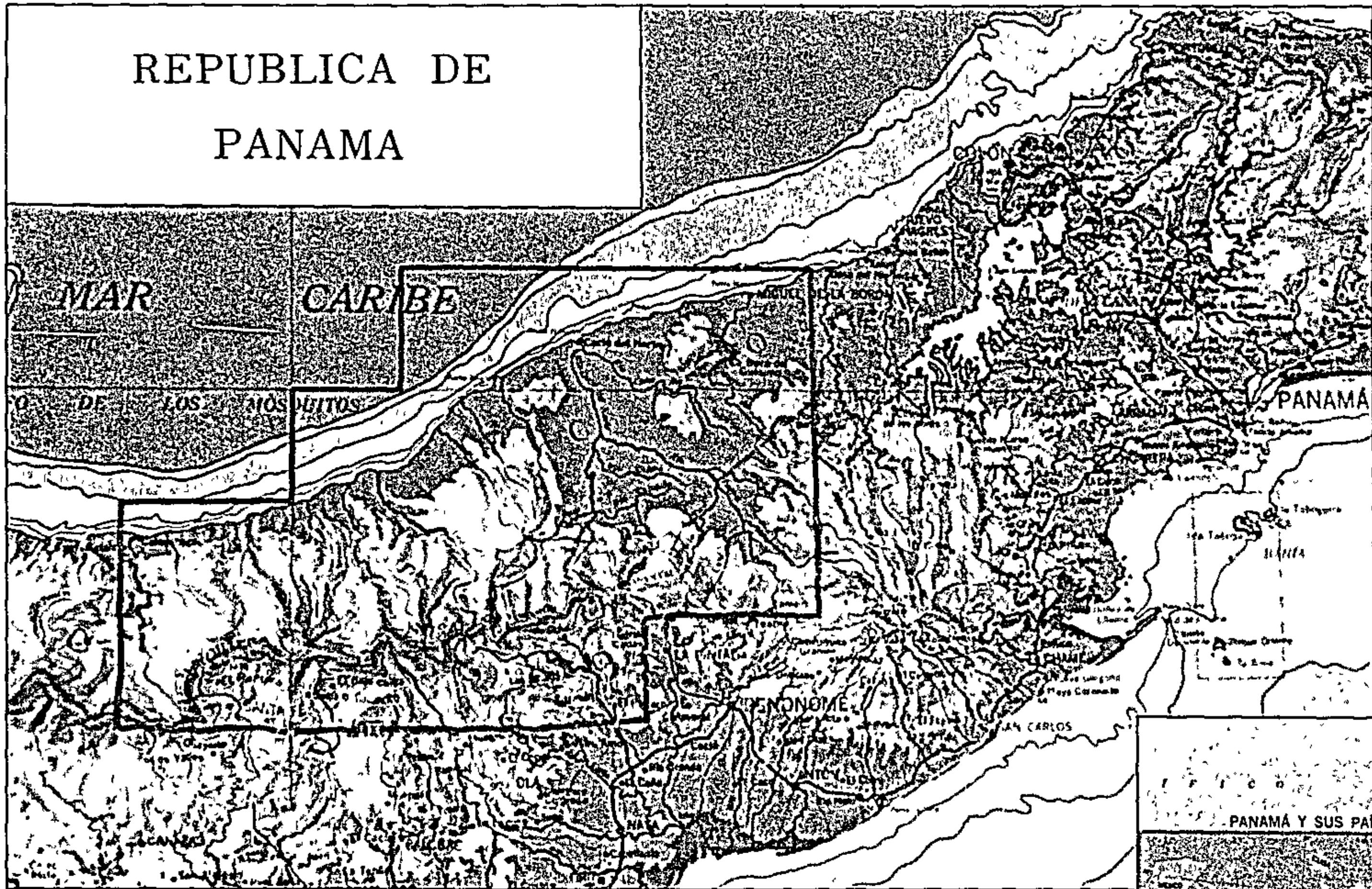
No. 40

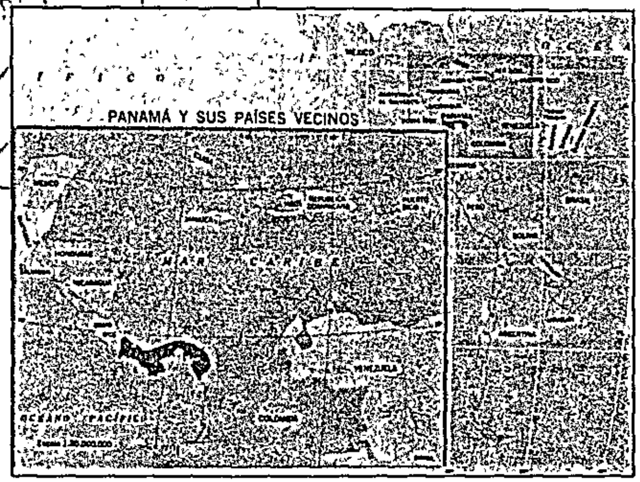
THE TOPOGRAPHIC MAPPING PROJECT OF THE CARIBBEAN COASTAL AREA OF THE REPUBLIC OF PANAMA

FINAL REPORT

March, 1981

JAPAN INTERNATIONAL COOPERATION AGENCY





MAPPING AREA

PREFACE

In response to a request of the Government of the Republic of Panama, the Japanese Government decided to conduct a survey on the topographic mapping of the Caribbean Coastal area (coverage: approximately 6,000 km^2) and entrusted the survey to the Japan International Cooperation Agency (JICA).

The JICA sent several survey teams to Panama during the period from January 1979 to October 1980 and conducted the field survey including aerial photography. Following the field survey, aerial triangulation, stereo-plotting, scribing, printing, etc. were carried out in Japan and the present final report has been prepared together with the 1/50,000 topographic maps (12 sheets).

I hope that this report and the topograhic maps will be useful as a basic reference for development of the project area and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Panama, particularly the National Geographic Institute "Tommy Guardia", for their close cooperation extended to the teams.

March 1981

Keisuke Arita

President

Japan International

Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Keisuke Arita

President

Japan International Cooperation Agency

Tokyo

March, 1981

Tokyo

Dear Sir,

Upon the successful completion of the topographic mapping project of the Caribbean coastal area of the Republic of Panama, which was started from January 1979 at your request, I herein submit to you the final report on the project comprising a progress report and a comprehensive report.

The results of the project can be attributed to the concerted efforts made by members of the survey team and Panamanian counterparts from the National Geographic Institute. Truly, our technical cooperation has been brought to fruition through the project.

On behalf of the survey team I hereby express my heartful gratitude to the officials of our government who gave kind guidance to us during the execution of the project, the officials concerned of the government of the Republic of Panama, and those of the Japanese Embassy in Panama who helped us.

Yours sincerely,

Kazuo Muraoka

Kazuo Muraoka

Leader, Survey Team

Topographic Mapping Project of the

Caribbean Coastal Area

Republic of Panama

International Engineering

Consultants Association

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I. Introduction

As a project in the international technical cooperation programs, the Government of Japan undertook a mapping project in the Republic of Panama. A three-year project was inaugurated in 1979 with an aim to prepare 1/50,000 topographic maps covering an area of about 6,000 km^2, which includes the northern part of Colón Province, the northwestern part of Coclé Province and the northern part of Verguas Province (See the illustration on the front page.) It has been completed almost as scheduled. Upon the successful completion of the project, this final report has been prepared. A summary of the progress of the first- and second-year work and a progress report on the third-year work are given in Part II, and a comprehensive report in Part III.

We hope that the results of the survey will contribute to a future development plan of the project area and also that the present report will help the authority concerned draw up a future survey plan and carry it out.

II. Progress Report

1. Summary of the works through the 2nd year.

The following is excerpted from progress reports on the work through the second year. For details, refer to the respective progress reports on the first- and the second-year works.

1-1 First-year work

1-1-1 Field staff

The Japanese side: 11 persons

The Panamanian side: 5 persons

1-1-2 Period of the field work (from the time of departure unit time of return to Japan).

January 27, 1979 to April 18, 1979 (82 days)

1-1-3 Type and volume of the work

Type of the field work	Planned	Executed	Output
Control point survey (by NNSS)	9 points	9 points	100%
Aerial photography	8,000 km^2	5,900 km^2	74%
Signalization	0	2	To cope with the following year's work in relation to aerial photography

1-2 Second-year work

1-2-1 Field staff

The Japanese side: 12 persons

The Panamanian side: 8 persons

1-2-2 Period of the field work (from the time of departure until time of return to Japan)

August 29, 1979 to December 27, 1979 (121 days)

1-2-3 Type and volume of the work

Type of the work	Planned	Executed	Output
Field work			
Aerial photography	2,100 km^2	2,085 km^2	99.3% (Aerial triangulation is possible over the whole area)
Control point survey (by NNSS)	4 points	4 points	100%
Signalization	4 points	5 points	120%
Indirect leveling	7 points	7 points	100%
Prick control points	8 points	8 points	100%
bench marks	400 km	400 km (70 points)	100%
Field identification	whole area	whole area	100%
Domestic work			
Aerial triangulation	100 models	100 models	100%

2. Third-year work

Aerial triangulation was continued through the third year from the previous year, and completed. On the basis of the results from this, plotting and compilation were done. With the reproduction of the manuscripts, field completion was conducted. Thus, field-completed manuscripts were prepared. Prior to the field work, Panamanian counterparts were notified in writing of such items to be discussed bilaterally or prepared on their part. After returning to Japan, drafting was made by means of the scribing method. Together with Panamanian counterparts on a visit to Japan, the proofs were checked jointly. After the proof prints were approved by them, printing was done.

2-1 Aerial triangulation

Aerial triangulation was conducted by means of the block adjustment method by independent models in an analytic manner. The program used for this is the one called PAT-M.

The number of models totaled 150. Accuracy was high. With regard to the horizontal residual in control point, the mean error was ±1.22 m and the maximum deviation from mean value 2.35 m; regarding the residual of height, the mean error was ±0.73 m and the maximum deviation from mean value -1.60 m.

2-2 Plotting and compilation

For the sake of plotting and compilation, the Swiss Wild A-8 Model stereograph plotter was used. On the basis of 1/60,000 aerial photographs, a 1/50,000 map was plotted. The sheet line was 15' (east to west) x 10' (north to south), and the contour interval 20 m.

Plotted area: 5,700 km^2 (Of the total area, 500 km^2 were the blank parts in the existing adjacent maps)

Compiled area: 5.956 km^2 (Of the total area, 756 km^2 were for the sea area compiled from the data on the nautical chart.)

Number of sheets: 12

Sheet material used: Microtrace NSW#500

The applied map format was based on the MT-321 format used by the National Geographic Institute of Panama (Institute Geográfico Nacional "Tommy Guardia", hereinafter referred to as "IGN".)

2-3 Field completion

2-3-1 Outline of the work

(1) Work at the IGN office in Panama City

Efforts were directed to drawing the political boundary, noting place names and other notes, including their position and spelling, obtaining the confirmation and approval by the Panamanian side and consulting with them on future work such as drafting and printing.

(2) Confirmation in the field

Confirmed in the field through the supplemental survey were questionable and dubious points raised during the period of plotting and compilation, and suspected secular changes in some districts. Thus, a field-completed manuscript was prepared. The field work was done by a joint team consisting of four Japanese and three Panamanian counterparts. Additional two teams were organized by the Panamanian side, each of which was composed of two Panamanians.

(3) Materials used

Copy of the compiled manuscript: Diazotraceter 0.08mm thick

Copy of the compiled manuscript: Indigo printing

2-3-2 Organization of the survey team and the period of activity in the field

Leader (general) Kazuo Muraoka: Aug. 22-Sep. 5, 1980
Oct. 3- Oct. 20

Member (sub-leader) Masao Sato Aug. 22- Oct. 20

Member (coordinator) Toshio Hayashi Aug. 22-Oct. 20

Member (chief surveyor) Tadakichi Uchiyama Sep. 7-Oct. 15

Member (technical coordinator) Sadao Watanabe Aug. 22-Sep. 20

Member (surveyor) Nobuo Shimizu Sep. 7-Oct. 15

Member (surveyor) Shigetaka Matsuo Sep. 7-Oct. 15

Member (surveyor) Shinichi Onda Aug. 22-Oct. 15

Mr. Watanabe was mainly engaged in consultations with Panamanian counterpart on drafting and printing.

For the sake of the survey work, the following two persons flew to Panama from Japan:

Kazuo Yoshida, Geographical Survey Institute (field superintendent)		Aug. 22-Sep. 5 Oct. 3-Oct. 20
Hiroshi Kimura, Japan International Cooperation Agency (coordinator)		Aug. 22-Sep. 5 Oct. 3-Oct. 20

During their stay in Panama, they consulted the Panamanian side, and supervised the work. At the same time, they took necessary measures for the maintenance of materials, equipment and vehicles. (See the Annex on pp 9-17.)

2-4 Drafting and printing

2-4-1 Drafting

On the basis of the field-completed manuscript and other related source maps and in compliance with the map format MT-321, drafting was executed by means of the scribing method. The plate was separated into five colors. Also, necessary masks and positives were made. The punching method was applied for registering.

The following materials were used for drafting:

Scribing base (0.12mm thick) yellow base, K and E Co.
Masking base (0.12mm thick) peel coat, Kimoto Co.
Polyester base (0.12mm thick) Diamat, Kimoto Co.
Negative film (0.12mm thick) COS-7, Dupont (final negative)
Negative film (0.06mm thick) COS-7, Dupont (used for the work)

After drafting was completed, multicolor composite print was produced on polyester base and subjected to proof reading and inspection.

2-4-2 Printing

Printing was done by offset method in five colors. Printing plate was made by photomechanical process. A total of 12 sheets were made and 1,000 copies were printed for each sheet.

For proof five-color proof print was prepared. Prior to proceeding to the final printing, approval was obtained from an authorized Panamanian counterpart on a visit to Japan.

3. Progress of the project

Following is the progress of the topographic mapping project of the Caribbean coastal area of the Republic of Panama:

Date	Item	Contents
Jan. 7, '77	Request	Request of the Panamanian Government to the Japanese Government concerning technical cooperation for a mapping project for the area.
Dec. 19 - Dec. 23	Preliminary survey	Dispatch of a contact mission to Panama to obtain details of the project.
Jun. 10 '78 - Jul. 29	Preliminary survey	Visit to Panama of a preliminary survey team for the project (for consultation with the Panamanian side on the S/W and field reconnaissance)
Jan. 27 '79 - Apr. 18	1st-yr. work	Arrangements for the 1st-yr. work, field work (satellite observation, signalization, aerial photography)
Feb. 2		The S/W signed by both parties
Jun. 30 - Jul. 15	Visit of Mr. Tejada, Director IGN, to Japan	Arrangements for the project
Aug. 29 - Dec. 27	2nd-yr. work	Field work (satellite observation, signalization, aerial photography, leveling, pricking, field identification)
Dec. 28 -Mar. 31, '80		Domestic work (aerial triangulation)
Feb. 11, '80 -Apr. 10	Visit of Messrs. Rodriguez, Oilvero to Japan	Individual training (geodesy)

Date	Item	Contents
Jul. 19 - Aug. 14	Visit of Messrs. Feliu, Sopalda to Japan	Individual training (photogrammetry)
Apr. 11 - Aug. 29	3rd-yr. work	Domestic work (aerial triangulation, plotting, compilation)
Aug. 22 - Oct. 20	3rd-yr. work	Field work (field completion)
Oct. 21 - Mar. 20, '81		Domestic work (scribing, printing)
Jan. 19, '81 - Mar. 4	Visit of Messrs. Villarreal, Camarena to Japan	Individual training (cartography)
Mar. 2 - Mar. 16	Visit of Mr. Icaza to Japan	Final checking of the results
May	Scheduled	Presentation of the final results and explanation

ANNEX

RECORD OF DISCUSSIONS OF THE PHASE III WORKS OF THE TOPOGRAPHIC MAPPING PROJECT OF THE CARIBBEAN COASTAL AREA OF THE REPUBLIC OF PANAMA

The Japan International Cooperation Agency (hereinafter referred to as "the JICA") and the National Geographic Institute (el Instituto Geográfico Nacional "Tommy Guardia", hereinafter referred to as "the IGN") had meetings on October 6, 10, 13, 15, 16 and 17, 1980. During these meetings, on October 15, Ing. Julio Mock C., Minister of Public Works, expressed his appreciation to the successful progress of the project as a first big project of the Japan's technical cooperation and also stressed that the results are invaluable for the planification of development of mining and other natural resources and regional development of the area, requesting further cooperation in mapping of other areas needed for urgent development.

Both sides acknowledged the progress of the work of the Phase III field completion (or revision in the field), carried out in Panama and agreed on some additional points of the application of the map format and future schedule of the remaining part of the project as follow:

1.- Progress of the work

On the basis of the Record of Discussions signed on September 2, 1980 (hereinafter referred to as "the R/D"), field completion has been carried out in Panama with the colaboration of the IGN and the JICA survey team as follows:

1) Works in the office

On the basis of the manuscript of compilation, in the IGN office, were carried out checking of notations and inserting of administrative boundaries by using source materials.

2) Works in the field

Besides two parties jointly consisting of the IGN and the JICA team members proposed in the R/D, the IGN organized two parties by itself. By these four parties, works were carried out not only for the areas proposed in the R/D, but also for almost all sheets concerning the clarification, confirmation and supplement of uncertain points found in the stage of compilation and in the above office works.

3) Revision of the copies of the original manuscripts

By using the results surveyed by the above works 1) and 2), the copies of the original manuscripts were revised, which were acknowledged by both sides.

2.- Map format

1) Marginal information

According to the understanding done in the R/D, the JICA proposed an example of marginal information, which was confirmed by the IGN.

2) Materials for marginal information

Information for magnetic north, "DIAGRAMA DE COMPILACION" and "DIAGRAMA DE LIMITES" for each sheet was submitted from the IGN to the JICA survey team.

3) Application of the map format

Besides the items concerning the application of the map format discussed in the R/D, some additionals and amendments were proposed by the IGN and agreed after discussion as given in the appendix I.

3.- Schedule for the succeeding works

Schedule for the succeeding works of the project to be carried out in Japan will be as follows:

1) Revision of the original manuscripts

The original manuscripts will be revised by using the revised copies of the original manuscripts mentioned in the paragraph 1-3). The confirmation of this work will be entrusted to the JICA survey team.

2) Scribing and printing

On the basis of the revised original manuscripts, scribing and printing will be carried out from November, 1980 to March, 1981.

4.- Training in Japan for the Panamanian counterparts

The IGN expressed its intention to send the Panamanian counterparts to Japan for the training of scribing and printing works to be carried out in Japan.

In response to the IGN's intention, the JICA suggested that it would be appropriate for the IGN to send three counterparts (two for scribing and one for printing) to Japan during the period from mid-January to mid-March 1981, considering that the training involves such important task as checking of scribed sheets and final approval of proof-prints by them.

The IGN acknowledged such importance of the training and promised to take necessary measures including the presentation of application form to the Japanese Embassy in Panama as soon as possible.

5.- Disposal of the survey equipment and materials in Panama

With regard to the JICA's survey equipment and materials to be left in Panama, as listed in the Appendix II, the IGN expressed the intention to make them availabe for the IGN for its future works according to the Scope of Work signed on February 2, 1979 (hereinafter referred to as -- "the S/W").

The JICA suggested the IGN that provision of such equipment and materials would be made based upon the IGN's formal request letter submitted to the JICA Headquarters through the Japanese Embassy in Panama, and also such provision would be undertaken in Panama concurrently with the presentation of the final results of the project.

The IGN accepted the suggestion and promised to take good care of such equipment and materials for their custody until the time of presentation of the final results.

6.- Presentation of the final results

1) The JICA and the IGN discussed in details on the final results which are to be presented by the JICA to the IGN in/around May 1981 in Panama. Both sides agreed upon as shown in the Appendix III, after some revisions on the list of the final results attached to the S/W.

2) Referring to the printed topographic maps which are invaluable outcome of the joint work of Japan and Panama, the IGN agreed that some

extra copies (ten copies) could be made available for the JICA for its commemorative distribution to the organizations concerned in Japan.

3) The IGN also agreed that there would be no restrictions on duplication of the printed topographic maps (whole or a part of a sheet) for publications (such as technical periodicals) by the JICA or its approved organizations, provided that each copy of such publications — should be forwarded to the IGN for its reference.

At Panama City, October 17, 1980

On behalf of the JICA

MR. KASUO YOSHIDA
Technical Adviser of the
Japanese Mission

On behalf of the IGN

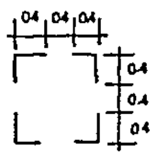
ING. JOSE A. TEJADA S.
National Director
MOP - IGNTG

Appendix I

APPLICATION OF THE MAP FORMAT

1. Arrangements of numerals for grid should be on the same lines as those of the adjacent sheets on the east side and on the same rows as those of the adjacent sheetson the south side.

