Leslie H. Perry
National Ocean Survey, NOAA
Rockville, MD 20852

Photogrammetric Summary of the Ada County Project

A detailed summary of the man-hour effort in the geodetic densification by photogrammetric means of Ada County, Idaho.

Abstract: *The National Ocean Survey completed a geodetic densification of the pre-recovered section corners in Ada County, Idaho, through highly sophisticated photogrammetry. This paper deals with the photogrammetric effort and cost involved in completing this project. The project is looked at from specific phases: planning, field, mensuration, and data reduction. A separate discussion of the specialized equipment is also included. The Ada County Project covered an area of 350 sq. m.. Within that area, 15 first-order and second-order geodetic horizontal control stations were used to position 346 section corner monuments to second-order geodetic accuracy. The resultant photogrammetric effort and cost per section corner mark is detailed.*

Introduction

The efforts to complete the photogrammetric densification of geodetic control in Ada County, Idaho are summarized. The endeavor is known as the Ada County Project. The project was performed through a joint effort of Ada County and the U.S. Department of Commerce, NOAA, NOS. NOS supplied planning, photographic, measuring, and data reduction resources. The project involved a major portion of Ada County, in which the inclusive recovered section corners were determined to second-order geodetic accuracy. The application of photogrammetry to geodetic densification has been discussed comprehensively by Slama (1978). Therefore, this paper is restricted to the Ada County Project. For this exercise, the Ada County Project has been divided into four phases: planning, field, mensuration, and data reduction. Each is discussed according to its content and effort required. The completion of this project required some specialized equipment, which is discussed separately.

Planning

The project area covered a major part of Ada County, Idaho, encompassing some 350 sq. mi. (Figure 1). Within the area fell 346 section corner markers whose geodetic positions would be determined. The 150-mm focal length of the special geodetic camera cone, along with other factors, determine the photogrammetric geometry. Previous experience with this photogrammetric system has shown that the expected RMS error in metres is equal to 1:500,000 of the inverse of the scale. The desired accuracy of 50 mm for Ada County results in a maximum flying height of 12,000 ft. above ground level. The second factor requires a minimum of nine rays intersecting per image. Therefore, each target shall be seen by at least nine photographs. Given the high overlap and endlap and the one-mile spacing of the targets, a minimum flying height to meet this condition is 12,000 ft. Thus, a photo scale of 1:24,000 was selected.

The photo coverage for the project area required some 750 9 by 9 inch format photographs. The coverage included 16 east-west flight lines with two-thirds side- and forwardlap and a second coverage of nine north-south lines at two-thirds forwardlap and fifteen percent sidelap. Also, color photography at one-third the designed flying height was taken for target identification in selected areas.

The status of the existing geodetic control and the section corners was an important consideration during the planning phase. The 11 existing geodetic

* Presented at the 1981 ASP-ACSM Annual Convention, Washington, DC.

0099-1112/84/5005-0563$02.25/0

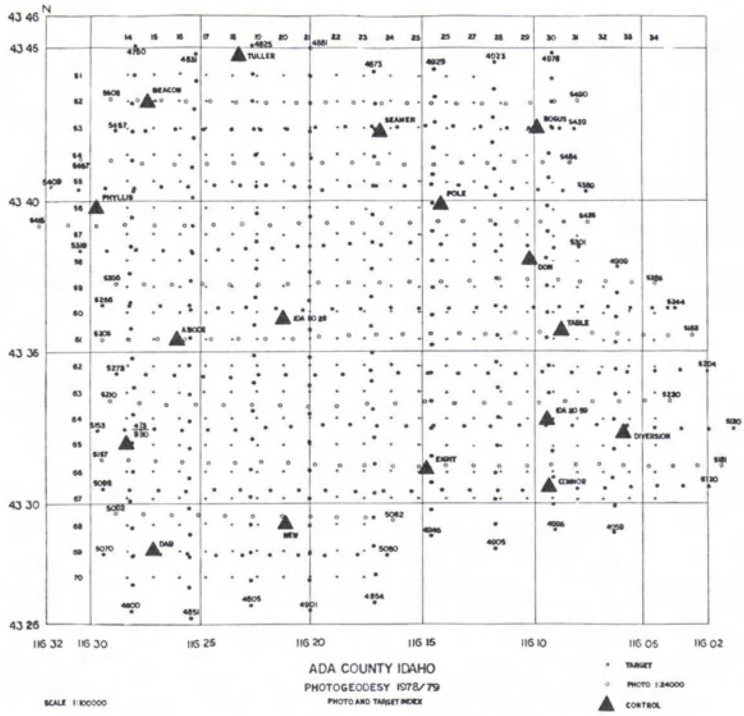

FIG. 1. Ada County Project target and photo index

stations were supplemented with six new geodetic stations to provide sufficient control over the 350 sq. mi. area. The conditions of the section corners in terms of recoverability and targeting were of obvious concerns. All but a handfull of the section corners could be driven to. Approximately one-third of the corners could not be targeted directly due to interference of photographic visibility and, therefore, required offset points.

