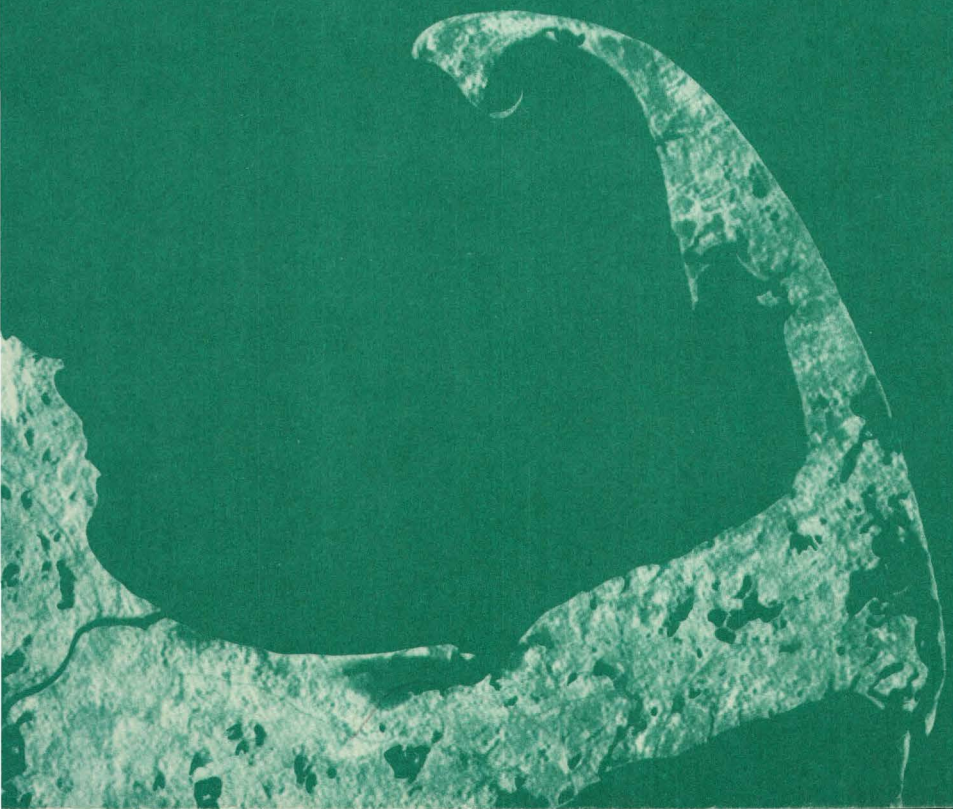
Topographic Division, U. S. Geological Survey

Cartographic Research

1977



CARTOGRAPHIC RESEARCH 1977

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FOREWORD

Two major subjects of the current research of the Topographic Division as reported here are related to policy decisions affecting the National Mapping Program of the Geological Survey. The adoption of a metric mapping policy has resulted in new cartographic products with associated changes in map design that require new looks in graphics and new equipment. The increasing use of digitized cartographic information has led to developments in data acquisition, processing, and storage and consequent changes in equipment and techniques.

This report summarizes the activities in cartographic research and development for the 12-month period ending June 1977 and covers work done at the several facilities of the Topographic Division: the Western Mapping Center at Menlo Park, Calif., the Rocky Mountain Mapping Center at Denver, Colo., the Mid-Continent Mapping Center at Rolla, Mo., and the Eastern Mapping Center, the Special Mapping Center, the Office of Plans and Program Development, and the Office of Research and Technical Standards all at Reston, Va.

Product and manufacturer names are specified as information directly related to the research conducted and not as endorsements by the Government or the Geological Survey.

Roy R. Mullen

CONTENTS

ABBREVIATIONS

AFB	Air Force Base
AWAR	area weighted average resolution
B&W	black and white
BGN	Board on Geographic Names
BLM	Bureau of Land Management
CIR	color infrared
CPU	central processing unit
DGC	direct geodetic constraint
DMA	Defense Mapping Agency
DMATC	Defense Mapping Agency Topographic Center
DPROS	Digital Profile Recording and Output System
EDC	EROS Data Center
EDIES	EROS Digital Image Enhancement System
EMC	Eastern Mapping Center
EROS	Earth Resources Observation Systems
ERTS	Earth Resources Technology Satellite (Landsat)
GD	Geologic Division
GIANT	General Integrated Analytical Triangulation
GIPSY	general information processing system
GNIS	Geographic Names Information System
GSC	Goddard Space Flight Center
IBM	International Business Machines
ICR	image coordinate refinement
IMC	image motion compensation
IPS	Inertial Positioning System
IR	infrared
JSC	Johnson Space Flight Center
LSA	least squares adjustment
MC	mapping center
MCMC	Mid-Continent Mapping Center
MHW	mean high water
MSS	Multispecial scanner
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
NGS	National Geodetic Survey
NGSIC	National Geodetic Survey Information Center
NOS	National Ocean Survey
NPS	National Park Service
OCS	Outer Continental Shelf
OES	Office of Earthquake Studies
OQ	Orthophotoquad
RBV	Return Beam Vidicon
RCA	Radio Corporation of America
RISP	Ross Ice Shelf Project
RMMC	Rocky Mountain Mapping Center
RMSE	root mean square error
RT-P	Branch of Photogrammetry, Office of Research and Technical Standards
SCS	Soil Conservation Service
SMC	Special Mapping Center
SWA	superwide angle
UK	United Kingdom
UN	United Nations
USAETL	U.S Army Engineer Topographic Laboratories
USFS	U.S. Forest Service
UTM	Universal Transverse Mercator
WMC	Western Mapping Center
WRD	Water Resources Division

FIELD SURVEYING

Inertial Positioning System

USGS used a DMA Inertial Positioning System (IPS) mounted in a Chevrolet Blazer (fig. 1) to control mapping projects in northern Maine. Personnel from EMC and the division staff were accompanied by two operators from the DMATC Geodetic Survey Squadron, F. E. Warren AFB, Cheyenne, Wyo.

The orthophoto project covered 25 percent of the State, about 21,300 km^2. Previous mapping was done in the 1950's when many of the quadrangles had no access roads. The area is still the largest wilderness section east of the Mississippi River.

Field operations began with control and route reconnaissance before the IPS arrived. Control reconnaissance consisted in recovering horizontal and vertical marks and transferring the positions and elevations to locations that the IPS could occupy. Route reconnaissance was needed to select the image points and to determine the condition of the road network and accessability, since much of the project included large parcels of land owned by paper and timber companies. In such areas the roads are built and maintained by the owners, and access is controlled by locked gates.

The IPS was on the project a total of 34 days--22 spent on production, 6 spent on testing, and 6 lost because of system or vehicle malfunctions. The IPS operated for 140

Figure 1.--Console of truck-mounted Inertial Position System used in mapping projects in Maine.

hours (not counting travel time to and from the work area), traversed 2,744 km, and established control on 328 image points. In addition to mapping control, positions were determined for 175 town-line/ road crossings, valuable in positioning town lines on the maps.

EMC computed the data for 70 control lines, which were processed through a refinement program that removed systematic errors and adjusted each line to the fixed positions; 16 interior junction points were then adjusted, and a final refinement program run was made holding the junction-point positions. Closures indicate an accuracy (standard error) of 1:20,000 in distance and 43" in azimuth.

With the IPS, 245 control points were established in addition to the 83 points required for aerotriangulation. Of these points, 66 were obtained to strengthen the geometry of the IPS survey net. Discounting the latter points, the cost per control point was 9 man-hours. The cost by conventional methods (paneling and electronic traverse) was estimated at 15 man-hours per control point. In spite of well-above-average rainfall (200 percent above normal for the period) no days were lost to weather as would have been the case with conventional surveys.

METAL DETECTOR EVALUATION

A bench-mark recovery course was installed on the grounds of the National Center in the summer of 1976. Adjacent to previously established monuments (included in the course as control stations), 16 subsurface stations were set. The stations were bench marks (BM) of various materials and configurations, described in table 1. The relative recoverability of the stations demonstrated the performance of five types of metal detectors.

The evaluated detectors are the Schonstedt GA-32 and GA-22, the Garrett Hunter, the Aqua Magnetic Locator, and the Teledyne Gurley L^2 Locator. All models are magnetic and, except for the Garrett Hunter, are thus limited to ferrous metal detection. The Garrett Hunter is sensitive to all refined metals as well as ferrous metals and ores. All except the Aqua Magnetic Locator generate an audio signal by a battery-powered oscillator. The Aqua Magnetic Locator does not need electrical power because it registers response by a metered magnetic dip needle. Approximate costs of the instruments are: Schonstedt GA-32, $450; Schonstedt GA-22, $410; Garrett Hunter, $240; Aqua Magnetic Locator, $45; and Gurley Teledyne, $350.

In addition to any variation in response inherent in the designs of the instruments, different operators often gave different ratings to the same instrument. Considering the overall response from BM 2 through BM 9, none of the various metal wire-ring bench mark configurations significantly increased recoverability. However, the response improved at all stations with magnets. Thus a magnet should be installed as part of monumentation where recovery is likely to be difficult. Time saved in recovering the station would offset the cost of the magnet.

TABLE 1.--Bench mark recovery test course

BM	Date set	Depth (feet)	Description
1	4/10/74	0.0	Aluminum tablet/magnet in cap (Berntsen monument).
2	5/28/75	1.0	Brass tablet/no modification.
3	5/28/75	1.0	Brass tablet/soldered wire ring, 13 cm diameter.
4	5/28/75	1.5	Brass tablet-soldered wire ring, 18 cm diameter.
5	5/28/75	2.0	Brass tablet-soldered wire ring, 23 cm diameter.
6	5/30/75	1.0	Aluminum tablet/no modification.
7	5/30/75	1.0	Brass tablet/crimped wire ring, 13 cm diameter.
8	5/30/75	1.5	Brass tablet/crimped wire ring, 18 cm diameter.
9	6/02/75	2.0	Brass tablet/crimped wire ring, 23 cm diameter.
10	6/04/75	1.0	Aluminum tablet/magnet, horizontal.
11	6/04/75	1.0	Brass tablet/magnet, vertical.
12	6/13/75	1.5	Two magnets held together by epoxy.
13	6/13/75	2.0	Three magnets held together by epoxy.
14	6/17/75	0.3	Brass tablet/copper coated steel rod, 91 cm long.
15	6/17/75	0.2	Magnet, vertical.
16	10/16/75	1.9	Magnet, vertical.
17	10/16/75	3.0	Magnet, vertical.

Note: Magnets in stations 10-17 are polarized alnico cylinders 25 mm in diameter, 33 mm long. Those set vertically are with the north pole toward the surface.

The Aqua Magnetic Locator appears to be the most sensitive and reliable of the instruments tested. It responded to the buried magnets, as did the others, but its response to the bench marks with wire rings was consistently higher. The simple mechanical-magnetic design provides high performance at the lowest cost.

The bench-mark recovery course will remain as a permanent facility for evaluating additional instruments as they become available and for other bench-mark experimentation.

ACCURACY TESTING

Since July 1, 1975, the USGS accuracy testing program identified failure of one horizontal and two vertical accuracy tests to meet National Map Accuracy Standards. The tests are summarized in table 2.

Table 2.--Results of field survey accuracy tests by USGS

Fiscal year	Horizontal tests		Vertical tests grouped by contour interval									
			5-ft		10-ft		5-m		20-ft		40-ft	
	No.	Avg. RMSE (ft)	No.	Avg. RMSE (ft)	No.	Avg. RMSE (ft)	No. (m)	Avg. RMSE (ft)	No.	Avg. RMSE (ft)	No.	RMSE (ft)
1973.	19	18.9	12	1.41	50	2.39.			34	4.05	0	
1974.	18	18.8	13	1.47	28	2.20.			23	3.29	1	7.30
1975.	18	18.9	22	1.30	39	2.25.			11	3.80	1	10.30
1976*	10	21.5	15	1.40	29	2.37.			11	4.32	1	9.61
1977**.	9	25.7	3	1.33	15	2.45	1	0.94	10	4.46	0	
Tests of Forest Service work (1976)	----	------	-----	-----	-----	-----	-----	-----	1	4.05	2	9.69
Tests of contract work (1976)			1	1.23	1	1.88						

* Includes results for 3-month transition period.
** First 5 months only.

The Crownpoint, N. Mex., OQ project was evaluated. The 91 OQ's were made for BIA, with publication by USGS. The investigation determined (1) that the public land net from published line maps would fit the OQ imagery reasonably well and (2) that the OQ's probably meet National Map Accuracy Standards. Three formal accuracy tests, made by RMMC in the early 1960's, were applied to the OQ's as part of the evaluation.

Some problems in matching Landsat images to maps and in fitting and testing gridded images led to development of procedures to measure their scales and study their geometry. The scales were measured along the four sides of each image and across each diagonal.

Examination showed (1) scale variation across the image in both along-track and crosstrack directions, and (2) maximum scale differences along-track versus crosstrack and between the diagonals. Up to seven separate images each of eight scenes were studied. Images processed by IBM and the new EROS Digital Image Enhancement System (EDIES) were also analyzed.

The studies are still in progress. Nevertheless, some observations and figures from the conventional electron beam recorder (EBR) images show:

1. Scale varies unpredictably in magnitude and direction. Alongtrack scale varied from 0.01 to 2.1 percent; crosstrack, from 0.06 to 1.2 percent. No side was consistently larger.

2. All images are somewhat affine. The scale difference alongtrack versus crosstrack varied from 0.1 to 1.1 percent; diagonals, from 0.13 to 1.32 percent.

3. Usually the diagonals have a larger error differential that the sides.

4. All images from Landsat-1 have the larger diagonal scale northeast-southwest; from Landsat-2, northwest-southeast.

Distortions were large enough to indicate a need for systematic quality control of Landsat image processing.

LEVELING FOR CRUSTAL MOVEMENT

EMC evaluated all available field observations for precise level lines in Georgia, Maine, Maryland, Massachusetts, New York, North Carolina, South Carolina, and Virginia for the Geologic Division. Twenty-five profiles covering approximately 4,000 km of leveling were compiled and transmitted to the Branch of Eastern Environmental Geology to be used with other data to study the Earth's crustal movement with respect to the suitability for nuclear reactor sites.

EARTHQUAKE MONITORING

Releveling begun in 1975 in Yellowstone National Park was completed to determine crustal movement resulting from a major earthquake near Norris, Wyo. In 1976, 170 km of second-order leveling was run according to first-order class II procedures.

Under first-order specifications a 1942 USGS line at Oroville, Calif., was releveled a second time. The 26-km line was first releveled after the Oroville earthquake (magnitude 5.7) of August 1, 1975. The second releveling was needed to provide USGS geologists with comparison values for determining vertical creep along the fault.

In September 1976 an annual releveling program began under an agreement between WMC and OES. Several monitor lines in Southern California are being leveled to first-order class I specifications. Also included in the program is Geodolite measurement of OES's trilateration strain nets that extend along the San Andreas fault from northern California to the Mexican border and along the Sierra Nevada fault in the Owens Valley area of central California. The project required monumentation of about 30 new stations--each built to accommodate the La Coste-Romberg plate on which the gravity meter will rest.

SUBSIDENCE LEVELING

To monitor subsidence 72 km of first-order leveling was run near Tucson, Ariz. The leveling, extending from Tucson, was a continuation of 1975 leveling within the city. Results are expected to provide a more accurate measurement of subsidence in the area.

FLOOD-DAMAGE SURVEYS

Surveys were conducted to define the high-water profile of the flood area from Teton Dam to American Falls Dam, Idaho. Because of the destruction of transportation routes and inaccessibility of some areas, helicopter transportation assisted the crews. Elevations were obtained by fly levels (to third-order standards) on 284 high-water points. Planetable elevations were established on 45 points on the canyon walls near the dam, and 23 cross sections, ranging in length from 0.8 to 9.6 km, were run and plotted on 1:24,000-scale topographic maps. The data will be used to define flood-damaged areas and to help calibrate a one-dimensional model of unsteady flow that can be used to predict the effect of a large flood.

Two 1.8-km monitor lines were established for BLM across the Centennial Wash, 64.4 km west of Wickenburg, Ariz. These lines are being established to help determine conditions that might have led to a dam failure across the wash. For each line two tablets were set in the mountain bedrock on either side of the valley. Intermediate tablets were placed from 0.8 to 1.6 km apart on driven copperweld rod. About half of the marks have a cement collar for lateral stability, for horizontal as well as vertical measurements.

RIVER CROSS SECTIONS

MCMC is furnishing horizontal and vertical information for 322 cross sections along the channnels of the Cimarron and Salt Fork Rivers of Oklahoma and Kansas to the Corps of Engineers, Tulsa District.

The information is to be generated by semianalytical control extension from available photographs and control. Resulting data will define the horizontal and vertical positions of points along cross sections of the flow channels of the rivers. The points will be located to define slope changes where elevations differ by 30 cm or more. The cross section information is to be used in backwater studies of the river basin.

