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 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 establishment of various geographic information systems (approximately 20,740 km^2)

(3) To transfer related technologies 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 succeeding effective supports to 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

Phase I

(1) New mapping area (approximately 3,700 km^2)

(2) Digitalization for the area of the whole country (approximately 20,740 km^2)

Phase II

(3) Includes the main disaster areas resulting from the earthquakes (approximately 5,100 km^2)

The Study areas are shown in Figure 1.

Figure 1 Study Area
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Figure 2 Study Flow Chart
obj/english/study_fl.xls

2.3. Scope of Work

2.3.1. Phase I Study

Phase I 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
2) Ground control point survey
3) Aerial triangulation
4) Field identification
5) Plotting
6) Field completion
7) Compilation
8) Preparing of printing films

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

(3) Structurization

(4) Technology transfer

2.3.2. Phase II Study

Phase II Study shall be covered the following items:

(1) Updating the base map for disaster areas

(2) Field Study

(3) Preparing Disaster Map of Damaged Areas

(4) Preparing Sediment-related hazard maps for Landslides and Hazardous Areas indicating the potential hazardous places.

2.4. 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.

2.5. 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 Figure 3.

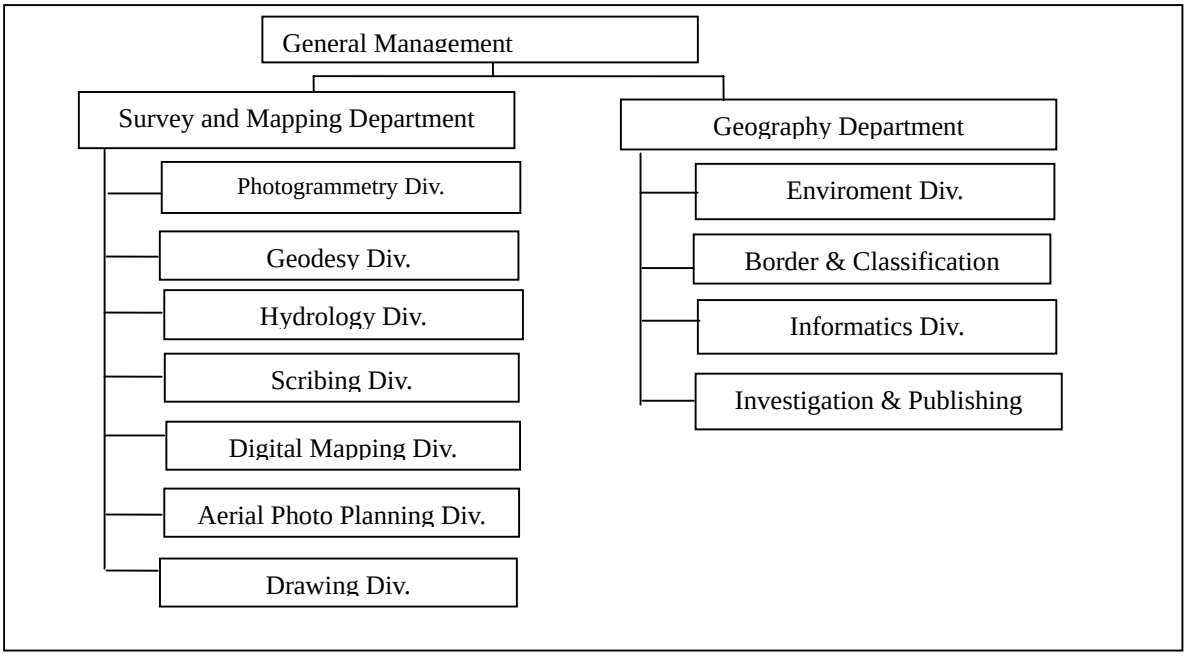

Figure 3 Organization chart of IGN

4. Members of JICA Study Team

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

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. Details of Phase I Study

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

Digital data of 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 4. Details of each process are explained below.

