

APPENDIX A

Example of a Typical Photogrammetric Mapping Project Cost Estimation

A.1 SPECIFICATION

Project Description

The contractor is requested to supply all necessary equipment, staff, and expertise required to generate full planimetric and topographic mapping of a site in Jersey County, IL, near the town of Elsah, IL. The data produced for this project will be used for general planning and preliminary engineering for flood control and infrastructure development (cut and fill). The final mapping products will include 1 in. = 100 ft planimetric mapping with 2-ft contours. The mapping will be referenced to the Illinois (East) SPCS, NAD 83, and NAVD 88. The mapping will be in feet. The site location and project boundary is shown on a portion of the Elsah, IL-MO USGS 7.5-ft quadrangle sheet (1991). A copy of the site location map with the boundary is attached to this specification. The contractor will be required to collect new black and white aerial photography, establish necessary ground control for aerotriangulation and subsequent photogrammetric mapping, perform aerotriangulation procedures necessary to densify the ground control and to rectify the imagery to the earth, collect all planimetric detail that is visible and collectable at the required map scale, and collect topography of the site in the form of mass points and breaklines, and contours. This project shall follow standard industry procedures, and the final products will meet or exceed ASPRS Class I standards for 1 in. = 100 ft mapping with 2-ft contour intervals.

Client-Furnished Information

The client has furnished as part of this specification a project location map. The project location map is a paper copy of the USGS 7.5-ft Elsah, IL-MO quadrangle sheet. The project boundary is clearly annotated on the project location map. Any

additional information, right of entry, equipment, or data is the responsibility of the contractor.

Description of Tasks

The contractor will:

1. Develop a project plan that will include flight lines, ground control locations for the project, and a brief text describing the project location (including a map with the project boundary, flight lines and photo frame locations, and ground control locations). This plan will note the scale of the photography, the type of film, the forward lap and sidelap of the photography, the horizontal and vertical datums to be used for the ground control and photogrammetric mapping products, and an anticipated time line for completion of the project. The project plan will also include a brief description of quality control procedures that will be used by the contractor to validate the accuracy of the final mapping products.
2. Establish all necessary horizontal and vertical ground control for the project. Ground control may be a combination of ground panels and photo-identifiable features. Photo-identifiable features will require location data to be established after photography is completed. All ground control points shall be referenced and tied to at least two other features near each point site. A neat sketch of each site describing the point, its location, and the location of the tie points shall be prepared. A ground control report shall be prepared describing the ground control plan, control points used, expected accuracies, and final accuracies. This report, to be signed and stamped by a registered land surveyor of the state of Illinois, will also provide a map indicating the location of the actual points (a copy of the 7.5-ft USGS quadrangle) and control points used. Any problems encountered and how they were resolved will be discussed in the report.
3. Fly and photograph the site with black and white film during leaf-off conditions during the early spring of the year. The photography will be captured with minimal cloud cover (less than 5% in any frame), no snow on the ground, and no flood waters that would obscure ground information collection. Aerial photography shall be collected during a period of the day when the sun angle is 30% or higher and captured at an approximate photo scale of 1 in. = 500 ft with a forward lap of 60% and sidelap of 30%. The camera used shall be a typical 9 × 9 in. format metric aerial photography camera with a 6-in. focal length lens. The camera shall have a current (within the last three years) USGS certification. A copy of the USGS certification shall be furnished as part of the final product for this project. The film will be processed and labeled, and two sets of paper black and white prints (9 × 9 in.) will be produced of each exposure. Film labeling shall be across the top of each exposure with the date of photography, project name (Elsah, IL), photo scale (1 in. = 500 ft), flight line, and frame numbers.
4. Mark the ground control locations on the back of one set of prints to be used for aerotriangulation and mapping. The location and type of control point (horizontal and/or vertical) shall be marked on the front of required control prints.
5. Generate diapositives or scanned images to be utilized in the aerotriangulation process and subsequent map feature compilation.

