4 DATA PREPARATION FOR IIMS

4.1 Preparation of Spatial Data Infrastructure

The GIS data in IIMS comprises both basic geographic map data (called the spatial data infrastructure) and additional data for urban management. The process of preparation of spatial data infrastructure, explained in this section, contains several steps. Firstly, data specification (section 4.1.1) and data contents (4.1.2) are examined. Secondly, basic topographic data including aerial photo survey (4.1.3), land survey (4.1.4) and field survey (4.1.5) are modified. Finally, digitization of the spatial data (4.1.6) is explained.

4.1.1 Examination of Data Specifications

Geographic features to be applied in the IIMS were selected and their data specifications were examined in this study.

The spatial data infrastructure was produced based on a 1:5,000 map. The map scale was selected for the following reasons.

1) A large-scale map is required to manage the detailed and substantial data in a metropolitan area.
2) The 1:5,000 and 1:10,000 scale maps have already been produced in this Study area and many materials are available.
3) The 1:20,000 scale aerial photos taken in 1997 are kept in the DTGC.
4) The digital data based on 1:5,000 scale maps was used for the urban planning.

At the start, the data composition for IIMS was examined. The GIS data should comprise both basic topographic map data and additional data for urban management. The former is called the spatial data infrastructure. Geographic features composing the spatial data infrastructure were selected based on a legend of existing maps. All geographic features on the 1:5,000 topographic map were basically accepted in the spatial data infrastructure. The detail of selected geographic features is explained in the next paragraph.

Secondly, the process to prepare the spatial data infrastructure was examined. The study area was covered by many existing maps and materials. The most suitable process to shorten the preparation term was adopted. As the Cap-Vert District was covered with 1:5,000 scale topographic maps produced in 1981, initial basic data was digitized from existing maps and updated by aerial photos taken in 1997. The data for the rest of the area was acquired by digital mapping. As digital data to make croquis maps by the DTGC was usable for preparing GIS data, maximum usage was attempted.

The croquis maps produced by DTGC in cooperation with IGN France were prepared by digital photogrammetry. However, the work stages of ground control surveying and aerial triangulation were missed out in this project. Plotting was carried out based on the stereo model oriented using existing same scale maps. Geographic features were acquired digitally from these models. The coordinate system adopted was the Expand Lambert System in France and not the Clarke 1880 ellipsoid in Senegal when the data was acquired. Also, the y-coordinate values were moved 1000km to south. Although this data cannot be converted to other geographic coordinates, the figures of geographic feature are applicable. Therefore, conversions were made utilizing judgmental modifications.

Geographic features composed of the spatial data infrastructure were defined as follows.

4.1.2 Spatial Data Infrastructure Contents

1) Built Up Area

Sites containing buildings are represented on a large-scale map as aggregate in the urban area or as independent buildings in the suburban area. Such built sites are classified in existing maps as two categories by general buildings and principal buildings, the latter being large public facilities or bigger individual buildings. Now that spatial data infrastructure is used for urban planning, built sites are divided into settlement area and industry area. Settlement area is then subdivided into 6 categories defined by the DUA and industry area is subdivided into 2 categories.

a) Settlement area

HPAP: Habitat Planife avec Petites Parcelles (planned settlement, small parcel)
HPAG: Habitat Planife avec Grandes Parcelles (planned settlement, large parcel)
HVT: Habitat Vilageois Traditionael (rural settlement)
HI: Habitat Spontane a Treme Reguliere (regular settlement)
HM: Habitat Mixte (commerce residential)
HIR: Habitat Spontane a Trame Irreguliere (irregular settlement)

b) Industry area

-Plant
-Warehouse

Figure 4.1.1 Classification of Settlement Area

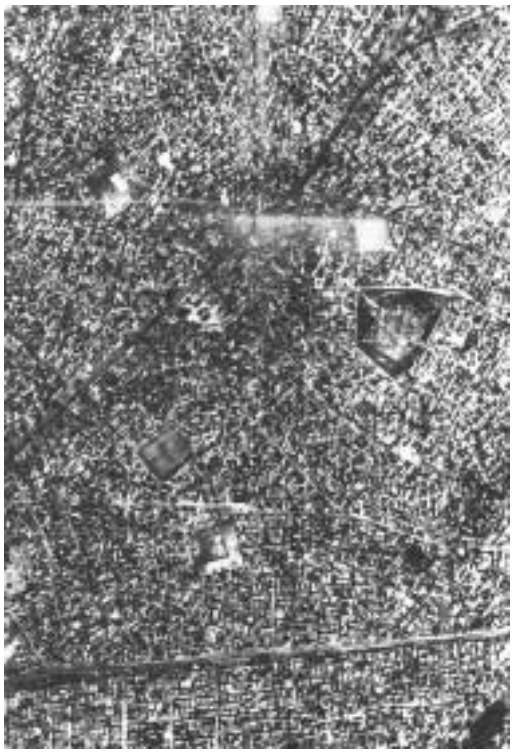
(1) HPAP: Planned settlement with small parcels

(2) HPAG: Planned settlement with big parcels

(3) HVT: Rural settlement

(4) HI: Regular settlement

(5) HM: Mixed settlement s (with administrative or commercial land use)



(6) HIR: Irregular settlement

2) Administration

Administration in Senegal is composed of region, Department and Commune d'Arrondissment hierarchically. The study area belongs to Dakar Region, which has 3 Departments. Departments are composed of several Commune d'Arrondissments.

Boundary of Commune d'Arrondissments therefore should be defined first. Administrative boundaries of Departments and Regions are derived as aggregates of Commune d'Arrondissments.

3) Electric power line

Power lines are an essential element of basic infrastructure as well as water supply and sewerage. High and middle voltage power lines are represented on the existing maps. Therefore power lines were acquired in GIS data.

4) Road and Railroad

Roads are classified into 4 categories by administrative rank in DTP-MET, such as national, regional, department and roads in city. Farm roads were also added. Roads in city and farm roads were acquired as the main ones. Center lines of roads were acquired as network.

