ESTIMATING COST FOR PHOTOGRAMMETRIC MAPPING AND AERIAL PHOTOGRAPHY

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ABSTRACT: The paper addresses elements of a cost-estimating approach for photogrammetric mapping and related aerial photography and control surveying services. The background for the estimating approach is presented, as are the details related to the elements incorporated in the algorithm to estimate costs. Available details for unit costs and unit hours of effort to complete tasks are provided. The paper also provides supporting information and documentation, including a set of parameters that should be specified in the contract or be known or assumed to help in the development of a cost estimate using the algorithm described here. The set of parameters includes estimates of the time involved in stereomodel setup and the time involved in stereocompilation for several conditions of topography and planimetric detail. Also included are current photogrammetric mapping, surveying, and aerial photography services' contracting costs, and unit efforts of various federal, state, and private companies as obtained during the execution of this project.

INTRODUCTION

The goal of this project was to render the work of cost-estimating large-scale aerial mapping in an algorithmic form. Further, the algorithm was to be based on unit costs and unit hours of effort to make the product useful even when cost figures change over time due to inflation and different technological processes. The result was an applicable approach to a difficult process of developing estimations.

A variety of government, industry, and professional society personnel were involved in the research and development of the algorithm. The algorithm represents an approach that has value for the photogrammetry industry, and potentially it can provide assistance in cost estimating. It may also be useful for acquainting personnel with the various efforts required for the production of a map or map product.

APPROACHES TO ESTIMATING COSTS

Initially, it is important to specify the activities involved in making a map to be completed by the contractor and those to be performed by the sponsor or other contracting groups. Generally, the sponsor or client and/or other related agencies will do some portion of the work. Many groups, however, participate only in the contracting of the work and do not conduct activities associated with large-scale mapping, the generation of digital data, and creation of mapping products.

The estimating algorithm presented here can cost-estimate all, or only

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certain parts of, a given mapping project. This approach forms a hierarchical format, or "add/subtract" approach. It was developed so as to maximize the applicability of the algorithm. This approach allows each group to develop a cost-estimating method that incorporates the information they need, and is responsive to existing expertise and equipment and the portions of the mapping project to be conducted by each participant in the project.

A group using the following algorithm should indicate which of these activities needs to be cost-estimated. Work to be omitted from the contract and performed by the contracting group can be excluded from this cost-estimating algorithm, and ignored for any given project calculation.

The topical areas in this study and cost-estimating algorithm are well known and constitute the steps in a given mapping project that might be separated and contracted in part or in total.

The steps in the cost-estimating algorithm for aerial mapping include aerial photography, photo control requirements, and map production. Map production includes aerotriangulation, stereocompilation, and conversion to computer-aided drafting and design (CADD) format.

The cost-estimating algorithm is presented in its entirety. The algorithm provides the individual cost elements, or items, that should be estimated. Under each item heading is an entry for the quantity (Quantity), the unit measure (U/M, e.g., hours), the unit price (U/P, e.g., $____/hour), and the amount (Amount) or total for the item. These elements can then be summed under the appropriate cost headings (e.g., Direct Labor, Hours or Material Costs). These cost-element headings can be summed up for the total, and indirect costs and profit can be calculated to arrive at the cost estimate for the project at hand.

Direct costs may also be characterized as costs that do not have additional costs associated with their use. For example, hourly costs often are associated with personnel, and personnel have benefit packages that may be charged in proportion to the time these personnel are used on the project. Direct costs may also be characterized by the fact that certain direct cost items might not be charged with additional indirect costs.

BACKGROUND

Development of Estimation Procedures

It is desirable to specify a number of variables to help best characterize a large-scale mapping project and the work to be performed. This is to assure that an accurate and precise cost estimate can be completed, and that the significant cost elements or items are addressed.

It also helps to develop and continue the use of a systematic estimation procedure. Continued use of such a procedure and methods will allow the user to track the estimated costs along with the actual costs encountered. Over time, evaluations can reveal the value of the systematic estimation approach.

The cost elements, or items, can be different for various approaches to cost-estimating, and vary by region and by type of work effort. To provide necessary detail and to remain flexible, we developed a complete list of significant needs and costs. For a given project application, the required specifications can be selected from the list to customize the content for a cost estimation.

The list of specifications used here presents an example of what information needs to be supplied before a cost estimation is made. This list is not exhaustive, but it includes many contributions. Any effort may include

other variables as determined by those employing this approach, or algorithm. The list is composed of variables that are necessary to most projects, and variables that are significant cost factors in a project.

To facilitate the development and use of systematic cost-estimation approaches, this project examined cost-estimating procedures used in government and industry. Research on existing and historical cost-estimating approaches was made in several ways. The literature was evaluated to identify previous efforts and to identify specific approaches to cost-estimating. The bibliography in Appendix III attempts to list all available references on the topic and make it simple for the reader to pursue background information.

As part of this yearlong project, plant tours were made to evaluate equipment, personnel considerations, and unit-of-effort estimates. Interviews were conducted with industry, government, and professional society personnel familiar with cost-estimating of aerial mapping and photography services. Presentations were made to groups to obtain ideas and assess the accuracy of unit measures. The algorithm and results of analyses were evaluated by a peer-review panel of photogrammetrists.

The results of the project include the list of specifications and items to be cost-estimated. The necessary and significant cost items are organized from the lists in Appendix I. The entries in these lists represent the items that might or might not be used for estimating a given job. A number of entries to the algorithm listings in Appendix I may be estimated by reference to Figs. 1–6(e).

The estimation of costs using the algorithm is made by summation of listed entries (Appendix I). This can be performed by activity, as described in the lists.

