Islamic Republic of Mauritania
Ministry of Habitat, Urbanism and Land Development
Direction of Cartography and Geographic Information

THE STUDY ON FORMULATION OF GEOGRAPHIC DATABASE OF NOUAKCHOTT IN THE ISLAMIC REPUBLIC OF MAURITANIA

FINAL REPORT
(Summary)

June 2010

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PASCO CORPORATION
ASIA AIR SURVEY CO., LTD.

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Currency Equivalents

Currency Unit : Mauritania Ouguiya (MRO)

1 EUR = 336.046 MRO (Interbank Rate May 13, 2010)

1 EUR = 117.65 YEN (Interbank Rate May 13, 2010)

PREFACE

In response to the request from the Government of the Islamic Republic of Mauritania, the Government of Japan decided to conduct “the Study on Formulation of Geographic Database of Nouakchott” and entrusted the study to the Japan International Cooperation Agency (JICA).

The JICA organized the study team headed by Mr. Eisaku Tsurumi of Pasco Corporation in association with Asia Air Survey Co., Ltd. and dispatched it to Mauritania eight times from April 2007 to April 2010.

Having discussions with the Ministry of Habitat, Urbanism and Territorial Development, Ministry of Environment, Nouakchott City and other organs, the study team formulated the digital geographic database of Nouakchott and conducted technology transfer to the technical staff of Mauritania.

More than 30 stakeholder meetings were held to collect information from various organs concerned during the period; and a seminar in the final stage of the study was held to diffuse the database utilization. After then, the team finalized this report in Japan.

I hope that the database would contribute to rehabilitation and development of Nouakchott and the transferred technologies would be fully utilized for maintaining the database and distributing the data to the public. I also hope that this report would contribute to promote future project and to enhance friendly relationship between the two countries.

Finally, I wish to express my deep appreciation to the officials concerned of the Government of Mauritania for their cooperation extended to this study team.

June 2010

Kiyofumi KONISHI
Director of Economic Infrastructure Department
Japan International Cooperation Agency

Mr. Kiyofumi KONISHI
Director of Economic Infrastructure Department
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Mr. Kiyofumi KONISHI,

It is my great honor to submit you the Final Report on “The Study on Formulation of Geographic Database of Nouakchott in the Islamic Republic of Mauritania” that was implemented based on the contract with your agency.

The study was carried out by the joint venture of PASCO CORPORATION and ASIA AIR SURVEY CO. LTD from April 2007 to May 2010. The results are 1/20,000 aerial photographs, 1/10,000 topographic maps and their digital data with the GIS database and GIS model systems, and we transferred mapping technologies to technical staffs of the Mauritanian Government.

This report summarizes all the works processed through three phases from fiscal year 2007 and suggests some schemes for diffusing the data to various fields of use. I am convinced that the report will contribute as the base to support the rehabilitation of Nouakchott and its future development.

Finally, on behalf of the Team, I wish to convey my sincere appreciation to the officials in the Direction of Cartography and Geographic Information, and other organs concerned for providing us with facilities and cooperation. I wish also to express my thanks to the officials of your agency and the organs of Japanese Government concerned for providing us with suggestive advices and directions during the implementation of the study.

June 2010

Eisaku TSURUMI
Leader of the Study Team

Direction of Cartography and Geographic Information

Presentation of results of the Study

Discussion between DCIG and the Team

Discussion with technical staffs

Seminar on April 4, 2010

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List of Abbreviations

AFD	French Development Agency
CAD	Computer-Aided Design
CUN	City of Nouakchott
DATAR	Direction of Land Development and Regional Action
DCIG	Direction of Cartography and Geographic Information
DEM	Digital Elevation Model
DFE	Direction of Finance and Evaluation
DGPC	Direction General of Civil Protection
DIT	Direction of Infrastructures of Transport
DP	Direction of Purification
DS	Direction of Healthcare
DTC	Direction of Topography and Cartography
DU	Direction of Urbanism
EU	European Union
FAO	Food and Agriculture Organization
GCP	Ground Control Point
GIS	Geographic Information System
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
LPS	Leica Photogrammetric Suite
OJT	On-the-Job Training
OMRG	Mauritanian Office for Geological Surveys
RTO	Round Trip Observation
SNDE	National Society of Water
SOMELEC	Mauritanian Society of Electricity
TIN	Triangulated Irregular Network
UNDP	United Nations Development Programme
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations International Children’s Emergency Fund
UTM	Universal Transverse Mercator
WFP	World Food Programme
WHO	World Health Organization
WGS84	World Geodetic System 1984

CHAPTER 1. INTRODUCTION

In response to the request of the Government of the Islamic Republic of Mauritania, the Government of Japan decided to conduct "the Study on Formulation of Geographic Data Base of Nouakchott in the Islamic Republic of Mauritania" (hereinafter referred to as "the Study"). The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, sent the Preparatory Mission to Mauritania and made an agreement with the Mauritanian Government on the Scope of Works for the Study (S/W) on December 15, 2006.

JICA organized the Study Team for implementing the project, (hereinafter referred to as "the Team"). The counterpart agency of Mauritanian side is the Direction of Cartography and Geographic Information, Ministry of Habitat, Urbanism and Land Development (hereinafter referred to as "DCIG").

The project started in April 2007 and finished in May 2010. The period was divided into three phases.

1.1. Objectives of the Study

The objectives of the Study are:

(1) To take color aerial photographs of Nouakchott and its vicinities at the scale of 1:20,000 and to make digital topographic map at the scale of 1: 10,000.

(2) To create GIS model systems for city planning and management based on the digital topographic map.

(3) To transfer the necessary technology for digital mapping, data updating, and data usage to technical staffs of DCIG and other relevant agencies.

1.2. Study area

The Study area is shown in Figure 1.1 on the next page. The size of the Study area is 2,000 km^2, 69 km at the longest distance in north-south and 32 km in east-west. Color aerial photographs were taken at a scale of 1:20,000 for the whole study area as shown with red lines. Ground control point survey and Aerial triangulation were conducted for the whole photographed area. Based on the aerial photographs and the results of ground control point survey and aerial triangulation, the area of 1,200 km^2 shown with blue lines was mapped at a scale of 1:10,000. The mapped area is divided into 47 map sheets as shown with thin black lines.