EQUIPMENT

JMR-1 Doppler equipment

A JMR-1 Doppler Survey Set including microprocessor (JMR-1MP) was leased for 3 months during the 1976-77 Antarctic austral summer for operational testing in the Antarctic environment on RISP. The JMR-1MP operates as an accessory to the JMR-1 Doppler Survey Set and provides a one-pass real-time position (latitude/longitude) of the occupied site. Both units are battery operated, compact, weatherproof, and rugged. For remote locations the equipment shows considerable utility for navigating and obtaining mapping control.

PHOTOGRAMMETRY

CAMERA CALIBRATION

The USGS optical calibration laboratory has received 70 aerial mapping cameras for calibration from private contractors, State highway departments, a university, USFS, NASA-JSC, NOS, USAETL, a company in Guam, the Kingdom of Saudi Arabia, and the UN Geneva Division of Narcotic Drugs.

The camera calibration data bank now contains 400 camera-magazine calibrations, 90 of them suitable for fully analytical aerotriangulation; 110 additional sets contain data on fiducial-mark coordinates, lens resolution, and model flatness. The data include owner, manufacturer, number, lens type, lens number, magazine and platen number, calibration date, and number of fiducial marks.

Two master grid plates, a high-definition resolution test plate, and associated calibration data were provided to the MC's. The plates were made with Kodak high-resolution emulsion on microflat glass. The resolution plates contain an array of 17 USAF standard resolution charts. The resolution range is 1 to 203 cycles/mm, in a $\sqrt[6]{2}$ progression, of high-contrast clear lines on dark background.

ANALYTICAL AEROTRIANGULATION

High-altitude (6,600-m) SWA photographs obtained 3 years ago for the Louisburg, N.C., project were reprocessed with the ICR program and the new technique of grid modeling the combined radial lens distortion and platen deformation. The refinement greatly improved the quality of the aerotriangulation adjustment by the DGC program. The block contained 28 quad-centered photographs taken on north-south flights.

A statistical analysis of residuals on known points produced the following results:

	Horizontal			Vertical		
	Held	Test	Total	Held	Test	Total
Points	7	2	9	85	88	173
RMSE (ft)	3.7	5.2	4.1	2.7	3.9	3.4

Medium-altitude (3,300-m) SWA photographs of the same area taken with the same camera were similarly processed for radial distortion refinement and with the DGC program. The block contained 94 photographs taken on east-west flights. Nearly all the same points were adjusted in both the

medium- and high-altitude blocks. The statistical analysis results from the medium-altitude photographs of the Louisburg area are as follows:

	Horizontal			Vertical		
	Held	Test	Total	Held	Test	Total
Points	6	8	14	90	116	206
RMSE (ft)	2.1	4.5	3.6	1.2	1.8	1.6

While the difference in vertical results correlate with the ratio of the flight heights (2:1), the horizontal RMSE for the two blocks does not. The high-altitude photographs would easily satisfy the horizontal requirements for 1:24,000-scale mapping and the vertical requirements for the 20-ft (5-m) contour interval but would not satisfy the vertical requirement for 10-ft (2-m) contours.

NUMERICAL ORIENTATION OF STEREOMODELS

Orientation parameters computed from aerotriangulation data are being derived for use in stereocompilation. The data include (1) air base, in ground feet and millimeters at model scale, (2) differential elevation of the two exposure stations, in feet, and (3) and grad tilts tailored for any of the instruments used. The data are derived from relative orientation elements from aerotriangulation plotters or from analytical models in conjunction with absolute orientation elements determined by block adjustment of independent models. If properly calibrated, Kern PG 2 and Wild B 8 plotters (and the Wild PPO 8 orthophoto printer) can use the data directly. Other plotters need a millimeter scale, a Z-stick for measuring projection distance, and a graduated level trivet.

Initial results of numerical orientation with Kelsh plotters are favorable. Numerical orientation is within two floating-mark diameters of Y parallax, 13 m in scale, and 0.001 times the flying height in level. About 25 percent of the models needed no touchup. Time for numerical orientation and refinement varies from 15 to 35 min, two to four times faster than empirical methods.

It is premature to forecast savings in using these new methods, but most operators believe that numerical orientation is faster and easier than conventional methods, and initial results confirm their opinions. Considerable savings should be realized once all equipment is calibrated to use the data.

The computer programs for these procedures in numerical orientation are:

1. Image coordinate refinement (H-252).-- modified to provide printed- and punched-card output or relative orientation parameters computed during the formation of analytical models from comparator data.

2. Simultaneous Block Adjustment of Models (H-256).-- modified to provide absolute orientation elements computed in the block adjustment of either analytical or stereoplotter independent models.

3. Numerical Model Orientation (new).-- computes settings for ER-55, Kelsh, B 8, or PG 2 plotters and for the PPO 8 orthophoto plotter using absolute orientation data from H-256 and relative orientation data from either H-252 (for analytical models) or hand written from A 7 or PG 2 settings (for stereoplotter models).

CLOSED-CIRCUIT TELEVISION SYSTEM FOR MAP MEASUREMENT

The Branch of Research and Design has developed a miniaturized closed-circuit television system for map mesurement. The TV system, which has been adapted to the Haag-Streit and Aristo coordinatographs (fig. 2), provides the operator with an efficient and accurate means of measuring control points and plotting positions of derived points. The system is expected to be an improvement over the current method of observing control points with a viewing microscope.

The system consists of a camera, a reticle and lens assembly, and a 12-inch monitor. The horizontal resolution at picture center is 600 lines measured on a standard RETNA resolution chart. A usable picture is obtained with 0.45 foot-candle scene illumination, and full video with 4.5 footcandles.

The reticle and lens system assembly consists of two RCA #16-1.8 f/1.8 lenses, focal length 16 mm, with iris. The front lens projects the map image onto the primary image plane of the TV camera, where the reticle is placed. The objective lens of the camera projects the combined reticle and map image to the vidicon pickup without parallax. The reticle is a 0.20-mm-lineweight cross on glass. The reticle and map imagery are focused in the same plane by adjusting the reticle and lens position in the barrel; critical focus is obtained by adjusting the vidicon tube position.

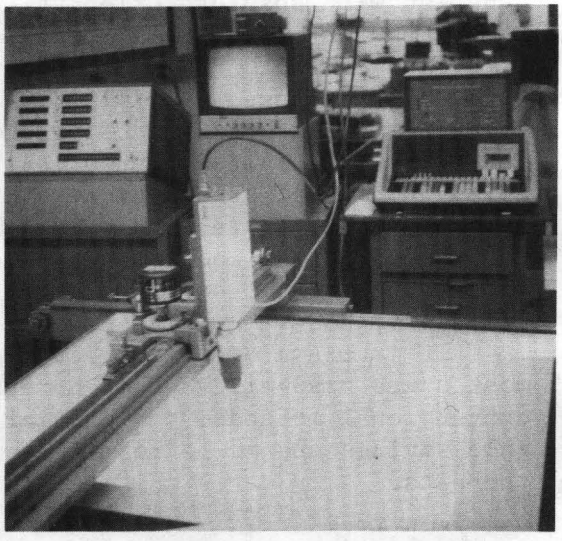

Figure 2.--Closed-circuit television system mounted on a coordinatograph.

The camera and lens assembly is mounted vertically on the plotting head of the coordinatograph and adjusted so that a 1.5-mm-square area of the map manuscript is imaged on the monitor. The nominal magnification of the system is 20X. The system clearly shows PUG points as small as 30 μm. Tests indicate repeatability of pointing within 13 μm, one count of the Aristo coordinatograph.

SWA VERTICAL BRIDGING BY FULLY ANALYTICAL AEROTRIANGULATION

Research Project MCMC-16 is to determine whether elevations established from SWA photographs by fully analytical aerotriangulation are sufficiently accurate and economical for vertical control extension for a 5-ft (2-m) contour interval. Varied control configurations and production procedures are being evaluated for adequacy, cost effectiveness, and potential for vertical control extension.

The Tama 15-min quadrangle of the Pella, Iowa, project was tested. Photographs were obtained at 2,670 m with a Zeiss RMK 8.5/23 camera calibrated in March 1975. The test area was completely controlled by fly levels for standard compilation, and many auxiliary elevations were obtained. The measurement data were reduced by the GIANT program.

Preliminary results show that vertical data established are inadequate for controlling maps with either 5-ft or 2-m contour intervals but adequate for compilation with a 10-ft interval, allowing flexiblility in selecting control elevations. The final report will include a recommendation for testing at lower flight heights.

RELATIVE ACCURACY TESTING

Many older topographic maps in the Eastern United States are being evaluated for horizontal accuracy by a photogrammetric method in which relative horizontal accuracy is checked by comparing stereomodel positions from high-altitude photographs with corresponding positions on the map base. If the accepted rejection criterion of either 8-ft (2.4-m) standard error for graticules or 35-ft (10.5-m) RMSE for planimetry is exceeded, the quadrangles are recommended for remapping rather than standard revision.

ORTHOPHOTOMAPPING

SCALING TO AVAILABLE BASES

MCMC experimentally scaled orthophotographs of the Cleburne-Van Buren, Ark., project to available bases. To confirm the feasibility of the method, eight quadrangles were tested for accuracy. In addition to the necessary field control, positions were obtained for additional points required for aerotriangulation if the scaling process failed.

EMC scanned the orthophotos on T-64 and T-61 Orthophotoscopes, and negatives were returned to MCMC to be scaled. Camera negatives at 1:24,000 scale are being prepared photographically. When they are complete, the maps will be tested to determine whether the orthophotographs meet National Map Accuracy Standards.

WILD PPO 8

A Wild PPO 8 orthophoto printer was installed at WMC in 1975. Through January 1977, 1,932 quadrangles (3,464 models) were scanned. These figures do not include rescans, which average one for every 30-40 quadrangles.

A two-man team helps to use the instrument more efficiently. While one scans a model, the other prepares the next one. Preparing models involves collecting diapositives and numerical orientation data and doing any auxiliary computing. When scanning is complete, the two operators exchange functions.

Scanning time varies with both the size of the exposure slot (selected according to the amount of relief) and the scanning speed, variable from 1 to 12 mm/s. Representative model (1:45,000-scale) scanning times:

Slot size (mm)	Average speed (mm/s)	Scanning time (min)
2	6	90
3	6	60
4	8	34
5	10	21
6	10	18
8	12	12

The setup time per model is 10-20 min and includes (1) centering diapositives, (2) orientation with precomputed settings determined from aerotriangulation data, (3) moving the drum to the starting point, and (4) preparing to scan. When operated three shifts per day the instrument can produce over 2,000 quadrangles per year.

QUAD-CENTERED PHOTOGRAPHS FOR VERTICAL CONTROL

WMC has developed production procedures and specifications to establish elevations from quad-centered 1:80,000-scale photographs for control of lower altitude photographs used for 20-ft contouring. Two blocks were used in the test, each with quad-centered photographs taken at 4,500 m and field control established for 10- or 20-ft contour intervals.

Stringent limits were imposed on a number of production variables. Of 158 test points, 13 failed to be within 5 ft (maximum, 8 ft) for no apparent cause other than random error. Thus 92 percent of the test points are within 0.25 times the contour interval of 5 ft. The RMSE of the test points is 3.9 ft, which satisfies National Map Accuracy Standards.

Recommendations to achieve such results on future production blocks are:

1. Position vertical field control near the center of each sidelap at intervals not to exceed one model at flight ends and two models in the interior. The end flight interval may be two models if the two end models are overedge.

2. Types of terrain that should be avoided for vertical field control or aerotriangulation pass points include areas on quad-centered photographs void of imagery within a 200-ft circle, sharp tops, and sidehills.

3. Paneling or very distinct natural panels are preferred to pinholed images; misidentification cannot be tolerated for this type of block.

4. An eight-fiducial camera should be used.

5. Aerotriangulation diapositives should be contact-printed on glass plates.

6. Aerotriangulation pass points should be located along neat model boundaries. Extra flight ties are recommended so that three points and a perspective center are common to adjacent models in the flight and three are common to adjacent models across flights.

7. Point coordinates should be read with a precision stereocomparator, such as the Zeiss PSK-2, with 3 to 5 readings per point.

8. A simultaneous block adjustment method should be used, with weighting of held control 1.5 to 2.5 times that of pass points. The program Simultaneous Block Adjustment of Models (SBAM) give results slightly superior to GIANT. Either program is acceptable, although cost and simplicity of SBAM seem to justify use of analytically formed models as adjustment units.

Success of this test should significantly reduce field elevation requirements by 25-35 percent in areas of 20-ft (5-m) contour intervals. The procedure is being used for the BLM mapping project in western Oregon. Although aerotriangulation procedures are more time-consuming, a considerable overall cost reduction is expected.

MAPPING FROM HIGH-RESOLUTION HIGH-ALTITUDE PHOTOGRAPHS

USGS is attempting to obtain high-altitude photographs (normally 12,000 m) of sufficient resolution for compilation of standard 7.5-min quadrangle maps with a 20-ft contour interval. Previous research indicates that quad-centered photos can be used if resolution is improved.

Photos for the test were taken in September 1976 with two Zeiss RMK A 15/23 cameras. Bar targets were placed on the Poncha Springs, Colo., quadrangle, which contains a variety of topographic features. One camera contained Kodak 2402 film; the other contained SO-022. The trial stereocompilations are being compared with standard compilation.

IMAGE BASE MAPPING

Expanded use is being made of orthophotoimage bases for compiling standard topographic maps. The procedure combines all planimetric compilation and color-separation phases into one operation so that map content is scribed only once. All map features except contours are final-scribed directly on color-separation guides containing the orthophotoimage. Field-annotated photographs greatly assist interpretation. Contours and any planimetric detail not discernible on the image guides are stereocompiled. The contours are final-scribed, and the added planimetric features are transferred to the proper culture guides for final scribing. More than 3,400 km^2 of 7.5-min quadrangle mapping has been completed thus far by this procedure, which saved about 10 percent of the cost of earlier procedures.

ATLANTA AREA ORTHOPHOTOMOSAIC

The Atlanta area orthophotomosaic, a companion product to the completed regional line map, is in final mosaicking for lithographic printing. The 1:100,000-scale orthophotomosaic covers an area of 1.5° long by 1° lat. Orthophotoquads at 1:24,000 scale were reduced in three steps by processes aimed at eliminating sunspots, flares, haze, and image-tone mismatches due to photography at different times. Initial mosaics were made in blocks by the photomontage method of alternate masking and exposure. The Atlanta area will eventually be covered by topographic maps, orthophotoquads, and land use maps at 1:24,000 scale and a topographic map, an orthophotomosaic, a slope map, and a land use map at 1:100,000 scale.

IDAHO STATE MAP REVISION

The 1:500,000-scale Idaho State map is being revised. Landsat paper prints covering the State and quad-centered photographs were obtained for transfer of detail to the map. In the areas with sufficient planimetry, transfer was made directly with a Bausch & Lomb Zoom Transfer Scope. In areas of light planimetry, the transfer was made to the Landsat imagery. The Landsat imagery was then scaled to the State map, and the linework was transferred to the imagery.

ALASKA LANDSAT MOSAIC

WMC helped with aerotriangulation of a Cibachrome color 1:1,000,000-scale Landsat mosaic of Alaska, produced under the Regional Alaskan Mineral Assessment Program. That far north excessive distortion in the Lambert conformal projection (standard parallels 55° and 65°) requires scene rectification (assuming that projection distortion is partially compensated by tilt deformation). The GIANT program was used to determine the fictitious tilt and to aerotriangulate corner cross positions for mosaic control. Image coordinates from 1:250,000-scale maps were held as control points.

Because of insufficient overlap for conventional adjustment, all elevations were constrained to sea level--a unique application of analytical adjustment programs. A simultaneous horizontal linear adjustment was used for the remainder of the State, with procedures similar to those for previous Landsat mosaic projects. In both cases, the adjustment RMSE was about 400 m on control and 250 m on tie points, which indicates significant affine systematic distortions in scenes from northern latitudes.

Scenes of bands 4, 5, and 7 on 70-mm film are being rectified to 1:1,000,000 scale. A private photolab will contact print the rectified scenes of the northern area and enlarge the 70-mm scenes elsewhere. Geologic Division will prepare mosaics with templets showing positions of the corner crosses of each scene.

FLORIDA IMAGE FORMAT MAPS

Image format maps were prepared as byproducts of the 1:500,000-scale satellite image mosaic of Florida. Of the 16 nominal scenes, 11 were printed at 1:500,000 scale as individual maps, each with a UTM grid (except the Florida Keys scene), marginal text, a National Atlas insert, and reference coordinates of the graticule. Ten of the image maps were made from copies of bands 5 and 7 of the original images enlarged for the Florida mosaic. The image for the Florida Keys map was digitally enhanced in bands 4, 5, and 7 to accentuate underwater detail.

A grid-fitting technique was used wherein a UTM grid was computed and plotted to the imagery of each map in a curved configuration to minimize ground-coordinate errors for points measured from the grid. The Florida Keys grid fit was somewhat more complicated so that an undistorted UTM grid was used although the resulting RMSE of positions measured from the grid exceeds 200 m.

MAPPING FOR ENVIRONMENTAL ASSESSMENT OF INLAND WETLANDS

Research Project MCMC-17 is underway with the following objectives:

1. To obtain definitions of wetlands from map users who believe present wetland map features are insufficient for their needs.