Railroads also were acquired as line data. Railroads are classified by main lines and branch lines for plants and port. Railroad stations are classified by station and halt are also acquired.

5) Vegetation

Areas of vegetation are acquired classified by 4 categories; such as Forestry, Swamp area, Grassland and Farmland.

6) Water Surface

Water surface is composed of sea, lakes and rivers. The sea data is acquired to encircle by coast and the border of the study area as polygon data. Rivers are acquired as line data in case of narrow stream, as polygon data in case of wide.

7) Topography

Topography is represented as 2 meter interval contour lines in the existing maps. In GIS, grid data is most useful for identifying topographical features, and analyzing ground undulation or inclination. Accordingly, in this study, 10 meter interval grid data is prepared as Digital Terrain Models (DTM)

8) Control Points

There are two types of control points: triangulation control and benchmark. All control points administrated by DTGC are prepared as control point data. Additional control points surveyed in this study are also added. The coordinates and elevation are added as attributes of control points. Image data is also useful to establish where control points are, thus photographs are added as an attribute.

9) Public Facilities

Public facilities are acquired classified by 12 categories;

- Government Office
- International Organization
- Embassy
- Education; elementary school, secondary school, high school, university and others
- Health Facility; Hospital, Health Center, Health Post, and others.
- Security; Military, Police, Fire Station, and others.
- Sports; Golf course and Play ground.
- Culture; Museum, Theater and others.
- Tourism; Hotel
- Information; Post office and others
- Religion; Mosque, Church and Cemetery.
- Market;

10) Orthophoto

Aerial photographs are most useful for understanding land cover information. Accordingly, orthophotos derived from aerial photographs are added. Orthophoto images are divided into each sheet numbered and named. The coordinates of four corners is added so that image data can be geocoded easily.

11) Annotation

Annotations are also very useful information in the map. However, geographic features in GIS have information on both figure and attribute. Annotations are stored as one of attributes, therefore annotations were not acquired as an item of geographic feature in this study.

4.1.3 Aerial Photo Prints

The aerial photos were reprinted as the materials to create the spatial data infrastructure. For reprinting these photos, the negative films of the photos were

used which were taken by the IGN France in 1997 and had been kept by the DTGC. There are a total of 70 sheets of aerial photos for 5 strips including the Study Areas.

The following materials were prepared:

1) Contact prints: 70 sheets
   Used for the field survey and leveling.
2) Positive films: 70 sheets
   Used for the aerial triangulation and orthophoto production.
3) Quadruple-enlarged aerial photos: 70 sheets
   Used for the field survey and photo interpretation.
4) Quadruple-enlarged partial photos: 27 pairs
   Used for pricking the control points.

In reprinting these photos, the materials carried from Japan and the equipment possessed by the DTGC were used and the photo processing work was carried out Senegalese engineers. The Study Team received the final results of this work after having confirmed that these photos have the quality to allow them to be used for the subsequent work.

Instruments used:
- Contact Printer
- Rectifier, Zeiss-SEG6

In addition, the existing topographic maps were also reprinted (Refer to the map sheet index as attached hereto).

5) 1:5,000 topographic maps (made in 1981): 21 sheets
   Prepared by the 1:20,000-scale aerial photos taken in 1981.
6) 1:1,000 topographic maps (made in 1981): 30 sheets
   Prepared by the 1:6,000-scale aerial photos taken in 1981.
7) 1:10,000 draft maps (made in 1998): 8 sheets
   Prepared by the 1:20,000-scale aerial photos taken in 1997.
8) 1:5,000 draft maps (made in 1997): 6 sheets
   Prepared by the 1:20,000-scale aerial photos taken in 1997.

4.1.4 Ground Control Survey

The ground control survey was carried out to implement the aerial triangulation. The ground control survey consists of the control survey to orient the horizontal position of a control point and the leveling to orient its elevation.

(1) Control Point Survey

For orientation of the horizontal position, the GPS survey was made using a GPS receiver. In Senegal, two coordinate systems are used; one is the coordinate system having the datum point at ADINDAN (located at the border between Sudan and Egypt) and the other is the System 74 having the datum point at HANN (Senegalese DTGC). In the case of connecting to the international survey network, the ADINDAN coordinate system is used, and this system is used in the 1:50,000 topographic maps. The System 74 is used for large-scale mapping of the Cap-Vert District in Dakar, and this coordinate system is used in 1:5,000-, 1:2,000- and 1:1,000-scale maps. In this Study, the 1:5,000-scale topographic maps were used as the basic maps, so that the System 74 was adopted for mapping.

- Geodesic System: System 74
- Reference ellipsoid: CLARKE 1880
- Projection: UTM projection
- Datum point: No. 202 (the lightning rod on the rooftop of the building of "Le Soleil" in Hann)

Geographical coordinates:	N 14˚ 43' 16.6"
	W 17˚ 26' 18.6"
UTM coordinates:	X 237431.50
	Y 1628774.53 (unit: m)

As the final results of the ground control survey, the results of the measurements made for the period from 1933 to 1939 and recalculated in 1974 were used. In the years of 1980 to 1981, the 5-order control points were established in Goree Island and in the north of Rufisque. These points were obtained by the method of intersecting from the existing points. In addition, there is a result of the 12th parallel survey that was made in the years of 1968 to 1970. These survey results were used as the existing control points in the Dakar Metropolitan Area.