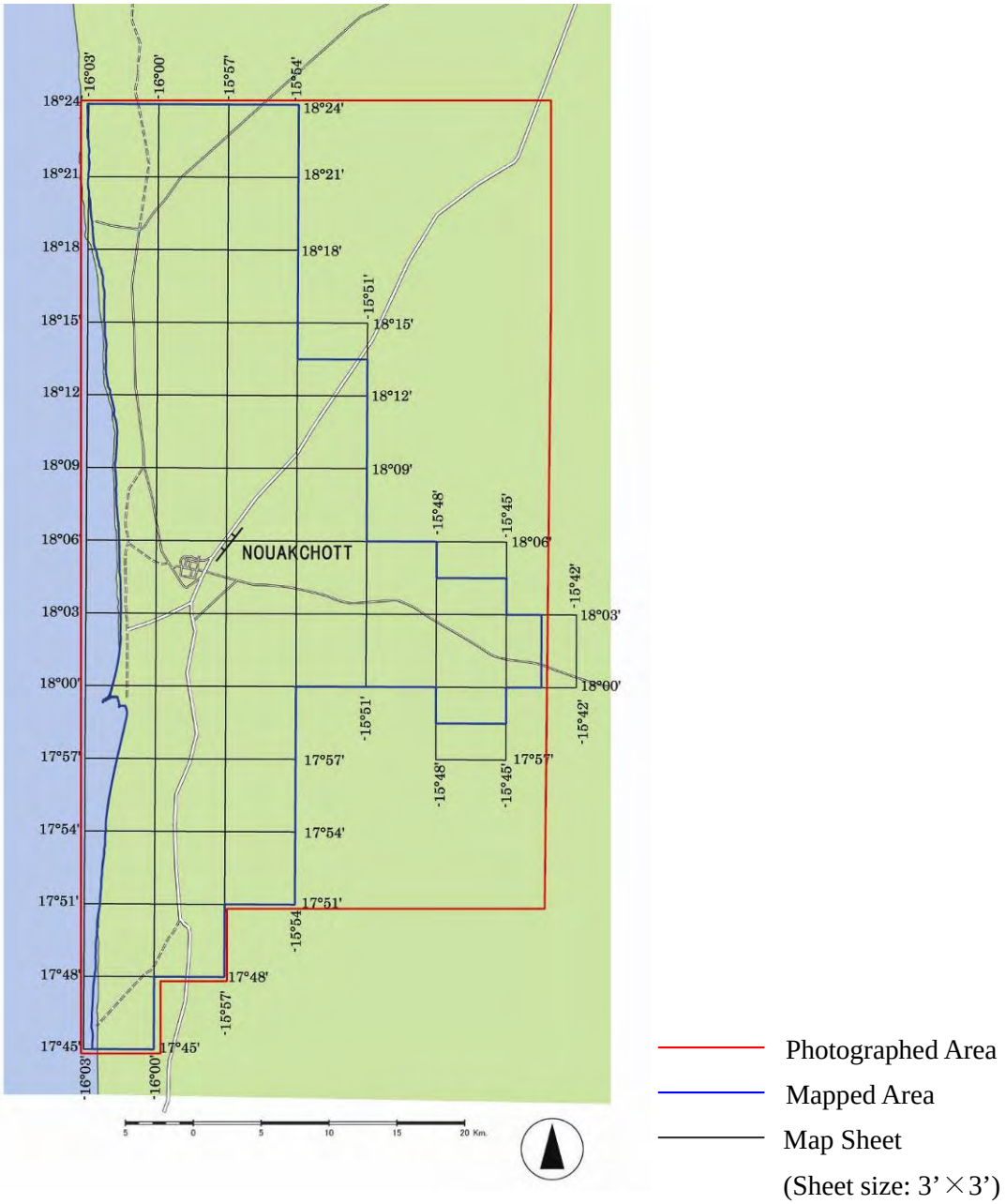


Figure 1.1 Study area

1.3. Context of the Study

(1) Growth of population in Nouakchott

The population of Nouakchott, the capital of Mauritania, has rapidly grown with increasing speed for these decades due to mass migration from rural regions for better employment opportunities and living conditions. Most of the migrants have formed informal settlements in and out of the town. These settlements are poorly equipped with basic public facilities and services such as water supply, sewage disposal and garbage disposal.

The above conditions have caused serious problems in sanitation, protection against disasters and so on. Moreover, the rapid population growth has caused a variety of urban problems. The national government and the government of Nouakchott (CUN) are required to take urgent measures against these problems.

(2) Urban development planning

On the other hand, there are new urban development plans for future and some ongoing projects at present in Nouakchott. They are, for instance, constructions of main road networks, new international airport, and resort development. These plans are expected to make big effects encouraging economic activities of the city. The recent project of offshore oil production may have a big impact upon the activities as well.

(3) Necessity for new geographic data

Any planning of new project of urban development requires updated geographic data. Geographic data is also required for executing and managing ongoing projects of urban development. For the Nouakchott area, however, geographic data which satisfy these requirements had been unavailable for many years.

The existing maps covering the areas where the above-mentioned problems take place are outdated and they are not in digital form. The absence of useful data had made it difficult for decision makers and urban planners to perform their tasks. Therefore, they had been anxious to use some well-updated and detailed geographic data in digital form for their analyses and designing. In order to catch up with their requirements, this mapping project was started and achieved.

This mapping project aims to supply the data indispensible for taking measures against the problems from various viewpoints such as protection from disasters, environmental conservation, urban rehabilitation and new urban development, and economic development and stabilization.

1.4. View of the Study area

As mentioned in Section 1.3, the population of Nouakchott has grown rapidly due to mass migration. According to the Census 2000, the population of Nouakchott Capital District (Wilaya de Nouakchott) was 558,195. It was about 22% of the national population. There is an estimated population of 800,000 for 2008. Some source says that the ratio to the national population is one-third at present.

It is reported that the recent serious droughts caused the migration from rural regions, where most people are nomadic. According to the Bureau of Statistics, nomadic people were 12% of the total population in 1988, while it is 5.1% in 2000. The present percentage is presumably much less.

Most of the migrants settled down in several places in the town and its surroundings without being controlled. They built small houses to live disorderly with materials available at hand. Especially in communes of El Mina, Arafat and Toujounine, large-sized precarious settlements are developed. These small houses are precisely plotted on the map produced under this project. These settlements have raised difficult problems for the urban planning of the capital.

As a whole, the population growth has raised not only the above-mentioned problems but also various problems such as people's safety, sanitation and health, employment and children's education. Public facilities such as water stations and schools are thoroughly shown on the map.

On the other hand, the recent economic activities in some sectors of business raise construction of new buildings and related objects, which make an impact on the conditions of the central part of Nouakchott and brings about a rapid change of land use and environment.

It should be a great concern that the Nouakchott is absolutely limited in capacity for holding such a large population that has grown without care and control. First, it is essential to review and examine the physical geography of this area in order to find the capacity of this area. After then, solutions should be pursued from various points of view.

Mauritania is bordered on the west thoroughly by the coastline of the Atlantic Ocean, which is over 600km in length. Sand beaches are predominant throughout the coast. For the southern-half portion of the coast, from Râs Timirit to the mouth of Senegal River, an arc-shaped sand beach extends for 400km without a break.

Along the coast, there is a long and flat lowland (coastal plain) extending from the north of

Nouakchott to the Senegal River mouth. This is called “Aftout essaheli”
The lowland is bordered on the west by a beach ridge (cordon littoral) which extends parallel with the sand beach. Top of the ridge overlain by coastal sand dunes is less than 10 meters above the sea level and the lowland is -2 to 4 meters.
The lowland is bordered on the east by the sand dune area of the Sahara Desert. Nouakchott is developed over the lowland and sand dune area.
It is inferred from geomorphologic aspect and deposit of a large quantity of shells in the soil that the lowland used to be a lagoon when the beach ridge had not been fully developed or it was broken as the result of some natural event in the recent geologic history. The lowland is characterized by hard and impermeable layers of gypsum on the surface. The Study area is included in arid zone. The average annual precipitation at Nouakchott is less than 130mm. There is no perennial stream in the Study area. However, in case of an intensive rainfall, the lowlands are liable to be flooded. The inundation stays long where the ground is under sea level and/or the surface materials are impermeable. The most recent inundation occurred in September 2009.
Historic record says that Nouakchott suffered inundations which originated from Senegal River in 1890, 1932, 1950 and 1987. Flood water came to Nouakchott traveling through Aftout essaheli for a distance of 180km. It is reported that the risk of Senegal-origin floods have been minimized since the construction of dams in 1986 and 1987.
Inundations are also caused by outbreak of the beach ridge when a storm surge attacks the coast. A gap (brèche) on the ridge is liable to be broken. It is reported that some gaps were formed by production of sand and shells for materials of concrete, and some are by driving vehicles on the beach. It is reported, however, that such mining and driving are restricted today. Several gaps have been filled up and conserved by planting.
Gaps in high risk of outbreak are found on the south of the Port de l’Amitié. They were formed by beach erosion caused by strong shore current. The coastline of Nouakchott had ever been very simple in arc-shape. Shore current along the Mauritanian coast flows from north to south at a constant speed, but after construction of the jetty of the port, the current was forced to change its behavior subject to hydromechanics. As a result, the coastline became exceptional in shape only around the port, that is, on the north of the jetty sand sedimentation occurred to form a large sand beach, and on the south of the jetty the beach was eroded and retreated to form gaps.

