1. Introduction

The Republic of El Salvador was heavily damaged in the past by the Civil War which extended over 13 years from 1979 to 1992, a large-scale earthquake in 1986, disastrous hurricane Mitch in 1998 and so forth. The Government of El Salvador has been promoting economic development in the areas of eradication of poverty, reconstruction of infrastructure and protection of the natural environment. The country is at present still progressing on of the development in such fields.

The Government of Japan again started again the provision of aid to the Republic of El Salvador in 1992, and provided reconstruction support such as Yen Loans in the fields of electric power and the water supply.

Under the above circumstances, the Government of El Salvador requested the Government of Japan to prepare topographic maps for areas not covered by the existing 1/25,000 scale topographic maps and basic geographic digital GIS data for the various development plans.

In response to the request of the Government of El Salvador, the Government of Japan decided to conduct a project to improve the basic geographic data (hereinafter referred to as "Phase I Study") in accordance with the relevant laws and regulations in force in Japan. The project name is "The Study for Establishment of National Basic Geographic Data in the Republic of El Salvador"(hereinafter referred to as the "Study").

Accordingly, Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of Japan, undertook the Study in close cooperation with the authorities of the Government of the Republic of El Salvador.

Recently, the earthquakes occurred off coastline of El Salvador on January 13, 2001 with a magnitude on 7.6 on the Richter Scale, then followed again on February 13, 200l. It is reported that all of El Salvador's 14 departments (administrative regions) were seriously affected.

Immediately after the earthquakes mentioned above, JICA decided to dispatch the JICA Study Team (hereinafter referred to as the "Study Team" or "Team") for the Study's phase II (hereinafter referred to as "Phase II Study"). The main objectives of the Phase II Study are to prepare "Disaster Maps of the Damaged Areas" resulting from the earthquakes in January and February 2001, and to prepare the "Sediment-related hazard map for Landslides and Hazardous Areas" for indicating the potential hazardous places.

The study period of the Phase I & II Studies is from March 1999 to July 2001.

2. Outline of the Study

2.1. Objectives of Study

The objectives of the Study are as follows:

Phase I

(1) To prepare 1/25,000 scale topographic maps (approximately 3,700 km^2) to assist the Government of the Republic of El Salvador in preparing the various development plans.

(2) To create the digital data (approximately 20,740 km^2) whose positional accuracy is corresponding to the existing 1/25,000 scale topographic maps in order to assist the Government of the Republic of El Salvador in the establishment of various geographic information systems

(3) To transfer related technological knowledge to the counterpart personnel of El Salvador.

Phase II

(4) To prepare “Disaster Maps of Damaged Areas” that resulted from the earthquakes in January and March, 2001 for helping support the reconstruction plans.

(5) To prepare “Sediment-related hazard map for Landslides and Hazardous Areas” to indicate the potential hazardous areas to a secondary disaster.

2.2. Study Areas

The Study areas are selected for:

Phase I

(1) The area that is not covered by the existing 1/25,000 scale topographic maps (approximately 3,700 km^2) for preparing both digital data and 1/25,000 scale topographic maps.

(2) The area of the whole country (approximately 20,740 km^2) for creating digital data.

Phase II

(3) The study area is approximately 5,100 km^2 and includes the main disaster areas resulting from the earthquakes in January and February, 2001.

The Study areas are shown in Figure 1.

Figure 1 Study Areas
obj/english/sheet_id.xls

2.3. Scope of Work

2.3.1. Phase I Study

Phase I of the Study shall cover the following items:

(1) To prepare the 1/25,000 scale topographic map and digital data. (approximately 3,700 km^2)

1) Aerial photography
Black and white aerial photos covering the prepared areas shall be taken at scale of 1/40,000.
2) Ground control point survey
Ground control point survey by GPS shall be carried out to determine the horizontal and vertical coordinates of ground control points.
3) Aerial triangulation
Aerial triangulation shall be carried out to establish photo control points.
4) Field identification
Topographic information shall be identified through the field survey using the aerial photos.
5) Plotting
Plotting shall be carried out to prepare 1/25,000 scale digital topographic data. Existing 1/5,000 or 1/10,000 scale manuscript maps will be used as much as possible.
6) Field completion
Field completion shall be carried out in the Study areas to identify natural and artificial terrain features that are difficult or impossible to recognize on the aerial photographs.
7) Compilation
Compilation of the plotted data shall be carried out based on the result of field identification and prepared data by Instituto Geografico Nacional “Ing. Pablo Arnordo Guzman”, Centro Nacional de Registros, Ministerio de Justicia (IGN)
8) Preparing of printing films
Printing films shall be prepared using laser-plotter at scale of 1/25,000.

(2) To digitize the existing 1/25,000 scale topographic maps (approximately 17,040 km^2)

1) Digitizing
2) The existing 1/25,000 scale topographic maps shall be digitized using printed maps.
3) Updating
The digitized topographic data which partially covers San Salvador city and its surroundings shall be updated (approximately 100 km^2)

(3) Structurization

Topological structurization shall be carried out for completion of digital topographic data.

(4) Technology transfer

In order to facilitate technology transfer to the counterpart personnel, a part of updating process of digital topographic data shall be carried out by the Salvadoran side under the technical supervision of the Survey Team.

2.3.2. Phase II Study

Phase II Study shall be covered the following items:

(1) Updating the base map for disaster areas

The topographic map at scale of 1/25,000, being prepared by the ongoing study has not updated the present geographic features correctly, although the data was already digitized. This is because that updating of the information was originally scheduled after digitalization of the map data. The simplified updating of the data will be carried out using satellite imagery and other existing image sources such as aerial photographs and 1/5,000 scale topographic maps to avoid unnecessary confusions in making rehabilitation relief plans.

(2) Field Study

Field verification was carried out to confirm the damaged areas and to update the existing maps through field survey. Moreover, survey for landslide areas was conducted at several points for the future rehabilitation programs.

(3) Preparing Disaster Map of Damaged Areas

Using the results of the field survey as supplementary data, the existing base map was corrected and new data was added, and then the more precise Disaster Maps were prepared. Such data is required to be delivered to IGN as Plot Files on CD-ROM.

(4) Preparing Sediment-related hazard maps for Landslides and Hazardous Areas

Sediment-related hazard maps for Landslides and Hazardous Areas were prepared by identifying hazardous areas of steep slope and landslides along mountain streams and urban areas with analysis of topographic map data, DEM (Digital Elevation Model), and existing aerial photos. The Japanese standard on “landslide prevention” and “disaster measurement” were to be applied for this study

2.4. Basic Policy of the Study

The Study was conducted based on the Scope of Work agreed on between the IGN and JICA on December 4, 1998 and the Work Instructions presented at the explanatory meeting held in El Salvador on February 2, 1999. The details of the basic policy are the followings:

1) The digital data for GIS shall be produced within a period of 28 months for the urgent national rehabilitation of the infrastructure.
2) The existing materials for the Study shall be utilized as much as possible.
3) Appropriate technologies and a cost efficient computer system shall be considered for the Counterpart Agency, IGN.
4) The Phase I Study shall aim to support the following activities of the Counterpart Agency, IGN:
   - Production and correction of the digital data for the GIS
   - Maintenance of the digital data
   - Sustainable supply of the digital data
   - Standardization of the digital data
5) The disaster information database on the Phase II Study shall aim to support the rehabilitation plan.
6) The hazard analysis database on the Phase II Study shall aim to provide a information to the residents and enhancement of awareness for prevention against disasters support the rehabilitation

2.5. Specifications

The specifications of the Study are shown on Table 1.

Table 1 Specifications of the Study

Map Symbols	To be decided based on the representation method in El Salvador through mutual discussion.
Survey Standards	Reference ellipsoid: Clarke 1866 Coordinate datum: Northern American Datum 1927 (referred to the first grade triangulation point at Soledad) Leveling datum: Mean sea level (measured at La Union) Projection: LAMBERT Conformal Conic Plotting scale: 1/25,000 Contour interval: Primary contour 10 m Neat line: 5’ x 7.5’
Precision	To be decided through mutual discussions.
Special Annotation	The following annotation shall be provided in each data file: “This map was prepared jointly by Japan International Cooperation Agency (JICA) under the Japanese Government Technical Cooperation Program and the Government of the Republic of El Salvador.

2.6. Deliverables

The deliverables of the Study are shown on Table 2.

Table 2 Deliverables of the Study

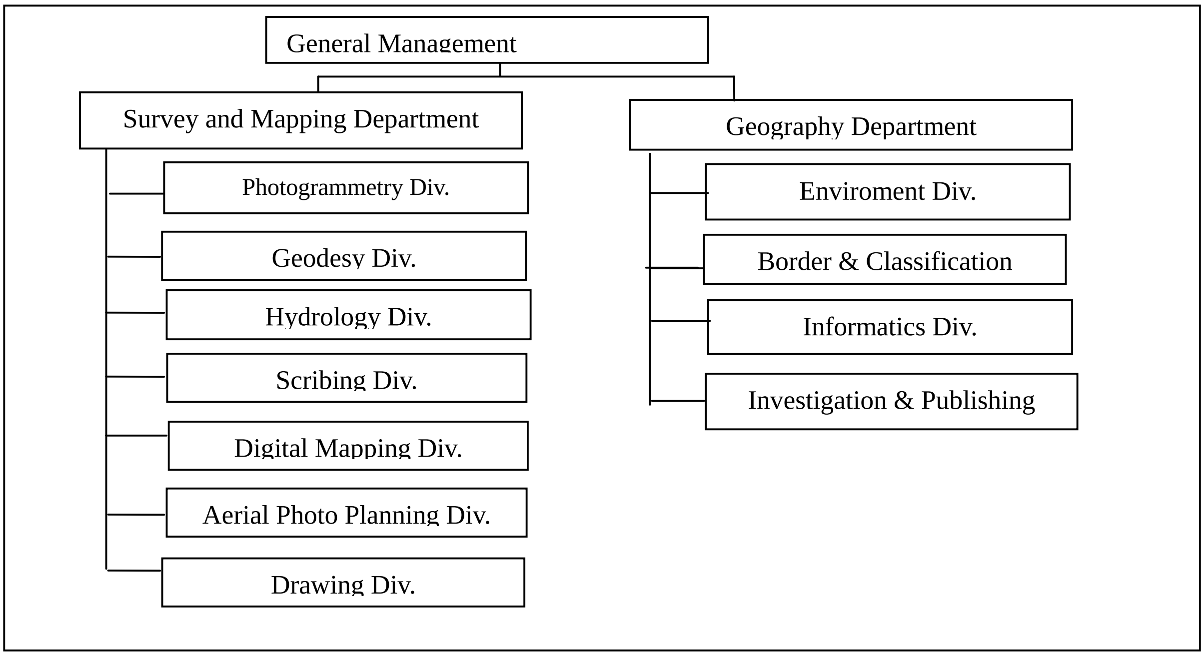
Item	Description	
Outputs	1 Study reports	
	1) Inception report (English and Spanish)	20 copies
	2) Progress report 1 (English)	20 copies
	3) Progress report 2 (English)	20 copies
	4) Draft final report	
	Main report (English and Spanish)	20 copies
	Summary (English and Spanish)	20 copies
	5) Final report	
	Main report (English and Spanish)	20 copies
	Summary (English and Spanish)	20 copies
	2 Aerial photographs at 1/40,000 scale, panchromatic, about 4,000 km^2	
	1) Negative films of the aerial photographs	1 set
	2) Index map of the aerial photography	1 set
	3) Contact prints of the aerial photographs	1 set
	3 Ground control points survey	
	1) Ground control points list	1 set
	2) Index map of ground control points	1 set
	4 Aerial triangulation	
	1) Result of aerial triangulation	1 set
	2) Index map of the aerial triangulation	1 set
	5 Topographic maps at 1/25,000 scale in the new mapping area (about 3,700 km^2)	
	1) Printing films	1 set
	2) Digital data for symbolized topographic maps (CD-ROM)	3 sets
	6 Digital topographic data for GIS	
	1) Digital topographic data for GIS (CD-ROM)	200 sets
	7 Disaster maps and sediment-related hazard maps (about 5,100 km^2)	
	1) Plotted maps at 1/25,000 scale	1 set
	2) Digital data (CD-ROM)	20 sets

3. Counterpart Agency

The Counterpart Agency of the Study is the National Geographic Institute (Instituto Geográfico National "Ing. Pablo Arnoldo Guzman"; hereinafter referred to as "IGN") of National Registration Center (Centro National de Registros; hereinafter referred to as "CNR") under the Ministry of Economy (Ministerio de Economía).

Organization chart is shown in as following.

Organization chart of IGN



4. Members of JICA Study Team

The members of the JICA Study Team and the assignment periods are shown below:

Table 3 Member of Phase I

Task	Name	Period
Team leader	Shun TAKAGI	March 31 to May 29, 1999 October 22 to November 20, 1999 January 15 to February 13, 2000 March 28 to April 11, 2000 June 15 to September 12, 2000 May 12 to May 21 ,2001
GCP Survey	Yutaka NAKADA	April 15 to May 29, 1999 October 22 to December 5, 1999
Aerial photography	Yutaka KYAKUNO	November 1 to December 30, 1999
Field verification	Daikichi NAKAJIMA	December 17 to February 13, 2000 October 7 to November 5, 2000
Digital mapping (1)	Hidetoshi KAKIUCHI	March 31 to April 29, 1999 January 15 to February 13, 2000 May 15 to August 27, 2000 May 12 to May 29 ,2001
Digital mapping (2)	Masaru TERADA	July 5 to October 17, 2000
Digital Data Digital mapping (3)	Kouzou YAMAYA	July 30toSeptember 27, 2000
Operation and Management	Myo THANT	June 15 to July 14, 2000 May 12 to May 29 ,2001
Study Coordination	Kazunobu KAMIMURA	March 31 to April 29, 1999 October 22 to November 20, 1999 June 15 to July 14, 2000
Geology (1)	Hideaki UMEDA	May 12 to May 29 ,2001

Table 4 Member of Phase II

Task	Name	Period
Deputy Team Leader	Fujio ITO	February 18 to March 11, 2001
Geology (1)	Hideaki UMEDA	February 18 to March 11, 2001
Geology(2)	Eiichi HAYAKAWA	February 18 to March 11, 2001
GPS surveyor (1)	Nobuhiro SATA	February 18 to March 11, 2001
GPS surveyor (2)	Mitsuhiko ASAI	February 18 to March 11, 2001
Study coordination	Hidetoshi KAKIUCHI	February 18 to February 28, 2001

5. Chronology of the Study

Each item of the Study operations is shown below in order of the work phases. The Study was executed based on the Flow Chart of the Study Operation in Figure 2.

Figure 2 Flow Chart of the Study Operation
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Table 5 Work items on each working year of the Study

Year	Items
The 1st year	**(1) The Preparatory Work (1) in Japan** Collection / Arrangement of Related Materials Preparation of Schedule Plan, Specifications and Subcontract Agreement for Photography Preparation of Inception Report
	(2) The First Work in El Salvador Explanation and Discussion of Inception Report Discussions on Map Representation and GIS Data Specifications Collection of Related Materials Reconnaissance Survey of Ground Control Points Identification of Issues Related to Digital Map Information Systems Study of Organizational and Legal Systems
	(3) The First Work in Japan Digitization of the Existing Maps (17,040km2) Digitization of the Existing Contour Maps (3,100km2) Data Structure Creation 1 Preparation of Progress Report 1
	(4) The Preparatory Work (2) in Japan Arrangement of Related Materials Preparation of Schedule Plan, Specifications and Subcontract Agreement for Aerial Photography
	(5) The Second Work in El Salvador Explanation and Discussion of Progress Report 1 Installation of Signals for Aerial Photography Ground Control Points Survey by GPS Aerial Photography for New Mapping Field Identification Check of Computer System of the Study On the Job Training and Technology Transfer
The 2nd year	**(6) The Second Work in Japan** Preparation of Progress Report 2

	(7) The Third Work in El Salvador Phase I Explanation and Discussion of Progress Report 2 Study of Operation and Management of the Digital Data Updating of the Digital Data of San Salvador OJT and Technology Transfer Supplemental Survey Presentation Phase II Collection of available materials Field activity for updating of the existing maps Photo-interpretation and Satellite image interpretation Survey of landslide areas
	(8) The Third Work in Japan Aerial Triangulation Checking of Map Quality Digital Plotting
	(9) The Forth Work in Japan Phase I Preparation of Draft Final Report Map Symbolization Inspection of Output Data Structure Creation 2 Official Inspection Phase II Disaster map preparation Sediment-related hazard map preparation DIS database and Disaster database preparation into CD-ROM
The 3rd year	**(10) The Fourth Work in El Salvador** Explanation and Discussion of Draft Final Report Operation and Management of the Digital Data Recommendations to IGN Presentation
	(11) The Fifth Work in Japan Preparation of Final Report Production of Printing Films Writing the Digital Data to CD-ROM

6. Details of Phase I Study

6.1. Reports and Meetings

The Study Team prepared Inception Report, Progress Report 1, Progress Report 2, Draft Final Report and Final Report, and the Study Team initiated those plans into practice with the agreement of IGN after discussions between IGN and the Study Team. Summaries of each discussion are shown below and minutes of meetings are attached on the Appendix.

6.1.1. Explanation and Discussions of Inception Report

On April 7, 1999, the first meeting was held regarding the Inception Report at the office of IGN. The Inception Report was presented to IGN during the meeting.
The second meeting, a continuation of the discussion, was held on April 8, 1999 with the same members.

The following technical issues were discussed and confirmed during the meetings:

1) The primary map projection of 1/25,000 scale topographic maps is Lambert Conformal Conic and the coordinates of UTM have to be described also.

2) GPS receivers for ground control points survey shall be checked and maintained by IGN.

3) An aircraft for aerial photography may be brought in from a neighboring country by the Study Team if it is difficult to charter the appropriate aircraft in El Salvador.

4) The boundary information on 1/50,000 scale maps with authorized signatures on each sheet shall be provided to the Study Team by IGN.

5) New mapping area (3,700 km^2) is to be bounded by the new national boundaries.

6) Because the territorial area of the map sheet 2558-II SW is small, this area shall be included as an extension of the map sheet 2557-I-NW.

7) The digitizing work shall include the area of the Meanguera Island.

8) IGN shall prepare and provide the Study Team with the following duplicate maps.

   - 1/25,000 scale contour maps
   - 1/10,000 scale contour maps
   - 1/5,000 scale contour maps

6.1.2. Discussions on Map Representation and GIS Database Specifications

The IGN members and Study Team members attended the meeting. The discussions were made on the data layers for GIS and map symbolization for printing of the 1/25,000 scale topographic maps to be applied to the Study. The results of those discussions are as follows:

(1) IGN will decide how hidden lines of the rivers shall be digitized. IGN will study the maps of the cities of San Salvador, San Miguel and Santa Ana, and after the study, IGN will provide the Study Team with the maps so that the hidden-lines are marked with visual lines.

(2) The existing map of San Salvador was prepared in 1988, and presents some errors in the legend. These mistakes are not found in another maps of the year 1996.

(3) Large buildings are digitized in the scaled polygons (the same shape as they really are).

(4) Irrigation canals will be digitized as only one type for GIS data. They will be drawn in blue.

(5) Water tanks will be digitized in three sizes (big, medium and small) using one layer and three classes of attributes. Oil and gas tanks will be digitized in the same method as water tanks. Symbols will be used as the same as 'CONVENCIONES TOPOGRAFICAS DEL INSTITUTO PANAMERICANO DE GEOGRAFIA E HISTORIA'. Annotation will be put beside each symbol to specify a type of tank, for example, water, oil or gas.

(6) Sports centers will be digitized as polygon features, and a circle containing the letters CD will be put in each sports center. The symbol for paper maps should be the same as of the existing maps.

(7) Schools and churches will be digitized depending on size. Those smaller than 3 mm on the existing maps, will be digitized as a point feature only, and those larger than 3 mm will be digitized as both a polygon feature and a point feature. The point feature will be used for symbolization of a flag for the school or a cross for the church oriented to the North.

(8) Vegetation areas will be digitized as polygon features.

(9) Streams will be digitized as both polygon and line features. If a stream appears as a line in maps, it will be digitized as a line feature only.

(10) Five colors (red, blue, green, black and brown) will be used for printing maps.

(11) Code numbers for GIS will be taken from the numbers of symbols of ‘CONVENCIONES TOPOGRAFICAS’.

Note:

1) Symbols of ‘CONVENCIONES TOPOGRAFICAS’ will be used for the printed maps.

2) Alternate methods may be used to complete the work after discussions and mutual agreement between IGN and Study Team if a problem or difficulty should arise.

6.1.3. Explanation and Discussion on Progress Report 1

On November 3, 2000, a meeting was held regarding the Progress Report 1 at CNR. The Survey Team presented the Progress Report 1 to IGN, Japanese Embassy, and the Resident Representative of JICA in El Salvador. The Progress Report was accepted by IGN.

6.1.4. Explanation and Discussion on Progress Report 2

On April 3, 2000, a meeting was held on the Progress Report 2 at CNR.
The Progress Report 2 was presented to IGN, Japanese Embassy, and JICA in El Salvador. The Progress Report 2 was accepted by IGN.

6.1.5. Additional Work

JICA and IGN discussed and mutually agreed on the following issues:

1) Additional work will be carried out to create the GIS database equivalent to the 1/25,000 scale topographic map of the southeastern part of the country covering 85 km^2. The boundaries will not be represented in the GIS database
.

2) IGN will provide the Study Team, by December 15, 2000, with the existing materials including aerial photographs covering the above mentioned additional study area.

6.1.6. Explanation and Discussion on Draft Final Report

On May 14, 2001, a meeting was held on the Draft Final Report at CNR.
The Study Team presented the Draft Final Report to IGN. The Draft Final Report was accepted by IGN.

6.2. Organization and Legal System of the Counterpart Agency

6.2.1. History

The National Geographical Institute was created on November 5, 1946, as the Office of Mapping. It had the objective of preparation of the Basic Map of El Salvador, mainly for the United States to acquire information. The office changed in July 1947 to the Cartography and Geography Office and from 1951 to 1955 as the Cartography Department. From the following year in 1956, it became the General Cartography Department, and on January 1, 1968, it was changed to "National Geographical Institute"; then in 1972, a legislative decree gave the current name, "National Geographical Institute Ing. Pablo Arnoldo Guzman". In 1995, it was passed to the National Registry Center under the Ministry of Justice.

The National Geographical Institute, from the beginning as the Office of Mapping until 1995, was under the Ministry of Public Works and had a structure composed of the General Management, Sub General Management, Administrative Division, Financial, Cartographic Division and Cadastral Division. Each Division had respective Departments and Sections. The former structure had supporting functions as Planning, Legal, Public Relationships and support from the Defense Mapping Agency (DMA).
Despite the formalization of the organization, the organization needed to work with a limited budget assigned by the Central Government because of the Civil War and/or of the damages to the infrastructure due to the earthquake in October 1986.

Upon ending the Civil War, the Republic entered a reconstruction stage and presented the needs of updating maps for such reconstruction. However, IGN could not give immediate response due to the financial situation and the stated reasons: Therefore, the Republic requested international economic and technical cooperation projects and some of those projects were implemented with assistance of Japan or other countries and international organizations such as the World Bank.

At the same time the Government of El Salvador moved to implement the National Modernization Plan and within this context the National Registry Center (CNR) was established as a part of the Justice Ministry. IGN was placed under CNR in accordance with the Executive Decree No 62 on December 5, 1994 and the Legislative Decree No 462 on October 10, 1995.

During the last three months of 1995 and 1996, CNR integrated institutions of Land and Mortgage Registry (Registro de la Propiedad Raíz e Hipotecas), Social Land Registry (Registro Social de Inmuebles) and IGN. The functional organization seems to be changing in the modernization process in CNR.

