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PROJECT PLANNING AND FIELD SUPPORT FOR N.O.S. PHOTOBATHYMETRY

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ABSTRACT

Successful data acquisition for the NOS photobathymetry program is highly dependent on office project planning, scheduling, and field support. Considerable effort is expended prior to the aerial photography phase in developing the horizontal and vertical control specifications, tidal datum requirements, and flight parameters. Specifications for all field support activities are conveyed to the field unit by detailed instructions, job diagrams, and pertinent data collected during the planning phase. Field operations, which include premarking horizontal and vertical control stations and obtaining tidal data, are accomplished in conjunction with the photographic mission and are critical to the success of the data reduction.

INTRODUCTION

Over the past 25 years, the National Ocean Survey (formerly the Coast and Geodetic Survey) has accumulated and perfected a group of techniques and procedures which collectively form the basis for modern coastal mapping. These operations include premarking of ground control, tide-coordinated photography, specialized applications of various photographic emulsions, multi-camera photography, analytical aerotriangulation, and compilation with modern or semi-automated equipment. While these techniques are applied in various combinations, to effect a variety of coastal mapping capabilities, their largest application remains with the primary mission of the Coastal Mapping Division which is support to nautical charting.

Traditionally, the National Ocean Survey (NOS) has charted the shoreline (mean high water line) and the sounding datum (mean low water on the Atlantic coast, gulf low water datum in the Gulf of Mexico, and mean lower-low water on the Pacific coast). Until recent years, the responsibility for acquisition of the low water line was that of the hydrographer, which often presented a formidable task and slowed progress of the survey. The advent of tide-coordinated aerial photography on black-and-white infrared emulsion relieved the hydrographer of this problem to a great extent, but he must still contend with the frustrating and often hazardous nearshore areas of his survey. Further help is on the way through an operational system of photobathymetry developed by NOS.

The operational techniques which comprise the NOS photobathymetry system are primarily those which are combined to provide standard shoreline map products. Reduction of photogrammetric soundings and the need for an extensive vertical control net are basic additional requirements for photobathymetry. The major phases of a photobathymetric project are as follows; and in general they will be conducted in the order shown:

1. Project planning;
2. Control identification;
3. Aerial photography;
4. Aerotriangulation;
5. Compilation;
6. Field edit;
7. Final review.

Each phase is critically important to the successful completion of a project, and a great deal of coordination and scheduling is required for the proper transition from one phase to the next. Discussion in this paper will be limited to project planning and field operations required in support of photobathymetry.

PROJECT PLANNING

Project planning necessarily starts with long range considerations. To be as effective as possible, photobathymetry must precede the conventional hydrographic survey and must be scheduled accordingly. A lead time of approximately 15 months is required; planning can be accomplished in three months, allowing a full year for project execution through the compilation phase. Scheduling of office, field, and aircraft time must be considered at this early stage to avoid conflicts with other programs.

Preliminary project study

A potential photobathymetry project area is closely examined to determine its feasibility with respect to water clarity, existing horizontal and vertical control, existing tidal datums, support facilities for aircraft operations and field personnel, and weather characteristics. The NOS film library at our Imagery Processing Laboratory contains several thousand

rolls of aerial photography of coastal areas and is particularly valuable for making a water penetration analysis. The horizontal and vertical control data of the NOS National Geodetic Survey and tidal data from the Oceanographic Division are also readily available.

Once a proposed project is confirmed as a workable mission, more detailed job parameters are required. The exact project limits are defined, scales of photography and compilation are set, and an approximate time frame for field and photographic operations is established. All materials and data required for the job preparation phase are gathered and detailed planning commences.

Job preparation phase

The data collected for job preparation consists of descriptions, positions, and recovery notes for all horizontal and vertical control stations in the project area; nautical and aeronautical charts and quadrangle maps covering the area; and tidal data in the form of local datums, bench mark descriptions, and information pertaining to tide gages currently operating in or near the project area. Responsibilities of the office planning operation are detailed as follows:

1. *Research of control data* — Descriptions and recovery notes for all horizontal and vertical control stations in the project area are analyzed to ascertain their probable current status. Stations with recovery notes which indicate they have been destroyed or lost are eliminated from possible use in the survey. All others are listed with their geodetic positions, date of last recovery, and cross references to their descriptions and recovery notes in the source data. It is not uncommon for several hundred stations to make the "good data" list for a single project.

