the Burgomaster of The Hague. Lastly, I should like to say that the Dutch should be commended for planning and conducting the Sixth International Congress. I am sure many of us obtained much reliable information from the Congress and value very highly the opportunity to meet the many people in the field of photogrammetry in the various countries. The official record of the meeting is constituted by the International Archives. Action has been initiated to expedite preparation of these to the extent possible. We will receive more information about progress, costs and availability as soon as possible. When received our members will be notified.

CLEVELAND'S USE OF AERIAL PHOTOGRAPHY FOR CITY MAPPING†

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PERHAPS as a consequence of the modes of living and working during World War II, the American people have acquired new habits incorporating alacrity. It certainly can be said that considerable energy has been exhibited within the last decade toward getting results in a hurry. This briskness has manifested itself in many avenues; one particular manifestation is reason for the subject of this brief paper at your 1948 Semi-Annual Meeting of the American Society of Photogrammetry.

Cleveland wanted large scale topographic maps in a hurry. Existing plane table methods were too slow. Studies were made concerning ways and means to procure the much needed mapping in terms of the proverbial time limit, "yesterday."

One item of particular significance respective to fulfillment of the end point, the topographic map, is control. Considerable time is required to provide accurate horizontal and vertical control for an area the size of Cuyahoga County, i.e., 450 square miles. Cleveland has been acquiring that prerequisite for the past 10 years. In fact, the long-range program established in the Cleveland Regional Geodetic Survey effectively permits the short-range spot mapping by photogrammetric means.

The Cleveland Regional Geodetic Survey has been in existence since July, 1937. It is sponsored jointly by the City of Cleveland, the County of Cuyahoga, and the State of Ohio, through its Department of Highways. Inasmuch as accurate control is prerequisite to mapping of large areas, perhaps a few words concerning the Cleveland Regional Geodetic Survey are in order.

The Survey was initiated primarily due to the fact that Metropolitan Cleveland lacked comprehensive and accurate horizontal and vertical control and adequate mapping. The specifications adopted conform to those recommended in the American Society of Civil Engineers' Manual No. 10, Technical Procedure for City Surveys.

The skeleton of framework for the horizontal control, namely the triangulation network, embraces 133 triangulation stations. The area controlled by each station within urban areas is 2.5 square miles and that in rural areas is 4.0 square miles. The triangulation observing is about 90% completed and least squares adjustments have been completed on all field data observed to date.

† Paper read at the Semi-Annual Meeting of the American Society of Photogrammetry, October 7, 1948, Philadelphia, Pennsylvania.

As of October 1, 1948, a total of 950 directions had been observed 2,158 times for an average of 2.33 observations per direction. There are 7 base lines in the net ranging in length from 1.51 miles to 3.68 miles. These bases have been taped in accordance with accepted standards and the average probable error for all seven bases is 1:2,175,000 with a maximum of 1:1,523,000.

The average base-to-base discrepancy after side and angle equations have been satisfied is 1:204,000, not including one phenomenal discrepancy between bases Three and Five of 1:8,881,000.

Traverse supplements the triangulation control in order to provide a multiplicity of survey monuments for use by all survey parties. The observing program is identical for first and second-order traverse, the only difference occurring in permissible closures.

Quadrilaterals or center-point figures are employed to transfer the position data of a roof triangulation station to the ground. Pairs of bronze-capped, concrete monuments are located not only at the transfer stations, but also in the traverse lines to serve the surveying profession with starting coordinates and azimuths. These pairs are spaced approximately 0.6 of a mile apart in urban areas and 0.8 of a mile apart in rural areas. As of October 1, 1948, 1,617 monuments have been set.

The progress on traverse taping and angles as of October 1, 1948 is as follows:

First-Order Angles	533.69 miles
First-Order Taping	505.48 miles
First-Order Taping rerun	101.37 miles
First-Order Angles rerun	184.10 miles
Second-Order Angles	210.66 miles
Second-Order Taping	216.70 miles
Second-Order Taping rerun	6.05 miles
Second-Order Angles rerun	15.22 miles
Third-Order Angles	72.36 miles
Third-Order Taping	72.36 miles

The vertical control consisted of 93 loops of first-order observing. The average loop closure was 0.020 foot with a maximum of 0.063 foot. Each of these loops was further subdivided into 4 smaller loops by second-order observing. The level lines are spaced slightly less than a mile apart in urban areas and slightly more than a mile apart in rural areas. The vertical control is completed by 583.91 miles of first-order levels and 718.62 miles of second-order levels. This does not include 110.74 miles of first-order reruns and 75.83 miles of second-order reruns which were required to meet specifications.

As soon as any of the above mentioned control was adjusted, it was made available to the surveying organizations in the Cleveland area. Eventually, a publication will be issued including descriptions, elevations, and coordinates of all monuments and azimuths between those that are spaced in pairs.

Mapping by the plane table method was inaugurated just as soon as sufficient horizontal and vertical control was adjusted. Only two experienced plane table topographers resided in the area, both in administrative capacities, so it was necessary to train topographers.

From August 1940 to August 1946, the Survey averaged 4 plane table parties in the field. Certain strip areas for express highway planning were in demand by the Ohio Department of Highways. Accordingly, rather than completely map a sheet before going to a next one, the mapping was executed in strips ranging in widths from 1,000 feet to 4,000 feet.