Calculation Procedures

The activities, or steps, in the cost-estimating algorithm for aerial mapping include aerial photography, photo control requirements, and map production (aerotriangulation, stereocompilation, conversion to CADD format). The users employing the algorithm should indicate which of these activities needs to be cost-estimated. Work to be omitted from the contract and performed by others can be excluded from this cost-estimating algorithm, and ignored for any given project calculation.

For each of these activities, the cost estimates have been further stratified into categories, or cost elements, that make up the second level of the hierarchy. Elements of the cost-estimating algorithm are grouped into costs that are based on direct labor in hours, and direct costs such as materials. Under each second-level heading or hierarchical entry are the individual cost elements. This last breakdown represents a third level of detail.

The amount of work and the cost of the work that personnel will conduct is characterized as the "Direct Labor, Hours" by another unit cost. This has been done for a number of reasons, including: (1) It is convenient to express work in hours because it provides a per-unit cost basis for estimation purposes; and (2) surveying and mapping services often have an hourly component in cost estimating and this hourly approach is very suitable to conditions under which contracting will be conducted. Hourly costs are also easy to obtain from a prequalified contractor or from wage-rate determinations.

Following the cost associated with direct labor, or "hourly," activities, are the costs that are direct in nature. Direct costs such as material costs can be easily calculated and are fixed by the number of units of a direct

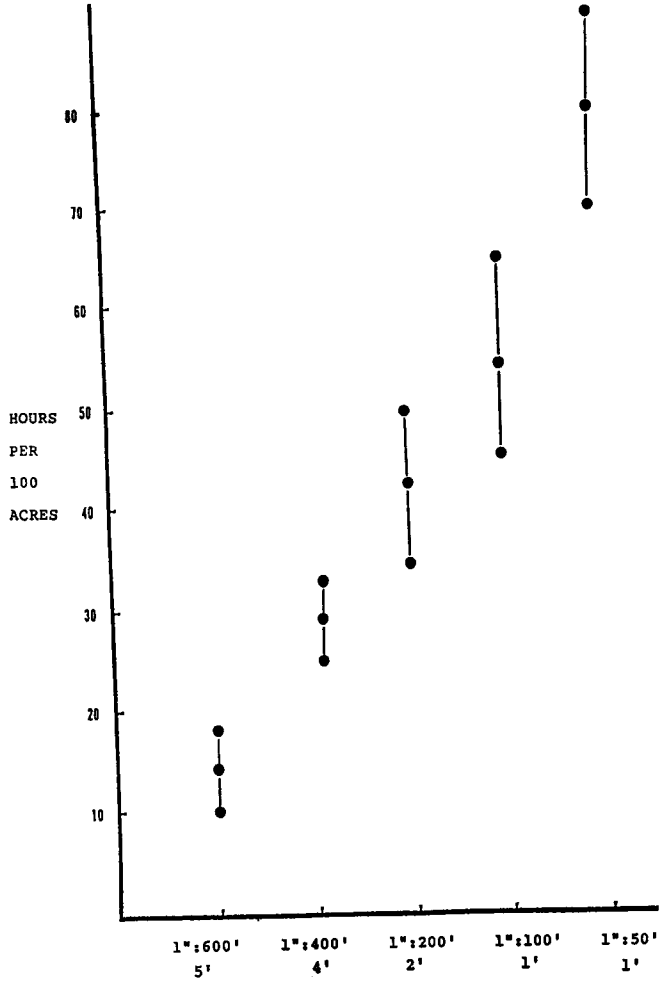

FIG. 1. Total Hours of Effort per 100 Acres (40.5 ha) Mapped

cost item that are required to complete the project. Typical direct cost items in large-scale aerial mapping would be the number of sheets—equivalents or feet of roll film that are exposed to provide coverage of the site.

Some direct costs may also be made on a per-hour basis. For example, this may apply to the case of aircraft time. So it is important to realize that a number of cost items may be direct or material costs, but may be reported in hours.

Here, the cost-estimating algorithm is presented in its entirety in list form. The algorithm provides the individual cost elements, or items, that should be estimated. Under each item heading is an entry for the effort (Item Description), quantity (Quantity) in a unit measure (e.g., hours) or unit price (e.g., $___/hour) and the amount in 1992 U.S. dollars (Amount) or total for the item. These elements can then be summed under the appropriate cost headings (e.g., Direct Labor, Hours or Material Costs).

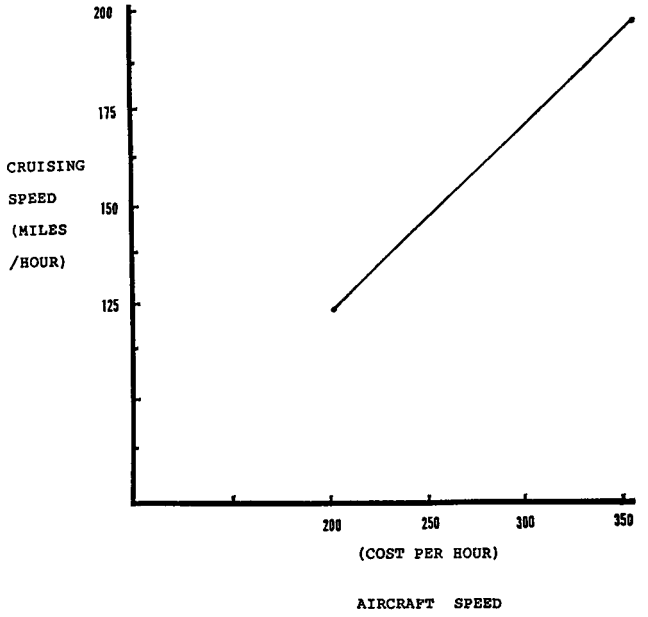

FIG. 2. Cost per Hour of Aircraft [after Falkner (1991)]

These cost-element headings can be summed up for the total, and indirect costs and profit can be calculated to arrive at the cost estimate for the project at hand.