2. To develop techniques and evaluate the suitability and efficiency of using remote sensors to extract data for mapping wetland features.

3. To determine the most acceptable scale and format for showing wetland features.

4. To contribute to the development of a standard wetland classification system.

Two widely separated areas with differing vegetation were selected for investigation--the SE/4 of the Vancleave, Miss., 15-min quadrangle (a flood plain with wetland vegetation) and the Goldwin, N. Dak., 7.5-min quadrangle (a prairie pothole area). All photographs covering the areas have been obtained including 3,700-m CIR photographs of the Goldwin area taken on April 21 and July 21, 1976. The April photographs were valuable in mapping high-water lines; and the July photographs, taken at or near the peak of the growing season, facilitated mapping of critical vegetation.

Compilation of the Goldwin area was completed with a PG 2 plotter. It appears that 1:12,000 is the smallest scale practical for mapping the rather narrow circular bands of wetland features associated with prairie potholes. The most effective film for wetland mapping is CIR. As expected, the 3,700-m photographs provided more clearly defined wetland data than higher altitude photographs.

To determine whether there are significant differences in the ability of operators to define and compile certain wetland features, a different operator has recompiled high-water lines, normal water lines (assuming water levels were normal on the July photographs), and wetland perimeters within an area equal to half a test model. Also, the July photographs were used to recompile the April wetland perimeters to determine if the season is a significant factor in mapping wetlands from CIR photographs. Comparison of the compilations is in progress.

INLAND (NONTIDAL) WETLAND MAPPING

Three versions of an image wetland map of the Auburndale 7.5-min quadrangle in Lakeland County, Fla., were prepared as part of a research project on inland (nontidal) wetland mapping. The objectives of the project were (1) to test the feasibility of mapping and classifying inland wetlands in more detail than is now shown on 7.5-min quadrangles, (2) to develop or identify a standard definition and classification system for USGS, and (3) to prepare sample products for user evaluation. Each version represents a

different wetland classification system (Martin and others, 1953; Anderson and others, 1975; L. M. Cowardin and V. Carter, written commun., 1975).

Available 1:20,000-scale SWA B&W photographs and quad-centered 1:76,000-scale CIR photographs were used to interpret and delineate the wetland boundaries and classes. The 1:24,000-scale photoimage bases were made from the CIR photographs by printing a rectified B&W transparency on yellow scribecoat. The three wetland classifications were then compiled from the aerial photographs on the photoimage bases. Ozalid copies of the three image wetland maps were prepared for distribution to selected users.

ENVIRONMENTAL AIR CONTROL

Clean-room technology is being applied to photogrammetric and photographic processes to eliminate product blemishes caused by airborne particulate and other contaminants. The use of clean rooms and clean work stations helps minimize contamination.

Laminar-flow air modules (fig. 3) are being adapted to instruments and equipment to provide class-100 air in critical areas. Class-100 air limits the number of particles 0.5 μm or larger to $100/ft^3$ and particles 5.0 μm or larger to $10/ft^3$. The mechanical filters used in the laminar-flow modules are high-efficiency particulate air (HEPA) type, 99.97 percent effective in removing particules as small as 0.3 μm.

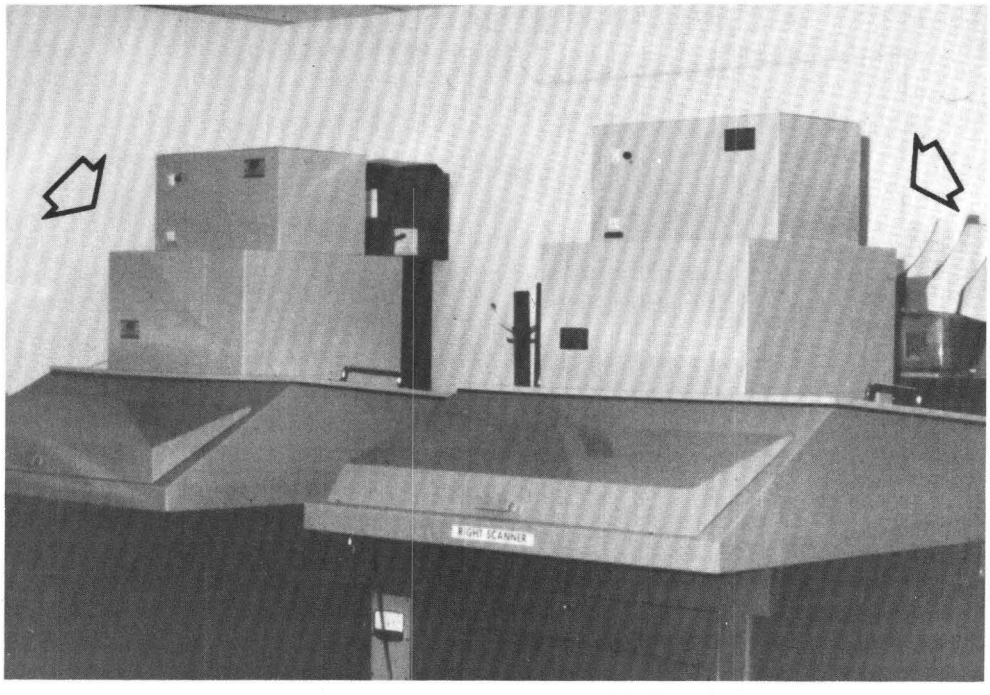

Figure 3.--Laminar-flow air modules mounted above the scanners of a Gestalt Photo Mapper II.

Use of modules is unique for the varied applications. System flexibility permits selective distribution of clean air through laminar flow, nonlaminar flow, and general room purging, and results in a clean environment at minimum cost.

EFFECTS OF IMAGE MOTION COMPENSATION OF FILM IMAGES

A Fairchild KC-6A and a Wild RC 10 camera were used at 3,600-m flight height to photograph a three-bar resolution target array on the roof of the National Center in Reston, Va. Several different films were used, and photographs were taken with and without the image-motion compensation available in the KC-6A. In addition to the resolution targets, many horizontal and vertical control marks in the area were paneled to evaluate the geometric accuracy of the KC-6A. Simultaneous photographs were taken on Kodak 2402 film with the two cameras. Kodak 3414, a very slow film with high definition, was also exposed in the KC-6A camera using image motion compensation. An AWAR of 29 1/mm was determined for the 3414 film; the RC 10 with 2402 film has an AWAR of 38 1/mm. This project also indicated that at 3,600 m the RC 10 provided slightly better resolution at f/8 than at f/4.

QUALITY CONTROL

We are continuing a calibration program to standardize all densitometers used by USGS and participating contractors through the use of a master stepwedge to test and identify each densitometer's characteristics. Instruments in which readings vary from the master more than 0.02 density unit are earmarked for recalibration. Interim tables with weighted values will be used to adjust a densitometer's readings to the master scale until it is recalibrated.

IMAGE QUALITY RESEARCH

Various negatives scanned with the Optronics rotating drum density reader were analyzed. Dodged and undodged and IR and panchromatic aerial negatives were scanned for comparison. Scanning breaks the contrast range of the gray scale into proportional steps for quantitative analysis. For each scanned negative an impression curve is drawn with the visual uncertainties in tones plotted against tones as represented in successive ratios of white to black.

The area under the curve is taken to represent the logical decision required to visually assess the tones for contrast and thus needed to extract information from the photograph. The aim of the research is to develop an objective means of assessing information content of photoimages used in orthophotoquad production.

PHOTOGRAPHY EVALUATION

The Itek VEMC was tested to determine its usefulness for evaluating mapping photographs. Matrixes for Kodak 2402 and 2405 film were acquired for use with the VEMC in measuring resolution. However, specific density and contrast data for the two matrixes were not provided and could not be obtained from the manufacturer. Therefore, a related study was needed to determine the density and the contrast value of each matrix element. Measurements established that the contrast ranges from 1.3:1 in row 1 to 7:1 in row 8 and that the contrast change between rows is not constant, as might be expected. The contrast difference between rows varies from 0.03 to 0.17, and the variations are similar for both matrixes.

Several image edges on nine photographs of the Ft. Huachuca, Ariz., test area were then measured with the VEMC to determine the effects of magnifications of 25X, 40X, and 100X. Results indicate that (1) consistent and relatively accurate contrast measurements can be made with any of the three magnifications, (2) different magnifications have little effect on measurement accuracy, and (3) 40X was the easiest for VEMC measurements on the project photos.

FILM MOSAICKING

The negative mosaicking technique is being used in the orthophotomapping process with good results. As in the paper-print method of mosaicking, images are scaled to control, adjacent imagery densities are matched, and imagery detail is registered. Trap windows are made for each image, and each window and its image are composited photographically. Density in the overlap areas of the images is matched by varying exposure and process timing; however, the key to successful film mosaicking is in constructing the masks with a gap between joining images. The width of the gap is empirically determined and depends on the type of diffusion sheet used to allow the exposing light to bleed the joints of the images and eliminate black or white lines.

Negative mosaicking has been successful in preparing film images for color-image printing from Landsat, Skylab, and aerial photographs. In orthophotoquad processing it eliminates one step and preserves resolution while maintaining accuracy.

Research is continuing in the use of a dodging printer for the film-mosaicking technique. A prototype 196-light bank was built with three-way switches on each light and overall voltage control. The exposure variation of the printer appears adequate to product a uniform tonal match across the join line of two orthophoto positives and to correct tonal imbalances throughout the image area. Several single-join mosaics were produced with excellent results.

CONTRAST AND RESOLUTION

A study of the influence of ground reflectance on film density and resolution for Kodak 2402 and 2405 film was completed. Results indicate that contrast of photoimages of various objects is normally less than the actual ground contrast of the objects and that the amount of contrast change from ground targets to film images can vary considerably. Resolution for different photographs of the same scene also vary considerably from photo to photo, although the measurements were made on identical ground targets with the same contrast. The table following shows the ranges of image contrast and resolution obtained for several photographs of the same scene.

Film type	Ground contrast at target	Photoimage contrast at target	Resolution (1/mm)
2402	6:1	2.5:1 to 6.3:1	32 to 41
2402	16:1	5.1:1 to 7.2:1	26 to 33
2405	16:1	8.2:1 to 10:1	38 to 33

SCENE REFLECTANCE

One cause for rejection of aerial photographs has been the failure to expose correctly in areas where scene reflectance varied greatly. In the future, such areas will be identified beforehand, and some flight lines will be broken so that exposures can be adjusted. Different film may be needed on different flight lines to accommodate extreme contrast variation.

TWIN-PORT HIGH-ALTITUDE AIRCRAFT PHOTOGRAPHY

One result of the twin-camera projects (see next item) has been to alert contractors to the potential of this method. The images made from B&W film and filter combinations can be used to produce a color image map suitable for land use and environmental control studies. The films can also be used for conventional mapping.

COLOR IMAGE MAPS FROM BLACK-AND-WHITE AERIAL FILM

Lithographed 1:24,000-scale color image maps have been prepared by assigning colors to two bands of B&W aerial film. The technique was used previously to produce 1:500,000-scale satellite image maps (such as the Florida mosaic) from two or more bands of imagery recorded by the Landsat MSS.

Two high-altitude photographs are simultaneously exposed in synchronized cameras--one containing B&W panchromatic film filtered to record the visible spectrum and the other containing B&W IR film filtered to record the near-IR spectrum. Negatives of the two images are rectified, scaled to 1:24,000, and processed for the optimum density range of 0.4-1.4. Halftone positives are made by screening the negatives for various combinations of yellow, magenta, cyan, and black, depending on the colors desired. Negatives made from the halftone positives are used to generate the printing plates. An additional negative is prepared for marginal information and the UTM grid. The final product is a 1:24,000-scale color image map that exhibits sharper tonal contrast and better resolution than an equivalent map produced from conventional color or CIR film.

Simple rectification

Two-camera imagery of Livingston, Tex., was used to produce the first experimental simulated CIR composite. NASA took the photographs at 12,000 m in a WB-57 fitted with two Zeiss RMK A 15/23 cameras. One camera contained B&W panchromatic film with a Wratten 25 filter for recording the red spectral band from 0.6 to 0.7 μm; the other camera contained B&W IR film with a Wratten 89B filter for recording the IR band from 0.7 to 0.9 μm. The photographs were rectified and scaled to 1:24,000 on a Wild E 4 rectifier. The panchromatic negative was screened for yellow and magenta, the IR negative was screened for cyan, and a simulated CIR Cromalin proof was prepared. The proof exhibited good register, good resolution, and a pleasing color balance.

Differential rectification

The same photographs of Livingston, Tex., were also differentially rectified on the GPM-2, which produced four single-model orthonegatives (two panchromatic and two IR) at model scale, necessitating mosaicking and enlargement to 1:24,000 scale before Cromalin proofs could be made. Experiments in mosaicking the orthonegatives both before and after enlargement were evaluated to determine if either would lead to improvement in image register in the final composite. Regardless of the mosaicking method, the mismatch between orthonegatives was slightly greater than that between negatives rectified on the E 4. Further experiments are underway to determine whether precise register is possible between panchromatic and IR images scanned on the GPM-2. There may be inevitable slight variations in machine ability to recover elevations from different types of film with different density structures.

Canada-United States color image maps

The first 1:24,000-scale color composite to be gridded, provided with a map collar, and lithographically printed is the Highgate Springs Port of Entry, Vt.-Que., color image map. Highgate Springs is one in a series of border maps being prepared for the U.S. Customs Service along a 322-km strip of the international border from St. Regis, N.Y., to the Maine-New Hampshire line. The photographs were taken by the Canada Centre for Remote Sensing at 10,500 m in a Falcon jet equipped with two synchronized Wild RC 10 cameras with 15-cm lenses; one contained B&W panchromatic film with a Wild 525-nm (minus-blue) filter, and the other contained B&W IR film with a Wild 705-nm filter.

Highgate Springs was experimentally printed in four versions for user evaluation: B&W (panchromatic image only); simulated CIR; simulated natural color involving masking techniques; and an alternative simulated natural color version prepared from panchromatic and IR images that were differentially rectified on a GZ-1 Orthoprojector. The final series of about 30 Canada-United States border color image maps will be printed at 1:25,000 scale in simulated natural color. All images requiring differential rectification will be scanned on the DPROS system, which is more practical than the GPM-2 for producing orthonegatives for color composites because (1) only the panchromatic models need to be scanned to obtain the digital profile data, (2) orthonegatives are printed at the desired scale without mosaicking, and (3) better register can be obtained because both orthonegatives are produced from the same digital profiles.

Doboy Sound, Georgia

An experiment is underway to produce a 1:24,000-scale color orthophotoquad of Doboy Sound, Ga.

The two-camera, two-band technique should be ideal for depicting low-relief coastal wetland areas in color composite form, because no differential rectification or mosaicking would be required. In addition, simulated CIR orthophotoquads of wetland areas could be used in conjunction with low-altitude CIR photographs for photointerpretation, and could also serve as excellent base maps for delineating various wetland classifications.

Photographs of Doboy Sound at 19,600 m were obtained in a U-2 equipped with two Wild RC 10 cameras with 30-cm lenses; one contained B&W panchromatic film with a Wild 500-nm (minus-blue) filter for recording the visible spectrum from 0.5 to 0.7 μm, and the other contained B&W IR film with a Wild 700-nm filter for recording the near-IR band from 0.7 to 0.9 μm. A new set of negatives is being processed to extend the insufficient density range (0.39) of the original negatives. If this can be done, the two images will be rectified to 1:24,000 scale, gridded, provided with a map collar, and lithographically printed as an experimental product.

Color image maps or color orthophotoquads are excellent complements to line maps of the same area. If two-camera imagery could be incorporated into orthophotomap production, three new image maps could be available to the user in addition to the standard B&W orthophotoquad prepared from the panchromatic image: (1) a B&W orthophotoquad prepared from the IR image, (2) a simulated natural color rendition of the combined panchromatic and IR images, and (3) a simulated CIR rendition of the combined images.

At present, the major drawback for two-camera photography is the limited number of commercially available high-altitude aircraft equipped with two mapping cameras. Until they become more readily available, production of color image maps or color orthophotoquads will likely remain experimental.

CARTOGRAPHY AND DESIGN

LARGE-SCALE URBAN MAPPING

The pilot program on large-scale urban mapping was virtually completed, including user evaluations of individual projects covering San Francisco, Chicago, Fort Wayne, Charleston, and Frederick, Md. A draft of the Large-Scale Mapping Handbook was distributed to about 100 communities throughout the country and a number of Federal and State agencies for comments. The comments and suggestions have been evaluated and are being incorporated into the final version of the book.

INTERMEDIATE-SCALE MAPPING

Under the new National Mapping Program, intermediate-scale mapping has been expanded. Maps in the 1:100,000-scale series are derived from published topographic maps and, as required, are updated (without field checking) from new aerial photographs and other sources. The new information is extracted either monoscopically or stereoscopically, depending on the amount of relief.

The 1:100,000-scale content is compiled on feature separates to provide a wide range of products to map users. Map features are delineated by single-line symbolization to facilitate future digitization. Present plans provide for planimetric and topographic editions.