2. *Control requirements diagram* — A job diagram is prepared on a suitable base map or chart covering the project area, and all horizontal and vertical control stations determined to be recoverable are plotted on the diagram. The manuscript sheet layout is designed for most efficient coverage using this base, as are the lines of photography planned for aerotriangulation. Control requirements, both horizontal and vertical, are indicated on the diagram by general areas where stations are needed for controlling the aerotriangulation process. Field personnel will be directed to recover a station in each area and place a panel on or near the station. The diagram is completed by indicating the tide station locations required for the project. Figure 1 is a reduction of the job diagram for a project at St. Croix, Virgin Islands.

Manuscript scale is typically 1 : 10 000, and aerotriangulation photography scales of 1 : 50 000 and 1 : 20 000 are usually assigned. Horizontal control panels are placed to image on the 1 : 50 000 scale photography. During the aerotriangulation of the smaller scale photography, horizontal positions are determined for points common to both scales. A block aerotriangulation of the large scale photography then utilizes the photogrammetric horizontal control and the paneled vertical control to complete the control densification.

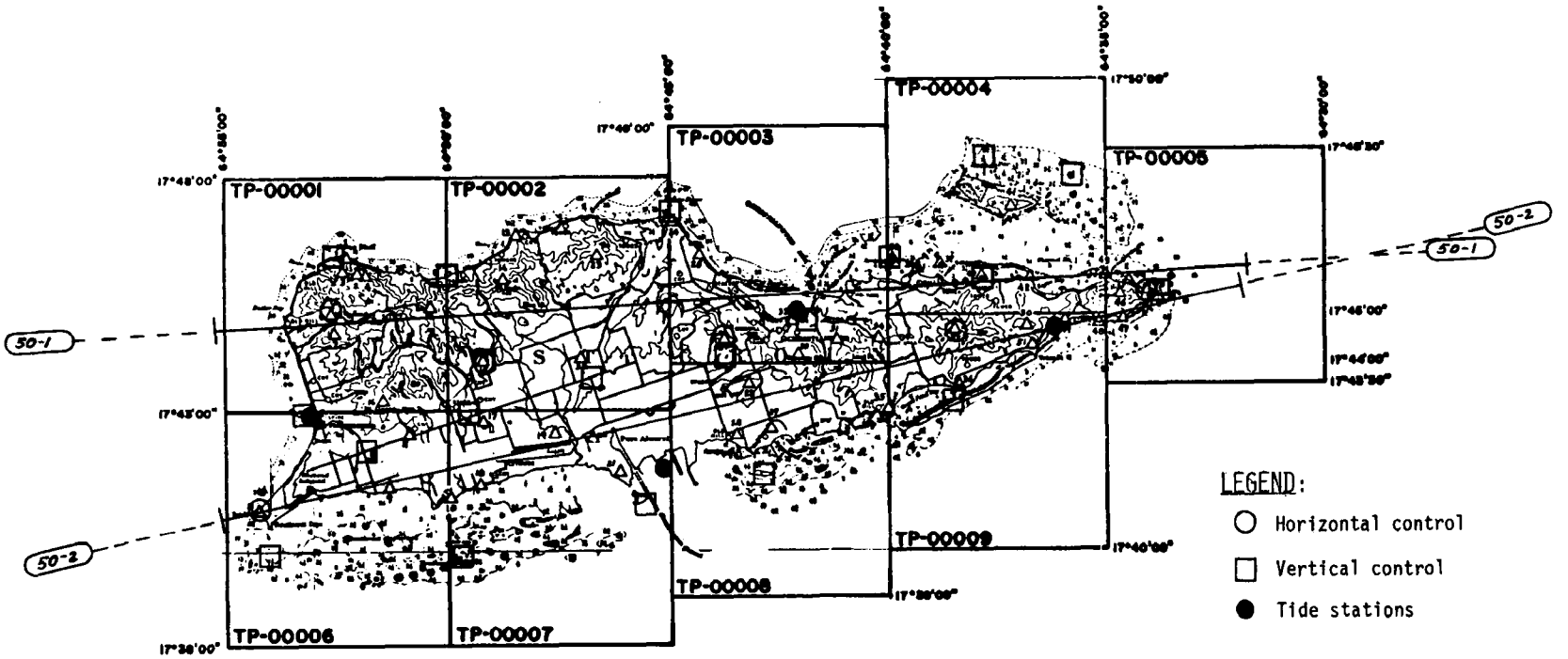


FIG. 1. — Job diagram.