METHODS

Project Specifications

It is necessary to have information on cost elements, or items, to best specify a project. Many of the items listed are inputs to the cost-estimating algorithm. Some elements, or items, are used in direct calculations of parameters, and make important contributions to the results of the algorithm. Other items are necessary to define the scope and size of the project.

It is desirable to provide a definition of the area to be mapped. This may be shown on available large-scale, engineering-style topographic maps. The area may also be located on available 1:24,000 scale U.S. Geological Survey (USGS) quadrangles, which are particularly useful for mission planning. Other descriptive and measurement data should be provided if they are available. Additional information may include details from surveys or deeds, and other distances and angles or area estimates.

Descriptions may also include north and south dimensions and east and west dimensions.

Other mapping parameters should be specified, and they may include:

- The final scale of maps
- The scale of photography
- Contour interval on the maps
- Flying height above the average ground elevation

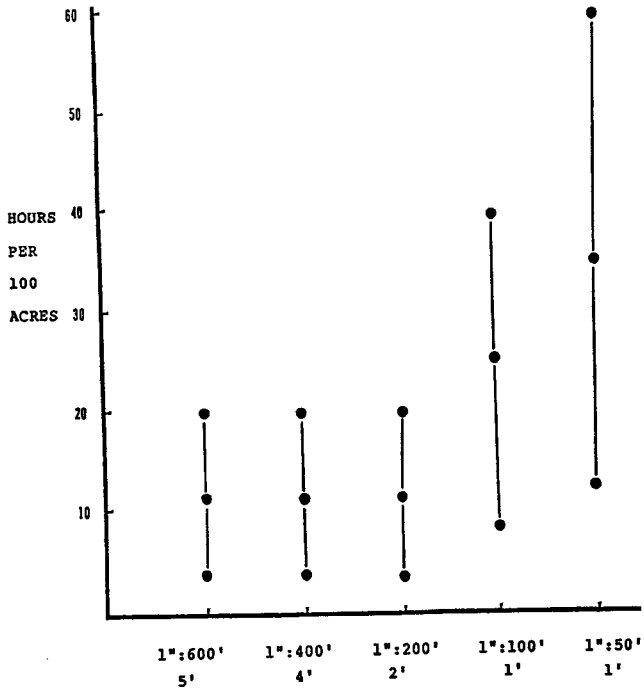

FIG. 3. Photo Control Survey Requirements for Three-Person Crew

- The type of film
- The focal length of camera
- The "c" factor of the analytical plotter
- The desired overlap (endlap)
- The desired sidelap
- The distance from airport to project area (if contractor is known)
- The aircraft speed
- The flight line distance
- The distance from survey office to project area (if contractor is known)
- The distance from nearby horizontal control to the project
- The distance from nearby vertical control to the project
- An estimate of topographic variability for the area or
- An estimate of proportion of site with various slopes or
- An estimate of cultural density in urban and suburban areas or
- An estimate of proportion of site with various slopes

A list of deliverables should also be supplied. This is desirable to both clearly specify the products of interest and to ensure good communication and hence good, accurate estimates of costs.

The following list consists of a number of possible products that may be requested. One should specify a product by including it on the list, and one also should indicate the quantity of copies or sets to be made: Contact

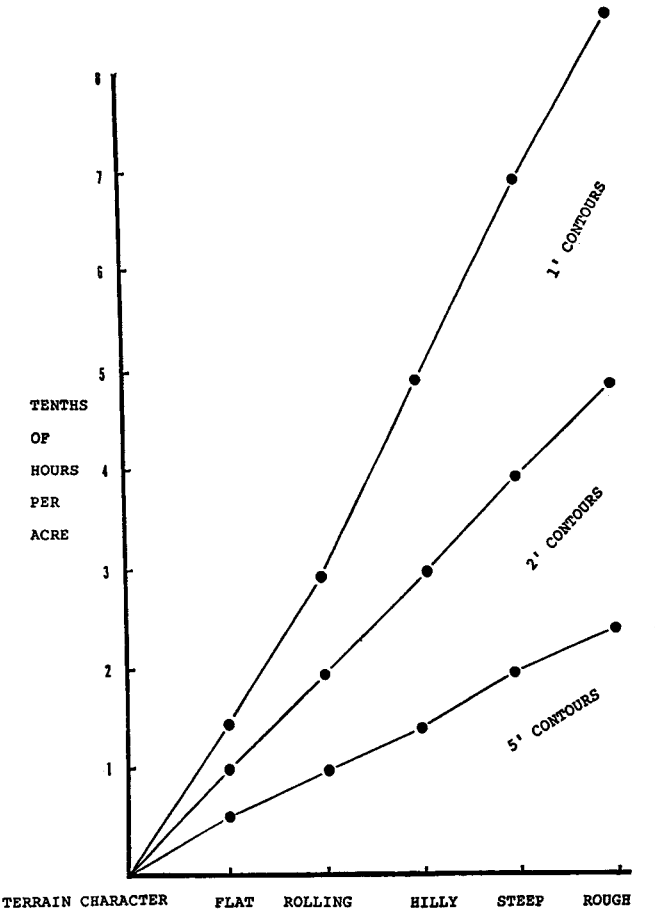

FIG. 4. Topographic Digitizing Time [after Falkner (1991)]

photos or prints, map sheets or copies, and digital data in CADD or GIS format.

Other deliverables and descriptive materials or documentation, include: Photos (additional copies), photo enlargements, photo index products, field survey data and descriptions, other mapping products, orthophoto products, and additional digital data products.

Calculated Values

There are some types of information that need to be calculated before estimating a contract. This information is necessary to describe the project and to supply input for solution of items in the algorithm. Much of the required inputs are supplied or summarized in the lists in Appendix I and the figures. An example is the section headed "Labor Costs."