In the process of inclusion of IGN to CNR, the organizational structure of IGN changed considerably, since the financial and administrative functions were absorbed directly under CNR. The Cadaster was merged directly with the Registry of Property; the remaining functions of IGN were the Geographical and Cartographic fields.

6.2.2. Laws and Standard of Cartography

The cartographic standards in El Salvador follow the standards set by the Instituto Panamericano de Geografía e Historia (IPGH) and the National Agency of Imagery and Mapping (NIMA), for mapping work at the scales of 1/50,000, 1/25,000 and geodetic networks of the first, the second and the third orders. For digital mapping, the legal framework is in the process of being established.

6.2.3. Personnel

The National Geographical Institute consists of a total of 138 persons of which people 15 persons are academic professionals. They have been trained in their different areas; several of them were trained abroad and internally. The general fields of academic disciplines are civil engineering, mechanical engineering, architecture, biology, and education. Some of the staff members hold Masters degrees. The education attainment level of IGN is considered high.

Willingness of acquiring digital mapping and GIS technology is very high. However, opportunities to acquire the digital mapping technology are limited because of the limitation of computer facilities.

6.2.4. Training Programs for IGN

Some persons of IGN have been trained in the following institutes:

Fuerte Clayton Panama
The Geographical Institute of Agusín Codazzi of Colombia
The Statistics Institute Geography and Informática in Mexico
The Pan-American Geography Institute and History in Mexico

The contents of the training program were mainly based on the cartography and the photogrammetry.

6.3. Digital Data Creation from the Existing 1/25,000 Scale Maps

Digital data covering the area (approximately 17,040 km^2) that has the existing 1/25,000 scale topographic maps was created using these existing paper maps and the existing contour edition of positive films in accordance with the Specifications agreed between IGN and the Study Team. A flow chart of the data creation is shown on Figure 3. Details of each process are explained below.

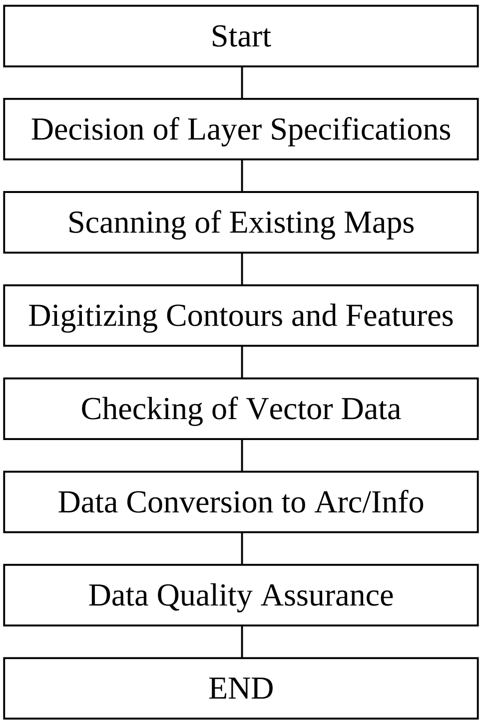


Figure 3 Digital Data Creation from the Existing 1/25,000 scale Maps

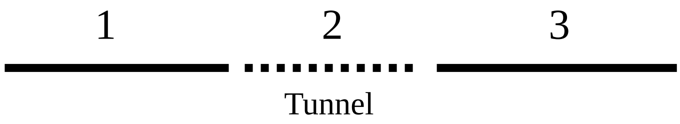
6.3.1. Decision of Layer Specifications

Nineteen layers of the digital topographic data were defined and types or characteristics of each feature and contour were expressed using eight attributes such as code, BT-code, dept, muni, dept-code, type, elevation and text. The layer specifications are shown on Table 6.

The main characteristics of the specifications are as follows:

1) BT-code

The road coverage has two kinds of attributes, Code and BT-code. (The word "coverage" is a term from Arc/Info GIS Software and means layer.) The Code item is for the type of road. For example, a Code number of 1020 means a type of paved road with two or more lanes. The BT-code item is for bridges or tunnels. For example, a BT-code number of 1195 is the inside part of a tunnel. It means that there are not independent layers of bridges or tunnels in this structure. This example is shown in Figure 4. The same method was applied to the coverage data of railways, hydrology and utilities.



ID-Number	Code	BT-code
1	1020	0
2	1020	1195
3	1020	0

Figure 4 Code and BT-code of Road

2) Wells

All types of wells and tanks are stored in the coverage of Well. This coverage has two kinds of attributes, Code and Type. The Code item is description instead of size. For example, the Code number of 1930 means a small sized tank. The Type item is for types of tanks. For example, the Type A means water.

3) Contours and Spot-heights

The contour coverage has three types of attributes, Code, BT-code and Elevation. The characteristic of this coverage is that the BT-code item means depressions. In Spot-height is the value of –9999 was input for a point that has unknown elevation data.

4) Neat lines

All the coverage data have neat lines. The four corner coordinates of the neat lines match the corresponding coordinates of the existing paper maps and the code value is 9999.

Table 6 Layer Specifications of Digital Topographic Data

No.	Theme	Cover	Type	Code	BT-Code	Attrb	Description
1	Admin. Areas	ADMIN	LINE	2220			National Boundary
				2230			City/District Boundary
				2240			Municipal Boundary
			POLY			Name	City/District Name
						Name	Municipal Name
2	Roads	ROAD	LINE	1150			Road under construction
				1140			Uncertain road
				1010			Highway/Paved road - 2 or more lanes (island)
				1020			Paved road - 2 or more lanes
				1030			Paved, one lane road
				1040			Unpaved road - 2 or more lanes
				1050			Unpaved, one lane, all seasons
				1060			Unpaved , dry seasons
				1070			Track
				1160			Street in Urban area
				1420			Ford
				Road Code	1195		Road inside of Tunnel
				Road Code	1430		Road Bridge
				Road Code	1380		Footbridge
3	Railways	RAIL	LINE	1340			Cable car, rope way
				1200			Single track railway
				1210			Non-operating railway
				1220			Multiple-Track railway
				1280			Railway yard
				Rail Code	1335		Railway inside of tunnel
				Rail Code	1440		Railway bridge
				Rail Code	1300		Turntable (Facility for the train to make U-turn)
4	Built-Up Areas	BUILT-UP	POLY	2320			Airport with facilities
				2330			Landing strip
				1480			Urbanized areas
				1670			Cemetery
				1672			Park
				1660			Sports centers
				2051			Mine (true size)
5	Buildings	BUILDING	POLY	1500			Houses shaded as solid black
				1510			Houses symbolized as dots
				1641			Public Office buildings (annotated)
				1643			Police Station (annotated)
				1644			Museum (annotated)
				1645			Market (annotated)
				1590			Warehouse (0.5 - 1.2mm on the map)
				1600			Warehouse (larger than 1.2mm on the map)
				1646			Farm (annotated)
				1647			Factory (annotated)
				1530			School (Larger or equals to 3 mm on the map)
				1560			Church (Larger or equal to 3 mm on the map)
				1648			Hospital (larger than 0.5x0.5mm)
				1620			Ruins (true shape, annotated)
				1610			Snowshed
				1310			Railway station (true shape)
				1962			Substation
				1980			Pool
				1990			Reservoir
				2010			Sewage disposal, Filtration plant

CODE = Map Feature Codes BT-CODE = Bridge/Tunnel Codes; ATTRB = Attribute (Different name for different cover)

Continued on the next page

Continued from the previous page

Table 6 Layer Specification of Digital Topographic Data

No.	Theme	Cover	Type	Code	BT-Code	Attrb	Description
	Settlements	SETTLEMENT	POINT	1490			Houses / huts (smaller or equals to 0.5x0.5mm)
				1520			School (smaller than 3mm on the map)
				1550			Church (smaller than 3mm on the map)
				1580			Hospital (smaller or equals to 0.5x0.5mm)
				1630			Ruins (smaller or equals to 0.5x0.5mm)
				1310			Railway station (Symbolized)
				2335			Heliport
				1642			Meteorological station
				2040			Chimney
				2041			Radio/TV antenna
				1690			Landmark (Monument, Tower,..)
				2050			Mine (Symbol)
				1646			Form
6	Well/Tank	WELL	POINT	1961			Hydrostation
				1963			Pumping Station
				3140			Spring
				3150			Well (water)
				1930		A/G/P/ M/S/O	Tank-small (A=Agua; G=Gas; P=Petroleo; M=Melaza; S=Gasolina; O=Others)
				1940		A/G/P/ M/S/O	Tank-medium (A=Agua; G=Gas; P=Petroleo; M=Melaza; S=Gasolina; O=Others)
				1950		A/G/P/ M/S/O	Tank-large (A=Agua; G=Gas; P=Petroleo; M=Melaza; S=Gasolina; O=Others)
				1960			Well (gas, oil)
7	Utilities	UTILITY	LINE	2020			Pipeline
				1470			Electric power transmission line
				2990			Flume, Penstock
				3000			Underground aqueduct
				Util. Code	3010		Aqueduct
8	Hydrology	HYDRO-POL	POLY	2811			Wide rivers and drainage
				2830			Wide intermittent streams
				2840			Lake/Pond (permanent)
				2850			Intermittent lake/pond
				2860			Dry or cyclical pond
				2911			Wide navigable canal
				2921			Wide abandoned Irrigation Canal
				3110			Fish pond
				Hydro code	2813		Underground Wide River
		HYDRO-LIN	LINE	2811			Centerline of wide rivers and drainage
				2812			Watercourse and drainage
				2830			Centerline of wide intermittent streams
				2820			Indefinite watercourse
				2910			Single Line of Navigable canal
				2911			Centerline of Wide Navigable canal
				2920			Single Line Abandoned Canal
				2921			Centerline Line of Wide Abandoned Canal
				2930			Uncertain Ditch
				2810			Shoreline (Ocean)
				Hydro code	2813		Underground Water Course (single line)
9	Cartographic Elements	CARTO-LIN	LINE	1880			Large Pier (true size)
				1870			Pier (Symbol)
				1800			Breakwater (Symbol)
				1810			Breakwater (true size)
				1820			Submerged breakwater (under water)
				1860			Revetment (upper)
				1861			Revetment (lower)

CODE = Map Feature Codes BT-CODE = Bridge/Tunnel Codes; ATTRB = Attribute (Different name for different cover)

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Table 6 Layer Specification of Digital Topographic Data

No.	Theme	Cover	Type	Code	BT-Code	Attrb	Description
				1410			Ferry
				2900			Small Rapids
				2890			Large Rapids, Falls (Upper)
				2891			Large Rapids, Falls (Lower)
				1730			Dam (Symbol)
				1740			Large Masonry Dam
				1750			Dam carrying road
				1760			Earthen Dam
				1780			Passable Lock
				1890			Ferry slip
				1910			Dry-dock
				1920			Marine Railway
				3270			Embankment (upper)
				3271			Embankment (lower)
				3280			Levee Carrying Road (upper)
				3281			Levee Carrying Road (lower)
				3290			Levee Carrying Railway (upper)
				3291			Levee Carrying Railway (lower)
				3300			Cutting (upper)
				3301			Cutting (lower)
				3310			Fill (upper)
				3311			Fill (lower)
				1700			Fence
				1710			Wall (Symbol)
				1720			Wall (True Size)
				1671			Site Boundary
		CARTO-PNT	POINT	1360			Road Tunnel Entrance Symbol
				1370			Railway Tunnel Entrance Symbol
				2980			Aqueduct Tunnel Entrance Symbol
				2814			Culvert and Closed Conduit
				1531			School (Symbol position)
				1561			Church (Symbol position)
				2290			Lighthouse
				2940			Penetration point
				1790			Sluice gate
				2530			Shipwreck
				2790			Anchorage for small vessels
				2800			Anchorage for large vessels
				3420			Cave
10	Landcover	VEGETATION	POLY	3120			Paddy
				3580			Pine trees
				3600			Savanna, Tropical grass
				3570			Coconut/Palm
				3030			Swamp
				3060			Marsh (near sea)
				3090			Mangrove
				3130			Marsh
				3590			Nipa
				3520			Trees
				3530			Dense bush
				3540			Scattered trees
				3550			Orchard/Plantation
				3560			Orchard/Plantation (temporary)
				3610			Tundra
				3630			Grass
				3650			Marshy areas (bush/scrub)

CODE = Map Feature Codes BT-CODE = Bridge/Tunnel Codes; ATTRB = Attribute (Different name for different cover)

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Table 6 Layer Specifications of Digital Topographic Data

No.	Theme	Cover	Type	Code	BT-Code	Attrb	Description
		LANDFORM	POLY	2350			Sandy areas
				3360			Gravel
				3350			Sand
				3340			Sand Dunes
				3040			Salt evaporator
				3050			Rock salt
				2370			Coral reef
				3380			Outcrop rock
				2360			Coastal cliff (upper)
				2361			Coastal cliff (lower)
				2440			Bare rocks, large rocks
11	Contours	CONTOUR	LINE	3170	3260	E	Index contour lines (Depression, Elevation)
				3180	3260	E	Intermediate contours (Depression, Elevation)
				3190	3260	E	Half interval contours (Depression, Elevation)
		SPOTHGT	POINT	2190		E	Spot elevation points (E=Elevation)
				2195		E	Water level value of lakes (E=Elevation)
12	Terrain			3250			Earth crumbling (upper)
				3251			Earth crumbling (lower)
				3500			Slope (upper)
				3501			Slope (lower)
				3240			Cliff (upper)
				3241			Cliff (lower)
13	Control points & others	CONTROL	POINT	2080		E	Triangulation points (E=Elevation)
				2100		E	Vertical control points (E=Elevation)
				2090		E	Horizontal control points (E=Elevation)
				2110		E	Leveling points (E=Elevation)
				2260			Limit-stones
14	Annotations	ANNO	POINT			T	Province names (T=Text string)
						T	District names (T=Text string)
						T	Municipality names (T=Text string)
						T	Water, Oil, Gas, Melaza (T=Text string)
						T	Elevation values (T=Text string)
						T	Water level value of lakes (T=Text string)
						T	Contour values (T=Text string)

CODE = Map Feature Codes BT-CODE = Bridge/Tunnel Codes; ATTRB = Attribute (Different name for different cover)

6.3.2. Scanning of the Existing Maps

The positive films of the contours and the existing topographic paper maps of 1/25,000 scale were provided by the Counterpart Agency, IGN and these materials were scanned to be used with the computer system. Since the appropriate mode and resolution of scanning is very important for the succeeding work to digitize the scanned images, numerous tests were made. High resolutions are needed to obtain fine scanned images. However, the higher resolution and the more disk space are needed to store the scanned images. An adjustment of brightness, contrast and sharpening filter were also tested. After careful testing, the following mode and resolution were decided.

The positive films of the contours were scanned in monochrome at a resolution of 200 dpi and were then geometrically corrected. These scanned images were used to extract digital data for the contours. Although a grayscale image is better than a monochrome image, the monochrome mode was selected for automatic extracting of contours in the next progress.

The existing paper maps were also scanned in color at a resolution of 200 dpi and were then geometrically corrected. These scanned images were used as background images for the manual extraction of feature data. In the Study, "features" are roads, buildings, vegetation, etc., all information from the existing maps except the contours.
An affine transformation function was used to correct the images geometrically. Although the minimum number of control points to calculate an affine transformation is three, the four corner points of the map sheets of the contour films and the paper topographic maps were selected for the control points.

6.3.3. Digitizing of Features and Contours

The scanned images of the contours were used to digitize contours automatically by raster to vector conversion. However, manually editing was needed for some areas because results of R2V processing depended on the topography and the condition of scanned images. After digitizing the contours, the digital data of the contours were created using VecEdit98 software to input attribute data such as codes and elevations. In this step, the digital data are vector data. After checking, the data was transferred to Arc/Info.

The scanned color images of the existing paper maps were used to digitize features of the maps by VecEdit98. The attribute data for the features were also input using VecEdit98.

Note:
R2V is advanced raster to vector conversion software for GIS and mapping. This software is capable of creating vector data and editing the data both automatically and manually. VecEdit98 is heads-up digitizing/editing software. This software is equipped with several editing and error-finding functions.

6.3.4. Checking of Digitized Data

After creating the digital data of contours and features, hard copies of the data were plotted for manual checking. Plotting allows the data to be checked quickly and easily. The main items for checking were features, invalid attribute values and edge matching between sheets. The processing of check and correction was reiterated using VecEdit98 until no errors were detected.

Digital data have usually errors of very small elements that are invisible to the naked eye during a paper check; therefore after converting the data to Arc/Info coverage data, the data were checked in Arc/Info and corrected if necessary.

6.3.5. Topology Construction of Digital Data

After correcting the digital data, coverage data were created by importing the digital data into Arc/Info. The coverage data means layer data of Arc/Info. The coordinates of the coverage data were transformed to the Lambert for the Study and were put the topology structure.

6.3.6. Data Quality check

Finally, the coverage data were checked and corrected by Arc/Info. Checked items for all coverage data were the followings:

1) Invalid code
2) Invalid feature type
3) Invalid text
4) Digitizing direction
5) Attribute items definition
6) Unnecessary attribute
7) Topology
8) Edge matching between sheets

Checked items of the individual coverages were as following:

Road, Rail, Utility and Hydro-lin	Dangle check
Built-up areas and Buildings	Dangle check Polygon check
Wells	Text check
Hydro-pol	Dangle check Polygon check Direction check
Carto-lin, Landform and Terrain	Dangle check Direction check
Vegetation	Dangle check Polygon check
Contour	Dangle check Unnecessary nodes Invalid text check

6.4. Processing for Area Void of the Existing 1/25,000 Scale Maps

There are two kinds of products for the area (approximately 3,700 km^2) where there are not the existing 1/25,000 scale paper maps. One is a set of printing films for the 1/25,000-scale topographic paper maps. The other is a set of the digital data for the GIS. These products were created using new aerial photographs. Conventional analytical plotters were used to obtain contour and feature data. Digital technology also was used for some areas and details of the processing are written in the section 5.5. In the present section, the conventional method using analytical plotters for map data generation is written. A flow chart of the processing is shown on Figure 5. Details of each processing step are explained below.

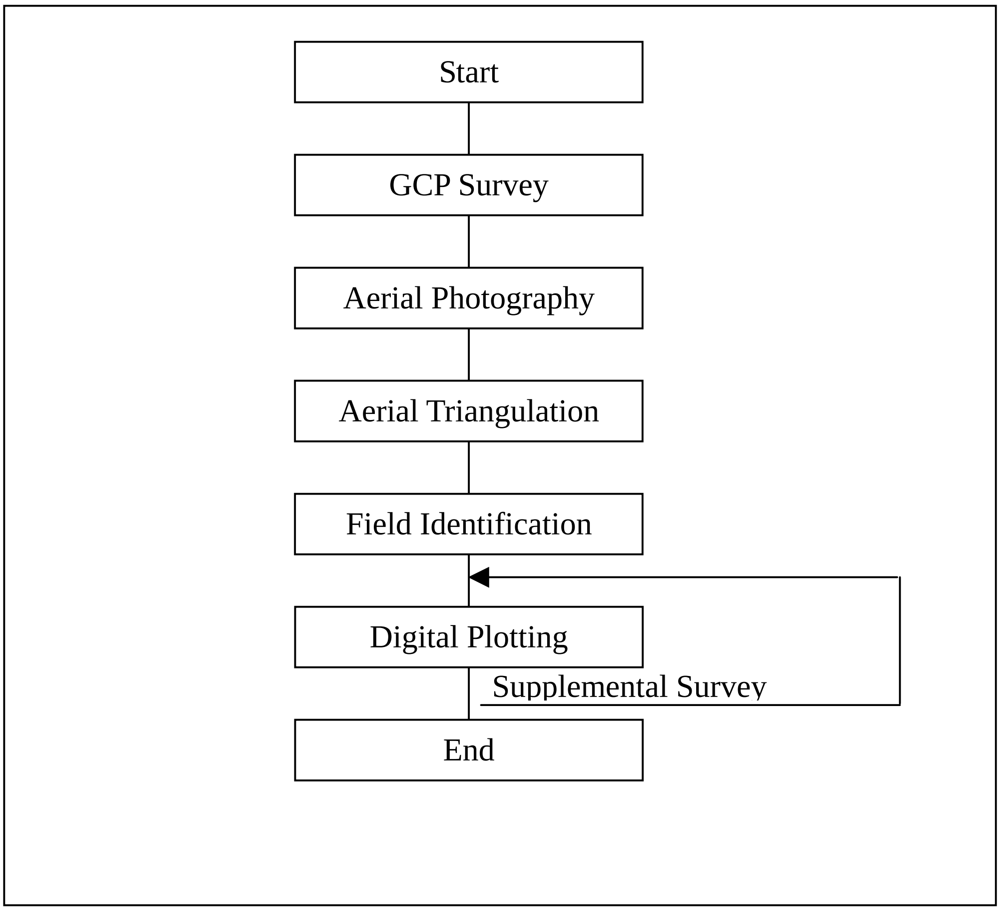

Figure 5 Map Data Creation for the New Mapping Area

6.4.1. Ground Control Points Survey

(1) Reconnaissance Survey of Ground Control Points

The reconnaissance survey of Ground Control Points was performed in accordance with the 1/50,000 scale maps and the descriptive information of the existing control points.

Locations of signals for aerial photography and locations of new points for the GPS survey were planned.

Former Established Ground Control Points

The main reasons of the reconnaissance survey are shown below:

1) To investigate the existing conditions of the established control points and suitability of the surroundings for newly planned GPS observations
2) To select preferentially the locations easily accessible by vehicles for the control points to be newly established.

The survey results are shown on Table 7 and Figure 6.

Many former established control points were found destroyed within some parts in the survey area where the anti-government forces had occupied during the Civil War. While, some control points could not be identified because the old residents, who know the locations of the established control points, had already been moved and the new residents did not know the locations. In another cases, some points established on the top of the hills have been destroyed or removed due to recent regional developments.

Former Established Benchmark

Many National Benchmarks were established along the old roads that were left destroyed due to the expansion work on the road development projects. The benchmarks established under the ground in the older periods were located exactly on the position of the descriptions of the points. The benchmarks established after the road expansion could be identified because each of them has a monument on the ground.

Plan of Ground Control Points Survey

Some ground control points were established along the new boundary line between El Salvador and Honduras, and the coordinates of the points were determined by IGN. These points were planned to be used for the GPS observation and as signals for the aerial photography.

Figure 6.   Point Description (Sample)

obj/common/figure/figure6.jpg

Table 7 Result of Reconnaissance Survey for Ground Control Points

obj/common/figure/table7.jpg

(2) GPS Observation

A total of 29 control points were observed by GPS for the eight separate photogrammetric digital mapping areas. 3 control points out of the 29 points were located out of the aerial photography area as reference points for the net adjustment computation.

Four geodetic survey teams from IGN observed the points. The work period was from November 11, 1999 to November 25, 1999 immediately after the completion of the aerial signal installation. A session of the GPS observation is shown in Table 8, and the distribution of GPS stations is shown in Figure 7.

The Survey was carried out using four ASHTECH geodetic GPS receivers, with 1.5 – 2.0 hours of observation time at each station. The observed vectors were post-processed by ASHTECH FILLNET GPS software at the office of IGN in San Salvador. The whole network was later adjusted using Trimble GPSurvey three dimensional net-adjustment software in Japan. Adjustment was referred to two geographic coordinates of WGS-84 and NAD-27. Final coordinates were transformed to Lambert Conformal Conic.

A point description sheet was prepared for each of the GPS points. Each point was marked or pricked on contact prints of aerial photos. The final adjusted coordinates are listed in Table 9. The result of the GPS work is attached as Appendix.