To satisfy the immediate needs of various users, maps are compiled both in quadrangle and county format. Since the established series is in quadrangle format, all compilation for county format is extracted and used for producing the standard quadrangle, eliminating dual compilation.

A study is in progress to determine the feasibility of compiling all intermediate-scale map data at 1:75,000-scale anticipating that this base could then be converted to either 1:50,000 or 1:100,000 with minimum effort. Content is being feature separated to conform to any derived scale within these limits. The study includes determining the proper line weight, type size, collar information, content, and accuracy--the desirability of showing some features only at certain scales is also being studied.

COASTAL MAPPING

Experimental coastal maps of Beaufort, N.C., and Fort Pierce, Fla., have led the way for a series of coastal zone maps incorporating data shown on USGS topographic maps, NOS bathymetric maps, and BLM OCS resource management maps.

The maps are designed to give users a complete picture of the physical environment in a given area. With this type of map, coastal managers should be able to forecast the effects that offshore activities may have on the coastlines and to plan accordingly.

Topographic/bathymetric editions of the Los Angeles and Wilmington 1:250,000-scale quadrangles were published, and 250 other maps are in progress. In selected areas topographic/bathymetric maps are being prepared at 1:24,000 and 1:100,000 scale. The entire Georgia coast is being mapped at 1:100,000 scale--the five quadrangles will have a land contour interval of 2 m; bathymetric data will be depicted by 2-m contours with 1-m supplemental contours where necessary. In addition, 29 topographic/bathymetric orthophotomaps of a portion of the Georgia coastline are being completed at the scale of 1:24,000. Other projects are underway in Texas and California.

On topographic/bathymetric maps the bathymetric data and shoreline (MHW line) compiled by NOS are combined with USGS topographic map plates. Also combined with the topographic plates are data from BLM's official OCS protraction diagrams.

Comments from State and Federal agencies about the Coastal Zone Mapping Handbook were evaluated and incorporated in the final copy for printing in 1978. Information in the handbook is designed to assist State and local coastal planners in developing mapping programs to support their projects.

SPECIAL MAPPING PROJECTS

National energy transporation system

Nineteen maps at 1:7,500,000 scale were produced and published for the Committee on Commerce and the Interior and Insular Affairs Committee of the U.S. Senate. The maps are incorporated in a report on energy transportation systems compiled by the Congressional Research Service, Library of Congress. The maps portray the magnitude and direction of energy movement through the various transporation systems. Where appropriate, energy deposits, mining, processing, and production facilities and consumption data were also added to the maps. Companion color overlays were prepared for Senate committee hearings.

Pictured Rocks National Lakeshore

A special 67.5x105-cm map of Pictured Rocks National Lakeshore, Mich., was published for NPS at 1:62,500 scale with a contour interval of 20 ft. It is a derivative of four 15-min and six 7.5-min quadrangle maps.

Paneling and scribing were at publication scale. To save scribing time, complete topographic information is shown only within the park limits. Outside the proclamation boundary only a skeletal network of roads is shown. This outer area is covered with a screened brown tint.

NPS requested that the actual ownership boundary be shown in addition to the proclamation limits; to emphasize that boundary, the 95 percent woodland green tint is shown only within it. Standard recreational symbols were added as requested by NPS. Because of the importance of the few improved roads within the park, county road shields were added where appropriate.

Pueblo land use project

Work is in progress on a set of 1:50,000 scale maps for Pueblo County, Colo., including a line map, a land use map based on the USGS classification system, a land use map based on the Colorado system, and an orthophotomosaic of the county. The line map is in the USGS-Colorado cooperative county mapping program. The orthophotomosaic was assembled from 1:24,000-scale orthophotos prepared as part of a cooperative project with SCS. The land use overlay for the Colorado system of classification was provided by the State.

Federal lands subject to mineral restrictions

A preliminary edition of the map Federal Lands Subject to Mineral Restrictions was published at 1:7,500,000 scale. Prepared in the National Atlas format, the map is printed in two sheets--Alaska is separate. The map provides an overview of Federal lands affected by current regulations, emphasizing restrictions against mineral development. While no statement is made to identify the type of restriction, the color sequence and legend order present an implied order of decreasing criticality based on current USGS mineral policy. The Federal lands depicted fall into three general categories, (1) those to be preserved in their natural state, (2) those specifically excluded from the provisions of the Mining Law of 1872, the Mineral Leasing Act of 1920, the Acquired Lands Act of 1947, the Geothermal Steam Act of 1970, and the Materials Sales Act of 1947 as amended, and (3) others principally under the administration of BLM or USFS. Delineation of the lands shown is limited by map scale. All Federal lands to be preserved in their natural state are shown, symbolized where necessary. Generally other areas less than 22,500 acres are not shown.

Crater Lake orthophotoquad

Crater Lake was included in the 11,700-m quad-centered aerial photographs for the Klamath Falls OQ project. The lake is almost centered on the line between two 7.5-min quadrangles (Prospect 1 NE and NW). One 7.5x15-min quadrangle was made to include the entire lake.

The coverage for the two 7.5-min quadrangles was scanned on the Wild PPO 8 at the scale of 1:45,000. The four scans were enlarged to 1:24,000 scale and mosaicked by the film montage method. The mosaic was retouched so that the four join lines that intersect in the middle of the lake cannot be seen (fig. 4). The negative was combined with a base containing grid lines and a title block.

Dry Valley, Antarctica

The Dry Valley, Antarctica, project has been compiled and edited, and the maps are being prepared for printing. The project consists of eight quadrangles, each covering 1° long and 15° lat, an area of 5,418 km^2. The contours were stereocompiled on a Kelsh plotter and final scribed at

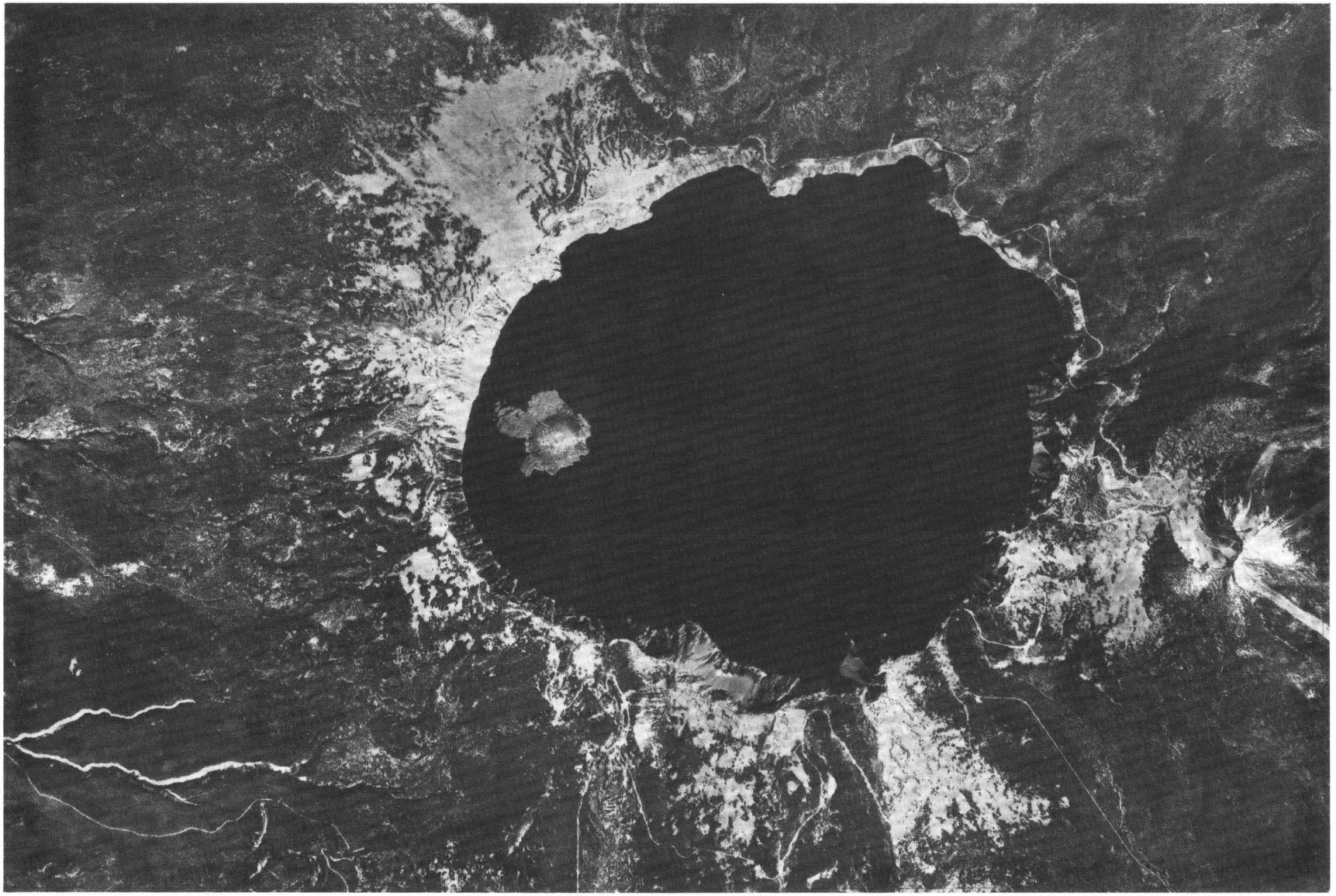

Figure 4.--Mosaic used for 1:24,000-scale 7.5x15-min Crater Lake orthophotoquad.

1:50,000 scale, with a basic contour interval of 50 m and a supplemental interval of 25 m. The planimetric features were compiled by a combination of stereoscopic and monoscopic procedures from an orthophotoimage base. Delineation of the snow, glaciers, exposed areas, and other features peculiar to this terrain and climate required special considerations and treatment.

Orthophotomaps of Cape Canaveral

USGS displayed new orthophotomaps of the Cape Canaveral area for the Bicentennial exhibit at the John F. Kennedy Space Center. Three quadrangles were Cape Canaveral, False Cape, and Orsino. The old maps of the area, interim revised once, needed extensive planimetric updating, although contours not disturbed by new construction were accurate. Contouring of changed features, planimetric additions, and classification annotations were recorded on field boards bearing orthophotoimages. Final color-separation drawings of the planimetric detail and land classification were scribed on transparent scribecoat by following the image detail on orthophoto film positives laid beneath the scribecoat. The maps were prepared for printing without stereocompilation or preparation of any manuscripts. Editing was done in conjunction with color separation.

To provide an outside display, the six quadrangles were mosaicked as orthophotoquads at 1:24,000 scale and encased in plastic. The 112x188-cm orthophotomosaic was provided as a Cromalin proof with collar and interior landmark names. Overedge imagery was retained along the north edge to include a historical launch pad and the entire length of an aircraft runway.

MAP INDEXES

A new design is being used to produce State map indexes for Pennsylvania and Ohio. To improve readability and economy of maintenance, the design features a new four-color scheme, bolder titling type, reduced base detail, large-scale quadrangle names oriented to town symbols, and insets explaining small-scale and special map coverage.

POCKET MAPS

Two experimental projects were completed to evaluate the utility of folded topographic maps for outdoor recreationists, naturalists, and tourists. Yosemite Valley (in Yosemite National Park, Calif.) is a 1:24,000-scale standard topographic map folded with a special glued-on cover printed in colors, featuring a photograph of Yosemite Valley Falls.

Twenty-two 7.5-min, 15-min, and Alaska quadrangles were folded and packaged in waterproof, dustproof reusable plastic pouches. A feature of using pouches is that standard folding, packaging, and titling do not require customizing each map. A marketing aid was prepared for dealers of topographic maps. A 28x36-cm counter display card is fitted with a transparent pocket to hold a sample pocket map.

DRAFTING MEDIA

Two new pieces of equipment purchased in 1976 complete in-house facilities for testing bid samples of scribecoat and peelcoat material used in mapmaking. A Dillon model ML universal tester measures tensile strength of the polyester base material. A TenneyTen model TTRS temperature-humidity test chamber is used to determine changes in bid samples. These tests were formerly made by DMATC or NBS. About 20 tests are performed on the bid samples, covering physical characteristics of the base material and the engraving layer and scribing and photographic qualities.

SATELLITE TECHNOLOGY

In FY 1977, NASA, the EROS program of the Department of the Interior, and USGS continued research in the cartographic applications of space imagery and high-altitude photographs. As Landsat-2 continued its third year of operation and Landsat-1 ended its fifth, the demonstrated possibilities of operational applications became increasingly significant, particularly for areas not yet adequately mapped even at the small scales of 1:500,000 or 1:1,000,000. The shallow seas, for example, have been charted fairly well for navigation, but not adequately for the resource exploration and development underway worldwide.

HARTFORD 1:250,000-SCALE IMAGE MAP

A gridded 1:250,000-scale image map of the Hartford, Conn., area was printed from a mosaic prepared from enlarged photographs taken by the S-190A multispectral camera on Skylab Mission 3. In processing this image map, which covers the 1°x2° format of the Hartford quadrangle, two sets of four photographs were used. One set was exposed with red-sensitive film and the other set with infrared-sensitive film. Yellow and magenta plates printed the red image, and a cyan plate printed the infrared image.

PARAMETERS FOR AN OPERATIONAL LANDSAT

Based on the results of investigations and experiments with satellite and high-altitude aircraft images an operational Landsat that retains the basic parameters of Landsat-1 and -2 has been defined to assure the continuity of data flow from the Landsat missions.

Following are the recommended parameters:

Sensor type	Multispectral linear arrays (MLA)	
Wavebands		
Blue-green (water penetration) . .	0.47-0.57* µm	
Green-red (boundary delineation) .	0.57-0.70* µm	
Near infrared (water, vegetation, and cultural delineation). . . .	0.76-1.05* µm	
Spatial frequency (resolution) or picture element (pixel) in terms of ground coverage.		
Band 1 (blue-green).	60-90* µm	(similar to Landsat-1, -2, and -C)
Band 2 (green red)	30-40* µm	
Band 3 (near infrared)	60-90* µm	(similar to Landsat-1, -2, and -C)

Quantizing level (radiometric sensitivity)	64-256 levels (6-8 bits)
Sampling frequency	1-4 times per pixel (same as Landsat-1, -2, and -C)
Data rate	Approximately 15 megabits per second (Mb/s; capability of Landsat reception stations)
Sensor weight (est.)	40 kg
Sensor power requirement (est.)	40 W
Expected sensor life	6-10 years
Satellite orbit	Circular Sun-synchronous at 919 km (same as Landsat-1, -2, and -C)
Ground coverage	185 km swath (same as Landsat-1, -2, and -C)
Orbital position and attitude stability and determination	Improved over Landsat-1, -2, and -C--perhaps by a magnitude
Data storage capability	Equal to or better than Landsat-1, -2, and -C

LANDSAT MAPPING AND CHARTING OF THE SHALLOW SEAS

Although USGS is not actively engaged in either hydrographic surveys or nautical charting, other bureaus of the Department of the Interior and such industries as oil, mining, utilities, and fisheries are concerned with offshore mapping. Consequently, the EROS program has sponsored studies of water penetration and arranged for objective tests and exhibits of high-gain enhanced Landsat images of areas in the Caribbean Sea and Indian Ocean.

In the Caribbean, investigations showed that with suitably clear water and bottom conditions and with appropriate calibration data, water depths to 22 m could be determined radiometrically with RMSE of only 10 percent. In the Chagos Archipelago area, images (fig. 5) indicated dramatic changes in position and shape of reefs as depicted on current nautical charts as well as the existence of a previously uncharted reef.

*Subject to adjustment based on engineering tests.

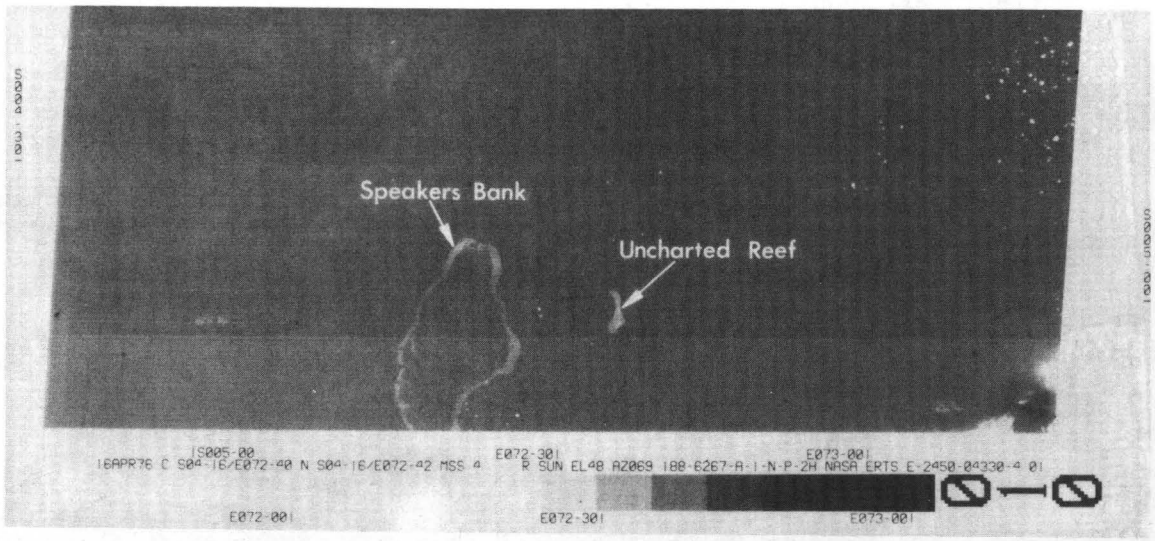

Figure 5.--Portion of Landsat-2 image of Chagos Archipelago area, received April 16, 1976, clearly showing an uncharted reef.

