Chapter 4
Photogrammetric Mapping Planning and Cost Estimating Principles

4-1. General

This chapter contains guidance for USACE project engineers, project managers, or project engineering technicians who are required to plan and develop cost estimates for negotiated qualification-based Architect-Engineer (A-E) contracts for photogrammetric mapping projects.

a. *Section I* provides guidance on the elements of project planning and estimating costs for all phases of a photogrammetric mapping project.

b. *Section II* provides the elements of a general costing procedure.

c. *Section III* presents a sample scope of work and estimate for a typical project.

Section I

4-2. Photogrammetric Mapping Project Planning

a. In order to estimate photogrammetric mapping costs, it is necessary to visualize production procedures that must be accomplished. The project manager should design a specific procedural scheme before a Government cost estimate is formulated. With a logical project plan in mind, it is possible to estimate man-hour and material needs and apply cost factors. Since hourly labor rates, equipment rental rates, overhead, and profit margins vary widely, it is necessary to estimate costs for contract negotiations based on a specific production system.

b. Digital mapping projects require several basic operations:

(1) Aerial photography, which may or may not involve ABGPS, with appropriate film types.

(2) Field control surveys using conventional and/or GPS procedures.

(3) Aerotriangulation utilizing a workstation or an analytical stereoplotter.

(4) Collection and editing of digital planimetric and/or topographic data with an analytical stereoplotter or a workstation.

(5) Orthophoto images generated with a workstation.

c. Some production items are rather straightforward to determine. For instance, once the relevant photo scale is selected, it is relatively easy to calculate the number of photos, which is a determining factor for a number of production parameters. Other costs may be rather difficult to determine and will vary from one project site to another, depending on the ground conditions and product requirements of the specific project. Many unit item timeframes can be estimated only with a fairly thorough understanding of the equipment and production procedures, generally termed "experience." Unfortunately, these difficult items usually form the bulk of the project costs. This is coupled with the fact that most USACE commands cannot afford the time and money to train experienced photogrammetrists to estimate mapping costs.

d. During the estimating process of a project, it is essential to include every item that could be required. The estimator must include overhead expenses and, when working through a private contractor, a reasonable profit for the contractor.

e. One of the principal objectives of planning is the assessment of risk that may be inherent in a project. There are several types of risk: programmatic, technical, schedule, and cost. Risk should be identified whenever possible, and the project plan should include actions to mitigate their possible impact.

f. USACE Commands contract most of their photogrammetric work to commercial mapping firms. The relationship between the USACE project manager and the private contractor should not be adversarial. Rather, it must be a cooperative effort to produce a product of legitimate quality for a reasonable price. Both the USACE representative and the private contractor should cooperate toward this end. Since digital mapping is a dynamic discipline, USACE cost estimators should make a positive effort to visit the map production facilities of private contractors in order to enhance familiarity with state-of-the-art equipment and procedures. Private mapping contractors are deservedly proud to display their facilities and share their technical expertise, especially if it contributes to the collective understanding of project requirements. It is recognized that the USACE project manager and a private contractor will not necessarily approach cost estimating from a singular perspective. However, if both have a similar understanding of the specifications and a common knowledge of production procedures, their independent cost estimates should provide a basis for negotiating a reasonable fee that will provide a quality product.

g. Before specific cost estimating can be addressed, the project manager should study the procedures discussed in other chapters of this manual to gain a technical knowledge with regard to issues of practical photogrammetric production. The project manager and the Contractor may consider developing a production flow diagram noting all major tasks and associated schedules.

4-3. Photo Scale, Contour Interval, and Target Map Scale Determination

Photo scale, contour interval (CI), and target mapping scale are integrally related and directly affect the cost of a spatial data product.

a. Photo scale selection. Planimetric and topographic detailing are the two main factors that must be considered in selecting a photo scale for digital mapping. Usually one or the other will govern the final photo scale.

(1) Planimetric (cultural) features. On larger-scale mapping projects, a great deal of finite features (poles, street signs, inlets, traffic signs, sidewalks, manholes, etc.) are drawn. As map scale gets smaller, progressively more of this finite detail is omitted (by reason that it may not be visible and/or identifiable on the photos or to reduce map clutter), and some features may be symbolized because of minimum size limitations. This dictates that large-scale planimetric mapping requires large-scale photos. In most cases, the enlargement factor from photo to map for USACE mapping should not exceed the *maximum* factors in Table 2-4 for determining maximum enlargement ratios for a specific map class. Tables in Chapter 2 should be used as a guide for appropriate flight heights and photo negative scales required to achieve specified map scales and accuracies.

(2) Topographic (terrain) features. Flight height determines the attainable accuracy of the vertical data and also regulates photo scale. Tables in Chapter 2 should be used as a guide for appropriate flight heights and photo negative scales for topographic feature detail required to achieve specified map scales and accuracies.

Sample photo and map target scale applications. Figures 4-1 through 4-8 may an aid in selecting optimum photo negative scales and map target scales based on specific engineering and planning applications. Figures 4-1 through 4-7 depict typical planning, engineering, and real estate mapping applications, showing a portion of the manuscript (digital database) at various target scales. The aerial photographs in Figure 4-8 show the varying detail available at different flying heights.

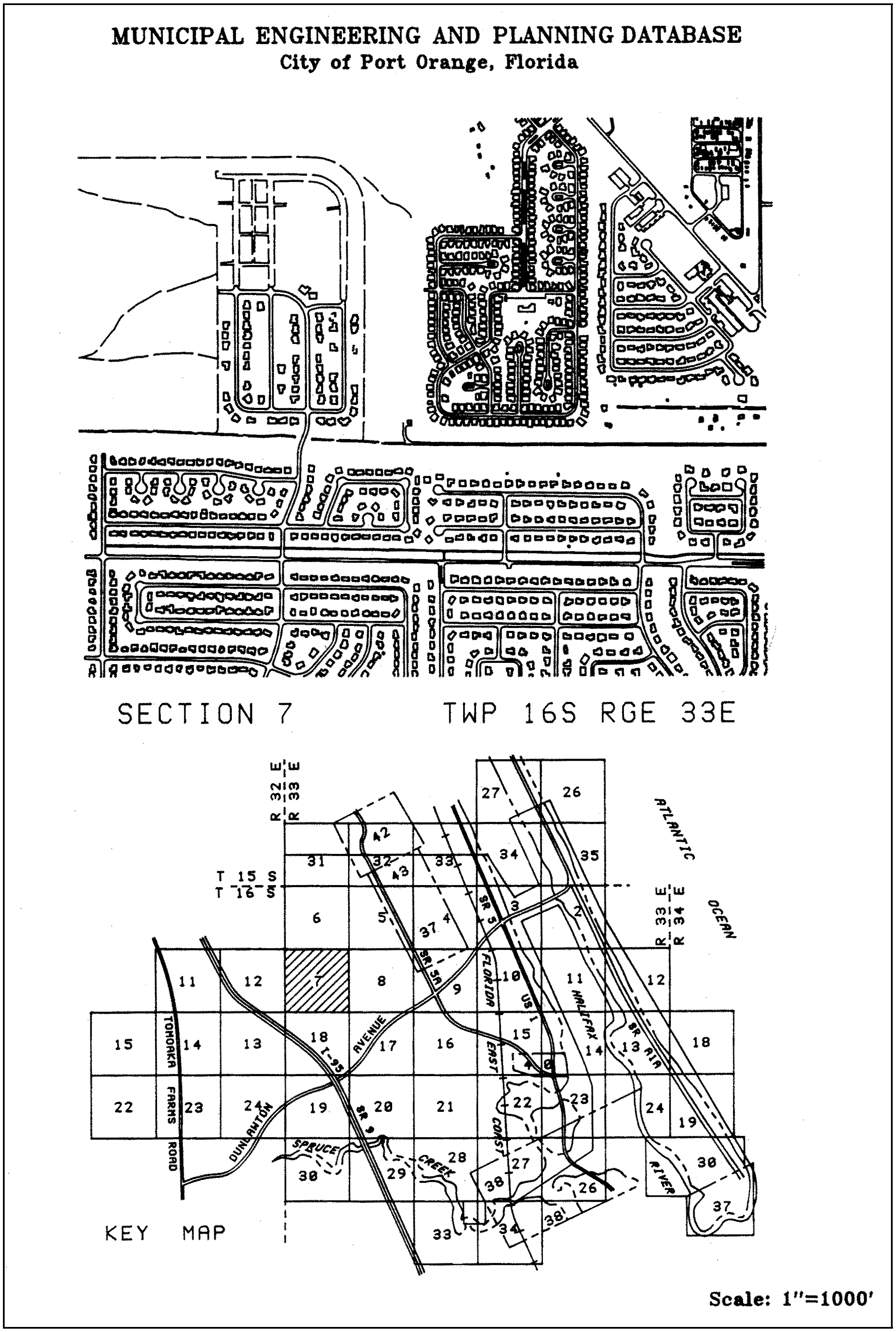


Figure 4-1. General planimetric feature mapping, 1-in. = 1,000-ft scale, with small-scale index map (Courtesy of Southern Resource Mapping Corporation)