In addition to the above-mentioned, Nouakchott has another risk, that is, sand dune encroaching on the fringes of the town. Attempts to apply vegetation belts have been made on the surrounding areas. On the map produced under this project, details of sand dunes are

shown with precise contour lines of 2 meter interval and green belts are plotted.

Above-viewed aspects of the Study area are summarized in the diagram below.

Relation between physical condition and social problems in Nouakchott

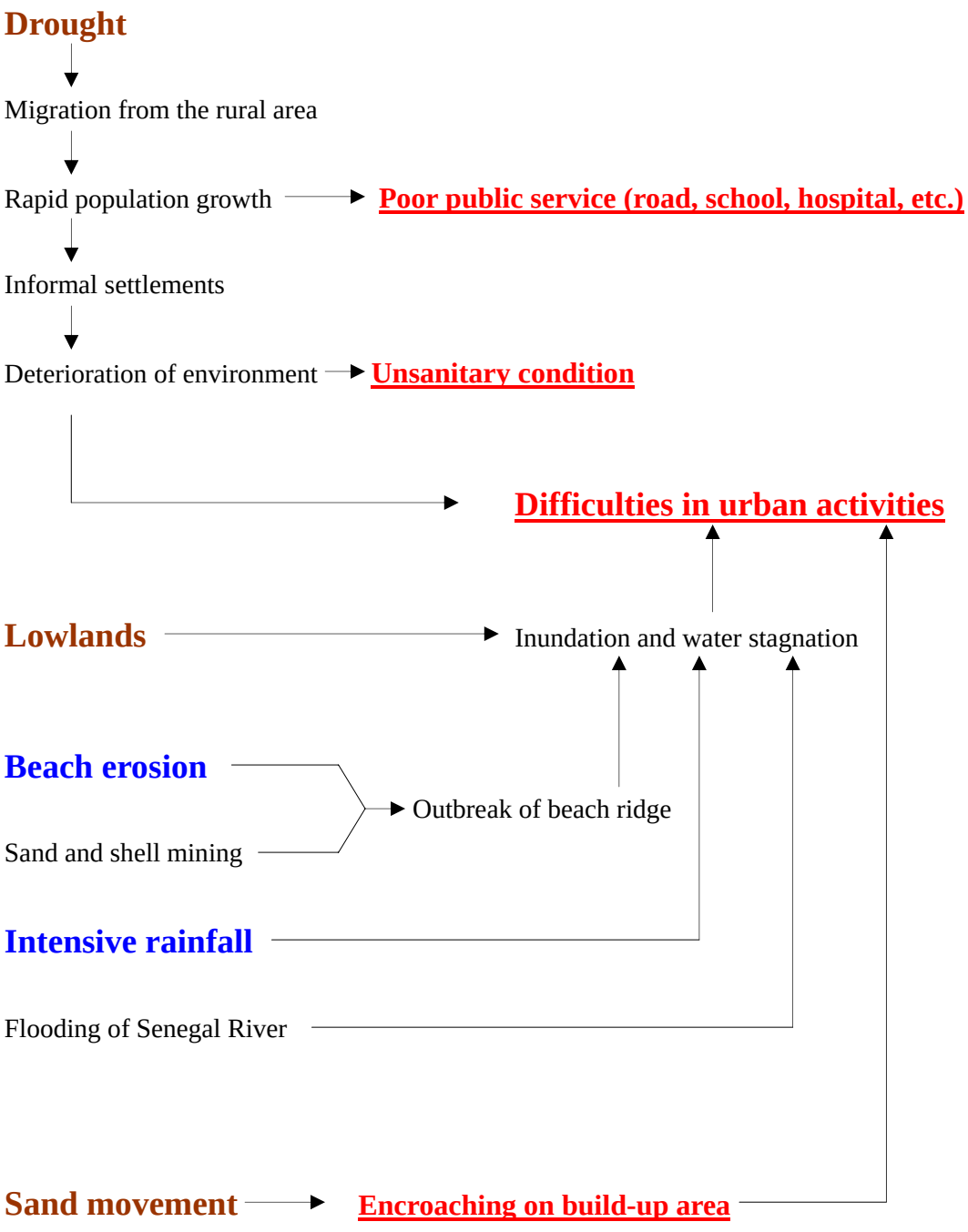


Figure 1.2 Residential area of Nouakchott

Figure 1.3 Precarious settlement

Figure 1.4 Main water pipe

Figure 1.5 Water station and donkey

Figure 1.6 Water station and water truck

Westward

2007

2010

Southward

2007

2010

Northward

2007

2010

Figure 1.7 View from Hotel Al Khaima – Example of land use change in the central part of the city

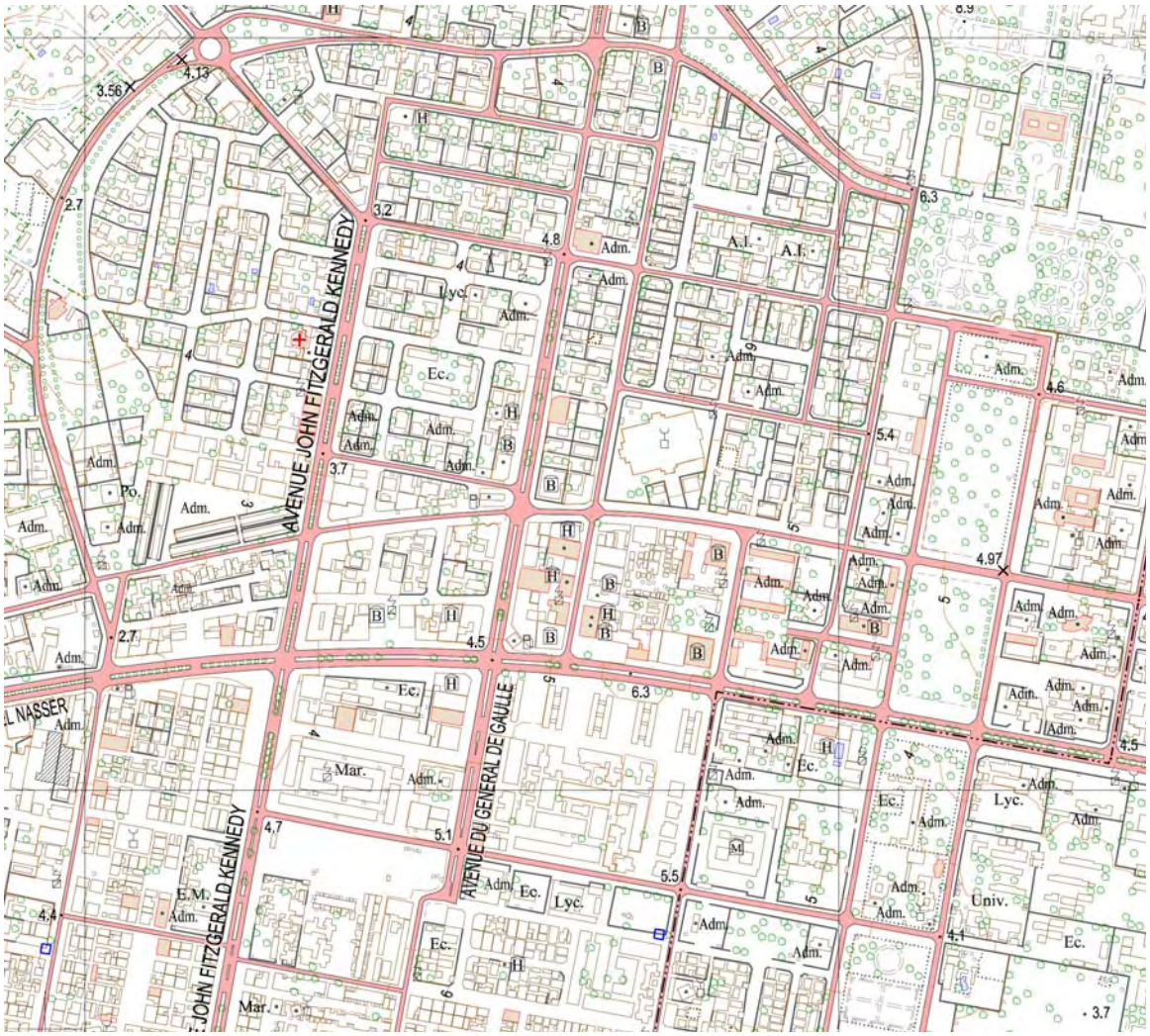


Figure 1.8 Topographic map of the central part of the city

Figure 1.9 Residential district under construction

Figure 1.10 Central part of the city

Figure 1.11 Shells on the surface of the lowland

Figure 1.12 Gypsum layer

Figure 1.13 Port of Friendship

Figure 1.14 Beach ridge with planted vegetations

1.5. Sequence of the project

In the first phase (from April 2007 through March 2008), Aerial photography, Ground control point survey, Field identification, Aerial triangulation and Digital plotting were carried out as planned. The Ground control point survey and Field identification were done as an OJT. In addition, formulation of the concept of GIS data and model system was investigated with collected documents and on-site surveys.

