Eleventh Congress of the
International Society of Photogrammetry

Lausanne, Switzerland
July 8–20, 1968

National Report of the United States

Compiled by James P. Webb

U.S. Army Map Service
Washington, D.C.

THE NATIONAL REPORT of the American Society of Photogrammetry to the 1968 XI International Society of Photogrammetry Congress of Lausanne identifies the work accomplished in the United States since the 1964 Xth Congress of Lisbon.

PUBLICATIONS

Since the 1964 ISP meeting in Lisbon, the American Society of Photogrammetry has experienced several noticeable achievements in the field of technical publications. The *Third Edition of the Manual of Photogrammetry* published by the Society early in 1966 has received world-wide acceptance. A compendium of selected papers in the field of *Remote Sensing* was published in July 1966. Currently, a *Manual of Color Aerial Photography* is near completion and scheduled for release early in 1968. This manual will include the results of a series of tests conducted by the Society in cooperation with government agencies and industry to determine the comparative qualities of color versus black and white aerial photography. The Society's official journal, *Photogrammetric Engineering*, is now published monthly instead of bimonthly as in past years.

MAJOR ACTIVITIES

The Society has sponsored three major symposiums since Lisbon. These are identified as symposiums on: Aerial Triangulation held February 28—March 4, 1966, University of Illinois, Urbana, Illinois, ISP Commission III; on Measurement held October 13–14, 1967, Colorado School of Mines, Golden, Colorado; and on Computational Photogrammetry held December 4–8, 1967, Gaithersburg, Maryland.

The ASP Distinguished Lecturer Series now in its fourth year has been most successful. Supported by the National Science Foundation, it has been possible to increase the scope of this valuable educational program. As a part of this series, Dr. Bertil Hallert of the University of Stockholm lectured at 21 colleges and universities and 7 technical societies, and spoke to over 3000 people in the U. S. and Canada during 1966.

The annual and semi-annual meetings of the Society have been well attended (3,000 and 1,500 registrants, respectively) as have the technical meetings, seminars and symposia sponsored by several ASP regions and committees. The annual meeting is always held in Washington, D. C. The National Council of the American Society of Photogrammetry has established locations for future semi-annual meetings of the Society for the next five years.

The Society participated in the foundation of the American PhotoTechnical Council for the purpose of coordinating meetings and programs. Other members are the Society of Photographic Instrumentation Engineers and the Pattern Recognition Society. Negotiations with other societies in this general area are in the discussion stages.

AWARDS

Two additional awards are available for presentation each year by the Society, which is now a total of nine. The Autometric Award for the outstanding technical publication on photographic interpretation sponsored by the Raytheon Company was awarded for the first time in 1965. The first Louis Struck Award was presented in 1967 by the Struck family of Mexico City. The purpose of the award is to stimulate Pan American understanding in the field of photogrammetry.

Organization

The Society has experienced continued growth and development. The National Headquarters staff has been augmented to include additional personnel and a full-time Executive Director. The working structure of the Society has been strengthened by reorganization of its committee structure and through the creation of new committees in the areas of Technical Program and Aerial Photography. The Board of Direction recently approved a divisional structure for a more effective organization of the Society's technical effort.

Photogrammetric Development

Photogrammetric development in the United States from 1964 to 1968 is depicted in the 280 technical articles that were published in Photogrammetric Engineering magazine during that period. Needless to say, the photogrammetric mapping efforts that prevailed in 1964 have steadily increased in volume and scope in both private practice and governmental agencies. Although completely automated mapping systems are not used generally, nevertheless many parts of systems have been automated and are being used, and a few very sophisticated systems are in operation. Analytic (computerized) systems have increased at a high rate, where as the use of first-order analog plotting instruments have increased very slowly.

A few of the highlights of these developments are included in the following paragraphs.

Segmented photography from Lunar Orbiter was utilized through an application of orbital constraints to the analytical photogrammetric problems associated with production of detailed topographic maps of the lunar surface.

LASER technology has been applied to the scanning, manipulation, and recording of information on film. Experiments have demonstrated that it is feasible to scan at resolutions exceeding 256 line pairs per millimeter and to distinguish between 31 levels of gray.

Experimental orthophotomaps involving several types of terrain and culture are being produced in an effort to determine those for which photo image representation is most effective, and include both flat areas (a mosaic of scaled and rectified photographs) and nonflat areas (a mosaic of scaled orthophotographs).

A selected group of employees engaged in stereoscopic compilation was provided with special optometric services, including periodic on-the-job and clinical examinations, together with prescriptions and corrective glasses as required. Psychological testing of all participants was also included.

Airborne infrared imagery has shown the location of the salt/fresh water interface in an estuary and the distribution of effluents from thermal power plants in lakes and streams.

Infrared (false-color), color, and black-and-white aerial photography have been tested for detecting and assessing tree diseases.

