Chapter 9
Stereocompilation Procedures

9-1. General

This chapter reviews stereoplotter and softcopy workstation map compilation procedures and discusses the instruments and procedures employed in compiling line and digital map products. The primary focus is on modern analytical plotters and softcopy workstations that can directly translate photographic images to digital files for use in CADD, GIS, LIS, and AM/FM databases.

9-2. Preparation

Preparation for stereo map compilation begins with gathering the materials required to perform the compilation and then georeferencing the stereomodel in the stereoplotter or softcopy workstation.

a. Materials required. Materials required to begin stereoplotter setup and compilation include the following:

(1) Positive transparencies. Positive transparencies for the stereoplotter must be radiometrically dodged from the original negatives. Positives are made by contact printing from the original film negative of a standard 9- by 9-in. format camera and must be printed on a dimensionally stable film base (termed film positives). Positive transparencies may not be required for softcopy workstations depending upon the project requirements, exposed film conditions, equipment, and expertise of the contractor.

(2) Camera calibration parameters. Camera calibration parameters define the interior orientation of the imaged bundle of rays. The camera calibration parameters may be stored in the analytical stereoplotter's computer data files. The camera calibration report should be current (within the last 3 years). The Contractor should provide proof that the camera system is in proper working condition as it was originally intended. This information is not included in the camera calibration report.

(3) Ground control data. A file of ground coordinate values for all the photo control points surveyed on the ground and the pass points located by aerotriangulation is required to perform absolute orientation of each stereomodel. The coordinate file must be accompanied by a set of photo prints showing all photo control and pass points clearly symbolized on the image and identified on the back of the print.

(4) Photographic prints. A set of photographic prints should be available to the stereoplotter operator. These prints are used with a stereoscope to familiarize the operator with the terrain prior to compilation of a stereomodel. The prints can also be used by the operator during compilation for notations concerning interpretation of features and difficult areas to contour. Sometimes mapworthy detail is interpreted from observations in the field in advance of stereo compilation. This information should be annotated on the contact prints given to the operator for incorporation into the map.

b. Stereomodel setup. Stereomodel setup proceeds through the three orientation steps: interior, relative, and absolute. The stereoplotter operator must use care in performing each orientation step and check each completed stereomodel for accuracy. Model setups should be checked for systematic model deformations by examining control coordinate discrepancies and image residuals. Stereomodels can be uniformly tilted in any direction, twisted (opposite diagonals systematically high or low), bowed (center systematically high or low), or incorrectly scaled. Proper placement of photo control points will alleviate these conditions.

9-3. Stereoplotters

A general overview of existing stereoplotter designs and general operating procedures is presented in this chapter. For the purposes of this chapter, only instruments that perform a complete restitution of the interior and exterior orientation of the photography taken will be considered. Since the inception of commercially viable photogrammetry in the 1930s, several generations of steromapping systems have become obsolete. Only those which are capable of generating digital geospatial data will be discussed in this text.

9-4. Types of Stereoplotters

The three main component systems in all stereoplotters are the projection, viewing, measuring, and tracing systems. Stereoplotters are most often grouped according to the type of projection system used in the instrument.

a. Analytical stereoplotters. Analytical stereoplotters use a mathematical image ray projection based on the collinearity equation model. The mechanical component of the instrument consists of a precise computer-controlled stereocomparator. Since the photo stages must move only in the x and y image directions, the measurement system can be built to produce a highly accurate and precise image measurement. The x and y photo coordinates are encoded, and all interior and exterior orientation parameters are included in the mathematical projection model. Except for the positive format size that will fit on the photo stage, the analytical stereoplotter has no physical constraints on the camera focal length or model scale that can be accommodated. See Figure 9-1, Typical analytical stereoplotter.