The planning effort included assembling information, carrying out correspondence, preparing flight maps, reviewing geodetic control, and preparing project instructions.

FIELD

The field effort included placing and maintaining the photographic targets and performing the aerial photography. Some 380 targets were placed on the section corner marks and geodetic control stations. The targets consisted of a 30-inch orange disk placed over a black background. The 8-ft square background of tar paper was used on most terrain conditions except for pavement, where the background was painted onto the surface. The targets were placed by 12 two-man crews in six working days. During the targeting operation, the positions of the targets were plotted on 1:24,000-scale USGS topographic maps covering the project area. During the interim, from target completion to photographic completion, the target sites were monitored daily and maintained in a photographic ready state.

The primary photography was completed in one day. The spotting photography for identifying targets was completed the following day. It should be noted that the photography was flown the day following the completion of the targeting. It would not be uncommon to have to wait a week or two for good photographic weather, even though it was a favorable season and location for photography. The completed photography consisted of four rolls of panchromatic film and three rolls of color film. The lab processing consisted of negative processing, indexing, and contact printing of the color film.

MENSURATION

The mensuration was performed on a Mann Automatic Stellar Comparator (MASC). Prior to measuring, a number of preparatory operations were performed (Figure 2). These included preparing the original negatives, digitizing the topographic marks, and digitizing negatives. The original film is cut and placed in plastic bags for protection and easy handling. During the film indexing, the photograph nadirs are plotted on the topographic maps. The maps are digitized to create a data base of approximate air station and target positions.

This data base, along with the digitizing of the photographs, provides the information required for the management of the thousands of measurements performed. On each photo an average of 90 images are observed, of which only eight are located manually. These eight included three reseau images for

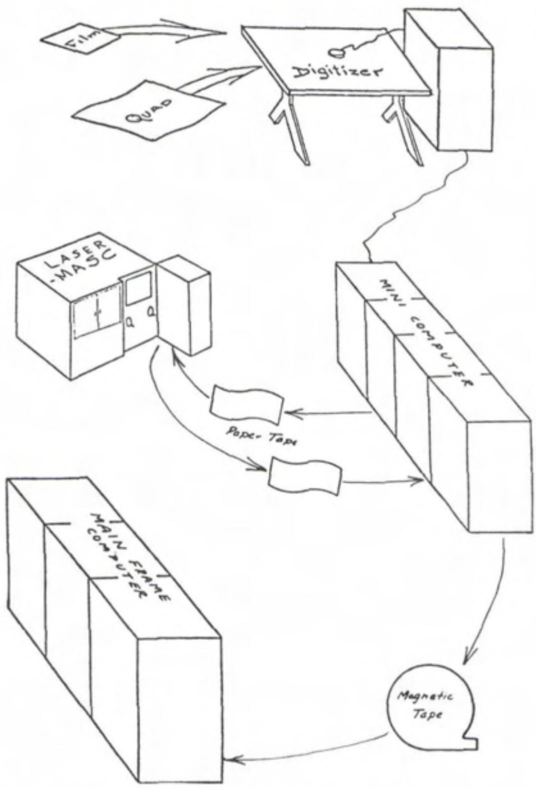

FIG. 2. Depiction of mensuration and data reduction

transformation and five target images (three minimum) for photo resection. The digitized photo information and the target position are processed in a computer program which performs a photo resection and develops a measuring map of the photo. This map, in file form, carries all of the point identification data as well as photo positions of all the images to be measured. This file is converted to punched paper tape for compatibility with the MASC. The image identification is developed from the photo digitizing and the quad digitizing. The information from these two files generates the identification for each of the hundreds of thousands of pointings.

The MASC operator utilizes the paper tape to drive to the desired images where he makes manual settings. For each target image some 35 points are performed. This high number of pointings come from multiple settings and utilizing six reseaus about an image. With this technique, completion of 1,500 measurements per 4-hour shift was possible.

DATA REDUCTION

The data reduction involved a few steps to take the data from the raw measurements to final run through the block adjustment program. First, a primary editing is performed on the raw data. This editing is done during transfer of the punched paper tape to media on the minicomputer. Next, the data are processed through a program that performs coordinate refinement, including corrections for film deformation, comparator calibration, and lens calibration. A secondary editing process is a part of the running of this program. The output from coordinate refinement is on media compatible with the mainframe computer.