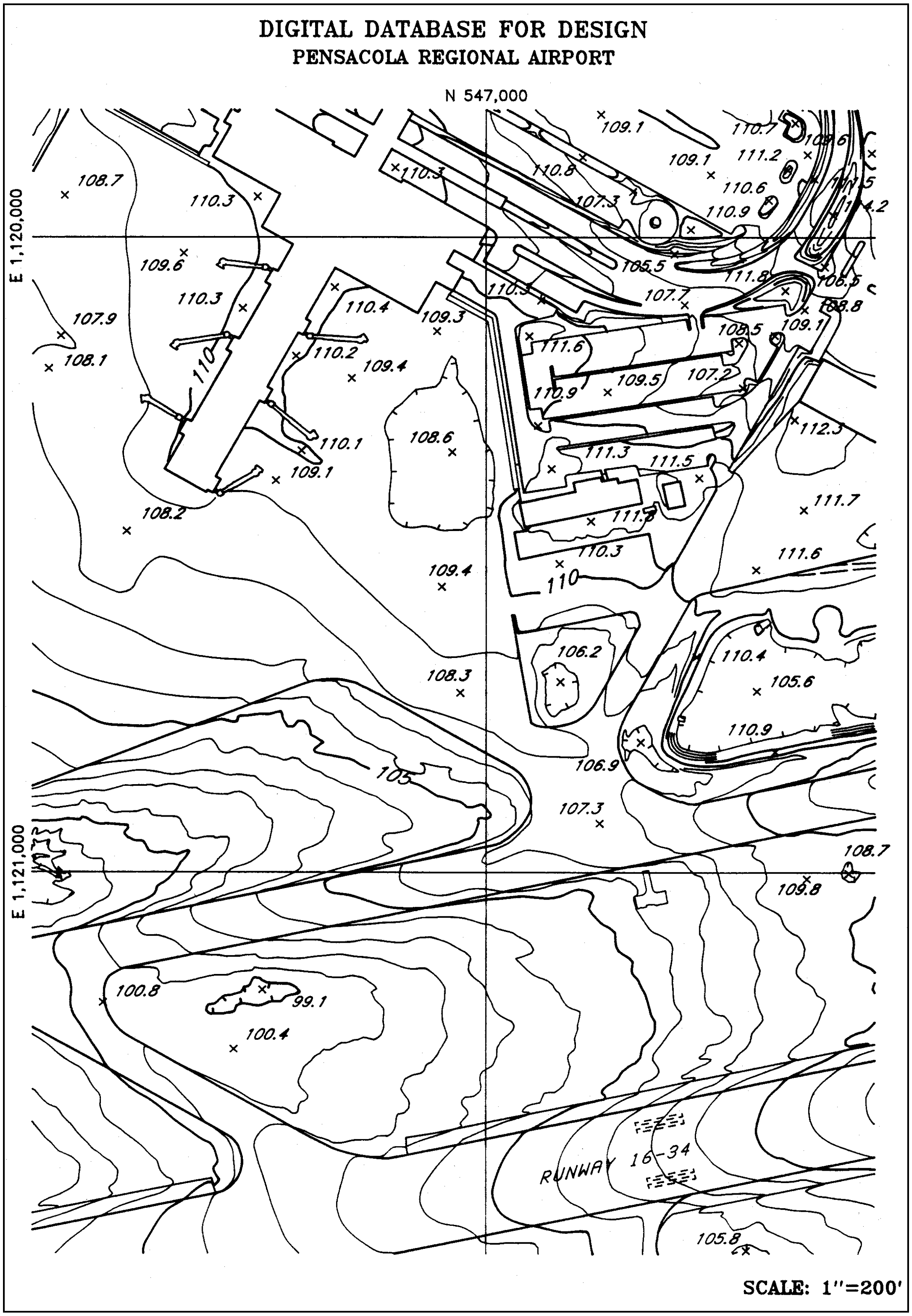


Figure 4-2. Topographic map with 1-ft contours, 1-in. = 1,000-ft scale, for general airfield drainage study/design uses (Courtesy of Southern Resource Mapping Corporation)

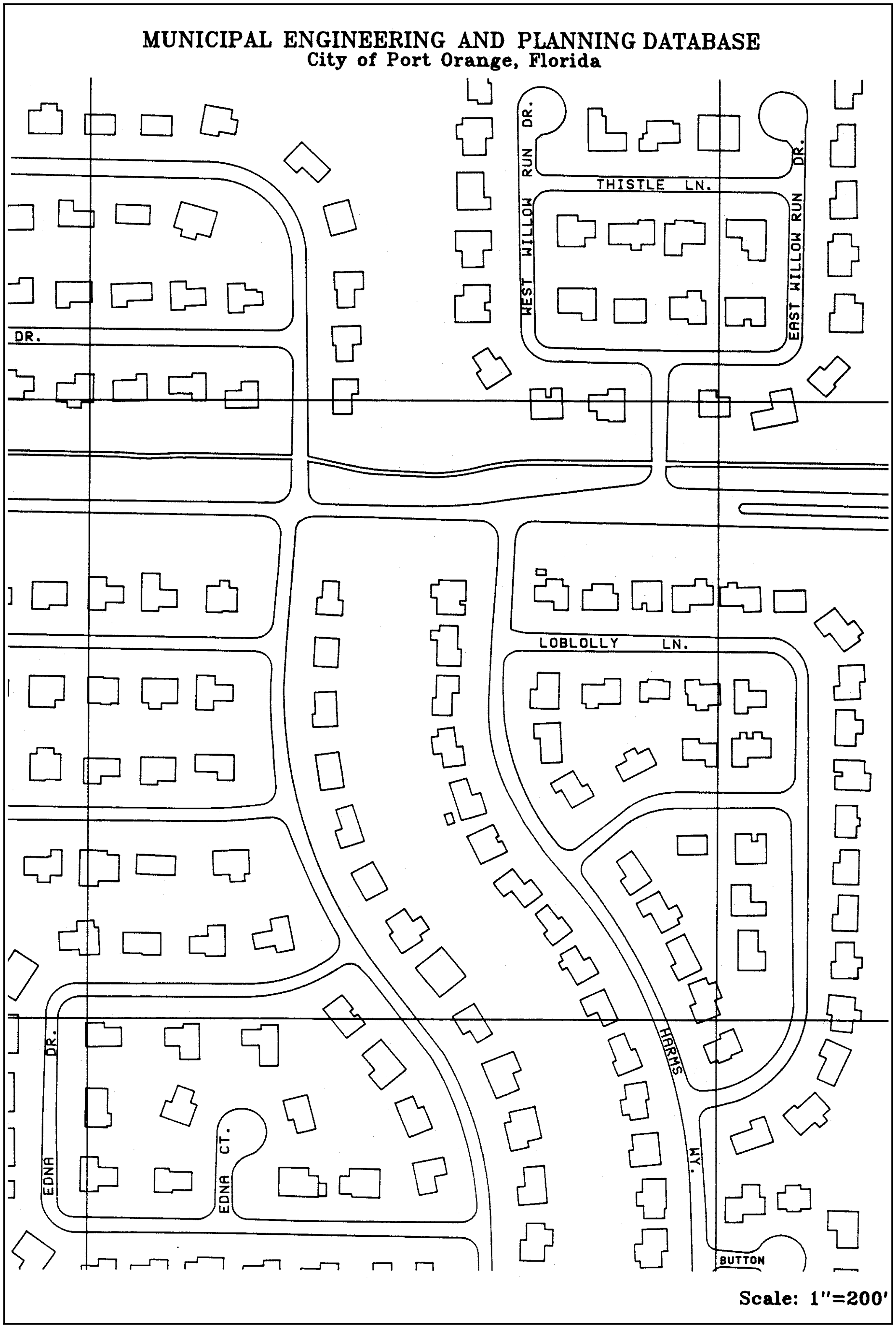


Figure 4-3. Planimetric map of residential area, 1-in. = 200-ft scale, for general planning purposes (Courtesy of Southern Resource Mapping Corporation)

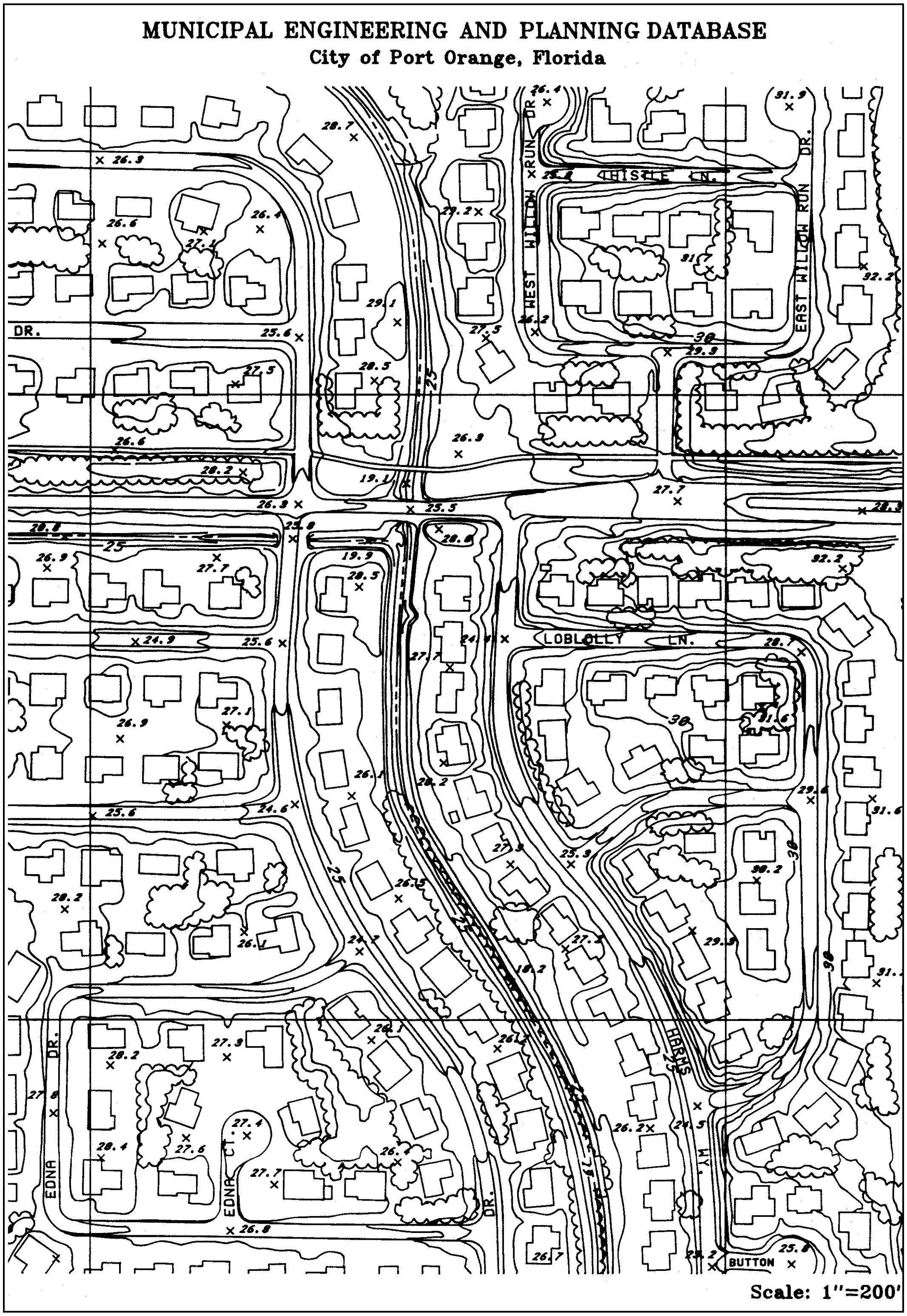


Figure 4-4. Topographic and vegetation layers added to Figure 4-3, 1-in. = 200-ft scale (Courtesy of Southern Resource Mapping Corporation)