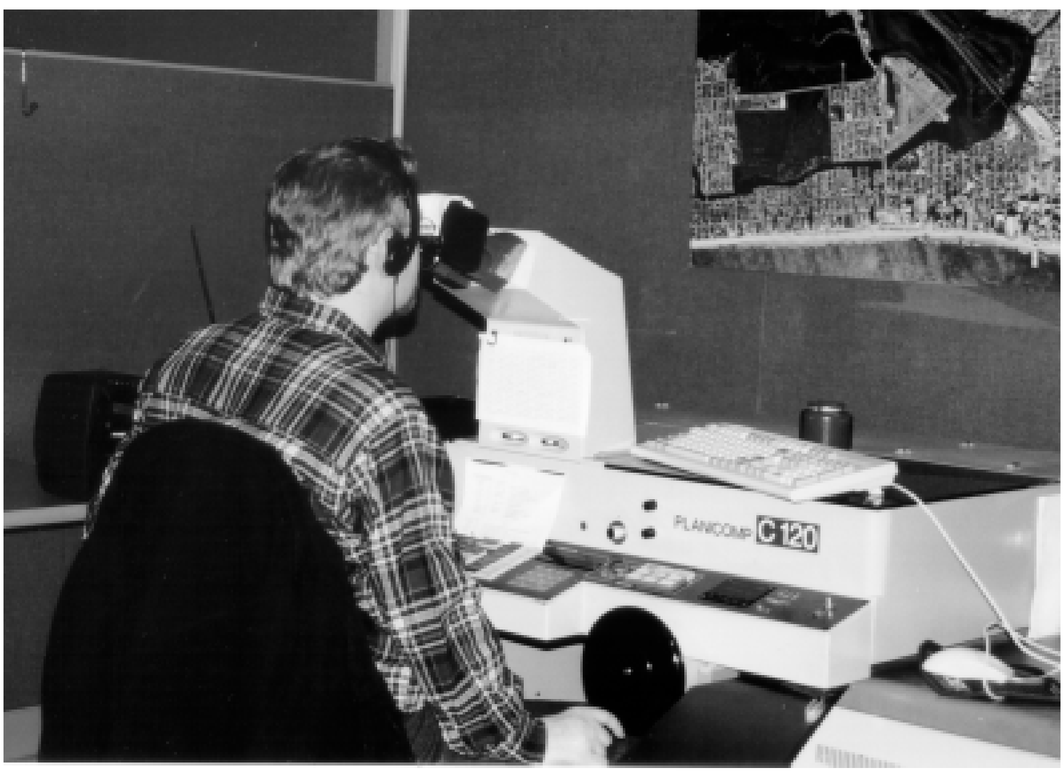

Figure 9-1. Typical analytical stereoplotter (courtesy of Surdex Corporation)

(1) The viewing system is an optical train system typically equipped with zoom optics. The measuring mark included in the viewing system may be changeable in style, size, and color. The illumination system should have an adjustable intensity for each eye.

(2) The measuring system consists of an input device for the operator to move the model point in three dimensions. The input device is encoded, and the digital measure of the model point movement is sent to the computer. The software then drives the stages to the proper location accounting for interior and exterior orientation parameters. These operations occur in real time so that the operator, looking in the eyepieces, sees the fused image of the floating mark moving in three dimensions relative to the stereomodel surface. The operator's input device for model position may be a hand-driven free-moving digitizer cursor on instruments designed primarily for compilation, or it may be a hand wheel/foot disk control or similar device on instruments supporting fine pointing for aerotriangulation.

(3) Analytical stereoplotters are accurate because the interior orientation parameters of the camera are included in the projection software. Therefore, any systematic error in the photography can be corrected in the photo coordinates before the photogrammetric projection is performed. Correcting for differential film deformations, lens distortions, and atmospheric refraction justifies measuring the photo coordinates to accuracies of 0.003 mm and smaller in analytical stereoplotters. To achieve this accuracy, the analytical stereoplotter must have the capability to perform a stage calibration using measurements of reference grid lines etched on the photo stage.

d. Digital stereoplotters. The latest generation of stereoplotters is the digital (or softcopy) stereoplotter. These instruments will display a digital image on a workstation screen in place of a film or glass diapositive. The instrument operate as an analytical stereoplotter except that the digital image will be viewed and measured. The accuracy of digital stereoplotters is governed by the pixel size of the digital image. The pixel size directly influences the resolution of the photo coordinate measurement. A digital stereoplotter can be classified according to the photo coordinate observation error at image scale. Then it should be comparable to an analytical stereoplotter having the same observation error, and the standards and guidelines in this manual should be equally as applicable. At the time of writing this document, the generally accepted guidance is that softcopy and analytical stereoplotters can achieve the same resulting map accuracies for most projects. Some projects may require that the aerial photography be captured at a lower altitude to achieve required accuracies. The Contractors opinion regarding softcopy data (flight heights, image scanning specifications) requirements should be considered. See Chapter 2, Tables 1 through 8, for expected map accuracy requirements utilizing softcopy stereoplotters. See Figure 9-2, Typical Softcopy Workstation.

9-5. Stereoplotter Operations

Models in stereoplotters must be georeferenced to the ground for measuring or mapping in three consecutive steps: interior, relative, and absolute orientation.

a. Interior orientation. Interior orientation involves placing the photographs in proper relation to the perspective center of the stereoplotter by matching the fiducial marks to corresponding marks on the photography holders and by setting the principal distances of the stereoplotter to correspond to the focal length of the camera (adjusted for overall film shrinkage).

b. Relative orientation. Relative orientation involves reproducing in the stereoplotter the relative angular relationship that existed between the camera orientations in space when the photographs were taken. This is an iterative process and should result in a stereoscopic model easily viewed, in every part, without “y parallax” the separation of the two images so they do not fuse into a stereoscopic model. When this step is complete, there exists in the stereoplotter a stereoscopic model for which 3-D coordinates may be measured at any point; but it may not be exactly the desired scale, it may not be level, and water surfaces may be tipped.