One should determine and calculate for a given project the photo scale, the number of flight lines, the location of the flight lines, number of flight line miles, the estimated number of exposures or stereo pairs, and the flying height.

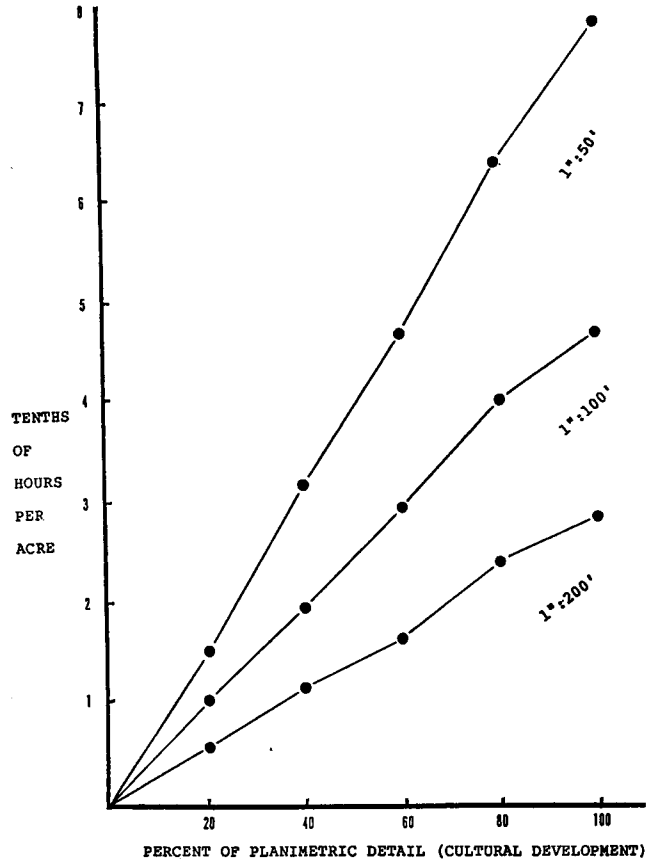

FIG. 5. Planimetric Digitizing Time [after Falkner (1991)]

Aerial Photography

The following items are to be specified to assist in the calculations of costs associated with aerial photography.

- Aircraft transport distance to site (miles)
- Aircraft speed (miles/hour)
- Aircraft cost ($____/hour
- Number of flight line miles (miles)
- Flight altitude [Above Ground Level (AGL)]
- Photo scale, nominal
- Project size/dimensions (acres, north-south and east-west dimensions, in miles)

Contractor costs or wage rates

- Time of aircraft pilot, $____/hour
- Time of aero photographer, $____/hour

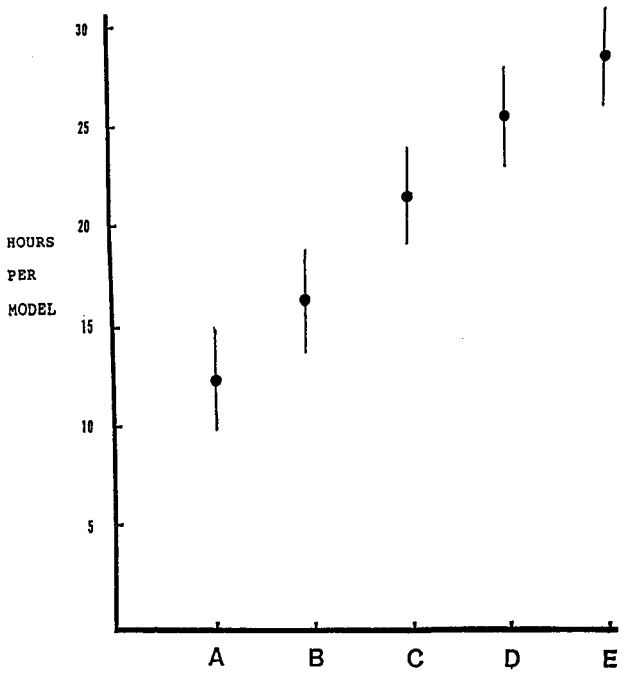

FIG. 6(a). Stereocompilation Time for 1 in. = 50 ft/1 ft Contour (1 cm = 6 m/0.31 m). [A = Minimum Planimetric Detail and Flat Terrain; B = Minimum Planimetric Detail and Hill Terrain; C = Moderate Planimetric Detail and Flat Terrain; D = Moderate Planimetric Detail and Hilly Terrain; and E = Heavy Planimetric Detail and Mixed Flat/Hilly Terrain. See Falkner (1991, 1994) and USACE (1992).]

- Time of flying crew (pilot + aero photographer), $___/hour
- Time of photo lab technician (processing), $___/hour

Photo Control Surveying Requirements

The following items are to be specified to assist in the calculations of costs associated with photo control requirements: Distance or time from survey office, distance to off-site horizontal control from project area, distance to off-site vertical control from project area, estimate of distance associated with surveying horizontal control, estimate of distance associated with surveying vertical control, number of points to be surveyed (horizontal and vertical), time of survey crew (party chief, instrument man, rod man), $___/crew hour or

Time of party chief ($___/hour)

+ time of instrument man ($___/hour)

+ time of rod man ($___/hour)

= total time of crew above ($___/crew-hour)

Cost Estimation Algorithm in Tabular Form

The items or elements of a cost-estimating algorithm, or procedure, are provided in Appendix I and Figs. 1–6(e). Other necessary contract speci-