In the second phase (from May 2008 through March 2009), Digital compilation, Field completion, Supplementary map compilation, Map symbolization, Data structurization, and Creation of GIS model systems were carried out. In addition, technology transfer of Aerial triangulation and Data structurization were conducted to technical staff members. The Progress Report reporting the processes and results of these mapping works and the technology transfer was presented to DCIG in February 2009.

In the third phase (from May 2009 through May 2010), topographic mapping at a scale of 1:10,000 and formulating its geographic database were carried out to complete the final products, and technical training on the remaining subjects were conducted. In the last stage of the phase, a seminar was held on April 4, 2010 in Nouakchott to diffuse the usage of the results of the Study to potential users who were interested in the products.

Whole process of the project is shown in Figure 1.15. Because of a suspension of works due to political movement in Mauritania, the original plan of works for the second and third phases was partially changed.

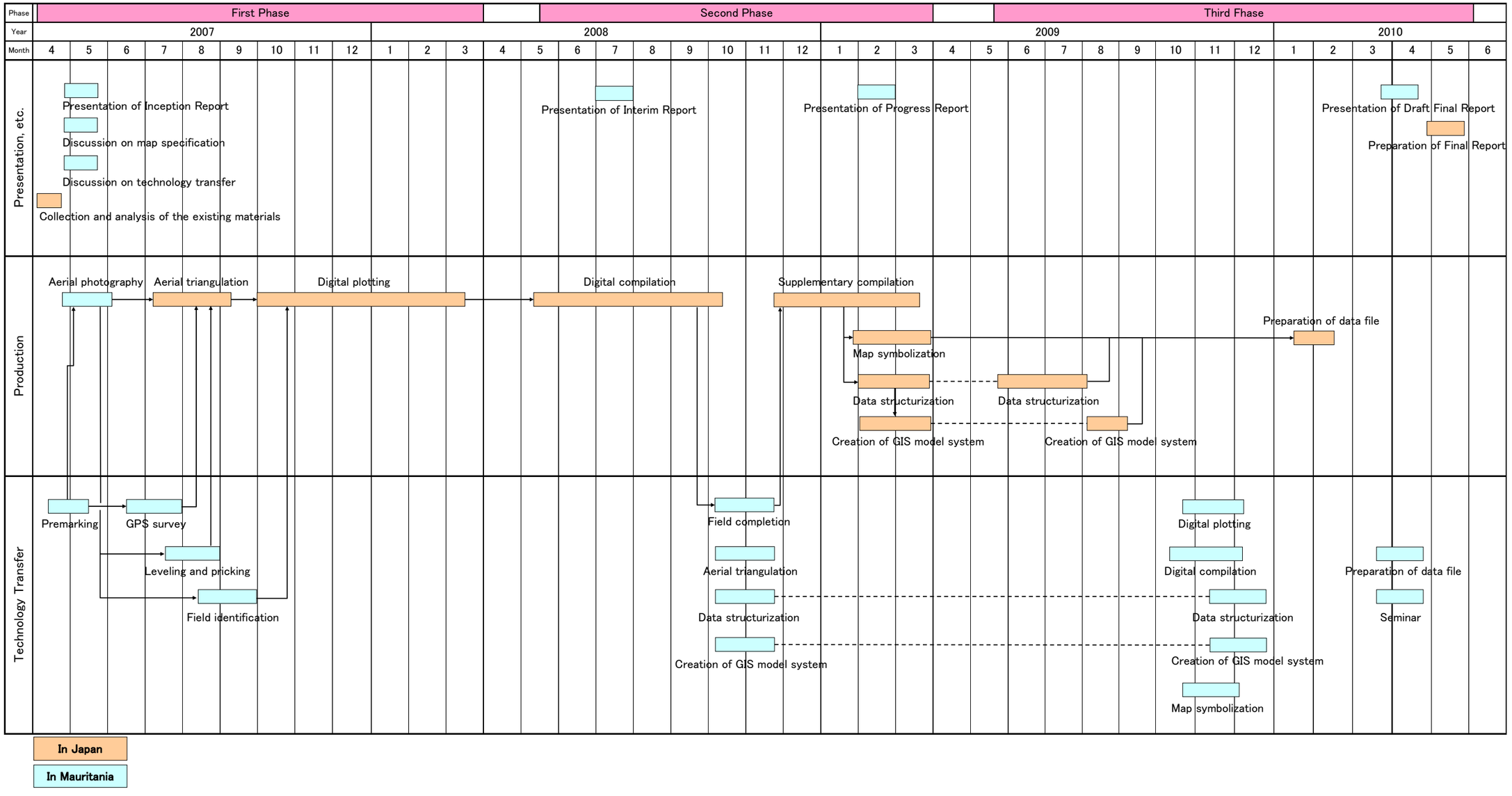


Figure 1.15 Chronogram of the works of the project

1.6. Counterpart agency

The Direction of Topography and Cartography in the Ministry of Equipment and Transport (hereinafter referred to as “DTC”) was the counterpart agency to the Team in the beginning of the first phase of the Study. Soon after then, with reorganization of the Government, DTC moved to the Ministry of Equipment, Urbanism and Habitat. Soon after then again, DTC was reorganized as the Direction of Cartography and Geographic Information (hereinafter referred to as “DCIG”) belonging to the Ministry of Decentralization and Land Development. With this reorganization, the counterpart agency to the Team has been changed to DCIG, which succeeded the discussions and agreements already made between DTC and the Team. After the political change of August 2008, DCIG moved to the Ministry of Habitat, Urbanism and Development of Territory.

1.7. Constitution of the project

Works in Mauritania were carried out in collaboration between the Team and Mauritanian side.
Field works, that is, Control point survey, Field identification and Field completion were performed by technical staff members of DCIG and other organizations under the control of the Team members as the on-the-job-training (OJT) scheduled in the program of technology transfer.
Results of these works were fully employed in map making in Japan.

1.8. Coordinating Committee

During the first phase, the Team recommended to Mauritanian side to organize the Coordinating Committee for coordinating user’s needs and promoting usage of geographic database. On May 24, 2007, DTC invited the Standing Commission of the National Committee of Remote Sensing (CNT) to a meeting on organizing the Coordinating Committee. Then, the Mauritanian side started the preparation to organize it, and completed the draft of the ordinance for organizing the National Commission of Geographic Information (CNIG). The draft depends on approval of the government now.
The product of this study will be subjected to this committee, after it is established.
The Team had recommended to set up the committee soon, where the Team would present usefulness of the geographic database produced under this project.
In addition, since the beginning of the project, the Team had visited governmental and non-governmental organs and collected a lot of information relating to the needs of these organs, in order to develop reliable databases and GIS models.

In addition, the Team visited several organs to present GIS models for the purpose of diffusion

of GIS usage.