6. Utilize the ground control and diapositives with appropriate software and hardware to generate a suitable aerotriangulation process that will allow map compilation that will meet or exceed ASPRS Class I standards for 1 in. = 100 ft mapping with 2-ft contours.
7. Generate an aerotriangulation report that will include the procedures, software, and hardware used in the aerotriangulation effort. This report will indicate the expected accuracy of the final aerotriangulation process, as well as the results of the process, and will discuss any problems encountered and how they were resolved, including ground points withheld from the solution, why they were withheld, and how this affected the final solution. The report will be signed by the author and the project manager.
8. Employ either softcopy or analytical stereoplotter methods to collect the planimetric features within the project boundaries. Feature collection will follow and be in compliance with the FGDC standards. All planimetric features that can be seen and plotted shall be collected. Feature collection will include, but is not limited to, all roads, trails, buildings, permanent structures, bridges, utility poles, edges of water bodies, dams, walls, parking lots, tanks, silos, sporting facilities, cemeteries, levees, aboveground pipelines, and airport facilities.
9. Collect topographic features (in ASCII format) throughout the project area, which includes mass points and breaklines and contour files that will describe the character of the earth's surface within the project boundary. In addition, the topographic detail in the contour files will note areas of major high and low points as spot elevations. Sufficient topographic detail in flat areas will be collected and displayed to depict the general lay of the land.
10. Provide the final data sets on CDROM disks. Two copies of planimetric data and contour files will be submitted in AutoCad Version 14, and the mass points and breakline files will be submitted in the ASCII format that is fully compatible with AutoCad Version 14.
11. Produce metadata for the entire project to include the aerial photography, ground control, and all feature collection that is fully compliant with the FGDC "Content Standard for Digital Geospatial Metadata," FGDC-STD-001-1998.

Deliverables

The final deliverables will include:

- A project plan
- All exposed film
- Two sets of prints (one clean set and one control set)
- One copy of the USGS camera calibration report for the cameras used for the project
- All ground control information and ground control reports
- Aerotriangulation report
- Two sets of final data on CD; final data sets include planimetric features in AutoCad version 14, mass points and breaklines, and contour files
- One digital set of the FGDC compliant metadata

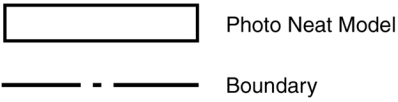
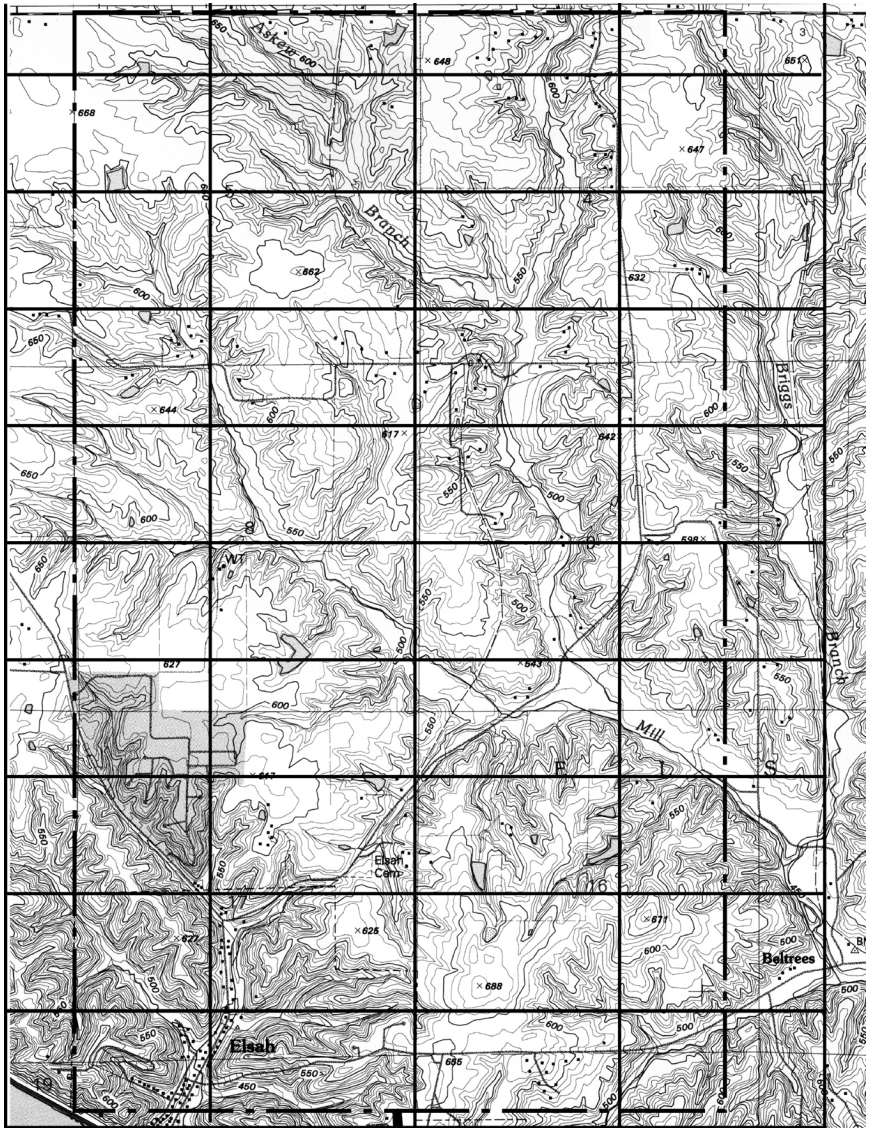


Figure A.1 Photo neat model layout.