Figure 9-2. Typical softcopy workstation (courtesy of Dave Kreighbaum & Earthdata Corporation)

c. Absolute orientation. Absolute orientation uses the known ground coordinates of points identifiable in the stereoscopic model to scale and to level the model. When this step is completed, the X, Y, and Z ground coordinates of any point on the stereoscopic model may be measured and/or mapped.

9-6. Stereoplotter Output Devices

Stereoplotters may be connected to a variety of devices for hardcopy plotting or storing of digital data. Modern stereoplotters are quite often interfaced to a graphical or digital output device. Examples of these output devices include hard disk storage devices and pen or inkjet plotter.

a. Stereoplotters are computer assisted. The movement of the measuring mark of these stereoplotters is digitally encoded. The digital signal is sent directly to a computer-controlled coordinatograph. The operator can include feature codes in the digital signal that the computer can interpret to connect points with the proper line weight and type, plot symbols at point locations, label features with text, etc. The final map product can be produced at the manuscript stage by an experienced operator.

b. A digitally encoded stereoplotter is interfaced to a digital compilation software system in which the compiled line work and annotations appear on a workstation screen. Similar to the computer-assisted stereo-plotter and coordinatograph, the compilation on the workstation screen can be displayed with proper line weights (or colors and layers), line types, symbols, and feature labels. In addition, since the map exists in a digital computer file, basic map editing can be done as the manuscript progresses. Typically, the digital compilation file is converted (or translated) to a full CADD design file where it can be merged with adjacent compiled stereomodels and final map editing performed. The deliverable product from these systems is often in digital form on computer tape or disk.

9-7. Softcopy Workstation

Softcopy Workstations can be employed as mapping instrumentation. Softcopy workstations are generally composed of an image high-resolution scanner (Figure 9-3), high-speed computer processor, large high-resolution monitor coupled with appropriate software for viewing scanned images in 3-D, drawing and editing planimetric and topographic information, and translating data sets to various formats for the end user.

a. Image scan. Where stereoplotters utilize a photographic image, softcopy workstations require the photo to be scanned to create a digital image file. Scan resolution can vary depending upon the accuracy requirements of the mapping. Generally, an image scan file with a pixel resolution between 11 and 15 microns provides the most efficient image file for planimetric and topographic map compilation. However, for some special cases (very large-scale mapping projects) it may be necessary to maintain pixel size at the 7- to 8-micron level. Depending upon the production system of the contractor, either the negatives may be scanned directly or film transparencies must be produced and scanned. When possible, is it preferable to scan directly from the photo negative.

b. Model orientation. Once the scanned model files are created, the operator can select a stereopair and register the two working images on the monitor screen. Using a cursor, the operator points to the photo control stations on the images. The computer then georeferences the two images to one another and then produces an absolute orientation. Typically, projects will utilize aerotriangulation methods to extend the field surveyed horizontal and vertical control to a network sufficient to set up each stereomodel within the project area. This process will produce the interior, relative, and absolute parameters that are used by softcopy workstations to perform the model orientations. When choosing the model to be set up, the operator loads the orientation parameters enabling the workstation to display the stereomodel in its correctly georeferenced state.

c. Stereomapping. Through the medium of spectacles (using light polarization principles), the operator observes a single 3-D model on the monitor screen. Guiding the reference mark over the surface of the stereomodel with a cursor, the operator may draw planimetric features, lines of equal elevation (contours), and/or digital elevation model data (mass points and breaklines).

d. P*roduction.* Softcopy is a versatile concept. With this instrumentation the operator can provide aerotriangulation, create orthophoto image, and/or produce mapping. Mapping products can include digital elevation data, planimetric features (vectors), and raster images all in various formats. Generally, data sets provided to the end user are very large and are often provided on CD ROM disks.

9-8. Softcopy Workstations Output Devices

Softcopy workstations generally are connected to the same types of output devices as stereoplotters (i.e., pen plotters, film writers, and high-resolution laser plotters). All data utilized, collected, and processed is digital.

9-9. Stereoplotter Accuracies

Stereoplotter accuracies are best expressed in terms of observation error at diapositive scale. In this way, instruments can be compared based on the fundamental measurement of image position on the positive. Measurement error on the positive can be projected to the model space so that expected horizontal and vertical error in the map compilation can be estimated. Stereoplotter accuracy affects the maximum allowable enlargement from photo scale to map scale and the minimum CI that can be plotted from given photo scale.