As described above, there are a number of control points established in the Study Areas. These existing control points were used at first, additional control points were established for higher accuracy, and it was planned to implement the aerial triangulation using the aerial photos taken in 1997. However, the verification survey of the existing control points was made and some control points with a large errors were found. Then, all the control points necessary for aerial triangulation were re-measured by GPS survey. The re-measured control points were pricked on the aerial photos. For the control points that could not be pricked on the aerial photos, the features that could be interpreted on the photos clearly were pricked, and their positions were obtained by the eccentric survey using the plane table

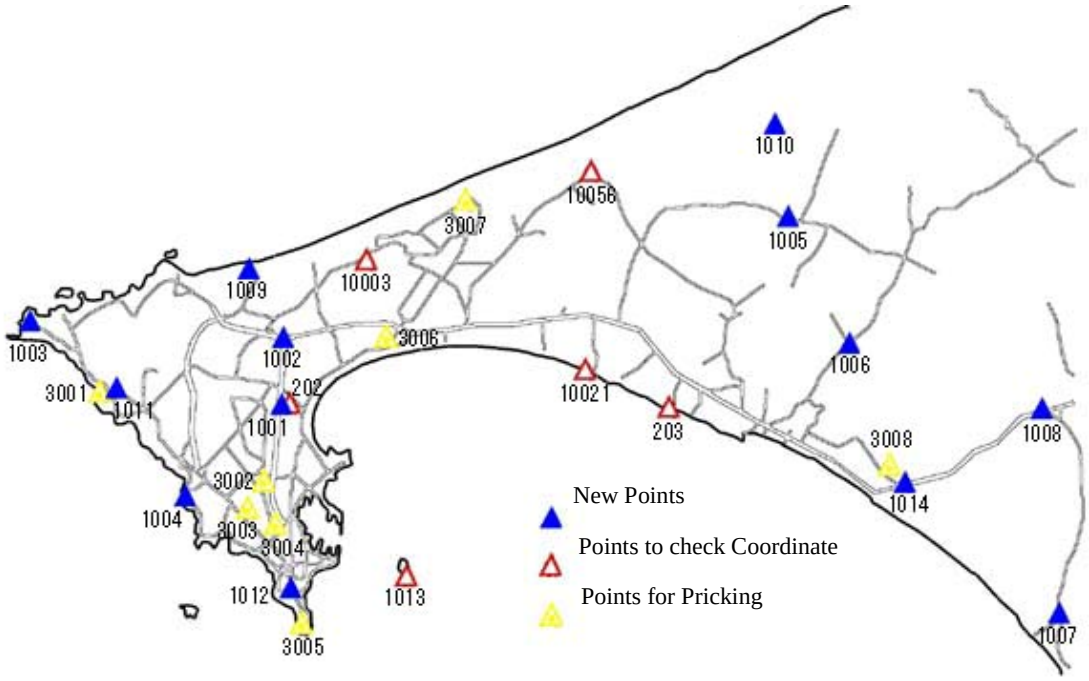
survey. The existing control points whose coordinates could not be fixed were pricked and surveyed for verification in the aerial triangulation.

17 control points for which GPS survey was made are shown in Figure 4.1.2.

- New GPS-surveyed points: 13 points
- Existing control points with the fixed coordinates: 6 points
- Pricked control points: 8 points

The GPS survey was carried out to ensure that a survey net was configured. The closure error in each loop was obtained to check its accuracy. Then, the closure error was checked to ensure it did not exceed the criteria.

Figure 4.1.2 Control Points



Source: JICA Study Team

Table 4.1.1 Closure Error of GPS Observation

	Closure Error (m)		
	dx	dy	dz
NET 1	0.187	-0.067	0.056
NET 2	0.032	-0.019	0.002
NET 3	0.002	-0.066	0.009
NET 4	-0.067	0.067	0.023
NET 5	-0.044	0.053	-0.031
NET 6	-0.043	0.013	-0.155
NET 7	0.079	-0.053	-0.067

Source: JICA Study Team

Note: 1) NET is defined as a network string of observed sides between each control point. (Refer to Volume II, Table A2.2.

NET1：202>1001>1002>200>200>1003>1004>1012>202

NET2：202>1011>1004>202

NET3：202>1012>1013>10021>202

NET4：202>10021>203>1006>1005>10056>10003>1009>202

NET5：202>10021>203>1010>202

NET6：203>1007>1008>1006>203

NET7：202>1001>1002>200>1003>1004>1012>1013>10021>203>1007>1008>1006>1005>10056>10003>1009<202

2) Each number corresponds to the number of Control points.

3) NET7 is composed of Net1, Net3, Net4 and Net6.

(2) Leveling

In Cap-Vert District in Dakar, there are routes for which the 1st order leveling was carried out in the years of 1952 to 1954 and routes for which the 4th order leveling was made in the years of 1980 and 1981. In this Study, the vertical control survey necessary for aerial triangulation was conducted by using the existing bench marks in these routes. These routes where the leveling was made are shown in Figure 4.1.3. The points at which their elevation was measured were pricked on the contact prints of the aerial photos and the elevation values were entered in the prints, which were prepared as the materials for aerial triangulation. The 5th order leveling was carried out in cooperation with Senegalese engineers, and the Study Team received the results after having checked that those closure errors did not exceed the criteria.