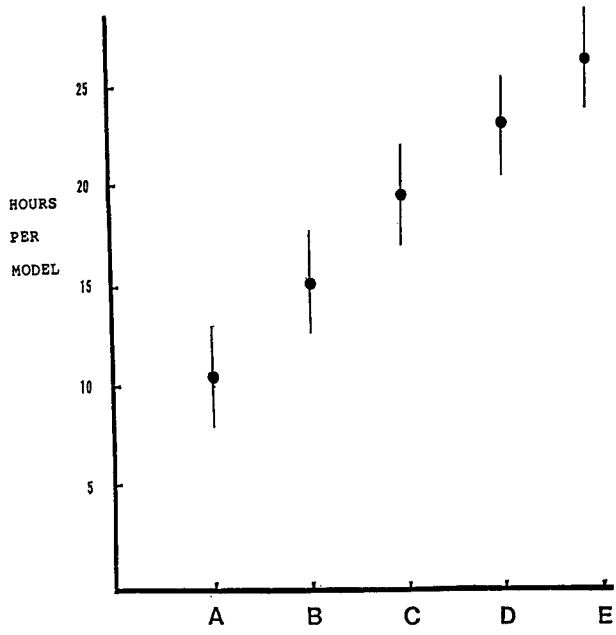

FIG. 6(b). Stereocompilation Time for 1 in. = 100 ft/1 ft Contour (1 cm = 12 m/0.31 m)

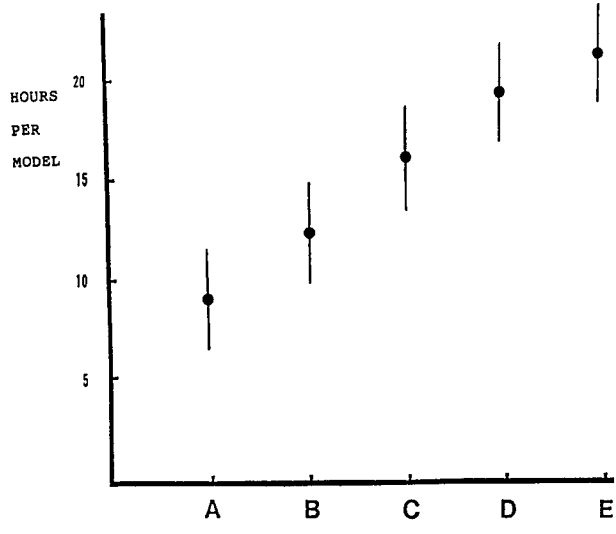

FIG. 6(c). Stereocompilation Time for 1 in. = 200 ft/2 ft Contour (1 cm = 24 m/0.61 m)

fication information is also provided under the headings "Aerial Photography," "Photo Control Requirements," and "Map Production" (aerotriangulation, stereocompilation, conversion to CADD format).

The format used here begins with detailed specifications for the individual

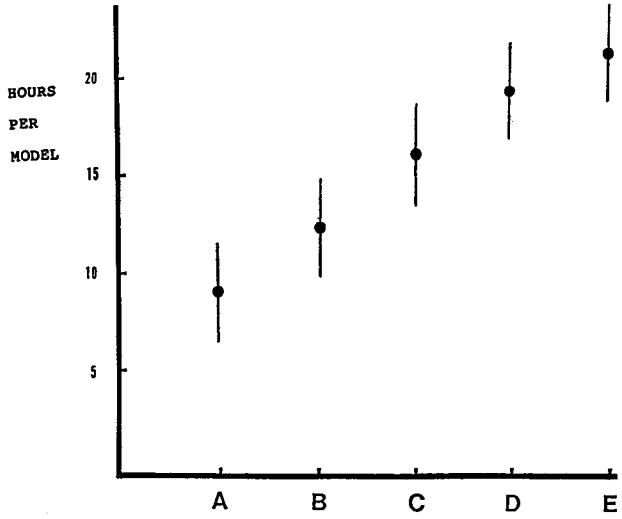

FIG. 6(d). Stereocompilation Time for 1 in. = 400 ft/5 ft Contour (1 cm = 48 m/1.52 m)

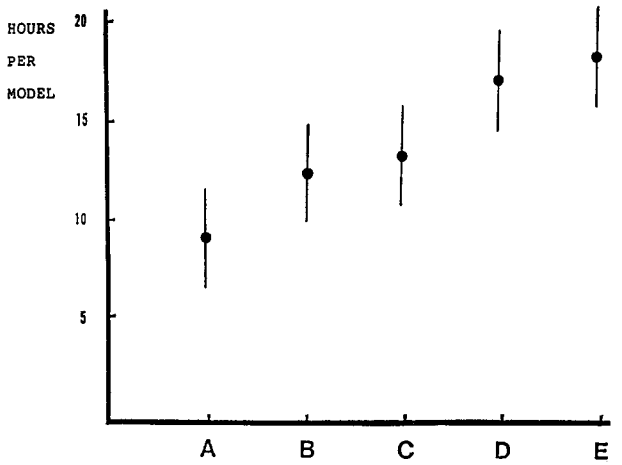

FIG. 6(e). Stereocompilation Time for 1 in. = 400 ft/10 ft Contour (1 cm = 48 m/3.05 m)

contract effort. The "Direct Labor, Hours"–related cost elements are provided as subheadings, and then "Material Costs" are addressed to complete the list of algorithmic items that are to be used in cost-estimating photogrammetric mapping and aerial photography services. Under "Photo Control Surveying" an additional heading of "Travel and Transportation Costs" is included.

Cost Estimating Figures

Figs. 1–6(e) support cost estimates by supplying per-unit estimates for costs. A mean value is provided as well as a range in the number that

accounts from some project variability and uncertainty. Several assumptions have been listed previously and they apply here.

The figures apply to projects at a variety of scales and contour intervals. In particular, the common engineering scales in U.S. customary units are addressed along with the metric equivalent units, including 1 in. = 50 ft/1 ft contour (1 cm = 6 m/0.31 m); 1 in. = 100 ft/1 ft contour (1 cm = 12 m, 0.31 m); 1 in. = 200 ft/2 ft contour (1 cm = 24 m/0.61 m); 1 in. = 400 ft/5 ft contour (1 cm = 48 m/1.52 m); and 1 in. = 400 ft/10 ft contour (1 cm = 48 m/3.05 m). Figures are also supplied for several conditions of planimetric and topographical detail, as described in the legend.