Table 8   Sessions of GPS Observation

Julian Day	Date	Station ID	Station Name	Data Recording Time
315	11-Nov.-1999	PCF4 ES20 **SIGN** F242	PCF-4 Boundary Point ES-20 **San Ignacio** Boundary Point F-242	13:00 –15:00 (2 hours)
316	12-Nov-1999	**SIGN** LCAV **TEJU** MANZ	**San Ignacio** La Cava **Tejutla** Manzano	11:00 –13:00 (2 hours)
319	15-Nov-1999	SDIE SOLE LCAV **TEJU**	San Diego Norte Soledad La Cava **Tejutla**	13:00 –16:00 (3 hours)
320	16-Nov-1999	MANZ F103 OCOT **ETOR**	Manzano Boundary Point F-103 Ocotillo **El Tortuguero**	13:00 –15:00 (2 hours)
321	17-Nov-1999	**ETOR** CUSC TECO **LPAM**	**El Tortuguero** Cuscatlan Tecomatepeque **Las Pampas**	13:00 –15:00 (2 hours)
322	18-Nov-1999	**LPAM MURI** PLAY PI97	**Las Pampas** **Murillo Ecc** Playa Dorada Pista 97	13:00 –15:00 (2 hours)
323	19-Nov-1999	**MURI** LCAR ALBE **ECOC**	**Murillo** La Carrera II Alberto II **El Cocal II**	11:00 –13:00 (2 hours)
327	23-Nov-1999	**PAVA** MAXI E329 **MONT**	**Pavana** Maximo E-329a **Monteca**	13:00 –15:00 (2 hours)
328	24-Nov-1999	**ECOC** ALEG VOLC **PAVA**	**El Cocal II** Valle Aregre Volcan II **Pavana**	13:00 –15:00 (2 hours)
329	25-Nov-1999	**MONT** **ETOR** VTAB RNEG	**Monteca** **El Tortuguero** Valle Tablon Roble Negro	12:00 –15:00 (3 hours)

Figure 7 Distribution of GPS Stations
obj/common/figure/figure7.jpg

(Network Map ： IGN GIS)

Table 9 Final Adjusted Coordinates by GPS

STATION					PLANE COORDINATES (LAMBERT)		
No.	GPS Station ID	Fix Status for GPS Processing	Point Information	P/M	X (m)	Y (m)	Ortho Height (m)
1	ALBE	Not Known	New Pillar	+	257,154.747 N	566,839.016 E	379.162
2	ALEG	Not Known	New Pillar	+	264,939.648 N	578,278.861 E	450.548
3	CVSC	**Fixed**	Existing Pillar	+	289,370.418 N	510,979.770 E	870.310
4	E329	Not Known	New Pillar	+	297,660.502 N	639,441.896 E	142.405
5	ECOC	Not Known	New Pillar	+	264,807.764 N	569,222.284 E	746.852
6	ES20	Not Known	Boundary Point	+	360,988.273 N	477,428.585 E	721.056
7	ETOR	Not Known	New Pillar	+	289,497.283 N	538,359.582 E	282.236
8	F103	Not Known	Boundary Pillar	+	322,360.993 N	536,426.637 E	109.584
9	F242	Not Known	Boundary Pillar	+	349,465.984 N	497,466.447 E	809.016
10	LCAR	Not Known	New Pillar	+	245,950.764 N	551,973.258 E	84.683
11	LCAV	**Fixed**	Existing Pillar	+	308,071.238 N	494,487.521 E	622.390
12	LPAM	Not Known	New Pin	·	265,674.376 N	524,090.465 E	165.694
13	MANZ	**Fixed**	Existing Pillar	+	324,349.509 N	507,531.939 E	462.610
14	MAXI	Not Known	New Pillar	+	259,324.412 N	638,162.345 E	8.373
15	MONT	**Fixed**	Existing Pillar	+	306,596.057 N	625,043.510 E	935.990
16	MURI	Not Known	Eccentric Point	·	247,061.246 N	524,660.170 E	2.351
17	OCOT	**Fixed**	Existing Pillar	+	315,224.629 N	539,071.039 E	1,013.800
18	PAVA	**Fixed**	Existing Pillar	Out	259,882.098 N	623,231.451 E	88.560
19	PCF4	**Fixed**	Existing Pillar	·	361,325.856 N	471,982.914 E	1,121.862
20	PI97	Not Known	Existing Pillar	+	231,936.799 N	548,538.474 E	1.059
21	PLAY	Not Known	New Pillar	+	241,309.936 N	512,257.833 E	0.724
22	RNEG	Not Known	Recovered Pillar	·	315,745.376 N	584,720.866 E	976.863
23	SDIE	**Fixed**	Existing Pillar	Out	349,998.796 N	448,197.069 E	786.610
24	SIGN	Not Known	Eccentric Point	+	357,222.520 N	480,988.632 E	1,046.050
25	SOLE	**Fixed**	Existing Pillar	Out	282,614.446 N	475,476.010 E	998.730
26	TECO	**Fixed**	Existing Pillar	·	281,301.377 N	531,998.500 E	498.780
27	TEJU	**Fixed**	Existing Pillar	+	339,083.787 N	488,701.471 E	352.520
28	VOLC	Not Known	New Pillar	·	262,543.554 N	580,602.688 E	469.250
29	VTAB	**Fixed**	Existing Pillar	+	304,238.958 N	587,508.979 E	775.750

** + : Aerial Signal Point · : Pricking Point Out : Out of Aerial photography

6.4.2. Aerial Photography

(1) Signals for Aerial Photography

A total of 20 signals of the aerial photography were installed at GPS survey points. The signals were put at the existing triangulation control points and newly established control points.

Four geodetic survey teams from IGN installed these points. The work period was from November 3, 1999 to November 10, 1999. The shape and size of the signal are shown in Figure 8.

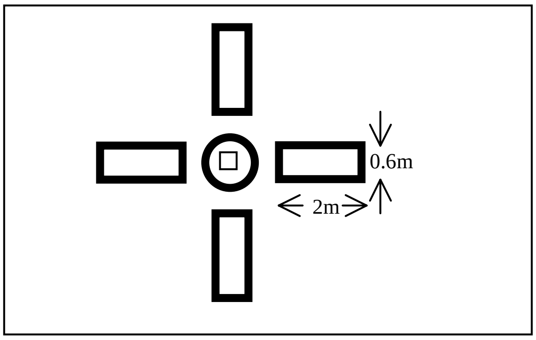

Figure 8 Shape and Size of the Signal

(2) Aerial Photography

<u>Planning</u>

An aircraft that can rise up to an altitude of 6,000 meters was scheduled to take aerial photographs with 1/40,000 scale. The area of photography consisted of 24 flight courses and covered the new mapping area (approximately 3,700km^2).

<u>Execution</u>

The aerial photographs were taken from November 9, 1999 to December 15, 1999. The progress and details of the execution are reported in "FLIGHT RECORDS".
For the flat areas, the photography proceeded smoothly under the favorable weather conditions throughout the work period.

However, for the northern mountainous areas along the Honduran border, where the weather is usually cloudy almost all year round, there were few chances to take clear photographs. Due to these unfavorable local weather conditions, some photographs contain minor cloud coverage.

Despite the number of trial flights, excellent results could not be obtained in the work period. However, these photographs were accepted because the small quantity of clouds would not affect the following aerial triangulation works and the existing photographs for the relevant areas could be obtained from IGN as reference data.

The work period and times of flights are as follows:

Work period: 38 days
Number of flights: 10 flights (in which photographs could be actually taken)
Hours: 15h 52m

Results

The results of aerial photography are as follows:

Films: 2 rolls
Flight Courses: 24 courses
Aerial Photographs: 351 photo frames

See Figure 9. Flight Index.

Photographic Processing

1) Inspection of Developed Films

After the photography, the developed films were inspected with full attention to the following points:

- Homogeneous tone and clear contrast of the images are ensured
- Emulsion and developing solution are removed thoroughly
- Image distortion occurs due to inadequate drying of films

2) Inspection of Contact Prints

After the printing, the contact prints were inspected with full attention to the following points:

- Forward overlap and lateral overlap
- Clouds, shade of clouds and unevenness of images
- Discrepancies between actual flight courses and planned courses
- Halation
- Mists, smokes, etc.
- Scratches on films

3) Annotation of Films

The films were annotated according to the specifications agreed upon with IGN. These specifications are shown in Figure 10.

Figure 9 Flight Index

obj/common/figure/figure9.jpg

Figure 10 Specifications of Film Annotations

obj/common/figure/figure10.jpg

6.4.3. Aerial Triangulation

Initially, the Study Team planned to pick up some Ground Control Points (GCPs) from the existing 1/5,000 scale and 1/10,000 scale maps, because only GCPs from GPS observations were not sufficient for aerial triangulation. However, after checking the existing maps, the Study Team understood that accuracy of the maps was not acceptable. The difference between the result of the triangulation and the existing maps were calculated. See Figure 11. The errors depended on the area and therefore points that had less error were selected for GCPs.

The Independent Model of PAT-M was adopted for the method of triangulation and the study area was divided into eight blocks. See Figure 9 for the location of each block. An example of the processing for the block 1 is shown below.

The processing was performed in 3 steps, as shown below.

Step 1:
GPS Points: 6
Check Items: Connection between models
Points from features of the existing maps
Triangle Points (x, y, z)
Step 2:
GPS Points: 6
Triangle Points (x, y, z) that were accepted to use in the step 1: 17
Check Items: Points from features of the existing maps
Triangle Points (x, y, z)
Spot Height (z) 126 points
Step 3:
GPS Points: 6
Triangle Points (x, y, z) that were accepted to use in the step 2: 17
Points from features of the existing maps (Error is less than 15 m): 18
Spot Height (z): 88

The processing was successfully finished and the result of the aerial triangulation was used for digital plotting. RMS Errors (horizontal and vertical errors) of GCPs that were used for the calculation are shown on Table 10.

Table 10 RMS Errors of GCPs

Block number	Horizontal error (m)	Vertical error (m)
Block 1	5.601	2.029
Block 2	3.387	3.052
Block 3	.668	2.102
Block 4	3.150	3.425
Block 5	5.070	1.766
Block 6	7.502	1.633
Block 7	.582	.708
Block 8	.365	.674

Figure 11　Difference between the result of triangulation and the existing maps
obj/english/figure11.xls

6.4.4. Field Verification

Field verification was carried out twice. The first time was for making manuscripts of plotting maps and the second time was for the checking of the manuscripts of the plotting. The second field verification is called the supplemental survey in this report.

(1) First Field Verification for Plotting

Before the field verification, preliminary interpretation of the aerial photographs was carried out using photographs enlarged two times and the existing 1/50,000 scale topographic maps. Based on the preliminary photo interpretation results, the following items were checked and verified in the field.

1) Work Items of field verification are as follows:
   - Confirmation of preliminary interpretation results
   - Identification of small objects that were difficult to interpret on the aerial photographs
   - Identification of roads, railways, buildings, control points, rivers, vegetation, and the names of valleys and hills
   - Study and collection of materials on administrative names and boundaries
   - Collection of information from Government Agencies
   - Names for annotation

2) Supplemental Survey Checking and arrangement
   The results of field verification were recorded on the enlarged aerial photographs, and they were arranged for plotting and map symbolization in accordance with the list and the application rules of map symbols.

3) Supplemental Survey Coordinates of new maps
   The corner coordinates of the map sheets for the new area were calculated. The coordinate values are shown in Table 11.

(2) Supplemental Survey

The supplemental survey was conducted for checking the manuscripts of plotting maps, checking the annotation data and checking the marginal information for printing paper maps.

Before the survey, color manuscripts of plotting maps were checked using the enlarged photographs with the results of the first field verification, data of administrative boundaries, data of control points, the existing 1/50,000 scale topographic maps and the corner coordinates of the corresponding maps in Japan.

The color manuscripts, black and white copies of the manuscripts and the enlarged photographs were used for the supplemental survey in El Salvador. Planning of the field works took five days at the IGN office and the field work took about two weeks.
The results were written on the black and white copies of the manuscripts. The substantial lack of public buildings was identified.

Table 11
obj/english/table11.doc

Table 11
obj/english/table11.doc

Table 11
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6.4.5. Digital Plotting

Digital data in DXF format were produced by three different methods depending on the topographic materials. The DXF data were then used to create the coverage data for Arc/Info, and were also converted to Illustrator data for cartographic symbolizing. Refer to Section 5.3 regarding coverage data creation and the following sub-section regarding cartographic symbolizing with Illustrator.

(1) For areas where there are not the existing 1/25,000 scale maps but 1/5,000 scale topographic maps exist, the following procedures were taken:

DXF data were created using analytical plotters. The existing 1/5,000 scale maps were not used because it would be very complicated to make 10 meter interval contours of 1/25,000 scale maps from 5 meter interval contours of 1/5,000 scale maps.

(2) For areas where possible to use the existing 1/10,000 scale topographic maps, the following procedures were taken:

Digital data of contours were generated using the existing 1/10,000 scale maps and digital data of features were digitized from the ortho rectified images that were recently created.

The work flow is shown in Figure 12.
Section 5.5 contains details about these procedures.

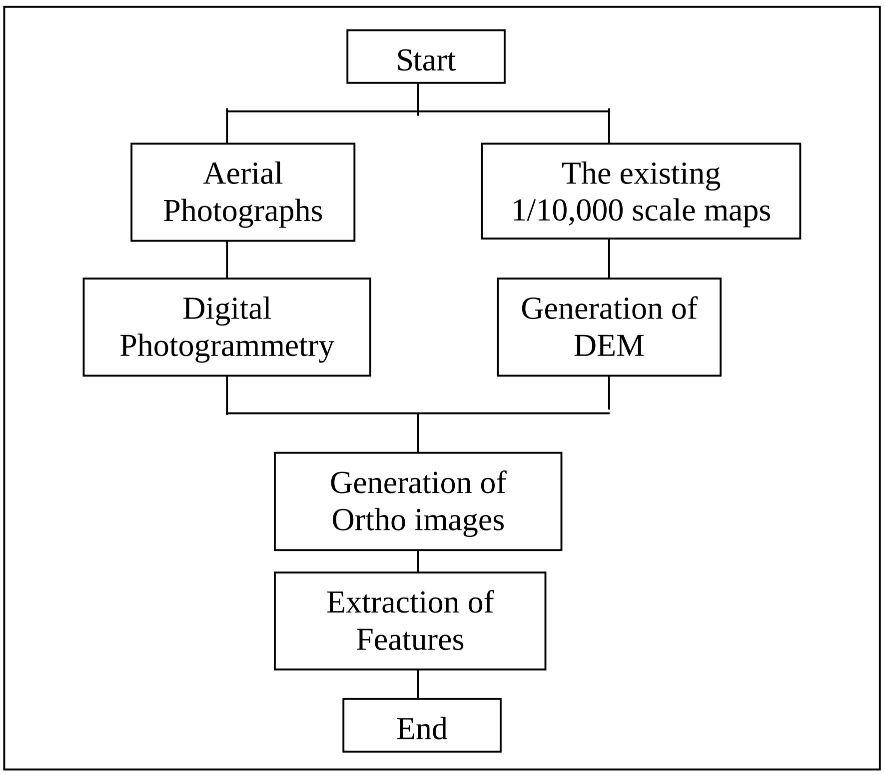


Figure 12 Feature Extraction from Ortho Images

(3) For areas where impossible to use the existing 1/10,000 scale topographic maps, the following procedures were taken:

Here, the processing was similar to those steps in 1). The digital data for contours in this area were generated from the existing 1/10,000 scale maps. The contour data from the 1/10,000 scale maps were not utilized without editing because the maps had low precision.

6.4.6. Symbolizing of Digital Data

The purpose of this procedure is to make digital data of conventional cartographic map images and printing films. Digital data for this step were produced from the DXF data by using Illustrator. Refer to Sub-section 5.5.2 for these procedures.

6.4.7. Creating of Digital Data

The coverage data of Arc/Info were created using DXF data. The method of creating and correcting the digital data was almost the same as the method for the digital data of the existing 1/25,000 scale maps. See Section 5.3.

6.4.8. Understanding of the Computer System for the Study

The computer system was checked and proper functioning was confirmed. At the same time, the availability of the digital data of the existing 1/25,000 scale maps that were produced in the first work in Japan was verified using the computer system. One of the purposes of these checking jobs was to train the engineers of IGN to understand the computer system including basic operation of application software.

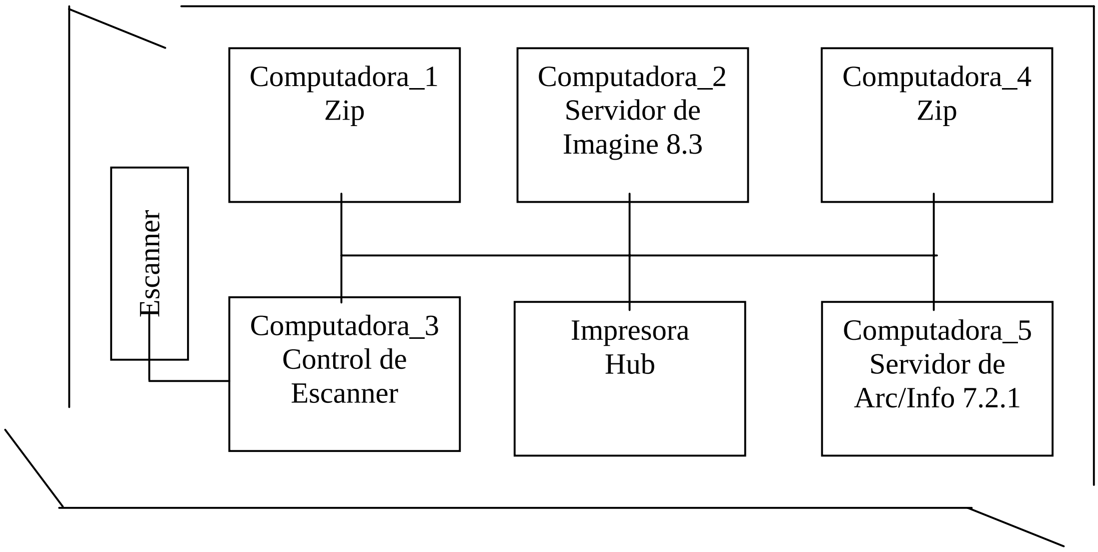
The following items were explained in detail:

- Method of making the digital data from the existing maps
- Configuration of the computer system
- Operation of Windows NT for Administrator Software
- Operation of the scanner
- Operation of ArcView Software

The engineers of IGN understood the method of making the digital data, the configuration of the computer system and the operation of Windows NT for Administrator.

Figure 13 was used to explain the configuration of the computer system for the training in El Salvador.

Figure 13 Computer system diagram



Número de Maquina	Nombre de PC	Dirección IP	Número de Licencia de Windows NT	Aplicación	Nota
Computadora_1	7942CKP30123	192.168.10.1	16899-OEM-0042834-65838	Zip	
Computadora_2	7942CKP30144	192.168.10.2	16899-OEM-0042834-65252	Servidor de Imagine8.3	Necesita Llave
Computadora_3	7942CKP30124	192.168.10.3	16899-OEM-0042834-65926	Control de Escana	
Computadora_4	7942CKP30150	192.168.10.4	16899-OEM-0042834-64526	Zip	
Computadora_5	7942CKP30141	192.168.10.5	16899-OEM-0042834-65015	Servidor de Arc/info 7.2.1	Necesita Llave
Impresora	PS(Phaser780)	192.168.10.6			

6.4.9. Updating of Digital Data

The Arc/Info coverage data for the map sheet of San Salvador (approximately 100 km^2) were used to train the engineers of IGN and the equipment for the training was the computer system for the Study including the application software. The job flow of the updating task is shown Figure 14. The topics of the technology transfer for updating the digital data are the following:

a) Generation of ortho rectified images
b) Updating of coverage data
c) Map symbolization

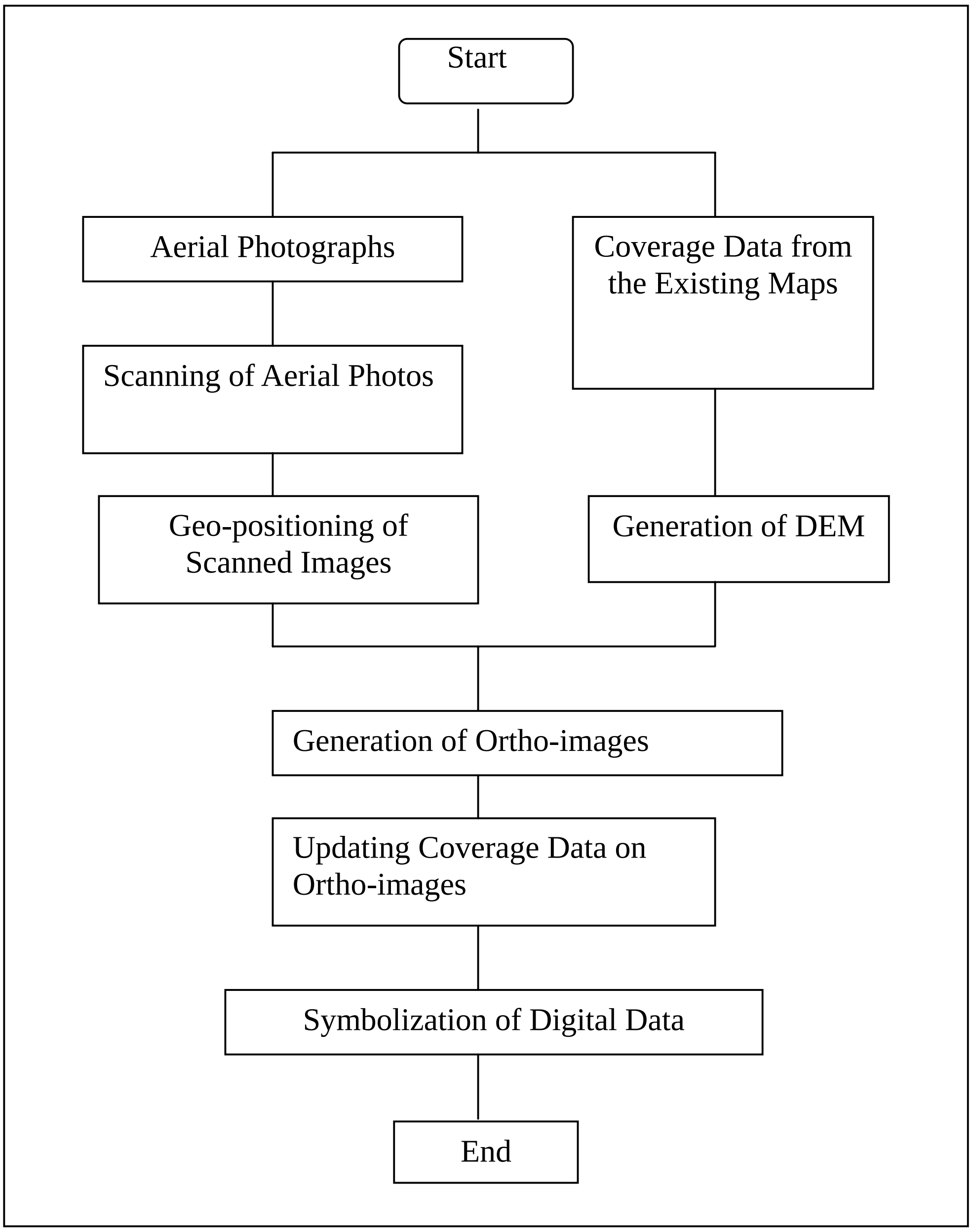


Figure 14 Work Flow of Digital Data Updating

(1) Generation of Ortho-images

Aerial Photographs

The aerial photographs for the Study were prepared by IGN. Since the latest photographs (January 2000) did not cover all of the area of San Salvador, photographs from 1997 and 1998 were also used to generate ortho-images of San Salvador. The aerial photographs used for ortho-images are shown in Table 12. The scale of the aerial photographs is 1/15,000.