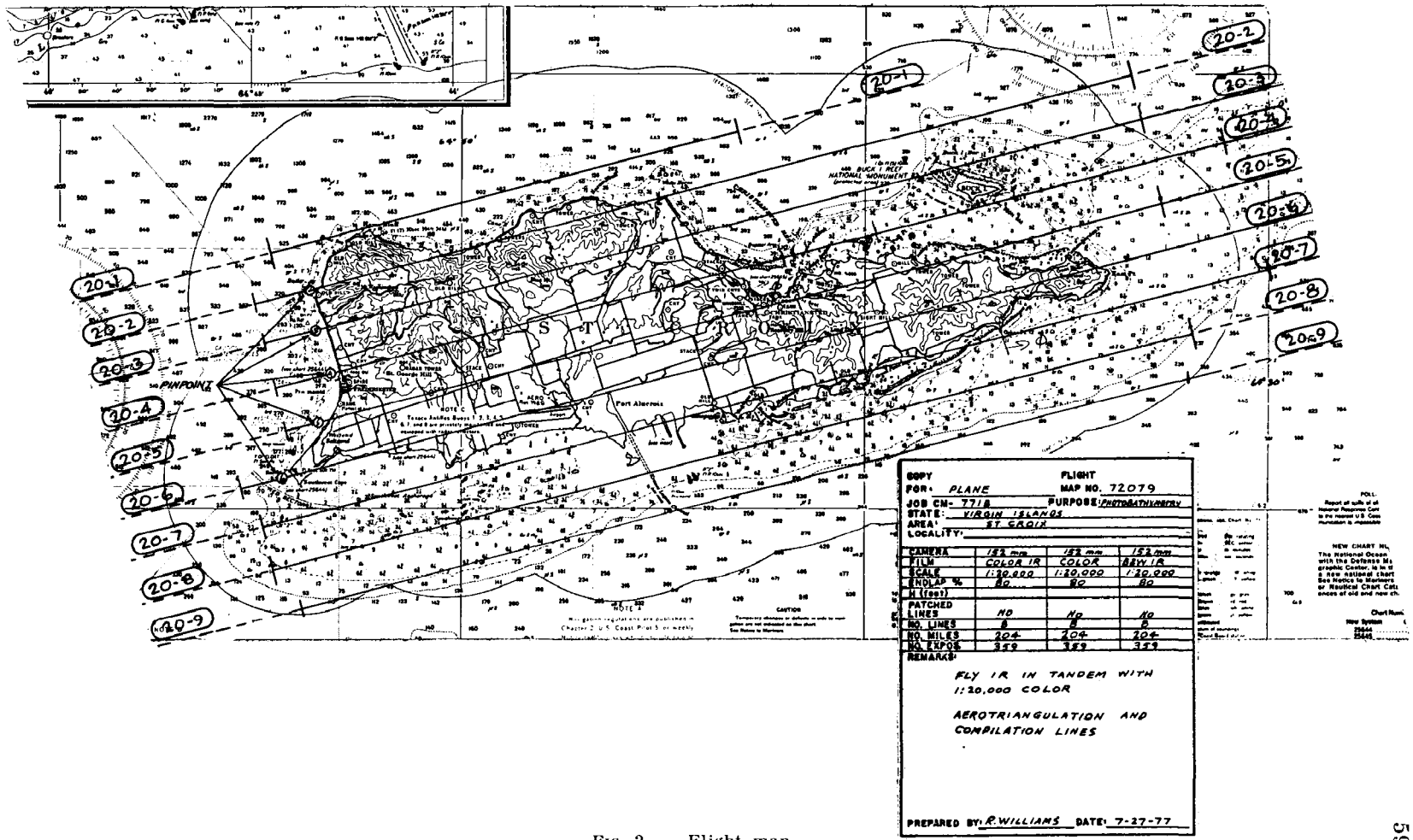


FIG. 2. — Flight map.