1.9. Technology transfer

Technology transfer to DCIG technical staffs and other organization's staffs was made. The subjects are Premarking, GPS Survey, Leveling and pricking, Field Identification, Field Completion, Aerial Triangulation, Digital Plotting, Digital Compilation, Digital Map Symbolization, and Data Structurization.

1.10. Final products of the Study

The final products of the Study delivered to the Government of Mauritania are listed in Table 1.1 below.

Table 1.1 Final products

	Items	Quantity	Remarks
(1)	Study Report		
	1) Inception Report		
	English	10 copies	
	French	10 copies	
	2) Interim Report		
	English	10 copies	
	French	10 copies	
	3) Progress Report		
	English	10 copies	
	French	10 copies	
	4) Draft Final Report		
	Main Report		
	English	10 copies	
	French	10 copies	
	Summary		
	English	10 copies	
	French	10 copies	
	5) Final Report		
	Main Report		
	English	10 copies	
	French	10 copies	
	Summary		
	English	10 copies	
	French	10 copies	
	CD-ROM	1 set	
(2)	Study Results		
	1) Aerial Photograph (1:20,000 Color)		2,000km^2
	Original negative film	1 set	2 rolls
	Digital data	1 set	478 frames
	Contact prints	1 set	487 frames
	Flight index	1 set	
	2) Results of Control Point Survey	1 set	2,000km^2
	3) Results of Aerial Triangulation	1 set	2,000km^2 463 models
	4) Digital Data File	2 sets	1,200km^2 DXF, KML, PDF
	5) GIS Models, etc	2 sets	

CHAPTER 2. PROCESS AND RESULT OF THE STUDY

The Team started the first phase of the project in April 2007. At the beginning of the project, in May 2007, the Team presented the Inception Report to DTC. Both sides had discussion on this report and agreed on basic policies for the Study, surveying standards, methods, schedule, etc. Then, both sides had a series of meetings to discuss specifications for acquisition of topographic data, map symbols and marginal information, and program of technology transfer and they reached agreements on these matters.

Processes of the mapping works and the results are presented in this CHAPTER. The volumes of the works are shown in Table 2.1, Table 2.2 and Table 2.3 below.

Figure 2.1 Presentation of the Inception Report

Table 2.1 Mapping works and their volumes in the first phase

Item	Area	Description and volume	Remarks
Aerial photography	2,000 km^2	Scale: 1:20,000 Color photography 14 runs 478 frames	Airborne GPS method
Ground control point survey	2,000 km^2	Premarking of GPS points (22 points) GPS observation (23 points, 11 sessions and one base line) Leveling (6 routes, 200km) Pricking (135 leveled points)	OJT in Mauritania

Photo scanning	2,000 km^2	Acquisition of digital data of photo image by film scanner 478 frames	In Japan
Orthophoto printing	1,200 km^2	Scale: 1:10,000 47 sheets	In Japan
Field identification	1,200 km^2	Preliminary photo-interpretation On-site verification and checking	OJT in Mauritania
Aerial triangulation	2,000 km^2	463 models	In Japan
Digital plotting	1,200 km^2	Scale: 1:10,000 47 sheets	In Japan

Table 2.2 Mapping works and their volumes in the second phase

Item	Area	Description and volume	Remarks
Digital compilation	1,200 km^2	Scale: 1:10,000 47 sheets	In Japan
Provisional map symbolization	1,200 km^2	Scale: 1:10,000 47 sheets	In Japan
Field completion	1,200 km^2	On-site verification and checking	OJT in Mauritania
Supplementary map compilation	1,200 km^2	Scale: 1:10,000 47 sheets	In Japan
Map symbolization	1,200 km^2	Scale: 1:10,000 47 sheets	In Japan
Data Structurization	900 km^2	Structurization from the compiled plotting data	In Japan
Creation of GIS model system	900 km^2	GIS Model System for Address Search / Display GIS Model for Potential Flood Risk Management GIS Model for Water Supply Facility Management GIS Model System for Facility Management	In Japan

Table 2.3 Mapping works and their volumes in the third phase

Item	Area	Description and volume	Remarks
Data Structurization	300 km^2	Structurization from the compiled plotting data	In Japan
Creation of GIS model system	300 km^2	GIS Model System for Address Search / Display GIS Model for Potential Flood Risk Management GIS Model for Water Supply Facility Management GIS Model System for Facility Management	In Japan

In addition to these mapping works, technology transfer was made. The result is presented in CHAPTER 3.

2.1. Works for the first phase

After the above-mentioned agreement with DTC on implementing the project, Aerial photography, Ground control point survey, Field identification, Aerial triangulation and Digital plotting were carried out as planned. The first phase finished in March 2008.

2.1.1. Ground control point survey (in Mauritania)

Ground control point (GCP) survey was conducted from April through August 2007 in the following work flow.

Planning → On-site investigation → Premarking of GCPs → Aerial photography → GPS observation → Leveling and pricking

Figure 2.2 Technical staffs of Mauritania

Figure 2.3 Existing GPS point (AZ 001)

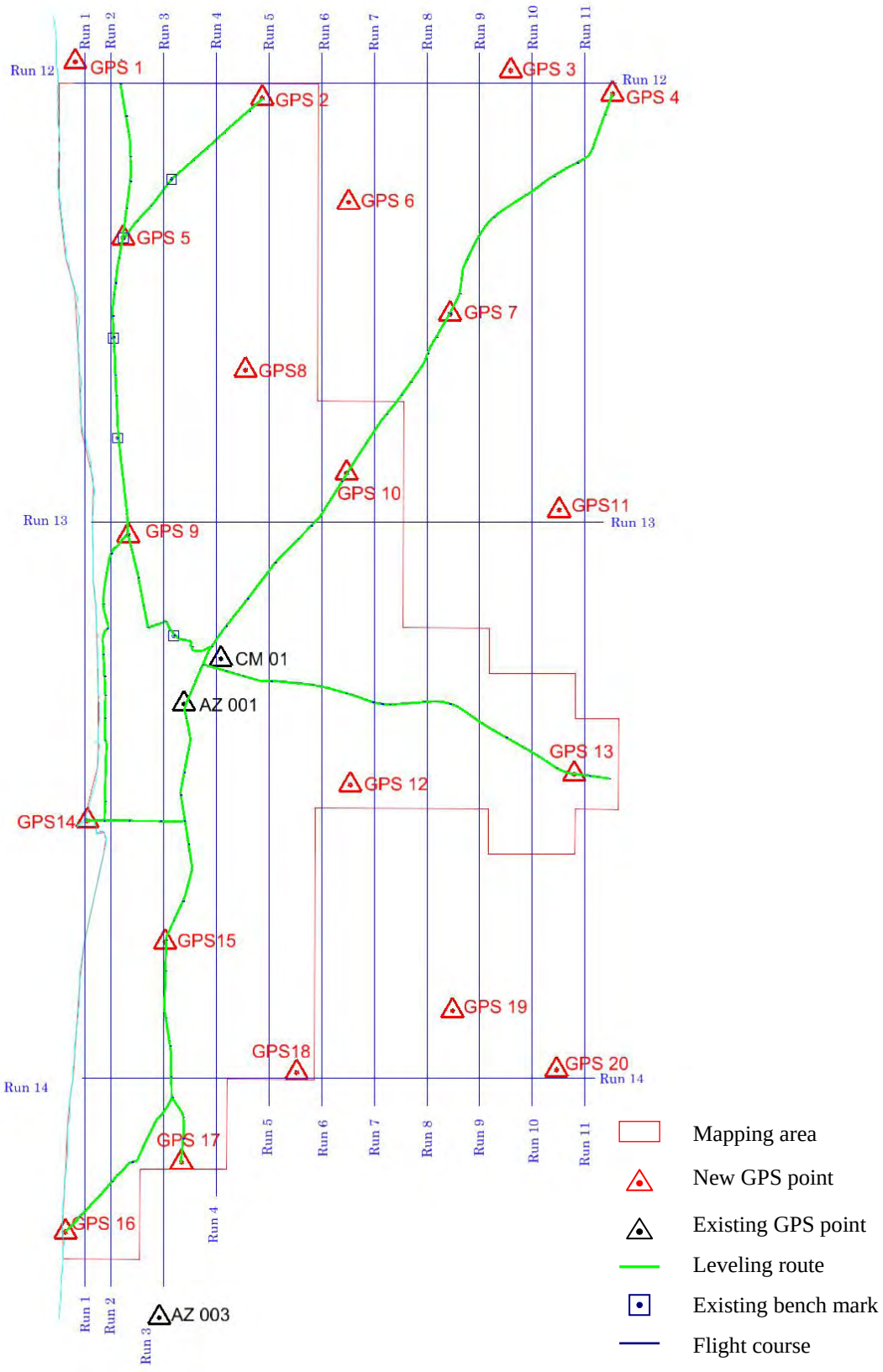


Figure 2.4 GPS points and leveling routes

a) Premarking of ground control points

Aerial signals were set up at the 22 GCPs before the aerial photography in April 2007.

