Japan International Cooperation Agency (JICA)
National Geographical Institute (IGN)
National Institute for Seismology, Volcanology, Meteorology and Hydrology (INSIVUMEH)
Secretariat of Planning and Programming for the Presidency (SEGEPLAN)

THE STUDY FOR ESTABLISHMENT OF BASE MAPS AND HAZARD MAPS FOR GIS IN THE REPUBLIC OF GUATEMALA

FINAL REPORT (SUMMARY)

NOVEMBER 2003

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PREFACE

In response to a request from the Government of the Republic of Guatemala, the Government of Japan decided to conduct the Study for Establishment of Base Maps and Hazard Maps for GIS in the Republic of Guatemala and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA dispatched a study team headed by Mr. Kazuo Furukata of Kokusai Kogyo Co., Ltd. to the Republic of Guatemala, six times between December 2000 and November 2003.

The team held discussions with the officials concerned in the Government of the Republic of Guatemala, and conducted field surveys in the study area of 30,000 km^2. Upon returning to Japan, the team prepared this report and completed the GIS database and national base and hazard maps.

I hope that this report will contribute to the promotion of future development projects in the Republic of Guatemala and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials of the Government and those concerned in the Republic of Guatemala for the close cooperation they extended to the study.

November 2003

Kazuhisa Matsuoka
Vice President
Japan International Cooperation Agency

Mr. Kazuhisa Matsuoka
Vice President
Japan International Cooperation Agency

November 2003

Letter of Transmittal

We are pleased to submit to you the report on the Study for Establishment of Base Maps and Hazard Maps for GIS in the Republic of Guatemala.

This study was conducted by a study team headed by myself, Kazuo Furukata of Kokusai Kogyo Co., Ltd., under a contract to JICA, from December 2000 to November 2003.

The team held discussions with the officials concerned in the Government of the Republic of Guatemala, and conducted field studies that included aerial photography, control point and disaster history surveys, and technology transfers. In Japan, the study team carried out plotting of modifications using the latest digital plotting system, creation of digital orthophoto maps and building of the GIS database, then prepared national base maps on a scale of 1:50,000 covering an area of approx. 30,000km^2 in Guatemala, together with digital data on CD-ROMs and printed maps, and also orthophoto maps on a scale of 1:10,000, hazard maps, digital data on CD-ROMs and printed maps.

This report covers the production process, study results and proposals for the future.

On behalf of the study team, I would like to express our heartfelt gratitude to the officials of the Government of the Republic of Guatemala and of the organizations concerned for their assistance and close cooperation during our stay in Guatemala.

I also wish to express my sincere appreciation for the invaluable advice and cooperation we received from JICA as well as from those concerned in the Ministry of Foreign Affairs and the Ministry of Land, Infrastructure and Transport, and from the Japanese Embassy and JICA office in Guatemala during the period of the survey,

Very truly yours,

Kazuo Furukata
Team Leader
Study Team on Establishment of Base Maps and Hazard Maps for GIS in the Republic of Guatemala

Areas for production of 1:50,000 national base maps

Areas for production of 1:10,000 orthophoto maps

Location Map for the Study for Establishment of Base Maps and Hazard Maps

Photos of the great earthquake in 1976 disaster areas stricken by Hurricane Mitch, and a photo of Pacaya Volcano

Contents

Chapter 1 Project Outline 1-1

Chapter 2 Objectives of the Project.....2-1

2.1 Background 2-1

2.2 Objectives of the Study 2-2

2.2.1 Establishment of GIS base map data 2-2

2.2.2 Production of hazard maps 2-2

2.2.3 Technology transfer 2-2

Chapter 3 Study Methods 3-1

3.1 Study Areas 3-1

3.1.1 Study area for establishment of GIS base maps.....3-1

3.1.2 Study area for production of hazard maps 3-1

3.2 Basic Policies 3-2

3.2.1 Basic policies for operation 3-2

3.2.2 Basic policies for technical matters 3-2

3.2.3 Basic policies for technology transfer.....3-2

3.3 Contents of the Study.....3-3

3.3.1 Items and volume of work 3-3

3.3.2 Study schedule 3-6

3.3.3 Members 3-6

3.3.4 Items produced.....3-7

Chapter 4 Contents of the Project 4-1

4.1 Establishment of 1:50,000 Scale GIS Base Maps.....4-1

4.1.1 Discussions on GIS specifications 4-1
4.1.2 Investigation of existing conditions 4-3
4.1.3 Aerial Photography 4-5
4.1.4 Rasterization (in technical cooperation with IGN) and vectorization 4-6
4.1.5 Temporal changes detection, photo interpretation and field survey 4-6
4.1.6 Production of spatial information database (Digital plotting of modifications and digital compilation) 4-11
4.1.7 Production of printed map data (digital compilation) 4-21

4.2 Production of 1/10.000-scale Orthophoto Maps 4-27
4.2.1 Ground control point survey (in technical cooperation with IGN) 4-27
4.2.2 Production of orthophoto maps 4-31

4.3 Hazard mapping 4-38
4.3.1 Outline of hazard mapping study 4-38
4.3.2 Hazard map creation environment 4-41
4.3.3 Hazard mapping 4-48

4.4 Transfer of Technology 4-60
4.4.1 GPS precise survey 4-60
4.4.2 Digital plotting/data compilation 4-63
4.4.3 Building of database/analysis of GIS 4-73
4.4.4 Digital printing 4-77
4.4.5 Technology transfer 4-82
4.4.6 GIS/Hazard map seminar 4-83
4.4.7 Evaluation of Technology Transfer Training by Participants 4-86

4.5 Noteworthy background of the Study 4-90
4.5.1 Response of Each Counterpart Agency 4-90
4.5.2 Expectations of Guatemala for this Study 4-98
4.5.3 Recognition by the top levels of the state (Presentation to the Vice President) 4-99
4.5.4 Importance of GIS for the country 4-100
4.5.5 Database required for an early recovery of the Peace Zone 4-104
4.5.6 Holding of the GIS and hazard map seminar 4-107

Chapter 5 Project Evaluation 5-1

5.1 Overall Goals and Project Purposes 5-1

5.2 Five-item evaluation 5-2

5.3 Evaluation results 5-3

Chapter 6 Conclusion and Recommendations 6-1

6.1 Conclusion 6-1

6.2 Future development of transferred technologies 6-2

6.2.1 Digital plotting/compilation technologies..... 6-2

6.2.2 Database/GIS technologies 6-4

6.2.3 Digital Printing technologies 6-5

6.2.4 Current tasks in IGN and INSIVUMEH and proposals for the future..... 6-7

6.2.5 Proposals for disaster prevention 6-10

6.3 Recommendations for project implementation of the disaster prevention plan formulation.....6-14

6.3.1 Types of disaster prevention plans..... 6-14

6.3.2 Local disaster prevention and use of hazard maps..... 6-16

6.3.3 Enhancement of functionality of the emergency action and measures organization 6-18

Contents of Table

Table 1-1	Work Schedule (Project Outline)	1-2
Table 3.3-1	Planned work	3-3
Table 3.3-2	Study team	3-7
Table 4.1-1	Ministry/Agency belonging to SNIG (as of the Study)	4-5
Table 4.1-2	Preset resolution and file format for scanning	4-6
Table 4.2-1	Items for plotting planimetric features	4-33
Table 4.3-1	Created hazard maps	4-40
Table 4.3-2	Major organizations for disaster prevention	4-41
Table 4.3-3	Hazard maps published in Guatemala	4-42
Table 4.3-4	Large disasters in history	4-43
Table 4.3-5	Approaches to estimation of hazardous areas in this project	4-48
Table 4.3-6	List of assumed cases of ground motion and liquefaction potential	4-51
Table 4.3-7	Selection of hazard type	4-52
Table 4.4-1	Survey Result of Baselines for Monitoring Volcanic Activity	4-61
Table 4.4-2	Content of technology transfer	4-65
Table 4.4-3	Participants in technology transfer program	4-66
Table 4.4-4	Details of technology transfer	4-69
Table 4.4-5	Participants in technology transfer	4-69
Table 4.4-6	Technology transfer schedule and items	4-72
Table 4.4-7	Participants in technology transfer	4-72
Table 4.4-8	Technology transfer (concerning hazard maps)	4-82
Table 4.4-9	List of questions	4-86
Table 4.5-1	Estimation of population growth made by INE	4-95
Table 4.5-2	Estimated population within the study area	4-96
Table 4.5-3	SNIG Member List	4-102
Table 6.2-1	Proposals for river improvement (example)	6-12
Table 6.3-1	Achievements of the Project related to hazard maps	6-17

Contents of Figure

Figure 1-1	Flowchart	1-3
Figure 3.3-1	Study schedule	3-6
Figure 4.1-1	Example of mosaic photo	4-7
Figure 4.1-2	Mosaic photo (edited (enlarged))	4-7
Figure 4.1-3	Inspection map prepared in Japan	4-9
Figure 4.1-4	Preliminary observation map for field completion survey	4-9
Figure 4.1-5	Example of overshoot and undershoot	4-13
Figure 4.1-6	Failure to connect	4-14
Figure 4.1-7	Missing node	4-14
Figure 4.1-8	Gap in closed figure	4-15
Figure 4.1-9	Compilation of 1:50,000 scale topographic map using MicroStation	4-18
Figure 4.1-10	Flow of data export into PAABANC	4-20
Figure 4.1-11	Coordinate values on grid lines and their positions on printed map	4-23
Figure 4.1-12	Example of annotation font size reduction and rearrangement	4-24
Figure 4.1-13	Example of annotations rearranged to avoid the overlaps with grid line values	4-24
Figure 4.1-14	National border lines with some deviations corrected	4-24
Figure 4.2-1	Control point survey	4-30
Figure 4.2-2	Mosaic Processing	4-34
Figure 4.2-3	Compilation of annotation data by MicroStation	4-34
Figure 4.2-4	Merger of annotation data and orthophoto	4-34
Figure 4.2-5	Input of schools and churches	4-36
Figure 4.2-6	Normal and garbled character lines	4-36
Figure 4.2-7	Connection between map margins	4-36
Figure 4.2-8	Generation of river centre line	4-36
Figure 4.2-9	Closed figure for lake or swamp	4-36
Figure 4.3-1	Overall flow of hazard mapping study	4-38
Figure 4.3-2	Sample disaster map	4-45
Figure 4.3-3	Movement of plates around Guatemala (G. Plafker, 1978)	4-45
Figure 4.3-4	Sample geomorphological map	4-46
Figure 4.3-5	Sample slope angle classification map	4-47
Figure 4.3-6	Flow of estimation of ground motion and liquefaction potential	4-49