Figure 9-3. Typical high-resolution scanner (courtesy of Walker Associates)

a. Enlargement from photograph to target map scale. The enlargement ratio from photograph to the target map scale refers primarily to the projection system of the stereoplotter. A contact positive of the original negative and a compilation of the stereomodel at final map scale are assumed. Criteria for maximum enlargement from photograph to map scale are guidelines for determining the smallest photographic scale that should be used to compile a given map scale on a given stereoplotter. If the focal length of the camera is specified (e.g., 6 in.), then the maximum flying height can be determined. Specific USACE criteria for maximum photo enlargement and flight altitude are provided in the tables in Chapter 2.

b. C-Factor. The C-Factor is a traditional expression of vertical compilation accuracy. It is defined as the ratio of the flying height above terrain to the minimum CI that should be compiled on the stereoplotter. The C-Factor is an empirical rating scale that depends not only on the stereoplotter instrument but also on the camera, film, photographic processing, ground survey control, aerotirangulation, and skill of the operator. An exact C-Factor is not to be specified for a specific instrument. It is a “calibration” factor of the entire photogrammetric system, and each production unit should be aware of its own limitations. When a photogrammetric project is planned, the C-Factor is an assumption and may be used as a rule of thumb to evaluate the relationship between photo scale and CI. If a ratio is indicated that is far outside the typical range, it may serve as a warning to evaluate the project plan more carefully. Few instrument manufacturers of photo mapping firms can quantify a specific C-Factor, and may be over optimistic in their ratings. The C-Factor is used to derive the negative scale and flight altitude to achieve the vertical accuracy based on the specified CI. Assuming too optimistic (high) a C-Factor will adversely affect the resultant accuracy of the map product. By the same token, an over-cautious approach may unnecessarily increase project cost. The maximum C-Factor ranges given in Chapter 2 are based on practical experience and are recommended for USACE engineering and design mapping work. They should not be exceeded regardless of manufacturer/contractor claims that they are too conservative.

9-10. Line Map Compilation Procedures

All planimetric features and contours are delineated by following the feature with the floating mark, adjusting the elevation so that the floating mark is always in contact with the apparent model surface as the compilation proceeds. The particular map details to be compiled depend on the type of map being prepared and the land use characteristics of the project area (Appendix D).

a. Compilation of planimetry. As a general rule, those features whose accurate positioning or alignment is most important should be compiled first. The relationship of the model to the datum should be checked at frequent intervals during the compilation process. It is preferable to compile all the features of a kind at one time; in this way, the chances of overlooking and omitting any detail are minimized. Some stereoplotters are equipped with superimposition of graphic data over the photo image, which makes keeping track of completed detail very obvious.

(1) Care should be taken when plotting objects having height, such as buildings and trees, to avoid tracing their shadows instead of their true positions. Buildings may have to be plotted by their roof lines, as the photograph perspective may cause their bases to be partially obscured.

(2) Planimetry should not be compiled beyond the limits of the neat model.

b. Planimetric features. All planimetric features identifiable on or interpretable from the aerial photographs should be shown on the final maps. The following feature lists may be modified by the Government in the contract scope of work to add or delete features in accordance with the purpose of the map (CADD, GIS, LIS, AM/FM, etc.) and the site-specific characteristics of the area to be compiled:

(1) Land-use features. Land-use features include parks, golf courses, and other recreational areas; historic areas; archeological sites; buildings; fences and walls; canals; ditches; reservoirs; trails; streets; roads; railroads; quarries, borrow pits; cemeteries; orchards; boundaries of logged-off areas and wooded areas; individual lone large trees; the trace of cross-country telephone, telegraph, and electric power transmission lines and their poles and towers; fence lines; billboards; rock and other walls; and similar details.

(2) Structural features. Structural features include bridges; trestles; tunnels; piers; retaining walls; dams; power plants; transformer and other substations; transportation terminals and airfields; oil, water, and other storage tanks; and similar detail. Structural features shall be plotted to scale at all map scales. Minor irregularities in outlines not representable by the limiting RMSE of the map standard may be ignored. Features smaller than 1/20 in. at map scale should be symbolized at 1/20-in. size.

(3) Hydrographic features. Hydrographic features include rivers, streams, lakes, ponds, marshes, springs, falls and rapids, glaciers, water wells, and similar detail. Wherever they exist, such features as the drainageways of draws, creeks, and tributary streams longer than 1 in. at map scale should be delineated on the maps.

(4) Scale-dependent features. On maps at scales of 50 ft to the inch or larger, there should be shown, in addition to the other required land-use features, curbs, sidewalks, parking stripes, driveways, hydrants, manholes, lampposts, and similar features dependent on the functional application.