A total of 15.66 square miles were mapped by plane table at a total cost of approximately $90,000. This did not include inking of sheets or reproduction costs. These additional costs were estimated to increase the total costs for final reproduced maps to $7,500 per square mile or approximately $11.50 per acre.

Just as serious as the financial problem was the matter of economy of time. At the existing rate, it would have taken about 150 years to completely map Cuyahoga County, about 450 square miles.

The Express Highways Committee of Metropolitan Cleveland has been making long-range plans for a system of freeways. One particular freeway had been fixed high in priority and in a tentative location for which there existed no topographic maps. How could these maps be obtained without waiting two or more years?

The writer had previously obtained estimates for photographing Cuyahoga County from the air and an approximate cost per acre, to produce topographic maps by photogrammetric methods. Likewise, a time estimate had been obtained and both these cost and time estimates were included in Report No. 4 of the Cleveland Regional Geodetic Survey published in 1945.

To expedite the procurement of the topographic mapping in the high priority region, the City of Cleveland's Department of Public Service, the County Engineers' Office and the Ohio Department of Highways entered into an agreement of cooperation to equally co-sponsor the cost of aerial photography and photogrammetric topographic mapping of eight map sheets. Specifications were written, bids were requested, and the job was let.

About one-third the area of the County was photographed during the spring of 1948. Included therein was the area for priority mapping. To assist in scale checking and both coordinate and elevation control in the operation of the stereo-comparator, four-foot square targets, made of stiff corrugated cardboard with a three-foot diameter circle in white, were placed over all monuments occurring in unpaved areas. Monuments in paved areas had a three-foot white or black circle painted directly on the pavement. White paint was put on blacktop and black paint on concrete roads and sidewalks.

The photogrammetric mapping is to the same scale as the plane table mapping; i.e. $1'' = 200'$, with a two-foot contour interval. Double scale ozalids were furnished the Survey for profile checking and editing. For two months during the summer, 6 four-man parties were running random profile traverses in the field for a comprehensive check against specifications. Planimetry was picked up at the same time. Coordinates were computed for the angle stations on the traverses and these plotted on the ozalids.

Profiles were plotted from the results of the field survey. Superimposed on the same sheets were the corresponding profiles extracted from the topographic maps. A total of 29.05 miles of traverses have been run in the field, of which 23.84 miles have been checked to date showing an average percentage of 94.8 meeting specifications. All planimetry checks were within specifications.

The September 30 issue of *Engineering News Record* shows about an equal split for the first 40 weeks of 1948 between public and private construction. The totals exceed by one billion dollars construction for the same period for 1947. Most construction requires a topographic base map. The engineers and planners in Cleveland have fallen in step with the most modern means to procure the medium to assist them in the conception, planning, design, estimating, and construction of engineering works.

One prominent highway planner said that lack of proper topographic maps has delayed the freeway program in the Cleveland area by at least two years.

The photographs and resulting mapping under the present contract will permit the early location of the centerline for the Medina Freeway. Portions along the projected alignment may be enlarged to $1'' = 100'$ by means of the precision pantograph or ideograph, and design features expanded to present data of sufficient detail for preliminary estimates. With the entire County photographed on stereo pairs to rigid specifications, there is no longer any need to fear the problem of time in the procurement of topographic maps.

The up-to-date air photos will likewise be an asset to the several public planning agencies in the County. The Regional Planning Commission and the City Planning Department have already inquired about availability of prints in certain areas. One large industry with an expansion program extending some 300 acres has inquired about the possibility of the topography being executed from the air photos. One private surveyor of over 20 years' service to the community is anxious to submit, with every large property survey, an air photo or photos delineating the area under contract.

Considerably missionary work is still essential to properly stress the value of the product obtained by this initial cooperative contract. Many old-time Cleveland surveyors and engineers are skeptical of the results of the Cleveland Regional Geodetic Survey—and now they are confronted with this new-fangled idea of having large-scale maps made from photographs. However, the officials of the City, County, and State in high executive positions are to be commended for their foresight in co-sponsoring this original project which will make available air photos which may be used for reproduction of topographic maps which, in turn, may be used for a multiplicity of purposes in a large metropolitan area such as Cleveland.

The question might be raised, and rightfully so, concerning the attitude of the private surveyor who depends on established and new clientele for his bread and butter. Will this photogrammetric approach to topographic mapping make inroads on his professional practice? To several surveyors in Cleveland, this question has been put and the replies have been in the negative. Their ordinary practice involves property or land surveys and, where any mapping contracts are executed, they usually entail a larger scale than that standardized by the Cleveland Regional Geodetic Survey.

The Federal-Aid Highway Act of 1944 marked the beginning of a new era in highway development. It provided $500,000,000 annually for the first three postwar years, this money to be matched by the states. For the first time in history, the Federal Government allotted a portion of the funds of this act to be used for construction and purchase of right-of-way within urban areas. States are still lacking in preparedness to utilize these funds. One main item germane to preparedness is topographic mapping. There is no quicker or cheaper way to obtain the necessary topographic maps than by the photogrammetric process.

Highways embrace one type of construction. There are many others which require the basic information provided in a topographic map. The construction industry ranks third in the nation and is one which always will be near the top. Aerial photos and photogrammetric topographic mapping will go a long way toward maintaining the place of the construction field.