Table 12 Aerial Photographs used for Ortho-images

Line	Number	Date
L-13	716,718,720,722	26/1/2000
L-12	773,771,769,767	27/1/2000
L-11	751,749,747,745,743	26/1/2000
L-10	775	27/1/2000
L-6	75,74	17/2/1998
L-5	173,174,175,176	15/12/1997
L-4	164,163	15/12/1997
L-2	39,41,43,45,47	16/12/1997

Scanning of the Aerial Photographs

The aerial photographs were scanned and the scanned images were enhanced visually using Adobe PhotoShop Software. During the training, the engineers of IGN understood the objective of this processing and they proficiently mastered the operation of the scanner and PhotoShop. The resolution of scanning was 300 dpi and the mode of scanning was grayscale. The brightness and contrast were decided after trials and the sharpen-filter was applied depending on the quality of images.

Generation of the DEM

Here, the Digital Elevation Model (DEM) is used to rectify the distortion caused by elevation of the scanned photo images. In other words, the DEM was used to generate ortho-rectified images in the following procedure. The coverage data of control points and contours were used to generate the DEM. The used application software used was Arc/Info and the grid interval was 25 meters.

Geo-referencing and Ortho-rectification

The scanned image of the existing 1/25,000 scale map of San Salvador was used as the base map for geo-referencing. However, there were unacceptable errors (about 20 meters, in some areas, over 50 meters) between the generated ortho-images and the scanned base map. After some experiments, IGN and the Study Team decided to use of the existing 1/5,000 scale maps. In this step, the engineers of IGN could understand very well about the accuracy of the existing maps and the concept of geo-referencing. The processing was carried out using ERDAS Imagine. About 20 control points were selected for each photo image and the value of RMS error was about one pixel in each processing. During these procedures, the operator was rotated every three days because only one license of ERDAS Imagine was available and there were four IGN engineers

who required training. The resulting 27 ortho-images were mosaikked into one image. The plotted mosaic image was used to check features to be updated. The digital mosaic was utilized as a background image in the next step for updating the coverage data.
Finally, an operation manual of ERDAS Imagine was prepared in Spanish as a review of this process.

(2) Updating of Coverage Data

When an experiment of updating was performed in Japan, horizontal positioning errors were found in the existing 1/25,000 scale map of San Salvador. Most of the areas have 20-meter errors and some areas have over 50-meter errors. IGN and the Study Team understood that these errors were made when the existing 1/25,000 scale maps were produced from the existing 1/5,000 scale maps. After the discussion, IGN and the Study Team decided that it would be better to update and correct the coverage data of San Salvador at the same time.

The objects that should be updated or corrected are as followings:

a) Roads
   Newly established roads
   Roads that are not within the width of the corresponding roads of the ortho-image
   Roads whose shape are described incorrectly
b) Newly established buildings
c) Newly established built-up areas

The objects that should not be updated or corrected are as follows:

a) Rivers
b) Vegetation
c) Contours

The staff of IGN prepared the necessary information for this processing as follows:

a) Class definition of roads
b) Changed administrative boundaries
c) Annotation data
d) Adopted newly established buildings

The features to be updated were described on the plotted ortho-images using the information mentioned above and the newest edition of the existing 1/15,000 scale road map of San Salvador. Before the processing, the Study Team instructed the IGN engineers in the operation of the Arc/Info editing system called ArcTools. However the instruction term was cut short because OJT was thought more important for IGN.
The updating was started using Arc/Info. The operator was rotated every two days because there was only one license of Arc/Info and there were four engineers from IGN. It was not bad thing because the job was very hard and none of the operators could continue the job for a long time with great concentration. The updating job continued for one month and finished completely. The main items taught during that time are as follows:

a) To load coverage data
b) To load ortho-image
c) To define tolerance for editing
d) Zoom in, zoom out and pan
e) To select features
f) To add line features
g) To delete line features
h) To move line features
i) To add node features
j) To delete node features
k) To move node features
l) To modify vertices
m) To input codes of line features
n) To change codes of line features
o) To modify label
p) To change available features, namely, Tic, Arc, Node and Label
q) To save edited coverage data
r) To make Topology

The Arc/Info ArcTools editing system is user friendly, with GUI (Graphic User Interface). An example of the GUI is shown in Figure 15.
Finally, an operation manual of the Arc/Info Editing Tools was prepared in Spanish as a review of this process.

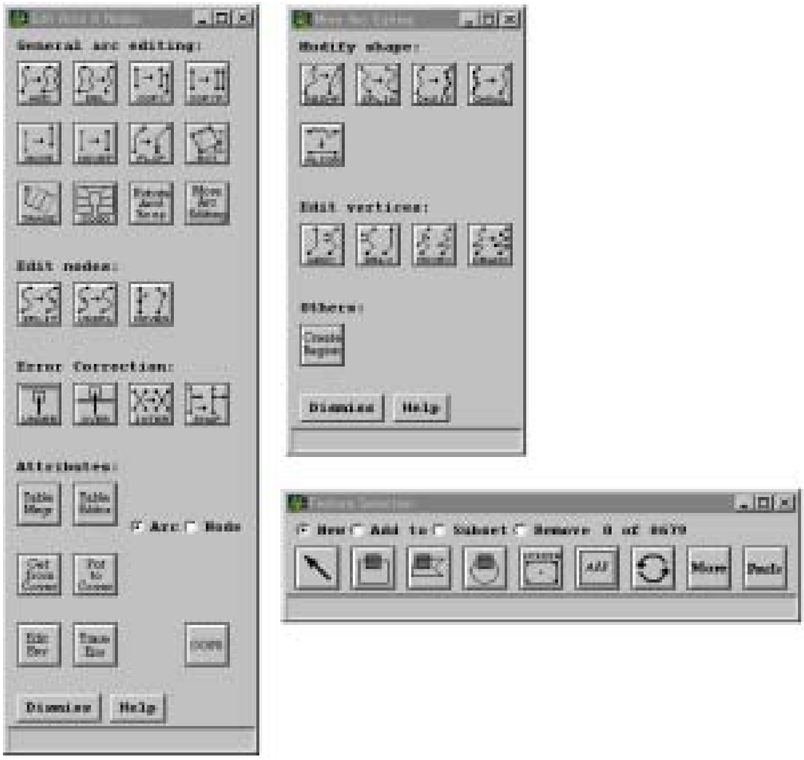


Figure 15 ArcTools GUI

(3) Map Symbolization

The objective of this training was to understand how to symbolize the updated coverage data in the form of a conventional cartographic paper map. Arc/Info and Adobe Illustrator were used. The training items are as follows:

a) Basic operation of Arc/Info and Illustrator
b) How to make map symbols and annotations in Illustrator
c) How to make documents of job instructions
d) How to transform the Arc/Info coverage data to Illustrator format data
e) How to symbolize the coverage data and how to edit maps
f) How to make the digital data for printing including the method of color separations

The job flow is shown Figure 16.

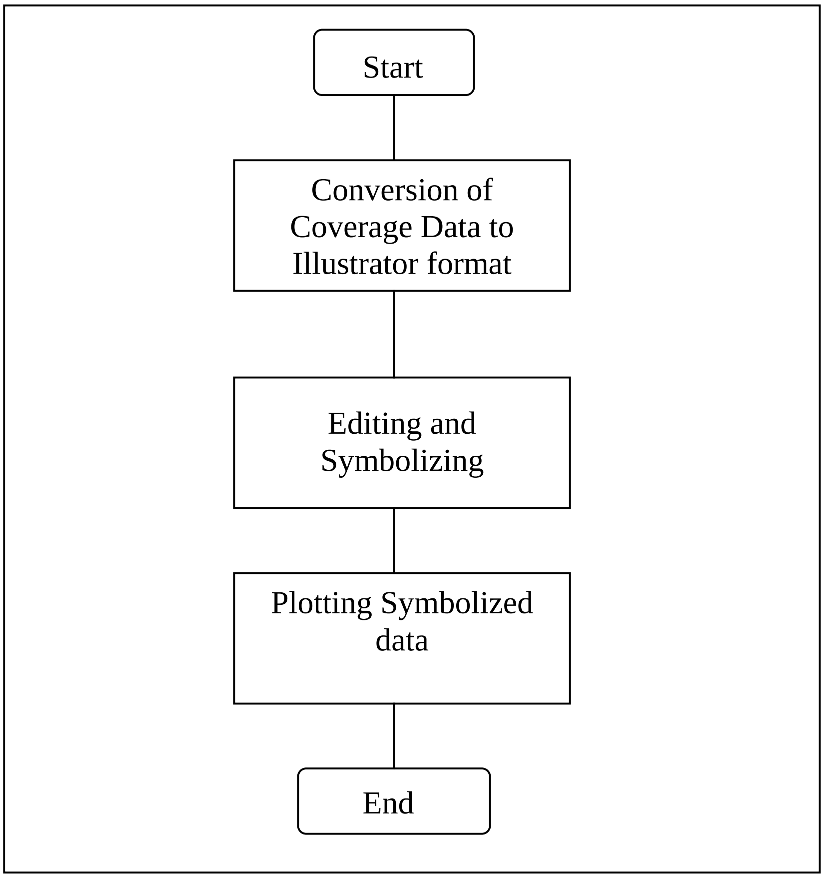


Figure 16 Job Flow of Map Symbolization

The IGN engineers clearly understood the operation of the software because they were accustomed to computers and were already using some application software. However, since the engineers were not specialized in map editing or cartography, the Study Team felt that the training was enough for this work. An example list of codes and symbols is shown in Figure 17.

Color / Color	%	Aplication / Aplicacion	Remark / Nota	Cover	Code
magenta black	20 100	0.8 6.10 2.05 1.65 0.4mm		Admin	2220
black	100	6.10 0.8 1.65 0.3mm		Admin	2230
black	100	0.4 1.65 0.8 0.15mm		Admin	2240
white black	100	0.15 0.4 0.1 0.55 0.8 0.55mm		Road	1360
white black	100	EN CONST. 0.4 2.55	6pt Helvetica oblique	Road	1150
black	100	6pt Helvetica oblique LOC.APROX		Road	1140
magenta black	100 100	4 VIAS 0.90 0.15 0.1mm	6pt Helvetica oblique Son anotadas las vias de carretero	Road	1010
magenta black	100 100	4 VIAS 0.80 0.15	6pt Helvetica oblique Son anotadas las vias de carretero	Road	1020
magenta black	100 100	0.55 0.10		Road	1030
magenta white black	100 100	2 VIAS 1.50 0.80 0.15 3.05	6pt Helvetica oblique Son anotadas las vias de carretero	Road	1040

Figure 17 Example of Codes and Symbols

6.5. Evaluation of the Study

The Study for Establishment of National Basic Geographic Data in the Republic of El Salvador has finished successfully on schedule. Almost all parts of each job were free of major problems. The relationship between the IGN and the JICA Study Team has been highly satisfactory during the Study term and the staff of IGN always stood by the Study Team in difficult times. No accidents occurred and all staff of IGN and the Study Team could work energetically and actively. Evaluations of each job are given below.

(1) Creating of the digital topographic data from the existing 1/25,000 scale maps

This processing was finished once on schedule and the digital data were temporarily delivered to IGN. During the final precise checking after the delivery, however, numerous errors were found and were corrected even though this task was difficult and required a few months. The main errors were incorrect elevation values of contours, incorrect codes of some features and code differences of map sheet connections.
There were also some types of errors in the existing maps themselves. For example, some small areas did not have contours or there was not much correspondence of vegetation between some map sheets. The solution of the problems will be decided after discussion and mutual agreement between IGN and the Study Team.

(2) Field survey of Ground Control Points

The reconnaissance survey and the observation of Ground Control points survey were performed very well because the engineers of IGN had considerable experience and were well informed on their network of GPS points.
Although the technology transfer for this kind of work was planned before the Study, the transfer was not required. The staff of IGN does not have any difficulty and problems in this field of work.

(3) Aerial photography

The aerial photography could be completed satisfactorily within the work period. The only problem was that there were few chances to take clear photographs fin the northern mountain areas along the Honduran border because of perpetually cloudy weather conditions.

(4) Field verification

The field verification and the supplemental survey were performed efficiently on the base of good cooperation between the staff of IGN and the Study Team. Some members of IGN were beginners but they worked hard under the instruction of the Study Team. The method of putting the collected data in order by computers was explained and put into practice.

(5) Check of the computer system

The setting up the computer system had to be postponed because the shipment of the system was late. The counterpart agency, IGN and CNR worked as much as possible to take the system out from the customs house. Since it took almost one month to receive the system at the office of IGN, the Study Team only a couple of days to install the system. However, a lot of people from IGN, not only direct counterpart members but also persons from other departments helped to set up the system.
The check of the computer system was performed smoothly and the first presentation using the system was able to finish in an excellent manner.

(6) Updating the digital data through OJT

The updating of the digital data through OJT (On the Job Training) was divided into three processing steps, namely, the generation of ortho-images, the updating of the coverage data and the symbolizing of the digital data. Although only one person could use a software application at the same time because there was only one license of each application, the training was scheduled very well and the updating job was finished promptly. Since the manuals were written in Spanish, the staff of IGN will be able to work by themselves using the manuals from now on.
During the OJT, the staff of IGN was very interested in this digital processing and worked with great concentration. They have already applied these digital updating methods to their other jobs.

(7) Aerial triangulation for the area where there are no existing 1/25,000 scale maps

Before the Study, the existing 1/10,000 scale topographic maps were considered to be useful for contours of the 1/25,000 scale digital maps and it was also planned to pick up some control points for aerial triangulation from the 1/10,000 scale maps. However, it was found that 68 % of the existing maps had differences over two millimeters on the maps from the results of the triangulation. That meant that the existing maps could not be used to connect to the new maps to supplement the areas where there were no existing maps.

After discussion and agreement with the counterpart Agency, IGN, JICA and JICA Study Team, it was decided that the conventional method of aerial triangulation might be used. Also, it was conformed that the data of the existing maps might not be connected to the new data for the areas of no existing maps.
No difficulty of the triangulation would have occurred if the measurement of more ground control points by GPS had been carried out. The difference between the existing maps and the results of the aerial triangulation also caused difficulty for the plotting processing.

(8) Technology transfer of the operation and management of the digital data

This technology transfer was carried out once in Japan. The trainee had a lecture of Arc/Info and practiced using the application software for about one month in November and December 2000. The training might not be sufficient because of very short term. However, this technology transfer will be done again in May 2001 in El Salvador. Moreover, manuals will be made in Spanish.

7. Preparation of the Disaster Maps and Sediment-related Hazard Maps

7.1. Field Activities for Phase II in El Salvador

The following activities were implemented from February 18 to March 9, 2001 in El Salvador.

7.1.1. Collection of available materials

Collected materials for the Phase II Study are the followings:

(1) Aerial photography

- Before the earthquake in January: Department of Usulután approximately 100 photos).
- After the earthquakes: disaster area (approximately 620 photos).
- 1/5,000 scale ortho-photos: Departments of Ahuachapán, Sonsonate and Santa Ana.

(2) The existing topographic maps

- The existing 1/5,000 scale topographic maps for the Departments of La Libertad, San Salvador, Cuscatlán, San Vicente and La Paz (approximately 90 map sheets).

(3) Digital data of disaster information

- Digital data on disaster information from Ministry of Environment and Natural Resources.
- Digital data on landuse and geology from Vice-Ministry of Housing and Ministry of Environment and Natural Resources.

(4) Request for Meteorological data

The Study Team requested IGN to provide the Team with meteorological data from the US Department of Commerce, National Oceanic & Atmospheric Administration. IGN accepted this.

7.1.2. Field activity for updating of the existing map

Field verification was carried out using Mobile GPS instruments and SPOT satellite imagery that was useful for pre-interpretation of secular changes. Eight field team members were deployed to obtain the secular changed data and took photography for damaged roads, houses and landslide using GPS camera. For the updating the Road information, Geoexplore-3 of Trimble was employed as Mobile GPS.
Procedure of GPS data collection is as follows:

(1) Preparation Work

Coordinates of El Salvador were prepared by using Pathfinder Office and transferred to GEOEXPLORES3. Lists of codes obtained in the field work were prepared by using Data Dictionary Editor of Pathfinder Office and transferred to GEOEXPLORES3.
Arc/Info World Image Files were prepared by scanning the existing 1/25,000 scale topographic maps for the purposes of checking the progress of the field work and data as well.

(2) Field Work

Secular change data in the field survey were captured by GEOEXPLORES3 in accordance with the preparatory codes. The secular change data were downloaded by using Pathfinder Office, and differentiated by using base files obtained from FTP site of Trimble Agent. The prepared data were checked on the existing 1/25,000 scale topographic maps. The captured data were output in DXF in codes. Following Figure is shown the GPS data on the existing map.

7.1.3. Photo-interpretation and Satellite image interpretation

The Study Team implemented photo-interpretation and Satellite image interpretation for the landslide area and the results were sent to Japan in order to delineate the outline of landslides on the disaster maps.
The following photographs were interpreted mainly for landslide area.

FOTOGRAFIAS ELABORADAS PARA LA MISION JAPONESA

Table 13 Aerial Photography After Earthquake

	LUGAR	ROLLO	LINEA	DESDE	HASTA	ESCALA	FECHA	TOTAL
1	Cordillera del Balsamo	267	1	7216	7231	1/15,000	16/01/01	16
2		267	2	7232	7247	1/15,000	16/01/01	16
3		267	3	7248	7263	1/15,000	16/01/01	16
4		267	4	7264	7280	1/15,000	16/01/01	17
5		267	5	7281	7295	1/15,000	16/01/01	15
6		267	6	7296	7311	1/15,000	16/01/01	16
7		267	7	7312	7321	1/15,000	16/01/01	10
8		267	8	7322	7330	1/15,000	16/01/01	9
9	Carretera Panoramica	276	1	8769	8773	1/5,000	19/02/01	5
10		276	2	8774	8783	1/5,000	19/02/01	6
11		276	3	8784	8789	1/5,000	19/02/01	7
12		276	4	8790	8796	1/5,000	19/02/01	7
13		276	5	8797	8800	1/5,000	19/02/01	4
14		276	6	8801	8805	1/5,000	19/02/01	5
15		276	7	8806	8812	1/5,000	19/02/01	7
16	Valcan de San Salvador	276	2	8608	8615	1/5,000	15/02/01	8
17	(GRIETAS)							
18	Las Colinas	268	1	7344	7358	1/5,000	17/01/01	15
19	Comasagua	268	1	7359	7377	1/5,000	17/01/01	19
20	Armenia	268	2	7378	7388	1/5,000	17/01/01	11
21		268	3	7389	7396	1/5,000	17/01/01	8
22		268	4	7397	7405	1/5,000	17/01/01	9
23	Las Colinas	268	1	7406	7408	1/5,000	17/01/01	3
24	Usulutan	268	1	7409	7423	1/5,000	17/01/01	15
25		268	2	7424	7438	1/5,000	17/01/01	15
26		268	3	7439	7453	1/5,000	17/01/01	15
27		268	4	7454	7468	1/5,000	17/01/01	15
28		268	5	7469	7483	1/5,000	17/01/01	15
29		268	6	7484	7498	1/5,000	17/01/01	15
30	Alegría	268	1	7499	7509	1/5,000	17/01/01	11
31	Berlín	268	1	7524	7534	1/5,000	17/01/01	11
32	Santiago de María	268	1	7510	7523	1/5,000	17/01/01	14
33	San Agustin	268	1	7535	7548	1/5,000	17/01/01	14
34	San Francisco Javier	268	1	7549	7558	1/5,000	17/01/01	10
35	Curva la Leona	268	1	7559	7561	1/5,000	17/01/01	3
36	Sta. Cruz Analquito	273	1	8205	8213	1/5,000	14/02/01	9
37	Curva la Leona	273	1	8216	8222	1/5,000	14/02/01	7
38	San Vicente	273	1	8223	8228	1/5,000	14/02/01	6
39		273	2	8235	8241	1/5,000	14/02/01	7
40		273	3	8242	8248	1/5,000	14/02/01	7
41		273	4	8229	8234	1/5,000	14/02/01	6
42	Cantón la Laguneta	273	1	8252	8263	1/5,000	14/02/01	12
43	(Mpio. San Juan Nonualco)							
44	San Miguel Tepezontes	273	1	8264	8269	1/5,000	14/02/01	6
45	San Juan Tepezontes	273	1	8270	8275	1/5,000	14/02/01	6
46	Volcán Chinchontepec	273	1	8295	8322	1/5,000	14/02/01	28
47	(GRIETAS)							
48	Cantón el Chile	273	1	8335	8338	1/5,000	14/02/01	4
49	(Mpio. Sn. Juan Tepezontes)							

50	Cantón la Laguneta	273	1	8339	8342	1/5,000	14/02/01	4
51	(Mpío. Sn. Juan Nonualco)							
52	Guadalupe	273	1	8344	8349	1/5,000	14/02/01	6
	Óáí							
53	Cojutepeque	273	2	8196	8203	1/5,000	14/02/01	8
54		273	1	8814	8822	1/5,000	14/02/01	9
55		273	4	8823	8833	1/5,000	14/02/01	11
56	Tecoluca	274	1	8835	8850	1/5,000	19/02/01	16
57	Ctón. y Crío. Veracruz	274	1	8655	8661	1/5,000	15/02/01	7
58	(Mpio. el Rosario)							
59	Ctón. y Crío San Antonio)	274	1	8662	8668	1/5,000	15/02/01	7
60	(Mapio el Carmen)							
61	El Rosario	274	5	8674	8660	1/5,000	15/02/01	7
62	Candelaria	274	1	8699	8702	1/5,000	15/02/01	4
63	San Ramón	274	1	8703	8708	1/5,000	15/02/01	6
64	San Cayetano de lstepeque	274	1	8709	8713	1/5,000	15/02/01	5
65	Jerusalen	274	1	8716	8719	1/5,000	15/02/01	4
66	Sta. Cruz Michapa	274	1y2	8722	8730	1/5,000	16/02/01	9
67	Verapaz	274	1y2	8731	8740	1/5,000	16/02/01	10
68	San Pedro Nonualco	274	1y2	8741	8752	1/5,000	16/02/01	12
69	Paraiso de Osorio	274	1	8753	8756	1/5,000	16/02/01	4
70	Sta. María Ostuma	274	1y2	8757	8766	1/5,000	16/02/01	10
	Óáí							
	TOTAL							619

7.1.4. Survey of landslide areas

(1) Objectives of the survey

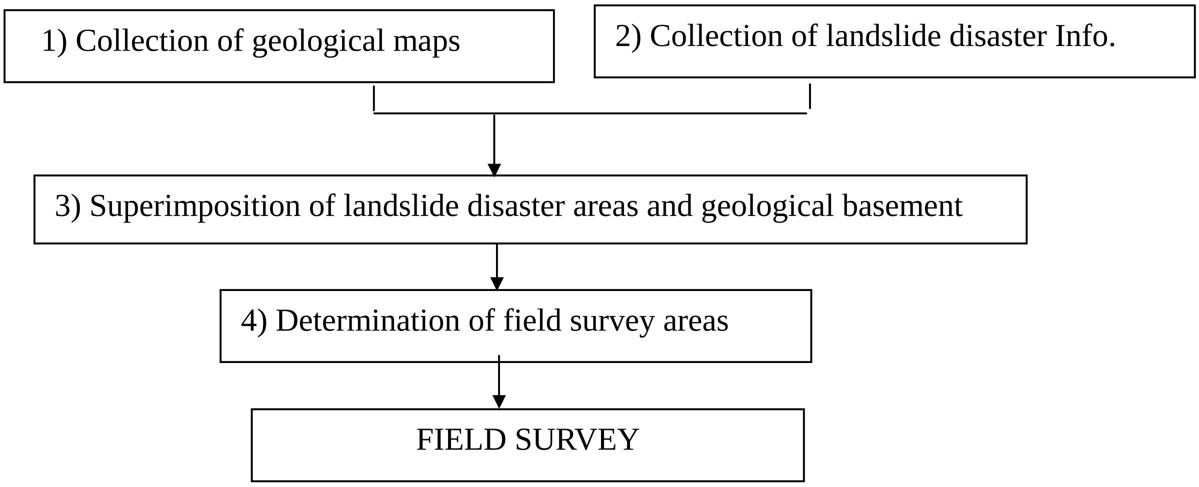
The objectives of the landslide disaster survey are to ascertain the cause of the disaster occurrence, and its survey results will be employed for the rehabilitation of the current disaster areas and also for future town and road construction planning.