Field instructions

Detailed field instructions provide the field personnel with specifications and a schedule for the premarking task. Panel dimensions are dependent on photography scale, and have been standardized to result in the optimum image size at each scale. Field instructions for the St. Croix project are given in Appendix A.

Flight maps

Flight maps are prepared for use by the Air Photo Mission in visual navigation of the flight lines. In addition to flight lines, the maps provide specifications for scale, emulsion, camera focal length, end-lap, and number of exposures required. Two types of map bases are provided; a nautical chart section is used to give sufficient ground detail for precise navigation, and a smaller scale aeronautical chart base is used to indicate controlled airspace, restricted areas, traffic patterns, and general aeronautical information. A typical flight map is shown in figure 2.

Where the project calls for block adjustment in the aerotriangulation phase, 60 % side lap is required. However, when adjacent strips are to be reduced only individually complete coverage must be assured, and flight lines are usually designed to provide a minimum of 20 % side lap.

Sunspot considerations

Relative and absolute orientation of stereoscopic models which fall primarily or entirely in water areas are dependent upon visibility of bottom features, as is the entire compilation process. Therefore, sunspot is an important consideration in planning both aerotriangulation and compilation photography. The photographic sunspot is a function of the latitude of the project area, time of the year, time of day, and surface conditions of the water. All but the latter are known and can be used to predict the size and position of the sunspot on the photography. The optimum sun angle of 20-25 degrees provides maximum bottom illumination and tends to minimize the sunspot problem. However, since aerial photography cannot be limited to the short period of optimum sun conditions, a sunspot diagram is constructed as a planning aid (see figure 3). Where possible, flight lines are positioned to place the spot on land or on a part of the photography which will have a minimal effect. In addition, 80 per cent photographic endlap is usually assigned to allow a better selection of stereoscopic pairs with respect to the sun problem.

FIELD SUPPORT

At this point, job planning is complete. Field personnel are provided all data, requirements, and operational plans in advance of their arrival on the working grounds, well ahead of the date scheduled for the start of photography.

DATE: 1 NOVEMBER 1977

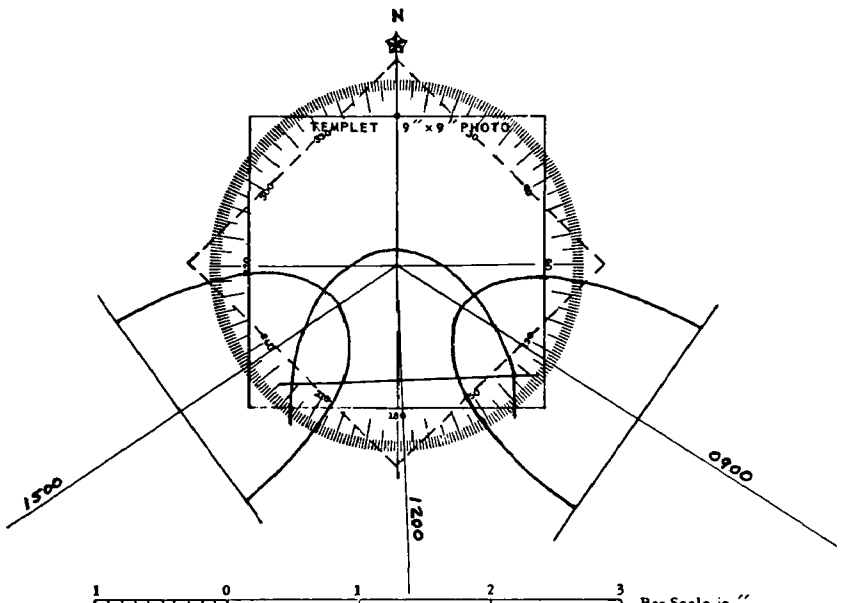
LOCALITY: ST. CROIX, VI

FORM C&GS-6313 (8-62)

U.S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY

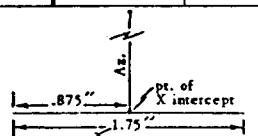
SUN SPOT COMPUTATION

REMARKS:



S T	S T ± W/E (zone diff) G M T	Nautical (or Air) Almanac G H A (Sun)	Dec. N/S	Sight Reduction Tables H.O. Pub. No. 249 GHA ± W/E (Long.) L H A	H_c	Z_n	Formulae X=1.5 Cot H_c	Formulae Y=.875/Sin H_c
h	h	°	°	°	°	°	"	"
0900	1300	19	15	314	34	123	2.2	1.6
1200	1600	64	15	359	58	178	0.9	1.0
1500	1900	109	15	44	36	236	2.0	1.5

Standard meridians	Zone diff
A.S.T.	+4h
E.S.T. - 75° W	5h
C.S.T. - 90° W	6h
M.S.T. - 105° W	7h
P.S.T. - 120° W	8h



Location of photography	
Longitude	Latitude
65° W/E	17° N

Notes: 1. X - gives distance in inches to X intercept.
2. Y - gives distance in inches from X intercept to Y intercept.

USCOMM-DC 6044-P62

FIG. 3. — Sunspot diagram.

Recovery of existing control

Horizontal and vertical control stations specified for premarking are searched for and, hopefully, recovered. If a station cannot be recovered, a nearby station may be a suitable substitute. Total lack of control in a designated area requires a conventional ground survey from the nearest control to establish a new position or elevation.

Premarking of control

Stations selected and recovered for premarking are targeted with panel arrays of the size and shape specified in the field instructions. The centre panel and recognition wings are usually prefabricated at the field headquarters from one-by-two inch strips of wood and white plastic sheets having a thickness of approximately 8/1,000 inch.

Where possible, control stations are paneled directly on the station mark, but this is often not the case due to the line of sight from the flight line to the target being obstructed by buildings, trees, or ground relief. A nearby substitute station must be paneled when this problem occurs, and its position or elevation must be transferred from the home station by conventional ground methods. In areas of sparse vertical control, elevations of new stations which are located near the shore may be determined by water level transfer from the nearest tide gage. Vertical control panels must be carefully constructed to insure they are flat and lie in a horizontal plane.

In some areas, vertical control must be extended into the water; several techniques have been applied successfully. Shallow water areas are conducive to fixed targets mounted on the bottom or on stands fixed to the bottom where bottom composition permits. A new technique was used for the St. Croix project. Large scale photography at 1 : 3 000 was obtained by the Air Photo Mission over each control area located in the water. The film was processed in the field, and selection was made of photoidentifiable features which would appear on the 1 : 20 000 scale aerotriangulation/compilation photography. At a later date, boats were directed over these features by a small aircraft with radio communication to the boats, and leadline soundings were recorded along with the date and time. Once reduced to the sounding datum, these points can be used for vertical control.

Tidal observation

Aerial photography for compilation of photobathymetry does not require coordination with a specific tidal datum. The shoreline and the zero sounding curve can be contoured stereoscopically during the compilation phase. However, since the photogrammetric soundings must be reduced to the sounding datum, as in conventional hydrography, the height of water relative to this datum must be known during the time of photography, and tidal observations are required.

There are three possible tidal datum situations that may occur, each of which requires a different level of effort by the field support unit.

1. *No tidal data in the project area* — In this case, the field unit is required to install and maintain tide gages at specified locations for a period of time sufficient to determine the tidal datums. It is not necessary for the datums to be known during the aerial photography phase since this information is not required until the compilation phase. The operating tide gages will automatically record all water level data needed during the photography.

2. *Tide gages already in operation* — The only responsibility of the field unit is to verify that all gages are operating properly at the time of photography.

3. *Recoverable tidal benchmarks only* — In this case, the field unit must recover the tidal datum by leveling procedures and install a temporary tide staff for use during the project.

Field support during the photography phase

All horizontal and vertical control panels must be monitored every few days to be sure they are still in place and have not been damaged by the elements or by vandalism. If tide gages are in operation, periodic checks are made to verify they are running properly. When manual tidal observations must be made during photographic flights, tide staff readings are recorded at 15 minute intervals along with time and date.

Post-photography requirements

After completion of photography, all panels are removed, all remaining ground survey work is completed, and a field report is prepared covering all pertinent operations performed. Data from the support work is finalized and forwarded with the report to NOS headquarters for dispersal to office units which will carry out the next phase of the project.

APPENDIX A

Chief, Coastal Mapping Division
Atlantic Marine Center
National Ocean Survey
439 West York Street
Norfolk, Virginia 23510.