The block adjustment program resides on the mainframe computer, which currently (1982) is a UNIVAC 1100/40. Prior to running the block, the data are run through a sort of program which prepares the data for the block program. The data are divided into strips or partial blocks and run through the successive sort and block programs. During the partial runs, the blunders, discrepancies, and control parameters are corrected and adjusted for the final run.

EQUIPMENT

A project the magnitude and scope of the Ada County Project required considerable equipment, some normally associated with a photogrammetric operation and some unusual special equipment. The special equipment deserves attention due to its direct contribution to the effort and measuring refinement of this project. The reseau camera cone, the Mann Automatic Stellar Comparator (MASC), and the supporting software all fall into this specialized equipment category.

The cone is a special Wild Universal Aviogon II lens with a projected reseau, which is compatible with the Wild RC-10 camera system. The reseau (10-mm grid) carried the weight of the mensuration and therefore required careful calibration. In fact, a considerable effort was put forth in calibration of the reseau. The final calibration utilized a plate flattener capability of the National Research Council of Canada. These plates, when measured on the MASC, modified with a laser measuring system, provided the ultimate in projected reseau calibration.

The MASC was not only instrumental in the reseau calibration but also in the measuring process. This precise measuring instrument, with the minicomputer, provided the automatic pre-positioning and the point identification management associated with each measurement, thus leaving the operator free to concentrate on pointing. The computer capability of MASC, small as it is, was instrumental in the efficient handling of over 200,000 measurements required by the Ada County Project.

The software and processing equipment, although not necessarily special equipment, played a significant role in the managing of the large amounts of data. Several computer programs involving over 8,000 lines of primarily FORTRAN code have been developed for the mensuration and data reduction phases of an UNPHOG project like Ada County. These programs utilize a DEC 11/45 processor, with

RSX-11M operating system, and a UNIVAC 1100/40 system.

Summary

The Ada County Project has been reduced to man-hours of effort and costs. The collection of information to provide this summary was from many sources within NOS and represents as comprehensive an effort as possible. In some instances, estimates of time and cost from first-hand individuals were used in place of recorded information.

Figure 3 depicts the breakdown of the total effort (5404 man-hours) to complete the Ada County Project. In some cases each phase is divided further. The source of the costs (Figure 4) was either actual cost, derived cost from actual manhours, estimated cost, or derived cost from estimated effort. The derived cost was determined by using a GS-11 at step 5 salary (1979) plus 60 per cent overhead factor. The amortization of special equipment was not included in these costs. These items were not included for a variety of reasons. In some cases the equipment was received through government surplus. In most cases all of the equipment is utilized in other projects and the computation of the Ada County requirements would be complicated and most likely incorrect. In some cases the development of the equipment was primarily for research and development reasons, which is an independent endeavor.

The amortization, or usage, of the following equipment was not included in the cost of this project: RC-10 camera system, special reseau camera cone and calibration, MASC, and DEC 11/45 and peripherals.

This paper has concerned itself with the effort involved in performing geodetic densification through photographic means. The effort involved with the operations has been addressed in detail. The cost of the project was determined to be $132,000 (1979 dollars). This figure includes, along with labor and materials, the aircraft with crew and the block program data processing cost. The special equipment and software development cost were not included. As mentioned earlier, a reasonable determination of the special equipment cost from proportional usage is improbable. Also, this one-time cost should be spread over several UNPHOG-type projects of which Ada County is the first. The cost breakdown, along with the discussion of special equipment, creates a good description of the project, providing a realistic basis for planning.

The total photogrammetric Ada County Project cost breakdown deserves discussion. These figures represent a system design and operating procedures that are new. In review of these items, it becomes clear that there existed considerable potential for reduced effort and resultant reduced cost. New procedures and software operations were used in the mensuration and the data reduction phases. The learning times of these sometimes complex operations were absorbed in the respective figures of each phase. Also, the mini- and mainframe computers are very new units to NOS. The familiarization with and the wringing out of the associated operating systems have also been absorbed in these figures.