LANDSAT INVESTIGATIONS

Two subjects of interest in Landsat activities were pursued in cooperation with NASA:

- Overall evaluation of Landsat (ERTS) imagery for cartographic applications. This is a study of the activities of all cartographers trying to apply Landsat data and report significant problems and results to NASA. For the past year, the following results are reported:

  (1) Landsat can improve nautical charting while reducing costs. This includes effective mapping of the shallow seas for purposes other than navigation.

  (2) Landsat data can assist both aeronautical charting and small-scale map preparation.

  (3) Landsat enhanced-image maps have been prepared, and improvements in displaying the cartographic potential of Landsat images have been developed.

  (4) Detailed geometric analysis of Landsat images indicates systematic anomalies that can largely be corrected before printing.

- Processing of Landsat imagery for distribution--This investigation concerns two fundamental problems in processing Landsat imagery for publication.

  (1) Determination of when and how to convert from digital to analog form.

  (2) Determination of specific enhancement procedures to make Landsat imagery optimal for general distribution.

Experiments with various band treatments and enhancements, both digital and analog determined that:

- By enhancing band 4, both growing and dormant vegetation can be shown.

- Edge-enhancement and other techniques demonstrated by IBM, JPL, EDC, and others increase feature contrast and therefore information content.

Combination of Landsat imagery with higher resolution radar imagery produces a composite that displays information not readily discerned in either of the original images. This significant result questions whether multispectral systems need to gather records of equal resolution. Tests and theory indicate that one properly selected high-resolution band can effectively increase the resolution of Landsat imagery without the quantum increase in data that results from increasing the resolution of all bands.

NIGHTTIME IMAGES

Under contract with Stanford Research Institute, nighttime satellite images were analyzed to assess such phenomena as gas flaring at producing facilities (fig. 6). The initial study was limited to assessing nighttime images obtained by the Defense Meteorological Satellite Program (DMSP) and will produce an atlas of the nighttime Earth as depicted by DMSP images, valuable to many investigators. The report also indicates the complementary role that Landsat can play in nighttime imaging of the Earth.

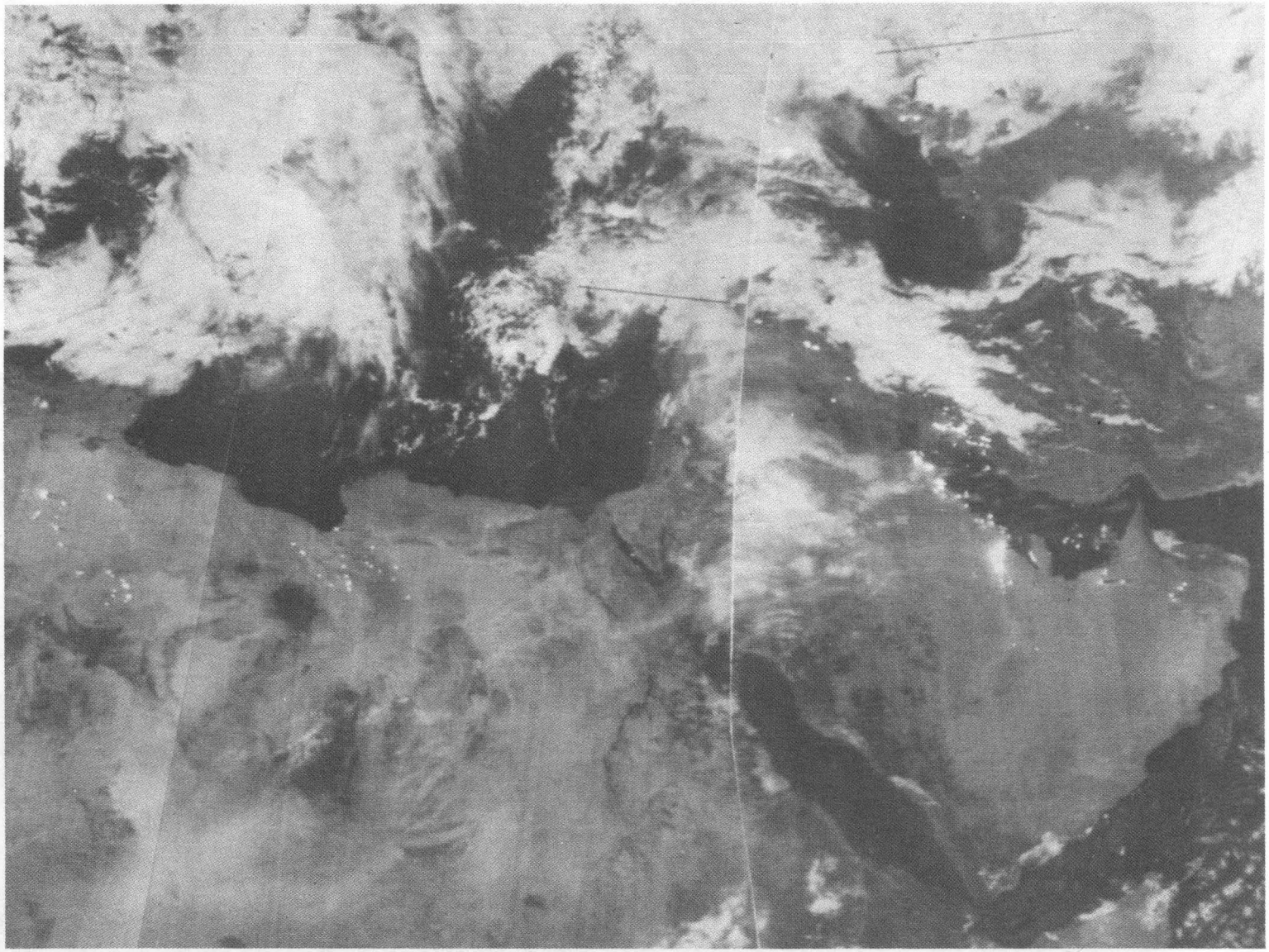

Figure 6.--Mosaic of imagery received from DMSP. Although illumination is only by moonlight, the Mediterranean and Red Seas and Persian Gulf are easily identified, as are gas flares from oil production areas.

HOTINE OBLIQUE MERCATOR PROJECTION APPLIED TO LANDSAT MAPPING

A feasibility study has shown that the Hotine oblique Mercator projection can be used for mapping Landsat images satisfactorily provided that new latitude zones and new projection constants are selected at intervals. Five zones are required for the descending half of the orbit. The same zones can be applied to the ascending orbit with projection constants reversed. A Fortran program of the projection, written by USGS, has been modified to fit the ground track of Landsat orbits.

Test computations using the NASA Landsat nominal positions of scene centers have established the following:

1. The transformation equations, as programed, operate forward and inverse in all quadrants with an accuracy in the centimeter range.

2. The along-track scale factor is stable within 3 parts in 100,000 between lat 23° N. and 23° S.

3. Normal to the projection axis, in the scan direction, the scale factor follows the standard Mercator pattern, increasing approximately as the square of the distance from the axis.

4. The curvature of the ground track in the projection plane limits the length of useful projection.

5. By dividing the orbit into five latitude zones and making the axis parallel to the ground track at the center point, the maximum distance of a scene center from the axis is:

Zone	Latitude range	Maximum distance (km)
1	48°-81° N.	27
2	23°-48° N.	7
3	23° N.-23° S.	6
4	23°-48° S.	7
5	48°-81° S.	27

LANDSAT IMAGERY FOR 1:250,000-SCALE MAPPING

USGS is experimenting with Landsat imagery (1) to investigate the feasibility of equidensity contouring, or density slicing, for theme extraction of open water, vegetation, and natural shaded-relief information, (2) to use available 1:100,000-scale material and theme extractions to prepare a 1:250,000-scale experimental map for evaluating economic, factual, and visual effectiveness of the application, and (3) to assess the effectiveness of reducing 1:100,000-scale material to make the 1:250,000-scale base.

The area selected for the experiment is covered by the published 1:250,000-scale Wenatchee, Wash., quadrangle. Research is divided into separate preparation of linework and imagery. A new 1:250,000-scale base of drainage and roads was prepared from reductions of the 1:100,000-scale linework. Images of open water, vegetation, and natural shaded relief were extracted from the imagery and preliminary fits were made to the linework.

Linework

Three feature separates were reduced from each 1:100,000-scale quadrangle--drainage (fig. 7), primary roads, and secondary roads (fig. 8). A color composite was made with drainage in blue, primary roads in red, and secondary roads and the graticule in black. The result was that the reduced linework was difficult to read, minimum clearance between features virtually disappeared, and intricate networks of unimproved roads were visually confusing. The next step was to increase lineweights, except for urban streets, and to delete some unimproved roads (fig. 9). The new color composite was bolder and more readable than the first.

Results indicate that (1) drainage detail can be salvaged nearly intact by reduction from 1:100,000 to 1:250,000 scale--cultural features might be salvaged if clearance is not important, and (2) editing of roads and trails (using other maps) is desirable to emphasize the maintained transportation network.

Imagery

A satisfactory shaded relief plate was extracted from band 7 of an October 1972 Landsat scene by density slicing. The open-water plate was derived from band 7 of a July 1975 scene. The woodland plate (fig. 10) was extracted from the same July 1975 scene, bands 5 and 7.

Two photographic steps were used to register the 1:100,000-scale image to the 1:250,000-scale base. After a first reduction of 2X, points with known coordinates were identified and measured to determine a precise copy camera magnification factor for the final reduction. A linear adjustment was applied to the measured points, using coordinates from the Space Photo Data Bank as control. The coordinates in the data bank were originally derived from published 7.5- and 15-min quadrangles. Identified points having residual errors beyond 200 m were not used in the adjustment, resulting in an RMSE of 160 m.

Density slicing cannot separate themes having similar densities or discriminate between shadows and themes. The use of digital processing will be investigated and compared with density slicing.

The general procedures used in the 1:250,000-scale Wenatchee may be applied to other areas. Extreme care is required in selecting Landsat imagery for analog theme extraction. Cloud cover, poor Sun angle, and shadows make many scenes useless for density slicing. Often, scenes with a low Sun angle needed for good results in shaded relief are not available. Compromises in desired results are inherent in selecting scenes from different seasons.

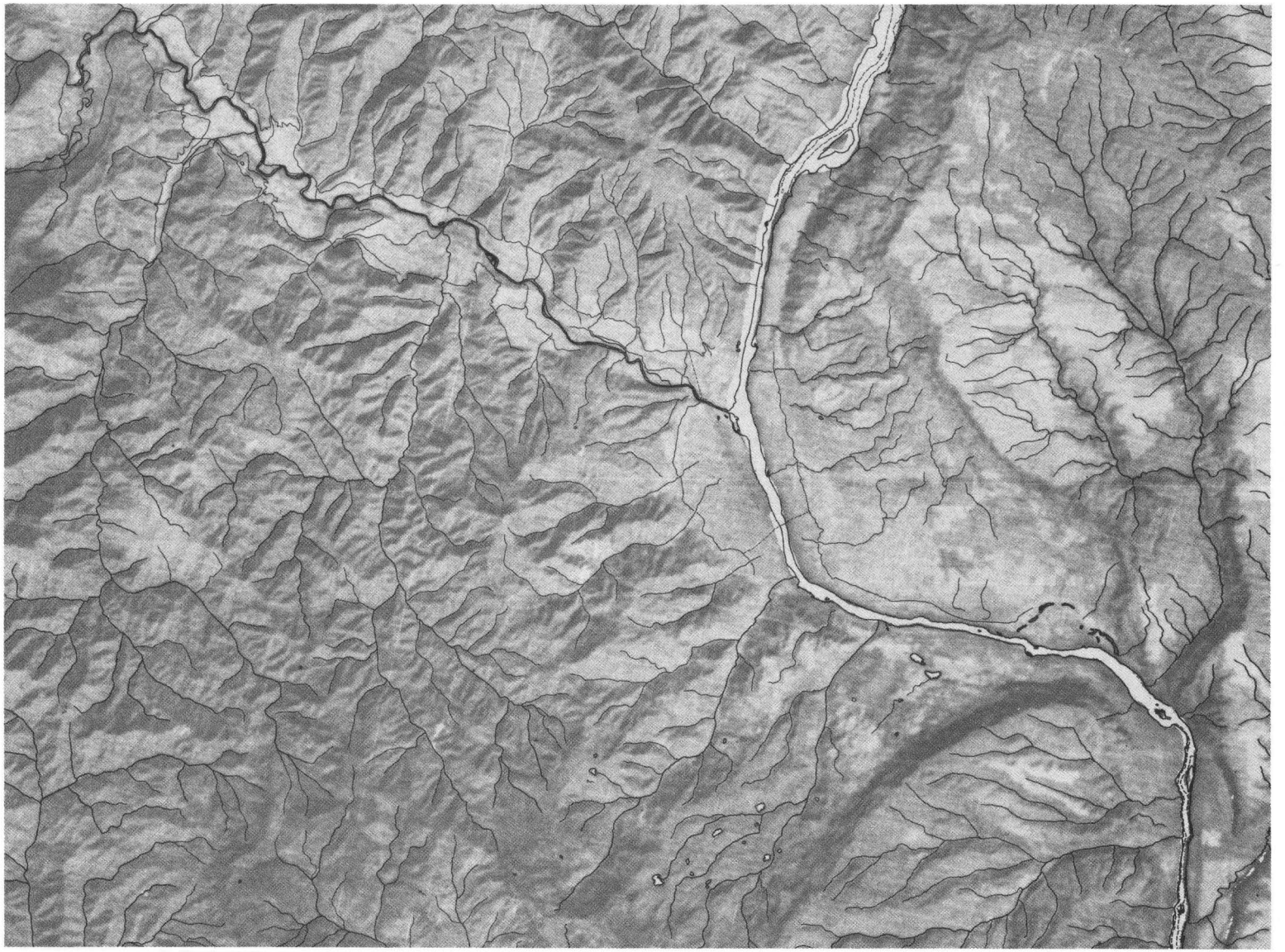

Figure 7.--Wenatchee, Wash., 1:250,000-scale drainage and natural shaded relief experiment with Landsat imagery.

Figure 8.--Class 3, 4, and 5 roads as reduced from Landsat imagery. Location as in figure 7.

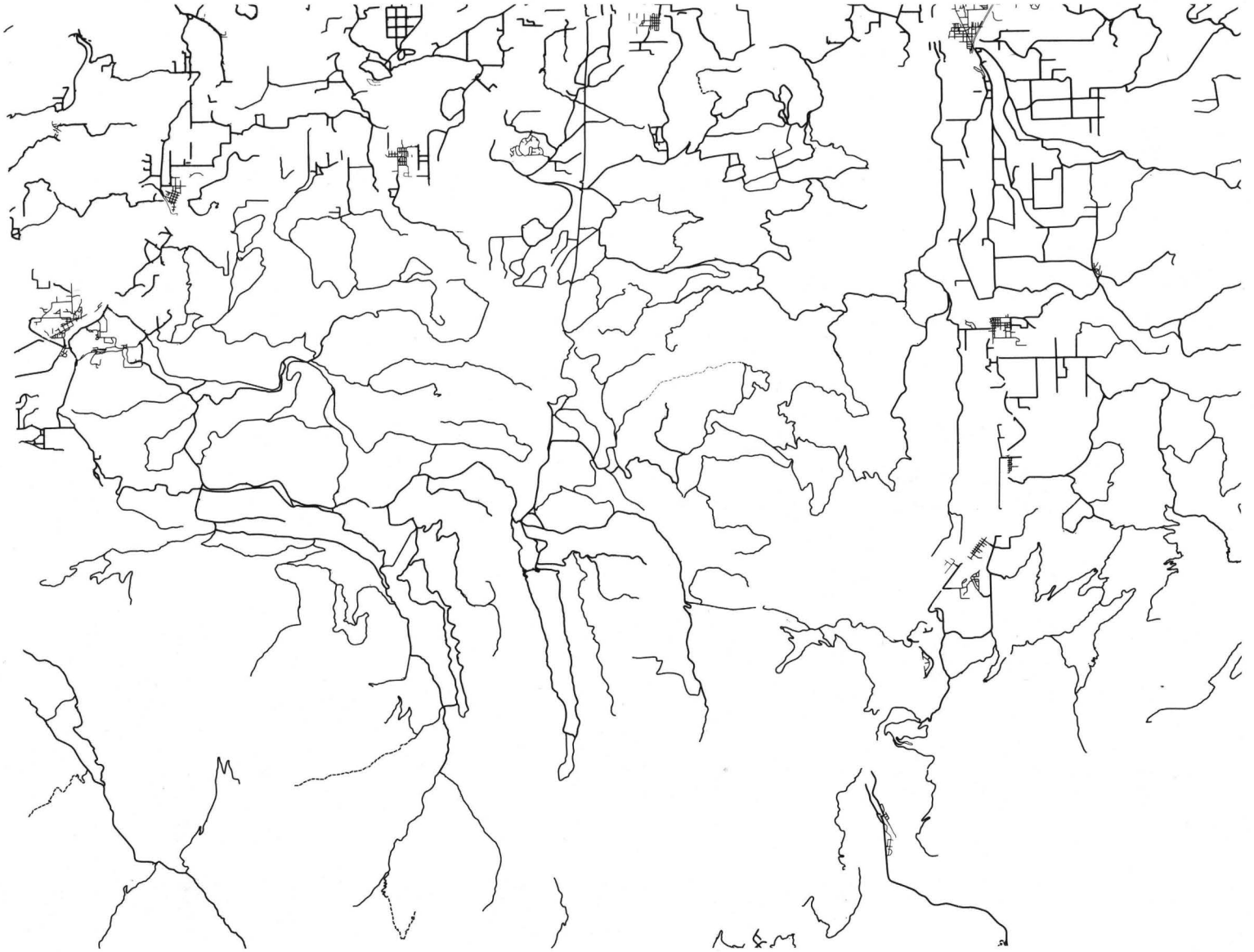

Figure 9.--Class 3, 4, and 5 roads spread and edited from Landsat imagery. Location as in figure 7.