2. The minimum size of the cemeteries on the map should be as follows:



3. Style and size for the name of triangulation stations, including notation "NNSS" for/NNSS stations, should be the same as those specified for "Mirador" given in No. 208, MT 321.

4. Paragraph 2, (1)-a in the Appendix IV of the R/D should be read as follows:

   "They shall be indicated in the map in case only one "PROVINCIA" and/or "DISTRITO" exists in one sheet. However, "PROVINCIA" and/or "DISTRITO" shall be indicated along the boundary in case there are two or more "PROVINCIA"s and/or "DISTRITO"s in one sheet."

5. Instead of notation "DISTRITO", the abbreviation "DTTO." may be used according to the space limit.

Appendix II

LIST OF SURVEY EQUIPMENT

NAME OF EQUIPMENT	QUANTITY	REMARKS
1. TOYOTA LANDCRUISER	5	Stored by JICA
2. TYPEWRITER	1	Stored by IGN
3. SLIDE-PROJECTOR	1	Stored by IGN
4. TENT	3 SETS	Stored by IGN
5. RUCK SACK	4	Stored by IGN
6. KNAP SACK	2	Stored by IGN
7. CUT BED (STEEL)	3	Stored by IGN
8. CUT BED (WOODEN)	3	Stored by IGN
9. MOSQUITO NET	7	Stored by IGN
10. SLEEPING BAG	6	Stored by IGN
11. TABLEWARE	1 SET	Stored by IGN
12. CAMPING EQUIPMENT	1 SET	Stored by IGN
13. PORTABLE GENERATOR	1	Stored by IGN
14. TOOL	1 SET	Stored by IGN
15. POLYESTER TANK	9	Stored by IGN
16. BAROMETER	2	Stored by IGN
17. WORKING SHOES	8	Stored by IGN
18. HEAD PHONE	1	Stored by IGN
19. ICE BOX	4	Stored by IGN

Appendix III

FINAL RESULTS

The category III in the list of the final results given in the Appendix III of the S/W shall be read as follows:

III Topographic Mapping

1. Pricked photos and identified photos.
2. Original manuscripts.
3. Manuscripts of restitution including blank parts of surrounding maps.
4. Diapositives.
5. Aerial triangulation results.
6. Color separation scribed sheets.
7. 1:50,000 topographic maps (12 sheets X 1.000 copies).

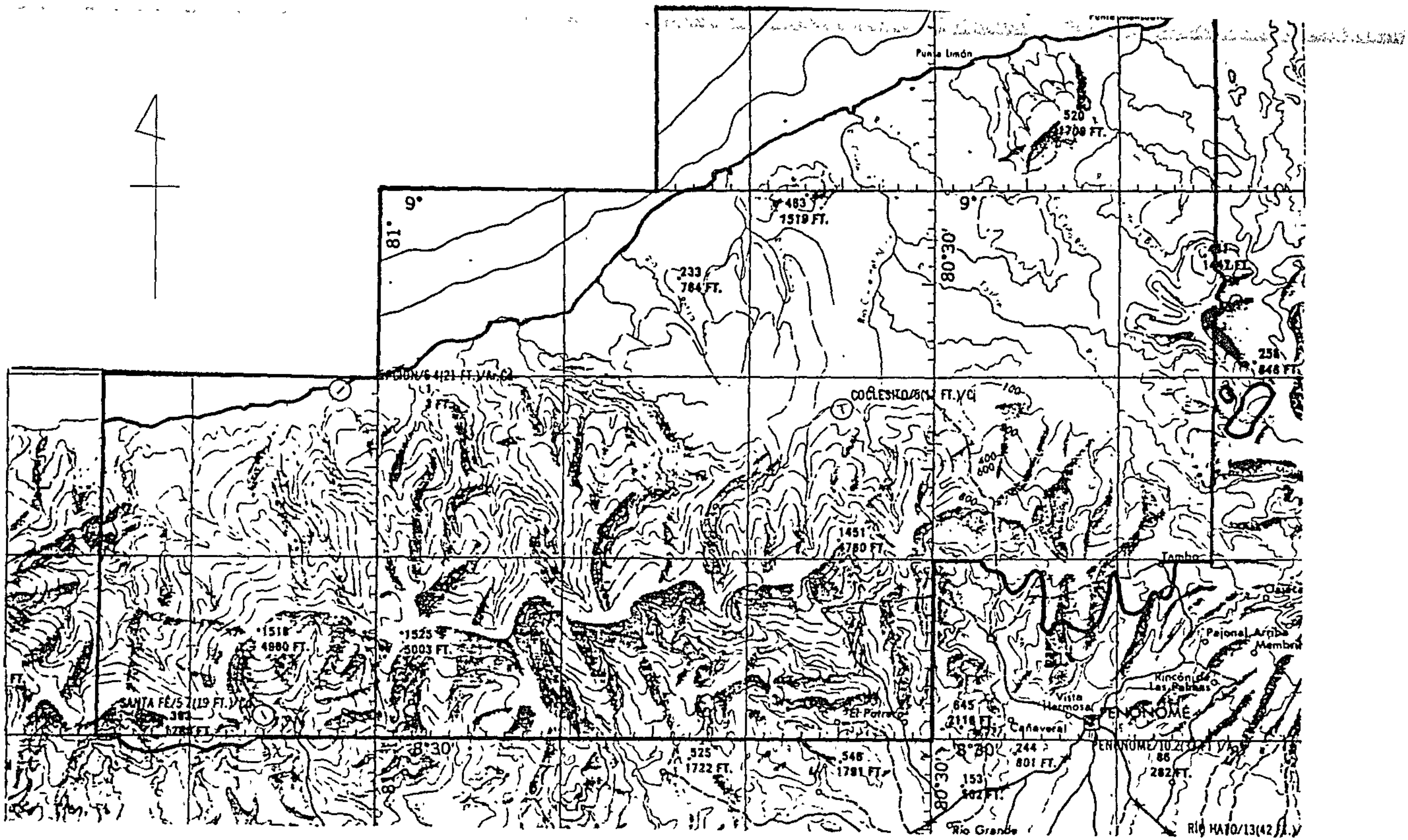


Figure 1. Project Site

III. Comprehensive Report

1. Introduction

1-1 Background of the project

1-1-1 Background of the request from the Government of Panama.

The Government of the Republic of Panama in July, 1977 requested Japan's cooperation with a topographic mapping project essential for the development of the Caribbean coastal area in the country. The background of this request is as follows:

a. So far, Panamanian efforts for national development have been concentrated on the coastal area facing the Pacific Ocean (between the boundary with Costa Rica and Panama City) through which the Pan American Highway runs. In contrast, the Caribbean coastal area which is densely forested, has been left intact. A major obstacle to the further development of the area is the fact that no basic map of the area has been prepared up to today.

b. Meanwhile, the Panamanian Government has embarked upon promoting planning of the following projects for the area:
   - Coclé del Norte hydroelectric power plant construction
   - Construction of a highway to run through the mountains in the area between Colón and Pintada
   - Development of Pataquilla copper mine
   - Development of Concrecito pasture ground
   - Development of forestry in Colón Province

These projects required the Government of Panama to prepare a topographic map for the Caribbean coastal area as early as possible. This led the government to request Japan's cooperation for its realization.

1-1-2 Contents of the request

Following are the details of the Panamanian request:

a. Content of a map: a 1/50,000 scale topographic map

b. Project area: about 6,000 km^2 (12 sheets) extending from the western part of Colón Province to the northwestern part of Conclé Province and the northern part of Veraguas Province

c. Contents of the work: plotting by means of aerial photogrammetry

d. Time of inauguration: the earliest possible date

e. Period of work: three years

f. Panamanian authorities concerned: the National Geographic Institute (Instituto Geográfico Nacional "Tommy Guardia")

1-2 Present state of surveying and mapping in the Republic of Panama

1-2-1 Basis of survey

As the reference ellipsoid, Panama uses Clarke's ellipsoid (1866) like the United States of America does. Similarly, as the datum point, the North American Datum Point (NAD 27, Meades Rauch, Kansas, 1927) is used. As the country is far away from the datum point, it is inevitable that a gap exists between the geoid and the ellipsoid.

Survey is totally based on the metric system in the country.

1-2-2 Triangulation network

Of the geodetic control networks as of 1974, the triangulation network is shown in Figure 2. There are triangulation chains along both the coastal areas facing the Pacific Ocean and the Caribbean Sea and those connecting them. These triangulation chains are part of the triangulation networks connecting the geodetic networks of the North and the South American Continents, which have been completed by the US Army Map Service, AMS, at present reorganized into the Defense Mapping Agency, DMA. Most of the triangulation chains on the Caribbean side were made later than those on the Pacific side by the second order triangulation. Due to the topographic condition there, the mean side length of each triangulation net on the Caribbean side is shorter than that on the opposite side. The old base line networks are found in four places.

1-2-3 Leveling networks

Leveling networks are shown in Figure 3. The total length of the first order leveling routes is 1,098 km, most of which are laid on the Pacific side. Such a route connecting both the coastal areas can be found only along the Canal Zone. On the Caribbean side, there are merely a few second order leveling routes. There are a total length of 1,959 km second order routes. A few years ago, the second order leveling routes were established connecting the coastal areas across the mountain range both in the central part and the western part of the planned survey area. (See Figure 11.)

The datum level of height is the mean sea level in Balboa Port derived from tide measurement. The tide was measured in two places on the Pacific side, Balboa Port and in the vicinity of David, plus one place on the Atlantic side, Colón. Of them, only in Colón was the result of tide measurement recorded.

On the Pacific side, tidal change becomes as much as several meters. On the contrary, it is just tens of centimeters on the Atlantic side. The mean sea level of the Pacific Ocean is 19.5 m higher than that of the Atlantic, according to the result of leveling.

1-2-4 Other geodetic surveys

As with other geodetic surveys, a survey of terrestrial magnetism was conducted between 1968 and 1969, and six magnetic stations were newly set up during the period. In December, 1972, a re-survey of terrestrial magnetism was conducted.

As a satellite geodetic observation, SECOR (Sequential Collation of Range) was once observed by the United States of America in 1960. However, at that time sufficient data were not obtained.

An observation by the Naval Navigation Satellite System (NNSS) was conducted by the IAGS (Inter-American Geodetic Survey) at three points along the Canal Zone. For the purpose of sounding in the Caribbean Sea, it is planned to set up more control points in the coastal area.

1-2-5 Standard specifications of geodetic control point survey

All the records of geodetic control points are being kept by the IGN. Generally speaking, no problem has been found in the maintenance of the control points, as mentioned in the section "field reconnaissance." Also, the records of the reconnaissance conducted after the installation of the control points are being kept by the IGN.

As for the shape of the control point monument, a small plate of gunmetal is buried in the top center of the concrete pole. (See the illustrated photo.)

The standard specifications of the geodetic control point survey are given in Tables 1 and 2 as follows:

Table 1. National Geodetic Networks (Horizontal)

Classification	Nationwide high precision traverse--Satellite Control	First-Order	Second-Order		Third-Order	
			Class I	Class II	Class I	Class II
Network component	Basic horizontal framework (control establishes the National Network)	Primary horizontal network (control develops the National Network)	Secondary horizontal control (control strengthens the National Network)	Supplemental horizontal control (Control contributes to the National Network)	Local horizontal control (control is referenced to the National Network)	
Nominal accuracy or precision between adjacent points	1 part in 1,000,000	1 part in 100,000	1 part in 50,000	1 part in 20,000	1 part in 10,000	1 part in 5,000
Recommended density of control	Traverses and satellite stations at 900 - 1,200 km. Stations at 15 km to limit of technical and geometric restraints	Arcs not in excess of 100 km. Stations at 12 - 20 km. Urban control 3 - 8 km.	Stations at 10 - 13 km. Urban control 1 - 3 km.	As required	As required	

Table 2. National Geoditic Networks (Vertical)

Classification	First-Order		Second-Order		Third-Order
	Class I	Class II	Class I	Class II	
Network component	Basic Vertical Network A (control establishes the National Network)	Basic Vertical Network B	Secondary Vertical Network (Control develops the National Network)	Supplemental Vertical Control (Control contributes to the National Network)	Local vertical control
Nominal accuracy between points*	$1.5mm\sqrt{K}$	$2mm\sqrt{K}$	$3mm\sqrt{K}$	$4mm\sqrt{K}$	$6mm\sqrt{K}$
Recommended density of lines	100 - 300 km	50 - 100 km	25 - 50 km	10 - 25 km	As needed

* One-half of permissible closure

1-2-6 Aerial photographs

The progress of the aerial photography is shown in Table 3 as follows: Table 3. Progress of Aerial Photography

Scale	Progress
1/30,000 ∿ 1/60,000	About 85% (figure 4)
1/16,000 ∿ 1/20,000	About 45% (figure 5)
Controlled mosaic (1/20,000 ∿ 1/50,000)	Prepared 105 sheets/ Total 220 sheets

Of the aerial photographs mentioned above, nearly all those of a 1/40,000 scale taken by the US Army cover the whole country, except for the eastern area bordering Colombia. But, widely spread areas are yet to be photographed. These remain unphotographed because of bad weather conditions. There are many such areas in the project area. Some photographs are found unclear or blank because of clouds. Not all the data required for the project, including negative films, are kept by the IGN.

Comparatively new aerial photographs of a 1/20,000 scale are also available to some extent, though they are limited to those of the Canal Zone and the Pacific side west of the Zone. However, no photographs are available for the project area except those for extremely localized parts.

Controlled mosaics from 1/50,000 to 1/20,000 have been prepared, covering almost half of the whole country.

Attempts were made to cover the areas yet to be photographed by the use of SLAR (Side Looking Airborne Radar) because it is scarcely affected by weather conditions. As for the area around Bayano Lake in the eastern part of the county, a good result was obtained from SLAR. In addition, some imageries taken by the LANDSAT were available.

1-2-7 Topographic map

The progress of the topographic mapping is shown in Table 4 as follows:

Table 4. Progress of Topographic Mapping

Scale	Sheet Lines Latitude Longitude	Colors	Progress			
			Prepared sheets	In preparation	Total sheets	Remarks
1:250,000	1° x 1°30'	6	12		12	Completed
1: 50,000	10' x 15'	5	124	6	170	Number of sheets 69% Effective area 60%
	15' x 15'		21		36	Figure 6
1: 25,000	5' x 7.5'	5	46			Canal Zone only
1: 10,000	2.5' x 3'		99			Eastern part of Azuero Pen.
1: 1,000 ~ 1: 5,000			86			Major 5 cities

A basic map is available on a scale of 1/50,000. Also available are such maps as a 1/25,000 map for the Canal Zone, a 1/10,000 map for the east coast of the Azuero Pen. facing the Pacific Ocean, and 1/1,000 to 1/5,000 maps for 5 major cities and surrounding areas.

The map projection used for the basic map and others is the UTM (Universal Transverse Mercator)--the grid zone 17 and the central longitude line, Long. 81°W. Sheet lines are marked off by latitude and longitude. Besides UTM grid lines every 1,000 m, ticks for lambert grid lines, setting 80°W as the reference longitudinal line, have also been drawn.

A map format in use is based on the revised Manual Tecnico de Convenciones Topograicas (hereinafter referred to as MT-321), which was agreed on by the South and Central American countries. The format itself and its application should be defined more concretely in future.