Figure 4.3-7 Distribution map of target earthquakes....4-50
Figure 4.3-8 Seismic hazard map(Seismic intensity)....4-51
Figure 4.3-9 Flow of estimation of volcanic hazards....4-52
Figure 4.3-10 An example of volcanic hazard map (Lava flow of Cerro Quemado volcano)....4-53
Figure 4.3-11 An example of volcanic hazard map (Lava flow, edifice collapse and pyroclastic flow of Pacaya volcano)....4-53
Figure 4.3-12 Flow of landslide hazard evaluation....4-54
Figure 4.3-13 Sample landslide hazard map....4-55
Figure 4.3-14 Sample landslide hazard map (Slope angle classification map)....4-55
Figure 4.3-15 Flow of flood hazard map production....4-56
Figure 4.3-16 Example of flood hazard map....4-57
Figure 4.3-17 Example of flood hazard map....4-57
Figure 4.3-18 Outline of hazard map GIS....4-58
Figure 4.3-19 An example of hazard map GIS screen image....4-59
Figure 4.4-1 Observation plan (1)....4-61
Figure 4.4-2 Observation plan (2)....4-62
Figure 4.4-3 Observation plan (3)....4-62
Figure 4.4-4 Flow of orthophoto map creation....4-64
Figure 4.4-5 Existing data + ortho, existing data + new line data, compiled line data + ortho....4-66
Figure 4.4-6 Flow of correction of secular changes to national base map....4-68
Figure 4.4-7 DEM....4-70
Figure 4.4-8 Contour....4-70
Figure 4.4-9 Vector data....4-70
Figure 4.4-10 Mosaic- processed orthophoto....4-70
Figure 4.4-11 Integration of orthophoto with vector data....4-70
Figure 4.4-12 Mosaicking process using “TNT-mips”....4-71
Figure 4.4-13 “MicroStationGeographics” screen....4-72
Figure 4.4-14 Samples of GIS application....4-74
Figure 4.4-15 Reconfiguration of GIS polygon from an area on topographic map....4-76
Figure 4.4-16 Error display on ARC/INFO....4-77
Figure 4.4-17 Data processing using Adobe Illustrator....4-79
Figure 4.4-18 Digital printing process....4-80
Figure 4.4-19 Main software used in DTP and data flow....4-81
Figure 4.4-20 Technical Transfer Course Evaluation....4-88

Figure 4.4-21	Self Evaluation by the participats [Your Level of UNDERSTANDING]	4-89
Figure 4.4-22	Self Evaluation by the participants [Your CONFIDENCE in carrying out the tasks you learnt from the trainings]	4-89
Figure 4.5-1	The IGN Logo	4-90
Figure 4.5-2	The INSIVUMEH Logo	4-92
Figure 4.5-3	The SEGEPLAN Logo	4-93
Figure 4.5-4	Population density map	4-94
Figure 4.5-5	Present state of land use	4-97
Figure 4.5-6	Overview of GIS	4-98
Figure 4.5-7	Difference between topographic maps (left) and GIS database (right)	4-100
Figure 4.5-8	Overview of SNIG	4-101
Figure 4.5-9	Logos of the organizations	4-101
Figure 4.5-10	Overview of the Project to Combat Chagas' Disease	4-103
Figure 4.5-11	Distribution of the disease, drawn up using GIS	4-104
Figure 6.2-1	3D vector data	6-3
Figure 6.2-2	Idea of evacuation areas based on hazard maps	6-10
Figure 6.2-3	Disaster map of Ciudad Vieja on June 13, 2002	6-12
Figure 6.3-1	Disaster prevention schemes	6-16

Chapter 1 Project Outline

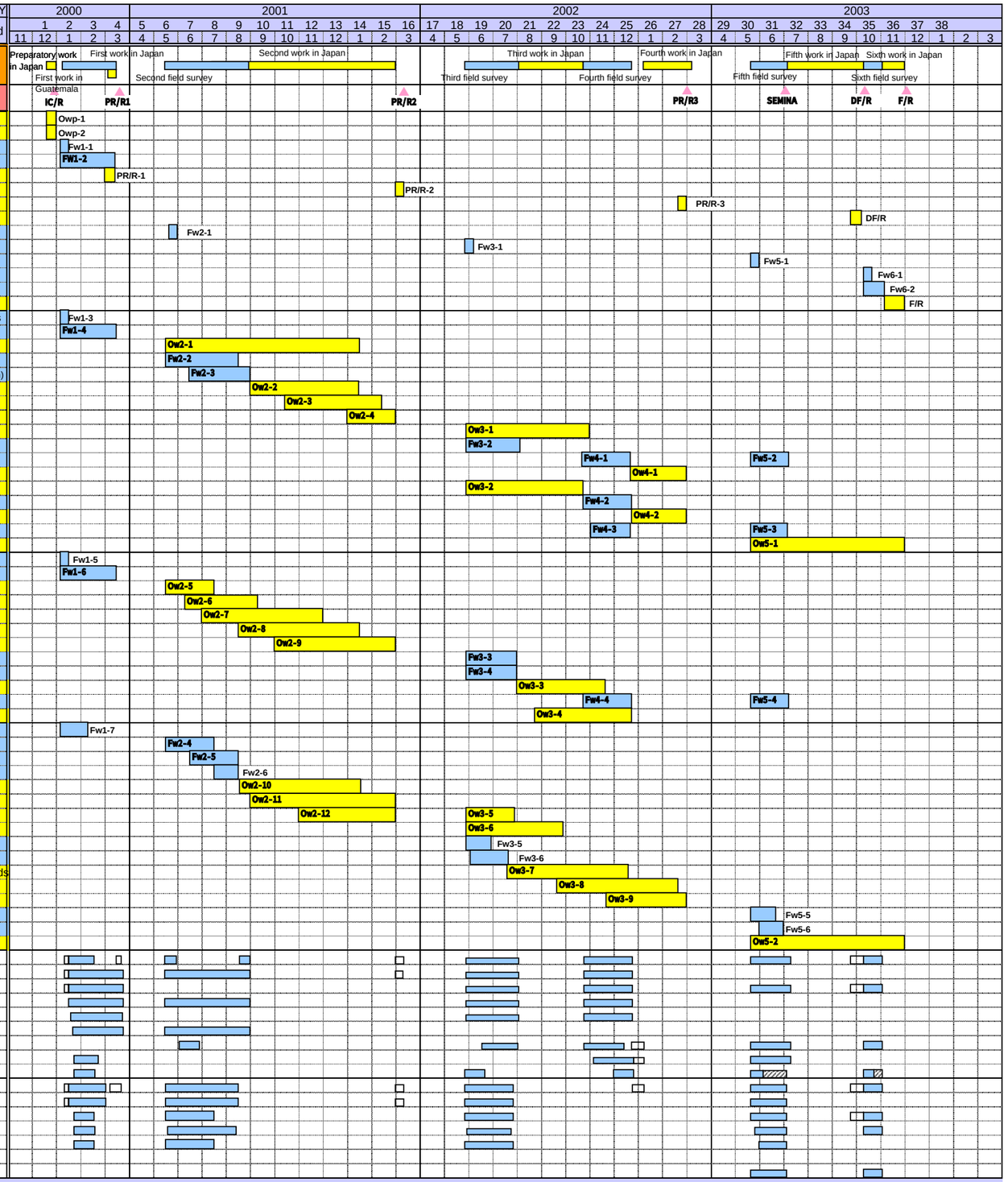
Table 1-1 shows the outline of the Project and Figure 1-1 shows the work flow chart of the entire Study operation.

Work Schedule (Project Outline)

Work Plan

Table 1-1

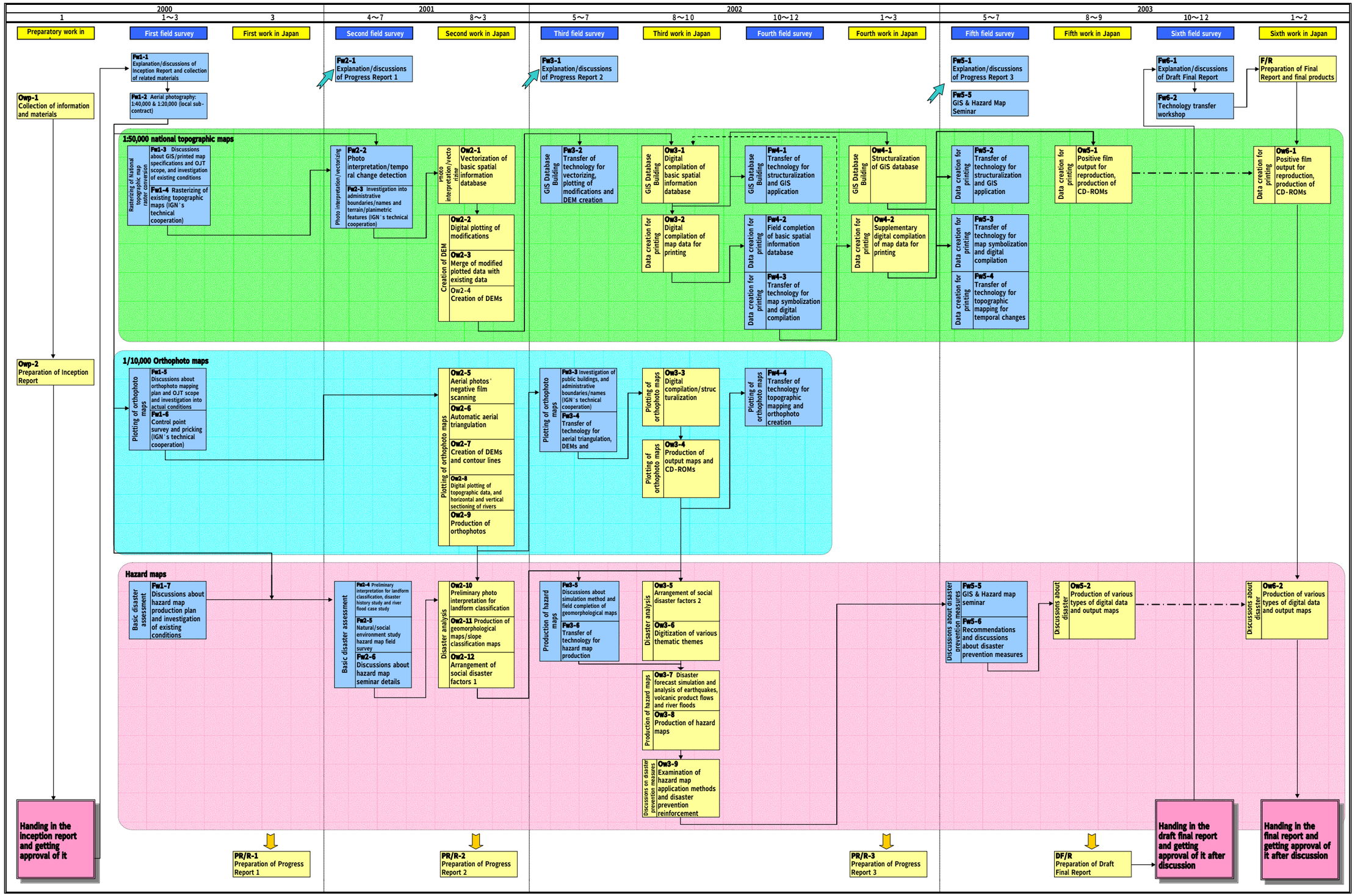
Type of Work	Work Item		Work Division (Field survey/Work in Japan) / Submission of Report
Common Items	Preparatory work in Japan	Owp-1	Collection of information and materials
		Owp-2	Preparation of Inception Report
	Explanation/discussions of Inception Report	Fw1-1	Explanation/discussions of Inception Report and collection of related materials
	Preparation of GIS base maps	Fw1-2	Aerial photography: 1/40,000 & 1/20,000 (local sub-contract)
	Preparation of reports	PR/R-1	Preparation of Progress Report 1
		PR/R-2	Preparation of Progress Report 2
		PR/R-3	Preparation of Progress Report 3
		DF/R	Preparation of Draft Final Report
	Explanation/discussions of reports	Fw2-1	Explanation/discussions of Progress Report 1
		Fw3-1	Explanation/discussions of Progress Report 2
		Fw5-1	Explanation/discussions of Progress Report 3
		Fw6-1	Explanation/discussions of Draft Final Report
	Technology transfer	Fw6-2	Technology transfer workshop
	Preparation of Final Report and final products	F/R	Preparation of Final Report and final products
1: 50,000 national base maps	Rasterization of national base maps	Fw1-3	Discussions about GIS/printed map specifications and a OJT scope and investigation of existing conditions
		Fw1-4	Rastering of existing topographic maps (IGN's technical cooperation)
	Photo interpretation/vectorization	Ow2-1	Vectorization of basic spatial information database
		Fw2-2	Photo interpretation/temporal change detection
		Fw2-3	Investigation into administrative boundaries/names and terrain/planimetric features (IGN's technical cooperation)
	GIS Database Building	Ow2-2	Digital plotting of modifications
		Ow2-3	Merge of modified plotted data with existing data
		Ow2-4	Creation of DEMs
		Ow3-1	Digital compilation of basic spatial information database
		Fw3-2	Transfer of technology for vectorizing, plotting of modifications and DEM creation
		Fw4-1／Fw5-2	Transfer of technology for stracuralizaion and GIS application
		Ow4-1	Structuralization of GIS database
	Data creation for printing	Ow3-2	Digital compilation of map data for printing
		Fw4-2	Field completion of basic spatial information database
		Ow4-2	Supplementary digital compilation of map data for printing
		Fw4-3／Fw5-3	Transfer of technology for map symbolization and digital compilation
		Ow5-1	Positive film output for reproduction, production of CD-ROMs
Production of orthophoto maps	Plotting of orthophoto maps	Fw1-5	Discussions about orthophoto mapping plan and OJT scope and investigation into actual conditions
		Fw1-6	Control point survey and pricking (IGN's technical cooperation)
		Ow2-5	Aerial photos' negative film scanning
		Ow2-6	Automatic aerial triangulation
		Ow2-7	Creation of DEMs and contour lines
		Ow2-8	Digital plotting of topographic data, and horizontal and vertical sectioning of rivers
		Ow2-9	Production of orthophotos
		Fw3-3	Investigation into public buildings, and administrative boundaries/names (IGN's technical cooperation)
		Fw3-4	Transfer of technology for aerial triangulation, DEMs and contouring
		Ow3-3	Digital compilation/structuralization
		Fw4-4／Fw5-4	Transfer of technology for topographic mapping and orthophoto creation
		Ow3-4	Production of output maps and CD-ROMs
Hazard maps	Basic disaster assessment	Fw1-7	Discussions about hazard map production plan and investigation of existing conditions
		Fw2-4	Preliminary interpretation for landform classification, disaster history study and river flood case study
		Fw2-5	Natural/social environment study hazard map field survey
		Fw2-6	Discussions about hazard map seminar details
	Disaster analysis	Ow2-10	Preliminary photo interpretation for landform classification
		Ow2-11	Production of geomorphological maps/slope classification maps
		Ow2-12／Ow3-5	Arrangement of social disaster factors
		Ow3-6	Digitization of various thematic maps
	Production of hazard maps	Fw3-5	Discussions about simulation method and field completion of geomorphological maps
		Fw3-6	Transfer of technology for hazard map production
		Ow3-7	Disaster forecast simulation and analysis of earthquakes, volcanic product flows and river floods
		Ow3-8	Production of hazard maps
	Discussions about disaster prevention measures	Ow3-9	Discussion about hazard map application methods and disaster prevention reinforcement
		Fw5-5	GIS & Hazard map seminar
		Fw5-6	Recommendations and discussions about disaster prevention measures
		Ow5-2	Production of various types of digital data and output maps
Personnel Plan	Team leader		Kazuo FURUKATA
	Data structuralization design /control point survey/field survey supervision		Satoru NISHIO
	GIS/structuralization supervision		Daisaku KIYOTA
	Photography supervision/field survey supervisior		Shozo SHIMODA
	Control point survey/field survey supervision 1		Morten STRAND
	Control point survey/field survey supervision 2		Mutsumi HANADA
	Digital compilation supervision		Noboru FUKUSHIMA
	Symbolizing supervision		Yumiko SASAKI
	Digitization supervision		Chiyo KIGASAWA
	Sub-leader/disaster prevention plan		Satoru TSUKAMOTO
	Volcanic disaster survey		Hitoshi TAKEUCHI
	Flood disaster survey		Hiroyoshi ISHIKAWA
	Landslide disaster survey		Valerio GUTIERREZ
	Earthquake disaster survey		Toshiyuki MATSUMOTO
	Coordination		Hiroyuki NAKAI
	Interpreter 1		Midori OISHI