Figure 10.--Unedited vegetation from Landsat imagery. Location as in figure 7.

Conclusion

Use of Landsat imagery to make the open-water plate for this quadrangle was not warrented economically, factually, or visually. Apparently some of the smaller lakes were lost on the Landsat imagery because ice and snow caused reflectance. The vegetation plate is useful, but it has limitations. Since IR images high chlorophyll content, field crops and natural grass must be edited, a step that has not been tried. The image appears to represent small patches of timber better than generalized compiled outlines. The shaded-relief plate is effective, but the one obvious visual weakness is that shadows are cast away from the viewer, which can cause the impression of pseudorelief. Much of the success of this plate depends on the landforms and the angle of their axes to the Sun. If a slope is entirely in shadow, its irregularities tend to be lost. At 1:250,000 scale, heavy timber does not seem to obscure underlying structures unduly.

DELINEATION OF THE ALASKA PIPELINE

A project to determine the feasibility of using Landsat imagery to revise medium- and small-scale (1:63,360 and 1:250,000-scale) maps along the Alaska pipeline route had negative results because of the low resolution of the imagery. The revision already done will be compared with new compilations and evaluated as to content and accuracy in interpreting and delineating cultural and hydrographic features.

RESEAU CALIBRATION OF THE RBV SYSTEM FOR LANDSAT-C

USGS cooperated with NASA and RCA in the geometric calibration of the RBV camera system for Landsat-C. The system contains two identical cameras that operate in the spectral band from 0.50 to 0.75 μm and will provide panchromatic Earth images with twice the ground resolution of the Landsat-1 and Landsat-2 multispectral RBV systems. Calibration of the cameras is essential for register and cartographic referencing of high-resolution photoimage maps. The reseau pattern of 81 crosses is on the inside of the RBV faceplate. Calibration includes establishing a coordinate reference and adjusting measured coordinates to fit it. A list of the reseau coordinates and a report for each RBV tube are available.

DOPPLER RESEARCH

USGS men at South Pole Station have been recording Doppler data from U.S. Navy navigational satellites continuously since 1971 in support of scientific and geodetic studies. These observations have shown that the South Polar ice cap has the mobility of a glacier whose vector movement is quite regular. It has also shown that the Amundsen-Scott South Pole Station (U.S.) is some 500 m from the true geographic South Pole and moving toward it at the rate of 8-11 m/yr.

DIGITAL APPLICATIONS

GESTALT PHOTO MAPPER II

The GPM-2 system became operational in June 1976. Projects comprising 273 7.5-min 1:24,000-scale quadrangles were scanned. The average scan time is about 4 hours per quadrangle for all types of imagery and relief. At this level of production, 1,000 quadrangles can be produced each year on two shifts arranged so that 4 employees can operate the GPM-2 nearly 20 hours a day.

For high-altitude, quad-centered photographs, the output is fixed at 1:80,000 scale, requiring mosaicking and enlarging to produce orthophotoquads at 1:24,000 scale. With a fixed-ratio enlarger, two methods have been used, (1) enlarging to 1:24,000 scale before mosaicking and (2) mosaicking at 1:80,000 scale before enlarging. The latter method is now used; tests indicate that it is more accurate and less expensive.

Most projects scheduled for the GPM-2 are areas of high relief. A contour plot of the model area is printed on film at the same time the image is exposed. The interval is usually set to record 100-ft contours. From 500 to 2,400 elevations per scanning patch, more than 1 million points for each quadrangle, are recorded on the magnetic tape in unjoined patch format. Computer programs are being written to join these patches to form digital elevation models. After they are joined and the data stored back on tape, terrain data can be retrieved from the tape at any desired interval. Future improvements in the system include electronic masking of the scan area, stereomate printing, double-model scanning to eliminate mosaicking, and general software improvements.

ANALYTICAL PLOTTERS

The AS-11A analytical stereoplotters, which have been fitted with minicomputers, are to be modified with new servosystems for all stage and coordinatograph axes and with a new computer interface. The servosystems will be controlled by microprocessors. The application software for the AS-11A's is being modified and slightly restructured for the new interface.

PHOTOGRAMMETRIC DIGITIZERS

The division purchased six Altek AC189 data acquisition systems (fig. 11), attached to encoders mounted on the axial shafts of plotters such as the PG 2, B 8, C 5, and Topocart to record digital information during the normal course of stereocompiling a map. The AC189 features operator control of point and stream recording, independent scaling and translation of each axis, and both thumbwheel and keyboard entry of identification information. The attachments can record contour, profile, hydrographic, and planimetric digital map data directly from the stereomodel onto 9-track 800-bpi magnetic tape.

Figure 11.--Altek AC189 system attached to digital encoders on a stereoplotter.

Graphic digitizers

Five Instronics Gradicon digitizing systems (fig. 12) recently distributed to the MC's are being used for research-oriented pilot projects. Land-net, political boundary, and hydrographic data have been digitized at 1:24,000, 1:48,000, and 1:100,000 scales on projects that include:

- Digitization of horizontal positions of bench marks in North Carolina from 7.5- and 15-min maps, part of the project to transfer all second-and third-order USGS geodetic control data to NGS.

- Digitization of hydrologic units of the United States, from 1:500,000-scale State base maps, to be merged with WRD well-data files. This project comprises 52 base maps.

- Digitization of the locations of names on 30 7.5-min topographic maps, to be included in geographic names information files.

- Digitization of section corner locations and related photoidentifiable points of 27 7.5-min maps and orthophotoquads of the Big Cypress National Park area, Florida, as requested by NPS. The data are to be used for land appraisal before anticipated land purchases.

A modification of the Gradicons will permit them to be used for planned topological structuring of digital map data and operate more efficiently. The ordered modifications will add full 48-character capability, a 16-character verification display, and an interface and serial-parallel code converter for adding voice-actuated hardware.

VOICE DATA ENTRY

A Voice Data Entry Terminal System (VDETS) for engineering test and evaluation (fig. 13) comprises a microphone, voice analyzer, minicomputer, cassette tape unit, and other input-output devices compatible with standard interface logic. As an operator speaks into the microphone, the system analyzes the sound and either stores it as part of the reference vocabulary or compares it to the vocabulary already stored. An operator trains VDETS by reading the vocabulary into memory, recorded on cassette tape. Because everyone has a unique voiceprint, each operator records a separate reference vocabulary.

In operation VDETS compares the spoken words with the stored vocabulary. When it finds a match, it responds according to the programed commands. Responses range from reading and recording data to controlling mechanical motions. Experimental projects for VDETS include obtaining and recording geographic name information and adding feature codes and other descriptive information to digital data acquired during map compilation.

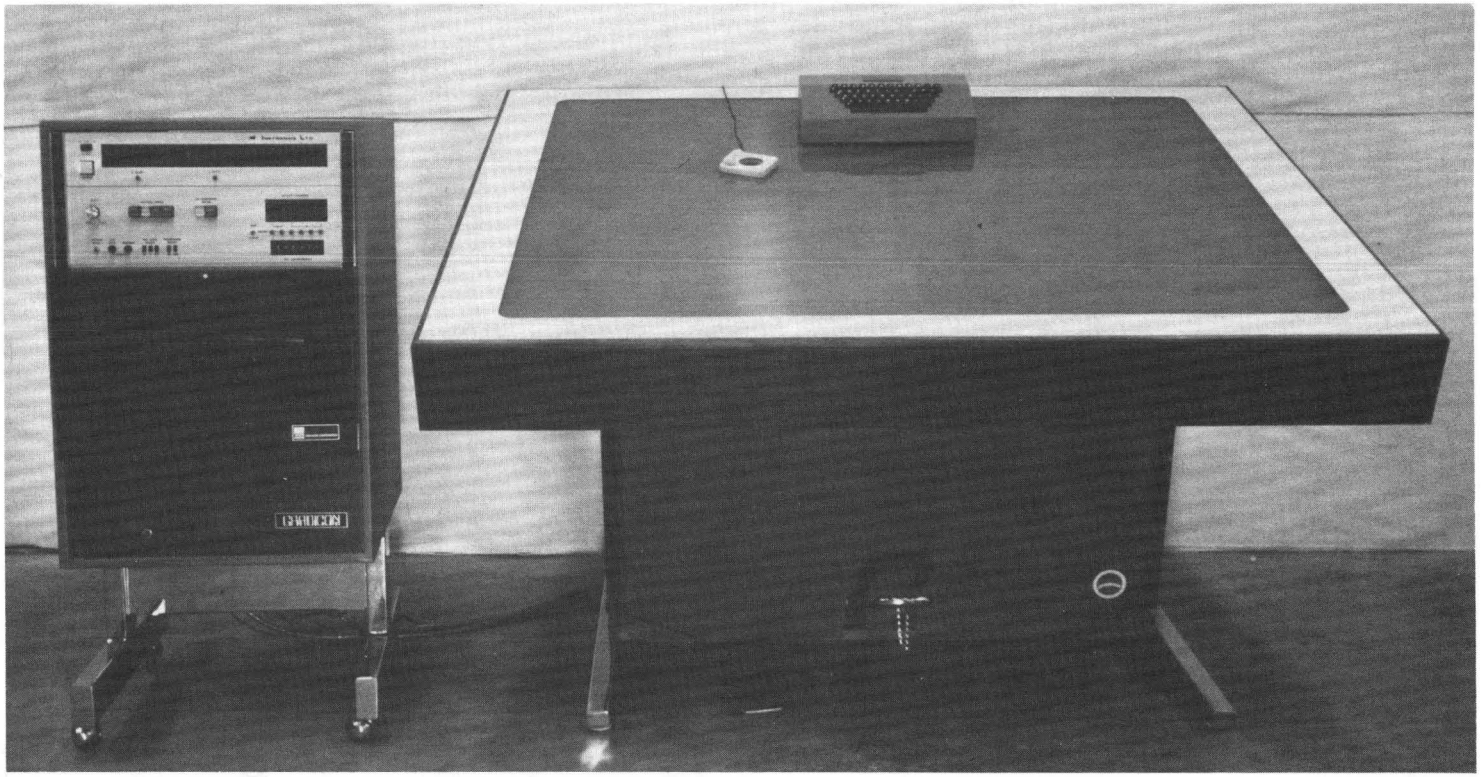

Figure 12.-- Instronics Gradicon digitizing system.

Figure 13.-- Voice Data Entry Terminal System for digitizing alphanumeric map data from spoken input.

PHOTOTYPESETTING DATA TRANSMISSION

Several Omnitext model 1500 word-processing systems (fig. 14) were purchased for use in phototypesetting. Each system comprises a core-memory microcomputer, CRT display, paper-tape reader/punch, and typographic keyboard. Operators can key in text and typesetting commands, view the data on the display screen, edit or correct the data, and then produce a punched paper tape.

The data tapes are used to control the Merganthaler VIP phototypesetter at Reston, Va., which produces the map type on transparent film.

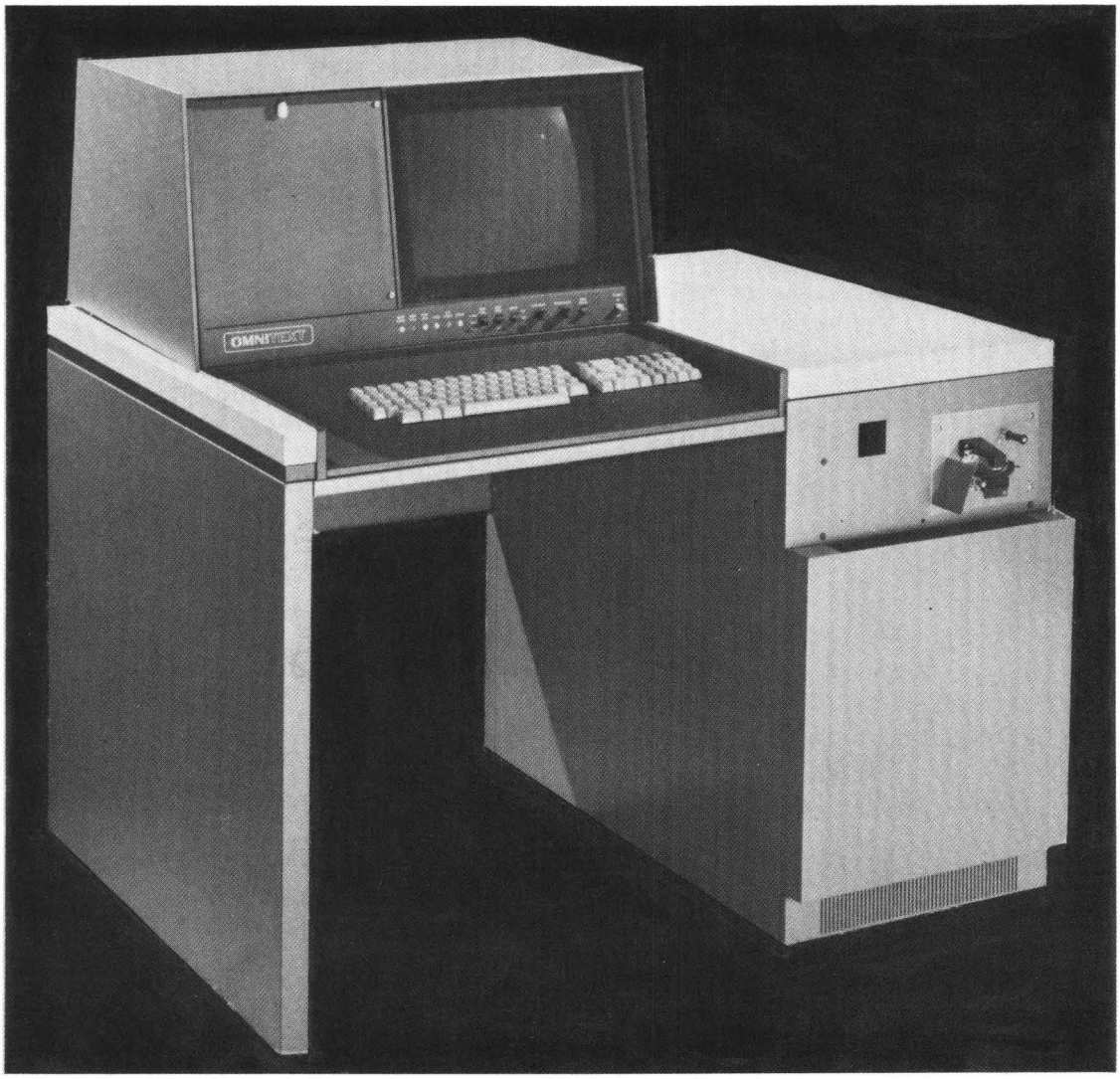

Figure 14.--Omnitext 1500 word-processing system.

INFORMATION

HP-65 PROGRAM LIBRARY

A library of programs has been compiled for the HP-65 programable pocket calculator. Each program has a complete coding listing, user instructions, and documentation in addition to a programed magnetic card. The library contains programs to convert geographic coordinates to State plane coordinates and vice versa, a worldwide UTM-coordinate and zone-number computation from geographics that will operated overedge, and all the Hewlett-Packard package programs.

MAP MICROFILMING

NCIC completed a program of copying 130,000 topographic maps on 35-mm B&W microfilm, after selection of the best copy from three separate map libraries for nearly complete high-quality file. Coding is alphabetical by State, on rolls, and in an increasing scale sequence so that the smallest-scale earliest map appears first and the most recent 1:24,000-scale map appears last. A 30-m roll of film contains about 500 map images reduced 20X and will sell for $20. A large State such as Texas requires 10 rolls for full historical coverage; smaller States require perhaps as little as 2 rolls.