(2) Contents of the survey

The contents covered of the landslide disaster survey are slope collapse, falling rocks and debris, and rehabilitation will be for planned for houses, public facilities and main roads.

(3) Selection of the field survey areas

The field survey areas were predetermined for the effective conduct of the field survey by taking the following steps:



(4) Collection of geological maps

Geological basement is the most important for analysis of the cause of the landslide disaster. It is known that the mass movement depends on the geological basement. The Survey Team purchased 1/100,000 scale geological maps from IGN, and obtained the digital data as Shape file of the above geological maps from the Ministry of Environment and Natural Resources.

(5) Collection of landslide disaster information

The Study Team collected disaster information for 104 areas caused by the earthquake on January 13, 2001.

(6) Superimposition of landslide disaster areas and geological basement

Geographical and geological distribution of the disaster areas were analysed by superimposing the landslide disaster areas on the geological maps.

(7) Determination of the field survey areas

First, the reported large disaster areas were predetermined for the field survey, and in order to analyse each landslide disaster having the different cause of occurrence, field survey areas were also predetermined in each geological basement and region.
Finally, approx. 20 survey areas were selected in consideration of the time limitation, and approx. half of them were surveyed by using the check sheet described below.

7.1.5. Check sheet of Mass Movement Survey

In order to standardize the survey items and contents within the Team members, the check sheets have been prepared for the field survey.

Reference materials for preparing the check sheets

"Survey Manual for Landslide Disaster" has been prepared by Ministry of Land, Infrastructure and Transport in Japan. The check list was prepared mainly based on the guide book titled "Guide Book for Prevention of Disasters", summarized of the above Manual, prepared by Road Dept. Ministry of Land, Infrastructure and Transport in Japan.
Detailed check items are shown on the "The Check Sheet of Mass Movement Survey" attached Append.

7.1.6. Site Survey

The Ministry of Environment reported 246 landslides countrywide; due to time limitations, sites visited were chosen taking into account these two important criteria:

(1) Landslides which caused human losses or are potentially dangerous to villages and communities.

(2) Landslides which affected important roads or highways.

The most affected areas are in the Departments of La Libertad, San Salvador Cuscatlán, La Paz, San Vicente and Usulután. This points out that most of landslides are confined to the main volcanic chain of the country. Soil falls and slides were by far the most numerous landslides, being rock falls the remainder. The larger soil slides occurred along cutting slope where the man-made steep slopes, the poorly consolidated volcanic soils, and the seismic activity induced most of the landslides.
Rock falls occurred also at cutting slope and at commercial rock exploitation sites being the latter the most potentially dangerous to dwellings.
Since earthquake-induced landslides have been always a major problem in El Salvador, it is strongly recommended to make a detailed hazard analysis of larger slide sites in the country. This study will give a better assessment and remedial or mitigation measures for each particular event. During the study, the following sites were visited:

(3) Department of Cuscatlán: Santa Cruz Analquito and Candelaria village

These two landslides are located at the stream banks of Rio Desague and Rio Jiboa respectively. The landslide at the Desague River caused to rise the water level at Ilopango Lake:
Furthermore, the large landslide at Rio Jiboa is threatening to overflow the area as the rainy season starts.

(4) Department of La Libertad. Las Colinas, Santa Tecla (Landslide)

This event caused the largest loss of human lives. More than 300 persons were killed.

Some small landslides were observed near this area. They could cause damage to the very populated neighborhoods, located at the foot of the mountain, during the rainy season.

(5) Department of La Libertad. Finca Buena Vista. (Debris flow)

This landslide should be carefully studied. It had a run-out distance of approximately 2.7 km. The debris flow was deposited on the Pan-American Highway, and blocked traffic.
More than 35 persons perished here.

(6) Department of La Libertad. Canton Las Cumbres (Landslide).

Soil-slide affecting road Tamanique.

(7) Department of La Libertad. Finca San Jose. (Soil and Rock fall)

It endangers the road to Omasagua City.

(8) Department of La Libertad. Pedrera las Lajas. Pan-American Highway to Santa Ana. (Rockfall)

In this quarry rocks are extracted by blasting. Very unstable rock masses threatening vehicles and people on the highway.

(9) Department of La Libertad. Rockfall near Hotel Monte Verde, Los Chorros. (Rockfalls)

This site is affecting the Pan-American Highway. The following two sites present the same characteristics: rockfall, commercial quarries, un-supervisied blasting, and no vibration control.

- Department of San Salvador.San Marcos Pedrera el Socorro. Rockfall affects dwellings.

- -Department of San Salvador. Ilopango. Pedrera Los Amates. Rockfoll presents danger for vehicles and people using this road to the lake.

(10) Department of San Salvador. San Martin. Colonia Las Anemonas. (Landslide)

Landslide occurred near abandoned railroad where people built barrack houses. It is very dangerous.

(11) Department of La Paz. Panamerican Highway. Canton Las Piedritas. (Rockfall)

This unstable rock mass blocked the Pan-American Highway to San Vicente. Forty people reported buried under rocks.

(12) Department of La Paz. Highway to International Airport of Comalapa. (Rockfall)

The highway had to be closed because road subsided and part of it collapsed into ravine.

(13) Department of Usulután. Road from Tecapan to Santiago de Maria. (Rockfall)

Rockfall affecting secondary road.

(14) Department of Usulután. Road between Santiago de Maria and Alegria. Curva el Cuyapo

Rockfall and soil-slide affecting unpaved road to these cities.

(15) Department of San Vicente. Pan-American Highway km.53. Curva Las Leonas.

Very Large soil and rock slide blocking Pan-American Highway to San Vicente. In this rock and soil quarry several employees were buried under landslide.

Even though landslides occurred at steep slopes, most of them were man-made at road cuts. This indicates that they could have been prevented through careful studies of slope stability. It is recommended that a detailed hazard analysis of critical areas being done as soon as possible.
This analysis will contribute to avoid future catastrophes that can be triggered either by the continuous seismic activity or by heavy rainfall.

8. Processing in Japan

8.1. Updating of 1/25,000 Topographic maps

1/25,000 topographic maps being studied currently has not adequately described the topographic status today, although its data is already digitized. The updating of the topographic data were carried out as much as possible using SPOT imagery, available ortho-photo, 1/5,000 topographic maps and GPS data obtained in the field verification. The different methodologies were taken based on each different available data source.

8.1.1. San Vicente and Usulután Departments by SPOT satellite imagery

The updating of the existing topographic features by Spot satellite imagery was done using the Arc/Info and ArcView software. For this, the SPOT ortho image and the topographic feature to be updated were kept in the same projection system, which is Lambert Conformal Conic Projection with Spheroid Clarke 1866 and Datum NAD 1927 Central America. The image and the shape file of topographic feature were displayed at scale of 1/25,000 keeping image in the background and topographic feature data on the top of the image.
Then, the updating was done visually by adding the information, which was found in the imagery, but lacking in the existing data. Conversely, the information, which was

present in the existing data but absent in the imagery, was deleted. After finishing the updating of one topographic feature, the same methodology was applied for the others.

Finally, the secular changes of Road were updated on Arc/Info coverage files on ArcView, and also by using DXF files for the data captured by GEOEXPLORES3.

8.1.2. Santa Ana, Sonsonate and Ahuachapán Department by the Ortho-photos

The methodology applied to update the topographic features by ortho photos was similar to that of using the SPOT ortho-image. The ortho photo and shape file of the topographic feature, having the same projection system, were displayed in the similar fashion as was used to update with Spot ortho imagery. However, the scale of ortho photos being 1/5,000, the displaying and updating could be done relatively at larger scale than 1/25,000.

8.1.3. La Libertad, Cuscatlán, San Vicente and La Paz Dpt. by the Exiting Maps

The exiting maps at scales of 1/5,000 and 1/10,000 were scanned with 300dpi and gray scale. Image files with the coordinates values were prepared from the scanned data by using Micro station in El Salvador to cooperate with IGN. The scanned Image files (Hmr format) were converted into TIFF with world files by using MicroStation, which can be displayed on Arc/Info and ArcView.

The methodology was applied to update the topographic and was similar to that of using the ortho photos.

The flow diagram of updating using Raster image such as Spot ortho-image, Ortho-photos and Topographic maps is shown in below.

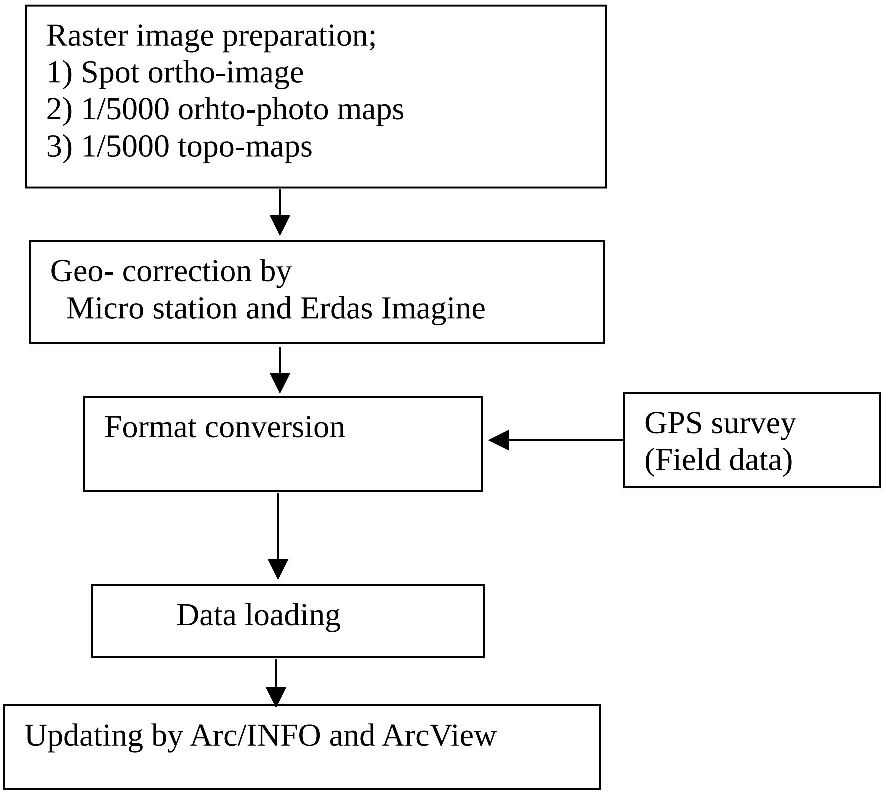


Figure 18 Updating Flowchart

8.2. Preparing the Disaster Map of Damaged Areas

Using the results of the field survey as supplementary data, topographic data were updated for secular changes, and the disaster maps of damaged areas were prepared as follows:

8.2.1. Aerial photo-interpretation

In order to prepare the draft disaster maps, the available aerial photos taken immediately after the earthquake were interpreted to delineate the outlines of the disaster areas, and those locations were shown on 1/25,000 scale topographic maps. To delineate the damaged areas in the course of the interpretation, the following topographic conditions were excluded from the disaster areas:

(1) Nakedness area (logged-off land)

The ridges and mountain streams are shown as natural features that have the neighboring wooded areas.

(2) Natural collapsed areas

Accumulation of large quantity of soils is not shown on the side of mountain stream.

(3) Soil collection place and quarry

Accumulation of soils is not shown on the lowland area, and accessible roads are extending there.

(4) Some parts in white color of the aerial photos probably due to halation in aerial photography in gentle ascent and flat areas.

(5) Small scale damaged areas.

8.2.2 Image Analysis for Landslide in San Vicente and Usulután

The analysis of SPOT satellite imageries (Panchromatic) was employed to delineate the landslide areas. For this, two sets of SPOT imageries, before and after the recent earthquakes (dated February 13, 2001), covering the Study area, were purchased. The flow diagram of ortho-rectification of the SPOT imageries and landslide area delineation is presented in Figure 19.

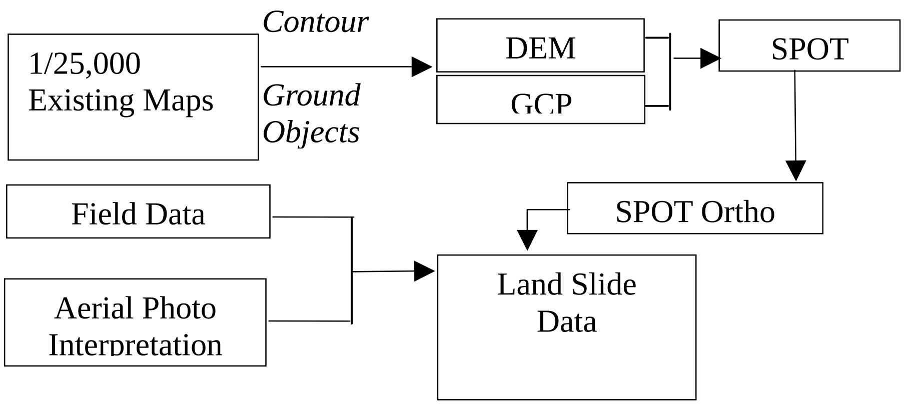
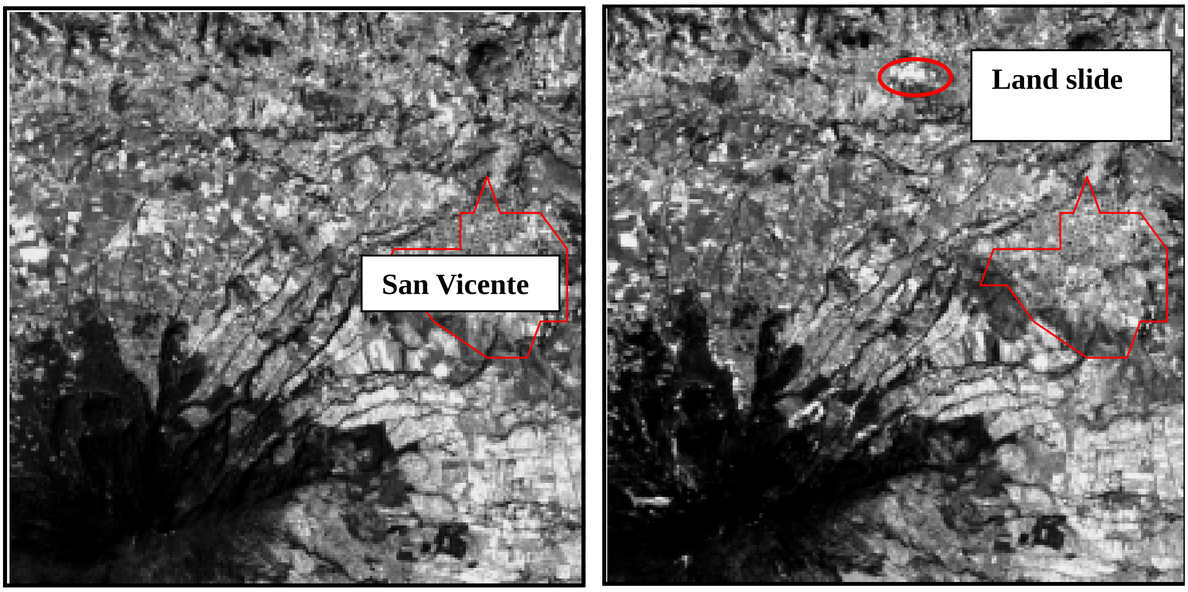


Figure 19 Work Flow for Land Slide

The Ortho SPOT images taken before and after the earthquake dated February 13, 2001 around the San Vicente area. Shown is one of landslide site located in the northwest direction of the San Vicente City (along the Pan-Americana highway)

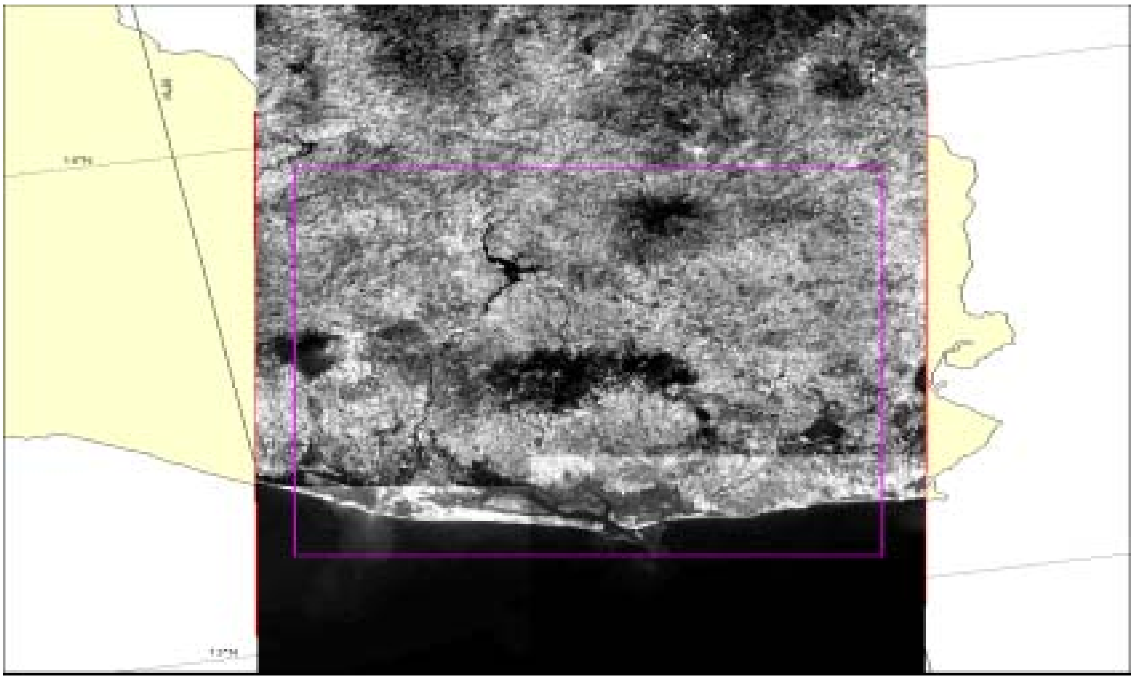
Figure 20   Satellite Interpretation



SPOT Ortho-image
(Before Earthquake)

SPOT Ortho-image
(After Earthquake)

Figure 21   SPOT Satellite Data Description



Following data were used as images after the earthquake:

Table 14 SPOT Data Description

SATELLITE	KJ	DATE	Hour	Instrument number	Mode of spectral	Incidence Angle	Cloud cover notation	Quality of the scene
4	613/322	20010209	161906	2	M	-26.5	AAAAAAA	EEEE
4	613/323	20010209	161915	2	M	-26.5	AAAAAAA	EEEE
4	613/322	20010209	161905	1	M	-23.4	BAAAAAA	EEEE
4	613/323	20010209	161914	1	M	-23.4	AAAAAAA	EEEE
4	613/323	20010214	162311	2	M	-19.6	AAAAAAA	EEEE

8.2.3 Preparation of GIS Data

Head-up digitizing in ArcView was carried out to prepare shape files by employing draft disaster maps prepared by photo and satellite interpretation.
Followings are contents of GIS disaster database.

Table 15 Contents of GIS database

Shape File Name	Type	Contents	Remarks
Field	Point	Field survey points	Link to field note
Ls_gps	Point	Field snapshot points on GPS Survey	Link to field snapshot
Slide	Polygon	Disaster areas identified by aerial photo interpretation	
Land_slide	Polygon	Disaster areas identified by analysis of SPOT imagery before and after the earthquake	
DEM	Grid	Digital elevation model	50 m spacing
Wtshd	Polygon	Watershed	
Protect	Polygon	Hazardous area for steep slope	
Debris	Polygon	Debris flow	

Table 16 GIS Data (provided by Ministerio de Medio Ambiente y Recursos Naturales)

Shape File Name	Type	Contents
areas_impactadas	Polygon	Disaster areas
Basepais	Polygon	National Base map
cabeceradpto_poly	Polygon	Major Cities
cabeceramunicipal	Point	Local towns
Cuencas	Polygon	Villages
deptos_line	Line	Administrative boundaries
Derrumbes	Point	Disaster points
Derrumbes_categoria_riesgo	Polygon	High risk disaster areas
Derrumbes_marn	Polygon	Hazardous areas (roads, residence areas, cultivated lands
Derrumbes_marn_gps2	Point	Points shown on aerial photos (link to aerial photos after the earthquake)
Derrumbes_mop	Point	Passable roads after the earthquake
Derrumbes_otros	Point	Other disaster areas
eventos_faes	Point	Disaster areas (landslide, submergence, cracks)
eventos_sismicos_marn	Point	Details of disaster caused by the earthquake (Contents of Field Survey)
eventos13feb	Point	Disaster Areas as of February 13, 2001
fallastectonicas	Line	Active fault
Geologico	Polygon	Geology
Geologico_piroclastitas	Polygon	Geological basement
Inventario_grupos	Point	Disaster areas (observation records and notes)
Municipios	Polygon	Towns
Pendientes	Polygon	Slope types
pendientes_mayores30%	Polygon	Steep slopes (more than 30%)
redvial25k	Line	Major roads
rios50	Line	Major rivers
sitios_atencion_inmediata	Point	Villages which required instant measures
Snanp	Polygon	
Vegetacion	Polygon	Vegetation

8.2.4 Preparation of Disaster Maps of the Damaged Areas

1/25,000 scale disaster maps were prepared by processing the various data as shown in above item 6.2.1,6.2.2 on 1/25,000 scale topographic maps.
Following functions were created on ArcView.

(1) Field survey points can be shown on 1/25,000 scale topographic maps, and field note can be shown for the point clicked.

(2) Disaster areas identified by aerial photo interpretation can be shown on 1/25,000 scale topographic maps.

(3) Disaster areas identified by SPOT image analysis can be shown on 1/25,000 scale topographic maps. SPOT imagery after the earthquake can also be superimposed.

(4) Exclusive bottom was created to link to two home pages (www.coen.gob.sv.and www.reliefweb.int) showing the above two maps that allow visitors to understand the whole pictures of the disaster caused by the earthquake.

8.3. Preparation of hazardous analysis maps for Mass Movement

Note: The term "landslide" refers to mass movement in general. In this report, mass movement that has large cubic volume and slow rate of speed is defined as a landslide (in a narrow sense). In comparison with a landslide (in a narrow sense), mass movement that has small cubic volume and a fast rate of speed is defined as a "collapse." The phenomenon of sediment running down in mountain streams while being united together and overflowing is defined as debris flow. The phenomenon known as mud flow also shall be regarded as a form of debris flow and is included in debris flow.

8.3.1. Policies of selection of the object

In El Salvador, many landslides and slope collapses were caused by a large-scale earthquake in the mountainous areas on January 13, 2001. As a result, due to movement of sediment, communities were hit directly by collapsing earth, which led to human loss of life.