Many figures show a mean unit estimate and error bounds or uncertainty on those estimates as a line extending from the mean point. The variability displayed by the error bounds is approximately two standard deviations. Sample size was derived from a population of professionals who supplied estimates derived from actual contracts.

Certain costs are fairly straightforward and do not require a figure. These include aerial triangulation costs, which are usually estimated at between $70 and $85 per plate. Also, aerial film and processing costs are estimated as 9 in. × 9 in. (23 cm × 23 cm) black-and-white film; $2.65 per foot ± $1.35 per foot ($8.70 per meter ± $4.43 per meter); film processing $2.52 per foot ± $1.65 per foot ($8.27 per meter ± $5.41 per meter); and black-and-white contact prints at $2.10 per print ± $0.60 per print. For color photographs: Film, $5.00 per foot ± $1.50 per foot ($16.41 per meter ± $4.92 per meter); film processing at $4.75 per foot ± $1.75 per foot ($15.59 per meter ± $5.74 per meter); and contact prints at $6.00 per print ± $0.70 per print. In addition, aerial target panels can be placed in 0.5 hr by the survey crew.

Several other conditions or assumptions prevail. To provide uniform conditions for cost estimation, several assumptions are made about approaches and technologies, including: (1) Analytical stereoplotters will be employed; (2) "bridging" of ground control across four or fewer photographic stereomodels of four or less, and hence "skeletal" survey control and aerotriangulation will be used; (3) that the hours for many activities can be estimated from the graphs supplied here; and (4) the cost per hour of personnel can be obtained from wage rates or from information supplied by the contractor. Also included is the assumption that model setup times for aerotriangulation seldom exceed 0.5 hr, and it is often part of the cost of aerotriangulation. The figures were developed using certain conditions, including, where applicable, a "c" factor of 2,500 was used for analytical instruments; all survey control was based on the use of aerotriangulation as opposed to full survey control of stereomodels; and the times for editing of the stereocompiled products is generally 50–80% of the stereocompilation times.

Fig. 1 includes all hourly efforts such as flying, processing, surveying, and stereocompilation.

RESULTS AND COMMENT

Initially, it is important to specify which of the activities involved in making a product will be completed by the contractor and which will be done by the client. Generally, some groups will want to do a portion of the work. Many such groups, however, conduct only the contracting of the work and do not participate in the main activities associated with large-scale mapping, the generation of digital data, and mapping products.

The cost-estimating algorithm presented here can cost-estimate all or only

certain parts of the mapping project, and hence can account for individual practices. This hierarchical format, or "add/subtract" approach, was developed so as to maximize the applicability of the algorithm. This approach allows each group to develop a cost-estimating method that incorporates the information they need, and is responsive to existing expertise and equipment within the contracting group and the portions of the mapping project to be conducted by the group.

To facilitate the understanding of the algorithm, an example is provided along with the solution. Appendix II contains a typical example project to supply a large-scale topographic map for engineering design and planning purposes.

Various parts of this approach are now used operationally in government. Many parts of the approach have been documented by USACE (1992) and Falkner (1994), and it is possible to apply these results to additional operational applications in government and industry.

CONCLUSIONS

It is desirable to specify a set of variables that describes the project before a cost estimate is made. Such a list, or set of variables, is provided here along with the algorithm. It is inclusive of most required items, and they should be known along with other information deemed to be useful for a given estimation. This would include algorithmic information provided here in lists, provided as information in the form of cost-estimating graphics or figures, or provided in the references cited in the bibliography (Appendix III).

ACKNOWLEDGMENTS

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APPENDIX I. NECESSARY AND SIGNIFICANT COST ITEMS

Aerial Photography in Direct Labor, Hours
Item Description

Quantity Amount

Time required for flight planning

Time of pilot, _____ hours × $_____/hour = $_____

Time for ground work related to the flight

Time of crew, _____ hours × $_____/hour = $_____

Time en route (airfield to area)

Time of crew _____ hour × $_____/hour = $_____

Time of photography

Time of crew _____ hour × $_____/hour = $_____

Total hourly wages $_____

Aerial Photography, Material Costs
Item Description

Quantity Amount

Aircraft

Aircraft operating costs in hours

Flight to site

_____ miles × _____ hours/miles = _____ hours
_____ hours × $_____/hour = $_____

Time over area to be photographed

_____ hour × $_____/hour = $_____

Total hours of aircraft time and cost

_____ hours, Total cost $_____

Aerial Photography, Film Processing, and Reproduction in Direct Labor, Hours
Item Description

Quantity Amount

Time required for film processing (includes film inspection, processing, titling, quality checking, etc.)

Time of photo lab technician

_____ hour × $_____/hour = $_____

Aerial Photography, Film Processing, and Reproduction, Material Costs
Item Description

Quantity Amount

Film
Number of exposures (cost per exposure or cost per foot or meter)

_____ exposures × $_____/exposure = $_____

or

_____ exposures × 9 in./12 in. = _____ number of feet of film

or

_____ feet of film × $_____/foot = $_____

Contact Printing
_____ sets of prints × _____ photos in set × $_____/print = $_____

Photo Control, Direct Labor, Hours
Item Description

Quantity Amount

Travel to Site for Crew, Round Trip
_____ trips × _____ crew hours × $_____/crew hour = $_____