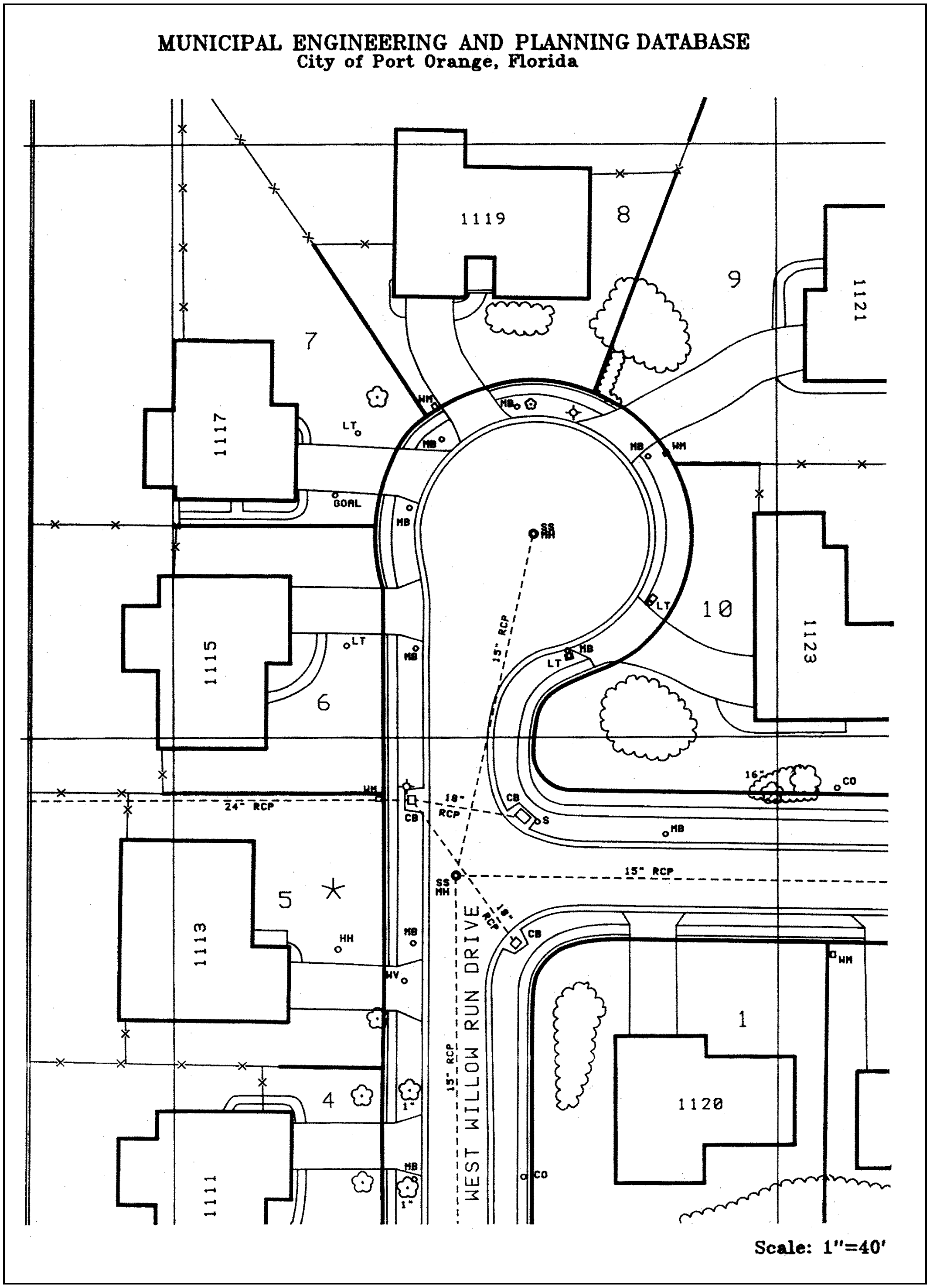


Figure 4-5. Planimetric feature and selected utilities, 1-in. = 40-ft scale, for detailed design of typical civil works project (U.S. Army Engineer District, Jacksonville) (Courtesy of Southern Resource Mapping Corporation)

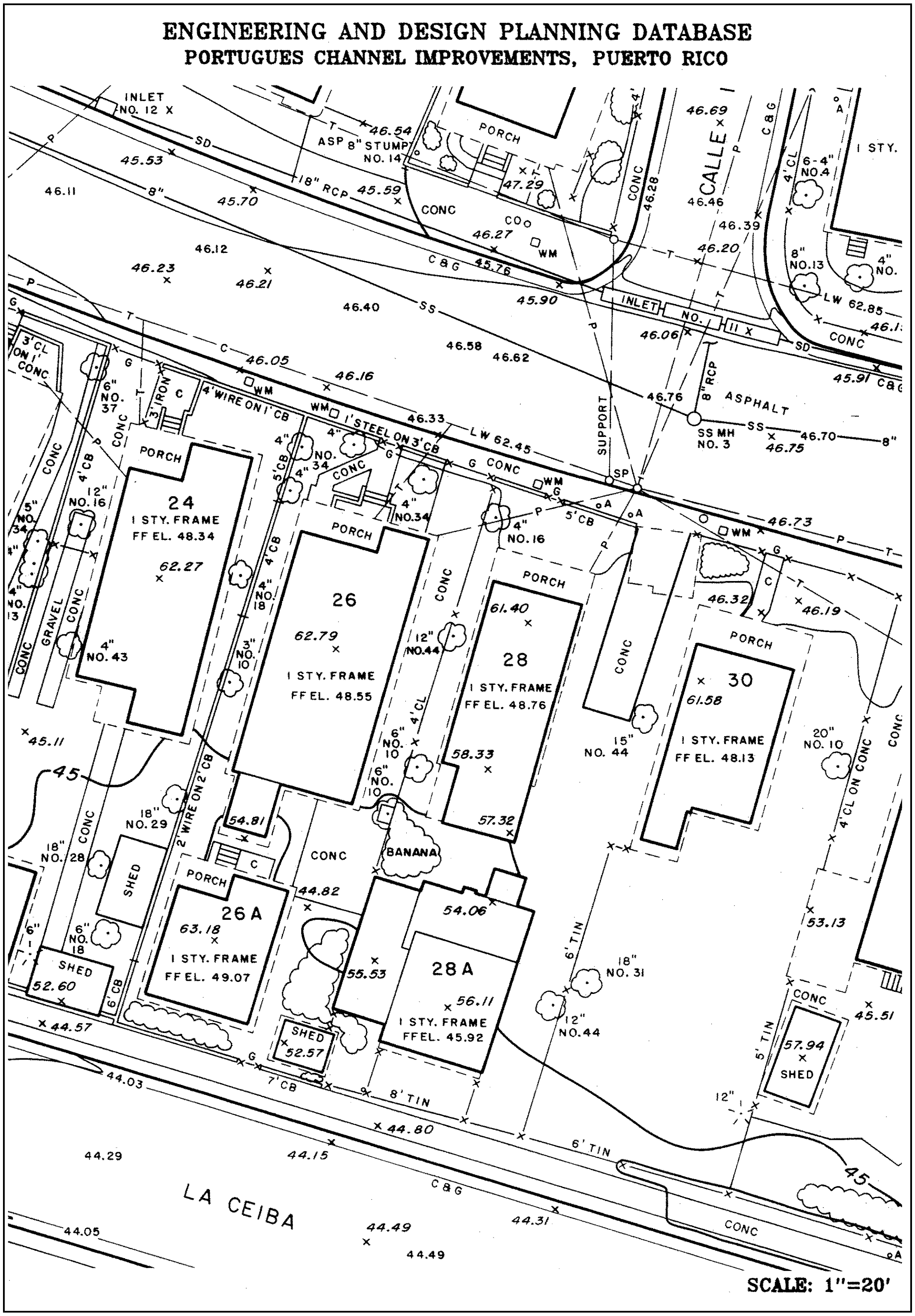


Figure 4-6. Full planimetric and topographic map, 1-in. = 20-ft scale, for detailed design use (Courtesy of Southern Resource Mapping Corporation)

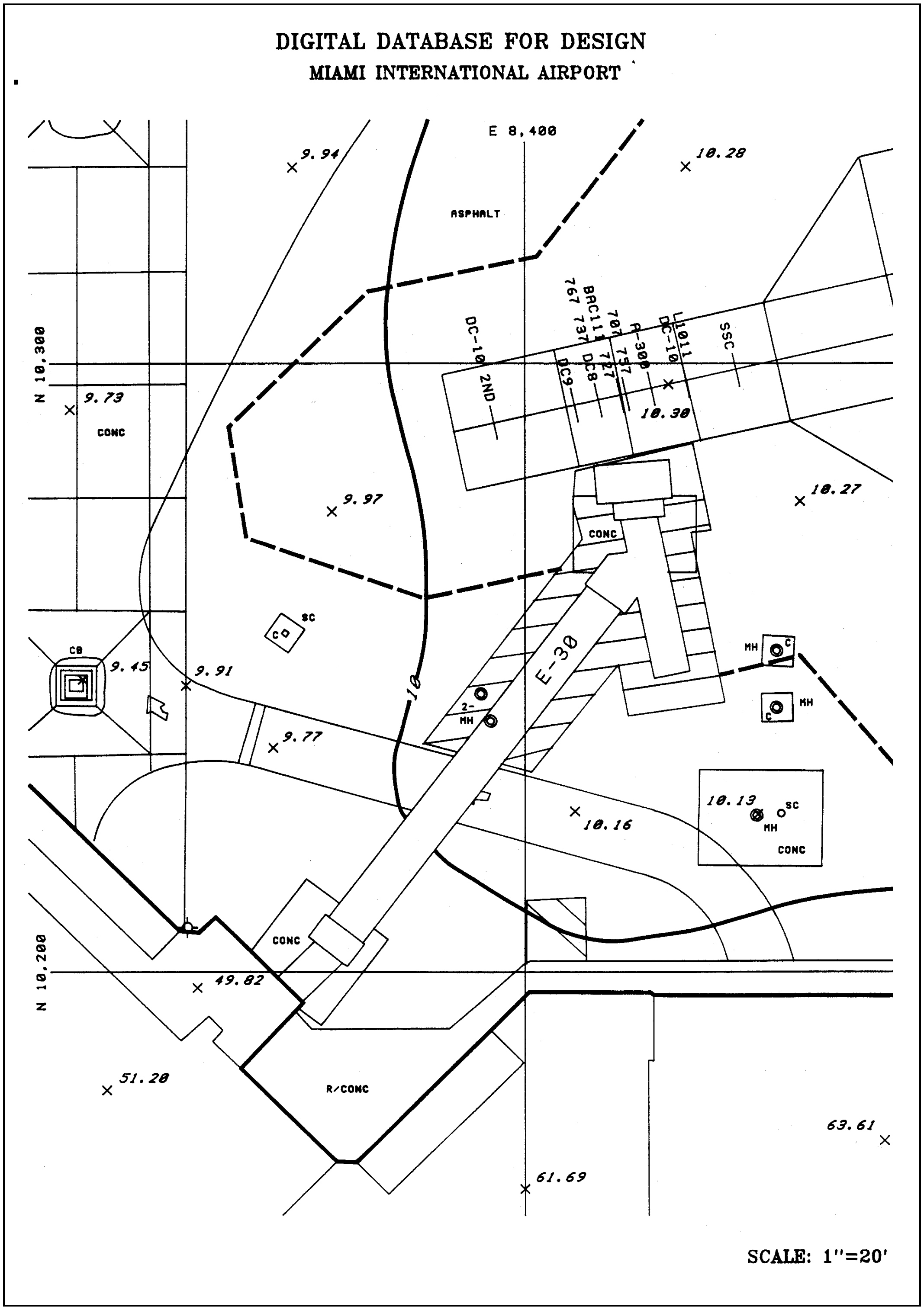


Figure 4-7. Full planimetric and topographic map of airfield, including drainage, 1-in. = 20-ft scale, for detailed design use (Courtesy of Southern Resource Mapping Corporation)