Once a slope receives vibration, sediment disasters can occur easily and frequently due to rainfall. In the mountain district, the expansion of collapsing land, remaining earth, and collapsing earth accumulated on the bed of mountain streams start secondary movement due to running water. It is expected that slopes without collapse have become unstable as a result of earthquake vibration, and there is the possibility that such slopes will collapse with even light rainfall.

The phenomena of sediment movement against which caution should be taken in the rainy season hereafter are the following:

(1) Phenomenon of slope collapses

Loose slopes and/or unstable lumps of earth collapse with rainfall or earthquakes, bringing about damage to houses and others directly under the slopes.

(2) Phenomenon of debris flows

Slopes inside mountain streams that collapse or sediment accumulated on the bed of mountain streams become debris flow: gravel and sediment overflow at the exit of the valley, bringing about damage to houses and others.

(3) Phenomenon of landslides

Existing places of landslides and/or loose land masses lose balance due to a rise of underground water. These then undergo landslide and cause damage to downstream houses and others, or intercept rivers and bring about flooding.

(4) Phenomena of floods

Running water becomes mud flows, which overflow downstream farther than debris flow, or together with drifting wood at bridges, etc. create a blockade and cause flooding of rivers in plains.

These phenomena are listed above in the order of their ease of occurrence. Namely, the phenomenon that occurs easily with even light rainfall is slope collapse. If such running water that conveys sediment is generated, it becomes debris flow. Downstream floods occur in the case of a considerably large amount of rainfall and can occur more easily than in the case of ordinary conditions (before an earthquake).

On the other hand, slope collapses and debris flow have a strong impact force when they hit houses directly, so there is a high possibility that these may affect human lives directly. It is, however, difficult to anticipate them because they occur suddenly. Accordingly, these phenomena are likely to be linked with human disasters. In comparison, in the case of the flooding of rivers, although the range of influence is greatly wider, there is a possibility that serious human disasters can be avoided by advance identification of places requiring caution, conveyance of warning information and provision of appropriate refuge.

Landslides have a great influence and tend to be linked with human damages. It is, however, difficult to extract places requiring caution in the short term because of the necessity of interpretation of landsliding topography and field confirmation surveys.

From these circumstances mentioned above, the sediment disasters covered by this survey shall be slope collapses and debris flow.

8.3.2. Places with a risk of sediment disasters in Japan

Places with a risk of sediment disasters in Japan (as defined by the Ministry of National Land, infrastructure transportation), such as slope collapses and debris flows, are as follows:

(1) Hazardous Places of Steep Slope Collapse

1) Hazardous Places of Steep Slope Collapse

Hazardous Places of Steep Slope Collapse (I) shall be those that are steep slopes of 5 m or more in height with a gradient of 30° or more (all steep slopes, including artificial ones) and that have five or more houses inside the area where damages are anticipated (including a place which has facilities related to assisting the weak in the event of a disaster, such as social welfare facilities as well as a public agency, school, hospital, station, hotel and/or inn, even if the number of houses is fewer than five). Places that have the same conditions as mentioned above but with one to four houses likely to be affected shall be Hazardous Places of Steep Slope Collapse (II). Five or more houses shall be in an area with houses densely built up on a series of step slopes. An area where houses are 50 m or more distant from each other shall not be called an area with houses densely built up and shall be regarded as a place different from the Hazardous Places of Steep Slope Collapse, even if it otherwise qualifies.
The area with damage anticipated shall have a distance under the cliff corresponding to double the height (H) of the cliff (down to 50 m) and a distance above the cliff corresponding to height (H) from a point where a slope gradient is 20° or less.

2) Statement of definition

Essentials for Checking of Hazardous Places of Steep Slope Collapse (By Slope Conservation Division, Erosion Control Department, River Bureau, Ministry of Construction in November 1999)

(2) Slopes Corresponding to Hazardous Places of Steep Slope Collapse

A place topographically equivalent with Hazardous Places of Steep Slope Collapse but without houses shall be a Slope Corresponding to Hazardous Places of Steep Slop Collapse. The range of extraction shall be places inside the urban planning area, cities/towns/villages with increasing population, areas where a development/promotion plan is made, and mountain districts where sightseeing and tourist sleeping accommodations can be built.

(2) Mountain Streams with Risk of Debris Flow and Areas with Risk of Debris Flow

1) Mountain Streams with Risk of Debris Flow

A mountain stream is a place that has valley-formed topography on the 1/25,000 scale topographical map, and a mountain stream with risk of occurrence of debris flow is referred to an area with topography forming a primary valley as the starting point and with a point that has a stream bed gradient of 3° (1/20) (2° in the volcanic and erosion control area) (1/30) as the terminus. A Mountain Stream with Risk of Debris Flow is a mountain stream with risk of occurrence of debris flow and a mountain stream that has a possibility of one or more houses being damaged (including a case of the existence of a public agency, school, hospital, facilities related to assisting the weak in the event of a disaster including social welfare facilities, and public facilities such as a station, hotel, inn, and/or power plant, even if there are no houses).

2) Areas with Risk of Debris Flow

An Area with Risk of Debris Flow is a place where accumulation and/or floods of debris flow are expected from topographical conditions and shall be the range where, based on topography, the distribution range of accumulation of debris flow in the past, and records of floods of debris flow in the past, it is anticipated that debris flow of the largest scale assumed will cause flooding. In principle, this area shall consist of the bed of mountain streams from a place where an avalanche occurs to a point with a river bed gradient of 3° (in the volcanic and erosion control areas, if there are records of occurrence of debris flow, the actual values shall be established as reference, or, if without such records, 2° shall be used), and the flat part (alluvial fans and valley plains) within a relative height of several meters from the bed of mountain streams. Areas where debris flow may occur shall be watershed with a stream bed gradient of 15° (10° in volcanic and erosion control areas).

3) Statement of Definition

Essentials of Surveys of Mountain Streams with Risk of Debris Flow and Areas with Risk of Debris Flow (draft) (by Erosion Control Division, Erosion Control Department, River Bureau, Ministry of Construction in April 1999)

(4) Mountain Streams Corresponding to Mountain Streams with Risk of Debris Flow

A mountain stream topographically equivalent with a Mountain Stream with Risk of Debris Flow but without houses to be conserved shall be a Mountain Stream Corresponding to Mountain Streams with Risk of Debris Flow. The range of extraction shall be basically inside urban planning areas.

(5) Places with Risk of Landslip

A Place with Risk of Landslip shall be a place that has the possibility of landslip and may bring about damage to houses and others directly or by secondary floods due to blockage of river courses.

8.3.3. Places with risk of sediment disasters extracted in this study

In this study, hazardous places with the possibility of affecting houses and other structures by slope collapse and/or debris flow were extracted. These correspond to Hazardous Places of Steep Slope Collapse, Mountain Streams with Risk of Debris Flow, and Areas with Risk of Debris Flow in Japan. The following definitions, however, have been made for this study because it was found from obtained information (1/25,000 scale topographical map) that distinction of houses and public facilities was difficult and because individual field confirmation was also difficult due to the time restriction.

(1) Hazardous Places on Steep Slopes

“Hazardous Places of Steep Slope Collapse” is shown on Table 17.

In this study, these hazardous places were selected on the available 1/25,000 scale topographic map by applying the Japanese Standard defined by the Ministry of National Land, infrastructure transportation.

Table 17 Hazardous Places of Steep Slope Collapse

<table>
<tr><th>Items</th><th colspan="2">Applied definition in this study</th><th colspan="2">Applied Japanese Standard</th></tr>
<tr><td></td><td colspan="2"></td><td colspan="2">Essentials for Checking of Hazardous Places of Steep Slope Collapse
(By Slope Conservation Division, Erosion Control Department, River Bureau, Ministry of Construction in November 1999)</td></tr>
<tr><td rowspan="2">Hazardous Places of Steep Slope Collapse</td><td colspan="2">Those that are steep slopes of 5 m or more in height with a gradient of 30° or more (all steep slopes, including artificial ones)</td><td colspan="2" rowspan="2">Divided Hazardous Places of Steep Slope Collapse (I), Hazardous Places of Steep Slope Collapse (II) and Slopes Corresponding to Hazardous Places of Steep Slope Collapse</td></tr>
<tr><td colspan="2">1 or more building inside the area where damages are anticipated on the 1/25,000 topographical map.</td></tr>
<tr><td>Hazardous Places of Steep Slope Collapse (I)</td><td rowspan="2">Selected as Hazardous Places of Steep Slope Collapse</td><td rowspan="2">Those that are steep slopes of 5 m or more in height with a gradient of 30° or more (all steep slopes, including artificial ones)</td><td colspan="2">5 or more houses inside the area where damages are anticipated
Even if the number of houses is fewer than 5, a place that has facilities related to assisting the weak in the event of a disaster, such as social welfare facilities as well as a public agency, school, hospital, station, hotel and/or inn.</td></tr>
<tr><td>Hazardous Places of Steep Slope Collapse (II)</td><td colspan="2">1 to 4 houses likely to be affected shall be Hazardous Places of Steep Slope Collapse (II).</td></tr>
<tr><td>Slopes Corresponding to Hazardous Places of Steep Slope Collapse</td><td colspan="2">No extraction</td><td colspan="2">A place topographically equivalent with Hazardous Places of Steep Slope Collapse but without houses shall be a Slope Corresponding to Hazardous Places of Steep Slop Collapse.
Places inside the urban planning area, cities/towns/villages with increasing population, areas where a development/promotion plan is made, and mountain districts where sightseeing and tourist sleeping accommodations can be built.</td></tr>
<tr><td rowspan="2">The area with damage anticipated</td><td>a distance under the cliff</td><td rowspan="2">Places to be conserved inside the area with damages anticipated shall be those where a building is confirmed on the 1/25,000 scale topographical map.</td><td>It is the same as the left</td><td>corresponding to double the height (H) of the cliff (down to 50 m)</td></tr>
<tr><td>a distance above the cliff</td><td>It is the same as the left</td><td>corresponding to height (H) from a point where a slope gradient is 20° or less.</td></tr>
<tr><td>Five or more houses shall be in an area with houses densely built up on a series of step slopes.</td><td colspan="2">Extracted as the same place</td><td colspan="2">Extracted as the same place</td></tr>
<tr><td>An area where houses are 50 m or more distant from each other</td><td colspan="2">Extracted as the same place</td><td colspan="2">Extracted as another place</td></tr>
</table>

(2) Mountain Streams with Risk of Debris Flow

Mountain Streams with Risk of Debris Flow are shown on Table 18.
On the table, those streams with risk of debris flow in Japan (as defined by the Ministry of National Land, infrastructure transportation) and those streams in this study are shown.

Table 18 Mountain Streams with Risk of Debris Flow and Areas with Risk of Debris Flow

Items	Applied definition in this study	Applied Japanese Standard
		Essentials of Surveys of Mountain Streams with Risk of Debris Flow and Areas with Risk of Debris Flow (draft) (by Erosion Control Division, Erosion Control Department, River Bureau, Ministry of Construction in April 1999)
Places with Risk of Debris Flow	It shall consist of the range of mountain streams (corresponding to Mountain Streams with Risk of Debris Flow in Japan) and the range where floods of sediment are expected (corresponding to Areas with Risk of Debris Flow in Japan).	No definition
A mountain stream	It is the same as the right	A mountain stream is a place that has valley-formed topography on the 1/25,000 scale topographical map
Mountain Streams with Risk of Debris Flow	Topographical conditions shall be equivalent to those of Mountain Streams with Risk of Debris Flow and Areas with Risk of Debris Flow. -A valley topography shall be present and the gradient of the mountain stream bed shall be 3° (or 2°) or more	a mountain stream with risk of occurrence of debris flow is referred to an area with topography forming a primary valley as the starting point and with a point that has a stream bed gradient of 3° (1/20) (2° in the volcanic and erosion control area) (1/30) as the terminus.
Areas with Risk of Debris Flow	The range of anticipated floods shall be the range where it is considered from topographical conditions that floods will occur.	An Area with Risk of Debris Flow is a place where accumulation and/or floods of debris flow are expected from topographical conditions and shall be the range where, based on topography, the distribution range of accumulation of debris flow in the past, and records of floods of debris flow in the past, it is anticipated that debris flow of the largest scale assumed will cause flooding.
	Places to be conserved inside Areas with Risk of Debris Flow shall be those where a building is confirmed on the 1/25,000 scale topographical map. As the gradients of the mountain stream bed, values for volcanic and erosion control areas (2° or more) shall be used in places judged from geological conditions to be volcanic.	In principle, this area shall consist of the bed of mountain streams from a place where an avalanche occurs to a point with a river bed gradient of 3° (in the volcanic and erosion control areas, if there are records of occurrence of debris flow, the actual values shall be established as reference, or, if without such records, 2° shall be used), and the flat part (alluvial fans and valley plains) within a relative height of several meters from the bed of mountain streams.
	It is the same as the right.	Areas where debris flow may occur shall be watershed with a stream bed gradient of 15° (10° in volcanic and erosion control areas
Mountain Streams Corresponding to Mountain Streams with Risk of Debris Flow	No selection	A mountain stream topographically equivalent with a Mountain Stream with Risk of Debris Flow but without houses to be conserved shall be a Mountain Stream Corresponding to Mountain Streams with Risk of Debris Flow. The range of extraction shall be basically inside urban planning areas.

8.3.4. Method of the survey

This survey was made to extract Hazardous Places on Steep Slopes and Places with Risk of Debris Flow. Investigations were made in the following flow.

(1) Pigeonholing of existing materials

Materials used for extraction of places with risk of sediment disasters are as follows:

-Topographical map (1/25,000)
-Geological map

(2) Preparation of slope type map

A slope type map was prepared based on altitude data among topographical digital maps. The slope type map was used for confirmation of gradients of the mountain stream bed in the extraction of Hazardous Places on Steep Slopes and in the extraction of Places with Risk of Debris Flow.

(3) Extraction of Hazardous Places on Steep Slopes

With reference to the sectional inclination map, Hazardous Places on Steep Slopes were extracted using the disaster map of damaged areas.

(4) Extraction of Places with Risk of Debris Flow

With reference to the sectional inclination map, Places with Risk of Debris Flow were extracted with the disaster map of damaged areas. The scope of anticipated floods was judged with topographical conditions taken into consideration, although interpretation on the 1/25,000 scale topographical map has limitation.

(5) Preparation of Sediment-related hazard map of places with risk of sediment disasters

The Hazardous Places on Steep Slopes and Places with Risk of Debris Flow extracted are overlapped, and the result was considered as an extraction map of places with risk of sediment disasters. With this as the original map for inputs, the extracted places were made to be GIS data.
The scope of Hazardous Places on Steep Slopes was made to be a polygon. This was also done for Places with Risk of Debris Flow, the ranges of mountain streams and anticipated floods.

Based on GIS data input, an extraction map of places with risk of sediment disasters was prepared.

8.3.5. Preparation of Sediment-related Hazard Maps

Based on GIS data with input of Hazardous Places on Steep Slopes and Places with Risk of Debris Flow, an extraction map of places with a risk of sediment disasters was prepared. An output map on a scale of 1/25,000 and was overlapped on the background map showing basic topographical elements and administrative boundaries.

8.4. Pattern analysis for Land slide

The following Land slide patterns were found during the Study.

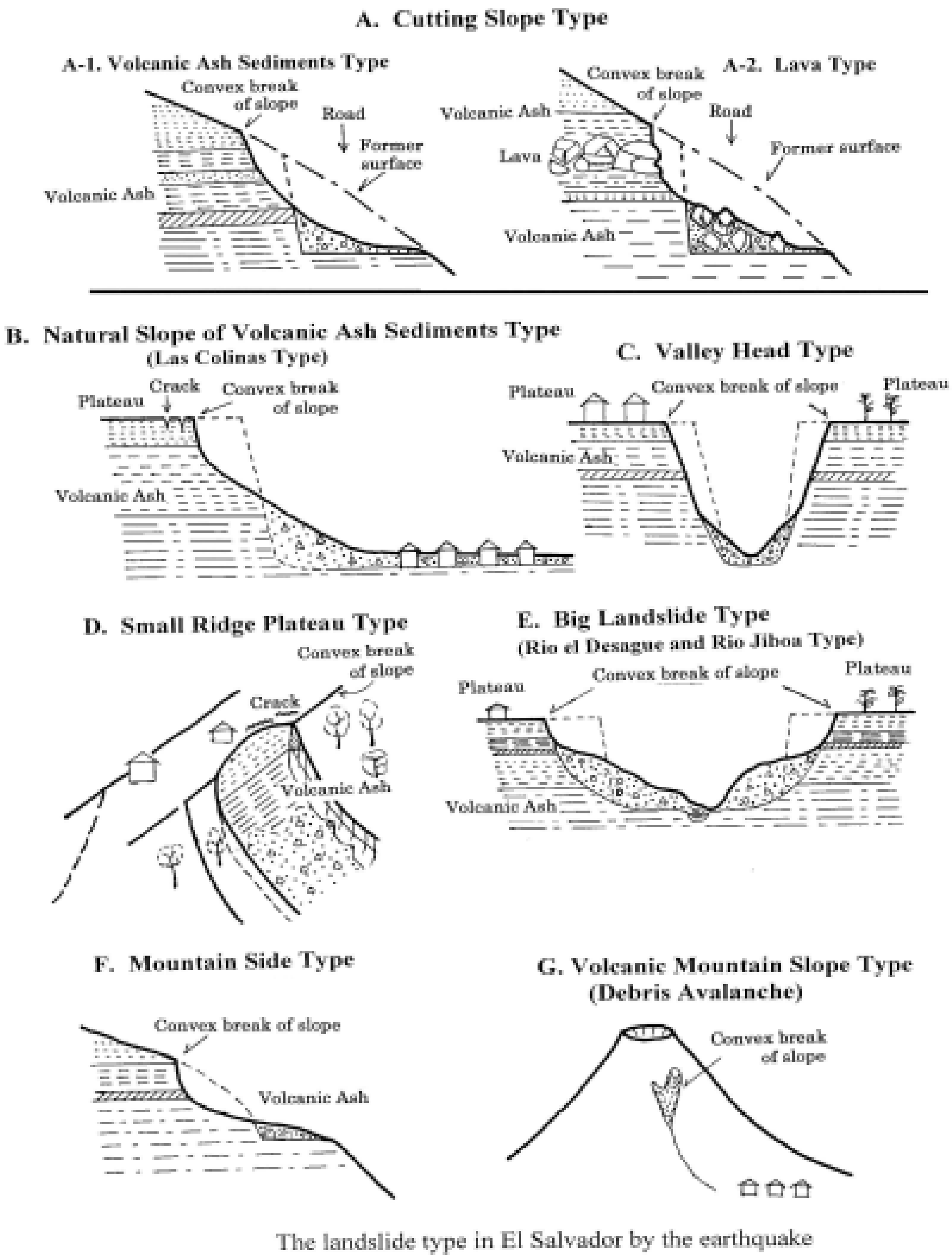


Figure 22 Land Slide Pattern in El Salvador

9. Operation and Management of Basic Geographic Data of this Study

Operation and Management Study by a series of interviews at fifteen governmental Agencies and public/private Organizations, as well as in CNR and IGN, was conducted to study the technical environment of both the Data User and Data Provider.

Based on the survey results, the Operation and Management issues for maintaining the accomplished data by this Study are discussed.

(1) Potential Users of Digital Topographic Maps

The survey results are attached in Appendix, summarized in (4), and the general applications in end user agencies, as discussed during the interviews.

1) Summary of Questionnaire

A tabular summary of questionnaire is listed in Table 19. It shows that almost all digital Map User agencies in this survey are developing Information Technology (IT) in terms of geographic information system and networking extension/development projects. They also show the interest in 1/25,000 scale basic geographic data. All agencies are using Internet through dialup lines, ISDN or others. Three Agencies will begin the study projects using Internet Map Servers in 2001.

In most Agencies, the number of hardware/software units and personnel employed are less than ten, with the exception in National Civil Police (PNC), CAESS Electricity Supply Company, and CNR, in which the systems have been implemented and beginning in operation mode. However, the status in such agencies, as the Ministry of Environment and Natural Resources, Election Supreme Authority, and Municipal Cadastre San Salvador would be changed within one or two years, as indicated by their expansion plan explained during the interviews.

Table 19 Summary of Questionnaire

obj/english/table19.xls

2) GIS/LIS at National Level

The development of GIS or Land Information System (LIS) at the National level is in progress, in which the governmental Agencies are carrying out several Study Projects, funded by USA, Japan, World Bank, Inter-American Development Bank (IDB), FAO, Germany, as well as by the National budget.

The Steering Committee is built beginning of the year 2000 by a United States Geological Survey (USGS) project, and set the scope for Central American region. IGN is the Member Agency in both Steering Committee and in Mitch Clearinghouse project, which involvement is on National basis.

The objective of building such Clearinghouse is to coordinate and exchange geographic information as the public service. It commonly begins with data standardization of geo-spatial data. The starting point is the preparation of "Metadata", which are the data about the content, quality, condition and other characteristics of the distributed data.

In U.S.A., the standard on information content of metadata about geo-spatial data was initiated in 1992, and approved in 1994 by the Federal Geographic Data Committee (FGDC) composed of fourteen Agencies. FGDC Secretariat in USGS was acting as the maintenance authority for those standards. The Executive order "*Coordinating Geographic Data Acquisition and Access : The National Spatial Data Infrastructure*" includes development of a National Geo-spatial Data Clearinghouse, in which the agencies shall document their geo-spatial data and make these documentation electronically accessible to the Clearinghouse network.

The International Organization for Standardization, Technical Committee 211 (ISO/TC211) is developing a suit of standards in the field of digital geographic information. Within the scope of ISO/TC211 the Geographical Survey Institute (GSI) of Japan, together with the private companies, has developed national standards and taken care of their implementation and dissemination.

a) Spatial Data Infrastructure Development

The "Mitch Clearinghouse" project in El Salvador has been initiated 1 1/2 years ago (1998/99), and it is on-going.

The member Agencies are :

- Ministry of Environment and Natural Resources (Coordinating Agency)
- Vice Minister; Urban Regional Planning - Ministry of Public Works
- Center of Geotechnical Survey
- Department of Economic Agriculture, Ministry of Agriculture
- National Geographic Institute

The objective of "Mitch Clearinghouse" includes developing the Spatial Data Infrastructure in El Salvador. A "Spatial Data Infrastructure Symposium" is scheduled in February 2001.

b) Thematic Mapping

Production of thematic maps is progressing by mostly local budget in several agencies visited for interview;

- Agricultural maps such as, Crops distribution, Land Use (1997) in the Ministry of Agriculture,
- Geology Map – 1/50,000 (1998), Mining, Landform, Soils, Hazardous Maps in the Ministry of Public Works,
- Pollution Source Map, Biodiversity Map in the Ministry of Environment and Natural Resources.

c) Systems and Information Technology (IT) Development

i) Ministry of Agriculture

The Ministry is planning to establish a network of all the Departments in the Ministry of Agriculture. The following three departments were visited for interview.

- Department of Economic Agriculture and Livestock

The department compiles data from other institutions, and produce agricultural information and Land Use maps. It has five years experience in using GIS; PC-ARC, ArcView, Idrisis.

This Department is Member Agency in Mitch Clearinghouse. It expresses the interest of data exchange, especially with Ministry of Environment and Natural Resources, Ministry of Public Works, as well as IGN.

- National Center of Agriculture and Forest Technology (CENTA)

This Center studies the agricultural production methodology from USA, Japan, Europe to transfer technology to the agricultural people. Research on production of new variety of crops is also carrying out. Currently, FAO, JICA, and World Bank projects are ongoing.

Relational Database Management System (RDBMS) – SYBASE on Windows 2000 will be installed by the end of year 2000. The present dialup line will be upgraded to ISDN line in year 2001 (Installation has been begun).

- Department of Natural Resources

This department is producing data relating to Drainage and Irrigation, Forest, Soil, Basin Boundaries, Land Use, as well as Meteorological and Flood Control information. It has four years experience in using GIS, ArcView and Idrisis.

