal coordinates defined with respect to a reference ellipsoid.

Geodetic Height
See Ellipsoid height.

Geodetic Latitude
The angle which the normal at a point on the reference ellipsoid makes with the plane of the equator.

Geodetic Leveling
The observation of the differences in elevation by means of a continuous series of short horizontal lines of sight.

Geodetic Longitude
The angle subtended at the pole between the plane of the geodetic meridian and the plane of a reference meridian (Greenwich).

Geodetic North
Direction tangent to a meridian pointing toward the pole defining astronomic north, also called true north.

Geodetic Reference System of 1980
Reference ellipsoid used to establish the NAD 83 system of geodetic coordinates.

Geoid
An equipotential surface of the gravity field approximating the earth's surface and corresponding with mean sea level in the oceans and its extension through the continents.

GPS (Global Positioning System)
DoD satellite constellation providing range, time, and position information through a GPS receiver system.

Gravimeter
Instrument for measuring changes in gravity between two points.

Gravity
Combined acceleration potential of an object due to gravitation and centrifugal forces.

Greenwich Meridian
The astronomic meridian through the center of the Airy transit instrument of the Greenwich Observatory, Greenwich, England. By international agreement in 1884, the Greenwich meridian was adopted as the meridian from which all longitudes, worldwide, would be calculated.

Grid Azimuth
The angle in the plane of projection between a straight line and the line (y-axis) in a plane rectangular coordinate system representing the central meridian. While essentially a map-related quantity, a grid azimuth may, by mathematical processes, be transformed into a survey- related or ground-related quantity.

Grid Inverse
The computation of length and azimuth from coordinates on a grid.

Grid Meridian
Line parallel to the line representing the central meridian or y-axis of a grid on a map. The map line parallel to the line representing the y-axis or central meridian in a rectangular coordinate system.

Gunter's Chain
A measuring device once used in land surveying. It was composed of 100 metallic links fastened together with rings. The total length of the chain is 66 feet. Also called a four-pole chain.

Gyrotheodolite
A gyroscopic device used to measure azimuth that is built-in or attached to a theodolite.

Histogram
A graphical representation of relative frequency of an outcome partitioned by class interval. The frequency of occurrence is indicated by the height of a rectangle whose base is proportional to the class interval.

Horizontal Control
Determines horizontal positions with respect to parallels and meridians or to other lines of reference.

Hour Circle
Any great circle on the celestial sphere whose plane is perpendicular to the plane of the celestial equator.

Index Error
A systematic error caused by deviation of an index mark or zero mark on an instrument having a scale or vernier, so that the instrument gives a non-zero reading when it should give a reading of zero. The distance error from the foot of a leveling rod to the nominal origin (theoretical zero) of the scale.

Indirect Leveling
The determination of differences of elevation from vertical angles and horizontal distances.

Interior Angle
An angle between adjacent sides of a closed figure and lying on the inside of the figure. The three angles within a triangle are interior angles.

International Foot
Defined by the ratio 30.48/100 meters.

International System of Units (SI)
A self-consistent system of units adopted by the general Conference on Weights and Measures in 1960 as a modification of the then-existing metric system.

Interpolation Method
Determination of a intermediate value between given values using a known or assumed rate of change of the values between the given values.

Intersection
Determining the horizontal position of a point by observations from two or more points of known position. Thus measuring directions or distances that intersect at the station being located. A station whose horizontal position is located by intersection is known as an intersection station.

Intervisibility
When two stations are visible to each other in a survey net.

Invar
An alloy of iron containing nickel, and small amounts of chromium to increase hardness, manganese to facilitate drawing, and carbon to raise the elastic limit, and having a very low coefficient of thermal expansion (about 1/25 that of steel).

Isogonic Chart
A system of isogonic lines, each for a different value of the magnetic declination.

Isogonic Line
A line drawn on a chart or map and connecting all points representing points on the earth having equal magnetic declination at a given time.

Laplace Azimuth
A geodetic azimuth derived from an astronomic azimuth by use of the Laplace equation.

Laplace Condition
Arises from the fact that a deflection of the vertical in the plane of the prime vertical will give a difference between astronomic and geodetic longitude and between astronomic and geodetic azimuth. Conversely, the observed differences between astronomic and geodetic values of the longitude and of the azimuth may both be used to determine the deflection in the plane of the prime vertical.

Laplace Equation
Expresses the relationship between astronomic and geodetic azimuths in terms of astronomic and geodetic longitudes and geodetic latitude.

Laplace Station
A triangulation or traverse station at which a Laplace azimuth is determined. At a Laplace station both astronomic longitude and astronomic azimuth are determined.