(5) Ground completion surveys. Areas that are obscured on the photography by buildings, shadows, or vegetation should be completed by ground survey methods that meet the accuracy class of the mapping. Ground surveys are also used to map features that cannot be seen on the photography such as underground utilities, easements and property boundaries, and political boundaries. A stereoplotter operator cannot be expected to pick up all objects on a given site even if visible in the photography. (**This is no different from**

conventional plane table surveying. A certain percentage of omissions is probable.) Requirements for surface and subsurface utilities or other critical features must be specifically and explicitly outlined in the contract scope, including requirements for ground verification, editing, etc. The Contractor cannot be held liable for normal or expected omissions if the Government fails to detail critical portions of the work, and program contract funds therefor. Failure by either the Government or the mapping contractor to adequately depict critical feature requirements is usually caught during construction, and the cost of construction change orders for "differing site conditions" resulting from these deficiencies will usually far exceed the original field mapping effort.

(6) Sample planimetric feature data. Figures 9-4 depicts portions of planimetric and topographic layers developed for engineering design (1 in. = 50 ft).

Figure 9-4. Typical planimetric data set with contours (courtesy of Barton Aerial Technology)

9-11. Compilation of Topography

Photogrammetric mapping generally considers topography compilation to include contours (lines of equal elevation), high and low points, and lines defining abrupt changes in elevation (breaklines). Topographic data are usually created through a process of generating mass points and breaklines (X,Y,Z) that may be processed through software to generate contour lines if desired. The process chosen for topography compilation should be based on available compilation equipment, contour interval required, character of the area that is being mapped, available time and funding budget. Generally, terrain model development and processing are used for contour generation. The Government will specify the media on which the terrain data shall be recorded and its arrangement and format, unless the data will be used exclusively by the contractor's organization in his design operations. The media may be magnetic tape, magnetic disc, or CD-ROM.

a. Types of terrain models. The terrain model may be grid, cross section, remeasurement, critical point type, or as specified by the contract. Terrain model development is a numerical representation of the ground surface that may be used as a substitute for a contour line map. A terrain model is easily stored and manipulated by a computer and may be used to generate a number of useful products. A terrain model may be used to interpolate and plot a topographic contour map, to determine earthwork quantities, or to produce an orthophotograph. It is normally translated into a three-dimensional CADD design file for these subsequent applications.

(1) Breaklines and mass points. The three coordinates (X,Y,Z) of critical points define the topography of an area similar to sideshots in a stadia field survey. Critical points recorded along terrain breaklines can be combined with grid type data to form a very accurate terrain.

(2) Grid, Digital Elevation Model (DEM). DEMs consist of elevations taken at regularly spaced intervals in two horizontal coordinate directions. These two horizontal directions may coincide with the northing and easting of the authorized project coordinate system or they may be skewed to it. DEM=s along with breaklines may be used for contour generation, for small-scale mapping.

(2) Digital Terrain Models (DTM). DTM=s consist of mass points and breaklines. See Figure 9-5, Typical Digital Terrain Model (DTM). The breaklines are collected at points of abrupt elevation change. Mass points are collected in areas and to a density sufficient to define the character of the topography. DTM generation is the preferred method for defining topography for large-scale mapping utilizing current technology and equipment. This method of terrain model generation generally provides accuracy and efficiency when collected by an experienced photogrammetrist.

(3) Triangulated Irregular Network (TIN) models. DEM and DTM data sets can be processed through software packages to develop a triangulated irregular network of data points to create a file of interpolated points at specific contour intervals (TIN models). The TIN models are then processed through software that connects points of equal elevation (contours). See Figure 9-6, Typical TIN File.

(4) Cross sections. Cross sections require that readings be captured at points of significant terrain change along profile lines stretching across a stereomodel.

(5) Remeasurement. Remeasurement defines the terrain after earthwork is completed. Original measurement may have been in grid or cross-sectional pattern; remeasurement extends only as far as construction operations changed the terrain, and it includes measurement of the same grid points or along the same cross-sectional lines, plus significant breaks in the surface as altered by construction.

b. Spot elevations. Spot elevations are elevations of certain topographic and cultural features that are required to furnish the map users with more specific elevations of these features than may be interpolated from the contours. Spot elevations should be recorded by the stereocompiler whenever needed to supplement spot elevations that may have been obtained in the course of field surveys. Spot elevations are typically shown in their proper position at the water level of lakes, reservoirs, and ponds; on hilltops; in saddles; at the bottom of depressions; at the intersection of well-traveled roads, principal streets in cities, railroads, and highways; and similar locations.