It expresses the interest of sharing information by an inter-agency network, in contact with the Department of Economic Agriculture and Livestock.

ii) Ministry of Environment and Natural Resources

Development of the National System for Environmental Management (SINAMA) began in 1994, and the Environmental Laws have been defined.

The Ministry has four years experience in using GIS; NT Arc/Info, ArcView with Extensions; Spatial Analyst, 3D Analyst; as well as Erdas Imagine, and it is now planning a Study Project using Internet Map-Server (ArcIMS – SYBASE) to be installed in year 2001.

This Ministry is the Coordinating Agency in Mitch Clearinghouse. It has commented that 1/25,000 scale basic geographic data should be updated by proper Quality Control.

iii) Ministry of Public Works

The following three departments were visited for interview.

- Department of Transport Infrastructure Planning

In line with the objective of the Ministry, GIS Application Study Project in the field of National Transport Infrastructure Planning is in progress (National budget). Arc/Info; ArcView and Oracle will be installed mid February 2001.

It has stated the interest of close relations, especially with IGN, which was used to be under the Ministry of Public Works, until 1995.

- Department of Urban Regional Planning

This Department is producing Land Use Zoning, Protected Areas, Urbanization, and Regional Transport Planning information. Within a Pilot Study, 1/25,000 scale maps covering the Study Area (about 830 km^2) are digitized and updated using SPOT and Landsat images of 1999. It has two and one half years experience in using GIS; Arc/Info NT, ArcView; and AutoCAD.

The Department is the member Agency in Mitch Clearinghouse. Data exchange agreement with IGN for 1/25,000 scale is interested. For Internet Web-Application development, ArcIMS and AutoDesk’s MAPGUIDE IMS as an alternative, are in consideration.

- Geotechnical Survey

In this Agency, Geology maps at a scale of 1/50,000 have been produced in 1970 by the technical assistance from Germany. Those maps are updated in 1998. Further, it produces maps relating to Volcanic Hazard, Mining, Landslides and Earthquake. It is said that the Agency has eight years experience in using MicroStation.

Geotechnical Survey is a member Agency in Mitch Clearinghouse.

3) Public Safety and Election Analysis

a) National Civil Police (PNC)

In August 2000, PNC has implemented System 911 for emergency call in San Salvador areas. The system, which is based on Intergraph and Oracle, can recognize location of this call and display on the background map. The essential map features are roads, administrative boundaries, parcels, and the reference points, such as school, hospital, church, and so on.

Digital maps (1/25,000 or larger) are provided by two electricity supply companies; CAESS for northern part and DELSUR for southern of San Salvador. This system is going to be expanded to the whole country, expectedly in two years. PNC is interested in 1/25,000 scale data for more detail map information, such as Vegetation.

b) Election Supreme Authority

Currently, the system developments have been initiated, including Election Cartography Project in Cooperation with CNR and IGN. The essential information required in this Agency are Census Map, Topographical Map (IGN) and Cadastral Map (CNR-Cadastre). GIS application based on Arc/Info and ArcView for Election Analysis is in planning. Basic geographic data at a scale of 1/25,000 in ArcView format are interested.

All the computers are connected in LAN, and ISDN line has been setup. The interest of communication network with Census, CNR, and IGN is emphasized.

4) Urban Development and Municipal Cadastre

a) Metropolitan Salvador Planning Agency (OPAMSS)

This agency is involved in preparation of planning support and housing information. Topographic maps at a scale of 1/25,000 (San Salvador) are digitized in this agency. It has two years experience in using GIS; ArcView; and MicroStation.

LAN is already installed, and Internet is in use through a dialup line. Updated digital topographic maps are interested by this agency. It has no plan, yet for participating in an inter-agency communication network, however, connection to Construction field, specifically housing is in consideration.

b) Municipal Cadastre San Salvador

This agency is making efforts in digitalization of the Cadastral records. At the same time digitalization of Cadastral maps are also on development. It has two and one half years experience in using MicroStation. A FoxPro application to faster update cadastral information is under development.

The agency emphasizes on standardization of Cadastre among CNR, OPAMSS and Municipal Cadastre.

5) Public Utilities

a) Hydroelectric Executive Commission of Lempa River (CEL)

This organization was used to be the mother organization of several groups, one of, which is the recently privatized Salvador Geothermal S.A. addressed in below. The major activity of CEL is the generation of hydroelectric power. A Design and Management System of Power Transmission Lines is under development, and it will be expectedly completed in the year 2001. LAN and Internet are in use, however, the interest in a multi-organizational communication is not mentioned.

b) Salvador Geothermal S.A.

The organization is privatized on the same day of this interview (Dec.11,2000). Its specialized field is Geophysics, and current major activity is generation of electricity from geothermal energy. The related agencies are Geotechnical Survey of MOP, Geographic and Cadastre of CNR, and the Universities. Updated 1/25,000 scale basic geographic data are interested.
For the future, this organization expects to be involved in producing aquifer information by geophysical survey. GIS or similar systems are in planning to develop a Geothermal Information Management System. LAN and Internet are in use by providing Web-page with the down-load option.

c) CAESS Electricity Supply

It is a private organization supplying electricity for northern part of San Salvador. The printed maps at the scales of 1/2,000 and 1/5,000 are digitized to produce the combined maps of Electricity Supply and Cadastre. This organization has two years experience in MicroStation.

d) TAHAL Consulting

It is a private organization providing consulting services to the local Agencies for Housing and Urban Planning. GIS is used on Project basis, in which the Software comes from Israel.

6) Users of Digital Topographic Maps

The potential digital map users in this survey might be differentiated in the following four categories, with respect to required information and their objectives.

a) Macro Level Information User

To the macro level users may include all the agencies currently involved in the development of National Spatial Data Infrastructure (Mitch Clearinghouse). Those agencies produce thematic maps, and use the topographic data as the basis. The study area is commonly large; Region or Country. The required map scale may be 1/25,000 and smaller.

These users also use 1/50,000 scale as the Base Map for creation of their application Databases. However, Regional analysis, such as "Regional Transport Planning" in MOP may prefer larger scale base map.

b) Micro Level Information User

Urban and Housing Development Planning (OPMSS) and Municipal Cadastre may both be the users of micro level information. Area unit is the Parcel and/or Building, which are much smaller than a Vegetation or Forest area. The map scale therefore is mostly large; 1/1,000 or in some cases larger. Middle scale maps are also used in rural areas.

However, they may differ from each other in using base maps; cadastral maps are the base maps for Municipal Cadastre, while the topographical maps are used as base map for Urban Planning information. OPMSS has digitized by itself the topographical map at a scale of 1/25,000 for their Pilot Project Area.

Data standardization among OPMSS, CNR, and Municipal Cadastre was addressed during the interviews. This may be meant by cadastral information such as parcel numbering, address system, and so on.

c) Public Safety and Election Analysis

The National Civil Police and Election Supreme Authority may be categorized separately, even though they are users of micro level information, especially cadastral data. Specific features such as, roads, administrative boundaries, etc. from topographic maps are also used. However, data exchange will be limited to the specific agencies, rather than a multi-organizational data sharing.

d) Utility Organizations

As for utility, only the Electricity Supply is included in this survey. Privatization policy can be noticed in this user community. CAESS Electricity Supply with forty MicroStation has the capability for digitizing maps. It has already been digitized 1/2,000 and 1/5,000 scale maps on project basis. It also has provided digital maps for PNC 911 application.

At present, the organizations interviewed are intensively working on Housing related projects. However, some of these users in the future may be Macro Level information user, as well; for example in designing and planning of Power Transmission lines. Sharing of spatial data by these organizations may be expected, when the National Spatial Data Infrastructure is correspondingly developed.

(2) Digital Mapping in CNR

CNR since 1995 is responsible for Mapping through IGN and Cadastre Department. Two Quality Control Committee have been built; one Committee under direct management of CNR will responsible for the quality of digital maps in MicroStation format, and the other under IGN management will responsible for the quality of printed IGN maps. It is said that the former Committee has already conducted quality control of 1/200,000 scale digital maps and 1/15,000 scale digital San Salvador map.

In El Salvador, a National Center for Remote Sensing is not established, yet.

1) National Surveying and Mapping

IGN is the Agency responsible for National Surveying and Mapping in El Salvador. It is established in 1946 under MOP and moved to CNR in 1995. Several small-scale maps have been produced; among which the map series at a scale of 1/50,000 was regularly updated (about 10 years interval) since its First Edition. This Agency participates in Mitch Clearinghouse Project. The Quality Control Committee in IGN, responsible for the quality of printed maps is composed of three members, and one of them is involved in the development of Metadata.

Topographical maps at a scale of 1/50,000, covering the whole country with a few exceptions, were produced in 1960s by hand-drawing. The updated Second Edition was complete in 1970s. With the introduction of scribing method, the next updated Third Edition was complete in 1992 (End of 1980s). This Edition is now under updating with the assistance of National Imagery and Mapping Agency (NIMA), U.S.A.; at present, fifty percent (50%) is complete.

Production of 1/25,000 scale maps started in 1978, and took about 20 years to complete 158 sheets. Those printed maps have been digitized, and the remaining map sheets to fully cover the whole country, are newly produced in digital form by the Technical Assistance of JICA.

Other small-scale maps include 1/100,000, 1/200,000 covering the whole country, as well as 1/15,000 scale San Salvador map.

Besides topographical mapping, the Environment Team of Geographic Section in IGN is cooperating with the other Agencies in production of 1/300,000 and 1/500,000 scale basin boundary map and thematic maps such as, Land Form, Land Use, Vegetation, Hazard, and so on.

2) Cadastral Mapping

The Cadastre Department in CNR with 11 Regional Offices is responsible countrywide for legal issues, such as Ownership Certificate, where as the Municipal Cadastre is involved in Property Tax. Before the Cadastre becomes a separate Department of CNR in 1999, it was under IGN for about 25 years, and five years under Register Department of CNR.

The Project, "Modernization of Register and Cadastre" funded by World Bank was started in 1996/97 by CNR with the objective, to firstly digitalis Cadastral maps of the whole country and then to establish the Maintenance Program. The Pilot Study in Sonsonate has been completed, and the project is ongoing. At present, digital cadastral maps for the western areas of the country, as well as the digital orthophotos at a scale of 1/5,000, covering three out of totally 14 departments (Prefectures) in El Salvador are accomplished.

3) Cartographic Standard and Feature Coding

The map products of CNR are summarized in Table 20. The cartographic standard for Cadastral mapping was revised in 1998. Updating the cadastral maps will be performed on Request by referring to the revised standard of 1998. For topographical mapping, the standard of Pan American Institute of Geography and History (IPGH) was used. Both Cartographic Standard and Feature Codes for topographical mapping is under review. However, the basic geographic data of 1/25,000 scale map series is feature coded by IPGH standards.

Table 20 Mapping in CNR

Scale	Department (or Section)	Printed in Year	Digitized in Year	Update Interval	Covered Area	Cartographic Standard	Feature Coding
1/1000	Cadastre	1982	1998	On request	West	1998	---
1/5000	Cadastre	1977	1999	On request	West	1998	---
1/10,000	Cadastre	1970s	---		Rural	1998	---
1/50,000	Topographic	1960s	---	10 years	Whole	Review (IPGH)	---
1/100,000	Topographic	---	---	---	---	---	---
1/25,000	IGN	1978 - 1997	---	---	158 sheets	Review (IPGH)	---
		---	1998 - 2000	---	Whole	---	IPGH

West: Western areas of the Country
IPGH: Pan American Institute of Geography and History
Whole: Whole area of the Country

4) Information Technology (IT) Development in CNR

CNR has setup the IT-Section in 1998 by organizing in three groups; System, Operation, and Administration. The System group is further organized into three; Database Team, GIS Team, Coordination Team, and has employed 20 staff members in total. Database Team has three well trained and 12 newly trained staff members for Relational Database Management System (RDBMS)-Oracle, and FoxPro programming; GIS Team has three well trained staff members for MicroStation Geographic; Coordination Team has two staff for documentation.

Technical support for the departments in CNR is provided locally, by assigning a System Engineer in each department and coordinated by the Administration team of the IT-Section.

It has been developed Web-Applications using MicroStation Internet Map Server (Model Server Discovery) for CNR Web Site. The system extension plan to connect all the Regional Offices of Register and Cadastre with the CNR Head Office in San Salvador has been started, and will be expectedly complete in 2001.

5) Basic Spatial Data Provider

The digital map users in categories II, III, and IV, as discussed in 6) of (1) are basically using micro level information. The local offices, such as regional offices of Register and Cadastre generally maintain such detail information.

The Cadastre Department of CNR through the Pilot Study in Sonsonate may have benefited to establish an "Operation and Management" program, and this Department with 40 registered MicroStation has a strong technical foundation to operate and manage the accomplished digital cadastral maps.

When the planned Network is implemented to connect all Regional Offices with Head Office, it will allow an effective and centralized dissemination of cadastral information for the Micro level information users.

Macro level information users are mainly the Ministries/Departments, who are performing various Analysis at National or Regional level, by utilizing dominantly GIS and geographic data. The map features such as, road, rivers are used by Several Agencies/Organizations in common, so that the data sharing system (Standardization, Clearinghouse) has been being developed increasingly in U.S.A., Japan, Europe, and other countries since mid 1990s. These users generally define a Base Map, for example 1/50,000 or 1/25,000, and this base map is referred for geo-referencing all layers in the database. The map features in such a geographic database are assigned by the standard codes, which are explained by "Metadata"; for example, which line features are major roads, or minor roads; which area features are paddy fields, plantations, or forest; which point features are schools, churches, or hospitals; and so on. Each layer in the database is maintained by ONE Agency to avoid redundancy, and shared by the others.

The National Surveying and Mapping Agency, IGN is expected to be the Base Map Data Provider in the above mentioned user community; it may also be the reason, why IGN is participating in the Mitch Clearinghouse.

(3) Operation and Management of Accomplished Data in this Study

Within the scope of this Study - "*Establishment of National Basic Geographic Data*", the map series at a scale of 1/25,000 has been digitized, covering the whole country area. All data are feature coded and organized in Arc/Info format, which is termed as "*Coverage*". The Pan American Institute of Geography and History (IPGH) standard is basically used.

Topographic database was created by digitizing existing maps and by newly mapping in digital form for the remaining sheets. Due to the time gap, Data Updating should be the first task to establish the Operation and Management Program.

1) Operation and Management Responsibility

CNR has implemented a well organized technical environment for operation and management of cadastral information. The fact that updating cadastral maps and maintaining topographic map series principally differ from each other, the same environment cannot be assumed to operate and manage the digital topographic maps.

IGN has more than 50 years experience in operation and management of conventional printed maps. However, digitalization of paper-maps began recently and therefore, a Study Project may be advisable with the objective to establish a long-term Operation and Management Program. The experience in Cadastral Information Maintenance System of CNR, as well as updating 1/50,000 scale map series, would facilitate IGN to design and execute a Study Project of such kind. The results of this survey are believed to provide useful information.

At present, there are 13 Sections in IGN, and re-organization is in progress.

a) Digital Cartographic Section

This Section is newly organized, and expected to be operationally responsible for maintaining 1/25,000 scale, as well as 1/200,000 scale digital maps covering the whole country, and the digital San Salvador map at a scale of 1/15,000. Section Chief is designated as the Coordinator and eight further technical staff members are employed; four of them are the Counterpart Team members of this Study.

b) Digital Photogrammetric Section

This Section was setup in 1998 with six staff members, and it is operating and managing the digital orthophotos at a scale of 1/5,000 covering three Prefectures (Departments) and 1/1,000 covering thirty two (32 km^2). This section is also producing Digital Elevation Model (DEM) and Contours.

A test sheet of 1/25,000 scale basic geographic data set, which is updated on-screen by displaying the digital orthophotos on background, was shown during the interview. The result of this test is demonstrating the software operation skill required for data updating by using MicroStation.

2) Existing Systems and Technology Transfer by the Project

Both Digital Cartographic and Digital Photogrammetric sections have sufficient hardware and peripherals; each staff has one PC-workstation. MicroStation is dominating software in the Departments of CNR, visited for interview. Through this Study, Arc/Info, ArcView, and Erdas Imagine are introduced, which are currently installed at Digital Cartographic Section.

Table 21: Software and Trained Staff

No.	Software Name	Purchased by	Digital Cartographic		Digital Photogrammetric	
			No. of Sets	Trained Staff	No. of Sets	Trained Staff
1	Auto CAD	IGN	1	2	1	2
2	MicroStation	IGN	9	9	7	6
3	Socet Set	IGN	none	none	2	5
4	E. Imagine	JICA	1	4	none	none
5	A. Illustrator	JICA	1	4	none	none
6	Arc/Info	JICA	1	5	none	none
7	ArcView	JICA	1	5	none	none

Technology Transfer by this Project has been conducted both in Japan and in IGN on-site. All four members of Counterpart Team have received training, and one of them has recently completed the training in Japan.

The topics of operational technology transfer are :

- Digital Ortho-rectification by using Erdas Imagine
- Updating digital maps by using Arc/Info Editing Tools
- Map Symbolization by using Adobe Illustrator

The operation manual for each of these topics has been made available in Spanish. In case of cooperative works such as, geodetic control, photo-interpretation, field verification, OJT (On the Job Training) was performed in Topographic, Geodesy, and Cartographic Sections of IGN. One staff in the Counterpart Team has experience in photo-interpretation as well as field verification in the past.

The Digital Cartographic Section during discussion mentions updating the data created in this Study by digital orthophotos. Further, it is commented that only one license of Arc/Info might not be preferable to this concern.

3) Operational Issues

a) Data Conversion

Table 21 in the previous Chapter shows that all of the staff in both Digital Cartographic and Digital Photogrammetric sections are trained and provided one set of MicroStation for each. It is certain that IGN prefers to update data by using MicroStaion, instead of Arc/Info, as the Study Team has introduced it. The reason is said to be the availability of "Only One Arc/Info License", which is rather expensive. This reason should be valid. Whatever, IGN select a software, the resulting "up-to-date" data is decisive.

The problem might be data conversion; specifically the transfer of "Feature Codes" addressed in 5) of (2), as well as the transfer of polygon (area) features between MicroStation and Arc/Info. The Digital Cartographic Section is suggested during the discussion, to study on a proper "Data Conversion" method. The Study Team, together with IGN would identify the need for assistance.

b) Digital Orthophotos or SPOT Orthoimages

Digital Photogrammetric Section is maintaining digital Orthophotos accomplished through the project - "Modernization of Register and Cadastre". The two Socet Set software sets of this project are also installed in this Section. Those orthophotos of scale 1/5,000 would be used for updating the digital maps.

The problem might be that those orthophotos cover only three prefectures (Departments), and what should be used for the remaining areas to update all digital map sheets. SPOT images are mentioned by the Counterpart. It is also said that Socet Set in Digital Photogrammetric Section does not have the SPOT optional module. On the other hand, technology transfer of ortho-rectification by Erdas Imagine has been completed, and this software is Image Processing Software, which also supports SPOT images. Using SPOT images for the rest areas may not have technical problem, except the data quality. The Study Team, together with IGN would identify the need for assistance.

c) Map Updating Approach

The importance of field verification, as well as interpretation of photo or image, when SPOT data is used, in updating maps is stressed by several staff of IGN and Cadastre. Topographic Section has suggested a proper Training to this concern.

The scope of this Study does not include data updating task. However, training for data updating was offered within the scope of technology transfer. The Counterpart Team has plotted the data, and provided to Topographic Section for identification of changes by photo interpretation and field verification. The detected changes are marked on the hardcopy of digital maps. This digital map sheet is then edited referring to those changes.

The same approach is supposed to be applied, as indicated by the Digital Cartographic Section. It might be understandable for a "short-term solution". The suggestion for corresponding Training should be considered in preparing Operation and Management Program.

4) Data Management Issues

a) Index Map

The National Boundary Map is under review in IGN. It may be one reason for not yet able to prepare a final index map.

It was found two digital index maps in different coordinate systems, and one Staff explained that index map is used as a "visual reference to identify the map sheets". However, index map in development of GIS database is used for geo-referencing and managing geographic data.

It is advisable to prepare a valid index map, as soon as the revised boundary map becomes available.

b) Data Management System

The Digital Cartographic Section is in a situation to manage the transfer of data among different software. It has mentioned that different sections or departments in CNR have different experience, in terms of software and data processing. It may be supplemented that the same is true in Data User environment, as well. The Digital Cartographic Section has commented that a standardized system is the best optimum solution.

However, standardization does not seem to be simple. Rather, it is advisable to consider a proper data management system. By a rough estimate, the digital map series of 1/25,000 scale is composed of 4000 data sets. A simplest and operational data management function of Arc/Info, which is termed as "Workspace" is used in this Study; more complex systems, such as Map Library, Spatial Database Engine (SDE) for further development are also available. The alternative option may be re-designing database, which does not seems to be advisable for "short-term operation plan".

c) Data Quality

There are two Quality Control Committees in CNR; one for digital maps in MicroStation format, and the other for printed maps. If the term "Digital Map" is interpreted as a formatted "Soft Copy" of printed map, then checking the quality of "feature coded" basic geographic data may still have to be established. If IGN is not planning to re-design the database, visual checking of data on the display, or on the hard copy, also termed as "check-plot", might be sufficient for "short-term operation".

Ministry of Environment and Natural Resources comments the updated data by proper "Quality Control System" during the interview, regarding the data produced in this Study. This comment is the view of Coordinating Agency in a Study Project with the objective to develop a National Spatial Data Infrastructure. Data quality is understood as a compromised judgment between cost and "fitness to use". The "Quality Control System" suggested by the Ministry of Environment might be a subject for development in long-term.

(4) Summary

Basic geographic data are made available in this Study by digitalization of topographic maps at a scale of 1/25,000. Primary users of such small-scale maps are the Ministries/Departments, who are performing spatial analysis in Region or Nation wide. Many agencies use the basic features such as, roads, rivers, as well as thematic information such as, land use, geology in common. These users usually define a Base Map, for example 1/25,000 scale or 1/50,000 scale, and this base map is referred for geo-referencing all the other layers in developing a GIS Database. Each layer in the database is then maintained by ONE Agency to avoid redundancy, and shared by the others.

The local government or public authorities such as, National Police, Election Supreme Authority are more interested in microscopic discrete information for example, parcel, houses, owner, and so on. The need of these users for the small-scale maps is for overview, rather than spatial analysis. CNR with the Cadastre and IT-Section is well organized to provide data for these users.

At present, study on data sharing system is initiated by Mitch Clearinghouse project, in which the Ministry of Environment and Natural Resources is the coordinating Agency. Most of the member agencies are conducting extensive studies and developing Information Technology (IT) in terms of geographic information systems and networking. The Ministry of Environment and Natural Resources, as well as the Department of Urban Regional Planning (Vice Ministry of Public Works) have initiated study projects using Internet Map Server for dissemination of spatial information through the Internet. These two Agencies are actively conducting GIS Study Projects, and technological infrastructure in terms of systems and networking is in place.

It is believed that IGN's strategy for Operation and Management of digital topographic maps might be the contribution to Nation's Spatial Data Infrastructure development. The Ministry of Environment during the interview has expressed the importance of quality control system and up-to-date data for the country. Users need oriented, continuous data updating approach by each Study Area of concerned (project base) is suggested by this Ministry. It may also be interpreted that this Ministry has strong interest in using the basic geographic data of this Study, in so far as the up-to-date quality data are available. It may be worthwhile to provide basic topographic data for this Ministry to study the "fitness-for-use" of the data in a real application environment.

10. Technology Transfer

10.1. Training in Japan

Training was conducted for the persons from IGN twice in Japan. The trainees were able to learn the skills in a short time. Visitation to some other companies was a very good occasion to understand the present condition of GIS activity in Japan.