Least Count
The finest reading that can be made directly (without estimation) from a vernier or micrometer.

Least Squares Adjustment
The adjustment of the values of either the measured angles or the measured distances in a traverse using the condition that the sum of the squares of the residuals is a minimum.

Level
Any device sensitive to the direction of gravity and used to indicate directions perpendicular to that of gravity at a point.

Level Datum
A level surface to which elevations are referred. The generally adopted level datum for leveling in the US is mean sea level. For local surveys, an arbitrary level datum is often adopted and defined in terms of an assumed elevation for some physical mark.

Level Net
Lines of spirit leveling connected together to form a system of loops or circuits extending over an area.

Line of Sight
The line extending from an instrument along which distant objects are seen, when viewed with a telescope or other sighting device.

Local Coordinate System
Where the coordinate system origin is assigned arbitrary values and is within the region being surveyed and used principally for points within that region.

Local Datum
Defines a coordinate system that is used only over a region of very limited extent.

Loop Traverse
A closed traverse that starts and ends at the same station. A pattern of measurements in the field, so that the final measurement is made at the same place as the first measurement.

Magnetic Bearing
The angle with respect to magnetic north or magnetic south stated as east or west of the magnetic meridian.

Magnetic Meridian
The vertical plane through the magnetic pole including the direction, at any point, of the horizontal component of the Earth's magnetic field.

Major Semi-Axis
The line from the center of an ellipse to the extremity of the longest diameter. The term is also used to mean the length of the line.

Map
A conventional representation, usually on a plane surface and at an established scale, of the physical features (natural, artificial, or both) of a part or whole of the Earth's surface by means of signs and symbols and with the means of orientation indicated.

Map Accuracy
The accuracy with which a map represents. Three types of error commonly occur on maps: errors of representation, which occur because conventional signs must be used to represent natural or man-made features such as forests, buildings and cities; errors of identification, which occur because a non-existent feature is shown or is misidentified; and errors of position, which occur when an object is shown in the wrong position. Errors of position are commonly classified into two types: errors of horizontal location and errors of elevation. A third type, often neglected, is errors of orientation.

Map Scale
The ratio of a specified distance on a map to the corresponding distance in the mapped object.

Mean Angle
Average value of the angles.

Mean Lower Low Water (MLLW)
The average height of all lower low waters recorded over a 19-year period.
Mean Sea Level Datum
Adopted as a standard datum for heights or elevations. The Sea Level Datum of 1929, the current standard for geodetic leveling in the United States, is based on tidal observations over a number of years at various tide stations along the coasts.

Metric Unit
Belonging to or derived from the SI system of units.

Micrometer
In general, any instrument for measuring small distances very accurately. In astronomy and geodesy, a device, for attachment to a telescope or microscope, consisting of a mark moved across the field of view by a screw connected to a graduated drum and vernier. If the mark is a hair-like filament, the micrometer is called a filar micrometer.

Minor Semi-Axis
The line from the center of an ellipse to the extremity of the shortest diameter. I.e., one of the two shortest lines from the center to the ellipse. The term is also used to mean the length of the line.

Misclosure
The difference between a computed and measured value.

Monument
A physical object used as an indication of the position on the ground of a survey station.

NADCON
The National Geodetic Survey developed the conversion program NADCON (North American Datum Conversion) to convert to and from North American Datum of 1983. The technique used is based on a bi-harmonic equation classically used to model plate deflections. NADCON works exclusively in geographical coordinates (latitude/longitude).

Nadir
The point directly beneath the instrument and directly opposite to the zenith or the lowest point.

National Geodetic Vertical Datum 1929
Formerly adopted as the standard geodetic datum for heights, based on an adjustment holding 26 primary tide stations in North America fixed.

National Map Accuracy Standards
Specifications of the accuracy required of topographic maps published by the US at various scales.

National Tidal Datum Epoch
A period of 19 years adopted by the National Ocean Survey as the period over which observations of tides are to be taken and reduced to average values for tidal datums.

Network
Interconnected system of surveyed points.

Non-SI units
Units of measurement not associated with International System of Units (SI).

North American Datum of 1927
Formerly adopted as the standard geodetic datum for horizontal positioning. Based on the Clarke ellipsoid of 1866, the geodetic positions of this system are derived from a readjustment of survey observations throughout North America.

North American Datum of 1983
Adopted as the standard geodetic datum for horizontal positioning. Based on the Geodetic Reference System of 1980, the geodetic positions of this system are derived from a readjustment of survey observations throughout North America.

North American Vertical Datum of 1988
Adopted as the standard geodetic datum for heights.

Northing
A linear distance, in the coordinate system of a map grid, northwards from the east-west line through the origin (or false origin).