Instructions — FIELD — Job CM-7718, Shoreline Mapping and Photogrammetric Bathymetry, St. Croix, Virgin Islands.

1. Purpose

These instructions provide specifications and a schedule for paneling horizontal and vertical control stations in advance of aerial photography and for furnishing field support necessary for the completion of aerial photography.

2. Area

Shoreline mapping and photobathymetry work will cover the entire shoreline of St. Croix and Buck Island. Limit of compilation will extend offshore to a depth of 18 feet.

3. Photography

Aerotriangulation photography will be obtained with natural color film at 1 : 50 000 scale. Supplemental aerotriangulation and compilation photography will be obtained in natural color at 1 : 20 000 scale using the 88 mm lens. In addition, color infrared photography will be obtained at an approximate scale of 1 : 12 000 using the 152 mm lens in tandem with the 1 : 20 000 scale photography. This photography may be flown at any stage of tide; however, the lowest possible stage is preferred. Air Photo Mission 1 is assigned the photography task.

4. Assignment

You are assigned all field operations required to place targets on horizontal and vertical control points on land areas and to photoidentify offshore vertical control points. The Chief, Air Photo Mission 1, will be responsible for scheduling photography at the appropriate time.

5. Horizontal Control

5.1 Horizontal control requirements for aerotriangulation have been indicated on a job diagram furnished as part of the field data.

5.2 Limit recovery of horizontal control stations to those needed to meet aerotriangulation requirements. Prepare and submit recovery notes for each station for which a search was made.

5.3 New control stations, where needed, shall be established by Third-order, Class I, triangulation, Third-order, Class I, traverse with electronic distance measuring instruments, or a combination of the two methods. Detailed specifications are provided in the Director's "Instructions for Third-Order Surveys", dated 31 October 1974.

5.4 Notify the Chief, Coastal Surveys Section, if recovery of existing control does not meet aerotriangulation requirements. An alternative will be selected, if possible, to avoid establishing new control.

6. Vertical Control

6.1 Vertical Control requirements for aerotriangulation have been indicated on a job diagram furnished as part of the field data.

6.2 Offshore vertical control points are required in the general areas shown on the job diagram. Color prints of existing photographic coverage will be provided. These points will be used for stereomodel leveling in areas where leveling on shoreline points is not possible or considered weak. Select one photoidentifiable underwater feature, as near as possible to each area indicated. Prepare a sketch of each selected point and surrounding features on NOAA Form 76-53, Control Station Identification Card. Measure the depth of the point below the water surface and record on Form 76-53 along with time and date of observation. Use of a light aircraft is suggested for providing reconnaissance in selecting specific points and, using radio communication, to guide a small boat to the desired areas for identification and depth measurements.

6.3 Alternative methods such as intersection or resection may also be considered for positioning the offshore vertical control points.

6.4 The elevations of vertical panels located on land shall be established by leveling from the nearest bench mark or by water level transfer from the nearest tide station.

7. Premarking of Control

7.1 Panel each station selected to meet horizontal control requirements in accordance with specifications given on the attached sheet for 1 : 50 000 scale photography.

7.2 Use panel array No. 1; it may be modified, as necessary to conform with local terrain conditions. Any deviation from given panel and spacing dimensions should be indicated on the large-scale sketch on NOAA Form 76-53.

7.3 The distance given for dimension "C" may be increased, but not decreased.

7.4 Panel substitute stations wherever shadows or relief displacement will obscure the home stations.

7.5 In cases where the target might be subject to vandalism, select two photoidentifiable objects. Observe directions and distances to them from the home station and record with sketch and description on separate NOAA Form 76-53.

7.6 Panel each land station selected to meet vertical control requirements using array No. 2 for 1 : 20 000 scale photography. Double dimension "B" for each panel.

7.7 Vertical station panels may be offset from bench marks.

7.8 It is critical that vertical station panels be constructed so as to insure that they are flat and lie in a horizontal plane.

8. Control Station Identification Card

Prepare and submit a control station identification card, NOAA Form 76-53, for each paneled station. Observe Photogrammetric Instruction 22, Revised 30 September 1965, except as follows:

8.1 Record distances and directions in the usual manner to the center of the station panel of all targets used as substitute stations for horizontal control stations.