a. 1 in. = 166.6 ft

Figure 4-8. Photographic negative scales for various engineering applications (Courtesy of Southern Resource Mapping Corporation) (Sheet 1 of 11)

b. 1 in. = 200 ft

Figure 4-8. (Sheet 2 of 11)

c. 1 in. = 250 ft

Figure 4-8. (Sheet 3 of 11)

d. 1 in. = 300 ft

Figure 4-8. (Sheet 4 of 11)

e. 1 in. = 400 ft

Figure 4-8. (Sheet 5 of 11)

f. 1 in. = 500 ft

Figure 4-8. (Sheet 6 of 11)

g. 1 in. = 600 ft

Figure 4-8. (Sheet 7 of 11)

h. 1 in. = 1,000 ft

Figure 4-8. (Sheet 8 of 11)

i. 1 in. = 1,200 ft

Figure 4-8. (Sheet 9 of 11)

j. 1 in. = 1,666 ft

Figure 4-8. (Sheet 10 of 11)

k. 1 in. = 2,000 ft

Figure 4-8. (Sheet 11 of 11)

4-4. Data Compatibility

There can be no doubt that the advent of digital databases has been a boon to mapping and GIS/CADD applications; however, there are photogrammetric pitfalls. Perhaps the greatest hazard, though seemingly an apparent strong suit, stems from the ability of a computer, driven by proper software, to accept almost any block of X-Y-Z data and create a map to any scale or contour interval. A primary advantage of automated information systems is not simply aggregating various themes to draw a composite map. More important is the capability of the user to reach into the database, select particular portions of information, and formulate reliable alternative solutions to given situations. Automated information systems will generate hard copy maps, data tabulations, and reports.

a. Information from a multitude of diverse sources can be integrated into a single database, since these systems are capable of comparing various blocks of dissimilar data and presenting the viewer with a composite scenario based on given situation parameters. This allows the manager to manipulate variable parameters to compare multiple solutions with limited expenditure of time.

b. Collected data for various themes are placed on specific data layers for convenience in accessing the database. For this reason, individual layers must be georeferenced to a common ground reference (State Plane, Universal Transverse Mercator, Latitude/Longitude) so that data from various layers geographically match one another when composited. Digital data for many layers will have been collected from various existing map and aerial photo sources. This implies that not all data are compatible.

c. All features go into a database as a group of individual spatial coordinate points that are relational to each other through a common geographic positioning grid. However, not all information is collected to the same degree of accuracy! A map is as reliable only as its most inaccurate information layer. Serious thought must be given to the compatibility of information that resides in an integrated database.

d. As was stated previously, there are two accuracy factors to be considered, each as an autonomous parameter.

(1) Horizontal scale. Assume that digital line graphics (DLG) information is purchased economically from the USGS. This would include transportation, hydrographics, political boundaries, and land lines digitized from 1:24,000 quadrangles. These data conform to U.S. National Map Accuracy Standards, which translates to allowable inaccuracy tolerance of 50 ground feet on 1:24,000 quads. If these data are merged with other data to create a map to scale 1 in. = 100 ft, some features can be realistically misplaced by 0.5 in. at the map scale, far beyond the inaccuracy allowance of 1.0-ft horizontal vector error for ASPRS Class 1, 1 in. =100 ft mapping dictated by Table 2-2.

(2) Topographic relief. Assume that digital terrain model (mass points and breaklines) information is purchased economically from the USGS. This would include 10- or 20-ft contour information, depending on which is available for the project site, digitized from 1:24,000 quadrangles. These data conform to US National Map Accuracy Standards, which states that 9/10 of contours should be accurate to within half a contour interval. This translates to 5 ft for 10-ft contours and 10 ft for 20-ft contours. If these data were to be used to create contours at 2-ft vertical intervals, which DTM software can readily accomplish, each 2-ft contour could realistically vary by as much as 5 to 10 ft from its true vertical position. This by far exceeds the inaccuracy allowance of 0.67 ft prescribed by ASPRS Class 1 mapping in Table 2-3.

(3) A word to the wise. Do not “mix & match” data just because they are readily available and/or economical. All data layers must mesh into the overall accuracy of the final product. Metadata must be developed for all data and be fully compliant with the Content Standard for Digital Geospatial Metadata (CSDGM) FGDC-STD-007-1998 and shall fully document data sources and accuracies.

4-5. Project Design

Prior to cost estimating a mapping project, there must be a concept, mental or written, as to what is required to complete that project. Writing the general job specifications and outlining the project design can be helpful. Appendix F includes several sample Scopes of Work for typical Corps of Engineers type photogrammetric mapping projects. The following factors must be considered in performing this effort.

a. Parameters.

(1) Project site. It is usually best to outline the site on a USGS quadrangle or another equally suitable map of the site.

(2) Contour interval. This must be upon the function for which mapping is intended. A general consideration is that smaller contour intervals are for design purposes, while larger intervals are for planning studies. See Chapter 2 for additional guidance in determining contour intervals for typical USACE projects.

(3) Mapping scale. This is also dependent upon the user's functional requirements (see Chapter 2 for guidance). It must be kept in mind that after the information resides in the database, a map can be generated to any scale, which can be advantageous or disastrous.

b. Aerial photography.

(1) Photo flight parameters. Determine photo scale, film type, flight altitude, number of flight lines, and number of photographs based on the guidance in Chapter 2 and other chapters in this manual. It is good practice, once these items are calculated, to make a preliminary photo mission flight map, preferably on a USGS quadrangle map.

(2) Aircrew cross country. Determine the distance from the photographer's base airport to the project site. This influences cross-country time for the craft and crew.

(3) Special considerations. Make some assumptions as to whether there may be any special considerations to this flight. Is the project in an area where overflights will be restricted to specific time slots? Are there any chronic adverse atmospheric (lingering haze, consistent cloud cover) or ground (snow, vegetation) conditions that will interfere with or prolong the flight?

c. Field surveys.

(1) Travel time. Determine how far it is from surveyor's office to project site. This will influence labor travel costs and per diem expectations.

(2) Control reference. Collect information regarding nearest existing benchmarks and triangulation stations that must be used as geographic reference ties. Ground control references to distant established control is labor intensive and costly.

(3) Photo control density. Determine the pattern of horizontal and vertical field control points that will be needed. If a project requires preflight ground targets, it is helpful to arrange the layout on a USGS quadrangle. Ground control point selection should be done with some thought toward amenable survey routing. Final ground control plan should be planned and agreed upon with the mapping contractor prior to implemenatation.

d. Aerotriangulation.

(1) Aerotriangulation is the control extension link between a limited amount of strategic field survey points and the stringent pattern of photo passpoints that control the photos for mapping.

(2) Control extension can be accomplished either with a stereoplotter or a softcopy workstation. If a stereoplotter is used, a supplementary point marking (pugging) on diapositives is required also. Aerotriangulation in a totally softcopy environment is a self contained operation. Film or diapositive is scanned and loaded into the softcopy system. Pugging is not required.

(3) The photos to be used in mapping are to be employed in the control extension.

e. Digital mapping.

(1) Map detail density. Because of the planimetric and topographic variability specific sites, each project site exhibits its own characteristics. The government estimator must get some perception for the density of cultural features and terrain character on the site. This is normally a great variable between sites and often even within a site. It is probably the biggest labor-intensive item in the whole project. It takes a much longer time to digitize all of the congested cultural detail in an urban area than the few features in a rural setting. It also takes a longer time to digitize DEM data in rough, steep hills than in a flat river valley.

(2) Data edit. Once the data digitizing is complete, an edit of these data must be performed.

(3) Data translation. After data are compiled and edited, they must be translated into whatever format is compatible with the user's CADD system.

(4) Data plot. A line plot of the digital data should be generated to ensure that the data are complete and valid.

f. Orthophoto images.

(1) GIS/LIS projects increasingly demand orthogonal pictorial images to merge as a background for other data layers.

(2) Orthophotos are as accurate as line maps except in areas of sudden vertical change. It may be necessary in these areas to patch images from other photos.

(3) Relevant DEM data are required to generate an orthophoto image.

(4) Scan resolution must be as finite as is required to maintain pixel integrity at the image enlarged image scale.

g. Miscellaneous. Determine what other auxiliary items may be specifically required to complete this project.

(1) Does the project require any accessory photo reproduction items (contact prints, indexes, enlargements, mosaics)?

(2) Are there any supplementary field surveys (bridge surveys, cross sections, well or boring location) required?

(3) Are there any supplementary digital mapping items (cross sections, boring locations, volumetrics) required?

(4) What hidden utility data text attributes will the mapper be required to integrate into the mapping database?

4-6. Photogrammetric Mapping Production Flow

In order to bring the various photogrammetric mapping procedures together in a logical sequence, Figure 4-9 , parts a and b, depict a typical photogrammetric mapping and orthophoto production flow, respectively. Orthophoto production flow is generally a part of a photogrammetric mapping project and utilizes much of the same information collected for photogrammetric mapping to include aerial photography, ground control, aerotriangulation, and digital terrain model development. However, when only orthophotos are required for a project the amount of digital elevation model collection can be reduced as well as vertical ground control. The end user should be warned that a digital elevation model developed ONLY for orthophoto production will not be suitable for contour generation. This chapter presents the project elements that must be addressed when planning, specifying, and estimating costs for a digital mapping project.