Legends: Field Survey | Work in Japan | Report submission | Assigned in Japan

Flowchart

Figure 1-1



Chapter 2 Objectives of the Project

2.1 Background

The Republic of Guatemala (hereinafter referred to as "Guatemala") forms a part of the Yucatán Peninsula, bordering Mexico, Honduras, El Salvador and Belize, and facing the Caribbean Sea and the Pacific Ocean. It has a population of approximately 11.1 million, the largest in Central America, and an area of 108,889km^2.

Guatemala has been a republic since it gained independence from Spain on September 15, 1821. The civil war that broke out in 1960 expanded nationwide and lasted for 36 years, resulting in the longest suffering in Central America. In the meantime, the economy was exhausted and the residents in the war zone became refugees within and outside the country. Most of the social infrastructure including roads, bridges, waterworks, schools and medical institutions were destroyed.

A "Peace Agreement" which led to the final agreement under global observation was executed on December 29, 1996 with the slogan "the control of law and the respect of human rights" to promise the proliferation of democracy. After the civil war, the Government of Guatemala established the "Working Plan for Performance of the Peace Agreement" as the action plan for economic, political and social aspects and exerted considerable effort to realize the plan. Initially, the peace promotion process made favorable progress, but in 1998, the performance of the Peace Agreement was hindered by domestic political disorder caused by economic problems including taxation reform followed by unprecedented disaster, Hurricane Mitch in November of the same year.

Considering the background as described above, the Government of Guatemala made a request to Japan for cooperation in development of "the national base mapping system for the southern, middle and western areas" in 1998. After that, Guatemala suffered from the disaster of Hurricane Mitch in October of 1998 and JICA implemented the "Study of Formulation of the Hurricane Reconstruction and Disaster Prevention Project" for the period of November to December 1999. As the result of the study, JICA dispatched the preparatory study team in June 2000 and the preliminary study team in August 2000. Then, the S/W was concluded between JICA Study Team and the IGN and INSIVUMEH of Guatemala as the implementing agencies.

2.2 Objectives of the Study

The objectives of the study are to modify the existing national base maps (1:50,000 scale covering the area of approx. 30,000 km^2) according to temporal changes and digitize them in order to provide data for GIS. Also, to produce hazard maps (1:20,000 to 1:50,000 scale covering the area of approx. 10,000 km^2) for earthquakes, volcanoes, landslides, and flooded sites to use for disaster prevention.

2.2.1 Establishment of GIS base map data

- Digitization of 1:50,000 topographic maps
- Modification of changes in 1:50,000 topographic maps
  (production of films for printed maps)

2.2.2 Production of hazard maps

- Production of 1:10,000 orthophoto maps
- Survey of disaster history and others
- Production of hazard maps

2.2.3 Technology transfer

In this study, technology transfer will be carried out through on-the-job-training and joint work: the technology of digitizing base maps, modification of temporal changes, creation of map files for printing and production of orthophoto maps, national base maps and GIS database production and application using database to IGN; production of hazard maps, simulation method and work related to INSIVUMEH.

In addition, seminars and workshops will be held for the SNIG member agencies and organizations including IGN and INSIVUMEH. These will cover applied use of GIS, such as classifying the development plans and disaster prevention programs, and the database maintenance techniques from a comprehensive point of view as well as individual point of view unique to each agency.

In the technology transfer, newly procured study equipment and materials will be used and the most up-to-date technology will be introduced.

Chapter 3 Study Methods

3.1 Study Areas

3.1.1 Study area for establishment of GIS base maps

The study areas will be approximately 30,000 km^2 in the southwestern area of Guatemala (covered by 74 sheets of existing topographic maps). For the detailed location, refer to the location map in this report.

3.1.2 Study area for production of hazard maps

(1) Earthquakes (approx. 600 km^2)

1:20,000 Quetzaltenango, Mazatenango, Escuintla, and Puerto Barrios

1:50,000 Guatemala City

(2) Volcanoes (approx. 1,700 km^2)

1:25,000 scale: Santiaguito, Cerro Quemada and Pacaya volcanoes

1:50,000 scale: Tacana volcano

(3) Landslides

1:25,000 scale (approx. 1,400 km^2): Guatemala City, Quetzaltenango and Antigua

1:50,000 scale slope classification map (approx. 5,000 km^2): Northwest region (El Quiche, Huehuetenango, San Marcos) and Central region (Sacatepequez, Chimaltenango, Solola)

(4) Floods (1:25,000 scale: 2,000 km^2)

Samala basin, Acome basin, Achiguate basin and Maria Linda basin

3.2 Basic Policies

3.2.1 Basic policies for operation

- ✓ Establishment of optimum communications system and discussions
- ✓ Thorough safety measures

3.2.2 Basic policies for technical matters

[GIS]

- ✓ Establishment of technical specifications
- ✓ Thorough quality control and process management for building database

[Hazard maps]

- ✓ Building database of basic information for disaster prevention
- ✓ Production of geomorphological maps for production of hazard maps
- ✓ Simulation of main disaster factors

3.2.3 Basic policies for technology transfer

[GIS]

- ✓ Database creation methods and GIS applications
  - 1:50,000 vectorizing, modification plotting and DEM creation
  - 1:50,000 symbolization and digital compilation
  - Structuralization and GIS application
- ✓ Production, maintenance and management of orthophoto map
  - Aerial triangulation, DEM and contour line creation
  - Topographic plotting and orthophoto creation

[Hazard maps]

- ✓ Field survey for landform classification and photo interpretation
- ✓ Basic idea of simulation of main disaster factors
- ✓ Use of hazard maps

3.3 Contents of the Study

3.3.1 Items and volume of work

The items, outline and volume of work in the Study are classified by fiscal year, and will be implemented as shown in Table 3.3-1 Planned Work.

Table 3.3-1 Planned work

Year	Division	No.	Work	Work outline	Work volume
First Year	Japan	Owp-1	Collection of information and materials	Collection and analysis of materials for this study	—
		Owp-2	Preparation of Inception Report	Basic policies, methods, processes and procedures of the study	English 20 copies, Spanish 20 copies
	Guatemala	Fw1-1	Explanation/discussions of Inception Report	Explanation, discussions, confirmation and agreement with Guatemala counterparts	—
		Fw1-2	Aerial photography: 1:40,000 & 1:20,000	1:40,000 & 1:20,000-scale photography (monochrome)	Approx. 24,600km^2 (1: 40,000) Approx. 7,000km^2 (1: 20,000)
		Fw1-3	Discussions on GIS/printed map specifications, about OJT scope and investigation of existing conditions	Discussions about GIS data structure and printed map digitizing specifications, and collection and investigation of materials	
		Fw1-4	Rasterizing of existing topographic maps	Digitizing with scanner (IGN's technical cooperation)	5 versions x 74 sheets = approx. 370 sheets
		Fw1-5	Discussions about orthophoto mapping plan, OJT scope and investigation of existing conditions	Confirmation of survey standards with the counterparts of Guatemala and collection and investigation of materials	
		Fw1-6	Control point survey and pricking	GPS survey (IGN technical cooperation)	Control points: 20 Prick points: Approx. 175 GPS bench marks: 25
		Fw1-7	Discussions about hazard map production plan and investigation of existing conditions	Understanding of hazard maps, existing data and potential needs	Earthquakes: Approx. 600 km^2 Volcano: Approx.1,700km^2 Landslide: Approx. 1,400km^2 (Slope classification map: approx. 1,400km^2) Floods: 2,000 km^2
	Japan	PR/R-1	Preparation of Progress Report 1	The details of the first-year work will be compiled.	English: 20 copies Spanish: 20 copies
Second Year	Guatemala	Fw2-1	Explanation/discussions of Progress Report 1	The results of the first-year work will be explained for approval.	Same as above
		Fw2-2	Photo interpretation/temporal change detection	Extraction of temporal changes from new aerial photos	
		Fw2-3	Investigation of administrative boundaries/names and terrain/planimetric features	Field survey of terrain and planimetric features (IGN technical cooperation)	Areas with temporal changes