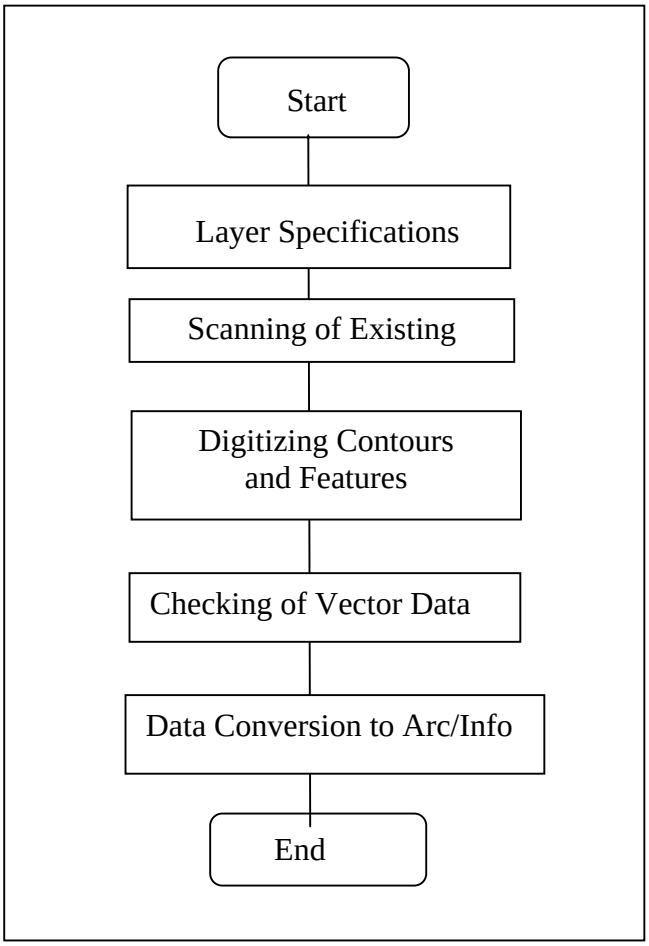

Figure 4 Processing of Digital Data Creation from the Existing 1/25,000 scale Maps

(1) Decision of Layer Specifications

Nineteen layers of the digital topographic data were defined and types or characteristics of each features and contours were expressed using eight attributes such as, code, BT-code, dept, muni, dept-code, type, elevation and text.

(2) Scanning of the Existing Maps

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.
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” mean roads, buildings, vegetation, etc., all information from the existing maps except the contours.

(3) Digitizing of Features and Contours

The scanned images of the contours were used to digitize contours automatically by raster to vector conversion. After digitizing the contours, the digital data of the contours were created to input attribute data such as code and elevation. In this step, the digital data mean a kind of vector data. After checking, the data send to Arc/Info.

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

(4) Checking of Digitized Data

After creating the digital data of contours and features, hard copies of the data were plotted for manual checking. The main items for checking were features, invalid attribute values and edge matching between sheets.

Digital data usually have 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.

(5) Topology Construction of Digital Data

After correcting the digital data, coverage data were created importing the digital data into Arc/Info. The coverage data mean 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) Data Quality check

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

1) Invalid code check
2) Invalid feature type check
3) Invalid text check

4) Digitizing direction check
5) Attribute items definition check
6) Unnecessary attribute check
7) Topology check
8) Edge matching

5.2. 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 no 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. A flow chart of the processing is shown on Figure 5. Details of each processing step are explained below.

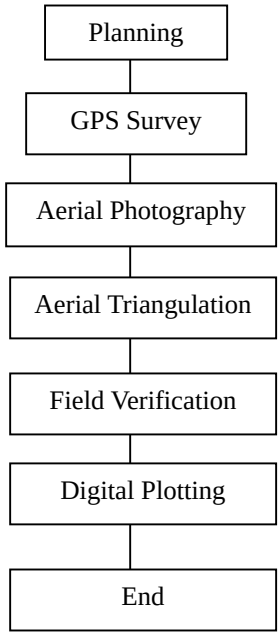

Figure 5
Digital Mapping Flow

(1) Ground Control Points Survey

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.

GPS Observation

A total of 29 control points were observed by GPS for the eight separate photogrammetric digital mapping areas. The survey was carried out using four ASHTECH geodetic GPS receivers, with 1.5 – 2.0 hours of observation time at each station. 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.

(2) 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.

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

The work period and times of flights are as follows:

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

The results of aerial photography are as follows:

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

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

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) Aerial Triangulation

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.

The Independent Model of PAT-M was adopted for the method of triangulation and the study area was divided into eight blocks. The processing was finished successfully 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 5.