(1) Drainage lines, large and small, center lines, road edges, and any abrupt change in elevation should be compiled as breaklines (lines with abrupt elevation change) prior to compiling the contours. Drainage is of great importance in obtaining the proper contour expression of landforms since most landforms have developed to some extent through the effects of erosion.

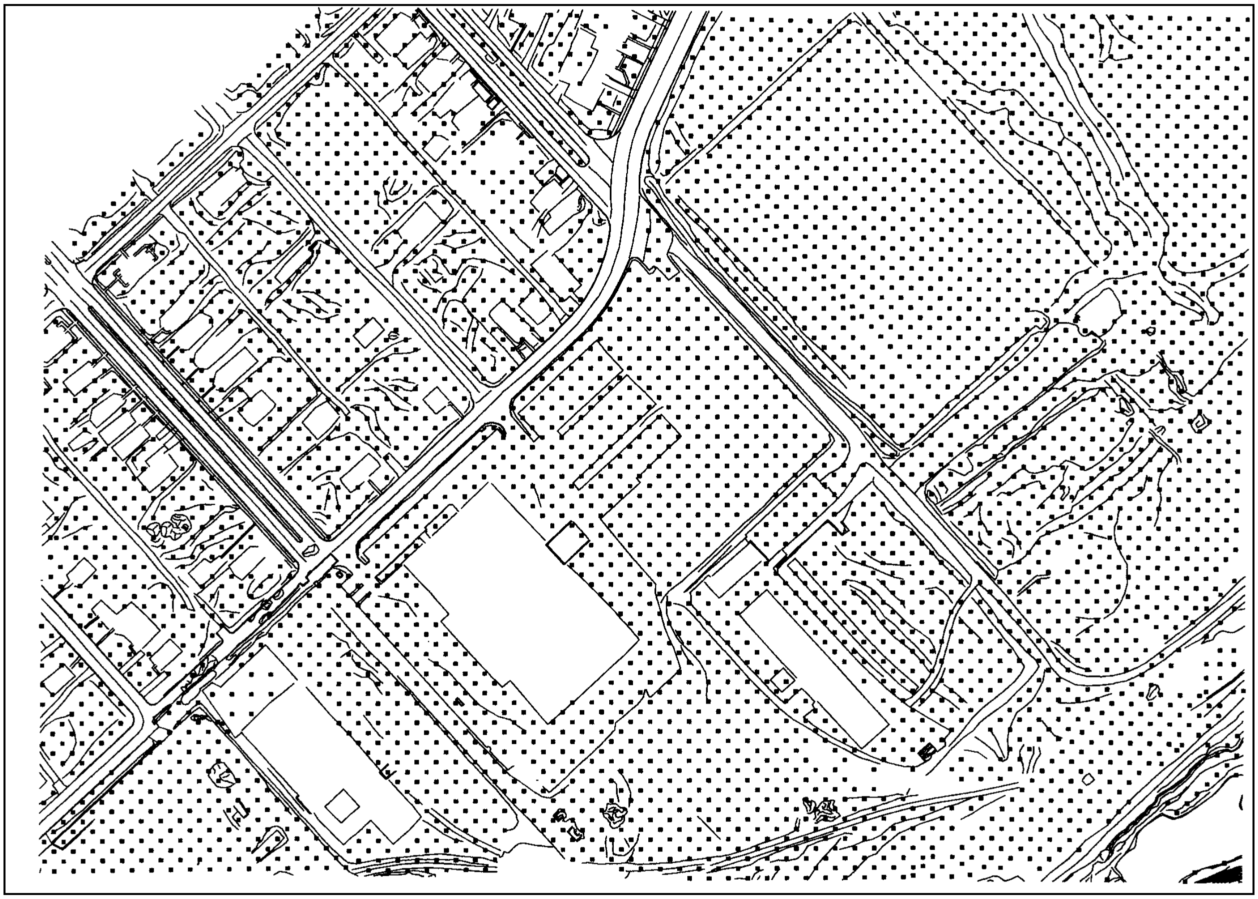

Figure 9-5. Typical digital terrain model (DTM) (courtesy of Barton Aerial Technology)

(2) Spot readings of terrain elevation may be needed in areas where it is difficult to follow the terrain by direct tracing of the contours. Such areas include very flat terrain, large monotone areas such as fields of grass, areas in shadow, and areas covered by trees. If a sufficient number and distribution of accurate spot readings can be made, then the contours can be interpolated from the spot readings. If there is doubt that the interpolated contours will meet the accuracy class of the mapping, then the contours should be shown by dashed lines and the area marked for possible field completion. Where the terrain surface is completely obscured by vegetation, the contours should be omitted and the area marked for field survey completion if the terrain in this area is critical to subsequent design and construction. Contours should not be estimated by tracing the tops of the vegetation and making a height adjustment.

c. Contract requirements. USACE commands will provide in each contract statement of work at least the following:

(1) Area. For design applications, USACE will provide a map of the area to be included in the terrain model, by outlining it. Written description may further define the area. For DEM, DTM, TIN, cross section, or remeasurement terrain models, USACE will also provide the topographic engineer a scaled map of the area required for the terrain model product.