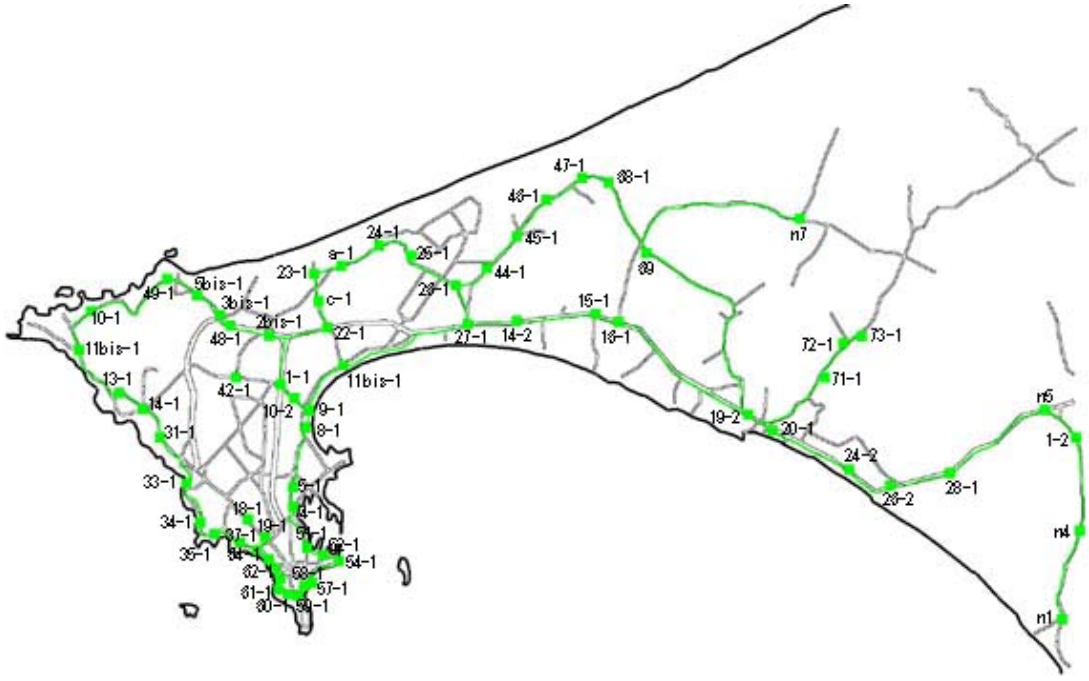
Equipment used

Level: WILD NAK2 S/N410028

NK2 S/N112175

Staff: Wooden 4 m

Figure 4.1.3 Leveling Routes for the 5th Order Leveling Implemented



Source: JICA Study Team

(3) Field Identification

A field survey was carried out to check the map data, prepare the statistical data, etc. In addition to checking the plotting area within the scope of the survey from existing maps collected, the year the maps were made was checked and the state of secular changes understood. Comparing the 1:5,000 topographical map made in 1981 and the present day, it is clear that farmland and wasteland in the suburbs have been turned into residential land and the city has expanded, and major changes have taken place over the years. Compared with aerial photos taken in 1997, over the intervening two years there has been a number of new houses built on vacant land in urbanized districts. Some principle building were acquired in field identification. It was felt that there has been a great transformation in districts where housing development is taking place, but construction is still under way and it will be more effective to update the data en masse after completion. If planning materials and maps can be obtained, they can be used to prepare spatial data. It was decided to prepare a spatial data infrastructure using aerial photos taken in 1997. Existing materials relating to public equipment already collected were prepared in 1982 and are out of date, and field checks highlighted the need for their renewal. Also, regarding the annotations incorporated in digital maps prepared by the DTGC, field

checks showed a disparity in the details and quality. As GIS requires data of uniform quality, it was decided to carry out a field survey using aerial photos, and to obtain the location and names of new public facilities from the survey.

4.1.5 Field Survey

A field survey was carried out to confirm the position, classification and name of the geographic features to prepare data for GIS. A database of facilities was prepared in advance of the field survey based on documents collected beforehand. The data was plotted on 4-times enlarged aerial photos that were brought to the field to confirm the references. The facilities database was updated with information confirmed during the field survey, and the correct positioning plotted on the 1:5,000 or 1:10,000 existing maps. There was a flood during the field survey, and consequently some flooded sites were surveyed.