Table 5 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

(4) Field Verification

Field verification was carried out twice. The first verification was for making manuscripts of plotting maps. Work items of the first 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

The second verification was for the checking of the manuscripts of the plotting. The second field verification is called the supplemental survey in this report. The supplemental survey was conducted for checks of manuscripts of plotting maps, checks of annotation data and checks of marginal information for printing paper maps. The color manuscripts, black and white copies of the manuscripts and the enlarged photographs were used for the supplemental survey in El Salvador.

(5) Digital Plotting

Creating of DXF data

Digital data in DXF format (feature data and contour data) were produced by three different methods depending on the topographic material. The DXF data were then used to create coverage data for Arc/Info and were also converted to Illustrator data for cartographic symbolizing.

For areas where there were no existing 1/25,000 scale maps but 1/5,000 scale topographic maps did exist the following procedures were used:
DXF data were created using analytical plotters.

For areas where it was possible to use the existing 1/10,000 scale topographic maps the following procedures were used:
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.

For areas where it was impossible to use the existing 1/10,000 scale topographic maps the following procedures were used:

The digital data for contours in this area were generated correcting the existing 1/10,000 scale maps and digital data of features were created using analytical plotters.

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.

Creating of Coverage 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.

6. Preparing the "Disaster Maps and "Hazard Analysis

6.1. Field Activities for Phase II in El Salvador

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

6.1.1. Collection of available materials

Collected materials for the Phase II Study are the followings:

(1) Aerial photography

- Before the earthquake in January: Department of Usulutan approx. 100 photos).
- After the earthquake: disaster area (approx. 620 photos).
- 1/5,000 Ortho-photos: Departments of Ahuachapan, Sonsonate and Santa Ana.

(2) The existing topographic maps

The existing 1/5,000 topographic maps for States of La Libertad, San Salvador, Cuscatlan, San Vicente and La Paz (approx. 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 the Vice-Ministry of Housing and Ministry of Environment and Natural Resources.

(4) Request for Meteorological data

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

6.1.2. Field activity for updating of the existing map

Field verification was carried out using Mobile GPS instruments and SPOT satellite imagery, which 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 updating of road information, Geoexplore-3 of Trimble was employed as Mobile GPS.

6.1.3. Photo-interpretation and Satellite image interpretation

The study team implemented photo-interpretation and Satellite image interpretation for the landslide areas and the survey results were sent to Japan in order to delineate the outline of landslides on the disaster maps.

6.1.4. Survey of landslide disaster

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

- Landslides caused human losses or are potentially dangerous to villages and communities.
- Landslides affected important roads or highways.

During the field study, the following sites were visited:

i) Department of Cuscatlan
ii) Department of La Libertad. Las Colinas, Santa Tecla (Landslide)
iii) Department of La Libertad. Finca Buena Vista. (Debris flow)
iv) Department of La Libertad. Canton Las Cumbres (Landslide).
v) Department of La Libertad. Finca San Jose. (Roadbed slide)
vi) Department of La Libertad. Pedrera las Lajas. Pan-American Highway to Santa Ana. (Rockfall)
vii) Department of La Libertad. Rockfall near Hotel Monte Verde, Los Chorros. (Rockfalls)
vii) Department of San Salvador.San Marcos Pedrera el Socorro. It affects dwellin
viii) Department of San Salvador. Ilopango. Pedrera Los Amates.
ix) Department of San Salvador. San Martin. Colonia Las Anemonas. (Landslide)
x) Department of La Paz. Panamerican Highway. Canton Las Piedritas. (Rockfall)
xi) Department of La Paz. Highway to International Airport of Comalapa. (Rockfall)
xii) Department of Usulutan. Road from Tecapan to Santiago de Maria. (Rockfall)
xiii) Department of Usulutan. Road between Santiago de Maria and Alegria. Curva el Cuyapo
xiv) Department of San Vicente. Pan-American Highway km.53. Curva Las Leonas.

Even though landslides occurred at steep slopes, most of them were man-made at road cuts. This indicates that they could have been prevented by 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 trigger either by the continuous seismic activity or by the heavy rainfall season.