Stereo side-looking airborne-radar (SLAR) techniques have been developed for certain kinds of mapping where continuous cloud cover prevents conventional photography.

A computer program was designed to produce fictitious data for the testing of extensive programs of analytical aerotriangulation. The program generates the positions of ground points and exposure stations, and the angular orientation elements for the photographs. This program was employed to produce the data used in the I.S.P. Commission III tests on analytical triangulation.

The automated analytical stereoplotter with orthophoto system, AS-11C, performs automatic orientations, contouring, profiling, terrain digitization, orthophoto printing, and recording of hypsocline contour plots. A scanning pattern is fitted to the terrain by a computer, resulting in a geometric high-fidelity orthophoto. Automatic mode is achieved without compromising versatility or operator ability to view and control operation.

The universal automatic map compilation equipment (UNAMACE) operating automatically under computer control accurately measures and outputs detailed altitude variations over the stereo field presented by a variety of photographic inputs. In concurrent operations produces orthophotographs of high resolution. Orthophotos from contiguous stereo pairs can be output on a common sheet avoiding the manual mosaicking operation. The system can operate as a precision stereo comparator and perform relative and absolute orientation calculations required to create accurate stereo models.

A thermal infrared scanner was developed for airborne geologic research.

A nine-lens "multiband" aerial camera enables simultaneous photography of the earth's surface in narrow-band regions of the visible and near-infrared spectrum. The camera employs three rolls of aerial film, each traversing three matched lenses equipped with appro-

priate filters to give a narrow-band input to the film.

The stellar calibration of an aerial camera is an ultra-precise method of camera calibration by utilization more than two thousand photographic images of more than 400 stars to determine all the elements of interior camera orientation and all metric lens defects with a statistical validity of one or two microns. The refinement is expected to result in significant reduction of photogrammetric error propagation and to lead, ultimately, to the qualification of aerial cameras as tools of geodesy.

A computer program in FORTRAN IV for Multiple Station Analytical Triangulation (MUSAT) computes the positions and attitudes of the photographs simultaneously in the coordinate system of the ground control using the method of least squares. The final position of unknown image points are computed by intersection using the final air station positions and camera attitudes. The programs are designed to accept a 100-photograph block with up to 100 image points per photograph.

Analytic aerotriangulation was programmed and documented for the entire problem of systematic error compensation, three-photo strip aerotriangulation, strip adjustments, and the simultaneous adjustment of blocks of up to 200 photographs in any overlapping configuration with any number of horizontal and vertical control points. Provision was made for varying the relative weight of photograph images with radial distance, the relative weight of photogrammetric and geodetic ground positions, and the weight which enforces the condition of colinearity on control points. All programs have been published in Fortran language.

A Sequential Independent Model Block Analytical Triangulation (SIMBAT) Computer Program is an integrated set of computer programs designed for the analytical triangulation of a block of photographs using sequential independent models. The programs are coded in FORTRAN IV for operation on the IBM 7090/7094 computer and in Automath 1800 for operation on the Honeywell 800 computer.

The equivalence of color and panchromatic aerial photographic films with respect to geometric fidelity has been established through a series of tests conducted on several brands of films. The tests included master glass grid-plate exposures for the measurement and analysis of the nature of film distortion, development of a mathematical model for film distortion based upon eight camera fiducial marks, evaluation of color glass diapositives for emulsion creep, studies of error progapation in analytic aerotriangulation, airborne tests of photographic resolving power and airborne tests of metric aerotriangulation through the use of the Ohio Camera Calibration Test Area.

The Stereo Image Alternator (SIA) was designed to be attached to production-type stereoplotting instruments to improve the stereoscopic viewing of photo imagery. In this system, the anaglyphic filters in projection and viewing fields are replaced by synchronized shutters rotating at high speed which allow rapid alternate projection of the left and right diapositive imagery and synchronous alternate viewing by the corresponding eye of the operator. The system provides better model resolution and brighter models. It provides the capability of viewing and working with color photography in projection-type instruments. Manufacturers have provided facilities for attaching the device to older instruments.

Semianalytical methods of aerotriangulation were designed to use available computers and stereoplotters, including the Kelsh, ER-55, B-8, PG-2, C-5, and A-7 plotters. Attachments for these instruments have been designed for the readout of model or strip coordinates.

An Arizona photogrammetric test site is a high-density control area which was established in 1965 within the existing Army Map Service test area near Phoenix, Arizona, for testing photogrammetric techniques and instrumentation. The test site provides several patterns of monumented and targeted (some temporary, some permanent) horizontal and vertical control points ranging from a 1/4-mile grid spacing over a 2- by 3-mile area to a 4-mile grid spacing for the entire 16-mile-square area.

A fully analytical aerotriangulation system—the Geological Survey's direct geodetic constraint method—has been used successfully to provide photogrammetric control for mapping two 7.5-minute quadrangles. The X and Y photograph coordinates were measured on the 1:24,000-scale glass-plate negatives with a monocomparator.