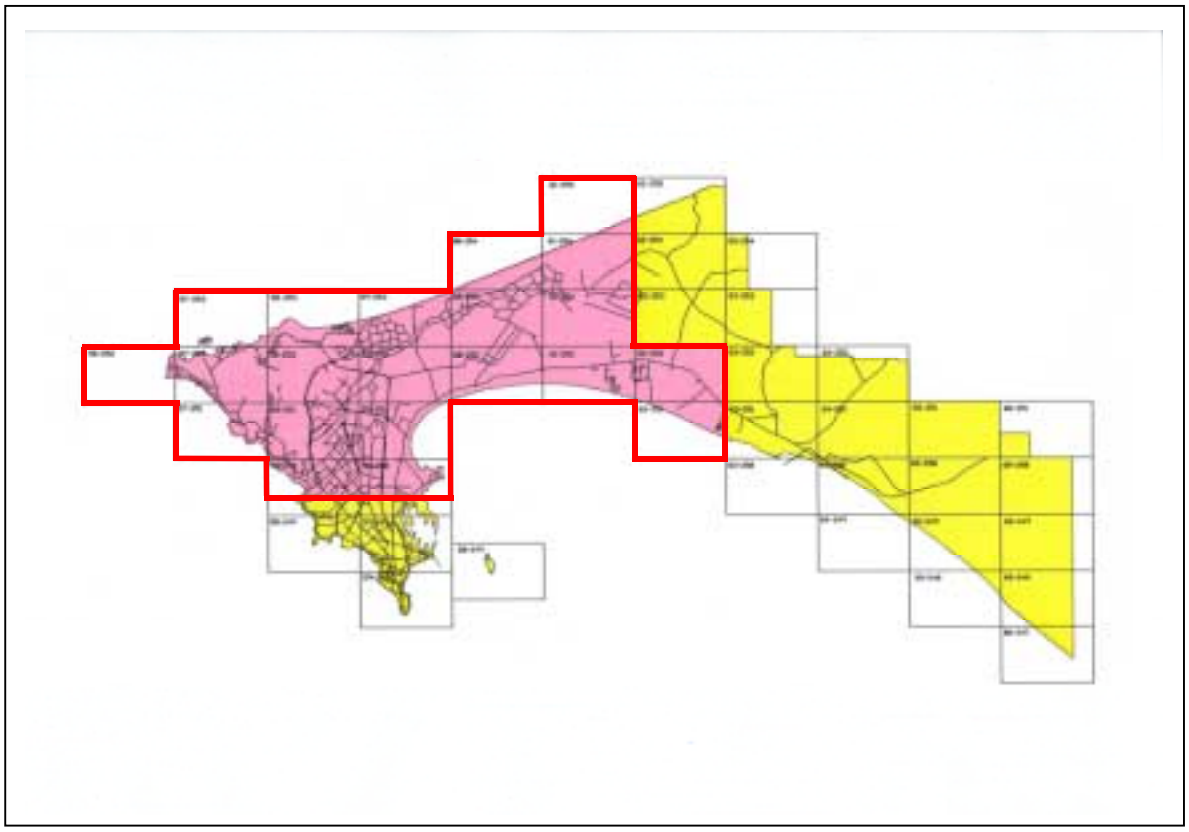
4.1.6 Digital Mapping Preparation

(1) Digitizing Existing Maps

In order to prepare the spatial data infrastructure, the 21 sheets of the existing 1:5,000 topographic maps covering an area of about 80 square km were converted to raster image with a scanner and recorded on CD-ROMs. Raster image data was displayed on the monitor, and vector data of the geographic features was digitized using the Micro/Station graphical data acquisition system. Since these maps were produced in 1981, the details are largely outdated and many geographic features have changed since then. The following geographic features that were available from existing data listed below and other geographic features were acquired during subsequent update mapping:

1) Built-up area: building
2) Electricity: power line
3) Road and railroad: road and railroad
4) Vegetation: boundary of vegetation
5) Water surface: river
6) Topography: spot height

Figure 4.1.4 Mapping Area



Digitized area from existing maps

Digital mapping area

Source: JICA Study Team

(2) Aerial Triangulation

In order to determine orientation parameters of all aerial photos taken in 1997, aerial triangulation was carried out over the entire area, and the orientation parameters of each aerial photo and the coordinates of pass-point and tie-point were determined.

As the Study Area is a peninsula, many photos contain sea area, so some models formed from these aerial photos became incomplete models. It was very difficult to solve block adjustment using the bundle adjustment programme. Finally, the software of independent model block adjustment (PAT-M produced by Zeiss, Germany) was applied to determine the parameters.

The final result was achieved and the document prepared.

(3) Digital Mapping of Study Area

The geographic features of the area missing from the existing maps were acquired by digital mapping. This area covered 120 square km.

1) Analogue/Digital (A/D) Conversion of Aerial Photos

In plotting by digital plotter, positive films were converted to raster image data using a scanner. The resolution of scanning was 20 micron. Seventy sheets of positive film were converted and recorded on CD-ROMs.

2) Preparation of DTM

By using image data and orientation parameters, each stereo model was oriented using digital plotter. The DTM was generated automatically by a DTM generation program. Contour lines generated from DTM were displayed on the monitor, and observed elevations were checked and corrected.

3) Preparation of Digital Orthophoto

By using image data, DTM and orientation parameters, digital orthophoto was prepared with a digital plotter. Each orthophoto was combined, adjusted for color tone and divided into each sheet. Prepared orthophoto was re-sampled in 50-micron resolution and recorded on CD-ROMs.

4) Digital Mapping and Compilation

Digital mapping was carried out in the Study Area that was missing from existing maps, covering about 120 square km. By displaying orthophoto image on the monitor, geographic features composing spatial data infrastructure were acquired as vector data on the monitor screen.

5) Digital update mapping and compilation

Update mapping was also carried out in the area digitized by existing maps.

By displaying orthophoto image and superimposing digitized vector data from existing maps on the monitor, geographic features were updated and newly acquired.

Spot heights acquired from the existing maps and spot heights observed by stereo model were used to collect initial DTM data. Contour lines generated from DTM were displayed on the monitor, and DTM was checked and corrected using spot heights.

(4) Data Correction

The digitized and mapping data were unified, then compiled according to the specification of the spatial data infrastructure. Prepared geographic features were converted to conform to such data structure as point, line and polygon.

(5) Field Correction

The spatial data infrastructure was prepared by digitizing the existing maps and mapping from digital orthophoto made during the work in Japan. During mapping of the spatial data infrastructure, some features could not be plotted because of uncertain features and unclear images. In order to prepare the accurate spatial data infrastructure the field correction was carried out in cooperation with Senegalese engineers. The conducted field correction for each geographic feature is as follows.

1) Built Up Area

Built up area was classified according to definition by specification. Some area of uncertain classification were verified.

2) Administration

Initial administrative boundaries of Commune d'Arrondissments were acquired from materials of DAT. Each administrative area of Departments and Regions was derived as aggregates of Commune d'Arrondissments. The unclear administrative boundary in the Commune of Bargny was confirmed in consultation with the DAT. It was also confirmed that the Commune de Bargny is not divided into Communes d'Arrondissement.

3) Electricity

The additional electricity network data constructed recently, was prepared by digitizing the new power line map of the SENELEC.

4) Road and Railroad

Name and code number of roads were added as an attribute. As the information of other attributes (width, pavement and so on) could not be collected completely, collected data was partly added.

5) Vegetation

As the vegetation could hardly be distinguished on the aerial photos, the definition was made as follows and boundaries of vegetation were acquired:

- Forestry: including trees and shrubs of which canopy are more than 50 percent;
- Swamp: wet land;
- Grass Land: including grass, shrub and waste land of which canopy are less than 50 percent;
- Farm Land: cultivated land, especially rice fields and fruit farms as gardens are not distinctive;
- Open Space: open space around housing sites; and
- Dune: sand area along the coast.

6) Water Surface

Names of rivers, canals and lakes were added as attributes.

7) Topography

The topography was represented by the DTM at intervals of 10 meter covering the study area. The DTM at intervals of 100 meter for GIS data was prepared later.

8) Control Points

The control points surveyed in this study were prepared as control point files with photo image to identify control points. As documents of other triangulation points stored in DTGC were acquired, data for these control points were added too.

9) Public Facilities

All the public facilities were verified for their location, types of facility, classification and names based on field survey.

10) Orthophoto

The orthophoto was prepared for geocoding from aerial photos at a resolution of 25-micron (50-centimeter resolution on ground) and divided into the sheet sizes of 1:5,000 scale map. The sheets of new 1:5,000 map were named and each orthophoto was given a sheet number and a sheet name.