Year	Division	No.	Work	Work outline	Work volume
Second Year		Fw2-4	Preliminary interpretation of landform classification, disaster history and river flood	Detailed interpretation of aerial photos	
		Fw2-5	Natural/social environment study hazard map field survey	Check and analysis of disaster factors from natural and social viewpoints	
		Fw2-6	Discussions about seminar details	Discussions and confirmation of seminars	
	Japan	Ow2-1	Vectorizing of basic spatial information database	Creating GIS/Printing basic data	
		Ow2-2	Digital plotting of modifications	Plotting of temporal changes	
		Ow2-3	Merge of modified plotted data with existing data	Merging of spatial base map database and temporal changes	
		Ow2-4	Creation of DEM	Mesh intervals 40m, contour line intervals 5m	
		Ow2-5	Aerial photo negative film scanning	Negatives of aerial photos will be converted to image data.	Approx. 1,740 sheets
		Ow2-6	Automatic aerial triangulation	Aerial triangulation by batch processing	Approx. 1,700 models
		Ow2-7	Creation of DEMs and contour lines	Automatic generation of DEMs followed by creation of contour lines using TIN	
		Ow2-8	Digital plotting of topographic data, and longitudinal survey and cross sectional survey using aerial photos	Plotting of roads, rivers and annotations, horizontal and vertical sections approx. 500m wide at 2km pitch	Plotting: Approx. 7,000km^2 Horizontal/vertical section: 50km at pitch of 2km
		Ow2-9	Production of orthophotos	1:10,000 to be stored in map sheet units	
		Ow2-10	Preliminary photo interpretation for landform classification	Understand the relation between landform classification, rough geological distribution and risk of disaster	
		Ow2-11	Production of geomorphological maps/slope classification maps	To be produced based on national base maps and orthophotos	
		Ow2-12	Arrangement of social disaster factors 1	Collection and arrangement of data of social vulnerability in disaster occurrence	
		PR/R-2	Preparation of Progress Report 2	The details of the second-year work will be compiled.	English : 20 copies, Spanish : 20copies
Third Year	Guatemala	Fw3-1	Explanation/discussions of Progress Report 2	The results of the second-year work will be explained for approval.	As above
		Fw3-2	Transfer of technology for vectorizing, plotting of modifications and DEM creation	Technology transfer will be carried out using manuals and study equipment.	
		Fw3-3	Investigation of public buildings, and administrative boundaries/names	Field survey and information collection will be carried out (IGN technical cooperation).	
		Fw3-4	Transfer of technology for aerial triangulation, DEMs and contouring	Technology transfer will be carried out using manuals and study equipment.	
		Fw3-5	Discussions about simulation method and field completion of geomorphological maps	Discussion about simulation methods, interim progress report	

Year	Division	No.	Work	Work outline	Work volume
Third Year		Fw3-6	Transfer of technology for hazard map production	Description of countries advanced in hazard map production, promotion of understanding of disaster risks	
	Japan	Ow3-1	Digital compilation of basic spatial information database	Digital compilation, using specifications for GIS data and printed maps	
		Ow3-2	Digital compilation of printed map data	Compilation of topographic maps in according to the specifications for printed maps	
		Ow3-3	Digital compilation/structuralization	Compilation of terrain data, planimetric data, annotations, administrative boundaries	
		Ow3-4	Production of output maps and CD-ROMs	Production of output maps by printer, data storage on CD-ROMs	
		Ow3-5	Arrangement of social disaster factors 2	Collection and organization of data of social vulnerability in disaster occurrence	
		Ow3-6	Digitization of various thematic maps	Digitizing of each thematic map acquired	
		Ow3-7	Disaster forecast simulation and	Evaluation of hazards	
		Ow3-8	analysis of earthquakes, volcanic product flows and river floods Production of hazard maps	Production of hazard maps based on the results of simulation	
		Ow3-9	Examination of hazard map application methods and disaster prevention reinforcement	Examination of hazard map application	
	Guatemala	Fw4-1	Transfer of technology for structuralization and GIS application	Technology transfer will be carried out using manuals and study equipment.	
		Fw4-2	Field completion of basic spatial information database	Check of data, confirmation of problems in Guatemala	
		Fw4-3	Transfer of technology for map symbolization and digital compilation		
		Fw4-4	Transfer of technology for topographic mapping and orthophoto creation	Technology transfer will be carried out using manuals and study equipment.	
	Japan	Ow4-1	Structuralization of GIS database	Phase structuralization of spatial base map data, coordination with external database	
		Ow4-2	Supplementary digital compilation of map data for printing	On-site supplementary data will be reflected in data for printed maps.	
		PR/R-3	Preparation of Progress Report 3	The details of the third-year work will be compiled.	English: 20 copies, Spanish: 20 copies
Fourth Year	Guatemala	Fw5-1	Explanation/discussions of Progress Report 3	The results of the third-year works will be explained for approval.	As above
		Fw5-2	Transfer of technology for GIS application	Technology transfer will be carried out using manuals and study equipment.	
		Fw5-3	Transfer of technology for map symbolization and digital compilation	Technology transfer will be carried out using manuals and study equipment	
		Fw5-4	Transfer of technology for topographic mapping of temporal changes	Technology transfer will be carried out using manuals and study equipment	
		Fw5-5	GIS and hazard map seminar	Report of disaster factor analysis and recommendations for GIS management policies	

Year	Division	No.	Work	Work outline	Work volume
Fourth Year		Fw5-6	Recommendations and discussions about disaster prevention measures	Discussions about disaster prevention measures using hazard maps	
	Japan	Ow5-1	Positive film output for reproduction, production of CD-ROMs_1	Preparation of completed 1:50,000 national base maps	
		Ow5-2	Production of various types of digital data and output maps_1	Preparation of completed hazard maps	
		DF/R	Preparation of Draft Final Report	All the work processes and recommendations for this study will be compiled.	English : 20 copies Spanish : 20 copies Summary English: 20 copies Spanish : 20 copies
	Guatemala	Fw6-1	Explanation/discussions of Draft Final Report	All the work processes and recommendations for this study will be explained for approval.	As above
		Fw6-2	Technology transfer workshop	The technology transfer carried out in this study will be compiled and a workshop and presentation seminar will be held.	
	Japan	Ow6-1	Positive film output for reproduction, production of CD-ROMs_2		[Digital data] Topographic maps/GIS: 20 sets
		Ow6-2	Production of various types of digital data and output maps_2		Orthophoto maps: 20 sets Geomorphological maps: 20 sets Hazard maps: 20 sets Hurricane Mitch disaster survey maps: 20 sets [Output maps] Same as above: 10 sets Hazard maps: 100 sets
		F/R	Preparation of Final Report and final products	Completion of the Final Report with comments of the Guatemala counterparts	English : 20 copies Spanish : 20 copies Summary English: 20 copies Spanish : 20 copies

3.3.2 Study schedule

The Study lasted for 38 months, from December 2000 to January 2003.

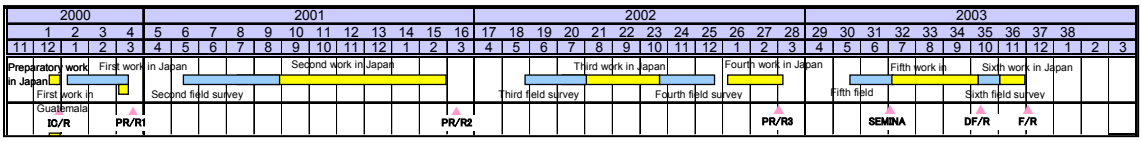


Figure 3.3-1 Study schedule

3.3.3 Members

The Study Team consisted of the following 15 members:

Table 3.3-2 Study team

Role	Name
Team leader	Kazuo FURUKATA
Sub-leader/Data structuralization design/control point survey/field survey supervision	Satoru NISHIO
GIS/structuralization supervision	Daisaku KIYOTA
Photography supervision/field survey supervision	Michiyasu MURATA→Shozo SHIMODA
Control point survey/field survey supervision 1	Morten STRAND
Control point survey/field survey supervision 2	Mutsumi HANADA
Digital compilation supervision	Noboru FUKUSHIMA
Symbolizing supervision	Yumiko SASAKI→Takashi YOSHII→Yoshimitsu FUKUMOTO
Digitization supervision	Chiyo KIGASAWA
Sub-leader/disaster prevention plan	Satoru TSUKAMOTO
Volcanic disaster survey	Hitoshi TAKEUCHI
Flood disaster survey	Hiroyoshi ISHIKAWA
Landslide disaster survey	Valerio GUTIERREZ
Earthquake disaster survey	James WILKINSON→Toshiyuki MATSUMOTO
Coordination	Hiroyuki NAKAI

3.3.4 Items produced

(1) Study reports

1) Inception Report: 20 English and 20 Spanish copies
2) Progress Report 1: 20 English and 20 Spanish copies
3) Progress Report 2: 20 English and 20 Spanish copies
4) Progress Report 3: 20 English and 20 Spanish copies
5) Draft Final Report
   - Main Report: 20 English and 20 Spanish copies
   - Summary: 20 English and 20 Spanish copies
6) Final Report
   - Main Report: 20 English and 20 Spanish copies
   - Summary: 20 English and 20 Spanish copies

(2) Items produced

1) Aerial Photographs (Black and White 1:40,000 and 1:20,000)
   a. Negative film of aerial photographs 1 set
   b. Diapositive film of aerial photographs 1 set

c. Contact prints of aerial photographs	1 set
d. Photo index map	1 set
2) Results of field survey	1 set
3) Results of aerial triangulation	1 set
4) Printing films for 1:50,000 scale topographic maps	1 set
5) Digital data files (e.g. CD-ROM)	
a. 1:50,000 scale topographic maps and GIS base maps	20 sets
b. Hurricane Mitch disaster maps	20 sets
c. Geomorphological maps	20 sets
d. Hazard maps	20 sets
e. Orthophoto maps	20 sets
6) Print out of maps	
a. 1:50,000 scale topographic maps	10 sets
b. Hurricane Mitch disaster maps	10 sets
c. Geomorphological maps	10 sets
d. Hazard maps	100 sets

Chapter 4 Contents of the Project

4.1 Establishment of 1:50,000 Scale GIS Base Maps

4.1.1 Discussions on GIS specifications

(1) Reconfirmation of the survey standards and work specifications

- Reference ellipsoid: WGS84 (a=6,378,137.0, f=1/298.257223563)
- Projection for topographic maps: Guatemala Transverse Mercator (GTM)
- Position of the datum: central meridian=90degree 30min longitude, latitude=equator
- Coordinate of the datum: X=0, Y=500,000m, scale factor: 0.9998
- Standard height: Mean Sea Level
- Transformation parameter from previous reference ellipsoid (Clarke1866) to new reference ellipsoid

  Shift (m) :X=64.9712323165, Y=193.5225720651, Z=58.3595349179
  Rotation（sec）:X=3.6404982054, Y=-0.4293259588, Z=2.3124451702
  Scale factor: 1.00001859859322

The study team prepared the work specifications necessary for ground control point survey, based on JICA overseas survey work specifications (for base maps). IGN and the study team discussed about this work specification and the Guatemalan survey work specifications.

(2) Confirmation of National Base Map Symbols

The Study Team held discussions with IGN to confirm the detailed information necessary to proceed with the work on the symbols (including annotations) for the national base maps.