(2) Stereomodel setup data. If the original data were compiled by another contractor, USACE will furnish the contractor the Ground Control Survey Report and the Aerotriangulation Report, which includes the X, Y, and Z ground coordinates of points for orienting the stereoplotter, and the stereoplotter orientation

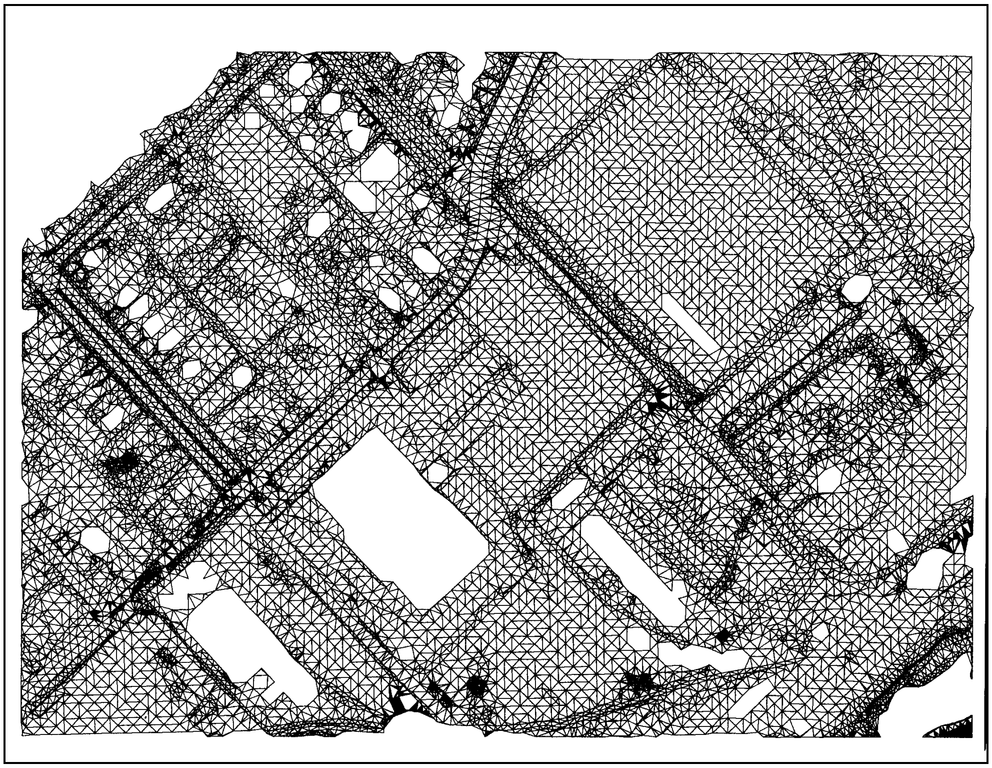

Figure 9-6. Typical TIN file (courtesy of Barton Aerial Technology)

settings if available from the aerotriangulation report. For remeasurement, it shall be the map used for the original measurements.

(3) Point location and spacing.

(a) For DEMs, USACE will specify the spacing of points and outline on the map the area or areas of the elevation model.

(b) For cross sections, USACE will specify the maximum spacing of points and the maximum spacing of sections.

(c) For critical mass points, USACE will specify that the points be collected in patterns and density that will accurately depict the features and terrain specified.

9-12. Map Manuscript

State-of-the-art photogrammetric mapping firms have direct CADD-compatible softcopy or stereoplotter output to video monitors, so the traditional paper or mylar "manuscript" is becoming obsolete. Hardcopy map manuscripts shall be drawn on dimensionally stable, matte-surface, polyester-type plastic drafting film at least 4 mils thick or bond paper.

a. All map detail plotted on the manuscripts shall be to the clarity and accuracy that will result in finished maps fulfilling the map class accuracy standard.

b. Each map manuscript shall be compiled at a scale equal to the target scale specified for the finished map.

c. The map shall be compiled directly into its final form on the graphic display and stored in a digital data base. Preliminary digital map plots or map manuscripts may be plotted on bond paper. The digital data base shall include the horizontal coordinate grid and the ground control points.

d. Map manuscripts shall show in the sheet margin the identification of map area, map scale expressed as both a representative fraction and a graphical bar scale, and flight number and photo numbers of the stereo-models contained in the map. Match notes of adjacent maps shall be shown on all sides of the plot. The original map manuscripts are a deliverable item and shall be maintained in a reasonably clean and legible condition. Lines must be of a clarity and density to provide clear, sharp, and legible paper prints from any standard reproduction equipment. Lettering on the manuscript shall be neat and legible.