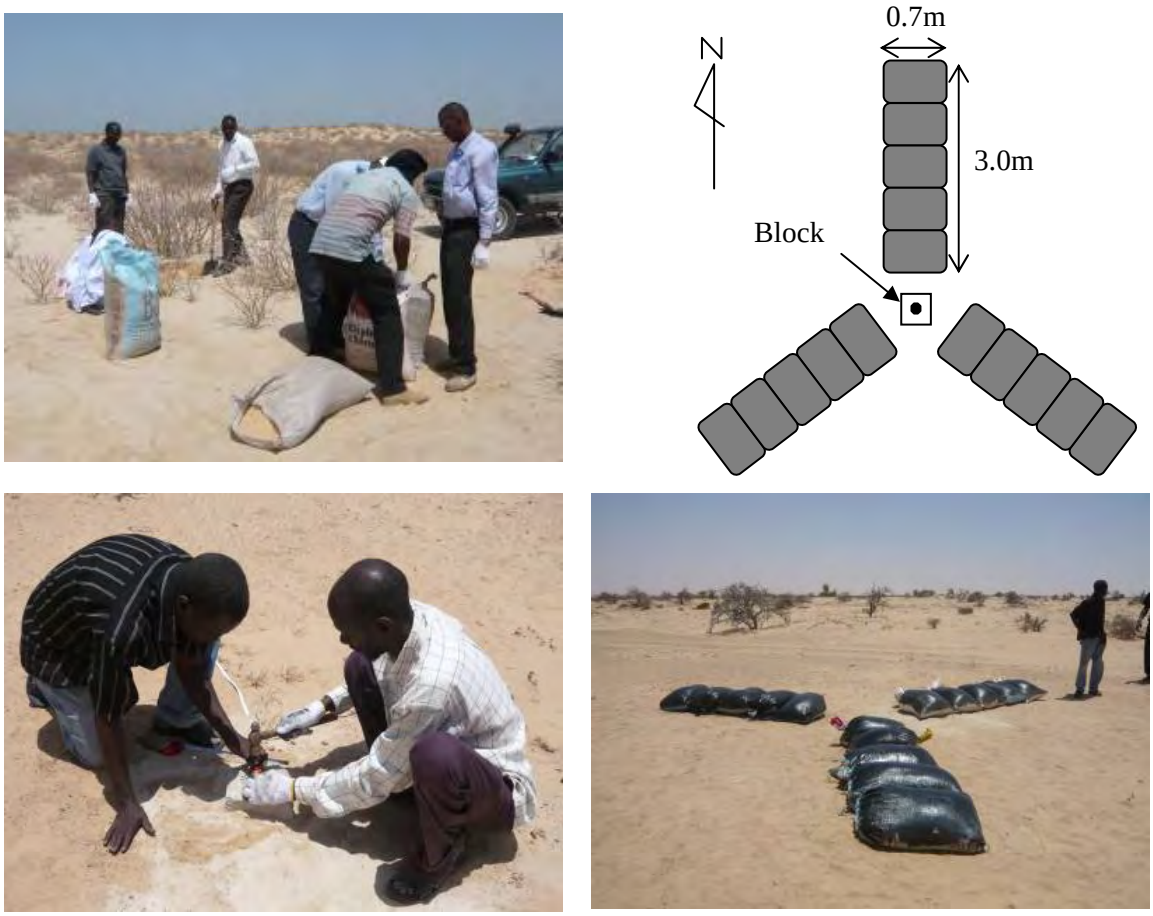


Figure 2.5 Aerial signal setting

b) GPS observation

GPS observation was performed in July 2007 for a total of 11 sessions and one base line organized with the 20 new GCPs and 3 existing GPS points.

The loop closing error was designed as not to exceed plus or minus 10mm + 2ppm x D (distance of baseline) in any closed polygonal route on the network after the baseline processing.

A total of 13 points were directly leveled and the elevations of the remaining 10 points were determined based on a geoid obtained by the GPS leveling.

The following observation method was applied to the geodetic network.

- Method: Simultaneous data receiving with more than three observation points.
- Type of GPS receiver: Dual frequency.
- Observation time: 2 hours as a rule
- Number of satellites received at one time: More than 5
- Number of existing control points to be connected: 3

As a result of pre-network adjustment, inconsistency between the 3 existing GPS points (CM01, AZ001, AZ003) was found to occur. DCIG specified CM01 to take part of the reference point in the network adjustment, because this point had been used as reference point for other surveys and would be well-protected in the future due to its location in an international airport. The result of 3D network adjustment was projected to UTM Zone 28.