- Whether a symbol should be adopted or not
- Difference in definitions of similar symbols
- Whether a symbol is represented as a real shape or a symbolized shape
- Where its true position (origin) is if it is

Photo 4.1-1 Meeting to confirm symbols

symbolized

- Standards for acquisition (minimum size, public use, etc. for representing symbols on maps)
- Whether an annotation is attached to a symbol or not. If attached, what annotation code is applied.

The results of the discussions were compiled as symbols for the national base maps, and were translated into Spanish and presented to IGN.

Especially, the following important points were noted in the memorandum and the technical note was exchanged with IGN:

- Final decision on font types and sizes
- Unclear points on map representation and on PAABANC, and problems related to the both
- "Administrative boundary and name" data provided by IGN in 2001
  In particular, regarding to the problem that the present form of the river along the national border was largely different from the national border data provided, IGN updated and submitted the data to the Study Team.

(3) Discussion about digitizing specifications

With regard to PAABANC specifications, JICA study team confirmed the extensibility and information coverage and agreed to retain it as a GIS data specification for this project. With regard to map printing specifications, IGN requested to follow the current specifications.

As a result, the specifications for digitization of the 1/50,000 national base maps were created to have the layer structure and the attributes of each layer in common with the GIS database specifications as much as possible.

(4) Discussions about printed map data specifications

Followed by the discussions of digitization specifications, the study team redefined the current specifications for printed maps, reclassified the printed map data structure, and integrated duplicate topographic features.

Also, the representations of topographic features will be modified to utilize the digitization process, so that it will be possible to link many features to the legend library.

4.1.2 Investigation of existing conditions

(1) Investigation of existing conditions

1) Existing topographic maps

In the past, several foreign organizations supported Guatemala to create topographic maps. As a result, the consistency of map projection and legend style has been lost during this period of map production and in the organizations that produced them. With regard to map projection, two cases (NAD83 or WGS84) had been used respectively. With regard to map legends, the IPGH (Instituto Panamericano de Geografia e Historia) style had been adopted previously. Recently, the DMA (Defense Mapping Agency) style, which changed its name to NIMA (National Imagery and Mapping Agency) in 1996 after organizational integration, has been adopted.

Regarding to the condition of reproduction films, it became apparent that IGN does not maintain all of the negative films and some are missing. However, IGN keeps and updates element films (mask films).

2) Technical capability of the counterpart

<IGN>

Almost all of the engineers have training experience for basic computer operation. Hence, when we think about technical transfers in GIS and digital mapping, it supports the fact that all have knowledge and experience of basic computer operation.

Generally most engineers have many training experiences in analogue mapping, which illustrates their high levels of knowledge and skills in mapping. However, only a few selected engineers have experience in GIS and digital mapping. As a part of this project, it was crucial to provide analogue mapping engineers with adequate on-the-job-training and transform them into digital mapping specialists. Only after this, efficient management and maintenance of mapping data and effective GIS use can be achieved.

<INSIVUMEH>

Currently, INSIVUMEH does not own any kind of GIS or satellite image analysis software. However, the importance and significance of GIS and satellite image analysis are well recognized since several engineers have received technical training. Based on their experiences, it is believed that the engineers have knowledge of GIS and are expecting technical transfer in analysis and simulation functions of GIS.

3) Equipment and materials to be brought in by JICA and consultants

<IGN>

IGN requires more engineers specialized in GIS and digital mapping and the existing engineers have to be more trained. However, IGN has no sufficient quantities and types of hardware and software.

- **Hardware**

In order to handle large image files for digitizing, it is essential to have more memory and a faster processor. The existing equipment (such as the processor or computer to connect a scanner to a plotter) is inefficient.

These conditions reveal that effective technical transfer and will not be achievable unless the study team brings adequate hardware and software during the course of on-the-job-training.

Recommendation: IGN, as an agency leading SNIG, should reinforce the analytical function to make the more effective use of the GIS.

- **Software**

Regarding the computers that have a LAN connection, GIS, CAD, and graphics software are installed and they seem to share the data and information via the network. On the other hand, on those computers without a network connection, Microsoft Office is the principal software component and it is mainly used for documentation and tabular calculation. At Cartografia, ArcInfo and ArcView are available, however digital mapping software is yet to be introduced. Hence there is high expectation that digital mapping software be made available by this project. Considering the fact that IGN needs to proceed to the level of applied use of GIS and to strengthen analytical skills as a leading organization in SNIG, the latest version of GIS software and additional modules are clearly imperative.

<INSIVUMEH>

The equipment at INSIVUMEH are no better than those of IGN and far from sufficient specification for producing hazard maps and analysis by the use of GIS and orthophoto. Also, INSIVUMEH basically uses Microsoft Office and graphics software but not GIS software. With the expectation that GIS will be a powerful tool in hazard map creation and analysis, the study team strongly believes the following equipment are essential for INSIVUMEH.

(2) Survey of SNIG Members on GIS

The survey on GIS was made through a questionnaire to members of the ministries and agencies constituting the Sistema National de Informacion Geografica (hereinafter called "SNIG") as shown in Table 4.1-1, and will be used to make recommendations for the effective use and future concept of GIS.

Table 4.1-1 Ministry/Agency belonging to SNIG (as of the Study)

	Ministry/Agency belonging to SNIG		Ministry/Agency belonging to SNIG
1	CONAP	9	INE
2	DGAG	10	INGUAT
3	DGM	11	INSIVUMEH
4	DGM-MEM	12	PRODETOTO
5	FIS	13	SEGEPLAN
6	FLACSO	14	UPE-MINEDEC
7	IGN	15	UPIE-MAGA
8	INAB	16	UVG

The survey contents were as follows.

- ✓ GIS-related Software
- ✓ Participation in Training in GIS-related Software
- ✓ Purposes of Use of Topographic Map Database
- ✓ Demands to Government, Ministry/Agency and Private Sector

As the target of the survey was SNIG member agencies, their positive attitude to implementing GIS in their actual work was highlighted. The expectations of a database as the product of the Project were so high that the Study Team was fully convinced that a wide range of applications will be found for the database after it is completed. In addition, it is expected that their firm attitude toward promoting the development and positive use of the GIS database in mutual cooperation at government level will become a role model for other developing countries that desire to introduce GIS.

4.1.3 Aerial Photography

- ✓ Local Sub-contractor: FINNMAP
- ✓ Specifications of aerial photography
  - Aerial camera: Leica RC30 Camera + Leica PAV30 gyromount + GPS (for photo coordinate measurement and navigation) + FMC (Forward Motion Compensation)
  - Aerial photo: Focal length: f = 15 cm , Picture plane size: 23 x 23 cm , Scale: 1/20,000 and 1/40,000 , Overlap: 60% on average / Side lap: 30% on average
- ✓ Products of photography

  1/20,000 aerial photos: 1,740 sheets, 1/40,000 aerial photos: 1,409 sheets
- ✓ Annotation of aerial photograph film

  The study team and the Government of Guatemala discussed about the annotation of the aerial photograph films. As the study team suggested, a film annotation form as shown below was used.

JICA-IGN GUATEMALA 1:20,000 C09 - 01 01/01/30 10:20:45

4.1.4 Rasterization (in technical cooperation with IGN) and vectorization

(1) Rasterization

As a result of provisional scanning, it was decided that negatives be scanned by black and white at 600dpi and element films by grayscale at 400dpi. The study team examined the scanned data of positives, which had been started previously by IGN, and assured of their usability as raster data.

The data was converted into image (raster) data at a preset resolution and saved in TIFF and JPG format.

Table 4.1-2 Preset resolution and file format for scanning

Film type	Resolution	Format
Positives	300dpi(black&white)	tiff(uncompress)
Elements	400dpi(grayscale)	jpg
Negatives	600dpi(black&white)	tiff(uncompress)

(2) Vectorizing

The raster data per block was digitized and vectorized. The method of entering each vertex with a mouse was used in conjunction with the method of automatically tracing the raster data in linear sequence.

For the vector data acquired through digitization, accuracy control of the following items (per map sheet) was conducted to correct any defective points.

- Faulty entries and omissions of codes (faulty entries include faulty attributes and inaccurate shapes)
- Edge mismatching points

4.1.5 Temporal changes detection, photo interpretation and field survey

(1) Preparation of mosaic photos

- Before undertaking the extraction work, mosaic photos of the same area at the same scale as the existing topographic maps were prepared to facilitate the task of photo interpretation. (The 1/40,000-scale aerial photos were reduced to 80% and the 1/20,000-scale photos to 40% for copying).
- 1,366 aerial photos (662 at scale 1/20,000, and 704 at scale 1/40,000) were used for the mosaic, and the same number was used for stereoscopic viewing.
- These color photos were put together to make 74 mosaic photos, with two copies each for the field survey and for editing (one original and one duplicate copy).

Figure 4.1-1 Example of mosaic photo

Figure 4.1-2 Mosaic photo (edited (enlarged))

(2) Extraction of temporal changes

- Temporal changes were extracted through visual comparison of the existing topographic maps with the mosaic photos.
- Temporal changes in vegetation were masked yellow on the mosaic photos to make them more identifiable in the field survey.
- Linear objects (roads and rivers) were excluded from the extraction work (because the maps will be compared with new photos when plotting the roads and rivers in Japan).
- Apart from these, buildings, contours, contour values, elevation points and symbols (churches, schools, hospitals, soccer stadiums, graveyards, coffee plantations, etc.) which were scanned by IGN in the First-Year Study will be vectorized in Japan.

(3) Acquisition of administrative boundaries and name data

The administrative boundary data file including national borders and provincial and city boundaries in ArcInfo data format was furnished by IGN.

(4) Acquisition of road attribute data

The Study Team received from IGN 71 copies of existing 1/50,000 topographic maps (3 of the 74 copies included no relevant roads) on which roads were marked and numbered, and an Excel file in which the road attributes for the numbered roads were entered. The entered road attributes consist of 4 items: classification, number, importance and accessibility.

(5) Acquisition of Annotation Data and Fonts

The work of creating the annotation data was conducted jointly with the technical cooperation of IGN. Annotations were extracted from the 74 map originals (black and blue blocks) of the existing 1/50,000-scale topographic maps. Each map sheet copy was

sequentially numbered. These annotations included representations unique to Spanish (such as accent signs), so IGN staff was in charge of all the typing work to create the annotation data in Excel file format.

Photo 4.1-2 Creating the annotation data

The annotations in the 1/50,000-scale topographic map database were applied to the annotations in the 1/10,000-scale orthophotos. In addition, annotation data in the portion (8 map sheets) for which no 1/50,000-scale topographic map database had been created was also created in the same way as in the work mentioned above.

All 10 fonts were used in this work, of which 8 fonts were provided by IGN, and it was agreed with IGN to purchase 2 commercially available fonts online.

(6) Survey of Topographic/Planimetric Features

- The places of temporal change in vegetation extracted in yellow on the mosaic photos were verified. For verification of the vegetation, places with good access by vehicle were chosen and interpretation keys were created. Vegetation at places with poor access was defined through photo interpretation using the interpretation keys.

Photo 4.1-3 Transfer of technology for working methods

- When a new village was found, its geographic name (village or town name) was confirmed at the municipal office or the provincial capital under whose jurisdiction it fell or at the site.
- Any new church, school or hospital was verified at the site and entered on the mosaic photo.
- In the event that a village was in ruins, its geographic name (or town name) was changed into an area name, which was entered on the topographic map carried by the working group.
- When a newly constructed road was found, the attribute of the road was surveyed.