A.2 COST ESTIMATION PROCESS

The project described above is briefly mentioned and described in Chapters 9 (“Photo Scale Selection”) and 11 (“Aerotriangulation”). The project boundary map (including approximate ground control and flight line locations) noted in the specifications is shown in Figure 11.4. Figure A.1 is another map depicting the approximate layout of photo neat models over the project area for the prescribed photography. As noted in Chapter 9, photo coverage for this project will require approximately 44 photos (4 flight lines with 11 photos per flight line). This total number will include one additional photo per flight line to insure complete stereo-coverage of the project area. Figure A.1 shows a layout of stereo neat models that will be required for compilation only. This layout will be the basis for the estimates described below. The estimates described below follow the procedures in Chapter 17, “Planning and Cost Estimating.” Refer to this chapter for additional detail.

| Production Hours for Aerial Photography |
|--|
| Direct Labor |
| Project mission |
| Flight preparation = 1.5 h |
| Takeoff/landing = 0.5 h |
| Cross-country flight = miles to site × 2 ways/mph |
| = 50 × 2/200 |
| = 0.5 h |
| Photo flight = 0.5 h to collect the photos over the flight lines |
| End turns = 4 lines × 0.08 h = 0.5 h |
| Photo lab |
| Develop film = 44 photos × 0.04 = 1.8 h |
| Check film = 44 photos × 0.04 = 1.8 h |
| Title film = 44 photos/45 = 1 h |
| Contact prints = 88 photos/45 = 2 h |
| Equipment Rental |
| Aircraft = project mission hours = 2 h |
| Film processor = develop film hours = 1.8 h |
| Film titler = title film hours = 1 h |
| Contact printer = contact prints hours = 2 h |

Photo control is often estimated either as an average cost per control point or with a detailed staffing and equipment estimate for the total project. As a general rule, photo survey control is not a large cost contributor. In these cases it is usually fair to estimate these efforts and cost on a per control point method. Detailed estimates should be reserved for unique projects where the ground surveys will compose a large part of the total project cost. The project manager should consult with others who have obtained these products to get a current unit cost that is fair and reasonable. For this example we are assuming that the ground control will be as described in Chapter 11 and shown in Figure 11.4. Approximately 20 horizontal/vertical points will be required. We will also assume that the collection and processing of all required ground control information as described in the specifications above will require approximately three days for a three-person survey crew plus two days in the office

checking data and producing necessary reports. The cost for this effort will be \$12,000. Note that these numbers are intended for this example only.

| Production Hours for Aerotriangulation | |
|--|----------------------------------|
| Direct Labor | |
| Photo scan | = 44 photos × 0.3 h = 13.2 h |
| Aerotriangulation (workstation): | |
| Model orientation | = 44 models × 0.2 h |
| | = 8.8 h |
| Coordinate readings | = 44 photos × 0.3 h |
| | = 13.2 h |
| Computations | = 44 models × 0.4 h = 17.6 h |
| Equipment Rental | |
| Scanner | = scanning hours = 13.2 h |
| Workstation | = aerotriangulation hours = 22 h |
| Computer | = computations hours = 17.6 h |

It is assumed that this project will be compiled with softcopy methods. Therefore, diapositives will not be required for aerotriangulation or compilation. The film will be scanned directly, and the scanned images will be incorporated into the system.