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6.2. Processing in Japan

6.2.1. Updating of 1/25,000 Scale Topographic Maps

1/25,000 topographic maps being studied currently are lacking with the adequate updated information of the topographic status that exists today, although its data is already digitized. Hence, the updating of the topographic data were carried out as much as possible using the various kinds of available source data likes SPOT ortho imagery, ortho photo, 1/5,000 topographic maps and GPS data obtained in the field verification. Thus, the methodology for updating the topographic features was based on the type of the used source data. The methodology used to update by various source data is briefly described below:

(1) San Vicente and Usulután Departments by SPOT satellite imagery

SPOT ortho image and the topographic feature to be updated, both having the same projection system, were displayed at the scale of 1/25,000 using Arc/Info and ArcView software. The topographic feature was displayed on the top of the ortho image. Then, the updating was done visually by adding the missing data and deleting that were not present in the imagery. 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.

(2) Santa Ana, Sonsonate and Ahuachapán Department by the existing ortho-photos

The methodology applied to update the topographic features by ortho photos was similar to that of using the SPOT ortho-image. That is, ortho photo and shape file of topographic feature, having the same projection system, was displayed in the similar fashion as 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.

(3) La Libertad, Cuscatlan, San Vicente and La Paz Department by Exiting maps

The exiting maps at scales of 1/5,000 and 1/10,000 were scanned with 300-dpi 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 technical section. 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 applied to update the topographic features similar to that of using the ortho photos.

6.2.2. Preparing 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:

(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, which locations were shown on 1/25,000 scale topographic maps. To delineate the disaster areas in the course of the interpretation, following topographic conditions were excluded from the disaster areas:

- Naked area (logged-off land)

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

- Natural collapsed area

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

- Soil collection place and quarry

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

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

- Small scale damaged areas.

(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 show on Fig. 6.

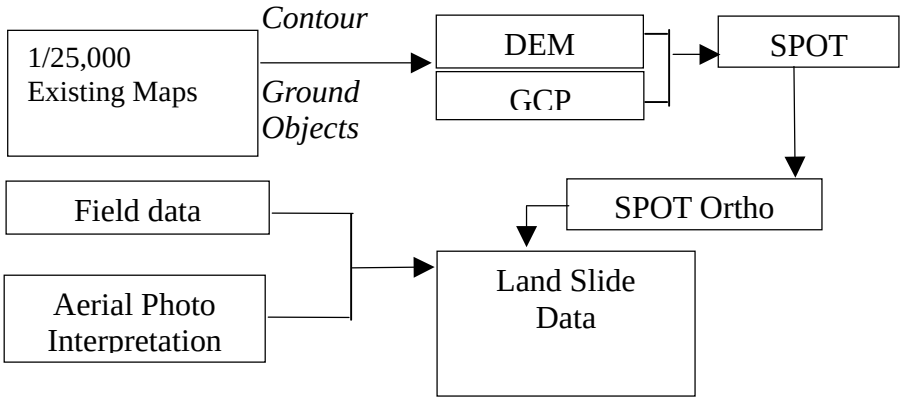
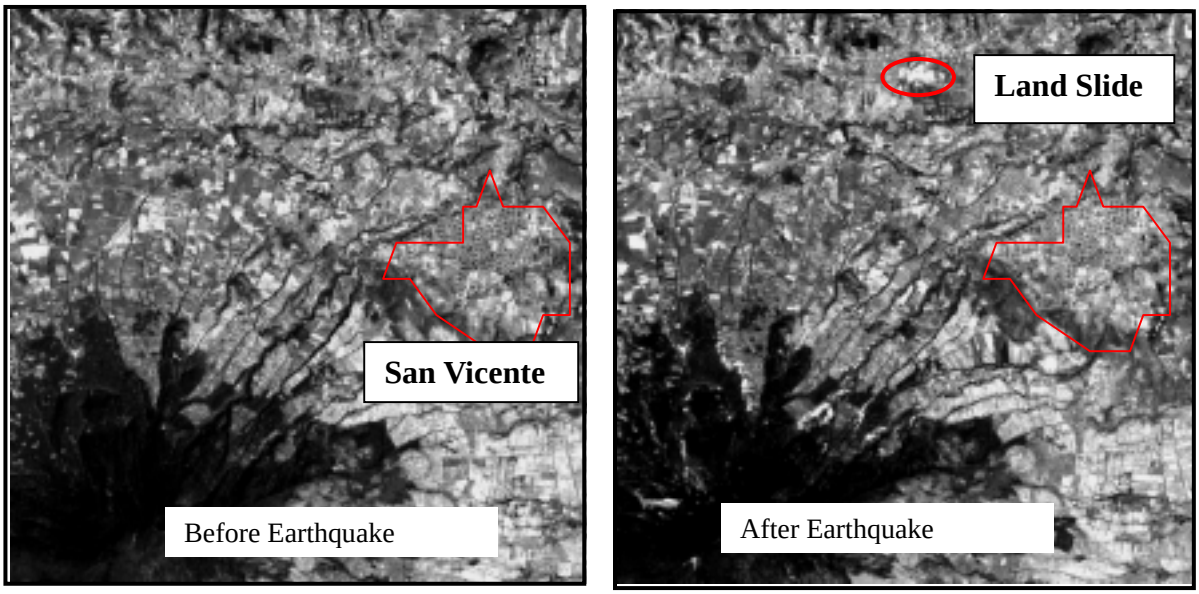