(7) Preparation in Japan for this field survey

- Inspection and correction on whether the polygons in the GIS data (ArcInfo) were created properly or not (correction of undershoots and overshoots)
- Checking and correction on the field survey photos on whether the labels (vegetation) in the GIS data were properly created
- Spelling check (the first) on the entry errors in annotations and checking, inspection and correction of their positions (overlaps on planimetric features)
- Creation of tie-strips and inspection and correction of tie points by map sheet
- Extraction and arrangement of indicated unclear points for field survey

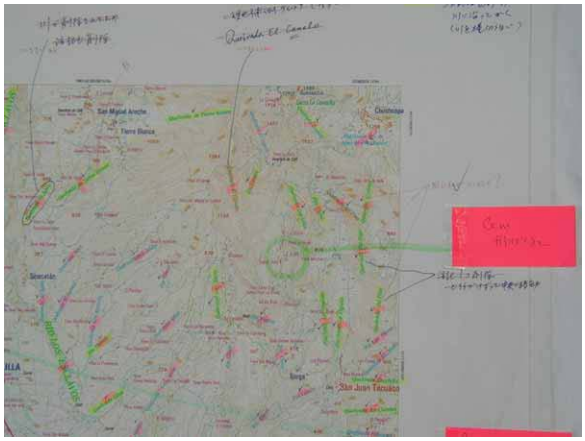


Figure 4.1-3 Inspection map prepared in Japan

(8) Preliminary observation work for inspection and field completion survey

23 counterparts and 3 members of the Study Team cooperated in doing the inspection work to extract the elements for the field survey, inspect the positions of annotations and to check the spelling (the second time). The items of inspection were arranged in the map for inspection of annotations and the elements for the field survey were arranged in the final-image output maps.

Figure 4.1-4 Preliminary observation map for field completion survey

(9) Field completion survey

The field survey was made under full security control because it included some areas considered as danger zones. The concrete security control methods were made by regular correspondences between groups and between IGN and each group.

The main works conducted in the field completion survey are as follows:

- Checking unclear points
- Survey on the accurate positions of annotations

- Survey on the newly added annotations
- Corrections of any secular changes to road attributes and planimetric features (bridges, public buildings, etc.)

Photo 4.1-4 Field survey

(10) Re-acquisition of materials from IGN

1) Review of road attributes

The data on road attributes errors and secular changes were found out during the Work in Japan. These were pointed out at the meeting of discussions with IGN and the review was requested to IGN. IGN checked on these data errors and changes and corrected the data. Then, IGN presented the final correction materials to the Study Team.

2) Re-acquisition of national border data and others

The problem that the form of the river along the national border was largely different from the form of the national border in the provided data was caused by the national border data owned by the SUNIL. The national border data was developed on the basis of the 1:250,000 scale topographic map of IGN. Therefore, IGN created the digital data in the 1:50,000 scale again. The correction of the national border data caused some discrepancies between the national border data and the provincial border data, which were corrected by the tie-strip processing at IGN.

On the municipal boundaries, which included some undefined points, it was discussed and decided that those boundaries remained in the GIS data by IGN's request, but that those were not represented in the printed maps.

4.1.6 Production of spatial information database (Digital plotting of modifications and digital compilation)

Originally, it was intended to extract the temporal changes by comparison with the existing maps and aerial photos and to conduct digital plotting of the models containing such temporal changes through map indexing.

However, when the corrective plotting was started, it was found that there were many temporal changes scattered over the entire map sheet and it was decided that map indexing of all models containing temporal changes to be updated was not realistic from the viewpoint of efficiency and accuracy. Therefore, the entire area was divided into several blocks and aerial triangulation was carried out in each block in order to enhance efficiency and ensure uniform accuracy.

(1) Positive Film Scanning of Aerial Photos

The Study Team conducted tentative scanning to extract samples of each typical terrain such as city area, grassland, mountainous area and bare land before data acquisition and collected the setting values for brightness and contrast. The data was acquired with a resolution of 30μm per pixel, 256 monochrome gradation levels and the original image data was saved separately from the work data file.

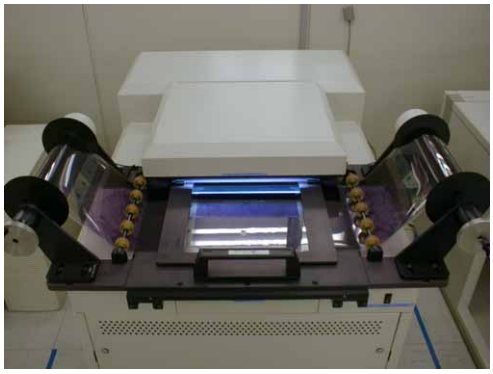


Photo 4.1-5 Special scanner dedicated to aerial photography

After the end of the scanning, accuracy control of each photo was conducted regarding the following items to confirm that there would be no problem in subsequent work:

- Resolution
- Brightness
- Contrast
- Noise (flaws and folds)
- Normalized processing (correction of mechanical errors)
- Data acquisition range (whether indexes are included or not)
- Possibility of index observation (whether in an observable condition or not)
- Image rotation
- Format (TIFF, uncompressed, 256 monochrome gradation levels)

- File name (whether data and file names coincide or not)

(2) Aerial Triangulation

The elements necessary for aerial triangulation were selected from the control points installed for preparation of the 1/10,000-scale orthophotos and definite planimetric features on the existing 1/50,000-scale maps. These elements were digitized and the points whose coordinate values had been acquired were also adopted as control points. In addition, the aircraft GPS data acquired when the photos were taken were also used as control points.

Accuracy control was conducted of the following items per block and it was confirmed that there would be no problem in subsequent work:

- Number of horizontal control points
- Number of elevation control points
- Number of canceled horizontal control points
- Number of canceled elevation control points
- Residuals of horizontal control point (standard deviation and maximum value)
- Residuals of control point elevations (standard deviation and maximum value)
- Residuals of bundle crossings (standard deviation and maximum value)
- Residuals of horizontal positions in aircraft GPS data
- Residuals of elevations in aircraft GPS data

(3) Preliminary Examination of Linear Planimetric Features (Roads and rivers)

Preliminary examination of the temporal changes in polygonal features was completed in the process of "Photo Interpretation/Temporal Change Detection". Temporal changes in linear planimetric features such as roads and rivers which were not covered in "Photo Interpretation/Temporal Change Detection" were examined in this process.

(4) Digital Plotting

Photo 4.1-6 Digital plotter

Photo 4.1-7 Analyzing plotter

Digital plotting of the temporal changes based on the preliminary examination was conducted using an analyzing plotter capable of overlay display and a digital plotter. Basic spatial information data was acquired of all the items necessary for topographic maps including the GIS database. The operators paid special attention to acquisition of elements with orientation (schools and hospitals).

(5) National base maps: Merge modified plotted data with existing data

The basic spatial information data which had been digitized and vectorized was overlaid on the temporal change data to replace the older data. In this process, the operators paid special attention to ensure that the road network, small objects and symbols were connected or not lost.

In the editing process, the layer items for the GIS database and those for the printed map data were checked and corrected for errors such as overshoots and undershoots, and processing for adjoining map sheets was performed. In addition, the data processing necessary for representation of topographic maps such as double lines for roads and arrangement of map symbols was performed. These work processes were controlled per map sheet and the basic spatial information database was configured.

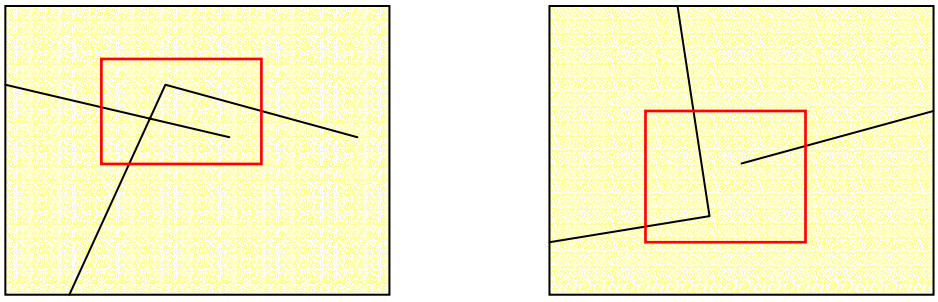


Figure 4.1-5 Example of overshoot and undershoot

(6) Creation of DEM

TIN models were created using the layers with 3-dimensional attributes (contours, elevation points and control points) from the data acquired as the basic spatial information database. DEMs in meshes of 40m intervals were created from these TIN models.

(7) Digital Compilation

The framework data to be converted into GIS data and printed maps was configured in the DGN file format unique to MicroStation.

In digital compilation the digital plotter used to create the framework data on the actual conditions does not support the function of adding topological structure, from the nature of the software. In addition, the functions of the plotter and its software are specific to topographic

map production. This means that these functions are designed to operate to create data with a level of accuracy that can be interpreted by a human.

When data for the production of printed maps and building of the GIS database is created under these conditions, the computer may not be able to interpret the planimetric features correctly. Below are given some examples of these problems, with a description of the points considered in the digital compilation.

1) Graphic intersections are not interpreted correctly

a When a line is not properly connected (Undershoot)

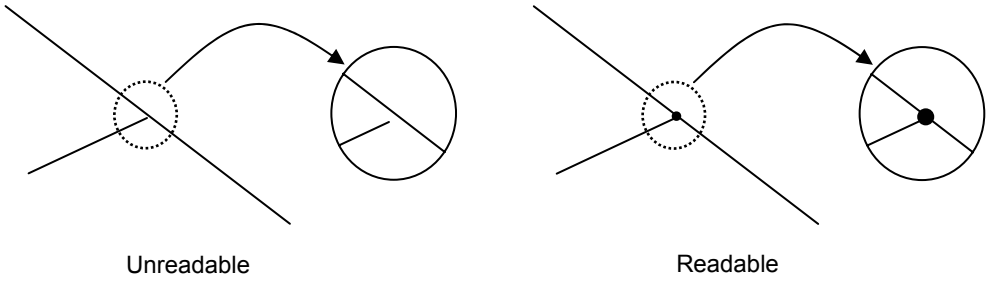


Figure 4.1-6 Failure to connect

b Lack of intersection data (node)

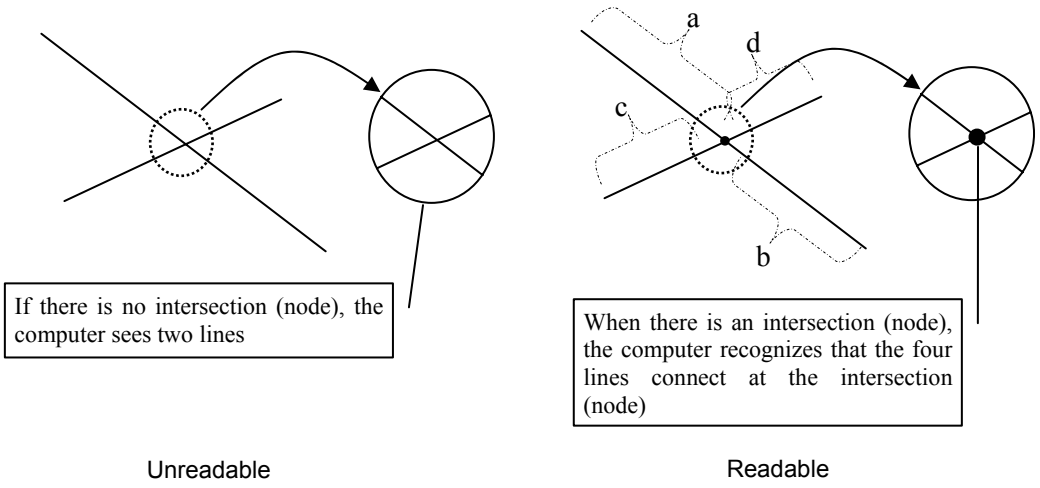


Figure 4.1-7 Missing node

c Closed figure that is not closed

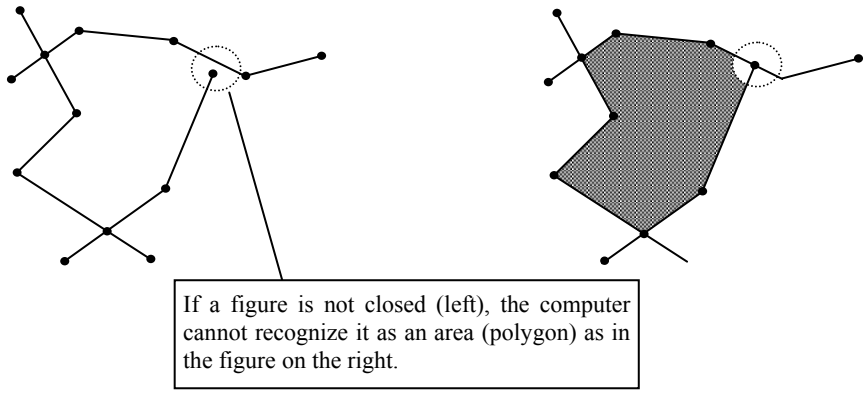


Figure 4.1-8 Gap in closed figure

The following three GIS software functions for correcting connections are considered effective in cases like those given above:

- Function to generating a point of intersection when one line stretches over another line;
- Function to connecting all points existing within a given (adjustable) range;
- Function to remove lines below a given distance (trimming)

However, when automatic connecting correction is done, the coordinate values are also corrected, resulting in incompatibility between the national base maps and the GIS database. Thus, every effort should be made to avoid the repeated use of these functions. In addition, when using MicroStationJ for digital compilation, the functionality of the software means that the relationships between figures have to be defined visually. This means that in practical terms it is very difficult to create data with accurate connections; undershoots and overshoots, are the result.

In view of these technical limitations, it was decided to draw the lines configuring a feature basically as overshoots, in order to avoid as far as possible the deformation of figures caused by automatic connecting correction by GIS software after structuralizing. This method allowed the computer to recognize a closed figure by adding a point of intersection and trimming the unnecessary line (overshoot). This had a huge effect on the reduction of the volume of correction work and accuracy enhancement.

2) Polygon type cannot be recognized

With regard to areas, there are several different types of line that make up an area, and their combinations are not standard, so that it is very difficult indeed to identify a polygon

configured by conversion, leading to a need for repeated interpretation of the topographic features. Since the work of interpreting the topographic features has already been carried out when the data was created using MicroStationJ, re-interpreting the topographic features again after the topological structuralizing would be a duplication of the work. Therefore, the special features of the software used to create the skeleton data and the software used to create the GIS database were utilized as described below with the aim of creating polygons effectively.

In digital compilation, therefore, a cell is placed within an area where a polygon should be formed and after structuralizing, the cell's attribute table (.acode) is linked with the polygon attributes, thereby allowing the type to be assigned to the polygon automatically. This process carried out after structuralizing is described in (9) "Structuralization".

(8) Data Export

In order to create the GIS data and the printed map data from the spatial basic information database prepared in the DGN file format, the following points were taken into consideration for exporting the data to various file formats:

1) Annotations and symbols

It is important that the information should finally be reproduced accurately with AdobeIllustrator even after having been subjected to data format conversion. Here the compatibility of the fonts used by MicroStation with the fonts used by ArcInfo and AdobeIllustrator was a problem. It became clear from verification of all these applications that by exporting the data in the EPS format from MicroStation directly into AdobeIllustrator, it was possible to ensure accurate reproduction of the information.

2) Polygon (land use)

The line elements forming a land-use feature do not necessarily form a closed figure in the DGN file. Therefore, a cell was placed inside the figure as described in (8) Digital Compilation, and the cell data and the line data forming the polygon were input simultaneously into ArcInfo.

3) Polygons (others), lines and points

Planimetric features forming polygons other than for land use (such as built-up areas, wide rivers, lakes and swamps, features with shape) which are always closed figures, features with linear form (roads, railways, narrow rivers, administrative boundaries, power

transmission lines and other infrastructure), and features forming points (such as buildings and land marks) were exported in the DXF format from MicroStation to ArcInfo.

(9) Structuralization

The DGN data created in MicroStation was converted into the ArcInfo Coverage format in order to add the topological structure to the data.

When producing the printed maps using graphic software, the addition of topological structure to the data was essential to provide the simple lines and polygons with the line types and patterns in conformity with topographic map representation.

This structuralizing process prepares the data for the production of the printed maps and at the same time adds the structure for the GIS database. At this point, the data does not yet conform with "PAABANC", the IGN-established specifications, so the data was not complete as a GIS database, but it can be used as the data source when the GIS database comes to be built later on.

In fact, because of the need to process a huge amount of data – 74 maps covering one-third of the land area of Guatemala – a program was written for the above format conversion work, and the processing was done automatically.

(10) Corrective entry 1

The corrective entry of the annotations for which the checking and correction was deemed to be necessary in the stage of work in Japan prior to the inspection work and the field completion survey in Guatemala were made using the digital compilation system as one item of study equipment and MicroStation after confirmation by the IGN side and in the cooperation between the Study Team and the counterparts.

(11) Corrective entry 2

The corrective entry was made on the basis of the inspected contents arranged in the annotation inspection map (paper) using the digital compilation system and the digital plotter as procured as the study equipment and in the cooperative work of the Study Team and the counterparts.

- The changes to annotations were corrected with the digital

Photo 4.1-8 Inspection by IGN staff member

compilation system and MicroStation.

- The line data that might be omitted in plotting were additionally plotted using the digital plotter as one item of the study equipment, on the basis of the prepared correction-indicating map. The main line data as corrected included the data of lakes, roads, rivers, Cem (cemeteries), Corral (fences) and local runways.
- The corrections in GIS data were made by redrawing polygons using ArcInfo.
- After completion of the correction work on all changes, the data was outputted again and the final inspection on the spelling of annotations, updating errors and others was made in the cooperative work with the counterparts.

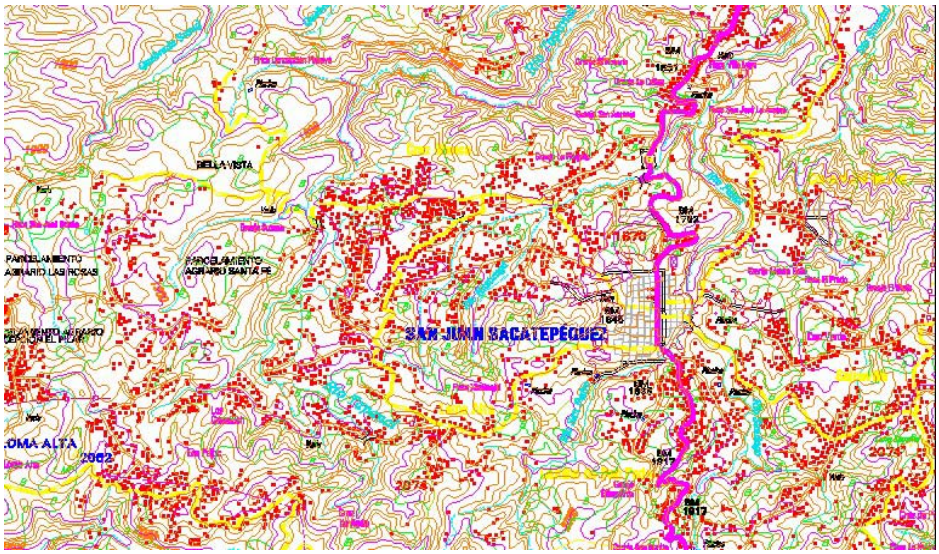


Figure 4.1-9 Compilation of 1:50,000 scale topographic map using MicroStation

(12) Inspection, correction and processing in Japan

- The annotations (in grouping) in which each character was separated from another were detected in the batch processing on ArcInfo and corrected to the normal style.
- The position of any building symbol protruded into a road for which the width was expanded was corrected by manual processing using MicroStation.
- The processing to delete any symbol protruding outside the neat line (into the margin) in the printed map data was executed.
- The logical check on contours and elevation points, and the checks and correction on whether there were the highest elevation points or not were executed using MicroStation.

(13) Adjoining of map sheets

The continuous figures, such as polygons and lines, had to be adjusted to adjoin the map sheets. These corresponded to the data in the above files ①ArcInfo Coverage file for polygons (for land use), ②ArcInfo Coverage file for polygons (for other planimetric features) and ③ArcInfo Coverage file for lines, the figures and attributes were adjoined and the data separated by neat line was integrated using the processing procedures as described below.

1. Preparation of figures (edge matching <node to node and arc to arc> and reconfiguration of topology)
   a. Edge matching
   b. Reconfiguration of topology
2. Preparation of attributes (deletion of unnecessary items → all items with the same attribute)
3. Adjoining of map sheets (74 sheets in one coverage by item by map adjoining/appending)
4. Processing after adjoining (Removal of sliver polygons and dangling arcs and topology reconfiguration → Connecting adjacent features with the same attribute by dissolving)
   a. Removal of sliver polygons
   b. Removal of dangling arcs
   c. Topology reconfiguration
   d. Connecting adjacent features with the same attribute by dissolving

(14) Exporting to PAABANC Specifications

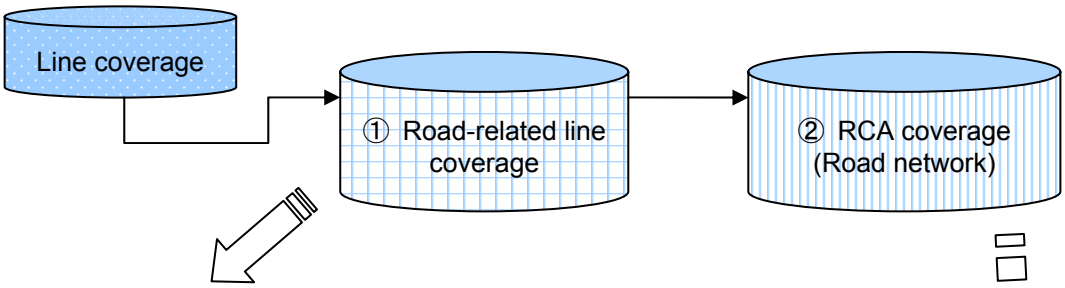
1) Arrangement of PAABANC specifications

The PAABANC data covered many planimetric features represented by vector figures such as points, lines (arcs), nodes and polygons in the 1:50,000 scale topographic maps. The detailed types by theme (such as, for example, an arterial road in a road network, a sidewalk) were categorized by the data attributes. The features with proper names were configured to hold vector figures having names as attribute values. In comparison between the printed maps of the 1:50,000 scale topographic maps and the PAABANC data, it was found that the categories of features represented in the topographic maps were more detailed, while all the features could not be represented under the PAABANC specifications. Therefore, these attribute items were added in the work process of this Project through discussions with IGN and the PAABANC standard of data acquisition was modified accordingly.

2) Exporting method

The PAABANC specifications were different from the GIS database built in this Project in the coverage categories and attribute items. As the PAABANC standard categorized the features into detailed themes, it was necessary to assign level and color attribute values to the database built in this Project. The combinations of levels and colors were assigned uniquely to the features represented in the topographic maps in accordance with the combinations of attribute items and values as specified in the PAABANC standard.