Section II

4-7. Approach to Estimating Detailed Photogrammetric Mapping Project Costs

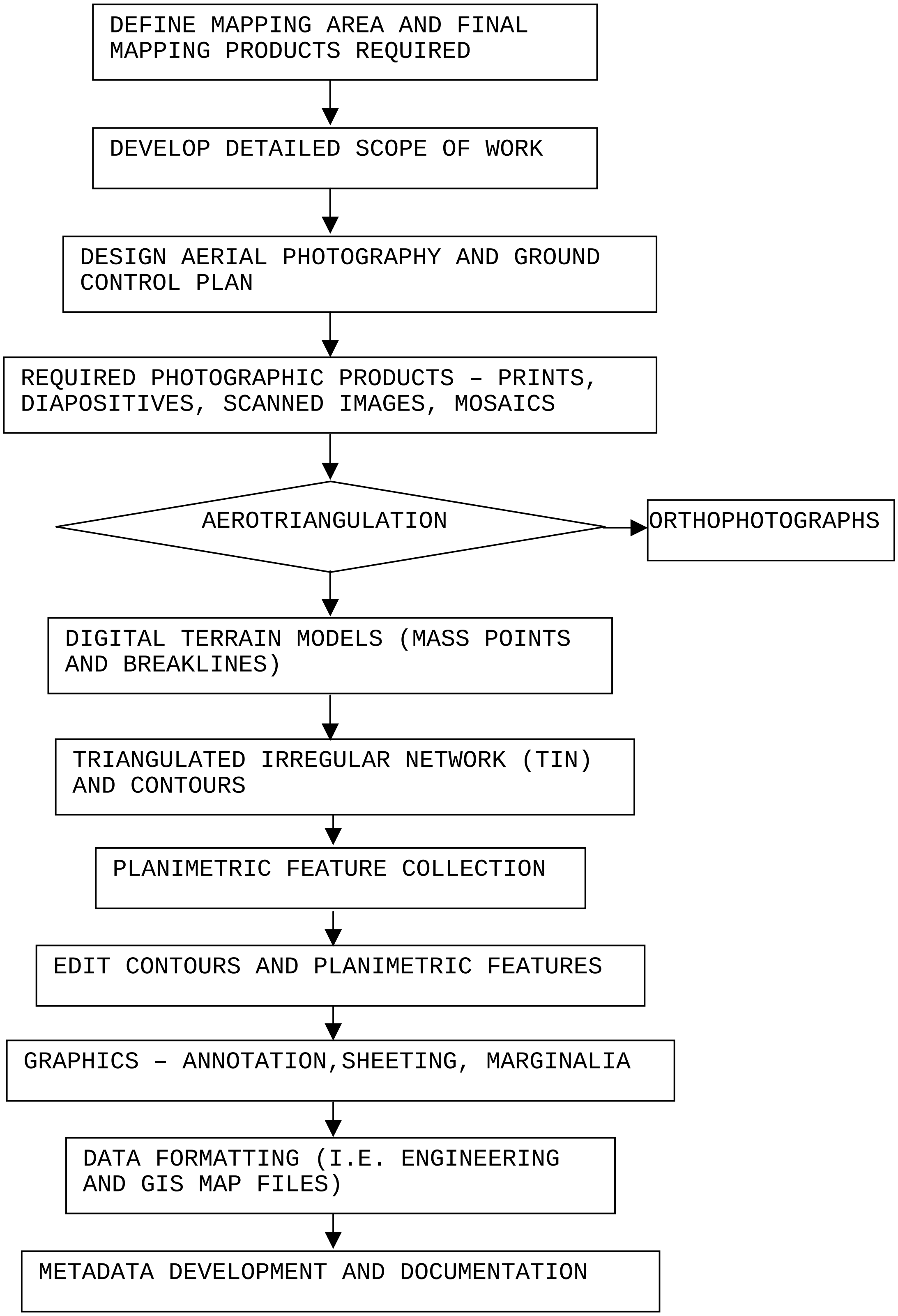
Detailed independent Government cost estimates are required for contract negotiation purposes and must specifically account for all significant cost phases of a digital mapping operation. This is necessary since these estimates (both the Government's and the Contractor's) may be subject to subsequent field audits and/or other scrutiny. Also, contract modifications must relate to the original estimate. Initially, it is important to specify which of the activities involved in making a map will be completed by the Contractor and which may be done by the Government. USACE and other agencies may do some portion of the work. Many USACE Commands, however, contract all the mapping work and participate in none of the actual production activities associated with the generation of digital mapping products.

a. General estimating procedure. The cost estimating procedures presented here can be used to estimate all or only certain parts of a mapping project. This approach allows each user to develop a cost estimating method that incorporates information needed in a specific locale. It allows for exclusion of portions of a mapping project to be conducted by USACE hired labor forces.

(1) Those using the following procedures should indicate which of these activities need to be estimated. As stated earlier, those steps in a cost estimating procedure for mapping include aerial photography, photo control surveying, aerotriangulation, map production, and orthophoto images. For each of these activities, the cost estimates have been further stratified into production elements.

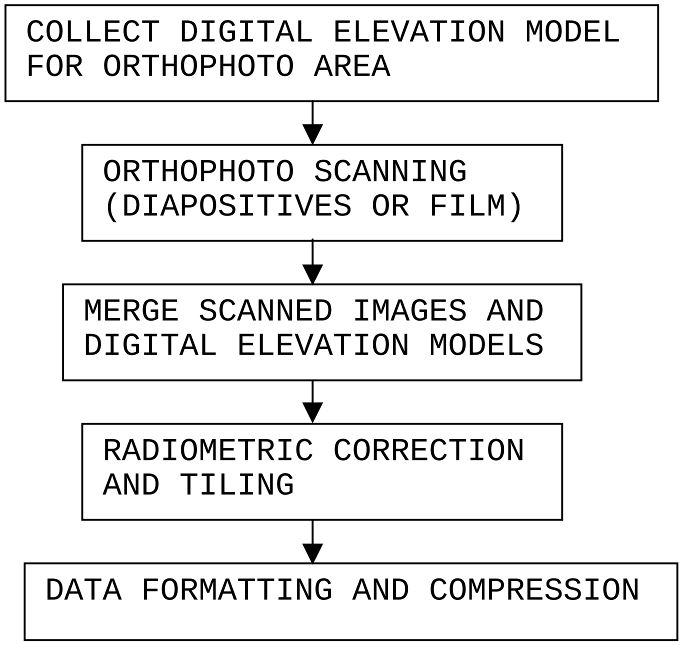
(2) Paragraphs 4-10 through 4-15 present the cost estimating procedure in its entirety. The procedure provides the individual production elements which can be summed with overhead and profit to arrive at estimated budgetary cost for a specific project.

b. Labor. One of the most significant production factors in a mapping project relates directly to hours expended by highly qualified technicians. Amount of work that personnel will conduct is characterized as Direct Labor. It is convenient to express work in hours because it provides a per unit cost basis for estimating purposes.



a. Photogrammetric mapping production flow diagram

Figure 4-9. Photogrammatic mapping processes (Continued)



b. Orthophoto Production Flow Diagram

Figure 4-9. (Concluded)

c. Capital equipment. Another significant factor in a mapping project relates to the capital equipment that technicians operate during production hours. Such sophisticated equipment as aircraft, airborne GPS, softcopy workstations, stereoplotters, scanners, computers, and film processors must be amortized through hourly rental during production phases.

4-8. Project Specifications

a. Variables. It is desirable to specify a number of variables to help best characterize the mapping project and to ensure that an accurate and precise cost estimate can be completed. A complete and accurate scope of work is paramount to a good Government estimate. See example scopes of work in Appendix F. Exact numbers and types of variables can be different for alternate approaches to cost estimating and may not be desirable in a scope of work. However, a complete list of possible needs (deliverables) can be provided, and the required specifications can be selected from the list to customize the content for each cost estimate. It is desirable to specify a set of variables that describes the project before a cost estimate is made. Such a list of variables is provided herein. It includes most required items that should be known along with other information deemed to be useful. The list of specifications presents a good example of what information needs to be supplied before a cost estimation is made. This list is not exhaustive and any effort may include other variables as determined by the Command employing this method.

b. Labor. Cost per hour of personnel can be obtained from regional wage rates or from negotiated information supplied by the Contractor. These can be applied to the estimated production hours to arrive at a project cost.

4-9. Contract Parameters

It is necessary to have information for the following items to best specify a project. Many of the items listed below are inputs to the cost estimating procedure and are used in calculations of parameters.

a. Area to be mapped. It is desirable to provide a firm definition of the area to be mapped. This may be delineated on large-scale topographic maps or 1:24,000 USGS quadrangles. Other descriptive and measurement information should be provided if available. Information may include details from surveys, deeds, or whatever other documents are available. Descriptions may also include gross north/south and east/west dimensions of project.

b. Parameters. Other mapping parameters should include the following:

(1) Final map scale consistent with data usage.

(2) Contour interval consistent with data usage.

(3) Photo scale based on enlargement factor and C-Factor.

(4) Flight height above mean ground level calculated from photo scale.

(5) Film type pertinent to data usage.

(6) Calibrated focal length of camera, usually 6-in. but may differ for special use.

(7) Assumed C-Factor (Chapter 2).

(8) Enlargement factor (Chapter 2).

(9) Nominal endlap, usually 60 percent but may differ for special usage.

(10) Nominal sidelap, usually 30 percent but may differ for special usage.

(11) Distance from aircraft base to project site measured on atlas.

(12) Number of flight lines based on calculations from project short dimension.

(13) Number of photos per flight line based on calculations from project long dimension.

(14) Distance from site to nearest established horizontal control reference measured from atlas.

(15) Distance from site to nearest established vertical control reference measured from atlas.

(16) Cruising speed of aircraft from equipment specifications.

(17) Terrain slope variability estimated from a 1:24,000 USGS quad.

(18) Cultural development variability estimated from a 1:24,000 USGS quad.

c. Deliverables. A list of delivery items should be supplied. This is necessary to clearly define the end products, which should ensure an accurate estimate of cost. The list below consists of a number of possible products that may be requested. Products should be specified in the contract. Also, the number of copies or sets to be furnished must be stated.

(1) Contact prints.

(2) Hardcopy map sheets.

(3) Digital data in CADD or GIS/LIS format (planimetric features, DEM, DTM, TIN, Contours).

(4) Photo enlargements.

(5) Photo index.

(6) Photo mosaics.

(7) Field surveys.

(8) Orthophotos.

(9) Aerotriangulation report.

(10) Field survey report.

(11) Aerial camera current USGS Calibration Report.