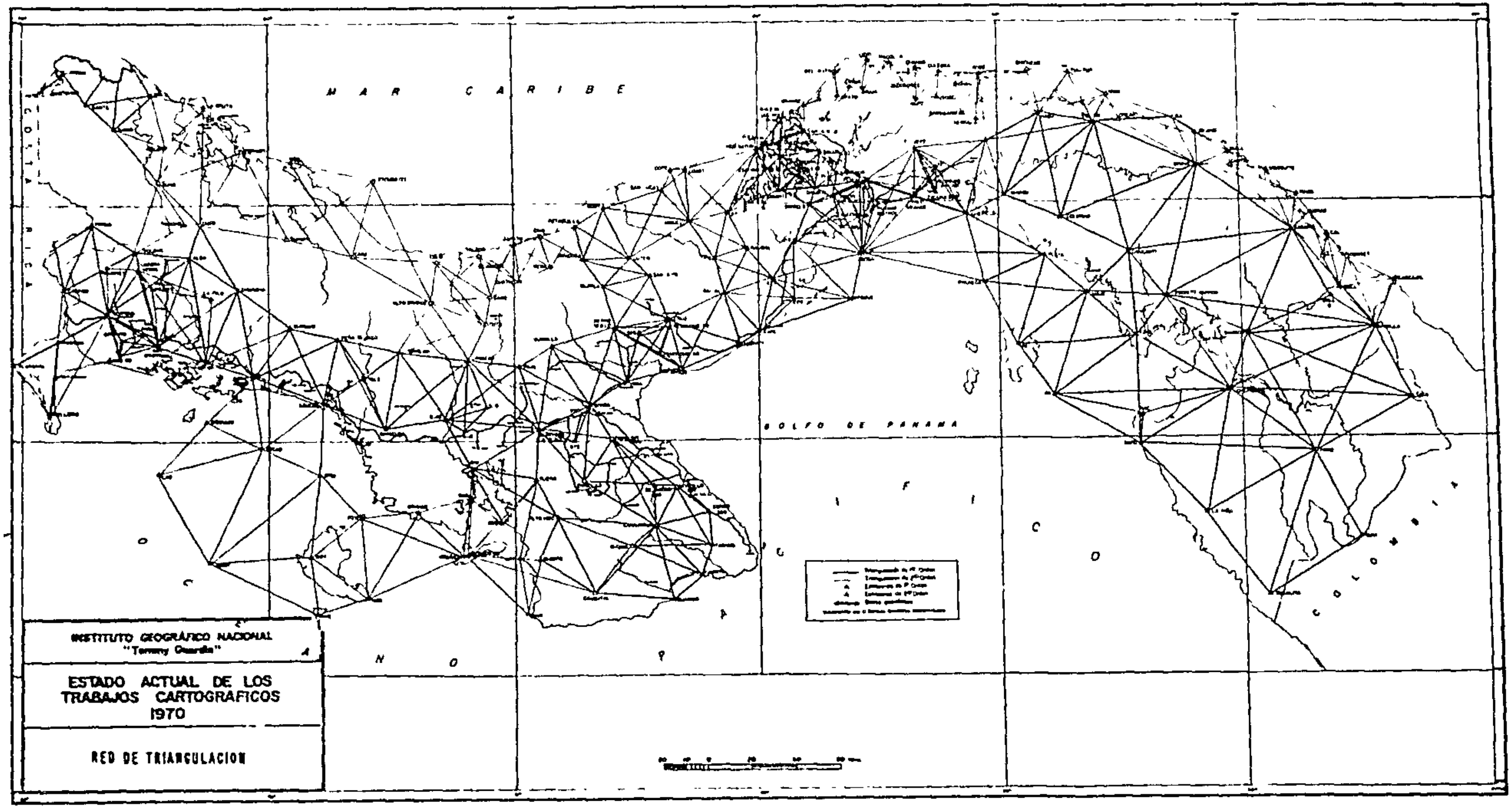


Figure 2. Triangulation Networks

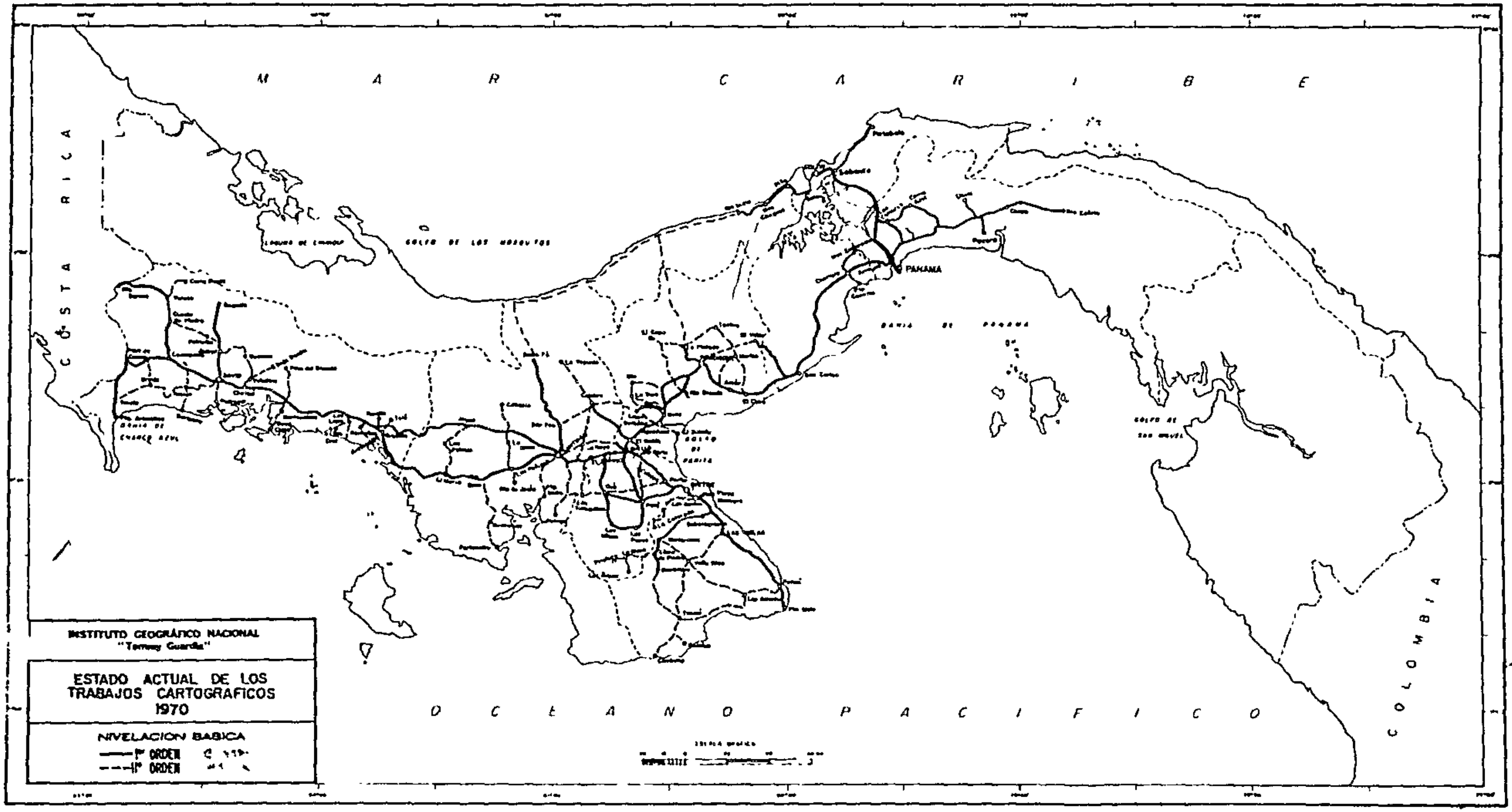


Figure 3. Leveling Networks

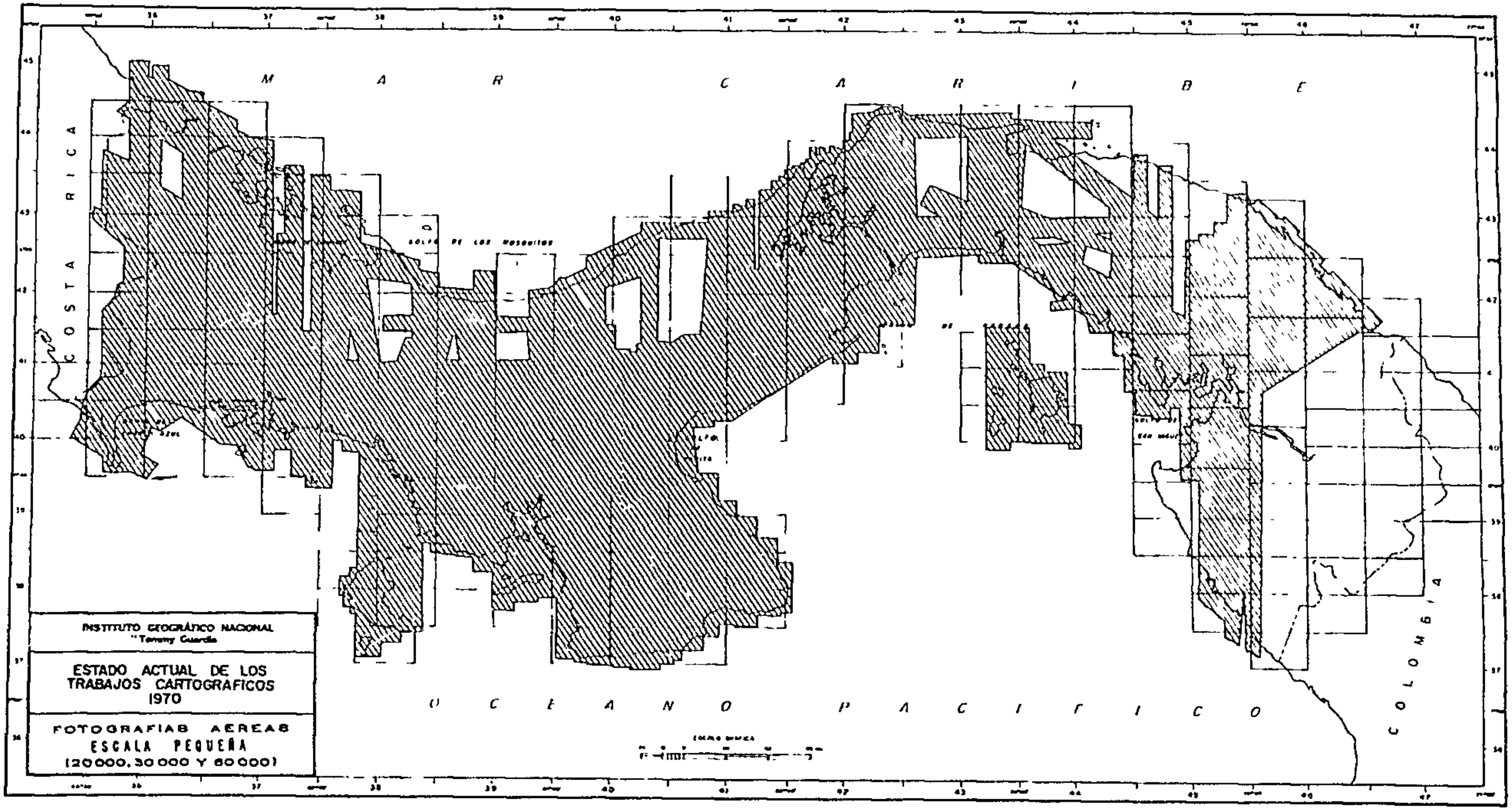


Figure 4. Aerial Photographs (1) (1/20,000 ∿ 1/60,000)

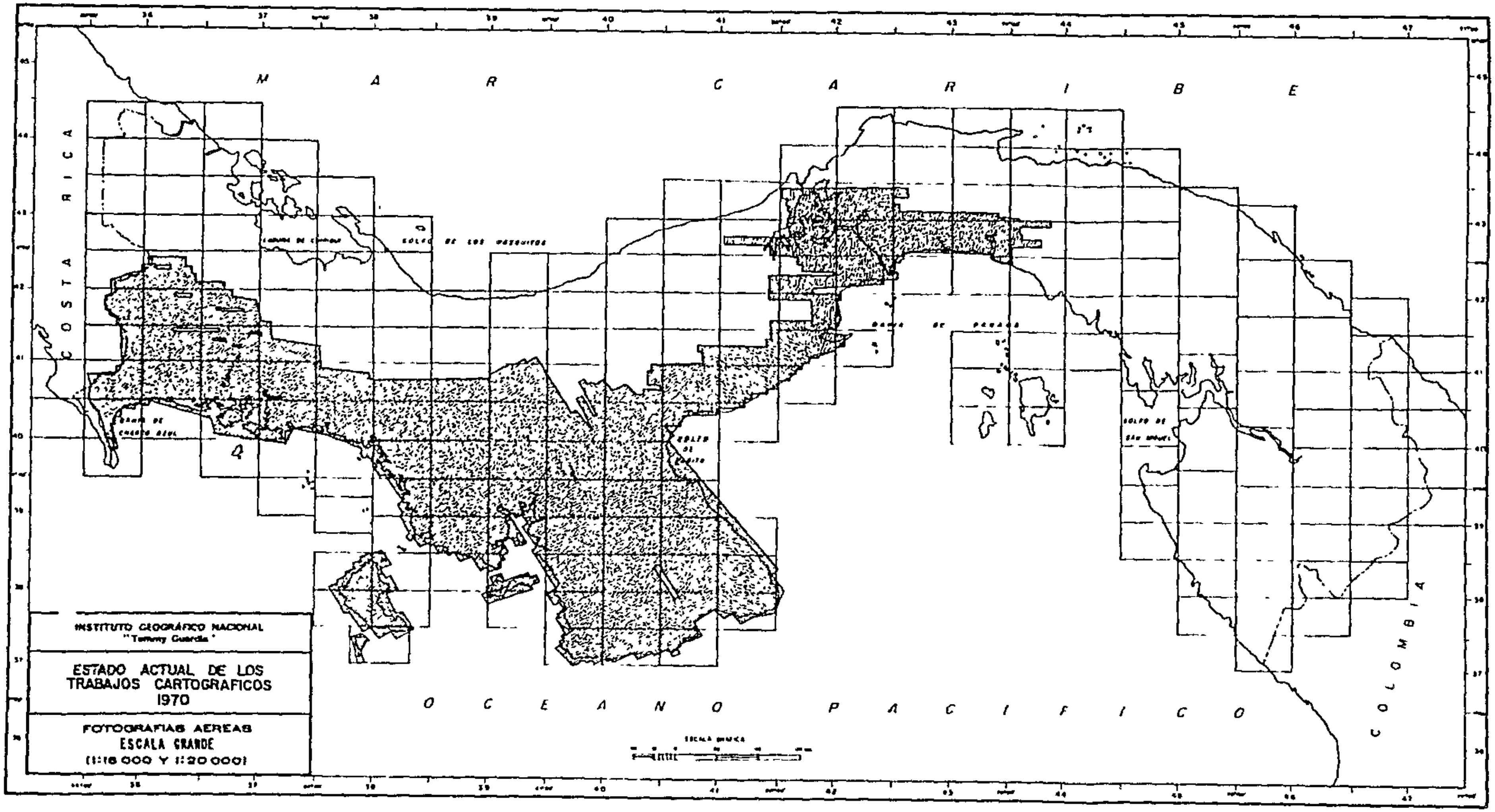


Figure 5. Aerial Photographs (2) (1/16,000 ∿ 1/20,000)

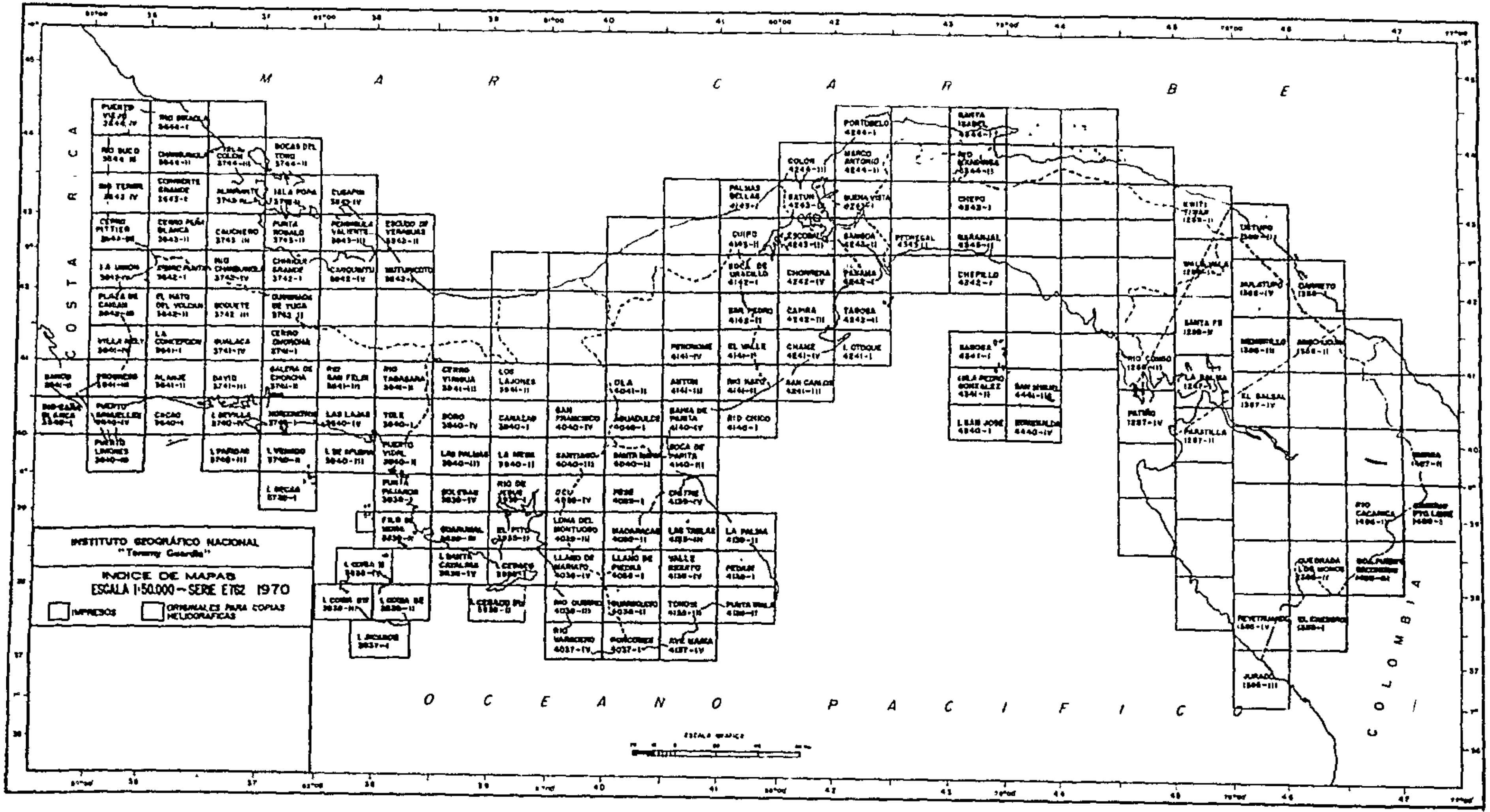


Figure 6. Progress of Topographic Mapping (1/50,000)

2. Dispatch of preliminary survey team and agreement of S/W

Prior to the inauguration of the project, the Japanese Government dispatched a preliminary survey team to Panama for 50 days from June 10 to July 29, 1978 to determine the scope of the work for the project through consultations with the Panamanian side, and to conduct field reconnaissance for working out a survey plan and a plan of operations. During the period, an agreement was reached by both sides on the S/W, a fundamental principle of the project.

Following are the important points of the agreement:

- The object of the project is to prepare a 1/50,000 topographic map. In consideration of the existance of the mountain-region in the project area, 1/60,000 aerial photographs should be taken by using a wide-angle lens.
- A map format should be based on that adopted by IGN. As for precision, JICA B class should be adopted (equivalent to DMA B class). In compliance with this, the number of control points should be determined.
- In consideration of the conditions in the field, the satellite doppler observation system (NNSS) should be used for the control point survey.
- Aerial triangulation should be done by the block adjusting method, where there is a possibility of using PAT-M. For the sea area, depth lines should be compiled from source materials available.
- As many signals as possible should be installed, as it may be difficult to prick in many cases.

3. General conditions of the project area

3-1 Field reconnaissance

3-1-1 Purpose

The purpose of the field reconnaissance is: to work out a proper survey plan for the project; to conduct a preliminary survey on necessary items related to the execution of the project in future; to determine a detailed plan for smooth implementation of the project thereby ensuring its successful fulfillment.

3-1-2 Importance of the field reconnaissance

The results obtained from the field reconnaissance, an important element of the preliminary survey, are essentially required to satisfy the following items:

(1) Drawing up a survey plan for the project.

(2) Determining a plan of operations and making an adequate estimation from the economical and reasonable points of view for the project

(3) Preparing a time schedule to ensure smooth implementation of the project

3-1-3 Background

As mentioned above, a primary importance in mapping should be attached to drawing up a survey plan and a plan of operations proper to the project area so as to obtain an effect proportional to the required cost. Insufficient preliminary survey will lead to an unsatisfactory result of the project. Efforts to make revisions once the project is underway may require additional time and expense. Therefore, the preliminary survey was organized so as to produce results proportional to the cost.

3-1-4 Study of results

(1) Method of survey

In accordance with the list of necessary inquiries, we obtained information by interview, by collecting data and by confirming or testing our inquiries in the field.

(2) Results of survey

Items surveyed in the field can be classified into the following:

a. General conditions

b. Reconnaissance of the project area

c. Investigation into materials and equipment

3-2 General conditions

3-2-1 Location

The project area is located between Long. 77°22'W. and Long. 83°00'W. in Central America which is called the Isthmus of Panama, a junction of the North and the South American Continents.

3-2-2 Gross area of the country 77,000 km^2

3-2-3 Total population 1,710,000 persons (1976)

3-2-4 Population density 222 persons/km^2

3-2-5 Population growth rate 3.2%/year

3-2-6 Official language Spanish

3-2-7 Climate

Climate is subtropical-tropical. There are both a rainy season (May to November) and a dry season (December to April). An annual rainfall on the Caribbean side exceeds 4,000mm. Humidity averages 82% through the year. Temperature averages 19°C in the mountainous region and 25°C in the coastal region.

3-2-8 Population of major cities:

Panamá	420,000
Colón	100,000
David	40,000

3-3 Reconnaissance of the project area

3-3-1 Outline of the area

The mapping project area of 8,000 km^2 or so is located in the central northern part of the Republic of Panama facing the Caribbean Sea. A mountain range with an average elevation of 1,500 m passes through the central part of the area from east to west. The area north of the range is a vast jungle untrodden in part. On the other hand, the southern side is mostly a comparatively developed Savannah.

In the jungly area, there are only a few villages located along large rivers and estuaries. Some foot paths are found around such villages. However, transportation between the villages entirely consists of either boats or canoes. In order to advance deep into the jungle, a new path has to be made by clearing the jungle. In addition, there are many hazards, including vipers. Consequently, it is very difficult to work there.

In sharp contrast, the southern side of the mountain range is comparatively developed. There is the Pan-American Highway just south of the project area. Along the well-maintained highway, comparatively large towns such as Santiago and Penonomé stand. Foods, daily necessities and gasoline are available in such towns. There are also hotels and public telephones available. It is possible to make telephone calls between these local towns and between them and Panama city.

In the field reconnaissance, we were always accompanied by Panamanian counterparts (IGN).

3-3-2 Meteorology

The project area is said to have the most peculiar weather in the country. However, there are no exact data for local weather available.

Meteorological data have been regularly collected by the IGN every day. However, they have no such data for the project area. Data available are only those on Petaquilla and Boteja provided by Cobre Panamá Corp. Consequently, it was inevitable that the preliminary survey had to resort to information obtained from the inhabitants. As a result of summing up such information, it was made clear that from the view point of meteorology, the project area can be largely divided into two parts, i.e., the region along the mountain range and the jungly region facing the Caribbean Sea.

For the sake of photography, both January and February are said to be most favorable in the region along the mountain range, and both September and October in the jungly region. More precisely, the favorable time for photography is slightly different even on the same side of the mountain range between the eastern and the western parts.

3-3-3 Access and route

Access and route are utterly different north and south of the mountain range, though the project area is not so large. (See Figure 7.) This is because the mountain range is 1,500 m high on the average and runs through the central part of the project area from east to west.

In planning and operation, due consideration should be given to the following:

(1) The sea route between Colón and Coclé del Norte often becomes unnavigable because of high waves.

(2) The river route between Coclé del Norte and Coclecito also becomes unnavigable in the dry season when the river drys up. So, navigable time is limited. What is more, in the rainy season, it is difficult to transport heavy materials upstream.

(3) The road between Coclecito and Panonomé is still under construction. So, a rainfall makes it impossible to use. An ordinary passenger car is not suitable for the road. More dependable are either a high-powered truck or a four-wheel driven jeep.

(4) When a helicopter is chartered, it should be navigated by a member of the survey team. This is because most local pilots have no flight experiences over the project area. Special care should be taken when flying the helicopter due to poor visibility caused by the frequent appearance of rain clouds over the area.

(5) There is another road available from Santiago, which crosses over the mountain range via Santa Fé. However, it does not reach Calovébora on the coast. In addition, rainfall makes it impossible to use the road.

As aforementioned, traffic conditions are poor in the project area, though the area is not so large.

As for as south of the mountain range is concerned, vehicles can be used for transportation, as roads which reach the foot of the mountain range are branches of the Pan-American Highway. But, there are many places where it is almost impossible to move except by a four-wheel-driven jeep.

On the Caribbean side, transportation is by boats or helicopters, as the villages there are scattered at the esturies and along the big rivers. There are some foot paths, but there are no bridges. To cross the river, it is necessary to resort to boats. It is difficult to charter outboard motor boats, because not so many villages have them, or, if they have, the number is extremely limited. To enter into the heart of the area, except for large rivers, one must rely upon canoes. To enter into jungles, use of helicopter is the most effective way.

As the weather of the area is quite changeable, it is necessary, when planning, to allow sufficient time for transportation for the sake of smooth implementation of the project.