The flow in Figure 4.1-10 shows the process of the work to create the RCA coverage (road network) under the PAABANC standard from the GIS database of lines created in this Project.



a)

Coverage	Detail		Level	Color
Line	Paved arterial road (passable in all the year): road with meridian strip		21	5
Line	- Ditto -	road with 2 or more lanes	21	3
Line	- Ditto -	road with 1 lane	21	4
Line	Unpaved arterial road (passable all the year) a: road with 2 or more lanes		22	3
Line	- Ditto -	b: road with one lane	22	4

b)

Coverage	IMPROTANCIA	VIABILIDAD
RCA	5 (road with meridian strip)	3 (paved road)
RCA	4 (road with 2 or more lanes)	3 (paved road)
RCA	3 (road with one lane)	3 (paved road)
RCA	4 (road with 2 or more lanes)	2 (unpaved road, passable all the year)
RCA	3 (road with one lane)	2 (unpaved road, passable all the year)

Figure 4.1-10 Flow of data export into PAABANC

4.1.7 Production of printed map data (digital compilation)

After digital compilation the spatial basic information data was converted into printed map data. This was digitally compiled and structuralized in AdobeIllustrator to reproduce the data for representation as the topographic maps.

(1) Data format conversion

In accordance with the specifications for printed maps determined through discussions with IGN, including the fonts, symbols, sizes, shapes and colors of the annotations, the representation of topographic features (such as double-line depiction of roads, railways, houses, etc.), line thickness and patterns, it was arranged so that polygons, lines, points, symbols and annotations would be automatically reproduced when the conversion to AI format was carried out.

The automation was mainly done by program, but specifically, the methods described below were used to represent lines, polygons, annotations and symbols on the topographic maps.

(2) Reproduction of topographic map representations

Prior to the production of the printed maps, first of all output maps for field survey to be used in the process of "Supplementary survey in the field for basic spatial information database" were prepared.

These output maps were prepared by creating the data for printed maps using the same procedure as that used for producing printed maps and outputting it on an ink-jet plotter. As the specifications for the topographic map representations for printed maps (such as the fonts, sizes, colors of annotations, representation of planimetric features, etc.) had not been determined, the specifications for field survey output maps were tentatively determined separately from those for printed maps, and these were used for reproduction.

There were two types of data for printed maps converted from the spatial basic information database; an AI file of the polygons and lines converted via ArcInfo, and an EPS file of annotations and symbols converted from MicroStation. Each of these files is in a format that can be edited in Illustrator.

1) Reproduction of line information

The spatial basic information database converted from ArcInfo into the AI format was only the data that could be edited in Illustrator, not the data reproducing the specifications for printed maps such as line widths and line types.

The reproduction of line information begins by determining what planimetric feature the lines represent. The key items specifying the type of feature is the combination of level and color input into MicroStation. In ArcInfo the level and color are held as line attributes, but in the AI format there is no line attribute that can be assigned freely. When the data was converted into the AI format, therefore, the level and color values were added to the CMYK values for line colors.

In Illustrator, the lines were classified by their CMYK value and divided into layers, and the type of planimetric feature was managed by layer. By managing the types of feature by layer, it became easy to carry out the continuous processing of overlapping contour lines, roads and rivers. It also becomes possible to reproduce line information layer by layer.

2) Reproduction of polygon information

Like the line information, polygon information was divided into layers and the polygon information was reproduced layer by layer.

However, the key items to specify polygon type are different for 'land-use' polygons and 'other' polygons. For 'other' polygons the key items are, as for line information, a combination of Level and Color; but for 'land-use' polygons, as Level and Color are not unique, cell names were the key items. The key items are not line colors but polygon colors.

The polygons on the field survey output maps were not represented by patterns, but block color. On the printed maps, polygons are represented by patterns, which if registered in Illustrator can be handled in the same way as block colors. The types of pattern were determined through consultation with the engineers of the IGN Cartography Division.

3) Reproduction of annotations and symbols

The annotation and symbol data were used only for printing after preparation in MicroStation; the data was not converted into the GIS database. This meant that the data was imported from MicroStation directly into Illustrator. The data conversion format used was the EPS format, using the print function of MicroStation. If the print function of MicroStation is used, the annotation data are outlined, and cannot be handled as text in Illustrator. The annotations cannot be corrected in Illustrator; the correction of annotations can be done only in MicroStation, which means that the data source is centralized.

(3) Supplementary digital compilation of printed map data

1) Annotations

The list of annotations of all types was prepared. This list was created to grasp the image of printed maps in using MicroStation to output the annotations in the actual process of producing printed maps. The font types and sizes of all types of annotations were checked on this list and agreed upon by the counterparts.

Parallel with the above checking work on the font types and sizes of annotations, IGN was requested to check and verify spelling errors and arrangements.

Similar to the existing maps, the grid lines per 1km were drawn on the 1:50,000 scale national base maps in order to arrange the coordinate values on the grid lines near three divided sections of the vertical and horizontal lines of the neat lines (See Figure 4.1-12.). The positions for arranging these values and the font types and sizes were also determined through discussions with the counterparts.

The font types and sizes of annotations in all the map sheets were changed by batch processing by the use of MicroStationJ as one item of the procured study equipment.

Once the font sizes of annotations were changed, it was also needed to check the arranged position of each annotation because the position of the origin on MicroStationJ was set at the center of the annotation to be arranged. Changing the font size in reference to this origin resulted in the unmatched position of the annotation arranged in two lines, the overlap with the corresponding feature and the overlap of the grid line value with the grid line. Therefore, the work of correcting these unmatched or overlapped positions was conducted. (See Figure 4.1-12, Figure 4.1-13) The arranged positions conformed to the order of arrangement in the NIMA standard. At the same time, all the results of the spelling check and field survey that were requested the counterparts were reflected on the data.

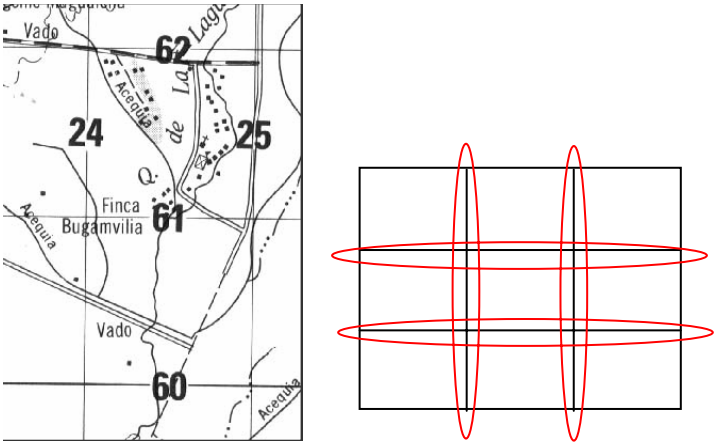
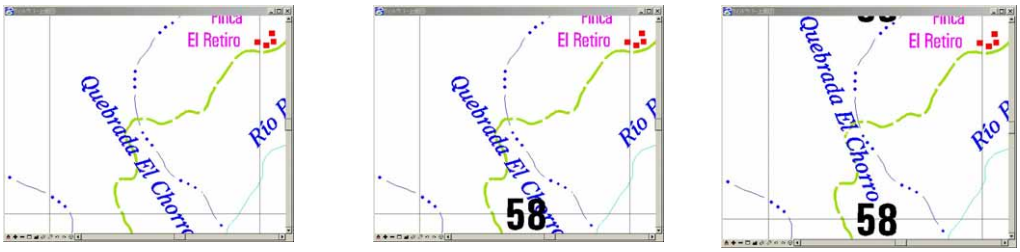


Figure 4.1-11 Coordinate values on grid lines and their positions on printed map

① ② ③

Figure 4.1-12 Example of annotation font size reduction and rearrangement



① ② ③

Figure 4.1-13 Example of annotations rearranged to avoid the overlaps with grid line values

2) Administrative boundaries

In the inspection stage of in "Digital compilation/structuralization", it was made clear that the administrative boundary data provided by IGN was unmatched with the topographic and planimetric features in which the secular changes were corrected.

The administrative boundary data provided by IGN included the national borders, the Department boundaries and Municipality boundaries.

The Study Team converted the new administrative boundary data file provided by IGN into the Design File and replaced the old data with the new administrative boundary data on all 74 map sheets in order to correct the positional relations of topographic and planimetric features. (See Figure 4.1-14.)

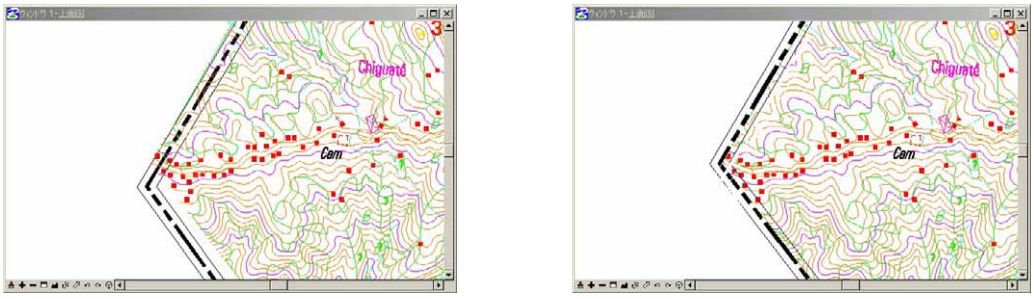


Figure 4.1-14 National border lines with some deviations corrected

However, all the Municipality boundaries in the entire country of Guatemala had not clearly been defined, so that the administrative boundaries were not represented on the printed maps but only the administrative names were indicated, although all the administrative boundaries were included in the GIS database.

The unmatched points with annotations that newly appeared due to changes of some administrative boundaries were corrected by changing the arranged positions of the annotations.

3) Topographic and planimetric features

With the planimetric features such as vegetation, there were some problems that "no divisional lines were entered" and that "there were some errors", though the polygonal shapes were proper. Thus, it was necessary to additionally plot the lacking divisional lines and correct the errors. The former problem was solved in the compilation by changing the attributes in the Coverage data (ArcInfo) after structuralizing the data. The latter problem was solved by additional plotting with the digital plotter to create the data file containing only the additional data. Further, the data was exported from MicroStationJ and structuralized again on ArcInfo in the same way as the work process of "Digital compilation of basic spatial information database". Then, the additional data was integrated with the polygon (land use) data created in the process of "Digital compilation of basic spatial information database" and the integrated data was used as the final data source for producing GIS database and printed maps.

Then, the data in ArcInfo Coverage format was converted into the AI format on AdobeIllustrator in order to produce the printed maps. In the case that there were some changes in division lines of the features such as vegetation, the line data was acquired using the digital plotter. Further, the digital compilation of the data was performed on MisroStationJ in the way that no discrepancies were caused with the surrounding polygons, and the polygonal shapes were corrected on ArcInfo.

4) Road attributes

As the road types, some points with obviously wrong attribute were found by comparing them with the 1:40,000 scale aerial photos and the past field survey results.

The Study Team changed the road attributes on MicroStationJ referring to the new materials provided by the IGN side.

(4) Output of printing positive films and production of CD-ROM

1) Printing data output

①Printing data output and visual check

The processed data were outputted in color and an inspection has been made visually and on a display screen to know whether the data were created as indicated in the Specification.

②Production and inspection of positive films

The completed data were converted into the EPS format (a format to output positive films). Then, the resolution of the image setter (dedicated output equipment) EPS-formatted data was preset to about 2,400 dpi and 175 lines, and the EPS-formatted data were outputted to prepare 4 positive films in 4-color separation per map sheet.

2) Production of CD-ROM

The spatial infrastructure information database and other data including those concerning all map sheets were compressed and stored in a CD-ROM. The recording format was standardized as follows:

- Spatial infrastructure information data format: ZIP self-decompression format (MicroStation dgn file)
- GIS data format: same as above (Arc/Info coverage file)
- Printed map data format: same as above (Adobe Illustrator ai file)
- Storage format: CD-ROM (CD-R)