9-13. Map Edit

Map manuscripts must be edited carefully before or immediately after the stereomodel compilation phase of the project is completed. The map editor should be someone other than the stereoplotter operator who compiled the original map manuscript.

a. Each map must be checked for:

(1) Compliance with the required map accuracy standards.

(2) Completeness of planimetric and topographic detail, as called for in the contract specifications.

(3) Correctness of symbolization and naming of features.

(4) Agreement of edge-matched planimetric and topographic line work with adjacent maps.

b. Preliminary digital maps may be plotted on bond paper for subsequent editing. Stereoplotters equipped with graphic superimposition in the viewing system can be used to assist the editor in checking the digital data. A typical independent CADD editing workstation is shown in Figure 9-7.

Final map sheets can be prepared by computer driven plotters from a graphic database file. Final sheets should be on dimensionally stable, matte-surface, polyester-type plastic film at least 4 mils thick and of American National Standards Institute (ANSI) (1980) F-Size, unless otherwise specified. Final map sheets should be produced utilizing plotter equipment that will meet the map class standard of accuracy required for the project. Digital data files shall meet the requirements for layers, symbols, line weights, attribution, etc. as specified for the project in the Scope of Work. The current Tri-Service Spatial Data Standards (TSSDS) shall be used unless otherwise specified. Upon completion, each map sheet should be reviewed and edited to ensure completeness and uniformity of the maps.

c. Layout. USACE will specify the final map sheet size, borderline dimensions, and map neat line dimensions and placement. A map sheet layout plan should be prepared for advance approval by USACE. Sheets should be laid out to cover the project area in an orderly, uniform, and logical fashion. The size and location of the stereomodels are dictated by the aerial photographs. The stereomodels may or may not coincide with the size, format, and positioning of the final map sheets.

Figure 9-7. Typical edit workstation (courtesy of Dave Kreighbaum & Earthdata Corporation)

d. Content

(1) Legend and drawing notes. The final drawings should show, at minimum, the following information:

(a) Project title.

(b) Scale and scale bar.

(c) North arrow and magnetic North.

(d) Legend of symbols used (if different from standards).

(e) Credit/Certification/Logo of the mapper.

(f) Adjoining sheet numbers or a sheet layout plan for large projects (i.e., index map).

(g) Grid projection or geographic coordinate datum.

(h) Date of photography.

(i) Date of mapping.

(j) Map Accuracy Statement

The drawing layout and content may be specified by the USACE, or it may be proposed by the Contractor for approval by USACE.

(2) Coordinate grid. The horizontal datum coordinate grid shall be shown on the map manuscript and on the final map. Spacing between grid intersections shall be 5 in. for English unit projects or 10 cm for metric projects at finished map scale. Each coordinate grid line shall be numerically labeled at its ending on the edges of each map sheet.

(3) Ground control. Monumented horizontal control shall be shown by the appropriate symbol on the final map. The location of the control point is the center of the plotted symbol. Monumented vertical control shall be shown by the appropriate symbol on the final map.

(4) Map detail. All planimetric, topographic, and spot elevation map detail shall be plotted directly from a digital data base by high-resolution, high-accuracy, computer-driven plotters. Each line shall be uniform in width for its entire length. Symbols, letters, and numbers shall be clear and legible. All names and numbers shall be legible and clear in meaning and shall not interfere with map features.

9-14. Reproduction

The final map shall be ready for reproduction by any of the standard printing processes so that all lines, images, and other map detail as well as descriptive material will be clear, sharp, and legible.

a. The final map shall be plotted at the target scale specified for the mapping project.

b. When a photographic reproduction is used, a master sheet format showing all standard margin information can be prepared and registered with each drafted or scribed sheet during the photographic reproduction of the final positive map sheets. This is accomplished by contact printing in a vacuum frame.

9-15. Deliverables

The following materials will be delivered to the Government upon completion of the project:

a. Stereomodel computer printouts of stereomodel setup.

b. Aerotriangulation Report.

c. Reproducible positives of each final map.

d. Paper prints of each final map.

e. Computer digital database files. The Government shall specify the media, either magnetic disk or magnetic tape. Files may include DEM=s, DTM=s, TIN=s, Contours, Planimetric detail, Orthophoto Images, and GIS maps as requested in a Scope of Work.

f. Digital files. The Government shall specify the media, magnetic disk, magnetic tape or CD-ROM.