4.2 Preparation of GIS Data

An inventory of the GIS data layers was developed for the IIMS system including the spatial data infrastructure. Section 4.2.1 combines both the spatial data infrastructure and additional data related to urban planning. The inventory is arranged using a set of classification developed for the IIMS and explained in the latter part of this section. Section 4.2.2 explains how the data was processed by the study team in order to fit the system.

4.2.1 Selection of GIS Data

A GIS data layer has been defined for each classification shown in Table 4.2.1 as "Data for IIMS". This table contains the spatial data infrastructure and the other GIS data. The contents of each layer is also explained.

Table 4.2.1 Spatial Data Infrastructure and Structure of Data

	Code	Layer of Geographic Feature	Class of Geographic Feature	Sub-Class of Geographic Feature	Data Structure
1	100	Built up area			
2	101		Settlement	Rural Settlement	Polygon
3	102			Settlement Regular	Polygon
4	103			Settlement Irregular	Polygon
5	104			Planned Settlement (middle)	Polygon
6	105			Planned Settlement (high)	Polygon
7	106			Commerce & Residence	Polygon
8	107		Industry	Plant	Polygon
9	108			Warehouse	Polygon
10	200	Administration			
11	201		Administrative	Ward	Polygon
12	202		boundary	Ward	Polygon
13	203			Village	Polygon
14	204			Department	Polygon
15	205		Qartier	Qartier	Point
16	210		Administrative		
17	211		boundary1981	Zone	Polygon
18	300	Basic infrastructure			
19	301		Electricity	High voltage line	Line
20	302			Middle voltage line	Line
21	303			Low voltage line	Line
22	303			Equipment	Polygon

Table 4.2.1 Spatial Data Infrastructure and Structure of Data (Continued)

	Code	Layer of Geographic Feature	Class of Geographic Feature	Sub-Class of Geographic Feature	Data Structure
23	304		Water supply	Water pipe	Line
24	305			Equipment	Polygon
25	306			Community tap	Point
26	307		Sewerage	Main Sewer pipe	Line
27	308			Sub-Sewer pipe	Line
28	309			Sewer pipe	Line
29	310			Equipment	Polygon
30	311		Drainage	Drain	Line
31	312			Drain pipe	Line
32	400	Road/Rail way			
33	401		Road	National Road	Line
34	402			Region Road	Line
35	403			Department Road	Line
36	404			Road in city	Line
37	405			Farm road	Line
38	406		Railway	Railway	Line
39	407			Railway Station	Line
40	408		Bus	Bus-Route	Line
41	409			Bus Terminal	Polygon
42	410		Garbage	Garbage Collection Route	Line
43	411			Garbage container	Point
44	500	Vegetation			
45	501		Vegetation	Forestry	Polygon
46	502			Swamp area	Polygon
47	503			Grassland	Polygon
48	504			Farmland	Polygon
49	600	Water surface			
50	601		Water surface	Sea	Polygon
51	602			Lake	Polygon
52	603			River	Polygon
53	604			River	Line
54	700	Topography			
55	701		Topography	DTM (10m)	Grid
56	800	Control Points			
57	801		Control Points	Triangulation Point	Point

Table 4.2.1 Spatial Data Infrastructure and Structure of Data (Continued)

	Code	Layer of Geographic Feature	Class of Geographic Feature	Sub-Class of Geographic Feature	Data Structure
58	802			Bench Mark	Point
59	900	Public Facilities			
60	901		Public	Public agency	Polygon
61	902		Facilities	International Organization	Polygon
62	903			Embassy	Polygon
63	904			Education	Polygon
64	905			Health Facility	Polygon
65	906			Security	Polygon
66	907			Sports	Polygon
67	908			Culture	Polygon
68	909			Tourism	Polygon
69	910			Information	Polygon
70	911			Religion	Polygon
71	912			Market	Polygon
72	1000	Orthphoto			
73	1001		Orthophoto	Orthphoto	Image
74	1200	Land Use	Land Use	Present land use map 1999	Polygon
75	1300			Urban Activity	Polygon
					Point
76	1400			Type of settlement	Polygon
77	1500			Spatial Structure	Polygon
78	1600			Past project and feature project	Polygon
					Line
79	1700			Potential of Site	Polygon
					Line
80	1800			Urban Equipment	Polygon
					Line
					Point
81	1900			Present land use map 1987	Polygon
					Line
					Point
82	2000			Land development framework	Polygon
				for 2021	Line
83	2100			Spatial development history	Polygon
84	2200			Occupation du SOL	Polygon
					Line

Table 4.2.1 Spatial Data Infrastructure and Structure of Data (Continued)

	Code	Layer of Geographic Feature	Class of Geographic Feature	Sub-Class of Geographic Feature	Data Structure
85	2300		Zoning	Flight control area	Polygon
86	2400			Zoning map for building control	Polygon
87	2500	Natural	Topography	DTM (100m)	Grid
88	2501			Slope map	Grid
89	2502			Relief map	Grid
90	2503			Depression	Grid
91	2600			Land form map	Polygon
					Line
					Point
92	2700		Soil	Agriculture potential map	Polygon
93	2800			Soil map	Polygon
					Point
94	2900			Soil degradation map	Polygon
95	3000		Hydrology	Water resource map	Polygon
96	3100		Natural Disaster	Inundation	Polygon
97	3200		Conservation	Protection area map	Polygon
98	3300	Land price	Land price	Land price map	Polygon
99	3400	Tourism	Tourist site	Tourist information map	Point
100	3500	Statistic Data	Population data		
101	3501			- Population data in 1996	
102	3502			- Population data in 1996	
103	3600		PDU of Dakar 2001 in 1982(DUA-MUH)		
104	3601			- Population data (Distribution of population in 1980, household survey in August 1980)	
105	3602			-Employment (population by employment, number of employees)	
106	3603			- Level of comfort utilities	
107	3604			- Construction methods	
108	3605			- Density of housing per ha and per habitat	
109	3606			- Enrolment ration in schools	
110	3607			- Public and private primary schools	
111	3608			- Public and private secondary schools	
112	3609			- Primary health centers and clinics	
113	3610			- Security, fir station, courthouse	
114	3611			- Movie theater, sports facilities	
115	3612			- Tourism facilities	
116	3613			- Information facilities	
117	3700		Land price in the official gazette in December 1989		

Source: JICA Study Team

1) Built up area

   Import from the spatial data infrastructure.