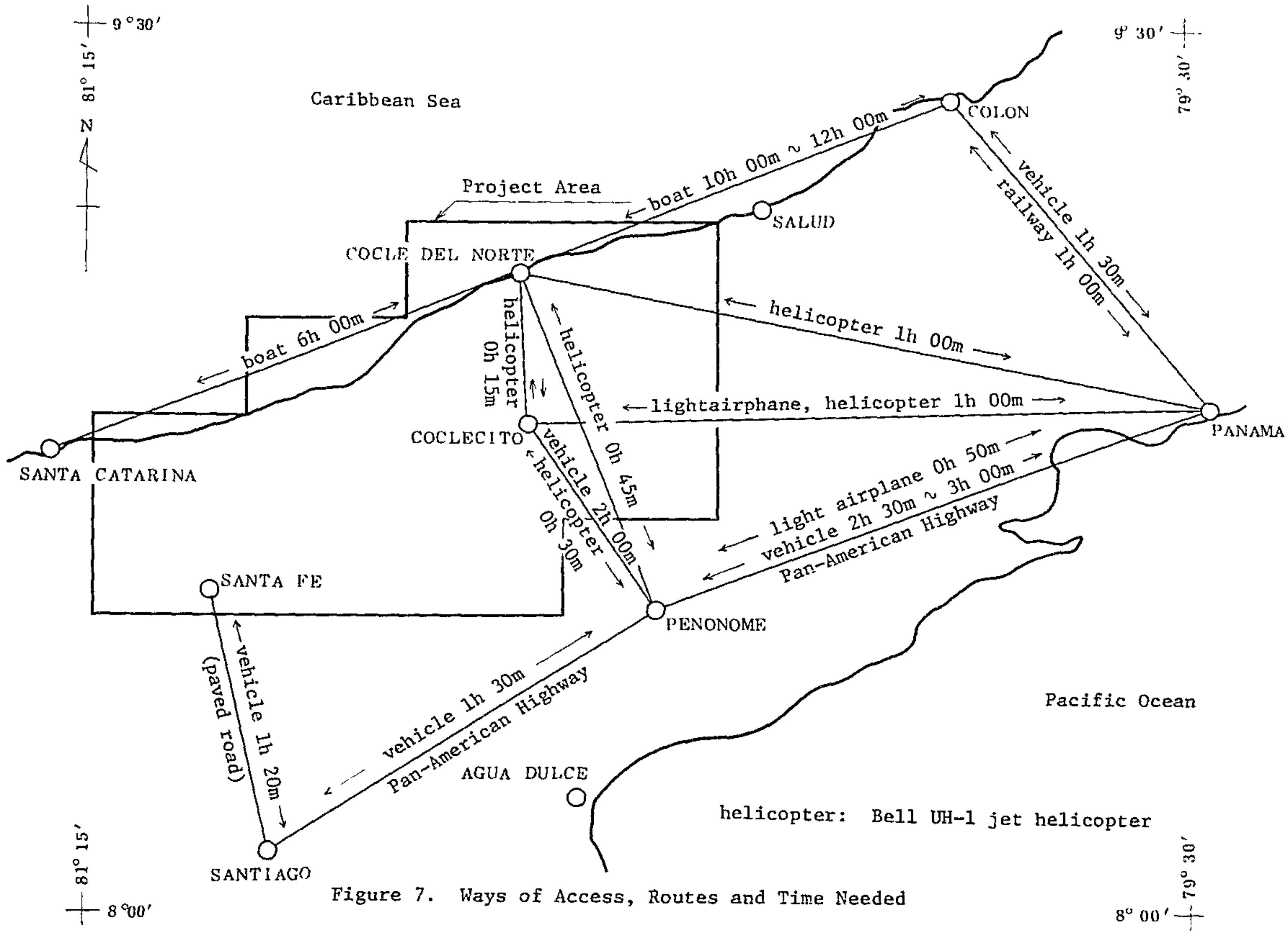


Figure 7. Ways of Access, Routes and Time Needed

3-3-4 Condition of roads and means of transportation

On the plain on the Pacific side, a well-arranged network of roads exist. On the contrary, on the Caribbean side, such a network is yet to be arranged. In general primary means of transportatin is by vehicle. Horses and small boats and canoes are used as an important means of transportation especially in the regions where roads are yet to be laid.

Accordingly, four-wheel-driven cars are required for transportation on the Pacific side where roads remain unpaved in part. On the Caribbean side, helicopters are required for transporting personnel and materials. At the same time, small boats or canoes are necessary for the execution of surveying.

Procurability of such means of transportation is stated below:

Of the required vehicles, passenger cars (taxis) can be secured easily. But, it is difficult to obtain four-wheel-driven working jeeps either in Panama City, the project area or its vicinity. As for boats, a large one is procurable on the coast facing the Pacific, as there are many such boats, but not so on the coast facing the Atlantic. Instead, a small outboard motorboat can be chartered in the villages on that coast.

As for the helicopter, a small one can be chartered easily. But, it is not easy to find medium and large size ones, because they are few in number.

Instead of a helicopter, a light plane which is effective for the transportation of large or heavy materials or equipment, can be chartered.

3-3-5 Airport within the project area

In Panama, air taxis are very popular, as a network of roads has not been arranged well and roads are impossable in many places during the rainy season, especially on the coast facing the Caribbean Sea which is within the project area. Accordingly, there are many small airports equipped with enough facilities for a light plane's taking-off and landing.

Within and in the vicinity of the project area are such airports as: Panonomé, Santiago, Caclecito Colón, Salud, Agua Ducel, Concepción, Punta Limón. However communication facilities are not installed in these airports.

Every village has space enough for a helicopter to take off or land. As for a helicopter, the problem lies not in facilities but in pilots, i.e., how to sècure a good pilot.

3-3-6 Condition of the existing control points

As for the existing control points in Panama, data are filed and well kept; monuments are also carefully maintained.
During the last field reconnaissance, seven triangulation points were confirmed of the existing 8 points, and 30 bench marks of the existing 31 marks. The loss of one triangulation point was due to past excavation of its location. The lost bench mark had been swept away by waves. The triangulation points in the jungle are densely veiled by trees, as they are rarely used. For confirmation of monument, it is advisable for the team to take along inhabitants, who had been hired as laborors for its establishment.

3-3-7 Accommodations and camping

Of the project area and its surroundings, in large towns along the Pan-American Highway, there are one or two hotels which can be used for accomodations. In villages on the Caribbean coast, a house will be rented or a camp set up.

In Panama City, many hotels are available and it is easy to rent an office in the city; but it is not easy to do so in the project area and its surrounding area.

In the project area, natural conditions, such as climate or topography are very severe; but the area has an advantage in that it is close to Panama city, a modern city. Taking the fact into consideration, it is felt that it is suitable to set up the base camp in Panama City, because:

(1) It is not so far from the project area-200 km maximum.
It is not necessary to set it up in a town close to the project area. By helicopter, it is possible to reach any spot in the project area within two hours.

(2) It is easy to make contact with IGN or other authorities concerned. In an emergency, it is possible to contact the field parties by making use of the wireless station of IGN.
Also, it is easy to procure materials.

As for subcamps, it is necessary to set them up in several places due to bad transportation conditions. The following places can be recommended for the subcamps: Penonomé, Santiago, Santa Fé south of the mountain range, and on the opposite side, Coclecito, Coclé del Norte, Santa Catarina, Concepción. For encampment on the north side, reasonable care should be taken to maintain materials and equipment, as heavy rainfalls occur there. Practically speaking, Penonomé and Coclé del Nort are the most recommendable places for subcamps.

Coclé del Norte is the biggest community in the Caribbean coastal area, and has advantages as follows:

(1) Accommodations are available;

(2) Some food is available;

(3) Canoes and other means of transportation necessary for surveying along the rivers are also available;

(4) Radiophone can be used for communication with IGN without obstruction by the terrain. However, neither telephone nor telegram are available.

Penonomé is the major local city in the southern part of the project area, and has advantages as follows:

(1) Communication with Panama City is easy through both telephone and land route;

(2) Materials are procurable;

(3) Well-arranged urban facilities such as hospitals, post office, banks, airport and accommodations are available to support the activities of the survey team.

3-4 Investigation into materials and equipment

3-4-1 Food and drinking water

It is easy to get food, except some Japanese foods. There are plenty of rice, meat, fish, vegetables, in addition to a variety of imported foods. In particular, nearly every kind of food is sold at supermarkets in Panama City. Among other things, canned food in the supermarket is more plentiful than in Japan. In other major cities located along the Pan-American Highway, it is also easy to get food, though it is not so plentiful as in Panama City.

It is also possible to get some daily necessities in small villages, too, such as in Coclé del Norte and Caclecito in the project area. But, they are not plentiful either in number or variety. Procuring the necessities there may have an adverse impact upon the villagers' daily life. So, it is advisable to purchase foods and daily necessities for the field work in Panama City.

In the field, protein will be in short supply. For example, eggs are not available there. Though wild pigs are left to room at large around each house in the village, pork is served only on special occasions. Also, chickens are left to roam at large. But, they are not many in number. Accordingly, it is difficult to have chicken. Only fish and turtle are procurable in the field as a source of protein. But catching them depends on luck. Vegetables are also scarce. Instead, name, platano and yuca are plentiful.

As for drinking water, water from the tap is drinkable as it is in Panama City.

In the villages within the project area, drinking water is obtained either by filtering rain water or taking it directly from mountain streams. Such water is plentiful and safe from mineral contamination. We have used the water for drinking. For safety, however, it is desirable to filter or boil the water. Frequent squalls peculiar to the area makes it easy to store rain water for drinking. Accordingly, it is unnecessary to worry about drinking water at all.

3-4-2 Materials and equipment

Daily necessities, stationery, cement and the like are also procurable in Penonomé, Santiago and other major cities in addition to Panama City.

3-4-3 Electric power supply

Commercial electric power supply (AC110V/60 Hz) is available on a nationwide scale except in the Caribbean region, where either lamps or individual electric power plants are used. Availability of the latter is limited (e.g., from 18:00 to 21:00).

3-4-4 Vehicle servicing factory

There are vehicle servicing factories not only in Panama City but also in major local cities (Penonomé, Agua Dulce, Santiago). As a whole, the servicing system is well-arranged in the country. In addition, Japanese auto-engineers are stationed in Panama City. Consequently, there is no need to worry about maintenance of vehicles.

3-4-5 Communication

The telephone system is well-developed in Panama City. Rarely are communications crippled by a breakdown. It is possible to speak by telephone between Panama City and Penonomé and Santiago located along the Pan-American Highway in the region adjacent to the project area. Telephones are available in hotels. Public telephone is available, too. Telephone calls from Panama City to local cities are not connected directly by dialing. You must wait for a moment.

It takes about ten minutes to communicate with Japan from Panama, and vice versa.

As telephone facilities (wires, poles, etc.) are not installed in the Caribbean coastal area, radiophone is the sole means of communication. This is essential for mutual communication between a survey team, subcamp and a base camp. Its availability, however, may be subject to natural conditions such as terrain and vegetation.

A high-powered radio apparatus is required for communication between a base camp and subcamps and among subcamps. It is advisable to use a radio apparatus whose frequency is the same as that of IGN. This makes it possible to use the IGN's radio apparatus which is in full operation from 8:00 to 15:00 hours every day except holidays.

Telex service is available in Panama City. The fourteen-hour difference in time between Japan and Panama is convenient for the exchange of messages. (Panama is 14 hours behind Japan.)

It takes several days for mail to be delivered between Panama City and Penonomé or Santiago. Airmail is sure to be delivered in a week or so between Japan and Panama.

International telegrams can be sent from and received in Panama City without delay by ITT. As for telegrams in the project area, there are ITT branch offices in Penonomé and Santiago which are located along the Pan-American Highway. But, it is impossible to send and receive telegrams in the villages on the coast facing the Caribbean Sea, as there are no branch offices there.

3-4-6 Laborers

(1) Laborer: It is easy to hire laborers. But, most of them have not been accustomed to working under the Japanese.

(2) Driver: They are also easy to hire. But, it is not easy to employ those who are familiar with the project area.

(3) Interpreter: Employees can understand only Spanish. Therefore, every instruction should be given in Spanish. Interpreters (Spanish to Japanese and vice versa) are necessarily required for the project work. Such interpreters are few in the country, and it is difficult to hire them.

(4) Guards: It is advisable to hire natives acquainted with the field.

Anyway, in order to secure reliable manpower in the field, thorough preparations are essential. At least, two weeks or so should be spared for preparation in the field.

3-4-7 Regulations and system on use of radio apparatus

(1) Relevant law: Uncertain

(2) Authorities concerned: Justice Ministry

(3) Application for official permission

1) Electromagnetic distance meter

IGN (acting an our behalf) will apply to the authorities concerned for approval to operate the distance meter. Prior to this, we should inform them of all the necessary information needed for approval--model, output, required number of the apparatus, and the planned period of use.

2) Radio apparatus

IGN (acting on our behalf) will apply to the authorities concerned for approval to operate the radio apparatus. Prior to this, we should inform them of all the necessary information needed for the approval--model, output, required number of the apparatus, and the planned period of use. The frequency for IGN (5,740 KHz) will be made available to us.

3-4-8 Diseases and vipers

Malaria: According to a 1978 survey, it is said that malaria has been almost eliminated in the country. However, it still remains in part. Therefore, it is desirable to take necessary measures to prevent contact with the insect and take a preventive treatment prior to leaving Panama City.

Yellow fever: The breakout of the disease has not been reported so far. For safety's sake, it is advisable to have an injection, prior to departure from Japan.

Endemic disease: There is an endemic disease called "Leishinaniasis" peculiar to the country. It is said that Japanese engineers have suffered from the disease in the past.

Remedy is still under study. The only way to prevent it is to evade the sand-fly carrying the germs. The latent period of the disease can be from two weeks to three years. So, it is a disease against which we should be extremely cautious.

In addition, special care should be taken not to be bitten by vipers, which inhabit the country--especially in suburban areas and the whole project area. Among them, the most dangerous one is the coral snake with a fatal poison which causes a neural paralysis. In the jungle, it is advisable to always carry an antidote and have two or three local inhabitants lead the party, because they can easily see snakes due to their sharp vision.

3-4-9 Medical facilities

There are many hospitals public and private in the region facing the Pacific. Apointments for medical examinations can be made by telephone. There is an institute for the study of tropical medicine in Panama City. A similar institution is managed by the U.S.A. in the Canal Zone.

The Panamanians are cooperative with foreigners as well as amongst themselves. When an emergency occurs in the field, it is possible to request the government or the U.S. Army stationed in the Canal Zone to fly helicopters or airplanes to the field.

4. Survey plan and plan of operations

Following are a survey plan and a plan of operations prepared on the basis of the results of the preliminary survey for the project. The intentions of the Panamanian side and the circumstances in the field were taken into consideration when preparing the following survey plan and plan of operations.

4-1 Map format and its application

As mentioned before, the map format is based on MT-321 drawn up on the basis of an agreement reached by the Latin American nations. Later, the map format was partially revised in consideration of the realities in Panama. However, its application is yet to be defined more concretely. This must be settled more definitely in part, in the course of the actual survey work.

Particular attention should be paid to the following:

- Standards for the selection of paths or foot paths.
- Criteria for the indication of the ends of small streams and intermittent streams.
- Classifications for the low forest, the abandoned burnt fields and arable land.
- Determining whether unidentified houses are aban doned or inhabited.
- Positioning of notations.

4-2 Survey plan

The project area is located in the central northern part of Panama, with the northern part of the area facing the Caribbean Sea. (Figure 1). Most of the field consists of jungle in steep terrain. It is not only difficult but also dangerous to enter the jungle. Consequently, advances into the field were kept to a minimum number of times. It was determined that the accuracy of a topographical map should meet Class B in the JICA standard for overseas surveying. The requirements for the accuracy of Class B are as follows:The position of the ground object, 1.0mm on the map; the height of the spot height, 2/3 of the contour interval; the contour, 1/1 of the contour interval.

4-2-1 Examination of survey system

(1) Photography

In the project area, the annual rainfall reaches a maximum of 7,000mm.

Weather conditions are extremely bad. Therefore, it is believed that the photography will be the most difficult task for the full-scale work. Consequently, it is advisable to take as many photos as possible irrespective of suitable or scheduled photographing time, or whether signalization has been done, or in spite of cloudiness and unfavorable contrast, so long as they can satisfy the minimum requirement for plotting.

The existing photographs available are limited to some parts of the project area. The scales of existing groups of photographs are not the same and some photos do not have sufficient lap. Thus, it was determined that the whole area should be photographed anew.

For photography, a wide-angle lens should be used. A scale of 1/60,000 is reasonable. The required altitude for photography is 9,000 m. This is related to the existence of the mountainous terrain in the project area.

Accordingly, an aircraft capable of high altitude flight is required for the photography. The flight course should be flown from east to west. In case of cloudiness, however, it may be necessary to fly the course from north to south.

The maximum relative height in the project area is 1,500 m. As the distribution of elevation is not leveled suitably for blocking, a uniform altitude for photography should be applied to the whole area.

Considering the distribution of existing control points, the range of photography should be much wider than that of mapping.

(2) Control point survey (horizontal)

The existing triangulation points have been maintained by IGN. Most of the monuments remain as they were. Their accuracy is reliable. It is advisable to fully use those triangulation points that are accessible. As shown in Figure 9, it is necessary to increase the number of control points for photo orientation. New control points should be limited to use for photo orientation and kept to the minimum number required for keeping 5 m accuracy equivalent to Class B.

The conventional method of setting up a high observation tower is expensive. It also takes a long time to make a sight line by cutting down trees and clearing the land around the tower. Taking the danger and difficulty in entering the field into consideration, it may not be practicable to set up such a tower (though it would not be impossible). In contrast, satellite doppler observation makes it possible to select a point independently and at will. Thus, troublesome efforts to obtain good visibility and to install a high tower would be unnecessary. This method is effective enough to guarantee the 5 to 6 m accuracy required for orientation in preparation of 1/50,000 topographic maps. The work method of combining a helicopter with satellite observation may be more suitable for surveying in the jungle. However, reasonable consideration should be given to the intention of the Panamanian side to use the points to be installed anew as control points equipped with permanent monuments. Therefore, in using satellite observation method, attention should be paid to increasing the accuracy of the survey as much as possible. (For example, the use of computation based on translocation or a precision ephemeris in observation should be considered. However, because of different accuracy, it will be necessary to distinguish such new points from those set up by conventional method when they are indicated on a map. Observation by NNSS is required on the existing triangulation points to convert the coordinates for the NNSS into those for geodesy.

(3) Signalization

The existing triangulation points in the jungle are convered by trees 20 to 30 m high. Consequently, there are few open spaces and objects that can be used for pricking at or near the control point on the photograph. Therefore, it is essential that air photo signals for triangulation points be set up after the trees have been cut down prior to photography.

Regardless of the conventionally scheduled time for photography, it may be started from early morning. (The trees east of a signal should be cut down carefully so that the sunlight will reach the signal at 8:30 a.m.)

The best season for photography is the dry season from January to March. As strong winds blow during the period, it is not possible to install signals on trees.

(4) Leveling

Similarly to the accuracy of existing triangulation points, the accuracy of the existing bench marks is supposed to be reliable as most of them remain as they were. Consequently, those within the project area are also available for use. In part, leveling routes are found away from the existing roads. What is more, they are laid out on abandoned roads completely covered with grass and trees. So, it may not be easy to find bench marks under the given circumstances. For some of the bench marks in the jungle, an eccentric observation should be done, wherein the observation is made at a nearby object or place which it is possible to prick.

Leveling routes run only along the roads in the westernmost region and the Coclé del Norte River. As for the inland jungle and the easternmost region, it is extremely difficult to even

approach these places. There is no element of height other than triangulation points. Accordingly, it is advisable to check the height of newly established control points by means of satellite doppler observation or establish height points by either trigonometric leveling (which is difficult) or barometric leveling (which is not very accurate).
The accuracy of the barometric leveling may remain within the practicable accuracy of 4 to 5 m. It is desirable that a barometric observation be conducted simultaneously upon two points with two barometers.

(5) Aerial triangulation

As for aerial triangulation, it is desirable to minimize the volume of the control point surveying in the field while maintaining the required accuracy, by applying an analytical method based on block adjustment. For this purpose, the newly developed block adjusting program by independent models, "PAT-M", which is now being put to practical use, should be considered. However, subject to the conditions of photography, the planned composition of the block may have to be changed, that is, be divided into smaller blocks. To cope with this, bridge courses should be taken into consideration in planning photography. In addition, increasing the number of control points may help the progress of photography.

(6) Plotting

Plotting should be limited to the land area covered by the planned plotting sheet. The sea area will be compiled on the basis of data to be provided by the Panamanian side. In compliance with a request from them, the blank in the existing sheets surrounding the project area, will also be plotted.