4-10. Calculation of Production Hours for Aerial Photography

PRODUCTION HOURS FOR AERIAL PHOTOGRAPHY

Direct labor

Project Mission:

Flight preparation = 1.5 hr

Takeoff/landing = 0.5 hr

Cross-country flight = miles to site H 2 ways / mph
= ______ H 2 / ______
= ______ hours

Photo flight =

End turns = lines H 0.08 hours = ______ hours

Photo Lab:

Develop film = ______ photos H 0.04 = ______ hours
Check film = ______ photos H 0.04 = ______ hours
Title film = ______ photos / 40 = ______ hours

Contact prints = ______ photos / 45 = ______ hours

Equipment rental

Aircraft = project mission hours = ______ hours

Airborne GPS = project mission hours = ______ hours
(if not included in aircraft rental)

Film processor = develop film hours = ______ hours

Film titler = title film hours = ______ hours

Contact printer = contact prints hours = ______ hours

4-11. Photo Control Surveying Cost Items

Offsite information. The following items are to be specified to assist in the calculations of costs associated with photo control surveying.

a. Distance from survey office to site.

b. Distance to horizontal reference.

c. Distance to vertical reference.

d. Time to complete horizontal photo control or number of points required.

e. Time to complete vertical photo control or number of points required.

No production estimating procedure is presented for ground surveys. This is best left to District survey branches once they are apprized of the number and location of required ground targets.

4-12. Aerotriangulation

<u>PRODUCTION HOURS FOR AEROTRIANGULATION</u>

Direct labor

Photo scan = ________ photos H 0.3 hours = ______ hours

Aerotriangulation (workstation):

Model orientation = ______ models H 0.2 hour
= ______ hours

Coordinate readings = ______ photos H 0.3 hour
= ______ hours

Computations = ______ models H 0.4 hours = ______ hours

Equipment rental

Scanner (for Softcopy Aerotriangulation) = scanning hours = ______ hours

Workstation = aerotriangulation hours = ______ hours

Computer = computations hours = ______ hours

4-13. Photogrammetric Compilation and Digital Mapping Cost Items

Site specific information. The following items are to be calculated, estimated, or measured to assist in the computing costs associated with digital mapping.

a. Number of stereomodels to orient.

b. Number of acres and or stereomodels to map.

c. Complexity of terrain character.

d. Complexity of planimetric culture.

e. Format translations of digital data.

PRODUCTION HOURS FOR STEREOMAPPING

Model Setup:

Model setup includes planning the collection procedures and setting models in the data collection system. Data collection may be accomplished by analytical stereoplotters or softcopy workstations. Analytical stereoplotters will require diapositives and softcopy workstations will require high resolution scans. For additional explanation and detail review portions of Chapters 5 through 10.

Model orientation = _______models H 0.1 hours = ______ hours

Photo scan = ________ photos H hours = ______ hours
(if not done previously)

Digital data capture:

Planimetry (cultural features) - The project planning map used to outline the mapping area should be overlain with a proposed flight line layout. The flight line layout should note the approximate location of each photo stereopair. The planimetric feature detail in each of the models should be assessed based on the amount of planimetric detail to be captured (full or partial stereomodel and the final map scale) and the density of planimetry to be captured in each stereomodel. As an example: Highly urban area stereomodels require more time to compile than rural area stereomodels. The following charts can be used as a guide for certain map scales.

CHART 1 **PLANIMETRY PRODUCTION**				APPROX. PLAN. **TIME (HOURS)/MODEL**			
				FINAL MAP SCALE			
DENSITY TYPE	MODELS/ TYPE	HOURS/ TYPE	TOTAL PLAN HRS	1"=40' TO 1"=60'	1"=100' TO 1"=150'	1"=200' TO 1"=300'	1"=400' TO 1"=1600'
LIGHT							
1				3.0	2.5	2.5	2.5
2				4.0	3.5	3.5	3.5
MEDIUM							
3				5.0	4.0	4.0	4.0
4				7.0	6.0	6.0	5.0
HEAVY							
5				10.0	8.0	7.0	6.0
TOTAL PLANIMETRY HOURS							
EDIT TIME: GENERALLY 30% OF TOTAL PLANIMETRIC COMPILATION HOURS							

Topography - The project planning map used to outline the mapping area should be overlain with a proposed flight line layout. The flight line layout should note the approximate location of each photo stereopair. The topographic feature detail in each of the models should be assessed based on the amount of planimetric detail to be captured (full or partial stereomodel and the final map scale). Topographic detail must consider the character of the land to be depicted. As an example: 1-ft contour development in a relatively flat terrain requires much less time than collection of 1-ft contours in very mountainous terrain. The chart below can be used as a guide for certain map scales.

CHART 2 **TOPOGRAPHY (TOPO) PRODUCTION** **COLLECTION OF MASS POINTS AND BREAKLINES FOR PRODUCTION OF CONTOURS**				APPROX. TOPOGRAPHY **TIME(HOURS)/MODEL**			
				FINAL MAP CONTOUR INTERVAL SCALE			
TERRAIN CHARACTER (SLOPE)	MODELS /TYPE	HOURS /TYPE	TOTAL TOPO HOURS	1 FT	2 FT	4 FT	5 FT TO 8 FT
FLAT				2.0	2.5	2.5	2.0
ROLLING				4.0	4.0	4.0	3.0
HILLY				6.0	6.0	5.0	4.0
STEEP				8.0	8.0	6.0	5.0
DISTURBED				10.0	10.0	8.0	7.0
TOTAL TOPO HOURS							
EDIT TIME: GENERALLY 30% OF TOTAL TOPO COLLECTION TIME							

4-14. Orthophoto Images

PRODUCTION HOURS FOR ORTHOPHOTOS

Current technology allows for total softcopy generation of orthophotos. See previous chapters for more detailed information. If a Contractor has collected the digital terrain model with an analytical stereoplotter and created diapositives then a clean set of diapositives must be made and scanned for orthophoto generation. However, if the Contractor uses softcopy stereo compilation for the elevation model collection then the same scanned images may by used to generate the orthophotos. The Government must assume one method or the other in developing a cost estimate. The difference in cost should be negligible.

Direct labor

CHART 3 ORTHOPHOTO PRODUCTION COSTS						
ELEVATION MODEL (DEM) DEVELOPMENT (ORTHO ONLY) DEVELOPED BY THE STEREO COMPILER						
# STEREO MODELS	HOURS/MODEL			TOTAL DEM TIME STEREO MODELS H HR/MOD		
	2 HR/MODEL					
TASKS BELOW ACCOMPLISHED BY SOFTCOPY TECHNICIAN						
NATURAL COLOR AND COLOR IR				BLACK AND WHITE		
	HRS/IMAGE	No. of Images	Total Hr.	HRS/IMAGE	No. of Images	Total Hr.
IMAGE SCANNING	0.3 HR			0.2 HR		
DEM - SCAN DATA MERGE	0.5 HR			0.5 HR		
RADIOMENTERIC CORRECTION	2.5 HR			2.0 HR		
TILING/SHEETING	0.25 HR					
TOTAL HR						

4-15. Summary of Production Hours

A summary of the production hours itemized above is shown in the following list. Current Unit Costs should be established for each task to be used in a project. The Unit Costs should include necessary equipment as well as labor. These rates may be most accurately estimated by reviewing similar current Government Contracts. Note that in addition to the total labor hours an appropriate overhead should be established and applied to the total cost of labor. Also, an appropriate profit should be established and applied to the total of labor and direct costs. Ground survey requirements established by Government survey staff should be added to the total costs.

CHART 4 PHOTOGRAMMETRIC MAPPING PROJECT PRODUCTION			
PRODUCTION LABOR			
	HOURS	UNIT COST	TOTAL COST
AERIAL PHOTOGRAPHY			
AEROTRIANGULATION			
MODEL SETUP			
PLANIMETRY			
TOPOGRAPHY			
ORTHOPHOTOGRAPHY			
TOTAL			
DIRECT COSTS			
	UNITS	UNIT COST	TOTAL COST
FILM			
PRINTS			
DIAPOSITIVES			
HARDCOPY PRINTS			
CD'S, DISKS OR TAPES			
AIRCRAFT W/ CAMERA			
STEREO PLOTTER			
SOFTCOPY WRKSTA.			
EDIT WRKSTA.			
SCANNER			
TOTAL DIRECT COST			

Section III

4-16. Photogrammetric Mapping - Sample Scope of Work and Cost Estimate

This section provides sample scope of work documents along with cost estimates. The samples provided are to be used as a general guide to highlight all items that should be included in a Government estimate. The Government estimate is to be a tool to use in negotiating a fair and reasonable cost for A-E mapping services. The negotiations for a specific project are to use the Government estimate along with technical knowledge of the project to arrive at a FAIR and REASONABLE cost. The unit and total costs along with associated labor and equipment times and efforts may vary for photogrammetric projects depending upon the location, time of year, specific contracting issues, and the contractor's capability and existing work load. However, if the Government includes all items required and a reasonable effort and associated unit cost, a suitable Government estimate should be obtainable from the methods provided in this chapter.

SAMPLE PROJECT #1

1. Description of work:

Mapping of portions of the ALCOA site in East St. Louis, IL, has been requested . The area to be mapped is approximately 800 acres. The final mapping products requested are digital, planimetric, and topographic map files in ARC/INFO format. The map scale will be 1 in. = 50 ft with 1-in. contours. The aerial photography will be flown at a negative scale of 1 in. =330 ft utilizing panchromatic (black and white) film. Minimal ground survey control to perform aerotriangulation (AT), develop digital terrain models (DTM), and produce the digital mapping will also be obtained. All photography will be flown at approximately 1,980 ft Above Mean Terrain (AMT). The final mapping will fully comply with ASPRS Class I Accuracy Standards for mapping at a horizontal scale of 1 in. = 50 ft with a DTM suitable for generation of 1-ft contours. All digital files will be fully compatible with the current ARC/INFO system at the E. St. Louis Business & Economic Development Department.