8.2 In the space provided for the sketch of Substitute Station A, make a large-scale sketch of the immediate vicinity showing the array used.

8.3 In the space provided for a sketch of Substitute Station B, make a smaller scale sketch that shows the relationship of the target to the surrounding terrain. Include one or more salient features to assist office personnel in locating the target on the photographs.

9. Tide Observations and Records for Photobathymetry Photography

9.1 Photography for compilation of photobathymetry does not require tide coordination with a specific tidal datum. However, it is necessary to know the stage of tide at the time of photography. Appropriate tide stations, as recommended by the Oceanographic Division, will be in operation to provide this data. The following stations will be operational before photography begins: (a) West Indies Laboratory, (b) Christiansted, (c) Fredericksted, (d) Limetree Bay.

10. Schedule

All stations shall be premarked and ready for photography by 1 November 1977. If premarking is not completed by this date, inform the Chief, Coastal Surveys Section, so that this information can be relayed to the Air Photo Mission.

11. Report

A field operations report covering all pertinent information as to field work performed is required upon completion of the field phase of the project. The report should be accompanied by all field data observed and collected and forwarded to Rockville, Attention: C3415.

12. Costs

All costs incurred on this assignment shall be charged to Task 833201.

13. Records

All field records will be routed to CAM513 for review prior to being forwarded to either the Aerotriangulation Section or a compilation office.

14. Modification of Instructions

If changes in procedures and methods seem advisable, please make appropriate recommendations to this office.

15. Receipt

Receipt of these instructions shall be acknowledged.

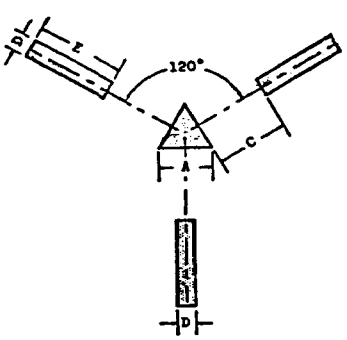
(signed)
Richard H. HOULDER,
Associate Director
Marine Surveys and Maps.

Attachment.

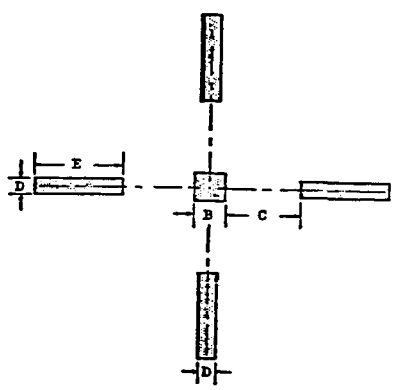
SPECIFICATIONS FOR PREMARKING CONTROL STATIONS

(Revised November 23, 1976)

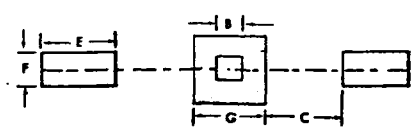
ARRAY NO. 1



ARRAY NO. 2



ARRAY NO. 3



Note :

1. The dimensions and centering of center panel over station or substitute station are critical.
2. Panel array No. 1 is preferred, but No. 2 is acceptable.
3. Array No. 3 — for contrast in very light colored areas.
   The border surrounding center panel and the recognition panels shall be in black.
4. Chief of party will select array that makes best application of field conditions and is authorized to adjust or omit one of the recognition panels if terrain is not suitable for placement of entire array.

Photography scale	*Panel and spacing dimensions (in meters)*						
	A	B	C	D	E	F	G
1:10 000	0.5	0.3	1.3	0.2	0.9	0.9	1.5
1:20 000	1.1	0.7	2.6	0.4	1.8	0.9	1.9
1:30 000	1.6	1.0	3.9	0.5	2.7	0.9	2.2
1:40 000	2.2	1.3	5.2	0.7	3.6	0.9	2.5
1:50 000	3.2	2.0	7.8	1.1	5.4	1.8	3.8
1:60 000	3.8	2.3	9.1	1.3	6.3	1.8	4.1
1:70 000	4.4	2.6	10.4	1.4	7.2	1.8	4.4
1:80 000	5.0	3.0	11.7	1.5	8.0	1.8	4.8
1:100 000	6.4	4.0	18.2	2.2	10.8	3.6	7.6