(7) Field identification

For successful field identification, it is necessary to understand Spanish and get acquainted with the local situations. Accordingly, cooperation from the Panamanian side with regard to the field identification is important and results of the survey should be confirmed by them. Actually, it is impossible to conduct a detailed survey into the whole area of the vast untrodden jungle. So, the actual survey will be limited to obtaining information from the inhabitants in villages scattered along the estuaries and the rivers after thorough pre-study by photo-interpretation. As for the field survey, efforts should be directed intensively toward the rivers which are vital to the inhabitants and the sole route to the outside by canoes.

Efforts for the classification of vegetation should be focused upon the preparation of keys for interpretation. The responsibility for the confirmation of the place names and administrative boundaries should be assumed by the Panamanisn side, from whom it is necessary to obtain written approval.

4-2-2 Total planning

(1) Survey area

The area of 6,000 km^2 covers the land area north of Lat. 8°30'N and between Long. 80°15'W and Long. 81°15'W, facing the Caribbean Sea, plus the blank areas in the existing adjacent maps. (See Figure 1.)

(2) Photography

1/60,000 aerial photography with a wide-angle lens of the above area covering about 8,000 km^2.

(3) Ground survey

Control point survey, signalization, indirect leveling, pricking of control points and bench marks; field identification and field completion.

(4) Topographic map

Scale, 1/50,000; contour interval, 20 m; sheet lines, latitude difference, 10'; longitude difference, 15'; five-color-topographic map, 12 sheets.

4-2-3 Time schedule

(1) First year

1) Photography: about 8,000 km^2

2) Control point survey: 9 points

Observation by NNSS: 5 new points

4 existing triangulation points

(2) Second year

1) Control point survey: 4 points

Observation by NNSS: 3 new points

1 existing triangulation point (pricking included)

2) Indirect leveling: 7 points

3) Pricking of bench marks: leveling route: 400 km

4) Field identification: 5,200 km^2

5) Aerial triangulation: about 300 models

6) Plotting and compilation: 1,700 km^2

(3) Third year

1) Plotting and completion: 3,500 km^2

2) Field cpmpilation: 5,200 km^2

3) Printing: 12 sheets (1,000 copies per sheet)

4-3 Plan of operations

4-3-1 Aerial photography

1/60,000 aerial photography (with a wide-angle lens) of the whole project area covering 8,000 km^2. Reference plane is set at 500 m with a flight height of 9,500 m for all areas.

4-3-2 Signalization

In principle, signalization should precede photography. Signals can be replaced by pricking if need be because of slow progress of photography or because of topography or terrain features. The shape of a signal should be either a triple blade, 150cm x 50cm, or a square, 150cm x 150cm and should be set up 50cm above the ground. It should contrast with the background.

4-3-3 Control point survey

For a control point survey using the satellite doppler system, a minimum of 20 paths should be observed by the same satellite at the same time at two stations on the basis of the translocation system. Subject to topography and vegetation, polygonal surveying with electromagnetic distance meter will be appropriate.

4-3-4 Indirect leveling

The height of two control points to be set up anew in the inland area should be determined by means of a simultaneous observation with known bench marks by using more than two barometers.

In the eastern part of the project area, trigonometic leveling should be applied to the existing triangulation points, if topography or vegetation permits the observation.

4-3-5 Pricking

Signalization on control points should precede photography, in principle. As photographing time, however, may be subject to meteorological conditions, pricking may have to be done instead of signalization. It may also be necessary to transfer the height of the existing bench marks to a place with topography and terrain features that can be easily pricked on the photograph by leveling.

4-3-6 Field identification

This is aimed at preparing such data as is necessary for plotting and compilation in cooperation with Panamanian counterparts.

The main work is to clarify the items difficult to interprete on the photographs and classify and select in the field items to be indicated on maps in accordance with the map format.

4-3-7 Aerial triangulation

For aerial triangulation, the analytical method will be applied using stereo-comparator and electronic computers. The block adjustment method will be used for adjustment.

4-3-8 Plotting and compilation

The stereo plotter will be sued and the scale should be 1/50,000. Contour interval shall be 20 m and, if necessary, auxiliary contours of 10 m interval shall be drawn.

As for sheet lines, latitude difference and longitude difference shall be 10' and 15', respectively. It was agreed that new sheets will be adjoined with the existing sheets when the difference between them is not more than 1mm on the map and that, otherwise, they will not be adjoined with each other.

4-3-9 Field completion

This is chiefly aimed at confirming place names, administrative boundaries and Spanish spelling. Such confirmation will be subject to a check and an approval by the Panamanian side. If necessary, a supplemental survey will be conducted in the field. Thus, the original manuscript will be completed.

4-3-10 Drafting

The color separation scribing method will be applied to drafting. Color composites will be prepared and will be subject to the final approval of the Panamanian side.

4-3-11 Printing

Five-color offset printing will be adopted, and 1,000 copies shall be printed for each sheet.

4-4 Problems anticipated in operation

4-4-1 Photography

Weather conditions in the area to be photographed are very bad, with an annual rainfall reaching 7,000mm or so. Accordingly, priority should be given to the photographing work by taking advantage of any opportunity for photography. As for the photographs taken in this way, they may be considered acceptable when they meet the minimum requirements for plotting in contrast, cloudiness and quality.

4-4-2 Control point Survey

Most of the existing triangulation points were established in the jungly region on steep terrain, whre it is extremely difficult for us to identify them. It takes excessive time and cost to set up signals or to prick on these points. Consequently, in some cases, it may be be preferable to establish new control points in places more accessible by using satellite doppler observation instead of approaching the existing control points. Nevertheless, it is still necessary to observe on the existing triangulation points, for the sake of transforming NNSS coordinates to the existing geodetic coordinates. Anyway, it is necessary to clear the jungle by cutting down the trees around such points, in order to improve the reception of waves sent from the satellite.

4-4-3 Field identification

The Japanese survey team, being unexperienced with the Panamanian map format and its applications, must study them well in advance for effective execution of the field identification. It is also necessary on execution, to consult the Panamanian counterparts on the classification of vegetation or ground objects.

4-4-4 Plotting and compilation

It is probable that steep terrain cannot be identified because of the dense vegetation covering it. In addition, there are many places we cannot even approach for field identification or field completion. This makes it difficult to plot the detailed terrain, thereby forcing us to depend on interpretation by sampling. This may also be the case with the interpretation of vegetation.

4-4-5 Base camp

In an effort to carry out the work satisfactorily, it is important to keep in touch with IGN and IAGS as well as secure a means of communicating with subcamps.

In a contingency, it is also possible to request help from the U.S. Army stationed in the Canal Zone through IGN or IAGS.

4-4-6 Subcamp

To be able to support sub-teams scattered about the jungle surveying, daily contact with them at a set time should be secured. For this purpose, it is necessary for a sub-camp to be equipped with reliable radio apparatus.

A subcamp leader always should be prepared to make a proper decision to cope with an accident or take proper rescue measures.

4-4-7 Means of transportation

There is no other proper means of transportation in the jungle than helicopters and canoes. Therefore, reasonable consideration should be given to weather conditions upon movement. Particularly, it is not wise to go on a forced march, irrespective of weather conditions. Such an unwise act will lead to an accident.

4-4-8 Animals

It is said that a numerous dangerous vipers inhabit the jungle. Accordingly, it is advisable to follow the local inhabitants during movement through the jungle. There are also such insects as scorpions, ants and bees, whose bite will cause bitter pain.

At the same time, care should be taken not to incite wild beasts such as tigers, pumas and alligators. As long as you do not incite them, you are safe.

4-4-9 Sanitation

There is a disease peculiar to the project area. Study of and prevention against this disease are yet to be accelerated. So, it is advisable to undergo a medical examination under normal conditions prior to departure and, after returning home, to undergo the same examination to compare the results with those from the previous examination. Also, reasonable care should be taken not to overwork. This will cause you to get ill.

5. Plan of field operations

In drawing up a plan of operations in the field, particular consideration should be given to harsh natural conditions in the project area.

5-1 Items to be taken into consideration

Efficient work requires thoroughgoing preparation for the following by touring the field and making contact with the local inhabitants: preparing explanation of the planned work; searching for information sources; negotiating the employment of guides and laborers and lodging; leasing boats, canoes and other goods; surveying the conditions of roads; and collecting of information.

- Fuel for the helicopter should be transported to its base. For this, help from the National Police Guards of Panama is essential, especially in the mobilization of a transport plane (skyburn) and a large jet helicopter (Bell HU-1). In this connection, a request for such cooperation should be made as early as possible.
- It is essential to secure a veteran pilot to insure safety in flying. This is because, in many cases, a pilot will be compelled to

fly a helicopter over an area under weather conditions that are extremely changeable or in an area unknown to him and which has no marks or guide maps for navigation. The frequent change in weather conditions may also result in a frequent change in an original flight plan for the helicopter. Accordingly, operation planning should be all the more flexible to reduce loss time. Squalls can make the roads passing through the mountain range extending east and west very bad. Therefore, the motorcade should include two four-wheel-driven vehicles driven by veteran drivers who are skilled in the operation of such type of vehicle and the winch attached to the vehicles. (It is dangerous for a lone vehicle to be driven along this road.)

- In the area facing the Caribbean Sea, there is no other available means of communication with higher efficiency than a radio apparatus linking a work team, a subcamp and the base camp. So, it is advisable to carry a high-powered radio apparatus proofed against humidity. The recommended power source for it is a fuel battery which is handy and reliable.
- Priority in the work should be given to work in the Caribbean coastal area in consideration of the difficulty of the flight by helicopter.
- To cope with a contingency attributable to bad weather conditions, a minimum of necessities always should be carried with you during movement by helicopter or vehicle, such as radio apparatus, water, food, medical supplies mosquito net, etc.
- Encampment on the Caribbean side should not last more than a week. It is desirable to move to a more comfortable place after a one-week encampment there.

5-2 Schedule for field operations

5-2-1 Advance party

Following is the assignment of the advance party:

N8°15'

(1) Consultation with the IGN representatives on the work to be undertaken and on detailed field operations with Panamanian counterparts who will accompany us.

(2) Preparation of vehicles, hiring of drivers, and the negotiation of a contract for the charter of a helicopter and the preparation of a flight plan.

(3) Tour by vehicle and helicopter to the field to make necessary arrangements and collect information.

(4) Acceptance and procurement of materials and equipment.

(5) Determination of transporting route, the means of transportation and the negotiations with the organizations concerned for the fuel for the helicopter and for its actual transportation.

(6) Setting up of some subcamps.

(7) Cutting down of trees at some selected points.

5-2-2 Work team (Main party)

Following is the assignment of the work team.

(1) Consulting with the accompanying Panamanian counterparts, obtaining data and examining them, and preparing for the work (including reconnaissance). All of this shall be done in the office.

(2) Procurement of materials and equipment and their inspection and management.

(3) Moving to a subcamp in the savannah area by vehicle by a land route.

(4) The work team in charge of the Caribbean side will wait for a chance to move by helicopter across the mountains.

While waiting, they will engage in work in a subcamp on the savannah side.

(5) Inspection of JMR and radio apparatus immediately after arrival in the field.

(6) Requesting local inhabitants to maintain materials and equipment and other necessary items for future work before leaving a survey spot.

As listed above, the work was conducted according to a survey plan and a plan of operations based on an outline of the project area obtained from field reconnaissance done in advance. Upon the execution of the work, instructions were prepared, and distributed among members for their respective work.

Given below is an outline of the operation, the differences between the planned work and the actual work and the problems arising during execution.

6. Aerial photography and signalization

6-1 Outline

Aerial photography was planned for field identification, aerial triangulation and plotting for maps at a scale of 1/50,000. The area to be photographed was extended toward the south of the planned area for plotting in order to include as many existing control points as were needed for aerial triangulation. The course was planned to run in an east-west direction. Three courses at the same scale were chosen to form the bridge courses to supplement the east-west courses. Of these, two courses ran along the leveling routes making pricking of bench marks much easier. Aerialphotography was performed over a two-year period due to the effects caused by the clouds (See Figure 8).

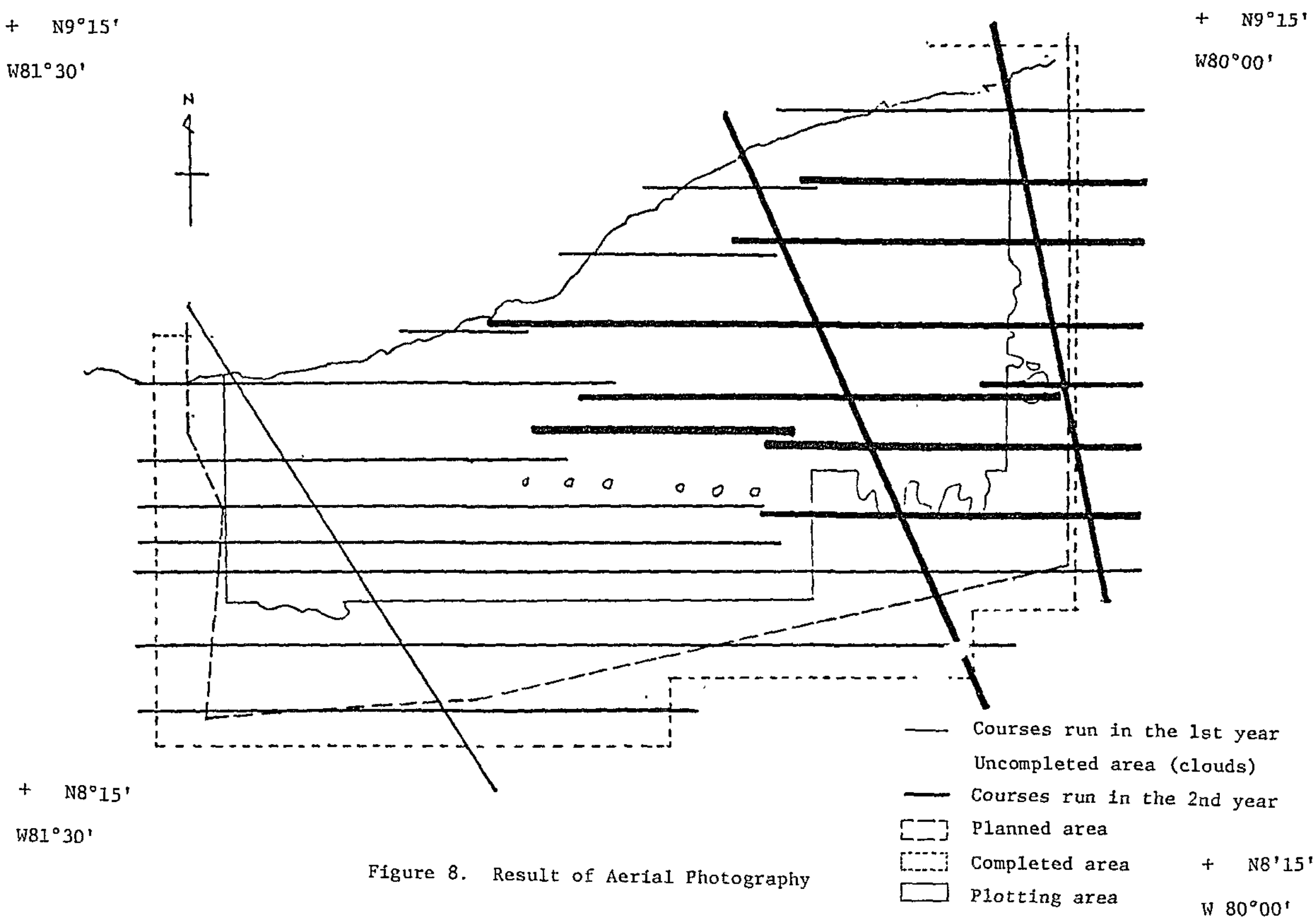


Figure 8. Result of Aerial Photography

The actual aerial photographic work was subcontracted out to Mark Hurd Inc. of the U.S.A. because they had similar work experience in Bolivia.

The base for the work was set up at Tocumen Airfield in Panama City, and the processing was executed at IGN facilities, offered for the use of the survey team.

6-2 Specifications

Amounts of work: 13 courses (including 3 bridge courses)

Total length of course: 1,200 km

Area of work: 8,000 km^2

Scale of photographs: 1:60,000 (mean)

Camera and lens to be used: Zeis, RMK 15/23

Flight height: 9,500 m (reference plane: 500 m)

Overlap: 60%, Sidelap: 10 to 35%

Tilt of camera: within 5 degrees

Angle of drift: within 10 degrees

Tolerable amount of clouds: There should be no clouds in areas that are important and that are to be represented on the map. There should also be no clouds in areas around control points and principal points within the stereo-effective range.

6-3 Certification of camera

The company who performed the aerial photography submitted a copy of certification for the camera to JICA dated March 30th, 1978, and issued by the Geological Survey, U.S. Department of the Interior. This certification met the standards of JICA.

6-4 Inspection

Photographs printed on contact-print paper were inspected at the site. Some positives were made on dry glass plates at the IGN facilities, and checked for their distortion by stereo-plotter A-7. After returning home to Japan, the team inspected these results at their office.

6-5 Signalization

Seven signals were set up ready for use on four new control points and three triangulation points. (See Figure 9).

6-6 Remarks

6-6-1 Aerial photography

Originally, aerial photography was planned to cover all the required areas in the first year of the Project. However, due to bad weather conditions, it took two years to finish it, leaving an unplotted area of 15 km^2 (0.2%) caused by clouds. In spite of this, the team succeeded in covering most of the required areas where very bad weather conditions prevailed by taking advantage of limited chances. The success can be attributed to the enthusiasm shown by the crew of the aerial photography company and to the telecommunicational work of the survey team members scattered about the sites.

6-6-2 Signalization

It was planned to set up signals on every control point before launching the aerial photographic operation. But due to bad weather conditions, the plan was changed from signalization to pricking so as to give priority to actual photographing. However, the operation could not be completed within the first year.

It was decided to continue the operation in the 2nd year, for which two signals were set up during the first year and 5 signals during the second year before operations began.

7. Geodetic control point survey and pricking

7-1 Control point survey by satellite observation

7-1-1 Outline

The survey to establish new control points was conducted with the use of the U.S. Navy Navigation Satellite System (usually abbreviated as NNSS).

The project area had only eight usable triangulation points. Nine additional points were set up. The work was performed during the following two periods: 1) February through April, 1979, and 2) August through December, 1979. During the first period, five and during the second period four additional triangulation points were established.

One set of TMR-1 and three sets of TMR-3 were used as the receivers for the NNSS system. The translocation method was adopted for four existing points and nine new points. The relationship between the geodetic coordinates of the existing triangulation networks and the ones of the newly determined control points (by NNSS) is given in paragraph 7-1-4. Distribution of control points is shown in Figure 9.

7-1-2 Discrepancy between plan and execution

Many problems were experienced with JMR-1 and -3 Doppler observation instruments.
The team members were forced to perform a round-the-clock watch on the instruments for a certain period of days and the work schedule had to be largely revised. A hard time was had by the IGN counterparts as well as the team members in handling the situation.
The observation by translocation was done in two stages as stated in 7-1-4 (1) and (2). Major problems with the instruments were as follows:

1) Trouble with pre-amplifier (suspected of being caused by some incomplete electric contact due to high humidity)

2) Poor electrical contact of the connector part of the antenna cord

3) Trouble with unit processors (rejection of data input)

4) Inpossibility of recomputation caused by inability to record the observed data onto cassette tape. This forced the team to perform re-observation.

7-1-3 Results of the existing triangulation points

Table 5 gives the results of the existing triangulation points available in the project area:

Table 5. Results of the Existing Triangulation Points

TRIANGULATION	B	L	H	U.T.M.	
				N	E
			m	m	m
I COAST (IAGS)	9° 9'27".836	80°16'45".523	72.52	1,012,306.22	579,182.02
I TAVI (IAGS)	8 46 54 .961	80 9 31 .925	421.83	970,786.00	592,511.14
MUELO (562)	8 28 39 .714	80 34 44 .798	573.69	937,074.73	546,327.03
II CRIS (IAGS)	8 52 36 .570	80 52 45 .819	64.37	981,174.66	513,260.89
I TUTO (IAGS)	8 29 19 .581	81 6 55 .110	1,453.00	983,275.75	487,308.55
I CAÑAZAS (IAGS)	8 20 20 .427	81 11 30 .766	708.26	921,722.92	478,872.59
II CALO (IAGS)	8 44 40 .112	81 15 58 .260	511.15	966,551.71	470,722.04
PENONOME (IGN)	8 30 54 .640	80 20 59 .123	88.94	941,253.04	571,565.80

These control points are first or second order triangulation points in the Republic of Panama. The results are based on the North American Datum, 1927.

7-1-4 Translocation

The translocation method in NNSS is used to obtain the coordinate difference between two points upon which signals from a satellite are received simultaneously. When one of the two coordinates is known, the addition of the difference gives the coordinates of the other point, where the former point is called master and the latter slave.