2. Information supplied by the Government:

a. Map showing project area.

b. Corpsmet 95 - available at:

http://corpsgeol.usace.army.mil

3. Work to be performed by the Contractor: Contractor shall provide equipment, supplies, facilities, and personnel to accomplish the following work:

a. Contractor will establish an aerial photo mission and ground survey control network for the project. The Contractor will fly and photograph the project area at an altitude of approximately 1,980 ft AMT with a negative scale of 1 in. = 330 ft in panchromatic (black and white). Photography will be flown with 60-percent forward lap and approximately 30-percent side lap. GPS data collection and processing will include latitude, longitude, and ellipsoid elevation for each photo center. All ground survey plans including survey network layout, benchmarks to be used, etc. shall be approved by the USACE prior to initiation of project. The plan submitted shall include but not be limited to maps indicating proposed GPS network, benchmarks to be used, flight lines, and project area.

b. Additional ground survey data will be collected to be used in the mapping process and to check the final mapping. The plan for additional ground survey control required for mapping and procedures to accomplish the ground survey control will be submitted to the USACE for approval prior to initiation of the project. In addition, USACE will provide approximate locations for two check profiles to be established and submitted directly to USACE to be used as an additional check of the topographic mapping. The check profiles will be 1,000 ft in length or shorter with an elevation established approximately every 100 ft. All original notes for these surveys shall be submitted and no copies shall be made by the Contractor. All survey data shall be in the Illinois West State Plane Coordinate System, referenced to WGS-84. Vertical datum will be NGVD88 w/ 93 (High Accuracy Reference Network {HARN}) adjustment. All surveys shall be accomplished in accordance with the technical section of Contract DACW43-98-D-0505.

c. Two sets of contact prints will be made in accordance with the technical section of Contract DACW43-98-D-0505. One set of the prints will be used as control photos for mapping. The control prints will have all ground control marked on the back and front of each photo. All photography will include in the border areas the negative scale (as a ratio), the dates of photography, flight line and frame numbers, and the title “E. STL – ALCO.”

d. Ground control (panel data and photo identifiable data) will be utilized to perform analytical aerotriangulation to generate sufficient photo control points to meet National Map Accuracy Standards for mapping at a horizontal scale of 1 in. = 50 ft with a DTM suitable for generation of 1-ft contours. The Contractor will produce a written report discussing the aerotriangulation procedures used, number of ground control points used, any problems (and how they were resolved), the final horizontal and vertical RMSE, and how to read the aerotriangulation print out (units, etc.). The written report will be signed and dated by the author.

e. The 1-in. = 330-ft photo diapositives will be utilized, and planimetric feature detail (all that can be seen and plotted from the photography) and digital terrain model (DTM) data will be collected for topographic mapping at a horizontal scale 1 in. = 50 ft with 1-ft contours. DTM production will utilize collection of mass points and breaklines to define abrupt changes in elevation. Data will be delivered in digital ARC/INFO GIS format (.e00)on CD ROM disks.

f. The Contractor will produce the planimetric feature data, DTM, and contour files in ArcInfo (.e00) format on CD-ROM disks. The data structure, symbology, and layers will comply with the Tri-Service SPATIAL DATA Standards. All files will be topologically structured.

g. The Contractor will produce a paper check plot of contours that will cover the areas of the check profiles. The locations will be provided to the Contractor by the Government after DTM and orthophoto files are delivered.

h. The Contractor will provide metadata for the aerial flight, ground control and mapping data sets in accordance with the applicable provisions of the Content Standards for Digital Geospatial Metadata Workbook, Workbook Version 1.0, Federal Geographic Data Committee, March 24, 1995. Metadata associated with all generated coordinated data produced shall be accomplished using CORPSMET95, version 2.0.

4. Delivery items:

a. Copy of computer printout of aerotriangulation solution. Aerotriangulation report, as defined in paragraph 3*c*, and one copy of the written aerotirangulation report.

b. Copy of camera calibration reports.

c. One copy of digital planimetric feature files and topographic data files at a horizontal scale of 1 in. = 50 ft, with 1-ft Contours. One copy of the DTM files suitable for 1-ft contours. The digital files will be in ARC/INFO formation CD-ROM disks.

d. All survey data (including ground surveys), raw GPS files ,any other survey information developed and or collected for the project and all check profile data.

e. Two sets of the panchromatic (black and white) prints, and one set of diapositives.

f. Flight line index for the project on paper maps indicating the flight lines and beginning and ending frames for each flight line along with altitude and negative scale of the photography.

g. Metadata on CD ROM for aerial photography, ground control, and mapping data sets.

h. All manuscript copies, horizontal and vertical control information, aerial photographs, pugged diapositives, and aerial film will be returned to the Government when the project is completed.

5. Schedule and submittal:

a. The Contractor will capture the photography before November 30, 1998. The Contractor will deliver all final products (including CD-ROM digital data files) within 45 calendar days after photography is flown.

b. All material to be furnished by the Contractor shall be delivered at the Contractor's expense to: U.S. ARMY CORPS OF ENGINEERS.

6. Time extensions:

In the event these schedules are exceeded for reasons beyond the control and without fault or negligence of the Contractor, as determined by the Contracting Officer, this task order will be modified in writing and the task order completion date will be extended one (1) calendar day for each calendar day of delay.

<u>PRODUCTION HOURS FOR AERIAL PHOTOGRAPHY</u>
Direct labor

Project Mission:

Flight preparation = 1.5 hr

Takeoff/landing = 0.5 hr

Cross-country flight = miles to site H 2 ways / mph
= 50 H 2 / 150
= 0.5 hr

Photo flight = 0.5 hr

End turns = 5 lines H 0.08 hr = 0.4 hr

Photo Lab:

Develop film = 40 photos H 0.04 = 1.6 hr
Check film = 40 photos H 0.04 = 1.6 hr
Title film = 40 photos / 40 = 1 hr

Contact prints = 80 photos / 45 = 2 hr

Equipment rental

Aircraft = project mission hours = 2 hr

Airborne GPS = project mission hours = ______ hr
(if not included in aircraft rental)

Film processor = develop film hours = 1.6 hr

Film titler = title film hours = 1 hr

Contact printer = contact prints hours = 2 hr

PRODUCTION HOURS FOR AEROTRIANGULATION

Direct labor

Photo scan = ________ photos H 0.3 hr = ______ hr

Aerotriangulation (workstation):

Model orientation = 40 models H 0.2 hr
= 8 hr

Coordinate readings = 40 photos H 0.3 hr
= 12 hr

Computations = 40 models H 0.4 hr = 16 hr

Equipment rental

Scanner = scanning hours = ______ hr

Workstation = aerotriangulation hours = ______ hr

Computer = computations hours = ______ hr

Model Setup:

Model setup includes planning the collection procedures and setting models in the data collection system. Data collection may be accomplished by analytical stereoplotters or softcopy workstations. Analytical stereoplotters will require diapositives, and softcopy workstations will require high-resolution scans. For additional explanation and detail, review portions of Chapters 2 through 10.

Model orientation = 40 models H 0.1 hr = 4 hr

Photo scan = ________ photos H hr = ______ hr
(if not done previously)

PLANIMETRY				APPROX. PLAN. TIME (HOURS)/MODEL			
				FINAL MAP SCALE			
DENSITY TYPE	MODELS PER TYPE	HOURS PER TYPE	TOTAL PLAN HR	1"=40' TO 1"=60'	1"=100' TO 1"=150	1"=200' TO 1"=300'	1"=400' TO 1"=1600'
LIGHT							
1		3.0		3.0	2.5	2.5	2.5
2		4.0		4.0	3.5	3.5	3.5
MEDIUM							
3	4	5.0	20	5.0	4.0	4.0	4.0
4	7	7.0	49	7.0	6.0	6.0	5.0
HEAVY							
5	16	10.0	160	10.0	8.0	7.0	6.0
TOTAL PLANIMETRY HOURS			229				
EDIT TIME: GENERALLY 30% OF TOTAL PLANIMETRIC COMPILATION HOURS			69				

TOPOGRAPHY (TOPO) COLLECTION OF MASS POINTS AND BREAKLINES FOR PRODUCTION OF CONTOURS				APPROX. TOPOGRAPHY TIME(HOURS)/MODEL			
				FINAL MAP CONTOUR INTERVAL SCALE			
TERRAIN CHARACTER (SLOPE)	MODELS /TYPE	HOURS /TYPE	TOTAL TOPO HOURS	1 FT	2 FT	4 FT	5 TO 8 FT
FLAT	4	2.0	8.0	2.0	2.5	2.5	2.0
ROLLING	6	4.0	24.0	4.0	4.0	4.0	3.0
HILLY		6.0		6.0	6.0	5.0	4.0
STEEP		8.0		8.0	8.0	6.0	5.0
DISTURBED	10	10.0	100	10.0	10.0	8.0	7.0
TOTAL TOPO HOURS			132				
EDIT TIME: GENERALLY 30% OF TOTAL TOPO COLLECTION TIME			40				

COST ESTIMATE WORKSHEET
IL EPA ALCOA E. ST. LOUIS, IL
PHOTOGRAMMETRIC MAPPING
CONTRACT NUMBER
TASK ORDER NO.

DISCIPLINE	HOURS	RATE (2ND)	EXTENSION
PROJECT MANAGER	24	$30	720.00
CHIEF PHOTOGRAMMETRIST	20	$30	600.00
PHOTOGRAMMETRIST SUPER.	40.	$23	920.00
AERIAL PILOT	3.5	$19	66.50
AERIAL PHOTOGRAPHER	3.5	$16	56.00
COMPUTER OPERATOR	40	$23	920.00
COMPILER	401	$15	6,015.00
DRAFTER/CADD OPERATOR	109	$11	1,199.00
PHOTO LAB TECHNICIAN	8	$9	72.00
TOTAL DIRECT LABOR			10,568.50
COMBINED OVERHEAD ON DIRECT LABOR AND GENERAL AND ADM. OVERHEAD AT 160.5%			16,962.44
TOTAL DIRECT LABOR AND OVERHEAD			$27,530.94

DIRECT COSTS

AIRPLANE W/CAMERA & GPS	2	$700.00 / HOUR	1,400.00
B/W PRINTS	80	$ 0.55 / EACH	44.00
B/W DIAPOSITIVES	40	$ 1.65 / EACH	66.00
CD-ROM	2	$ 5.00 / EACH	10.00
TOTAL DIRECT COSTS			$1,520.00