Figure 6 Work Flow for Land Slide Data

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

Figure 7 Delineating of land sliding



(3) Preparing GIS Data

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

Table 6 Contents of GIS Disaster 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	Water shade	
Protect	Polygon	Hazardous area for steep slope	
Debris	Polygon	Debris flow	

Table 7 GIS Data (provided by Ministerio de Medio Ambiente y Recursos Naturales)

xv) Shape File Name	xvi) Type	xvii) Contents
areas_impactadas	Polygon	Disaster areas
Basepais	Polygon	National Basemap
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 places (landslide, submergence, cracks)
Eventos_sismicos_marn	Point	Details of disaster caused by the earthquake (Contents of Field Survey)
Eventos13feb	Point	Disaster Places 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 30o)
Redvial25k	Line	Major roads
rios50	Line	Major rivers
sitios_atencion_inmediata	Point	Villages required emergency measures
Snanp	Polygon	
Vegetacion	Polygon	Vegetation

(4) Preparing disaster maps of the damaged areas

The 1/25,000 disaster maps were prepared by processing various data as shown on above item (1), (2) on the 1/25,000 topographic maps.
Following functions were created on ArcView.

1) Field survey points can be shown on 1/25,000 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 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 which allow visitors to understand

6.2.3. Preparation of Sediment-related hazard maps for Mass movement

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 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) 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 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

a. Topographical conditions shall be a height of 5 m or more and a gradient of 30° or more, and shall be equivalent to those of Hazardous Places of Steep Slope Collapse.
b. An area with damages anticipated shall have a distance equivalent to 2 H (within 50 m; H is height of the slope) under the slope and shall be within a distance equivalent to H from a point where the gradient of the slope is 20°.
c. In the case where intervals of buildings exceed 50 m
Places to be conserved inside the area with damages anticipated shall be those where a building is confirmed on the 1/25,000 topographical map.

2) Places with Risk of Debris Flow

a. 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
   - The range of anticipated floods shall be the range where it is considered from topographical conditions that floods will occur.
b. Places to be conserved inside Areas with Risk of Debris Flow shall be those where a building is confirmed on the 1/25,000 topographical map.
c. Places with Risk of Debris Flow 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).
c. As the gradients of the mountain stream bed, although conditions in volcanic and erosion control areas are different from those in other areas in Japan, values for volcanic and erosion control areas (2° or more) shall be used in places judged from geological conditions to be volcanic.

(2) Method of the survey

This survey was performed 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 disaster are:
-Topographic maps (1/25,000)
-Geological maps (1/100,000)

2) Preparation of slope type maps
Slope type maps were prepared based on altitude data on topographic digital maps.

3) Extraction of hazardous places on steep slopes
With reference to the slope type maps, 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 slope type maps, places with risk of debris flow were extracted using the disaster map of damaged areas.

5) Preparation of base maps for Sediment-related hazard maps

The hazardous places on steep slopes and places with risk of debris flow extracted were overlapped, and the results were 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. Based on GIS data input, an extraction map of places with risk of sediment disasters was prepared.

6) Preparation of Sediment-related hazard maps
Printing maps at scale of 1/25,000 were overlapped on the background map showing basic topographical elements and administrative boundaries.

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

In accordance with the item 3), (7), Article 5 of the Specification issued by JICA, the Operation and Management Study by a series of interviews was conducted during from December 6 through 14, 2000.

Fifteen agencies in this survey may represent the potential users of basic geographic data of this Study, at least four different purposes.