Reconnaissance Time
_____ hours × $_____/crew hour = $_____

Transfer Control to Site
Time for crew to traverse from horizontal control

_____ miles from control to site × _____ hours/mile for crew = _____ hours of crew, $_____/crew hour = $_____

Time for crew to level from vertical control

_____ miles from control to site × _____ hours/mile for crew = _____ hours of crew, $_____/crew hour = $_____

Place Control On-Site
Time for crew to traverse on-site horizontal control

_____ miles from control to site × _____ hours/mile for crew = _____ hours of crew, $_____/crew hour = $_____

Time for crew to level on-site vertical control

_____ miles from control to site × _____ hours/mile for crew = _____ hours of crew, $_____/crew hour = $_____

The time to develop measurements and map the site

_____ hours of technician (rod person) × $_____/hour = $_____

The time for computations to be made on a computer

_____ hours of computer operator × $_____/hour = $_____

Total direct labor, hours, and cost

_____ hours, Total cost $_____

Photo Control, Material Costs
Item Description

Quantity Amount

Aerial target panels

_____ number of targets × 0.5 hr/target × $_____/crew hour = $_____

Total costs $_____

Photo Control, Travel, and Transportation Costs
Item Description

Quantity Amount

Per-diem costs _____ people × _____ days × $_____/person day = $_____

The mileage costs for survey vehicles

_____ miles round trip × _____ trips × $_____/mile = $_____

The airfare for the crew
_____ people × _____ trips × $_____/person trips = $_____

Total costs $_____

Map Production, Direct Labor, Hours
Item Description

Quantity Amount

Stereocompilation
Time for planimetric line mapping

_____ models × _____ hours per model, $_____/hour plotter operator = $_____

Time for topographic mapping

_____ models × _____ hours per model, $_____/hour plotter operator = $_____

Map Production
Time for plotting

_____ sheets × _____ hours per sheet, $_____/hour plot operator = $_____

Time for map editing

_____ sheets × _____ hours per sheet, $_____/hour CADD station operator = $_____

Time for map testing

_____ sheets × _____ hours per sheet, $_____/hour CADD station operator = $_____

Development of Digital Data
Conversion of data into the desired format

_____ sheets × _____ hours per sheet, $_____/hour CADD station operator = $_____

Editing of digital data

_____ sheets × _____ hours per sheet, $_____/hour CADD station operator = $_____

Map Production, Material Costs
Item Description

Quantity Amount

Diapositives

_____ diapositives × $_____ per diapositives = $_____

Aerotriangulation

_____ plates × $_____ per plate = $_____

Total costs $_____

Summary of Costs

Direct Labor Costs
Aerial photography $_____

Photo control requirements $_____

Map production $_____

TOTAL $_____

OVERHEAD COSTS $_____

Material Costs
Aerial photography $_____

Photo control requirements $_____

Map production $_____

TOTAL $_____

TOTALS OF ABOVE $_____

PROFIT $_____

COST ESTIMATE $_____

Labor Costs
Contractor costs or wage rates used in estimating

- Time of aircraft pilot, $_____/hour
- Time of aerial photographer, $_____/hour
- Time of flying crew (pilot + photographer), $_____/hour
- Time of photo lab technician, $_____/hour
- Time of survey crew (party chief, instrument person, rod person), $_____/crew hour
- Time of party chief, $_____/hour

- Time of instrument person, $_____/hour
- Time of rod person, $_____/hour
- Time of stereoplotter operator, $_____/hour
- Time of plot operator, $_____/hour
- Time of CADD station operator, $_____/hour

APPENDIX II. COST ESTIMATING EXAMPLE OF SOLVED ALGORITHM

Topographic map of 1 in.:50 ft scale and 1 ft contours
Area to be mapped
North and south dimensions: 1.25 mi
East and west dimensions: 0.85 mi
Other mapping parameters should be specified, and they may include:

The final scale of maps: 1 in.:50 ft
Contour interval on the maps: 1 ft
The scale of photography: 1:3,000
Flying height above the average ground elevation: 1,500 ft
The type of film: black-and-white panchromatic
The focal length of camera: 6 in.
The "c" factor of the analytical plotter: 2,500
The desired overlap (endlap): 60%
The desired sidelap: 30%
The distance from airport to project area: 190 mi round trip
The flight line distance in miles: 5.2 mi
The distance from survey office to project area: 30 mi round trip
The distance from nearby horizontal control to the project: On-site
The distance from nearby vertical control to the project: On-site
The aircraft speed: 125 mi/hr
An estimate of topographic variability for the area: hilly terrain (class "B" on graphics)
An estimate of proportion of site with various slopes and/or an estimate of cultural density in urban and suburban areas
Minimum planimetric detail (class "B" on graphics) and/or an estimate of proportion of site with various slopes

Deliverables
Contact prints: two sets of 21 photos
Map sheets: 5
Digital data in CADD or GIS format: Yes

Other deliverables and descriptive materials or documentation, including:

Photos (additional copies): None
Photo enlargements: None
Photo index products: None
Field survey data and descriptions: Short report

Other mapping products

Orthophoto products: None
Additional digital data products: None

Cost Figures for Algorithm Items
Calculated values

One should determine and calculate for a given project

The photo scale: 1:3,000
The number of flight lines: 4
The general location of the flight lines
Number of flight line miles: 5.2 mi
The estimated number of exposures or stereo pairs: 21
The flying height: 1,500 ft
Given hourly values

Labor Rate
Contractor costs or wage rates
Time of aircraft pilot, $18/hr
Time of aero photographer, $15/hr
Time of flying crew (pilot + photographer), $33/hr
Time of photo lab technician (processing), $11/hr
Time of survey crew (party chief, instrument person, rod person) $31/crew hour or time of party chief, $15/h + time of instrument person, $9/hr + time of rod person, $7/hr = time of survey crew, $31/hr
Time of plotter operator, $15/hr
Time of plot operator, $11/hr
Time of CADD station operator, $11/hr

Aerial Photography
The following items are to be specified to assist in the calculations of costs associated with aerial photography.