GEOGRAPHIC NAMES INFORMATION SYSTEM

Information files added to the Geographic Names Information System (GNIS) include data about names in the State of Rhode Island (1,800 records), a doubling of the storage file of decisions by BGN (28,000 records), and of a file to coordinate and standardize names that identify the 1:100,000-scale quadrangle maps (1,800 records). The Rhode Island data were delineated on current 1:24,000-scale maps, and general textual data were input to General Information Processing System (GIPSY) records. The name records were then completed by adding geographic coordinates recorded on the Gradicon system. Completion of the project was a major step toward increasing the usefulness of outside files that can be converted to the GNIS format. For example, 32,000 name records have been compiled and recorded in machine language by the State of Virginia.

Total input of the file of decisions of BGN from 1890 through 1958 is complete. Data from this file and all other GNIS files were selectively written in various formats on 9-track magnetic tape and reproduced directly through the Xerox 1200 printer. The formatted data are available on request, or other formats can be queried directly from terminals communicating with Reston.

Additional research included (1) data entry experimentation with VDETS, a procedure tested with data from gazetteers of Hawaii and the Trust Territory of the Pacific Islands that were originally compiled and printed by BGN, (2) plotting data recovered directly from the GIPSY file onto a map overlay by means of the CAM program, and (3) construction of a test model of a 1:100,000-scale quadrangle map names index of Texas.

AERIAL PHOTOGRAPHY SUMMARY RECORD SYSTEM

The automated Aerial Photography Summary Record System (APSRS) was developed as a means of quickly collecting and disseminating information on available or planned aerial photographic coverage. Each summary record includes the name of the generating agency, date of coverage, photo scale, film type, extent of coverage to the nearest 7.5-min quadrangle or by State and county, agency project code, and status (planned, in progress, or complete). The potential customer must contact the responsible agency to determine whether the film meets his requirements.

The system developed in 1975 for handling APSRS is now operational. It is designed for data input by the agency holding the film and thus places responsibility for accuracy on that agency. Information is coded into the system (1) by State and county, (2) by 7.5-min quadrangle or columns of quadrangles, or (3) by any area that can be described by coordinates of four corners. Regardless of the filing method used, information is eventually stored in the computer as either partial or full 7.5-min quad units of coverage.

The cooperating agency codes the information and sends it to NCIC in either card or computer tape format. Only edited and verified APSRS data are entered into the computer file.

There are two standard forms of information output: (1) Computer-generated graphic catalogs, and (2) computer output microfiche.

In addition to the standard outputs, users can request printout for their specific areas of interest. Coverage may be selected by any single data field or by combinations of data fields; coverage of geographic areas may be searched by specifying a box of latitude and longitude or by specifying State and county. Output is a computer-generated map of coverage for the requested parameters, such as "color photographs taken in 1974."

Information in the APSRS, January 1977, consisted of 5,000 records. However, several major Federal data bases have not yet been entered, and only a token amount of the usable State and private company data have been summarized.

The reception of APSRS by Federal agencies has encouraged other organizations to contribute to and use the system, particularly for new and planned photography. NCIC plans to emphasize input of current and planned photography projects to support improved coordination.

EROS USER RESEARCH FACILITY

As part of the EROS program, USGS maintains a user research facility at the National Center (room 2A223B, telephone 703 860-6271) for government-agency, university, and industry investigators with approved projects. There is no charge for use of the facility, but investigators must provide their own materials and complete their own projects. Limited instruction on the use of equipment is provided, and use is restricted to qualified operators.

Available equipment includes:

Bendix Datagrid Digitizer with a 48x60-in light-table, Beseler CB-7 enlarger for projecting 70-mm-format film transparencies, and magnetic tape or typewriter output.

Spatial Data Systems Datacolor model 703.

Joyce-Loebl Mark III-C microdensitometer, with reflective optics attachment.

Richards light-tables with takeup reels for film widths to 9.5 in.

Bausch & Lomb zoom microscopes with magnification to 60X and stereo capability for 70-mm format film only.

Bausch & Lomb Zoom Transfer Scope with magnification to 14X and anamorphic correction.

Wild M 5 stereomicroscope with 6X-50X magnification and trinocular viewing.

Zeiss point marker.

Reference materials include a comprehensive file of 470 EDC-selected Landsat color prints covering the conterminous United States and a selection of Skylab images obtained with the S190A and S190B cameras on missions 2, 3, and 4.

EROS TECHNICAL MEMORANDUMS

The EROS Cartography Coordinator distributes technical memorandums on subjects related to cartographic applications of satellite data. The following were distributed in the past year:

EC-39-Landsat	Solid-state linear arrays as a candidate Landsat imager.
EC-40-Landsat	Photographic imagery and shallow-seas bathymetry by remote sensing.
EC-41-Landsat	Distribution of recent papers relative to Landsat cartographic applications.
EC-42-Landsat	Reports on scale differences and scale variation on Landsat images.
EC-43 Landsat	Developments in shallow-seas mapping application of Landsat.
EC-44-Landsat	Technical notes on EROS Digital Image Enhancement System (EDIES).

Unless specified otherwise, the following programs are written in FORTRAN IV for the IBM 370/155, SEL86, or SEL32/55 computer systems.

Camera Calibration

G133 Camera Calibration Data Bank
Generates, updates, and deletes records in the camera-calibration data bank, and provides for selective retrieval of the information.

G509 Camera Lens Distortion and AWAR Determination
Determines calibrated focal length, radial lens distortion, and area-weighted average resolution (AWAR) for cameras tested on the USGS multicollimator camera calibrator.

G952 Lens Distortion and AWAR
Determines calibrated focal length, radial lens distortion, and area-weighted average resolution for cameras tested on the NBS multicollimator camera calibrator.

H250 CDB Backup Program
Produces a tape or card backup for the Camera Calibration Data Bank.

H762 Camera Data File
Stores cards containing aerial camera information on temporary disk space and prints out the information in a form suitable for a multiple-page Camera Data File. Program will print as many copies for the file as requested.

W5351 Camera Calibration Data Reduction
Computes aerial-camera calibration from data obtained by the multicollimator method. Computes fiducial mark positions, indicated principal point position, calibrated focal length, radial lens distortion, distances between selected calibrated fiducial marks, angles between opposite pairs of selected fiducial marks, and area-weighted average resolution. When calibrating with diapositives, provides an affine transformation to the calibrated fiducial-mark coordinates and a linear transformation with editing if a fiducial mark fails in the linear transformation. Incorporates both linear and affine transformations and accommodates cameras of the most commonly used focal lengths. Radial-lens-distortion corrections in a format suitable for input to the Image Coordinate Refinement program (W5349) were added.

W5506 Stereomodel Flatness Test
Generates a model analytically from USGS multicollimator calibrator measurements and determines the flatness of the model. Acceptability of cameras for aerial mapping is partly based on this test.

Coordinate Refinement

C475 Satellite Imagery Simulation
Computes displacements of images on photographs from such factors as atmospheric refraction, Earth curvature, tilts, and elevations.

E397 STK-1 Coordinate Refinement
Corrects coordinate measurements made on a Wild STK1 stereocomparator for systematic errors.

G351 Image Measurements Preprocessing Program (PREPRO)
Corrects image measurements for distortions caused by film deformations, lens distortions, and atmospheric refraction.

G953 Poly 20
Determines the best-fitting distortion-correction polynomials from n frames of imagery. Coefficients from this program are used in Polycor (G954).

G954 Polycor
Corrects image coordinates for electronic or other distortions with a pair of 20-term polynomials. The program is useful for in-flight calibration of camera systems.

H187 Bandwidth for Simultaneous Adjustment of Photogrammetric and Geodetic Observations (SAPGO)
Preprocesses plate-coordinate data to be computed in SAPGO-MFL (H186). Written for Univac 1108.

H252 Image Coordinate Refinement with Analytical Orientation
Corrects comparator measurements of photographs for systematic errors. Provides (as sorted card decks) refined photocoordinates for GIANT (G350), model coordinates for a simultaneous block adjustment of models (H255, H256), or strip coordinates for a polynomial adjustment (H252, W5358).

W5348 Photogrammetric Refraction and Earth Curvature
Computes image displacements resulting from Earth curvature and refraction.

W5349 Image Coordinate Refinement, Version II
Corrects measured coordinates for systematic displacements due to temperature fluctuation, film shrinkage or expansion, radial lens distortion (by either linear or grid methods), atmospheric refraction, and Earth curvature.

Coordinate System Conversions

A207 X,Y to Latitude-and-Longitude Conversion
Converts x and y coordinatograph coordinates of points measured on a map to latitude and longitude and UTM coordinates. Modified to suppress abnormal job endings and to accept negative longitude values.

D0154 Grid Coordinate Conversion
Converts State plane coordinates to geodetic coordinates and vice versa. All needed zone parameters are permanently stored. Modified to provide card output for State plane coordinates of the graticule at specified intervals.

G385 Coordinate Transformation Between State Plane and Geographic (STAGEO)
Transforms coordinates from State plane to geographic system and vice versa.

G506 American Polyconic Projection Forward
Converts geographic coordinates of points to corresponding coordinates in the American polyconic projection.

G507 Oblique Mercator Projection
Converts plane coordinates of points to geodetic coordinates and vice versa, based on the oblique Mercator projection (for southeast Alaska).

H794 Custom-Designed Lambert Projection
Transforms geodetic coordinates to Lambert plane coordinates and vice versa. A custom-designed Lambert projection can be generated based on input of the two standard parallels, central meridian, latitude of y origin, and spheroid code.

J207 Albers Equal Area Projection Plotting on Calcomp
Transforms ground coordinates into Albers Equal Area projection plot coordinates. The data are converted to Calcomp flatbed plotter commands on magnetic tape.

J380 Coordinate Conversion
Converts geodetic coordinates to UTM and vice versa. Options exist to force the conversion to a specified zone and to select a standard ellipsoid. Also, UTM coordinates in one zone can be transformed to an adjacent zone.

J676 Grid Coordinates Conversion
Modification of D0154 to also produce geodetic coordinates in decidegrees and output on punched cards.

J381 Grid Inverse Computation
Converts grid coordinates in any State plane coordinate system or in the UTM grid system to geodetic coordinates.

W5377 Transverse Mercator Projection
Computes either UTM or State plane coordinates from geodetic coordinates and vice versa.

W5378 Lambert Projection

Converts plane coordinates to geodetic coordinates and vice versa, based on the Lambert conformal projection.

Digital Mapping

H755 Add Graph Elements to Digital Carto Files

H756 Produce Selective Plots of Digital Carto Files

H757 Initial Module of Node/Area Balance Verification of Digital Carto Files

H758 Last Module of Node/Area Balance Verification

H763 Digital Terrain Model Generator Program (DTMGP)
Reformats data generated on an AS-11B-1 to MMS-32 format for use with the Advanced Cartographic System at Rome Air Development Center (RADC). The reformatted data can be transformed, edited, and plotted on the Cartographic Digitizer Plotter. Written for GE 635 computer.

H778 CART/8 Preparation from RADC Digital Files
Translates the MMD-32 digital data files of the Advance Cartographic System at RADC (output from program H586) to a format for use with the Dynamap Ltd. CART/8 interactive editing system (under development).

J208 AS-11B-1 Data Plot on CALCOMP
Converts digital map data processed by program H586 to Calcomp flatbed plotter commands on magnetic tapes.

J223 Initial Module of Line Intersection Verification for Digital Carto Files
Component 1 of Line Graph Overlay System.

J224 Last Module of Line Intersection Verification
Component 2 of Line Graph Overlay System.

J225 Produce Listing of Contents of Digital Carto Files
Component 3 of Line Graph Overlay System.

J226 Edit/Modify Digital Carto Files
Component 4 of Line Graph Overlay System.

J227 Store or Restore Digital Carto Files
Component 5 of Line Graph Overlay System.

J228 Graph Overlay System Component 6

J229 Graph Overlay System Component 7

J230 Graph Overlay System Component 8

J231 Graph Overlay System Component 9

J232 Graph Overlay System Component 10

H585 AS-11B-1 Tape Translator
Translates digital map data from an AS-11B-1 stereoplotter into usable form.

H586 RADC MMS 32 Translator
Translates digital map data in MMS 32 format from the GS635 computer at RADC to usable form with compact storage.

H754 Read and Decode Bendix DataGrid Tapes
Written in PL/3.

J429 Lens Distortion Radial Function
Translates lens radial distortion characteristics from tabular to functional form for the Gestalt Photo Mapper II (GPM-2).

J430 Gestalt Data Package
Automates the input process to the GPM-2. Photo and ground parameters are output from the aerotriangulation program onto disk storage and are used by this program to produce the input to the GPM-2.

J432 DPROS Interpolation
Uses a tape containing digital profiles scanned on a C5 as input and interpolates intermediate profiles so that playback on a GZ1 orthoprojector can be at smaller slot widths to minimize image discontinuities.

J433 GRADICON Land Use Area Computation
Processes land use polygons digitized on an Instronics GRADICON to compute square inches, square feet, square miles, and acres for each polygon. Summary tables are also produced for each land use type.

Fully Analytical Aerotriangulation

G350 General Integrated Analytical Triangulation Program (GIANT)

Performs a least-squares adjustment of arbitrarily arranged and (or) constrained blocks of frame photographs. An efficient algorithm for the formation, solution, and inversion of large linear systems of equations permits the handling of 460 photographs. Input to the program is PREPRO output (G351).

H186 Simultaneous Adjustment of Photogrammetric and Geodetic Observations--Multiple Focal Length (SAPGO-MFL)
University of Illinois program for fully analytical aerotriangulation. Programmed for Univac 1108.

H287 Direct Geodetic Constraint Aerotriangulation Adjustment
Analytically adjusts up to 65 aerial photographs by the Direct Geodetic Constraint method. Requires up to 756k bytes of core.

H286 Direct Geodetic Constraint Aerotriangulation Adjustment
Analytically adjusts up to 94 aerial photographs by the Direct Geodetic Constraint method. Requires almost 1.4 megabytes of core.

H480 Direct Geodetic Constraint Aerotriangulation with Banding
Aerotriangulates a block of up to 500 photos through banding of the normal equations and efficient sorting and bookkeeping. Requires 465k bytes of core; can be easily expanded to handle 1,600 photos. A modification of the Direct Geodetic Constraint method of fully analytical aerotriangulation; modified to provide printed and punched output of the exposure station positions and orientations, to permit multiple block runs, to optimize disk usage, and to eliminate the incorrect computation of smaller blocks.

J527 DGC for Multiple Camera Blocks and Instrument Data Output
Program H480 has been extensively modified to allow use of different cameras within a block and to output model set up parameters for the B-8, PG-2, GPM-2, or E-4.

W5380 Small-Block Direct Geodetic Constraint (DGC)
A version of W8242 specially designed for small blocks of up to 31 photos.

W5382 DGC Version of August 1973
Applies a new formula for atmospheric refraction corrections and provides for interpolation of exposure station positions between the first and last exposure stations of each flight strip. An improved version of W8242.

Instrument Calibration

B316 Copy Camera Table Generation
Generates a table of lens and easel settings for different copy-camera magnifications.

H188 Orthophotomat Digital Profile Conversion
Verifies digital-profile tape to be used on the orthophotomat. Output includes a Gerber plot tape.

H259 Generalized Comparator Calibration
Calibrates comparators or coordinate plotters using up to 10 parametric terms. Each axis is treated separately for a total of 20 terms. Five different solutions are computed using 10, 8, 5, 4, and 3 effective terms. Written by John Kenefick for Kern Instruments, Inc.

H290 Complete Comparator Calibration
Calibrates comparators. Documented as NOAA Technical Report NOS57 (July 1973).

H750 Perspective Center and Stage Plate Mark Determination
Computes the coordinates of the perspective center of a stereoplotter projector from measurements made at the intersections of a projected grid. Plate coordinates of projected stage-plate marks can be determined as a byproduct, and subsequently the perspective-center coordinates; the stage-plate marks may be used instead of grid plates.

W5344 Perspective Center Determination
Determines perspective-center coordinates of a projector, using grid-plate projections.

W5347 Diapositive Printer Calibration
Determines errors introduced by diapositive printers, using the space-resection method.

W5355 Extended Comparator Calibration
Computes linear and secular scale error, nonorthogonality of axes, and weave of ways. Modified National Geodetic Survey program.

W5356 Comparator and Coordinate Plotter Calibration
Determines linear scale factors and nonorthogonality of a comparator from grid plate measurements. Modified NGS program.

W5361 Stereoplotter calibration
Computes the x obliquity and width errors in Wild A7 and A8 stereoplotters, using precise grid plates.

Miscellaneous

D0106 Phototrig Determination
Computes elevations from angles measured in the field and distances determined by aerotriangulation.

E308 HISTO
Fits either a normal distribution curve or a chi-square distribution curve to a histogram of grouped frequency distributions from a given data set.

H184 DataGrid Tape to Card Conversion
Converts data from the Bendix DataGrid digitizer tapes to punch cards.

H257 Analytical Rectification
Computes the required settings for a rectifier from known ground coordinates of image points and observed coordinatograph or comparator coordinates.

W8249 Gridding High-Altitude Photographs
Transforms ground coordinates to photograph coordinates by one of three options and punches out coordinates of grid intersections at specified intervals.