A graphic data recording system will accept analog voltages as input from an electronic stylus, cursor or other tracing device designed to be used with a Cartesian plotter. The analog input is converted to digital form and fed into a logic system which minimizes the number of points required to maintain a plotting accuracy of $\pm.005$ inches. These

points are then punched onto eight-channel paper tape as X-Y-coordinates.

An underwater panoramic camera covers a 38×120 degree field in water by employing a water-contact lens system where the front element forms the window through which the remaining lens elements scan. The lens resolves 50 lines per millimeter at the center with an aperture of f/2.4.

The Variscale Stereo Point Marking Instrument (VSPMI) permits the identification, selection and marking of conjugate image points on stereo pairs of aerial photographs. Input may be photographic plates of film, up to $9\frac{1}{2} \times 18$ inches. It can be used to transfer points from one photograph to corresponding imagery on the second photograph of the same terrain. One or both photographs of the stereo pair can be marked. A unique precision marking system molds a mark into the film emulsion without destroying or changing surrounding imagery. Mark intensity and contrast can be varied by the operator. The marking system accuracy is within 1 micron standard error. The output, in addition to the marked photographs, consists of an IBM 526 card, automatically punched with coarse coordinates of the marked points as well as other pertinent data.

A system was designed for the establishment of area control adequate for medium-large scale mapping. The measuring techniques on precision comparators and the adjustment programs were developed and tested in the Coast and Geodetic Survey, using an uncontrolled 60 by 70-kilometer test area in the southeast corner of Kansas, bounded by arcs of first-order triangulation. A block aerotriangulation was performed successfully and proved that large areas can be bridged to provide positions for any number of intermediate points well within the accuracy required for most mapping.

Propagation of the errors in a three-dimensional satellite triangulation adjustment was studied by means of a numerical model using fictitious data. The fictitious triangulation net consisted of five camera stations forming three triangles. The average length of the sides was about 1,500 kilometers. An error of ± 0.2 second was introduced into the orientation element of the camera axes, and an error of ± 2 microns was introduced into the plate coordinates. The results from several adjustments showed that the absolute positions of the unknown stations could be determined to better than 1/200,000.

During a study for the development of Objective Color Sensors, experiments were performed in order to determine the quantitative stereoscopic effect obtained from exaggerating the differential refraction of light frequencies in the visible spectrum.

Analytical triangulation of Lunar Orbiter Photographs included the analysis of the nonlinearities in the transmitted Lunar Orbiter photographs and the development of techniques and computer programs to produce control data for the production of lunar maps.

A precise block aerotriangulation project determined the relative movement between 50 well defined points within a 2 by 5-kilometer rectangular area in the city of Anchorage, Alaska, with the highest possible precision. The relative movement to be determined is that of the earth's surface and the technique for accomplishing it is through repetitive photography spaced at time intervals of 3 to 5 years. The photography is made at the lowest practical altitude (0.9 km) to attain maximum accuracy (approximately 7 cm) in three dimensional measurement.

On June 23, 1966 PAGEOS, a near polar earth orbiting satellite of the balloon type was launched for the purpose of providing a photographic target for the three-dimensional determination of the figure of the earth. The height of its near circular orbit is such that strong geometric figures are attainable using approximately 44 locations on land areas of the earth's surface. This is a part of a cooperative national geodetic satellite program. ECHO I and ECHO II are being used in a similar manner for shorter lines, to provide control for continental networks; 21 stations in North America were established successfully. The photogrammetric technique employ specially modified BC-4 cameras.

A set of six boresighted cameras was used as a multi-sensor system with combinations of films and filters to evaluate natural resources. Emphasis concentrated on water pollution studies, over controlled nutrient ponds; on engineering applications; and on agricultural applications.

Annually some 40 stock piles are inventoried photogrammetrically for volume determination. For several years, conventional contours planimetered for area were used to compute volume areas. In more recent years, digital cross-sections and electronic computation have been employed. Ten coal piles of approximately 40 acres and 750,000 tons each, plus approximately 40 large piles of bulk chemicals, have been involved.

A double-projection photogrammetric plotter equipped with a coordinatograph was used to determine state plane coordinates of

centerline control points and adjoining property corners of a section representing a proposed highway. Three areas representing different densities of land use were investigated. It was concluded that for well defined points in an urban area distances can be measured to an expected accuracy of ± 0.25 foot. For rural areas the expected accuracy is ± 0.5 foot. The relative accuracy of area determinations depends on size of the area.

Photogrammetric methods were applied to right-of-way relinquishment surveys and other cadastral surveys where high accuracies are required. A Zeiss C8 stereoplanigraph was used in combination with large-scale aerial photography and carefully targeted geodimeter control points to acquire the necessary survey information to describe the relinquished right-of-way. An electronic computer program proved helpful for the adjustment of photogrammetrically measured data.