Aircraft transport distance to site (miles): 190 mi
Aircraft speed (miles/hour): 125 mi/hr
Aircraft cost ($_____/hour): $200/hr
Number of flight line miles (miles): 5.2 mi
Flight altitude [Above Ground Level (AGL)]: 1,500 ft
Photo scale, nominal: 1:3,000

Project size/dimensions (acres, north-south, and east-west dimensions in miles)

680 acres
1.25 mi N-S
0.85 mi E-W

Contractor costs or wage rates

Time of aircraft pilot, $18/hr
Time of aero photographer, $15/hr
Time of photo lab technician (processing), $11/hr

Direct Labor, Hours

Item Description Quantity U/M U/P Amount
Time required for flight planning
Time of pilot, 1 hr × $18/hr $18

Time for ground work related to the flight crew hourly rate = 18 + 15 = 33/hr
Time of crew, 2 hr × $33/hr = $66
Time en route (airfield to area and return)
Time of crew 1.5 hr × $33/hr = $49.50

Time of photography
Time of crew 0.5 hr × $33/hr = $16.50
Total costs 5.0 hr = $165

Material Costs

Item Description Quantity U/M U/P Amount
Aircraft operating costs in hours

Flight to site

190 mi × 1/(125 mi/hr) = 1.5 hr
1.5 hr × $200/hr = $300

Time over area to be photographed (if applicable)

0.5 hr × $200/hr $100

Total hours of aircraft time and cost

2.0 hr $400

Film Processing and Reproduction, Direct Labor, Hours

Item Description Quantity U/M U/P Amount
Time required for film processing (includes film inspection, processing, titling, quality checking, etc.)

Time of photo lab technician, 3.0 hr × $12/hr = $36

Total costs $36

Material Costs

Item Description Quantity U/M U/P Amount
Film
Number of exposures (cost per exposure or cost per foot)

21 exposures × 9 in./12 in. exposures/ft = 15.75 or 16 ft of film

16 feet of film × $2.65/ft = $42.40

Contact Printing

2 sets of prints × 21 photos in set × $2.10/print = $86.10
Total costs $128.50

Photo Control Surveying

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

Field Surveys
Distance or time from survey office: 30 mi round trip
Distance to horizontal control from project area: On-site
Distance to vertical control from project area: On-site
Estimate of distance associated with surveying horizontal control: 7 mi
Estimate of distance associated with surveying vertical control: 7 mi
Number of points to be surveyed: 13 horizontal, 13 vertical
Time of survey crew (party chief, instrument person, rod person) $31/crew hour or time of party chief, $15/hr + time of instrument person, $9/hr + time of rod person, $7/hr = total time of crew, $31/crew hour

Direct Labor, Hours

Item Description Quantity U/M U/P Amount
Travel to site for crew, round trip

Time of crew, 10 trips × 0.6 crew hours × $31/crew hour = $186

Reconnaissance time

Time of crew, 8 hr × $31/crew hour = $248

Transfer control to the site

Time for crew to traverse from horizontal control time to recover control from on-site 0 mi from control to site × 0 hr/mi for crew = 0

2.5 hr of crew, $31/crew hour = $77.50

Time for crew to level from vertical control time to recover control from on-site

0 mi from control to site × 0 hr/mi for crew = 0

2.5 hr of crew, $31/crew hour = $77.50

The time to develop measurements and map the site

4 hr of technician (rod person) × $7/hr = $28

The time for computations to be made on a computer

10 hr of computer and computer operator (CADD station operator) × $15/hr = $150

Total Direct Labor, Hours and Cost

33 hr $767

Material Costs

Item Description Quantity U/M U/P Amount
Photo target panels

13 targets × 0.5 hr/target × $31/crew hour = $201.50
Total costs $201.50

Travel and Transportation Costs

Item Description Quantity U/M U/P Amount
Per-diem costs

0 people × _____ days × $_____/person day = $0

The mileage costs for survey vehicles

30 mi round trip × 10 trips × $0.25/mi = $75

The airfare for the crew

0 people × _____ trips × $_____/person trips = $0

Total costs $75

Map Production and Costs

The following items are to be specified to assist in the calculations of costs associated with map production and costs.

Direct Labor, Hours

Item Description Quantity U/M U/P Amount
Stereocompilation

Hilly terrain, medium planimetric detail (class B on graphics)

Time for planimetric line mapping

9 models × 8 hr per model, $15/hour plotter operator = $1,080

Time for topographic mapping

9 models × 8 hr per model, $15/hour plotter operator = $1,080

Map Production

Time for plotting

5 sheets × 2 hr per sheet, $11/hour plot operator = $110

Time for map editing

5 sheets × 10 hr per sheet, $11/hour CADD station operator = $550

Time for map testing

5 sheets × 1.5 hr per sheet, $11/hour CADD station operator = $82.50

Development of Digital Data

Conversion of data into the desired format

5 sheets × 1 hr per sheet, $11/hour CADD station operator and computer = $55

Editing of digital data

5 sheets × 1 hr per sheet, $55/hour CADD station operator = $55

Total costs $3,012.50

Material Costs

Item Description Quantity U/M U/P Amount
Diapositives

11 diapositives × $4.00 per diapositives = $44

Aerotriangulation

11 plates × $70 per plate = $770

Total costs $814

Summary of Costs
Direct labor costs

Aerial photography $201

Photo control requirements $767

Map production $3,012.50

Total $3,980.50

G&A overhead costs (140%) $5,572.70

Material Costs
Aerial photography $528.50

Photo control requirements $201.50

Map production $814.00

Total $1,544.00

Travel and transportation costs

$75

Totals of above $11,172.20

Profit (12%) $1,340.66

Cost estimate $12,512.86

APPENDIX III. BIBLIOGRAPHY

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