(1) Observation by translocation method

The translocation in this project comprised two steps as shown below.

1) First step

With existing triangulation point PENONOME as master, the following points were to be determined (See Figure 9):

CAÑAZAS (A), COAST, CAÑAZAS (B), CUCHILLA, CAMMARONES, CALLE LARGA, SANTA ROSA, COLLE DEL NORTE, COLLECITO.

N.B. CAÑAZAS (A): Existing triangulation point

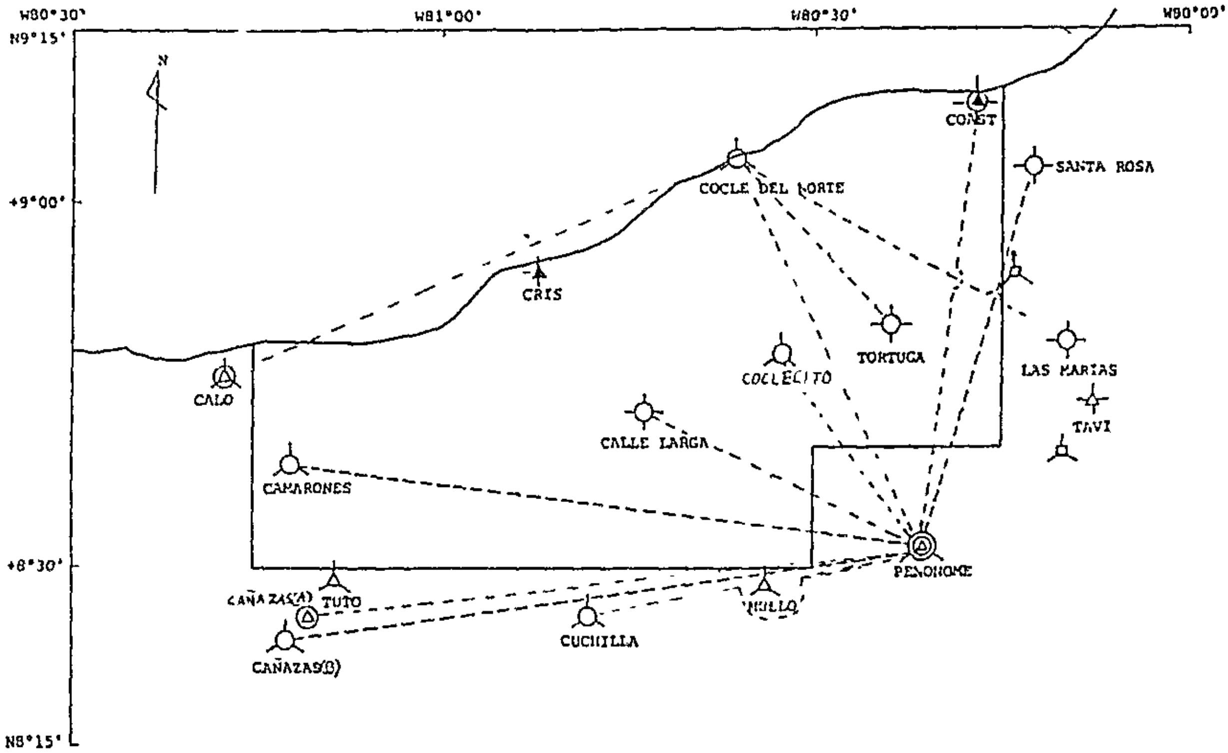
CAÑAZAS (B): Additional NNSS control point

2) Second step

With point COCLE DEL NORTE determined in the first step as master, the coordinates of the following points were to be determined. (See Figure 9):

CALO; TORTUGA; LAS MARIAS

Among the above, the ones underlined are existing triangulation poitns whose geodetic coordinates are known. These points were used for the transformation of the coordinates of additional points obtained by NNSS into the existing geodetic coordinates. (See 7-1-5).



- ▵ Triangulation point
- ◎ NNSS observation point (fixed)
- ○ NNSS observation point
- ▴ Triangulation point (signalized in the 1st year)
- ▫ Elevation point
- -¦- Signalized point
- ⅄ Pricked point
- ---- NNSS Translocation Observation

Figure 9. Execution of Control Point Survey, Signalization and Pricking on Control Points

(2) Calculation of translocation

The calculation of translocation was performed by the use of Program SP-2T of the JMR Instruments INC. This program allowed us to set various restricting conditions and parameters for calculation. For this Project, the following conditions and parameters were established:

1) To adopt data only when the altitude of satellite was between 15° and 75° to the horizon;

2) To establish one observation equation in about 30 seconds, and to reject any path where 16 equations could not be obtained (the length of a path being about 8 minutes);

3) To eliminate any observation equation of any path where the altitude was below 5°, and, after calculation of a path, any observation equation that had a residual twice as big as the path's mean error.

4) To decide whether a path was to be adopted or not was statistically made by a Chi-Squared test, where the apriori variance factor was to be 10 cycles and the probability level of 95% was used for determining the availability of a path;

5) For NNSS, WGS-72 was used as the reference ellipsoid. For the use of the Project, however, all the calculation results which were output were transformed into the reference ellipsoid of the North-American datum 1927 to which the existing triangulation networks refer. The parameters required for the transformation were as follows:

Elements of the ellipsoid:

Semi-major axis a = 6,378,206.40 m;

Flattening f = 1/294.979

Datum shift (from North-American datum to WGS-72)

$\Delta X = -22$ m

$\Delta Y = +157$ m

$\Delta Z = +176$ m

(3) Results of calculation of translocation

As mentioned in 7-1-4, the translocation was comprised of two steps for use in the Project. The right half of Table 6 gives the results of the calculation of the two steps.

Table 6. Results of Existing Control Points and NNSS Observation Values

	given latitude	given longitude	given height	NNSS latitude	NNSS longitude	NNSS height
PENONOME	N 8°30′54.″640	W 80°20′59″123	88.94 m	N 8°30′54″640	W 80°20′59″123	88.94 m
COAST	9 09 27 836	80 16 45 523	72.52	9 09 27.852	80 16 45 734	7197
CALO	8 44 40.112	81 15 58.260	51115	8 44 40 358	81 15 58 289	50502
CAÑAZAS (A)	8 20 20 427	81 11 30 766	70826	8 20 20 426	81 11 30 850	702.34
CUCHILLA			* 59181	8 25 25 631	80 50 54 448	58768
COCLE DEL NORTE			* 146	9 04 33.793	80 34 15 375	593
TORTUGA				8 52 43 998	80 23 11.475	6582
LAS MARIAS				8 53 19.217	80 13 07 089	20513
CALLE LARGA				8 44 51.258	80 44 00.712	9101
CAMARONES				8 36 31.537	80 12 41 876	187.07
SANTA ROSA				9 02 52.218	80 11 35.286	122.7
CAÑAZAS (B)				8 21 08 648	80 11 55 748	68020
COCLECITO				8 48 29 644	80 33 24 801	60.51

* By leveling

(4) Accuracy of translocation

As described in the foregoing, the calculation of translocation has as its objective the obtaining of the coordinates of the slave by the use of the fixed coordinate of the master. The accuracy of translocation leads to the reliability of the obtained coordinates of the slave. However, such values are not computed in Program SP-2T of the JMR Instruments INC. Instead, SP-2T gives the reliability (mean error) of each coordinate when the coordinates of both the master and the slave are calculated independently. On an average, such value is as follows for the Project:

Latitude ±1.5 ∿ 2.5 m

Longitude ±2.5 ∿ 3.5 m

Altitude ±2.0 ∿ 3.0 m

In the translocation method by SP-2T, however, the positions of the master and the slave are independently determined by the use of data that is common to both. It is, therefore, considered that the displacement due to the error in orbital elements will be eliminated by employing the coordinate difference. The above-mentioned values represent the apparent scattering when the coordinates of both points that include the errors in orbit elements are independently determined. Thus, the reliability of the coordinate difference, which is the coordinate of the slave when the master is fixed and originally an unknown quantity in the translocation method, will become higher. It is empirically considered that latitude, longitude, and altitude would have mean errors in the region of from 1 to 2 meters, in the translocation of 20 paths or so. However, it is considered that the accuracy for the slave in the second step would come to 2 ∿ 3 meters (mean error) since the slave (COCLE DEL NORTE) in the first step is used as the master in the second step.

7-1-5 Transformation of NNSS results into existing geodetic coordinate system

(1) Necessity of transformation

The coordinates of the newly established points by NNSS given in Table 5 are those transformed from WGS-72 into North American datum: using transformation factors between the two systems, the coordinate difference of the master and the slave on the ellipsoid to which the North American datum refers is calculated, and by adding the coordinates of the master on the existing geodetic coordinate system, those of the other slaves are obtained.

The geodetic coordinates of geodetic control points obtained by NNSS observation should coincide with their given values. However, they do not coincide in the cases and/or for the reasons given below:

1) In case the existing geodetic network is distorted due to the accumulated errors (plane);

2) In case there are differences in the scales between the one for the existing geodetic network and the one for NNSS (plane);

3) When the geoid is tilted greatly in the project area relative to the reference ellipsoid (altitude);

4) Because of coordinate errors in the existing triangulation points (plane and altitude);

5) Because of coordinate errors determined by NNSS (plane and altitude)

Among the above, 1), 2), and 3) are considered to be systematic, and 4) and 5) accidental errors.

NNSS observationwas performed at the four existing triangulation points. It was planned to estimate errors as described above using those coordinates of both the geodetic system and the NNSS with the aim of finding the most rational transformation method for coordinates.

In Table 7 the data given in the four lines starting from the top represent the geodetic results and NNSS observation results at the foru existing triangulation points expressed in UTM coordinates.

(2) Transformation of plane coordinates

A formula for transforming NNSS observation as given in Table 7 into geodetic coordinates was worked out. Taking into consideration that the project area is small (100 km x 80 km) and that rransformation factors have to be determined by using only four points, a linear conformal transformation equation (Helmert's transformation equation) was adopted as follows:

$$\left.\begin{aligned} X_G &= aX_N + bY_N + X_o \\ Y_G &= aY_N - bX_N + Y_o \end{aligned}\right\} \quad \ldots\ldots\ (2.1)$$

Table 7. Geodetic and NNSS Observation Results Expressed in UTM Coordinates

	Geodetic Results (UTM)			NNSS Observation (UTM)		
	N	E	H	NNSS N	NNSS E	NNSS H
PENONOME	94125304 m	57156580 m	8894 m	94125304	57156580	8894
COAST	101230623	57918202	7252	101230670	57917558	7197
CALO	96655171	47072204	51115	96655927	47072116	50502
CANAZAS(A)	92172293	47887259	70826	92172290	47887002	70234
CUCHILLA			59181	93109306	51668234	58768
COCLE DEL NORTE			146	100322515	54715106	593
TORTUGA				98145636	56745425	6582
LAS MARIAS				98257265	58591251	20513*
CALLE LARGA				96689401	52930912	9101
CAMARONES				95154469	47671388	18707
SANTA ROSA				100017628	58867792	1227
CAÑAZAS(B)				92320405	47810925	68020
COCLECITO				97361872	54873050	6051

where,

a, b, Xo, Yo ..... transformation factor (unknown)

X_G, Y_G .... geodetic coordinates

X_N, Y_N .... coordinates obtained by NNSS

The following transformation factors were obtained by solving the observation equations (2.1) for the four points:

a = 1.000007431

b = 0.00000725

Xo = -14.24 m

Yo = 7.91 m

Using the unknown quantities thus obtained, systematic or accidental errors described in (1) were examined.

1) Distortion in existing geodetic network

It is supposed that the distortion in the existing geodetic network is shown by the angle of rotation between the coordinate system of the existing geodetic network and NNSS.

This angle (R) can be obtained from equation (2.2).

$R = \tan^{-1} (b/a)$ .... (2.2)

Substituting the value of a and b mentioned above into equation (2.2),

$R = 0.0000097$ radian $\doteqdot 2''$

Viewed from the accuracy achieved in the NNSS results, this rotation cannot be regarded as significant.

2) Scale ratio of existing geodetic coordinate system to NNSS

The ratio (γ) of the scale of the existing geodetic coordinate system to that of NNSS can be obtained by the use of unknowns a and b as in equation (2.3)

$$\gamma = \sqrt{a^2 + b^2} \quad \ldots\ldots\ldots \quad (2.3)$$

Substituting the above-mentioned value into equation (2.3).

$\gamma = 1.0000074$

This value can not be regarded as significant when the accuracy achieved in the NNSS results are considered.

3) Accidental errors

It has already been mentioned that the systematic errors in (1) and (2) cannot be regarded as significant. But such accidental errors as differentiated from these systematic errors are going to be examined here. As was described in (1) above, such accidental errors are those found in the results of the existing triangulation points and those of NNSS results.

The quantity of accidental errors can be obtained as follows:

$$\left.\begin{aligned} \Delta X &= X_G - (aX_N + bY_N + X_o) \\ \Delta Y &= Y_G - (aY_N - bX_N + Y_o) \end{aligned}\right\} \quad \ldots\ldots\ldots (2.4)$$

Δx and Δy in equations (2.4) are the residual of Helmert's transformation equations (2.1), and can be regarded as representative of the accidental errors after excluding the systematic errors of both coordinate systems.

Δx and Δy of the four points are given in Table 8 below.

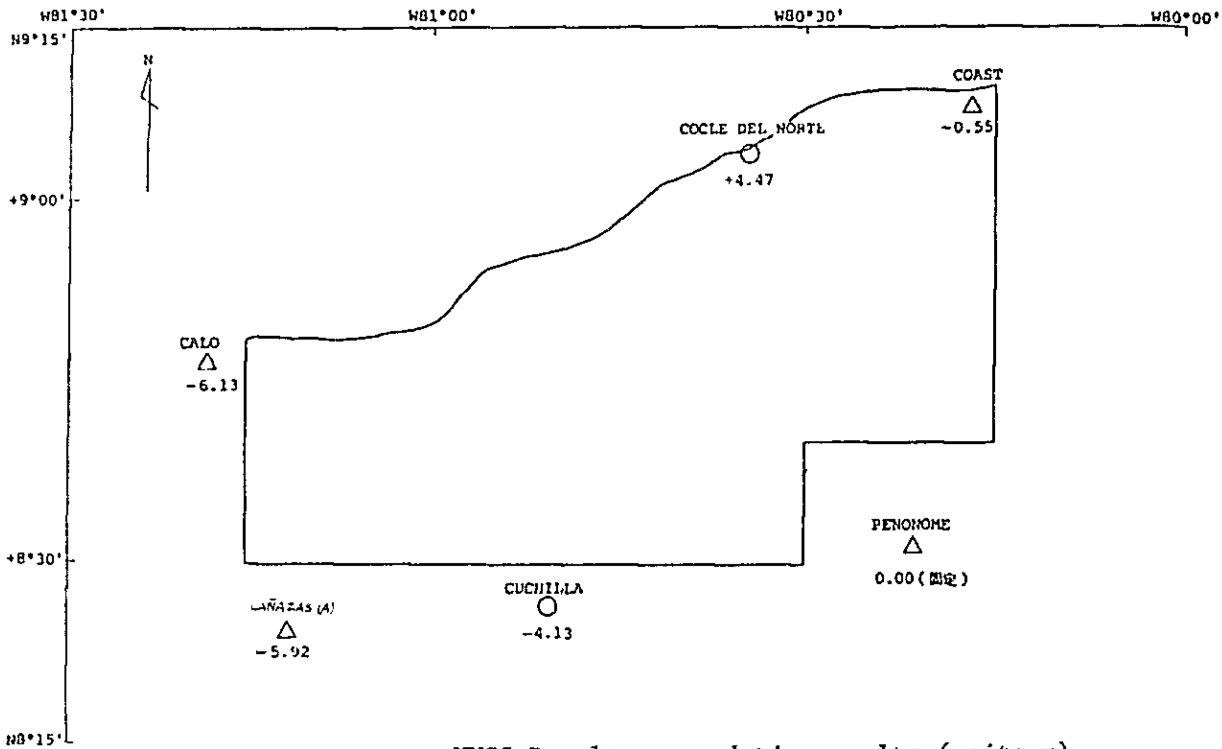
Table 8.

	ΔX	ΔY
CALO	-5.07 m	+1.13 m
COAST	+0.61	+4.07
PENONOME	+1.69	-3.00
CANZAS (A)	+2.77	+0.06

The values in Table 8 are not extraordinary considering the accuracy of translocation 2 ∿ 3 m described in 7-1-4 (4). It may be reasonable to consider the accidental errors to be 2 ∿ 3 m. This value complies with the accuracy requirement for horizontal control for the present 1/50,000 mapping (4-2-1).

(3) Conversion of height

The differences in heights of the four points between the NNSS results and the geodetic results are shown in Figure 10. It also shows the heights for two newly established NNSS points (COCLE DEL NORTE and CUCHILLA), which were determined by leveling from bench marks. Figure 10 shows a general east-west tilt. As described in (1)-3), systematic error in height is caused by the tilt of the geoid with respect to the ellipsoid. According to Astrogeodetic WGS 72 geoid map, which gives information on the global geoidal tilt, the geoid in this area has a tilt in the south-north direction, which is approximately 2 m/100 km. The tilt shown in Figure 10 may not be interrelated with the above information. It does not necessarily follow from this that all the differences in heights shown in Fig. 10 are regarded as completely accidental. Notwithstanding the above, additional conversion was not tried since there were no sufficient data available for recognizing any systematic errors from other sources. Further, the said differences in heights fall below the required accuracy (two thirds of the contour interval, that is, 13 m) in attaining the right altitude on the topographic maps (on the scale of 1/50,000) which is the primary objective of the Project; it was decided accordingly that such differences should be regarded as caused by accidental errors.



NNSS Results - geodetic results (unit: m)

Figure 10. Difference in Height between the NNSS Results and the Geodetic Results

(4) Conclusion and final results

As was described in (2) and (3) above, it is not possible to find any specific systematic errors in terms of both planimetry and height between the NNSS results and the already available geodetic results. It was decided, therefore, that the points at which NNSS observation was performed should be handled as follows:

1) The geodetic results both in planimetry and height are to be adopted at the existing triangulation points.

2) As for the planimetic coordinates of the newly set up points, the coordinates that are transformed by the use of equations (2.1) are to be adopted;

3) As for the height of such new points, when the height was determined by leveling from existing bench marks, the results of leveling are to be adopted; otherwise the NNSS results are to be adopted. The above conclusion was made on the basis of the following:

    1) The topographical maps to be made are for general use, and it is practical that the maps have as few contradictions and/or inconsistencies as possible in the existing triangulation points within the area to be mapped.

    2) Although no specific systematic errors were found in the transformation of plane coordinates, transformation equations were used so that the observed results are as close as possible to the official results.

    3) As for the accuracy of the height of the new points, the values obtained by leveling are seemingly more

accurate than those of NNSS. Therefore, for the points where leveling was performed leveling results are to be adopted.

On the basis of the foregoing conclusions, Table 9 was prepared as follows to show the final results to be used for later works at geodetic control points where observation by NNSS was performed.

Table 9. Final Results of Geodetic Control Points (UTM)

Point	N (m)	E (m)	H (m)
PENONOME	941253.04	571565.80	88.94
COAST	1012306.23	579182.02	72.52
CALO	966551.71	470722.04	511.15
CAÑAZAS (A)	921722.93	478872.59	708.26
CUCHILLA	931090.76	516685.04	591.81
COCLE DEL NORTE	1003223.68	547153.28	1.46
TORTUGA	981454.92	567456.83	65.82
LAS MARIAS	982571.41	585915.22	205.13
CALLE LARGA	966892.10	529311.57	91.01
CAMARONES	951542.15	476716.08	187.07
SANTA ROSA	1000175.19	588680.48	12.27
CAÑAZAS (B)	923201.32	478111.73	680.20
COCLECITO	973617.05	548733.02	60.51

7-1-6 Check of height by barometry

In the barometric leveling, three established points (existing bench marks) were arranged so as to enclose one or two unknown points. M-2236 and M-2236A type (minimum reading at 1/100 mb) aneroid barometers manufactured by Negrettl Zambra (Britain) were used to make required observation, (i.e. for one point, observation was made every one hour from 7:00 to 19:00 for three days).

A single observation consists of the mean of 6 readings. From the above observation, barometric height difference between an unknown point and a given point was obtained and then the height of the point was calculated on the basis of the given point. Averaging the above values for the other two given points, the height of a point was determined.