Open Traverse
Begins from a station of known or adopted position, but does not end upon such a station.

Optical Micrometer
Consists of a prism or lens placed in the path of light entering a telescope and rotatable, by means of a graduated linkage, about a horizontal axis perpendicular to the optical axis of the telescope axis. Also called an optical-mechanical compensator. The device is usually placed in front of the objective of a telescope, but may be placed immediately after it. The parallel-plate optical micrometer is the form usually found in leveling instruments.

Optical Plummet
A small telescope having a 90° bend in its optical axis and attached to an instrument in such a way that the line of sight proceeds horizontally from the eyepiece to a point on the vertical axis of the instrument and from that point vertically downwards. In use, the observer, looking into the plummet, brings a point on the instrument vertically above a specified point (usually a geodetic or other mark) below it.

Order of Accuracy
Defines the general accuracy of the measurements made in a survey. The order of accuracy of surveys are divided into four classes labeled: First Order, Second Order, Third Order and Fourth or lower order.

Origin
That point in a coordinate system which has defined initial coordinates and not coordinates determined by measurement. This point is usually given the coordinates (0,0) in a coordinate system in the plane and (0,0,0) in a coordinate system in space.

Orthometric Height
The elevation H of a point above or below the geoid.

Parallax
The apparent displacement of the position of a body, with respect to a reference point or system, caused by a shift in the point of observation.

Philadelphia Leveling Rod
Having a target but with graduations so styled that the rod may also be used as a self-reading leveling rod. Also called a Philadelphia rod. If a length greater than 7 feet is needed, the target is clamped at 7 feet and raised by extending the rod. When the target is used, the rod is read by vernier to 0.001 foot. When the rod is used as a self-reading leveling rod, the rod is read to 0.005 foot.

Photogrammetry
Deducing the physical dimensions of objects from measurements on photographs of the objects.

Picture Point
A terrain feature easily identified on an aerial photograph and whose horizontal or vertical position or both have been determined by survey measurements. Picture points are marked on the aerial photographs by the surveyor, and are used by the photomapper.

Planetable
A field device for plotting the lines of a survey directly from observations. It consists essentially of a drawing board mounted on a tripod, with a leveling device designed as part of the board and tripod.

Planimetric Feature
Item detailed on a planimetric map.

Plumb Line
The direction normal to the geopotential field. The continuous curve to which the gradient of gravity is everywhere tangential.

Positional Error
The amount by which the actual location of a cartographic feature fails to agree with the feature's true position.

Post-Processed Real-Time Kinematic GPS
GPS carrier phase positioning performed without real-time data link and solution.

Precision
The amount by which a measurement deviates from its mean.

Prime Meridian
The meridian of longitude 0°, used as the origin for measurement of longitude. The meridian of Greenwich, England, is almost universally used for this purpose.

Prime Vertical
The vertical circle through the east and west points of the horizon. It may be true, magnetic, compass or grid depending upon which east or west points are involved.

Project Control
Control used for a specific project.

Project Datum
Datum used for a specific project.

Projection
A set of functions, or the corresponding geometric constructions, relating points on one surface to points on another surface. A projection requires every point on the first surface to correspond one-to-one to points on the second surface.

Quadrangle
Consisting of four specified points and the lines or line segments on which they lie. The quadrangle and the quadrilateral differ in that the quadrangle is defined by four specified angle points, the quadrilateral by four specified lines or line-segments.
Random Error
Randomly distributed deviations from the mean value.

Range Pole
A simple rod fitted with a sharp-pointed, shoe of steel and usually painted alternately in red and white bands at 1-foot intervals.

Readings
The observed value obtained by noting and/or recording scales.

Real-time
An event or measurement reported or recorded at the same time as the event is occurring through the absence of delay in getting, sending and receiving data.

Real-Time Kinematic GPS
GPS carrier phase processing and positioning in real-time.

Reciprocal Leveling
Measuring vertical angles or making rod readings from two instrument positions for the purpose of compensating for the effects of refraction.

Rectangular Coordinate Systems
Coordinates on any system in which the axes of reference intersect at right angles.

Redundant Measurements
Taking more measurements than are minimally required for a unique solution.

Reference Meridian, True
Based on the astronomical meridian.

Reference Meridian, Magnetic
Based on the magnetic pole.

Reference Point
Used as an origin from which measurements are taken or to which measurements are referred.

Refraction
The bending of rays by the substance through which the rays pass. The amount and direction of bending are determined by its refractive index.

Relative Accuracy
Indicated by the dimensions of the relative confidence ellipse between two points. A quantity expressing the effect of random errors on the location of one point or feature with respect to another.