2) Administration

   Import from the spatial data infrastructure.

3) Basic infrastructure

   Basic infrastructure is composed of electricity, water supply, sewerage and drainage. Although electricity is imported from the spatial data infrastructure, data of other basic infrastructure are converted from the materials.

4) Road/Rail road

   Import from the spatial data infrastructure.

5) Vegetation

   Import from the spatial data infrastructure.

6) Water surface

   Import from the spatial data infrastructure.

7) Topography

   Import from the spatial data infrastructure.

8) Control point

   Import from the spatial data infrastructure.

9) Public facility

   Import from the spatial data infrastructure.

10) Orthophoto

    Import from the spatial data infrastructure.

11) Others

Others contain the Study area boundary data and map sheet information of 1:5,000 topographic map.

12) Land use

Land use layer contains each class of Land use and Zoning for building permission control.

13) Natural

Natural layer contains each class of Topography, Soil, Hydrogy, Natural disaster and Conservation.

Topography class is composed of 100m gridded data, Slope map, Relief map, Depression map, Aspect map, Run off map, Toposhape map, Watershed map, Counter map and Land form map.

Soil class is composed Agriculture potential map, soil map and Soil degradiation map.

Hydrogy class is composed of Water resource map

Natural disaster class is composed of Inondation .

Conservation class is composed of Natural protection map

14) Land price

Land price class is composed of Land price map.

15) Tourism

Tourism class is composed of tourist site with photo image.

16) Static Data

Static data contains three classes which class are population data class, Urban developing Project(PDU) of Dakar 2001 class and Land price class in December 1989.

Population data class is composed of Population data in 1996 and 1998.

The details of class and sub class are referred to Table 4.2.2.

4.2.2 Processing of the Other GIS Data for IIMS

Necessary data was selected from that identified by the data inventory survey (see Table 3.4.2), and processed into IIMS data in the following ways. The majority of the digital data was difficult to convert, while some of the field survey data was converted more easily.

(1) Those available as digital data

These are converted into the format of GeoConcept, which is the basic GIS software used for IIMS. This data includes water supply, sewerage, drainage, electricity, road network, and garbage collection service.

(2) Those available as paper thematic maps

These thematic maps were digitized via the scanner and digitizer, which were supplied by this study. They include administrative boundary, sewerage and drainage, electricity, and land use plan.

(3) Those available as statistic data

These were tabulated with personal computers in a form that can be used in IIMS. These are statistic data of population and demography.

(4) Those made by the survey of the Study Team

Some data was made or reinforced by surveys carried out by the Study Team. They include data on public facilities and public bus routes.

(5) Those digitally processed from the spatial data infrastructure

These include present land use, 100 meter DTM and topographical conditions.

Table 4.2.2 Selected Geographic features and Data structure for GIS

	Code	Layer of Geog. Feature	Class of geog. feature	Sub-Class of geog. feature	Data Structure	Attribute							Data Source
						Length	Area	Name	Field1	Field2	Field3	Field4	
1	100	Built up area											
2	101		Settlement	Rural Settlement	Polygon		Area						Definition by DUA
3	102			Settlement Regular	Polygon		Area						Classified by photo-interpretation
4	103			Settlement Irregular	Polygon		Area						
5	104			Planned Settlement (middle)	Polygon		Area						
6	105			Planned Settlement (high)	Polygon		Area						
7	106			Commerce & Residence	Polygon		Area						
8	107		Industry	Plant	Polygon		Area	Name					
9	108			Warehouse	Polygon		Area	Name					
10	200	Administration											
11	201		Administrative boundary	Ward	Polygon		Area	Name	Region	Department	Vill.	Ward	ADM and DTP
12	202			Ward	Polygon		Area	Name	Region	Department	Vill.		
13	203			Village	Polygon		Area	Name	Region	Department			
14	204			Department	Polygon		Area	Name	Region				
15	205		Qartier	Qartier	Point			Name					
16	210		Administrative										DUA
17	211		boundary1981	Zone	Polygon		Area	Name	Zone number				
18	300	Basic infrastructure											
19	301		Electricity	High voltage line	Line	Length			Voltage				ADM and SENELEC
20	302			Middle voltage line	Line	Length			Voltage				
21	303			Low voltage line	Line	Length							
22	303			Equipment	Polygon			Name					
23	304		Water supply	Water pipe	Line	Length							ADM
24	305			Equipment	Polygon			Name					
25	306			Community tap	Point				Classification Code				ADM,DUA
26	307		Sewerage	Main Sewer pipe	Line	Length			Diameter	Type			ADM and ONAS
27	308			Sub-Sewer pipe	Line	Length			Diameter	Type			
28	309			Sewer pipe	Line	Length			Diameter	Type			
29	310			Equipment	Polygon			Name	Diameter	Type			
30	311		Drainage	Drain	Line	Length		Name					
31	312			Drain pipe	Line	Length		Name	Diameter	Type			
32	400	Road/Rail way											
33	401		Road	National Road	Line	Length		Name	Code Name	Width	Surface		RD
34	402			Region Road	Line	Length		Name	Code Name	Width	Surface		
35	403			Department Road	Line	Length		Name	Code Name	Width	Surface		
36	404			Road in city	Line	Length		Name	Code Name	Width	Surface		
37	405			Farm road	Line								

Table 4.2.2 Selected Geographic features and Data structure for GIS (Continued)