(1) First Training

Trainee: Ing. Enrique De La O Lemus, Manager of Cartography Dept. IGN
Period: From February 21 to March 21, 2000 (30 days)
Content: Production process of digital mapping, Operational practice of scanner, Digitization of topographic maps (operational practice of R2V and VecEdit), Operational practice of ArcView, Generation of DTM (Arc/Info), Generation of Ortho-images (ERDAS Imagine), Symbolization of digital data (Illustrator)
Field trip: Tokyo Electric Power Company, Map Center and Kinki Regional Survey Department

(2) Second Training

Trainee: Ms. Yolanda Consuelo Escobar de Rodrizuez, Cartography Dept. IGN
Period: From November 16 to December 15, 2000 (33 days)
Content: Operation and maintenance of digital data (Arc/Info)
Field trip: Tokyo Electric Power Company, Map Center and Kinki Regional Survey Department

10.2 Training in El Salvador

On the job training in El Salvador on Phase I Study was conducted for the persons of the Counterpart Agency, IGN for the following four fields:

(1) GPS survey

Planning for establishing Ground Control Points, Observation by GPS receivers, Analysis of observation data and installation of signals for aerial photography were trained for 5 weeks for the following trainees;

- Ricardo Soto
- Hernan Estrada Calderon

- Armando Grande Ramos
- Jesus Alfons Uillalfa Diaz
- Jose Neftali Aquilar

(2) Installation of signals for aerial photography

Installation methods of signals for aerial photography, identification of the signals and pricking on the aerial photographs were trained for 5 weeks for the same trainees with the above (1).

(3) Field verification and supplemental survey

Methods of making keys for photographic interpretation, methods of photographic interpretation, and classification and compilation by using stereoscopes were trained for 15 weeks for the following trainees;

For Field verification:

- Jose Neftali Aguilar
- German Hernandes Landos
- Mario Albelto Palma
- Miguel Angel Izarpate
- Herman Estarada Calderon
- Douglas Batres Aveiles
- Oscar Rene Salazar

For Supplemental survey:

- Jose Neftali Aguilar
- Mario Albelto Palma
- Hernan Estada Calderon
- Douglas Batres Aviles
- Oscar Rene Salazar
- Nery Americo Llanes
- Gustavo Alonso Larin

(4) Updating of digital topographic data

Generation of ortho-images, updating of Arc/Info Coverage and symbolization of digital data were trained for 35 weeks for the following trainees:

- Yolanda Consuero Escobar de Rodoriguez
- Ana Silvia Barahona Rivera
- Alex Armado Manzano Bazil
- Luis David Flores Argueta

11. Workshop

The workshops were held three times in the course of the Phase I Study and the forth workshop will be held on April 2001 for Phase I & II Study.

(1) 1st Workshop

Date: February 10, 2000

Participants: CENTA, FAO, CODEM, MEA, MMARN, PNC, TELECOM, CAESS, MOP, CEPA, ANDA and OPAMUS

Objectives: Explanation of the digital data prepared in the 1st working year

Questions:
1) When will be the data results available?
2) Will be the present intermediate data available?
3) The data will be free or charged?

Answers:
1) The data creation is completed after June 2001.
2) The intermediate data will not be distributed.
3) Presently unknown.

(2) 2nd Workshop

Date: July 11, 2000

Participants: COCESNA, ANDA, CAES, CEL, CEPA, MEA, TELECOM, OPAMUS, MI, MMARN, MOP, CARE ISDEM, CND, TELEMOVIL, CIG, PNC, COEN and AMSS

Objectives: Explanation of applications of GIS digital data

Questions and Answers: The same as the previous Q&A on the 1st workshop

(3) 3rd Workshop

Date: August 22, 2000

Participants: Dr. Juan José Dabout, the Technical Advisor to the President of El Salvador, the Director of IGN, the Director General of CNR and the Japanese Ambassador.

Objectives: This workshop was held for Dr. Juan José Dabout the Technical Advisor to the President of El Salvador in compliance with the request of the Japanese Ambassador to present mainly how to apply the created GIS digital data of the Study's results.

Question: How will be the digital data updated?

Answer: The updating will be more effective by employing the aerial photographs newly taken in consideration of the accuracy and efficiency.

(4) 4th Workshop

Date: May 21, 2000

Participants: COCESNA, ANDA, CAES, CEL, CEPA, MEA, TELECOM, OPAMUS, MI, MMARN, MOP, CARE ISDEM, CND, TELEMOVIL, CIG, PNC, COEN and AMSS

Objectives: Methodology of Geographic Information Database,
Methodology of Updating, Disaster map preparation,
Risk analysis map preparation, Land slide analysis at Jiboa river

Questions: 1) How many map sheets does the study of the disaster cover?
2) How were the dangerous areas of debris flow extracted?

Answers: 1) The study area for the disaster covers 43 map sheets.
2) The dangerous areas were extracted manually in accordance with the Japanese criteria.

12. Recommendations

12.1. Phase I Study

In the developing countries at present, one of the reasons that the development of National GIS Spatial Database take times in such countries would be the lack of the financial sources, GIS technology and computer experts that allow and expedite the digitizing of GIS data from the existing maps.

In the Republic of El Salvador, once that GIS database covering the 1/25,000 scale topographic maps of the whole country has been created on the completion of this Study, the utilization of GIS are now fortunately ready to start countrywide.

We would like to recognize the problems that the Counterpart Agency, IGN has being confronted with, and make the recommendations as follows:

(1) Updating of 1/25,000 database

Most of GIS digital data created by this Study has not been updated, and it is therefore required in the due time to update these data by self-reliance efforts of IGN. The required technologies for this purpose have been transferred through this Study.

(2) Study of updating methods

It is recommended that Arc/Info and Erdas Imagine provided by this Survey and CAD (MicroStation) belong to IGN shall be jointly utilized in the effective methods for creating the digital data. The compatibility of Arc/Info Coverage and DXF data on MicroStation shall be technically studied for the effective methods.

(3) Utilization of the database

The users of the digital data will be divided into ones of the national GIS/LIS and the others of the specific detailed data such as of urban housing and municipal cadastre. The main users of the database created by this Survey will be ones of the national GIS/LIS. In consideration that CNR is currently responsible for the specific detailed data, IGN has to be responsible for the national GIS/LIS for its users. In addition, experts of GIS spatial data shall be trained within IGN because no expert in this field is currently available in IGN.

(4) Release of the data information

It is recommended that the created data shall be widely released by Internet, for example.

(5) Standardization of the data and establishment of the data clearing house

At present in El Salvador, various organizations have their stand-alone database for their own uses that is causing the duplicity of the data and the inefficiency of the utilization within the country. It is therefore recommended that the national data clearinghouse shall be established for the standardization of the common data.

(6) Continuous updating

Because GIS data has principally the secular changes, the data shall be continuously corrected and updated.

(7) Data Quality

There are two Quality Control Committees in CNR: one for digital maps in MicroStation format, and the other for printed maps. If the term “Digital Map” is interpreted as a formatted “Soft Copy” of printed map, then checking the quality of “feature coded” basic geographic data has to be conducted. If IGN is not planning to re-design the database, visual checking of data on the display, or on the hard copy, also termed as “check-plot”, might be sufficient for “short-term operation”.

12.2. Phase II Study

As the results of the large-scale earthquakes that occurred recently in El Salvador, collapses and landslides occurred in the mountains. There are also slopes that did not collapse or suffer landslide but are loose. These places may bring about human harm by outflow of unstable sediment in approaching the rainy season.

In this Phase II Study, an area (5100 km^2) considered to be particularly heavily damaged was selected.

Disaster maps and sediment-related hazard maps were prepared to urgently identified places with a possibility of danger of secondary disasters. Map information required for the preparation of these subject maps was updated with satellite ortho images, ortho photos, existing materials and GPS measurement within the short period of two months, and the survey could not extend to details. Therefore, it should be borne in mind that the disaster maps and the sediment-related hazard maps that are the products of this Study have the nature of urgent measures, and detailed survey will be necessary according to the purpose of uses.

What should be carried out from the viewpoint of prevention of disasters in El Salvador is as follows:

(1) Measures for the potential hazardous disaster areas

1) On the road (No.2 site survey point) located in the boundary of Municipio de CHILTIUPAN and JAYAQUE, Departamento de LA LIBERTAD, a passing regulation like prohibition of passing should be enforced for the following reason immediately:

This road point becomes sterile as the top of the edge of the sword, and it is a section to pass on the ridge. At present, roadbed slide is found at some of the both shoulder parts of the roadbed and many open cracks are found there too. Therefore it is very highly dangerous in the rainy season.

2) In Las Colinas (No.6 investigation point) Municipio de NUEVA SAN SALVADOR, Departamento de LA LIBERTAD, and in the westward land-slided slope (No.4 investigation point) , Finca San Buenaventura, Municipio de NUEVA SAN SALVADOR, Departamento de LA,
Many open cracks still exist in the ground surface of the top slope at where landslide occurred. Plastic sheets should be laid over such places to prevent the permeation of the rainwater during the rainy season. Though at present cement is poured in them, it is not likely to be effective to this purpose.

(2) Public announcement of Sediment-related hazard map

Sediment-related hazard maps shall be announced to the public and make the residents and organizations concerned realize the possibility of impending disasters and develop the warning consciousness of the residents.

(3) Making plans of evacuation and Public announcement

The plans of evacuation shall be made by employing Sediment-related hazard map for the public announcement to the residents and organizations concerned.
Although the disaster preventive plans shall be made in details for the usual activities, however, instant measures against approaching the rainy season shall be taken in making plans for such as:

-Evacuation standards
-Organizations for disaster prevention
-Communication systems for emergency evacuation
-Evacuation routes/Safety places
-Patrol plans for potential hazardous disaster places

(4) Extraction of hazardous places in the whole area of El Salvador

In this Survey, potential hazardous places were extracted which had particularly paramount urgency. As the recent earthquakes had also influences on mountainous districts other than this area, a nationwide survey is necessary.

(5) Update of topographical information in the whole area of El Salvador

It is necessary to update topographical maps and geological maps of the whole country to carry out a nationwide extraction of hazardous places that have the possibility of bringing about human harm. Fortunately, the technical level of the counterpart agency (NCR and IGN) is high, and 1/5,000 scale digital orthophotos is available in some areas. Based on fresh image sources such as the orthophot, and satellite imagery, it will be possible to update 1/25,000-scale topographic maps for whole country within a short period. This implementation is strongly recommended.

(6) Required upgrading of Disaster GIS database delivered

The disaster GIS database is prepared by employing the aerial photos, satellite ortho images and materials collected in the field survey along with the GIS layers provided by Ministry of Environments and other organizations. However, the database to be delivered is not covered whole disaster information since the project period was short and a material used to create the disaster database. Therefore, it is required for the end users of delivered GIS data to take further upgrading of the database because the database was designed to allow the effective uses by input of the additional layers and updating of the disaster data. Database is including the existing disaster data of Agencies concerned as one of layer in Shape file in order to avoid the mixed- up data.

(7) Recommendation for full-scale Disaster prevention Plan

Measures shall be taken for the disaster prevention are:
To predetermine the potential hazardous disaster places and to conduct the checking such extracted places, to conduct the preventive construction, to take the warning measures and emergency measures to be taken once the disaster occurs. The extraction of the potential hazardous disaster places and the disaster preventive measures are as follows:

1) Extraction of the potential hazardous disaster places

In order to prevent the disaster, it is important that first of all, the potential hazardous disaster areas with high risk shall be predetermined, and such potential hazardous disaster areas will be extracted by taking the following measures:

a) Determination of the preservative objects

The preservative objects are such as houses, cultivated fields and infrastructure. The objects of the Infrastructure are such as road, water supply, electricity, gas and public facilities.

b) Determination of the natural disasters

Natural disasters are such as land slip, landslide, debris flow, flood overflow and liquefaction of the ground.

c) Extraction of potential hazardous disaster areas

The potential hazardous disaster areas will be extracted by taking the following steps:

➢ Extracting in office work (refer to the Japanese Extractive Standard of the land slip and debris flow that was applied to this Study)

- Field Survey (refer to the check lists that used by this Study)

d) Creation of the database for hazardous disaster areas

2) Measures of the disaster prevention for the infrastructure

a) Usual measures:

In case of the infrastructure for the preservative object, usual checking of the facilities shall be conducted for the potential disaster. The checking procedures shall be determined by making plans for maintenance and management. The plans shall include the determinations of the organizations for checking, kinds of the disaster prevention's, and the checking periods, and preparation of the checking manuals, planning and implementation of the preventive construction.

b) Emergency measures

Regional Emergency Disaster Headquarter shall be established by the persons in charge of the infrastructures from the parties concerned and work in cooperation with the Governmental Emergency Disaster Headquarter.

3) Measures of disaster prevention for house, human life and property

It is necessary to establish the disaster prevention systems for taking the measures for house, human life and property in the mutual cooperation between the Government and the residents, and in making the disaster prevention plans, emergency disaster headquarters on the levels of the Government, Departments (Prefectures) and the regional administrative authorities shall be immediately established once disaster be occurred or in case that the disaster be forecasted.

It will be suggested for develop and raise the residents' consciousness of warning against the disasters to distribute the pamphlets to the residents and to held public contests for disaster posters and composition.

It is also recommended that the Disaster Departments within the administrative authorities shall be established, and their usual activities shall be conducted as follows:

- To realize potential hazardous places of land slip and/or landslide and to develop the public warning against the disaster.
- To realize the communication systems when disaster occurred.
- To determine and make public announce of the safety places and the routes for the evacuation.
- To conduct the evacuation practice.

The disaster prevention plans shall include the following items:

a) Emergency measures

- Establishment of Emergency Disaster Headquarter

The Emergency Disaster Headquarter shall be organized by the Governmental Organizations, and work in cooperation with police, fire authorities, an army, weather observation authorities, infrastructure organizations (road, electric, gas, water, telephone, etc.), mass-media (broadcasting stations and news paper companies) and so on.

- Determination of communication systems

The alternatives shall be considered in case any telephone lines and/or vehicles could not be used. For the communication methods to the residents, it will be considered the method through self-preventive organizations by the residents and direct method through publicity services cars, wire broadcasting, wireless broadcasting for disaster prevention and public broadcasting.

- Determination of the cooperative communication

Cooperative mutual communications between the levels of the Government, departments and regional administrative organizations shall be established.

- Patrol routine works against the potential hazardous disaster places

b) Establishment and development of self-defensive organization for disasters shall be established to protect the residents' lives and properties and be developed under the supports of the Government's Disaster Headquarter.

c) Disaster data preparation

- Potential hazardous disaster places with high risk
- Safety shelters, and so on

13. Persons Concerned

Counterpart Agency in El Salvador

Ing. Roverto Lopez Meyer	Director of Instituto Geográfico Nacional
Ing. Enrique de la O Lemus	Ex-manager of Cartographic Division
Ing. Katia Isabel Madrid	Coordinator of Digital Cartographic Dpt.
Yolanda consuelo Escobar	Engineer
Ana Silvia Barahona Rivera	Engineer
Luis David Flores Argueta	Engineer
Alex Armando Manzano Bazil	Engineer

JICA

Atsushi Kamishima	Resident Representative in El Salvador
Takahiro Shinchi	Senior Researcher

IDI

Seiichi Tanioka	Senior Counsellor
Yoshikazu Fukushima	Senior Counsellor
Hisashi Mori	Counsellor

Japan International Cooperation Agency
Instituto Geográfico National “Ing. Pablo Arnoldo Guzman”
Centro National de Registros, Ministerio de Economía

THE STUDY

FOR

ESTABLISHMENT OF NATIONAL BASIC GEOGRAPHIC DATA

IN

THE REPUBLIC OF EL SALVADOR

FINAL REPORT

July 2001

PASCO INTERNATIONAL INC.

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Preface

In response to a request from the Government of the Republic of El Salvador, the Government of Japan decided to conduct the study on the Reconnaissance Survey for the Establishment of Emergency Rehabilitation and Reconstruction of the Republic of El Salvador and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team consisted of Pasco International Inc. to the Republic of El Salvador, five times from March 1999 to July 2001.

The Team held discussions with the officials concerned of the Government of the Republic of El Salvador and conducted surveys at the study area. Consequently, the present results were prepared based on these surveys.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of El Salvador for their close cooperation extended to the team.

July 2001

Kunihiko Saito
President
Japan International Cooperation Agency

Letter of Transmittal

July 2001

Mr. Kunihiro Saito
President
Japan International Cooperation Agency

Dear Sir,

It is a great honor for me to submit herewith the Final Report of the Study for Establishment of National Basic Geographic Data in the Republic of El Salvador.

A study team, which was organized by Pasco International Inc., headed by myself, conducted the Field Survey five times from March 1999 to July 2001 in El Salvador in accordance with the Terms and References instructed by Japan International Cooperation Agency (JICA).

In El Salvador, the Field Survey required to prepare the new topographic maps was conducted along with the subcontracted aerial photography, the presentations for the digital data of the Study in collaboration with the Counterpart Agency.

The results of the Study are presented in the Final Report.

On behalf of the Team, I would wish to express my heartfelt appreciation to the officials concerned of the Government of the Republic of El Salvador for their warm friendship and cooperation extended to our Team during our stay in El Salvador.

I also would wish to express my sincere appreciation to JICA, Ministry of Foreign Affairs, Ministry of Land, Infrastructure and Transport, Embassy of Japan in El Salvador and other concerned government authorities for their valuable advice and supports.

Yours faithfully,

Shun Takagi, Team Leader
The Study for Establishment of
National Basic Geographic Data
in the Republic of El Salvador

Executive Summary

1 Study Background

In the implementation of the recovery and reconstruction from the Civil War, which lasted from 1979 to 1992, the Government of the Republic of El Salvador drives for the economic development mainly for the improvement of the living environments for such low income brackets as the local farmers. El Salvador also suffered from serious disasters from the furious hurricane in 1998 such as damaged to bridges and debris flows, and still today is on the course of the rehabilitation from the disasters. Meanwhile, the development planning for the agriculture and water resources are currently carrying out, and for their successful implementation, the urgent preparation of the topographic maps is required as the national basic geographic information.

In the Republic of El Salvador, the 1/25,000 scale topographic maps cover approximately 85% of the whole country and the remaining area approximately 15%, is uncovered. Digital data whose positional accuracy corresponding to the existing 1/25,000 scale topographic maps are not available at all. In fact, some government agencies such as Ministry of Agriculture and Livestock (Ministerio de Agricultura y Ganadería) and Ministry of Environment and Natural Resources (Ministerio de Medio Ambiente y Recursos Naturales) are developing their own Geographic Information Systems (GIS), however the geographical data which should be shared among the users of the agencies are not yet standardized. This is governmental issue which need to urgently be solved

Under the above circumstances, the Government of the Republic of El Salvador requested to the Government of Japan to conduct a project (Phase I Study) to produce topographic maps and digital topographic data for Geographic Information System to support infrastructure development planning for the reconstruction of the Republic of El Salvador. The Study was started in March 1999 and continued to July 2001.

Other sides, during the Phase I Study, an earthquake occurred in El Salvador on January 13, 2001 with a magnitude of 7.6 on the Richter Scale, and another earthquake followed on February 13, 2001. It is reported all of 14 departments in El Salvador were seriously affected.

The Phase II Study Team was organized by the Japan International Cooperation Agency (JICA). The main objectives of the Phase II Study are to prepare “Disaster Maps of the Damaged Areas” and “Sediment-related hazard map for Landslides and Hazardous Areas” resulting from the earthquakes in January and February 2001.

2 Contents of the Study

The study area covers approximately 3,700 km^2 for preparing the 1/25,000 scale topographic maps and approximately 20,740 km^2 for creating the whole country digital data. The main studies are the followings:

(1) To prepare the 1/25,000 scale topographic maps covering approximately 3,700 km^2.

(2) To create the digital data whose positional accuracy is corresponding to the existing 1/25,000 scale topographic maps in order to assist the Government of the Republic of El Salvador for establishment of various Geographic Information Systems covering approximately 20,740 km^2.

(3) To prepare the “Disaster Maps of Damaged Areas” covering approximately 5,100 km^2 that resulted from the earthquakes in 2001 for proceeding with effective support to the reconstruction plan.

(4) To prepare the “Sediment-related hazard map” for Landslides and Hazardous Areas covering approximately 5,100 km^2” to indicate the areas susceptible to a secondary disaster.

(5) To transfer related technology skills to the counterpart personnel of El Salvador.

3 Basic Policies of Study Implementation

The Study was conducted based on the Scope of Work agreed on between the Instituto Geográfico National (IGN) “Ing. Pablo Arnoldo Guzman, Centro National de Registros, Ministerio de Justicia and the Japan International Cooperation Agency on December 4, 1998 and the Work Instructions presented at the explanatory meeting held in El Salvador on February 2, 1999.

The details of the basic policy are the followings:

1) The digital data for GIS shall be produced within a period of 28 months for the urgent national rehabilitation of the infrastructure.
2) The existing materials for the Study shall be utilized as much as possible.
3) Appropriate transferable technology and a cost efficient sustainable computer system shall be considered for the Counterpart Agency, IGN.
4) Disaster map and sediment-related hazard maps shall be prepared to urgently identify places with a possibility of danger of secondary disasters
5) The Study shall aim to support the following activities of the Counterpart Agency, IGN:
    - Production and correction of the digital data for the GIS
    - Maintenance of the digital data
    - Sustainable supply of the digital data
    - Standardization of the digital data

4 Study Implementation

The Study was conducted generally as planned, however the major changes made in the course of the Study implementation are the following:

(1) Digital data for GIS (Arc/Info coverage data) on Sheet Numbers 2656II-SW and 26551-NW were additionally created because some islands located around the boundary with Honduras were missing on the existing 1/25,000 scale topographic maps.

(2) The poor accuracy of the contour lines on the existing 1/10,000 scale topographic maps limited their full use to the new 1/25,000 scale topographic mapping.

5 Utilization of the Output

The output of the Study has being utilized for the followings:

(1) The Counterpart Agency, IGN is applying the transferred technology for their works to update the secular changes of the digital data by using orthophoto images.

(2) The digital data whose positional accuracy is corresponding to the existing 1/25,000 scale topographic maps newly created as output of the Study were utilized for the damage research of the big earthquakes which occurred in January and February 2001 and for the secondary disaster prevention.

(3) Extension and update of GIS database including disaster data

6 Information Dissemination

The Objectives and the output of the Study were disseminated worldwide through the Internet, and in El Salvador, presentations were held four times, which received nationwide news coverage and resulted in many inquiries for the output of the Study from various parties.

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Acronyms of Organizations Concerned

ANDA:	Administración Nac.de Acueductos y Alcantarillados
BCR:	Banco Central de Reserva de El Salvador
CEL:	Comisión Ejecutiva Hidroeléctrica del Río Lempa
CEPA:	Comisión Ejecutiva Portuaria Autónoma
CNR:	Centro National de Registoros
JICA:	Japan International Cooperation Agency
IGN:	Instituto Geografico National “Ing. Pablo Arnoldo Guzman”, Centro National de Registros, Ministerio de Economia
IPGH:	Instituto Panamericano de Geografia e Historia
ISSS:	Instituto Salvadoreño del Seguro Social
MAG:	Ministerio de Agricultura y Ganaderia
MD:	Ministerio de Defensa
MI:	Ministerio de Interior
MOP:	Ministerio de Obras Publicas, Transporte y Vivienda
MRE:	Ministerio de Relaciones Exteriores
MSPJ:	Ministerio de Seguridad Pública y Justicia
MMARN:	Ministerio de Medio Ambiente y Recursos Naturales
MS:	Ministerio de Salud
MT:	Ministerio de Trabajo
PNC:	Policia Nacional Civil