Repeating Theodolite
Designed so that the sum of successive measurements of an angle can be read directly on the graduated horizontal circle.

Resection
Determining the location of a point by extending lines of known direction to two other known points.

Sexagesimal System
Notation by increments of 60. As the division of the circle into 360°, each degree into 60 minutes, and each minute into 60 seconds.

Set-up
In general, the situation in which a surveying instrument is in position at a point from which observations are made.

Spheroid
Used as a synonym for ellipsoid.

Spirit Level
A closed glass tube (vial) of circular cross section. Its center line forms a circular arc with precise form and filled with ether or liquid of low viscosity, with enough free space left for a bubble of air or gas.

Stadia Constant
The sum of the focal length of a telescope and the distance from the vertical axis of the instrument on which the telescope is mounted to the center of the objective lens-system.

Stadia Traverse
Distances are determined using a stadia rod. A stadia traverse is suited to regions of moderate relief with an adequate network of roads. If done carefully, such a traverse can establish elevations accurate enough for compiling maps with any contour interval now standard.

Standard Error
The standard deviation of the errors associated with physical measurements of an unknown quantity, or statistical estimates of an unknown quantity or of a random variable.

Systematic Error
Errors that affect the position (bias) of the mean. Systematic errors are due to unmodeled affects on the measurements that have a constant or systematic value.

State Plane Coordinate System (SPCS)
A planar reference coordinate system used in the United States.

Strength of Figure
A number relating the precision in positioning with the geometry with which measurements are made.

Subtense Bar
A bar with two marks at a fixed, known distance apart used for determining the horizontal distance from an observer by means of the measuring the angle subtended at the observer between the marks.

Taping
Measuring a distance on the using a surveyor's tape.
Three-wire Leveling
The scale on the leveling rod is read at each of the three lines and the average is used for the final result.

Topographic Map
A map showing the horizontal and vertical locations of the natural and man-made features represented and the projected elevations of the surroundings.

Transformation
Converting a position from one coordinate system to another.

Transit
The apparent passage of a star or other celestial body across a defined line of the celestial sphere.

Transit Rule
The correction to be applied to the departure (or latitude) of any course has the same ratio to the total misclosure in departure (or latitude) as the departure (latitude) of the course has to the arithmetical sum of all the departures (latitudes) in the traverse. The transit rule is often used when it is believed that the misclosure is caused less by errors in the measured angles than by errors in the measured distances.

Transverse Mercator Projection
Mercator map projection calculated for a cylinder with axis in the equatorial plane.

Traverse
A sequence of points along which surveying measurements are made.

Triangulation
Determination of positions in a network by the measurement of angles between stations.

tribrach
The three-armed base, of a surveying instrument, in which the foot screws used in leveling the instrument are placed at the ends of the arms. Also called a leveling base or leveling head.

Trigonometric heighting
The trigonometric determination of differences of elevation from observed vertical angles and measured distances.

Trilateration
Determination of positions in a network by the measurement of distances between stations using the inter-section of two or more distances to a point.

Universal Transverse Mercator
A worldwide metric military coordinate system.

US Coast & Geodetic Survey (USC&GS)
Now known as National Ocean Service (NOS).

US Survey Foot
The unit of length defined by 1200/3937 m

Variance-Covariance Matrix
A matrix whose elements along the main diagonal are called the variances of the corresponding variables; the elements off the main diagonal are called the covariances.

Vernier
An auxiliary scale used in reading a primary scale. The total length of a given number of divisions on a vernier is equal to the total length of one more or one less than the same number of divisions on the primary scaled.

VERTCON
Acronym for vertical datum conversion. VERTCON is the computer software that converts orthometric heights between NGVD 29 to NAVD 88.

Vertical Angle
An angle in a vertical plane either in elevation or depression from the horizontal.

Vertical Circle
A graduated scale mounted on an instrument used to measure vertical angles.

Vertical Datum
Any level surface used as a reference for elevations. Although a level surface is not a plane, the vertical datum is frequently referred to as the datum plane.

World Geodetic System of 1984
Adopted as the standard geodetic datum for GPS positioning. Based on the World Geodetic System reference ellipsoid.

Wye Level
Having the telescope and attached spirit level supported in wyes (Y's) in which it can be rotated about its longitudinal axis (collimation axis) and from which it can be lifted and reversed, end for end. Also called a Y-level and wye-type leveling instrument.

Zenith
The point above the instrument where an extension of a plumb (vertical) line at the observer's position intersects the celestial sphere.

Zenith Angle
Measured in a positive direction downwards from the observer's zenith to the observed target.

Zenith Distance
The complement of the altitude, the angular distance from the zenith of the celestial body measured along a vertical circle.