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

1. Number of stereomodels to orient
2. Number of acres to map
3. Complexity of terrain character
4. Complexity of planimetric culture
5. Format translations of digital data

| Production Hours for Stereomapping |
|--|
| Model Setup |
| Model setup includes planning the collection procedures and georeferencing 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 12. |
| Model orientation = 40 models × 0.1 h = 4.0 h |
| Digital Data Capture |
| It shall be assumed that this project will be compiled with softcopy stereo equipment and methods. Therefore, diapositives will not be required. The film will be scanned for incorporation into the softcopy system during the aerotriangulation process. The map shown in Figure A.1 indicates that the project area will require planimetric and topographic feature compilation in portions of 40 stereomodels. The map also notes that of the 40 models an equivalent of approximately 29 full stereomodels will be collected. This can be determined by tabulating the total number of full models that would fill the project area. Review of the project area indicates that the planimetric data capture will be moderate to light. The town of Elsayh, IL is the only area with any significant planimetric compilation. Road networks are limited to rural roads and highways. Water bodies will be limited to creeks and minor streams. No large water bodies are noted within the mapping area. It is assumed that 2 of the total 40 models will have moderate planimetric feature compilation. The remainder will be light. The topographic detail within the project is rolling to hilly. The hilly areas are in the southwestern portion (in the vicinity of the town of Elsayh) and along the edges of the streams. It is assumed that approximately 20 models will have hilly topography and 20 models will have rolling topography. |

[Table A.1](#) itemizes the estimation of production hours required to collect planimetric data, while [Table A.2](#) does the same for topographic data. Listed in [Table A.3](#) is a summary of the production hours itemized above. 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.

The process described above is to develop a rough estimate of the cost of a project for planning, negotiating, and budgetary purposes. Units and unit costs may vary and change based upon economics and equipment used by contractors. As equipment is improved, the time required for specific tasks may be reduced. However, the cost of the equipment and the person to operate the equipment may increase. By applying wage rates to labor hours and equipment rental to equipment hours the estimator can arrive at project budgetary costs. To support the process of estimating production hours of various photomapping phases, the estimator of a project is urged to seek current labor and equipment rates more applicable to a project or geographical area, perhaps using regional wage rates and actual negotiated contractor rates from recent or current contracts.

Table A.1 Summary of Productions Hours Required to Produce Planimetric Data

| Planimetry | | | | Approximate Planimetric Time (Hours/Model) | | | |
|---|-------------|------------|------------------------------|--|-------------------------------------|-------------------------------------|--------------------------------------|
| Density Type | Models/Type | Hours/Type | Total Planimetry Hours | Final Map Scale | | | |
| | | | | 1 in. = 40 ft to 1 in. = 60 ft | 1 in. = 100 ft to 1 in. = 150 ft | 1 in. = 200 ft to 1 in. = 300 ft | 1 in. = 400 ft to 1 in. = 1600 ft |
| Light | | | | | | | |
| 1 | 38 | 2.5 | 95 | 3.0 | 2.5 | 2.5 | 2.5 |
| 2 | | | | 4.0 | 3.5 | 3.5 | 3.5 |
| Medium | | | | | | | |
| 3 | 2 | 4 | 8 | 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 | | | 103 | | | | |
| Edit time: generally 30% of total planimetric compilation hours | | | 31 | | | | |

Table A.2 Summary of Production Hours Required to Produce Topographic Data

| Topography (Topo) Collection of Mass Points and Breaklines for Production of Contours | | | | Approximate Topography Time (Hours/Model) | | | |
|--|-------------|------------|---------------------|--|------|------|--------|
| Terrain Character (Slope) | Models/Type | Hours/Type | Total Topo Hours | Final Map Contour Interval Scale | | | |
| | | | | 1 ft | 2 ft | 4 ft | 5–8 ft |
| Flat | | | | 2.0 | 2.5 | 2.5 | 2.0 |
| Rolling | 20 | 4 | 80 | 4.0 | 4.0 | 4.0 | 3.0 |
| Hilly | 20 | 6 | 120 | 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 | | | 200 | | | | |
| Edit time: generally 30% of total topo collection time | | | 60 | | | | |

Table A.3 Summary of Direct Costs of Photogrammetric Mapping Project Production

| Photogrammetric Mapping Project Production | | | |
|---|--------------|------------------|-------------------|
| | Hours | Unit Cost | Total Cost |
| Production labor | | | |
| Aerial photography | 10.1 | | |
| Aerotriangulation | 40 | | |
| Model setup | 0.44 | | |
| Planimetry | 134 | | |
| Topography | 260 | | |
| Orthophotography | N/A | | |
| Total | | | |
| Direct Costs | | | |
| Film | 44 | Foot | |
| Prints | 88 | Each | |
| Diapositives | N/A | Each | |
| Hardcopy prints | N/A | Each | |
| CDs, disks, or tapes | 2 | Each | |
| Aircraft w/camera | 2 | Hours | |
| Stereoplotter | N/A | Hours | |
| Softcopy workstation | 303 | Hours | |
| Edit workstation | 91 | Hours | |
| Scanner | 13.2 | Hours | |
| Total direct cost | | | |