	Code	Layer of geog. Feature	Class of geog. feature	Sub-Class of geog. feature	Data Structure	Attribute							Data Source
						Length	Area	Name	Field1	Field2	Field3	Field4	
38	406		Railway	Railway	Line	Length		Name	Main/Branch				photo
39	407			Railway Station	Line	Length		Name	Gare/Halt				interpretation
40	408		Bus	Bus-Route	Line	Length		Name					CETUD
41	409			Bus Terminal	Polygon		Area	Name					
42	410		Garbage	Garbage Collection Route	Line	Length							CUD
43	411			Garbage container	Point				Classification Code				ADM
44	500	Vegetation											
45	501		Vegetation	Forestry	Polygon		Area	Name					The study team
46	502			Swamp area	Polygon		Area	Name					
47	503			Grassland	Polygon		Area	Name					
48	504			Farmland	Polygon		Area						
49	600	Water surface											
50	601		Water surface	Sea	Polygon		Area						
51	602			Lake	Polygon		Area	Name					
52	603			River	Polygon		Area	Name					
53	604			River	Line	Length		Name					
54	700	Topography											
55	701		Topography	DTM (10m)	Grid								
56	800	Control Points											DTGC
57	801		Control Points	Triangulation Point	Point			Name	Image	X	Y	H	
58	802			Bench Mark	Point			Name	Image	X	Y	H	
59	900	Public Facilities											
60	901		Public	Public agency	Polygon		Area	Name					Field Survey of the Study
61	902		Facilities	International Organization	Polygon		Area	Name					team
62	903			Embassy	Polygon		Area	Name					
63	904			Education	Polygon		Area	Name	Section				
64	905			Health Facility	Polygon		Area	Name	Section				
65	906			Security	Polygon		Area	Name	Section				
66	907			Sports	Polygon		Area	Name	Section				
67	908			Culture	Polygon		Area	Name	Section				
68	909			Tourism	Polygon		Area	Name	Section				
69	910			Information	Polygon		Area	Name	Section				
70	911			Religion	Polygon		Area	Name	Section				
71	912			Market	Polygon		Area	Name					
72	1000	Orthophoto											
73	1001		Orthophoto	Orthophoto	Image			Name of sheet	No. of Sheet				The study team

Table 4.2.2 Selected Geographic features and Data structure for GIS (Continued)

	Code	Layer of geog. feature	Class of geog. feature	Sub-Class of geog. feature	Data Structure	Attribute							Data Source
						Length	Area	Name	Field1	Field2	Field3	Field4	
74	1200	Land Use	Land Use	Present land use map 1999	Polygon		Area		Year				The study team
75	1300			Urban Activity	Polygon		Area		Classification Code				Dakar 2001
					Point				Classification Code				
76	1400			Type of settlement	Polygon		Area		Classification Code				Dakar 2001
77	1500			Spatial Structure	Polygon		Area		Classification Code				Dakar 2001
78	1600			Past project and feature project	Polygon		Area		Classification Code				Dakar 2001
					Line				Classification Code				
79	1700			Potential of Site	Polygon		Area		Classification Code				Dakar 2001
					Line				Classification Code				
80	1800			Urban Equipment	Polygon		Area		Classification Code				Dakar 2001
					Line				Classification Code				
					Point				Classification Code				
81	1900			Present land use map 1987	Polygon		Area		Classification Code				Dakar 2001
					Line				Classification Code				
					Point				Classification Code				
82	2000			Land development framework for 2021	Polygon		Area		Classification Code				DAT
					Line				Classification Code				
83	2100			Spatial development history	Polygon		Area		Classification Code				Dakar 2001
84	2200			Occupation du SOL	Polygon		Area		Classification Code				Dakar2001
					Line				Classification Code				
85	2300		Zoning	Flight control area	Polygon		Area		Classification Code				Dakar 2001
86	2400			Zoning map for building control	Polygon		Area		Classification Code				Dakar 2001
87	2500	Natural	Topography	DTM (100m)	Grid				Classification Code				The study team
88	2501			Slope map	Grid				Classification Code				The study team
89	2502			Relief map	Grid				Classification Code				The study team
90	2503			Depression	Grid				Classification Code				The study team
91	2600			Land form map	Polygon		Area		Classification Code				Dakar2001
					Line				Classification Code				
					point				Classification Code				
92	2700		Soil	Agriculture potential map	Polygon		Area		Classification Code				DAT
93	2800			Soil map	Polygon		Area		Classification Code				DAT
					point				Classification Code				
94	2900			Soil degradation map	Polygon		Area		Classification Code				DAT

Table 4.2.2 Selected Geographic features and Data structure for GIS (Continued)

	Code	Layer of geog. feature	Class of geog. feature	Sub-Class of geog. feature	Data Structure	Attribute							Data Source
						Length	Area	Name	Field1	Field2	Field3	Field4	
95	3000		Hydrology	Water resource map	Polygon		Area		Classification Code				DAT
96	3100		Natural Disaster	Inondation	Polygon		Area		Year				ONAS, The study team
97	3200		Conservation	Protection area map	Polygon		Area		Classification Code				The study team
98	3300	Land price	Land price	Land price map	Polygon				Sector name	Code	Description	Land price	Land price list (MEEP)
99	3400	Tourism	Tourist site	Tourist information map	Point				Location name	Code	Description	Photo	
100	3500	Statistic Data	Population data										
101	3501			- Population data in 1996									Le Soleil in 1996
102	3502			- Population data in 1996									ADM in 1998 (CETUDE)
103	3600		PDU of Dakar 2001 in 1982(DUA-MUH)										
104	3601			- Population data (Distribution of population in 1980, household survey in August 1980)									
105	3602			-Employment (population by employment, number of employees)									
106	3603			- level of comfort utilities									
107	3604			- construction methods									
108	3605			- density of housing per ha and per habitat									
109	3606			- enrolment ration in schools									
110	3607			- public and private primary schools									
111	3608			- public and private secondary schools									
112	3609			- primary health centers and clinics									
113	3610			- security, fir station, courthouse									
114	3611			- movie theater, sports facilities									
115	3612			- tourism facilities									
116	3613			- information facilities									
117	3700		Land price in the official gazette in December 1989										MEEP

Source: JICA Study Team