Plotting

B432 Autoplot Graph and Grid Drawing
Generates magnetic tape instructions for drawing a square or rectangular grid containing up to 90x90 lines. Selected lines can be made heavier.

C236 Line-Printer Plotting
Maps the locus of an image by plotting the cartesian coordinates of its integral points. The centroid, for centering the image in a reference frame, is computed as the mean of the sample points. The image is plotted by the line printer.

C237 1:250,000-Scale Base Sheet Preparation
Generates Autoplot magnetic tape instructions for plotting the neatline, geographic and UTM ticks, and points for 1:250,000-scale base sheets. Sheets not centered on the UTM grid zone are plotted with the shape of the corresponding zone-centered sheet.

C237A 1:250,000-Scale Base Sheet Preparation
Version of C237 in which all sheets are plotted with correct shape.

C476 Base Sheet Plotting, Version III
Generates Autoplot instructions on magnetic tape for plotting sheets bounded by lines of latitude and longitude and cast on the State plane-coordinate system.

G508 Autoplot Malfunction Test
Generates instructions on magnetic tape for testing the Autoplot for electronic or mechanical malfunctions. Version also exists for testing Cartoplot with a 9-track tape reader.

H183 UTM Grid Information
Computes the information necessary to add UTM grid ticks and grid declination to a standard base sheet during revision.

H471 Gerber Base Sheet Plotting Program
Produces a magnetic tape to plot standard quadrangle base sheets on the Gerber model 1232 automatic flatbed plotter.

H573 Autoplot to Cartoplot Conversion
Converts the instruction format and tool commands written to plot standard base sheets on an Autoplot to commands on tape for use on the Cartoplot.

H751 Gerber Line Base Plotting
Compiles instructions on magnetic tape for driving the Gerber plotter to prepare base sheets for standard topographic maps and special-purpose line maps (under development).

H752 Base Sheet Preparation for Bureau of the Census
Compiles instructions on magnetic tape for driving the Autoplot to prepare base sheets for 7.5x3.75-min quadrangles required by the Census Bureau. The two Census quadrangles comprising a USGS 7.5-min quadrangle are plotted together, with the common neatline represented by a single east-west line across the 7.5-min quadrangle. All grid and graticule edge ticks are shown along both sides of the line. The sheets are not labeled, and no points are plotted.

H753 Gerber Orthophoto Base Plotting
Compiles instructions on magnetic tape for driving the Gerber plotter to prepare base sheets for standard 7.5-min orthophotoquads.

H790 Base Sheet Preparation on Calcomp Plotter
Compiles instructions on magnetic tape for driving the Calcomp flatbed plotter to prepare base sheets for standard 7.5-min quadrangles and special-purpose line maps.

H793 Base Sheet Preparation on Cartoplot
Compiles instructions on magnetic tape for driving the Cartoplot to prepare base sheets for standard 7.5-min quadrangles and special-purpose line maps. Combination of programs C476 and H573.

J210 1:250,000-Scale Base Sheet Plotting on Calcomp True UTM Grid
Plots 1:250,000-scale base sheets on a Calcomp flatbed plotter. Modification of program C237A.

J404 Base Sheet Photoplotting on Gerber
Photoplots standard base sheets on the Gerber plotter.

Programing Aids

A592 FORTRAN Program Editor
Renames variables and improves readability of a source program. Picatinny Arsenal program.

B808 BCD to EBCDIC
Converts a card deck from BCD to EBCDIC code and punches out a converted deck.

Semianalytical Aerotriangulation

A487 Vertical Semianalytical Aerotriangulation (VERT)
Vertical semianalytical aerotriangulation of strip data. Programed in PL/1.

B616 Polynomial Adjustment of Strips and Blocks
RMMC version of W5358.

C326 Central Region Independent-Model Program (CRIMP)
Horizontal and vertical semianalytical block adjustment of independent models, with output to the SIM23 program.

C329 MCMC Horizontal Data Check
Horizontal semianalytical block adjustment of independent models, with output to the SIM23 program.

None Simulated Spline Adjustment (SIM23)
A simulated spline adjustment of strip tie points using output from either the CRIMP (C326) or Horizontal Data Check (C329) programs.

G536 Simultaneous Assembly of Photogrammetric Units (SAPU)
Performs a least-squares assembly of up to 1,000 two- or three-dimensional photogrammetric units in a simultaneous adjustment.

H254 Simultaneous Polynomial Block Adjustment
Performs polynomial transformations of three-dimensional strip data to generate blocks. In addition to its direct use in mapping, it is used for blunder detection and error elimination in blocks to be finally adjusted by more sophisticated procedures.

H255 Simultaneous Block Adjustment of Models (100 models)
Performs three-dimensional transformations of independent models to fit them to each other and to control. Input can be model data read out on a stereoplotter or generated analytically from photographic data.

H256 Simultaneous Block Adjustment of Models (200 models)
Identical to H255 but sized to handle blocks of up to 200 models. Includes option for card output sorted by quadrangle for subsequent use in orthophoto ratioing.

W5117 Horizontal and Vertical Block Adjustment (EMCSAAT)
Simultaneously adjusts a block of pass points by first- or second-degree horizontal and vertical transformations. Modified version contains illegal-character check routine for input cards and ability to suppress linear-adjustment printout. Also allows second- or third-degree adjustment of blocks after preliminary solution is derived from first degree transformations and vertical adjustment for small-scale models.

W5358 Schut Adjustment of Strips and Blocks by Polynomial Transformations
Horizontal and vertical adjustment of pass points in a repetitive or cycling adjustment.

W5374 Horizontal Block Adjustment, Simultaneous
Performs a least-squares second-degree simultaneous horizontal block adjustment of strip data.

Strip or Model Formation

B617 Kern Strip Transformer
Generates strip coordinates from stereomodel coordinates.

H251 WMC Independent Model Transformation
Produces output cards presorted for W5358 or H254. A modification of W5375, this program has a simplified input deck assembly.

W5345 Independent-Model Aerotriangulation--Proctor
Horizontal and vertical independent-model aerotriangulation based on the equations of Proctor.

W5359 Schut Analytical Strip Triangulation
Formation of models or strips from coordinate-refined comparator data. The National Research Council of Canada version of March 1973.

W5363 Schmid Single-Model Orientation
Forms a model from photocoordinates and performs absolute orientation.

W5375 Formation of Strips from Independent Models
Generates strip coordinates from stereomodel coordinates.

Transformations

A450 Horizontal Linear Adjustment Using Centroid
Forms strips from stereomodels, forms blocks from strips, and fits blocks to horizontal control. Transformations are based on lines from centroid of units to other points. Programed in PL/I.

A452 Edge Join and Adjustment (EDGE)
Horizontal adjustment of subunit edges. Programed in PL/I.

E728 Nonlinear Transformation of X, Y Coordinates
Performs nonlinear nonconformal transformation of coordinates after determining either 8 or 16 transformation parameters. The number of parameters depends on the input.

G505 Linear Transformation Without Scale Change
Performs least-squares linear transformation of the horizontal coordinates of a set of points with scale change inhibited.

G950 Trilateration on a Plane
Computes model coordinates for horizontal control stations that cannot be photoidentified by using trilateration principles. The program uses model coordinates of photoidentifiable images surrounding the control station and ground distance measurements from the station to identifiable images to compute station coordinates for use in photogrammetric adjustments.

G951 Resection on a Plane
Computes model coordinates for horizontal control stations that cannot be photoidentified by using resection principles. The program uses model coordinates of photoidentifiable images surrounding the control station and angles between photoidentifiable points as measured at the station to compute the station coordinates for use in photogrammetric adjustments.

H253 Linear Horizontal Transformation with Affine and Inverse Transformation Options
Performs linear affine horizontal transformations of a set of points. Provision is included to perform an inverse computation for observed coordinates from true coordinate input for use in such tasks as orthophoto scaling. Includes an affine transformation. The affine transformation separates x and y scaling and is useful where data are derived from media subject to differential distortions, such as paper maps or photographs.

W5357 Linear Transformation of Coordinates
Performs least-squares linear transformation of horizontal coordinates of set of points.

Wang 700/720 Programs

The following is a list of programs written for Wang 700 and 720 desk calculators. Most programs are designed for the 720 but can be run on the 700 with minor modifications.

WP-1 (abandoned)

2 Simultaneous Solution (Wang 700)
Solves as many as 12 symmetric equations for as many unknowns as there are equations.

3 Pantograph Adjustment (27 scales) (Wang 700)
Computes the corrections to be applied to each of three vernier settings of pantographs used with projection-type stereoplotters.

WP-4 Pantograph Adjustment (all scales)
A much more flexible and efficient version of WP-3.

5 Simultaneous Solution (18 unknowns)
Similar to WP-2, solves up to 18 unknowns from the observation equations. The need to precompute symmetric equations is eliminated.

6 720 Decoding Program
Converts Wang Machine Code to instruction memories.

7 Model Transformation
Using up to 10 points, performs a three-dimensional transformation that that maps one set of coordinates to another.

8 Linear Transformation with Editing and Inverse Options
Performs the linear transformation mapping one set of X-Y coordinates to another for up to 20 points. Options exist to edit-out points and recompute the transformation and to "back" transform or inverse.

9 Image Coordinate Refinement
Corrects raw coordinate measurements of points of photographs for systematic errors due to radial lens distortion, atmospheric refraction, earth curvature, film distortion, and comparator error.

10 UTM-GEO-UTM
Converts Geographic coordinates to UTM or vice versa on Clarke 1866 Spheroid.

11 UTM-GEO-UTM (Zone forcing)
Similar to WP-10 but allows computations in meters or feet with zone selection including two nested 3' zones.

12 Transverse Mercator Coordinate Conversion
Geographic to Transverse Mercator or vice versa in feet or meters. For any operator defined projection or spheroid.

13 Transverse Mercator Grid Tables
Prints scale factors and a table to TM coordinates for regular intervals of latitude and longitude.

14 Transverse Mercator Grid Tables (custom)
Similar to WP-13 for a custom designed zone.

15 Transverse Mercator Zone Distortion
Given latitude at maximum project width and meridional boundaries, computes the distortion at the boundary.

16 Transverse Mercator Scale Factor
Given project boundaries, computes scale factor at central meridian to equalize distortion at CM and project boundaries.

WP-17 Transverse Mercator Balanced Distortion Tables
Like WP-16 but produces a table for different latitudes.

18 Flight Design
For rectangular projects, develops the flight-design plan.

19 Linear Transformation
Like WP-8 for Wang 700 and 12 or fewer points.

20 Orthogonal Coordinate Transformation
Like WP-7 for Wang 700 and 6 or fewer points.

21 Wang 720 Data Ranking
Takes up to 220 numbers and ranks them in ascending numerical order.

22 TRANS 8 (Wang 700)
Performs a nonlinear nonconformal transformation of measurements at four or more points. Eight parameters are produced.

23 TRANS 16 (Wang 700)
Like WP-22 producing 16 parameters.

24 Wang 720 Core Storage
Produces a table of program step to register storage relationship. Requires 702 writer.

25 Core Dump
Prints contents of registers requested.

26 Space Resection (Wang 700)
Uses three-point Church space resection to compute camera coordinates and transformation parameters. Output can be plate or control coordinates, scale, omega-phi-kappa, tilt-swing, and Zeiss SEG-V settings.

27 Hex to Decimal
A utility routine to convert hexadecimal numbers to decimal.

28 RMMC Wang 720 Decoding
The function is similar to WP-6 but decoding is done automatically from cassette rather than manual input.

29 Least Squares Reduction (Wang 700)
Solve normal equations from observation equations.

30 Horizontal Least Squares (Wang 700)
Similar to WP-8.

31 Simultaneous Solution (Wang 700)
Similar to WP-29.

WP-32 GEO-SPC-GEO (LAMBERT)

33 GEO-SPC-GEO (MERCATOR)
Geodetic to State plane coordinates and vice versa for western States.

34 GEO-SPC-GEO (LAMBERT)

35 GEO-SPC-GEO (MERCATOR)
Same as WP-32 and WP-33 for eastern States.

36 GEO-SPC-GEO (LAMBERT)

37 GEO-SPC-GEO (MERCATOR)
Same as WP-32 and WP-33 for mid-continent States.

38 High-Speed Duplicating Film Exposure Data
Computes exposure time, flash line, and resulting gamma.

39 Rectifier Orientation (Wang 700)
Computes easel tilts and magnification for Zeiss SEG-V rectifier based on plate and map coordinates of four points.

40 Normal Equation Former
Forms normal equations from observation equations.

41 Interface Test
Exercises digitizer interface (old design).

42 Aerotriangulation RMSE
Computes RMSE from input of block adjustment residuals.

43 Geodetic Inverse
Computes forward and back azimuths and distance between two known geodetic positions using Robbins formula.
Corrects x-y coordinate data using known comparator calibration parameters.

45 Line Intersection
Given x-y coordinates of two points on each of two lines, computes the point of intersection.

46 UTM-GEO-UTM
Converts Geodetic coordinates to UTM and coordinates to UTM and vice versa. (Wang Laboratories program.)

47 Wang 700 Decoding
WP-6 for the Wang 700.

WP-48 (Abandoned)

49 RMMC Vertical Net Adjustment
Distributes randon errors, using method of least squares, with a network of level or VA/EDM observations, performs junction to junction adjustment, and evaluates residual errors.

50 Landsat Mirror Flash
Produces the mirror settings to produce a mirror flash (saturated pixel) on a Landsat image.

51 GEO-SPC-GEO (LAMBERT)

52 GEO-SPC-GEO (MERCATOR)
Geodetic to State plane coordinates and vice versa for Rocky Mountain States.

53 Analytical Relative Orientation
Using x-y coordinate data from photo observation, computes independent model coordinates.

55 Plate Coordinate Correction
Corrects coordinates to principal point.

56 Zero Memory
A utility routine to zero core.

57 Rotation-Matrix Computations
Computes the rotation matrix of a photograph based on the orientation angles. For use in analytical photogrammetry.

58 Transverse Mercator Projection Design
Provides various scale factors to aid in designing the projection. For the special plotting problems requiring a custom-design transverse Mercator projection.

59 MCMC Orthonegative Scaling Program
Scales orthonegatives to 1:24,000. The program computation is based on the average scales and azimuths of vectors from the centroid to the control points.

60 Linear Transformation for Online Card Input
WP-8 (Linear Transformation Program) rewritten for use on a digitized coordinatograph.

61 Parameters for Custom Designed Lambert Projection
For special plotting problems requiring a special Lambert projection. Input is the two standard parallels and the origin latitude.

WP-62 Geodetic to Plane Coordinate Transformation or Inverse (49 States)
A combination of various programs used to perform Lambert and transverse Mercator coordinate conversions. Within the one program are all data required to perform conversions in State plane coordinate zones (except Alaska zones 1-9), Puerto Rico, Virgin Islands, and Samoa.

63 Alaska Coordinate Transformation (zones 1 to 9)
Performs coordinate conversions for Alaska transverse Mercator zones 2-9 and oblique Mercator zone 1. A companion program to WP-62.

64 Linear Transformation for Digitizer Interface
A version of WP-8 (Linear Transformation Program) for interface with a digitized coordinatograph with entry of true coordinates via the keyboard.

65 Horizontal Accuracy Quality Control
Performs a linear least-squares fit on four points (usually quadrangle corners) and then gives inverse coordinates and residuals for any number of test points. Test-point residuals are printed with their RMSE. This program is especially useful for checking the horizontal accuracy of maps and orthophotos.

66 Linear Horizontal Transformation with Test Point Residuals
Performs a linear transformation on 2-12 held points followed by transformation of any number of additional points. If true coordinates of additional points are available, test-point residuals are printed with their RMSE.

67 Affine Horizontal Transformation with Test Point Residuals
Corrects for differential scale change in x and y directions and nonperpendicularity. Same as WP-66, but with affine coordinate transformation.

68 Model Transformation Using Card Reader
WP-7 (Model Transformation) modified for input of true and observed coordinates using a punch-card readers.

69 Linear Transformation for Online Card Input with RMSE
WP-60 (Linear Transformation for Online Card Input) modified to include computation of RMSE of residuals after transformation.

70 Copy Camera Tables
Computes a table of the settings for a cartographic copy camera to scale images to the proper magnification, given the calibrated focal length and corrections to lens and copyboard counters. Similar to FORTRAN program B316.

WP-71 Calibration of Cartographic Copy Camera
Produces the lens and copyboard corrections to be used in WP-70 (Copy Camera Tables), using a grid photographed on a cartographic copy camera.

72 Computation of Exposure and Camera Setting For High-Speed Duplication Film
Produces the data necessary for proper exposure and processing based on the camera constants and flash and exposure curves.

73 Linearity Test
Computes the deviations from a straight line of a series of points. These figures are useful in such operations as photogrammetric compilation testing to verify that straight road segments or other linear features are correctly portrayed.

74 Projective Transformation for Card Reader
Performs a projective transformation of photo points to map positions. Designed for use with digitizer and punch-card reader.

75 Geographic to Geocentric Coordinates
Converts geographic to geocentric coordinates on the Clarke 1866 spheroid.

76 Camera Orientation and Position
Computes orientation matrix and solves for orientation parameters from camera position in secant coordinate system.

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