The understanding of the reseau's effects on measurements can also lead to substantial reductions. Currently, the reseau measurement reflects the

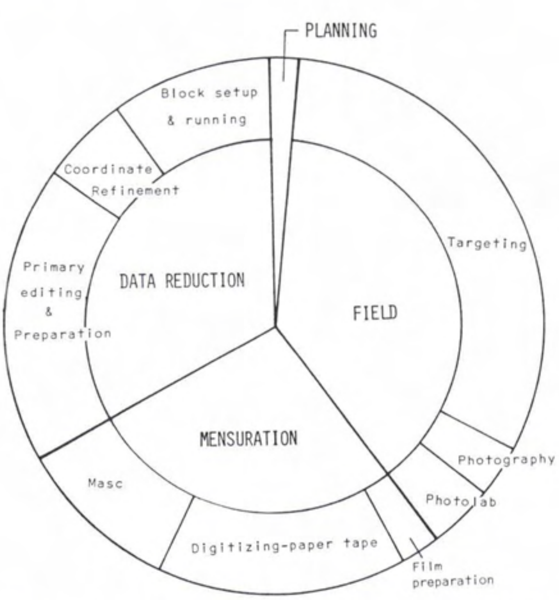

Fig. 3. Photogrammetric effort (man-hour) breakdown of Ada County Project

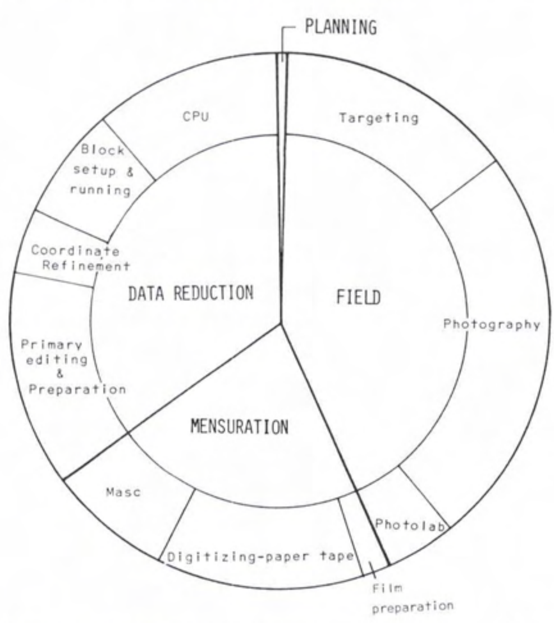

Fig. 4. Photogrammetric cost breakdown of Ada County Project

prototype system. There exists considerable confidence that at least 50 percent of the reseau mensuration can be reduced. The reduction, by nature of the process, will cause a direct reduction of the mensuration effort. An estimated overall reduction of 20 percent could be expected in future projects from improved system familiarity and reduced reseau measurements. A continuing effort exists to reduce the human effort and make the procedures more efficient. All of these factors should reveal significant cost reduction in future UNPHOG-type projects.

References

Slama, C. C., 1978. High precision analytical photogrammetry using a special reseau geodetic lens cone. Proceedings of ISP Commission II International Symposium, International Society for Photogrammetry, 31 July-5 August, Moscow, U.S.S.R.

(Received 18 September 1982; accepted 16 October 1983)

International Symposium on Spatial Data Handling

Zurich, Switzerland
20-24 August 1984

This Symposium—organized by the Department of Geography of the University of Zurich and the Institute of Technology (ETH) Zurich—will include the following formal sessions:

- Recent Developments in Spatial Data Models
- Knowledge-Based Approaches to Geographic Information Systems
- Spatial Data Handling for Hydrologic Research and Planning
- Advanced Cartographic Displays for Spatial Data Handling Systems
- Increased Efficiency in Manual Digitizing Operations
- Application of Spatial Data Handling Techniques to Environmental Maps and Atlases

For further information please contact

Symposium Secretariat
Dept. of Geography
University of Zurich (Irchel)
CH-8057 Zurich, Switzerland

1984 International Geoscience and Remote Sensing Symposium (IGARSS '84)

Strasbourg, France
27-30 August 1984

The primary goal of this symposium—sponsored by the IEEE Geoscience and Remote Sensing Society and cosponsored by the European Chapter Geoscience and Remote Sensing Society, Council of Europe, DFVLR, EARSeL, ESA, and NASA—is to enable participants to gain a general overview of the present status and future prospects of the geoscience disciplines and the techniques of remote sensing, together with more detailed summaries of recent technical progress in these fields. Main topics will include theoretical, experimental, and operational aspects of land observation, sea observation, and atmospheric observation from ground-based, airborne, and space-borne platforms with optical, electromagnetic, and acoustic techniques. These topics will include aspects of present and future sensor systems, present and future projects, proven and expected applications possibilities, and data management and data handling.

For further information please contact

Dr. J. P. Massué
Division for Higher Education and Research
Council of Europe
Avenue de l'Europe
F-67006 Strasbourg, France