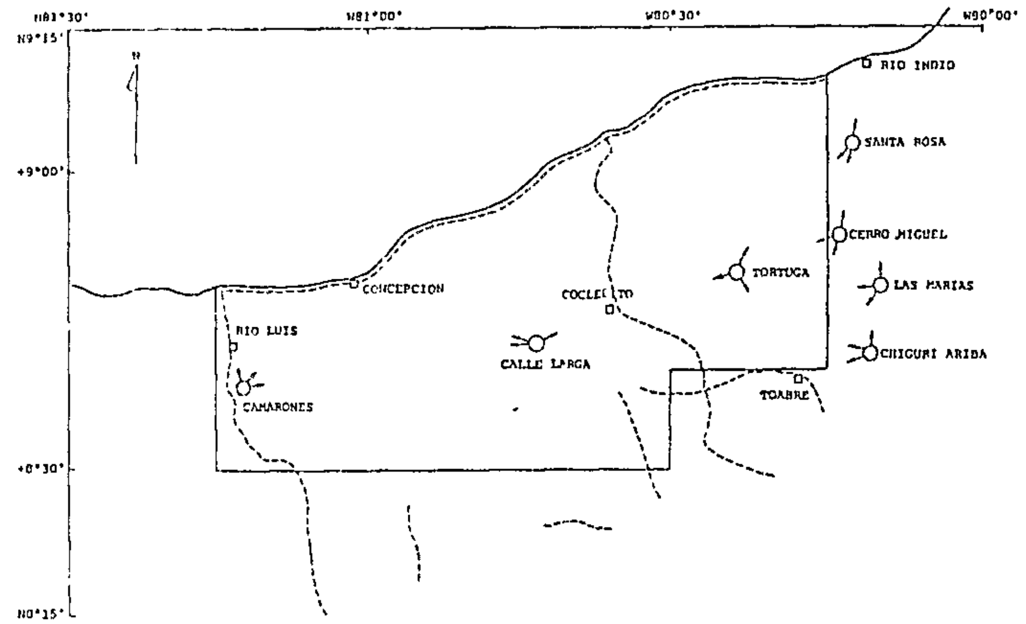
The following Laplace equation was used for the calculation:

$$h = 18646 (\log Bo - \log B) (1 + \alpha t)$$

where, h is height (m), Bo and B atmospheric pressure at higher and lower points (mb), α coefficient of expansion of the air 0.003665 and t temperature difference between higher and lower points (C°).

The difference between the obtained values and the NNSS values was a maximum 8.74 m and a minimum 0.60 m. It is considered that the check was reasonably successful.

Concerning the arrangement of observation points, see Figure 11, and Tables 10 and 11 for the observation results.



○ Unknown point for indirect leveling
→ Direction towards the given point
▫ Given point observed simultaneously
--- Pricked leveling route

Table 11. Execution of Indirect Leveling and Pricked Leveling Routes

Table 10. Results of Indirect (Barometric) Leveling

(Unit: m)

Scheme of observation: Simultaneous observation between one unknown and three known points

Single observation: Mean of 6 readings

Unknown point	Given point	Heights of given point	Relative height	Height of unknown point	Means of the height of unknown point B	Height obtained by NNSS obs. A	A - B
CERRO MIGUEL	COCLECITO	59.32	207.62	266.94	267.56		
	RIO INDIO	9.01	257.90	266.91			
	TOABRE	198.79	70.03	268.82			
LAS MARIAS	RIO INDIO	9.01	185.63	194.64	196.30	205.13	8.73
	COCLECITO	59.32	135.87	195.19			
	TOABRE	198.79	0.28	199.07			
CHIGURI ARRIBA	TOABRE	198.79	116.90	315.69	313.12		
	CACLECITO	9.01	302.52	311.53			
	RIO INDIO	59.32	252.82	312.14			
TORTUGA	TOABRE	198.79	-131.56	67.23	65.22	65.82	0.60
	RIO INDIO	9.01	54.71	63.72			
	COCLECITO	59.32	5.39	64.71			
CALLE LARGA	RIO LUIS	41.52	49.06	90.58	89.53	91.01	1.48
	COCLECITO	59.32	29.88	89.20			
	CONCEPCION	2.66	86.15	88.81			
CAMARONES	CONCEPCION	2.66	174.97	177.63	178.33	187.07	8.74
	COLECCITO	59.32	118.69	178.01			
	RIO LUIS	41.52	137.84	179.36			
SANTA ROSA	COCLECITO	59.32	- 51.29	8.03	8.68	12.27	3.59
	RIO INDIO	9.01	- 1.07	7.94			
	TOABRE	198.79	-188.72	10.07			

Table 11. Accuracy of Indirect (Barometric) Leveling

Unknown point	Given point	Distance	Observed date (1980)	Number of observations	Accuracy		
					Standard deviation	Discrepancy	
						Maximum	Minimum
CERRO MIGUEL	COCLECITO	37	10/18 ∿ 10/20	42	0.89	1.26	0.62
	RIO INDIO	27	10/18 ∿ 10/20	42			
	TOABRE	38	10/18 ∿ 10/20	42			
LAS MARIAS	RIO INDIO	39	10/22 ∿ 10/24	42	1.97	2.77	1.11
	COCLECITO	38	10/22 ∿ 10/24	42			
	TOABRE	28	10/22 ∿ 10/24	42			
CHIGURI ARRIBA	TOABRE	15	10/22 ∿ 10/24	42	1.83	2.57	0.98
	COCLECITO	37	10/22 ∿ 10/24	42			
	RIO INDIO	59	10/22 ∿ 10/24	42			
TORTUGA	TOABRE	27	10/14 ∿ 10/16	42	1.48	2.01	0.51
	RIO INDIO	41	10/14 ∿ 10/16	42			
	COCLECITO	20	10/14 ∿ 10/16	42			
CALLE LARGA	RIO LUIS	50	10/9 ∿ 10/11	42	0.76	1.05	0.33
	COCLECITO	19	10/9 ∿ 10/11	42			
	CONCEPTION	30	10/9 ∿ 10/11	42			
CAMARONES	CONCEPCION	32	10/9 ∿ 10/11	42	0.74	1.03	0.32
	CONCLECITO	72	10/9 ∿ 10/11	42			
	RIO LUIS	10	10/9 ∿ 10/11	42			
SANTA ROSA	COCLECITO	51	10/18 ∿ 10/20	42	0.98	1.39	0.65
	RIO INDIO	10	10/18 ∿ 10/20	42			
	TOABRE	55	10/18 ∿ 10/20	42			

7-2 Pricking

Pricking was done on a control point when it was clearly identifiable on the aerial photo. Otherwise, a clearly identifiable ground object close to the control point was pricked in place of it with eccentric measurements.

1/10,000 scale photos (approx.) were used for horizontal control and 1/15,000 scale photos (approx.) for vertical control.

Pricking, as well as aerial photo signals, plays a role in linking aerial photos to the ground. Skilled members took charge of the job where the area worked in was largely jungle and where it was difficult to find and select planimetric features for pricking.

8. Field identification

8-1 Study of work specifications

As to the application of the map format, the survey team had discussions before leaving Japan with the aim of unifying their views. Questions and obscurities were discussed with IGN in Panama. Some supplementary explanations and modifications were made by IGN. These matters took up most of the discussion time before field work was started. Discussions were also held on specific items with counterparts while working in the field.

Before commencing the work, items discussed concerning MT-321 were as follows:

- <u>No. 111</u>

  The ends of the roads should be closed to indicate no thru-traffic. Also, roads under 12.5mm on the map should not be indicated.

- <u>No. 116</u>

  There is no symbol for roads passing through city areas.

- <u>No. 147</u>

  High-voltage transmission lines would be indicated by data supplied by IGN.

o Nos. 149, 150, 151, 159, 160

Buildings or stables should be differentiated from cottages or temporary sheds respectively.

o Nos. 165, 205

No. 165 indicates planned location for mining and No. 205 indicates a mine in operation.

o Nos. 206, 207

Area where a number of small mines are scattered about will not be shown by either symbols No. 206 or 207, but will be surrounded by broken lines and shown by AMS No. 35A.

o Nos. 212, 214

The path point for aerial triangulation is not indicated on the final map. Bench marks should be indicated only when used for the present survey.

The value of a spot height should be indicated in brown, and a field-checked value should be indicated in black.

o Nos. 227, 228

Boundaries along conspicuous linear features (e.g. roads or single-line streams) should be indicated on the final map by only the third symbol.

o Nos. 258, 259

The depth by echo sounder is shown by No. 258 and the depth by rod is shown by No. 259.

o No. 293

This indicates running water which is not indicated by other symbols.

o Nos. 310, 302

These do not exist in Panama.

- <u>No. 356</u>

  This is read as "high plantation" (above the average height of human bodies) and not as permanent plantation.

- <u>No. 356</u>

  This is read as "low plantation" (below the average height of human bodies) and not as temporal plantation.

- <u>No. 359</u>

  This stands for vegetation in sea-water.

- <u>No. 362</u>

  This stands for vegetation in fresh water, but such vegetation is not found in Panama.

- <u>Annotation</u>

  The size of letters should be determined by the length and breadth of the area. Templates are used for this purpose.

- <u>Single-line stream</u>

  The standard application for single-line stream is described in TPC TMS-1 Chap. 6, Sec. X-1. Streams broader than 0.5mm on the maps are classified as double-line streams.

- <u>Cemetery</u>

  No differentiation is made between religious denominations.

- <u>Bridge</u>

  No differentiation is made between structural differences. Classification is made as to whether a bridge is passable by motor vehicles or pedestrians.

- <u>Cliff</u>

  This is not symbolized in Panama but is indicated in terms of contours.

o Road under construction

Roads under construction are indicated on the map, excluding those being planning. If roads are partially in service, the conditions at the time of the field survey should be indicated.

o Half interval contour lines

These should be applied as necessary for topographical representation.

o Tying to adjacent existing maps

Contour lines and planimetric features would not be corrected if there was a discrepancy of more than 1mm on the map when tied to an adjacent existing map. However, the discrepancy would be reported to IGN.

8-2 Field survey

In the field, survey items were entered onto twice enlarged photos with the cooperation of the Japanese survey team and counterparts. Place names were written down on contact prints by Panamanian counterparts and they made a list of place names from these contact prints.

In the jungle of the Caribbean coastal area north of the dividing ridge running in the east-west direction, the work was mainly performed with the use of helicopters. In the savannah south of the dividing ridge, the work was performed using motor vehicles and on-foot.

8-3 Remarks

The cooperation of the counterparts was indispensable when the work mainly consisted of listening to the inhabitants whose mother tongue is Spanish. In order to effectively perform the field work, it is necessary to study the standard application of the map format and various source materials and have discussions with the counterparts before commencing the on-site survey.

Since the Japanese survey team members often made mistakes in reading the Spanish name list prepared by counterparts during the editing work, it is desirable that such lists be prepared by typewriters so as to reduce individual discrepancies in writing.

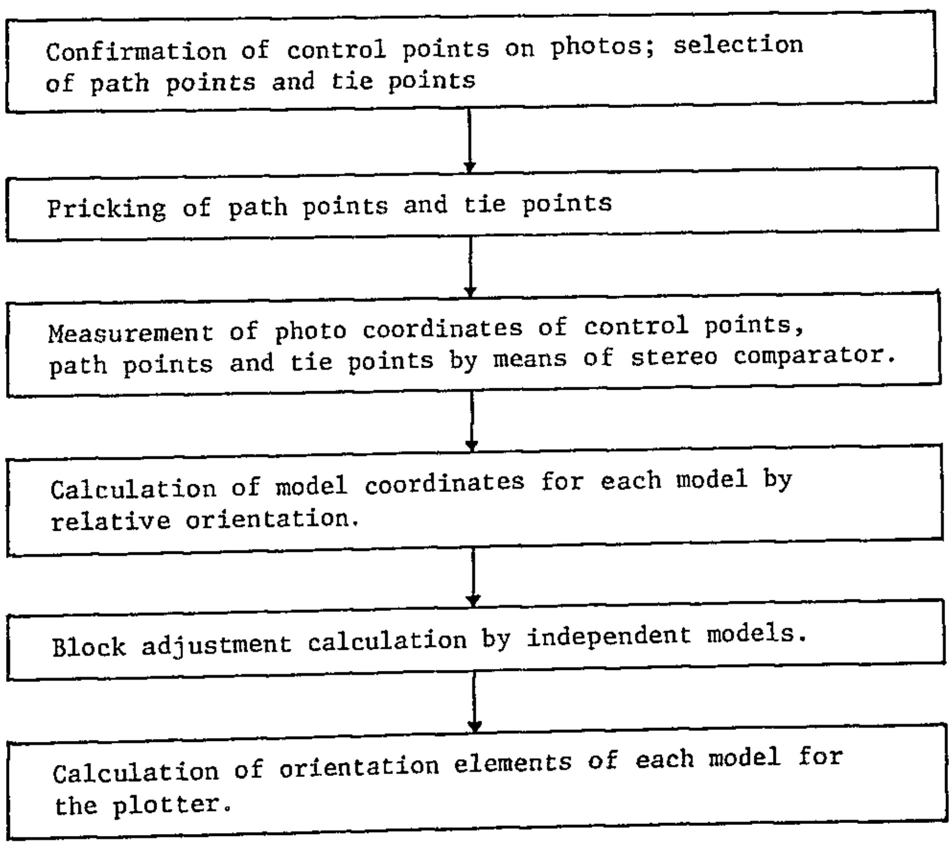
9. Aerial Triangulation

9-1 Outline

For the aerial triangulation a method involving block adjustment with independent models was adopted. The program used is called PAT-M and it is a block adjustment program with independent models developed by Stuttgart University in West Germany

The model coordinates of each model that provide the input of block adjustment calculation were obtained analytically from the photographic coordinates that were measured by a stereo comparator.

The following is the flow diagram of the aerial triangulation executed.



9-2 Specifications

The specifications for the work are as follows (Table 12).

Table 12. Specifications for Aerial Triangulation

Number of models	250 models
Number of courses	13 courses
Scale of photos	1:60,000
Principal distance	152.335mm
Overlap	60%
Sidelap	30%
Flight altitude	9,500 m
Number of path points	6 points/model
Number of tie points	0.5 points/model
Number of horizontal control points	16 points
Number of vertical control points	23 points
Comparator	Stereo comparator
Plotting scale	1/50,000
Maximum topographic relative height	1,500m

Further to the above, the positions of the center of photos, control points, tie points, etc. are shown in photo index map in in Figure 12.

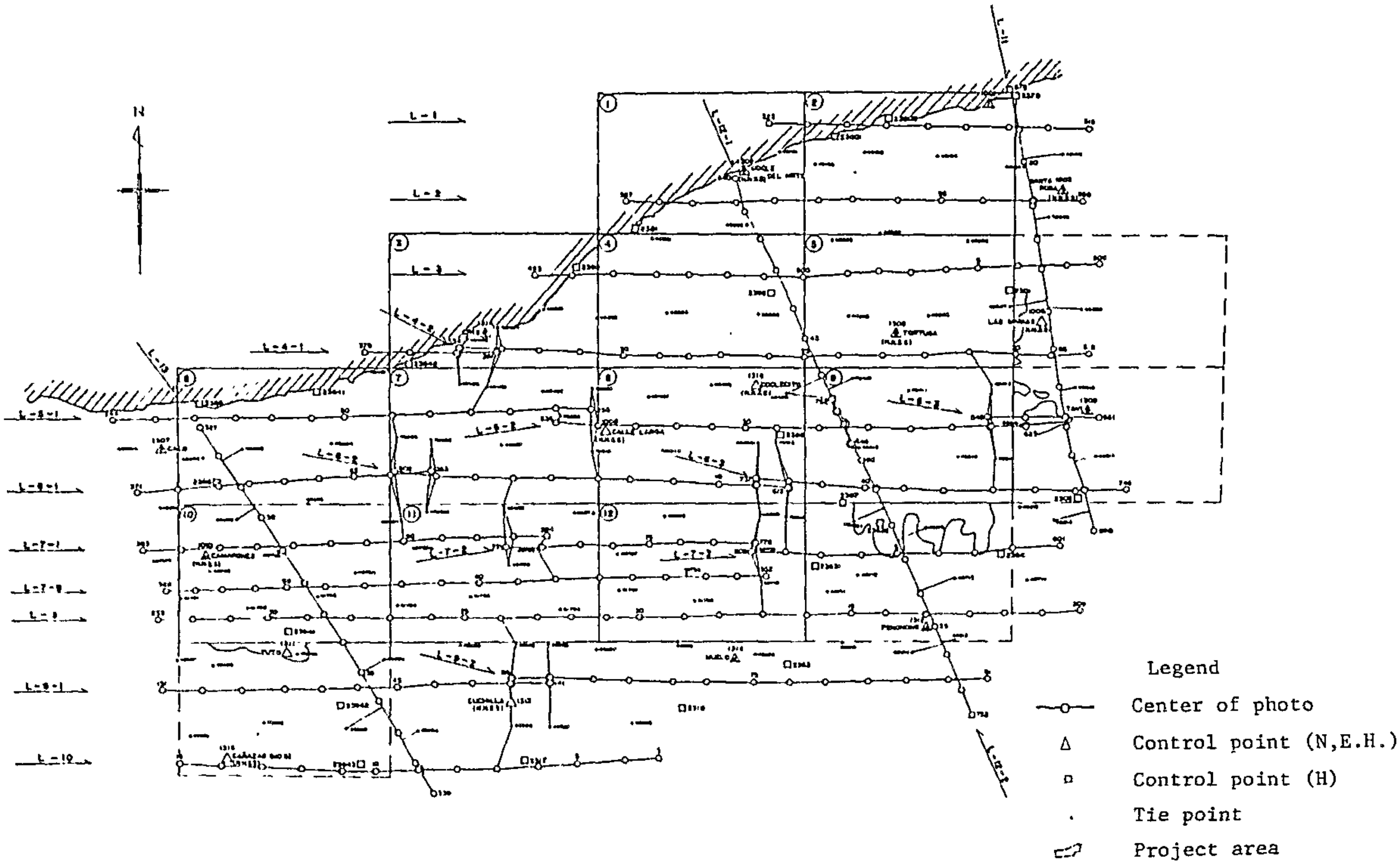


Figure 12. Photo Index Map

9-3 Block adjustment (PAT-M)

9-3-1 Conditions

The block adjustment program "PAT-M" that was used for the adjustment calculation has the function of setting up various conditions for calculation. The conditions set up for the present work were as follows.

(1) To correct the earth's curvature;

(2) Calculation shall be repeated as follows;

horizontal adjustment → vertical adjustment → horizontal adjustment → vertical adjustment → horizontal adjustment

(3) The weight matrix* was set up for various measured values coming into the adjustment calculation as follows;

1) Model coordinates (excluding perspective center)

$$\begin{bmatrix} 1.00 & 0.00 & 0.00 \\ 0.00 & 1.00 & 0.00 \\ 0.00 & 0.00 & 1.00 \end{bmatrix}$$

N.B.: The accuracy of the model coordinate measurement was taken as 1.00 and this value was considered to be the standard values.

2) Model coordinates of the perspective center.

$$\begin{bmatrix} 0.25 & 0.00 & 0.00 \\ 0.00 & 0.25 & 0.00 \\ 0.00 & 0.00 & 1.00 \end{bmatrix}$$

N.B.: The above values were empirically obtained by Professor F. Ackerman et al., Stuttgart University, West Germany, who developed the PAT-M Program.

3) Coordinates of control points

$$\begin{bmatrix} 1.00 & 0.00 & 0.00 \\ 0.00 & 1.00 & 0.00 \\ 0.00 & 0.00 & 1.00 \end{bmatrix}$$

N.B.: The overall accuracy of the model coordinates is about 30μm on the photos (which is about 2 m on the ground). The accuracies of the control points utilized are nearly of the same order. Therefore, the weight of the control point was regarded as equal to that of the model coordinates.

* Weight matrix ..... A matrix representing the accuracy ratio of various measured values unified to the scale on the ground. Diagonal elements (1.1), (2.2), (3.3) represent the weights of geodetic coordinates (N,E,H,) and non-diagonal elements represent correlation among them.

9-3-2 Adjustment Results

The results of adjustment are given in Table 13.

Table 13. Results of Adjustment

	Mean error	Maximum value
Residual of horizontal control points	1.5 m	4.3 m
Residual of vertical control points	1.1 m	3.0 m
Horizontal discrepancy of tie points	1.2 m	3.6 m
Vertical discrepancy of tie points	1.0 m	4.2 m

9-4 Remarks

Block adjustment by independent models as applied in the present survey, is the method evaluated as most suitable for topographic mapping in North America and Europe. In the present case, in spite of the relatively small number of control points, it was possible, by using this method, to obtain results called for in the project plan.

Regarding the horizontal control points, they are distributed around the blocks at a distance of 6 to 7 models, giving a nearly ideal layout. As for distribution of the vertical control points, the number is not sufficient. It is also a fact that there are great difficulties in achieving ideal layout in the case of mountain ranges. In order to prevent the incomplete models occurring in the northern coastal line from influencing adjoining models, it was necessary to establish auxillary vertical control points of zero height along the coastline.

The mean error of the results of adjustment for both horizontal and vertical control points was from 1.0 to 1.5 m. This is equivalent to about 0.15% of the flight altitude, and the adjustment can be considered good. The aerial triangulation in the present case is intended for 1/50,000 topographic mapping and therefore these adjustment results are fully satisfactory.