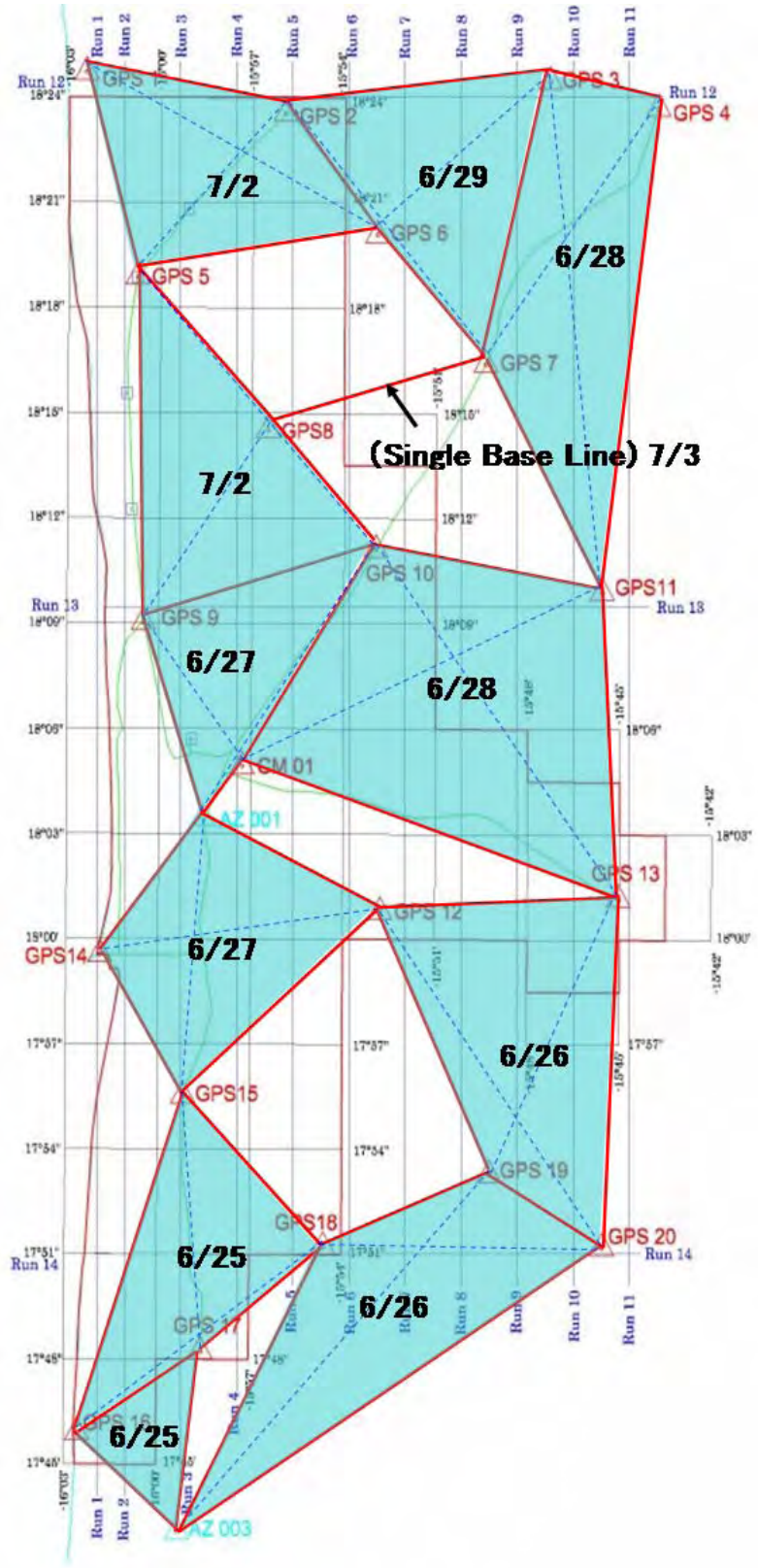


Figure 2.6 GPS observation network

c) Preparation of point description

Descriptions of GPS point were prepared after completion of the observation. The description of GPS point No 09 is shown in Figure 2.7 as an example.

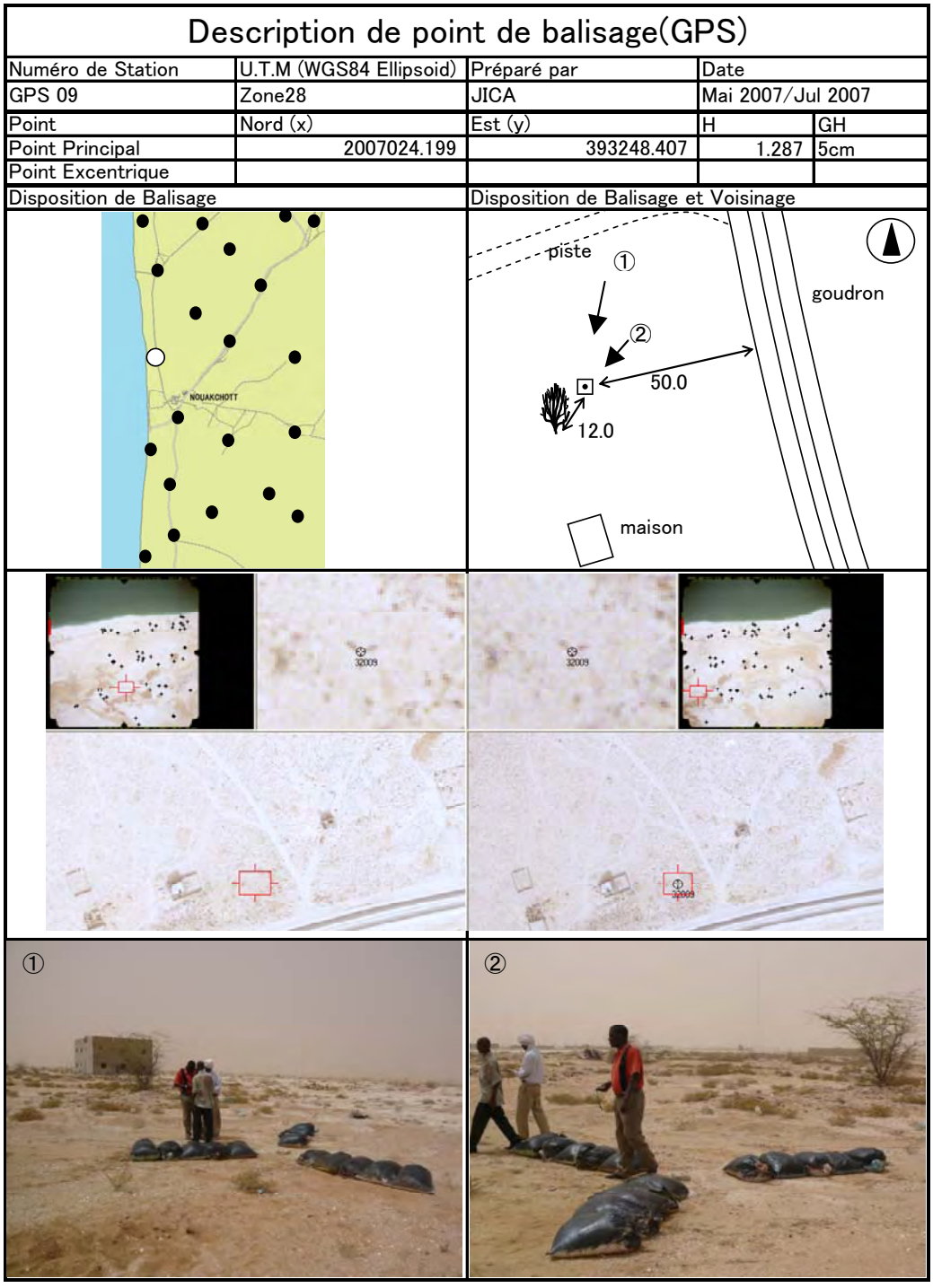


Figure 2.7 Point description of GPS point

Figure 2.8 GPS observation at a point (GPS20)

d) Leveling

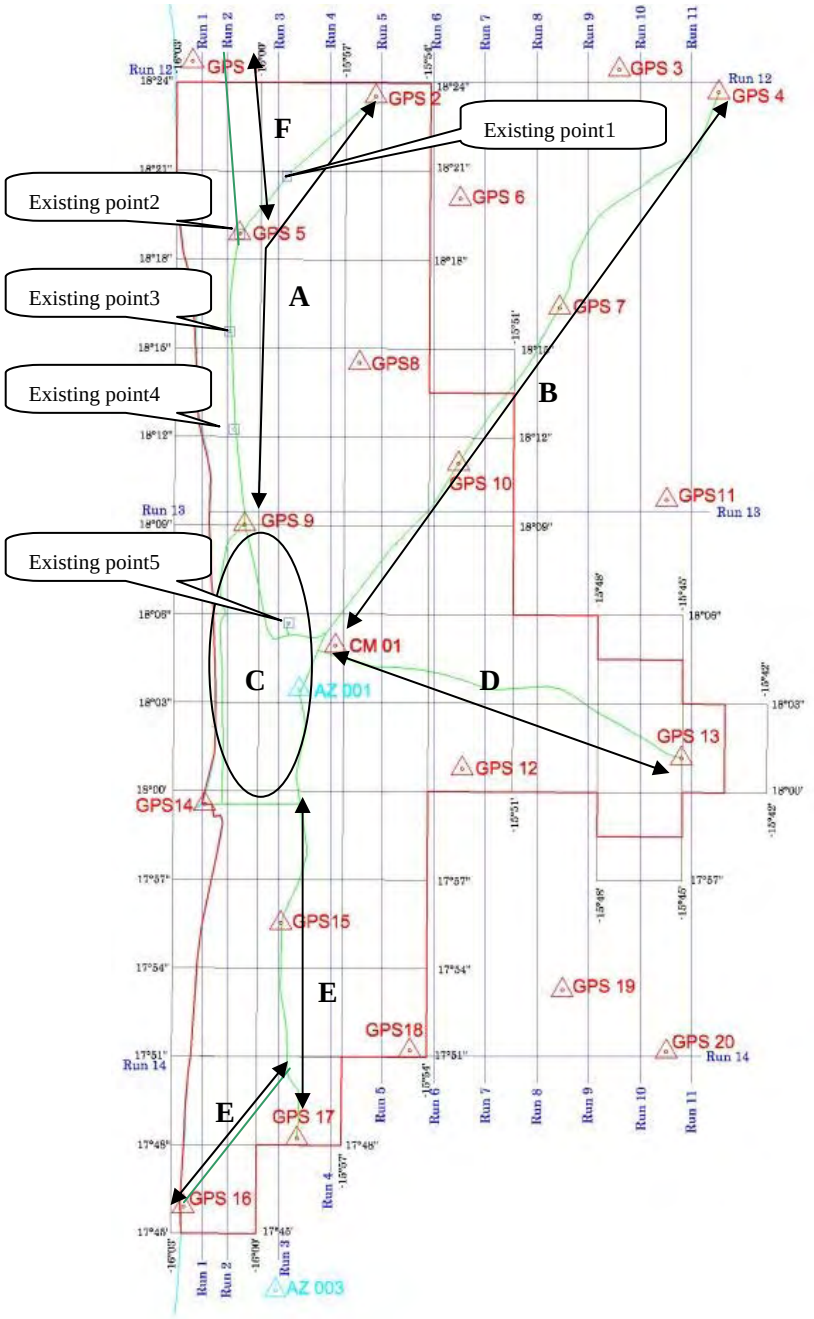
As a result of on-site investigation, 5 existing bench marks were found to be available for reference. A total of six leveling sections were set up along major roads including three national roads. The existing bench marks and 13 of the observed GPS points are included. Observation was performed in August 2007 for a total length of 200 km.