TOTAL DIRECT LABOR, OVERHEAD & DIRECT COSTS
$29,050.94

PROFIT @ 12% $3,486.11

SUBCONTRACT
GROUND SURVEYS
18 H/V 3 FIELD DAYS + 1 DAY COMPUTATIONS $ 6,400.00
TOTAL $38,937.05

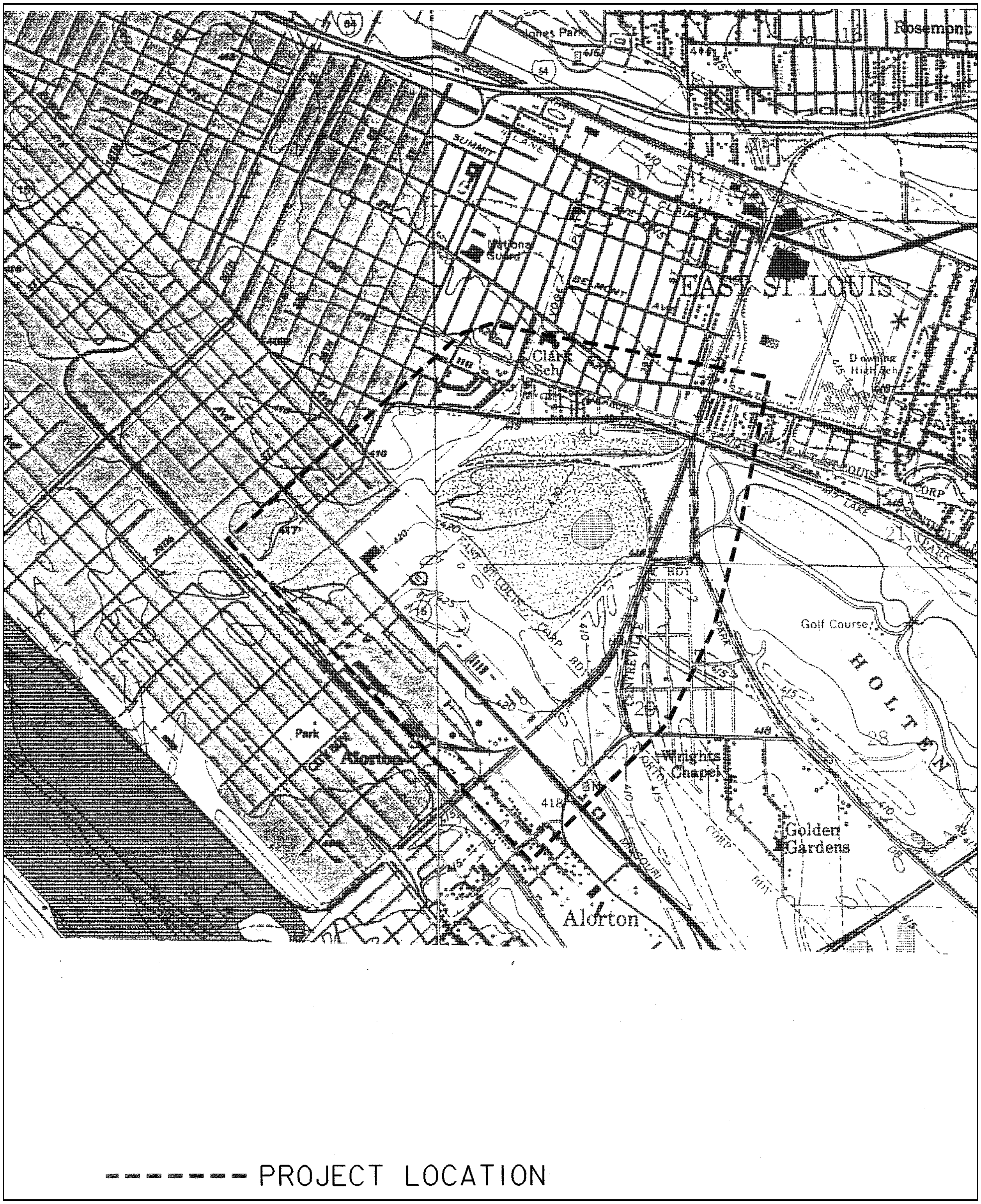


Figure 4-10. Project location

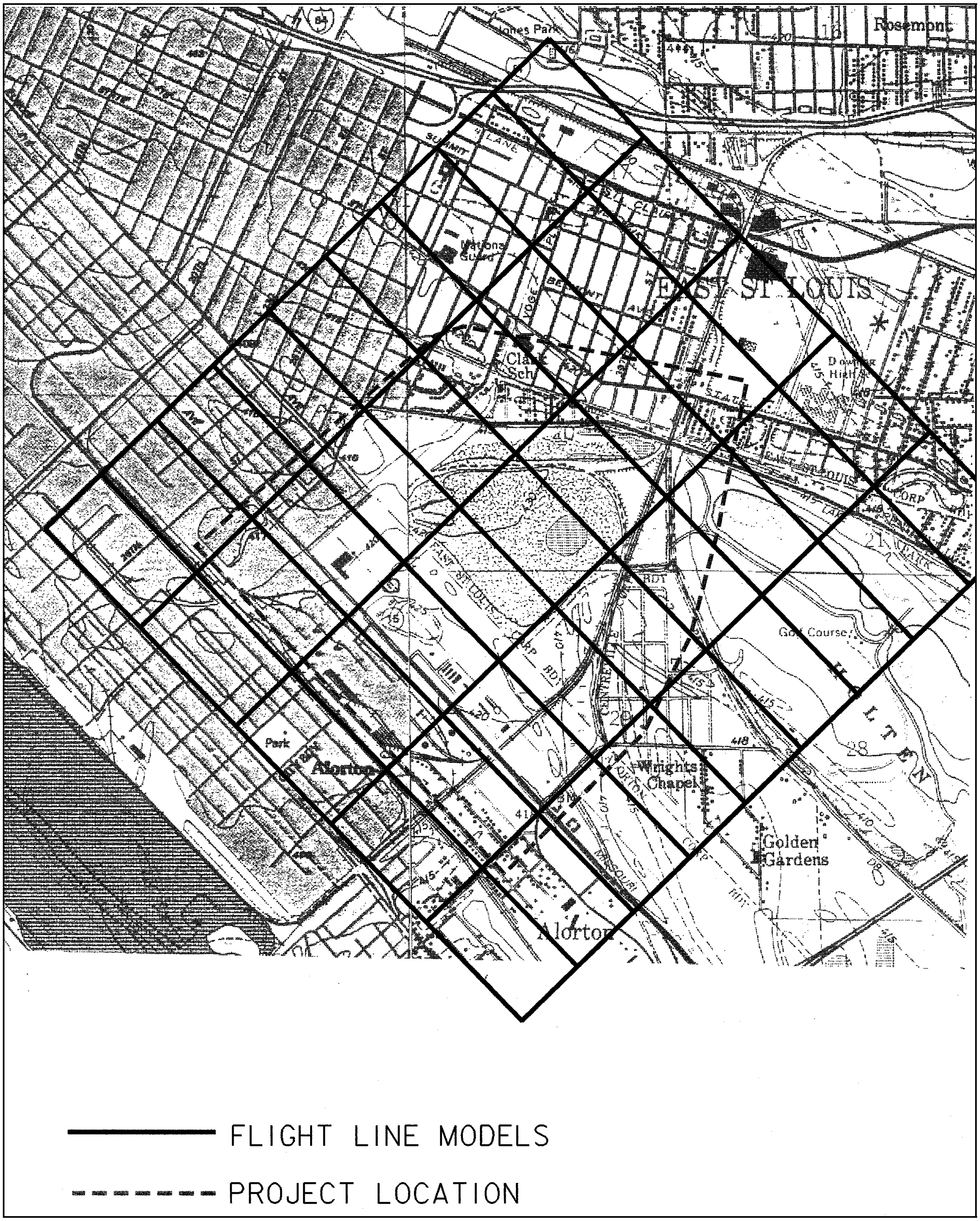


Figure 4-11. Project flight lines and stereo model coverage

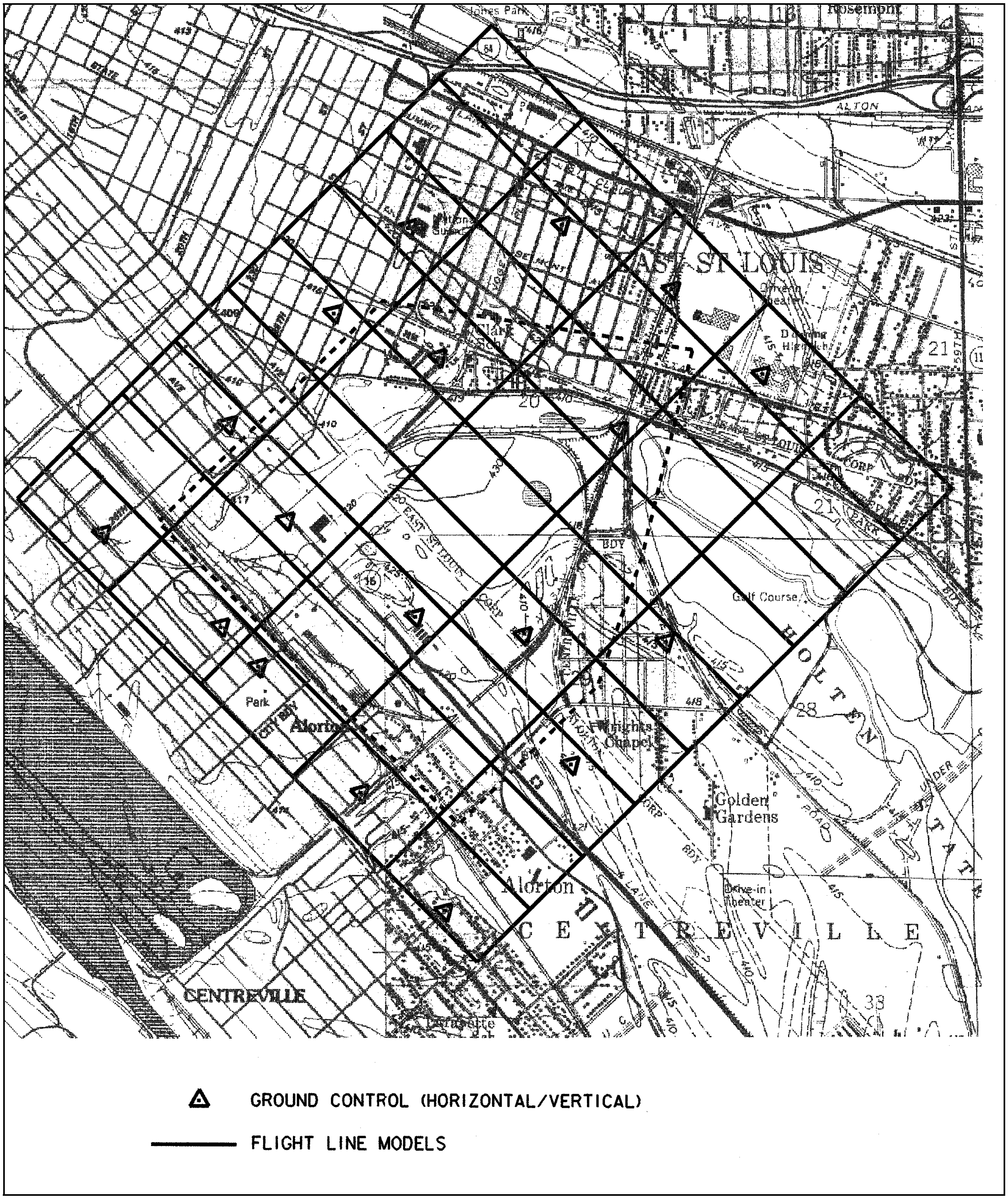


Figure 4-12. Project approximate ground control configuration