10. Plotting and compilation

10-1 Outline

Plotting and compilation were carried out with the results of aerial triangulation and field identification, according to the MT-321.

As for field identification, conditions at the site made complete field reconnaissance impossible; so portions of the roads, rivers, houses, vegetation, etc., were photo-interpreted

10-2 Specifications for plotting

Plotting scale	1/50,000
Contour lines	Intermediate contour 20m
	Index contour 100m
	Half interval contour 10 m
Plotting machine	Wild A-8
Projection	UTM Projection, 1 km grid interval
	Lambert Projection tick for 4 km grid interval
Area plotted	5,700 km^2
Sheet lines	East-West 15' x North-South 10'
Material	Microtrace NSW #500

10-3 Plotting

Plotting of control points

The plotting of control points and sheet lines was conducted with coordinate graphs, and the maximum error was less than 0.2mm on the map.

Relative orientation

Relative orientation was carried out using six pass-points, while residual parallax was kept within a maximum of 0.02mm on the positive film.

Absolute orientation

The error in position of control points and pass-points in absolute orientation was kept within a maximum of 0.5mm on the map, and the maximum error of height was kept within 5 m.

Detail plotting

Plotting of details was conducted in the following order: linear objects, buildings, contour lines and vegetation, etc. care was taken to avoid gaps in delineation. Unplottable parts covered by clouds were left blank.

Spot heights

Spot heights are principally distributed every 5 cm on the map, and located at mountain summits, saddles, river confluences, road intersections, and distorted surface areas. Double reading was done down to the unit of meters and mean value was adopted. The tolerance in the double reading was kept within 2 m. Contour lines were established at 20 m intervals for intermediate lines and 100 m for index lines, while in cases where cartographic necessity seemed to require it, 10 m half interval contour lines were added, especially in lowlands along the coastline.

10-4 Tying to the adjacent existing maps

If the discrepancy between adjacent existing maps was less than 1.0mm, tying was done. However, if the discrepancy was more than 1.0mm, plotting was carried out without taking tying into consideration and the effects were reported to IGN. There occurred a discrepancy of from 2 to 3mm up to 5mm as a whole, but topographical features were relatively similar to each other.

10-5 Compilation

10-5-1 Compilation operations

(1) Outline

Using the stereo-plotted manuscript and results of field identification, compilation was conducted according to the map format, and compilation manuscripts were drawn up.

(2) Drawing sheet

The size of the drawing sheets used was 76.5 cm by 61 cm, and the material was #500 polyester sheets, which have a relatively small rate of expansion and contraction.

(3) Plotting

Plotting of control points and sheet lines was conducted using a coordinate graph. Plotting error was kept at less than 0.2mm on the map.

(4) Compilation

1) Compilation manuscripts were compiled from stereo-plotted manuscripts and field identification data in accordance with the map format.

2) The elevation of control points was indicated. Only bench marks used in the project were indicated by the conventional sign CF and their elevation. Spot heights were distributed at a rate of 7 to 8 points per 10 cm x 10 cm on the map.

3) Villages and roads were classified and indicated using the materials of field identification.

4) Intermediate contour line interval was 20 m, and index contour line interval was 100 m.

5) For areas where supplementary field surveys were necessary, overlays for field completion were prepared for future operations. Items needed for surveys were indicated as follows:

   a) Questions regarding the existence of major roads connecting villages and roads that vanish.

   b) Inconsistencies in the orthography of place names and rivers believed to be identical.

   c) Points at which the notations of names of river or places were not clear.

   d) Questions concerning Spanish language orthography.

   e) Confirmation of position of notations of district names and mountain names.

10-6 Problems which arose during the work

Items requiring attention

- Oversights in the interpretation on plotter of rivers, paths and isolated houses in jungles.
- Mis-interpretation of an isolated house for an isolated tree.
- Discrepancies between contour lines and elevation on account of omission of contour lines.
- Inappropriateness of positions of notations and elevation figures due to overlapping with grid lines, grid values, rivers, roads, etc.

Points which required special care

- Due to lack of standards for detailed application of positioning of notations, judgements were left up to the team members to be made on a case-by-case basis, causing unnecessary work in some cases.
- Difficulty was experienced in the treatment of orthography and accent due to unfamiliarity with Spanish language.
- In principle, contour values were to have been indicated so as to be legible from lower to higher elevations, but the prevalence of northern slopes required some effort in positioning figures so that they could be easily read from the southern sheet line.

11. Field completion

11-1 Purpose

Field survey was mainly directed at clarifying questionable points and unidentified points encountered in the laboratory works in the areas west of the Río Indio as well as in the vecinity of Calcito, which seemed to have suffered many secular changes.

It was also directed at surveying and confirming place names, river and mountain names and boundaries in the areas where the field identification was insufficient.

11-2 Method of the survey

The survey of boundaries based on the 1980 census provided by IGN as well as determination of type and size of orthography and other indoor works were conducted at the IGN office. Field surveys were aimed at boundaries which were unclear from source materials provided by IGN, as well as the items noted above. For field work in areas where helicopter landings were not possible, landings were made at villages near the survey target areas and information was collected from local inhabitants. Further, in the case of four sheets for savannah areas, unfavorable air currents prevented survey by helicopter. In this case, an independent survey was conducted by IGN personnel working on horseback who surveyed items proposed by the Japanese survey team. Personnel involved in the field survey operation were 5 Japanese team members and 11 Panamanian members.

11-3 Results of the survey

Because the savannah areas which could not be reached by helicopter were reached by horseback, better survey results were obtained. Overlays of place names on the photos for field identification ought to have been prepared before field work and have been confirmed in the field. However, owing to the delay in aerial photography and preparation of the name list, locations of the place names were not confirmed in the field and there were many to be revised by the Japanese side on account of misreading of the hand-written manuscript of the name list.

11-4 Remarks

On the basis of the above-noted problems, it is felt that necessary materials should have been prepared before the aerial photography was completed, and that collation of field site photographs for field identification with source materails should have been completed before entering the field.

In particular, name-lists should have been typed rather than hand-written, as noted in section 3-3 above, in order to prevent misreading.

By means of the field completion work all field operations were completed. Concerning field operations, the following points should be noted.

a. IGN was very cooperative in facilitating the work of the Japanese survey team, which was unfamiliar with local conditions. This included not only providing the S/W, but in maintaining open channels for the reception of transmissions from the Japanese survey team on the IGN office shortwave apparatus throughout office hours. In addition, IGN provided excellent moisture-proof storage facilities for materials and equipment, as well as trucks, cars, radio and batteries, etc.

b. Restrictions on activities due to bad weather
Local variations in weather conditions during the rainy season (May - December) were more severe than anticipated.
There were a large number of instances in which plans had to be revised because helicopters or vehicles were unable to depart on schedule or had to turn back, etc.

Team members experienced considerable frustration in cases where preparations had been made to depart for field survey, but due to weather conditions departure time remained uncertain. In addition to this problem, it was impossible to provide definite information on the survey schedule to IGN counterparts for the same reason, thus preventing them from providing backup.

In case of movement by helicopter, it was necessary to make materials and equipment waterproof because they had to be placed on the outside of the aircraft.

12. Drafting and printing

12-1 Drafting

12-1-1 Outline

The color-separated scribed originals were prepared in accordance with the map format and its application for the purpose of making printing plates based on the original manuscripts which consisted of scribed sheets, maskings, sheets for notations and marginal information, grids, conventional signs, etc. At the same time color composite positives were prepared for checking and inspection.

12-1-2 Study of the application of the map format

Regarding the application of the map format, reference was made to MT-321 and DMA TPC's TM S-1, Chap 6. Sec. X-1. Concerning the marginal information and specifications for notation, agreement was reached on the following.

(1) Marginal information and notations

1) Concerning the format for marginal information, the title, sheet number, edition and serial number, legend, magnetic north, diagram of administrative boundaries, index of adjacent sheets, annotations, history, etc., were discussed. The positions of the legend and the

history will be changed from those on the existing sheets, and substantial changes will be made in the marginal information.

2) Since some of the specified typefaces for notations are unavailable in Japan, approximately identical typefaces will be substituted as follows:

	(Specified typeface)	(Substituted typeface)
Place Names	SPARTAN MEDIUM	FUTURA MEDIUM
Topographical Feature Names	SPARTAN MEDIUM ITALIC	FUTURA MEDIUM ITALIC
Contour Values	AMS SLOPE GOTHIC	LIGHT LINE GOTHIC ITALIC

3) In cases where there is a single Provincia or Distrito occupying a single sheet, the name will be inscribed near the center of the sheet as indicated below. In cases where more than one Provincia or Distrito appear on a single sheet, the names will be given on either side along the boundary separating the respective regions, and will not be indicated in the center area of those regions on the sheet.

(eg.) PROVINCIA DE VERAGUAS h $i<4h$ $d=3i$

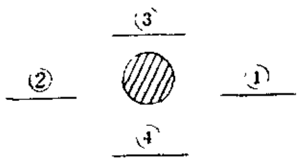
i d

4) As for rivers and other linear objects, names will be inscribed above the objects in such a way so as not to intersect the objects as far as possible, in the interests of legibility. For "Punta" and "Quebrada," care will be taken to inscribe the full name as much as possible.

(2) In the application of the map format, the following problems were solved:

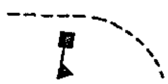
1) The order of preference for the inscription of administrative (village) names, as well as for explanatory notes, is as shown below:

For example:



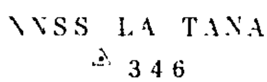
2) Conventional signs for schools, churches and other specific buildings should be inscribed so that the sign will be perpendicular to and on the opposite side of the building entrance.

For example:



3) As for the indication of NNSS control points, these will be given only on the map and not in the legend. An example of the mode of indication is given below.

For example:



4) Concerning the annotation of grid values, there are some ways they are represented on the existing maps; one way is giving one row and line of values and the other ways are giving more than one row and line of values respectively on the sheet. For the present project grid values are given in three rows and two lines.

Furthermore, the positions of inscriptions of grid values should be matched with those of adjacent sheets.

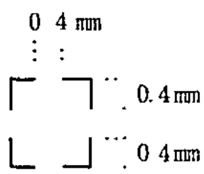
5) Areas covered by clouds will be seen as blank spots on the map; the explanatory notation "NUBES" will be inscribed in such spots.

6) Symbol for spot heights will not be given at road intersections.

7) Contour values of isobaths should be arranged so that they will be legible when the southern sheet line faces you.

8) In the case of small cemeteries, difficulties will be encountered in the representation of actual configuration. The minimum size on the map should be as given below.

For example:



9) Although the specifications for half interval contour lines call for a line width of 0.15mm, these should have a width of 0.10mm, as in the case of the intermediate contour.

10) All isobaths will be inscribed with a line width of 0.1mm, the same width as for the intermediate contours.

12-1-3 Scribing

(1) Materials used for scribing are as follows:

	(manufacturer)	
scribing base (thickness 0.12mm)	K & E Co.	yellow base
mask base (thickness 0.12mm)	Kimoto Co.	peel coat
polyester base (thickness 0.08mm and 0.12mm)	Kimoto Co.	diamat
negative film (thickness 0.12mm)	Dupont	COS-7 (final neg.)
negative film (thickness 0.08mm)	Dupont	COS-4 (intermediate neg.)

The sheet size is 76.2 cm x 61.0 cm.

(2) Process of operations

The process of scribing (work flow) as well as the content of the individual sheet is shown in Figure 13. For resistering each sheet, a punching hole system was adopted.

(3) Content of the color separation sheet:

1) Sheets for black

a) Base for marginal information ... Marginal information, notations, building symbols, etc.

b) Scribed base ... Planimetry (roads, buildings etc.), boundaries, isobaths, sheet lines, etc.

c) Base for grid ... grid lines, grid values, etc.

2) Sheets for red

a) mask base ... building clusters, paved roads, etc.

3) Sheets for blue

a) Base for annotation ... notations for water system

b) Scribed base ... water system, (rivers, lakes, reservoirs, etc.)

c) Mask base ... water surface (oceans, lakes, reservoirs, double line rivers, etc.)

4) Sheets for green

a) Base for zip-a-tone ... farms, marshes, etc.

b) Mask base ... forests, weeds, palm frees, etc.

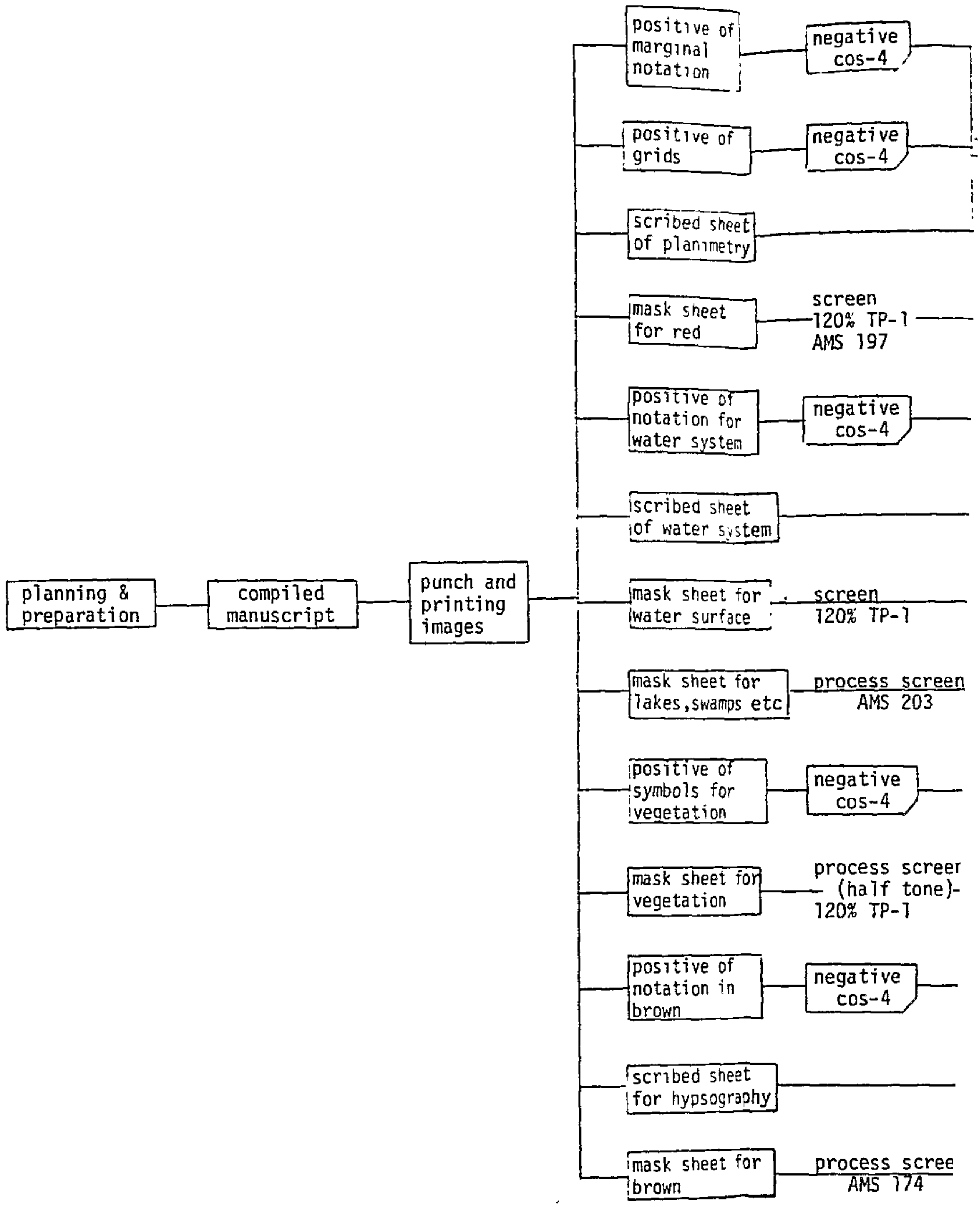
5) Sheets for brown

a) Base for annotation ... elevation values, local Lambert projection grid values

b) Scribed base ... contours, embankments

c) Mask base ... sandy areas

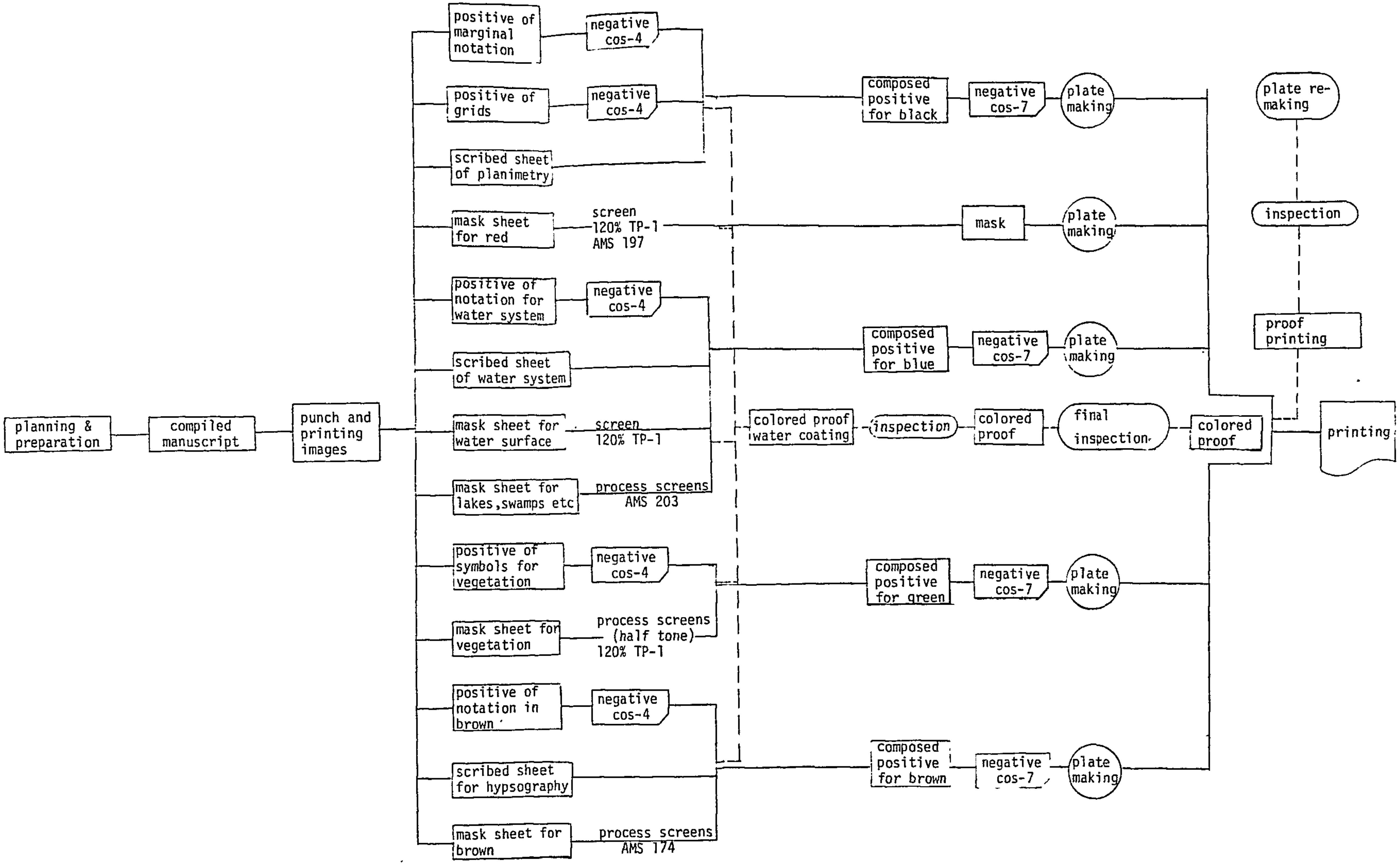
SCHEMATIC DIAGRAM FOR SCRIBING AND PRINTING



NOTE: 1. positive film --- Diamat 0.08 mm
2. negative film --- cos-7 0.15 mm
cos-4 0.10 mm
3. composed positive and colored proof --- Diamat 0.12 mm
4. scribing base --- K & E Co. yellow base 0.12mm
5. masking base --- peel coat o.12 mm
6. printing plate --- pre-sensitised plate

Figure 13. Dra

SCHEMATIC DIAGRAM FOR SCRIBING AND PRINTING



NOTE: 1. positive film --- Diamat 0.08 mm
2. negative film --- cos-7 0.15 mm
cos-4 0.10 mm
3. composed positive and colored proof --- Diamat 0.12 mm
4. scribing base --- K & E Co. yellow base 0.12mm
5. masking base --- peel coat o.12 mm
6. printing plate --- pre-sensitised plate

Figure 13. Drafting and Printing Processes.