1) The users such as Ministry of Environment, Ministry of Public Works and Ministry of Agriculture need the basic geographic data for their Spatial Analysis.
2) The Regional Offices such as, Urban and Housing Development Planning, Municipal Cadastre, primarily use the detail information such as, parcel, building, and so on. However, the small-scale maps are used for overview.
3) Public Safety and Election Authority are similar category of users addressed in (b), except that these Authorities may not be data provider for other organizations.
4) Utility Organizations are privatized, and are involved in housing projects at present. In the future however, these users may involve in National Infrastructure and Resources Planning, which will become more close to the users in (a).

The result of interviews shows that almost all of potential users are developing Information Technology (IT) in terms of geographic information system and networking extension/development plan. All agencies are using Internet, and three Agencies will begin the study projects using Internet Map Server for dissemination of geographic information through the Internet. They also show the interest in 1/25,000 scale basic geographic data. Except the users in (a), all the other agencies are more interested in detail information such as, Cadastre.

The user community addressed in (a) is involved in a Steering Committee and Mitch Clearinghouse project, which is in progress. The Ministry of Environment and Natural Resources is the Coordinating Agency, and the Ministry of Public Works, the Ministry of Agriculture and IGN are the Member Agencies. The objective of building such Clearinghouse is, like in U.S.A., Japan, to coordinate and exchange of geographic information as the public service.

The Cadastre Department of CNR is responsible for National Cadastre, and IGN is responsible for National Surveying and Mapping. A National Center for Remote Sensing is not established yet, in El Salvador.

The Cadastre Department through the Pilot Study in Sonsonate has benefited to establish an “Operation and Management” system. This Department with 40 licenses of MicroStation has a strong technical foundation for maintaining 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 detail information user community.

However, 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 basic geographic data of this Study. IGN has been producing several small-scale maps since it’s establishment in 1946, among which the map series at a scale of 1/50,000 was regularly updated (about 10 years interval). A Quality Control Committee is built, and it will responsible for the quality of IGN printed maps. This existing operation and management system is rather for the conventional mapping.

For Operation and Management of the basic geographic data of this Study, IGN seems to have sufficient resources. All, what lacking may be the experience and well organized Operational and Management system, which is advisable to establish by active participation in a GIS Application. It is to be stressed that the objective should be set to resolve the operational and management issues discussed above.

The Ministry of Environment during the interview has expressed the importance of quality control and up-to-date basic geographic data. It has further suggested to continuously updating data by each project base study area of concerned. This Ministry and also, the Department of Urban Regional Planning (Ministry of Public Works) are actively conducting GIS Study Projects and the technological infrastructure in terms of systems and networking is in place.

It is suggested to study the "fitness-for-use" of the data by the above Agencies in a "Real Application Environment". IGN's participation by productively updating data would benefit to resolve the operational and management issues, and to establish a proper Operation and Management Plan for the basic geographic data.

8. Technology Transfer

8.1. Training in Japan

Table 8 Training Program in Japan

Trainee	Period	Purpose	Contents
Ing.Enrique De La O Lemus	From February 21 to March 21, 2000	Training of digital map production.	Operational practice of scanner. Digitization of topographic maps. Operational practice of Arc/View. Generation of DTM, Generation of Ortho-images. Symbolization of digital data.
Mrs.Yolanda Consuelo Escobar de Rodoriguez	From November 16 to December 15, 2000	Operation and maintenance of digital data.	Operational practice of Arc/Info and Arc/Edit.

8.2. On the Job 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 Rodoriquez
- Ana Silvia Barahona Rivera
- Alex Armado Manzano Bazil
- Luis David Flores Argueta

9. Workshops

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 the data results be available?
2) Will the present intermediate data be 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 the applications of created GIS digital data

Questions and Answers: The same with 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 the digital data be 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.

10. Recommendations

10.1. 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 the both software (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".

10.2. 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 (5,100 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 digital orthophotos is available in some areas. Based on a fresh image sources such as the orthophoto, and satellite imagery, it will be possible to update 1/25,000 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 be occurred. 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 landslip, 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, 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

11. 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

(SUMMARY)

July 2001

PASCO INTERNATIONAL INC.

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PREFACE

In response to the request from the Government of the Republic of El Salvador, the Government of Japan decided to conduct the Study for Establishment of National Basic Geographic Data in the Republic of El Salvador and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Shun Takagi of Pasco International Inc. to El Salvador, five times between March 1999 and July 2001.

The team held discussions with the officials concerned of the Government of El Salvador and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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 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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