In the leveling work, the round trip observation (RTO) is performed in general. In this project, however, the Team adopted simultaneous one-way observations by 2 parties, because it was found that the skill and experience of the trainees were not enough for RTO and the Team considered that the method of one-way observation is the best way for effective instruction to the trainees under the condition of limited number of Team members and period.

The following observation method was applied to the leveling.

- Type of leveling equipment: Auto-Level (Leica SPRINTER100)
- Number of leveling equipment: 2 Auto-Levels, 2 staffs
- Staffs: Aluminum, Sectional, 3m
- Observation method: Simultaneous observation by 2 groups
- Pricking: At the pitch of 1km

The results were checked and found to be satisfactory in accuracy.



Leveling Section	Definition
LS_A	LS-C -GPS2
LS_B	LS-C -GPS4
LS_C	The circle based on French embassy
LS_D	LS-C -GPS13
LS_E	LS-C -GPS17
	GPS17-GPS16
LS_F	GPS5-near GPS1

Figure 2.9 Leveling sections

Figure 2.10 Leveling

e) Pricking

Those selected from the leveled points at the pitch of approximately 1 km were pricked on the photographs in order to acquire the vertical control points for aerial triangulation. A total of 135 points were pricked.

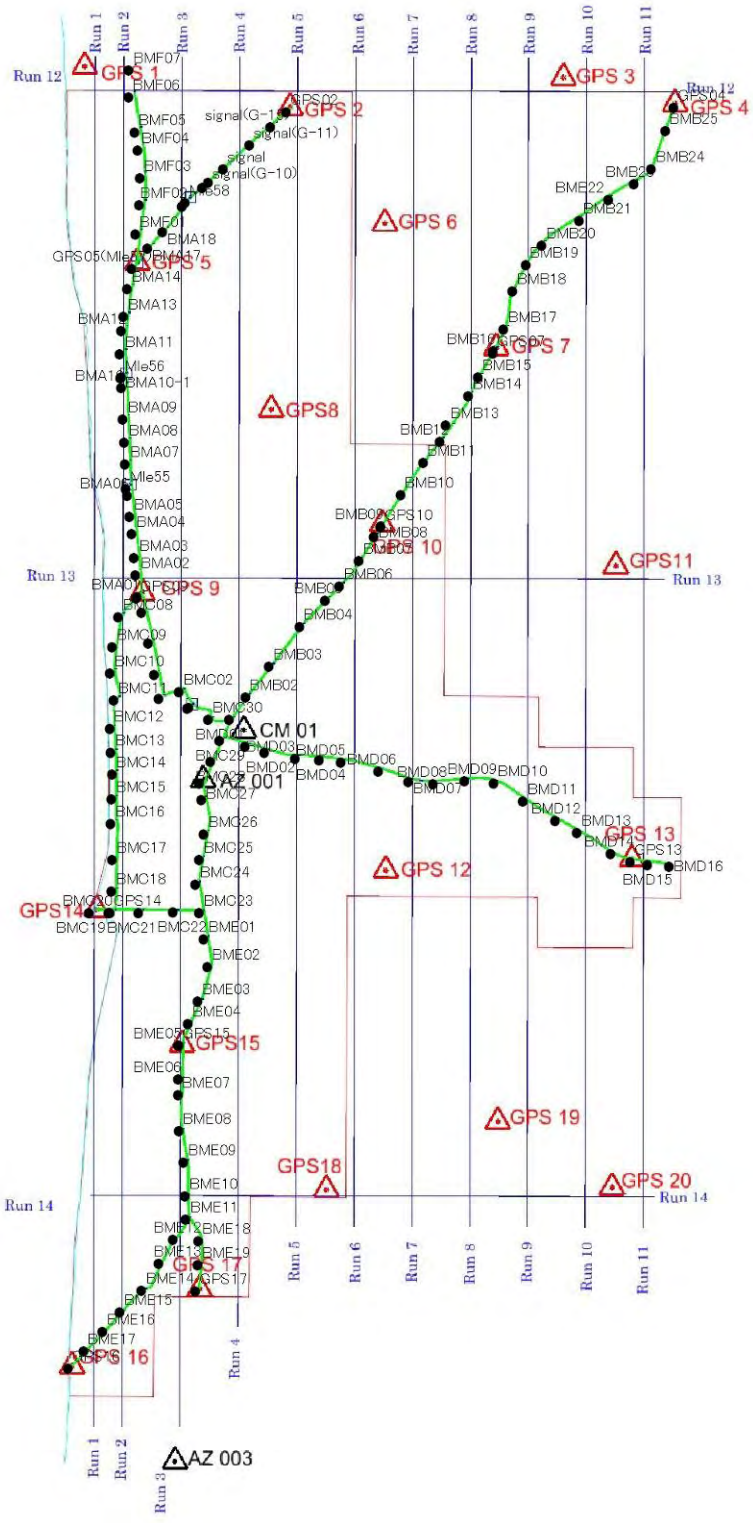


Figure 2.11 Pricked points

2.1.2. Aerial Photography (in Mauritania and Japan)

Aerial photography took place from April through June 2007 by a subcontractor under the control of the Team. The Study area (2,000 km^2) was completely photographed with a scale of 1:20,000 in color. A total of 478 frames were obtained.

Figure 2.12 Aircraft used for the aerial photography

The aerial photography was made by the airborne GPS method, with which the number of ground control points to be observed were much reduced.

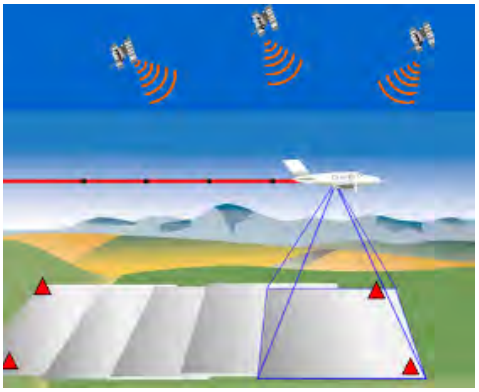


Figure 2.13 Diagram of aerial photography by airborne GPS Method

After shooting, the Team inspected all the photographs using the rush prints. These photographs were found satisfying the specifications.

a) Inspection of photographs

After shooting, the Team carried out a quality control of the photographs using the rush prints. As the results of inspection, all the photographs were found satisfying the specifications. Flight index map is shown in Figure 2.14.

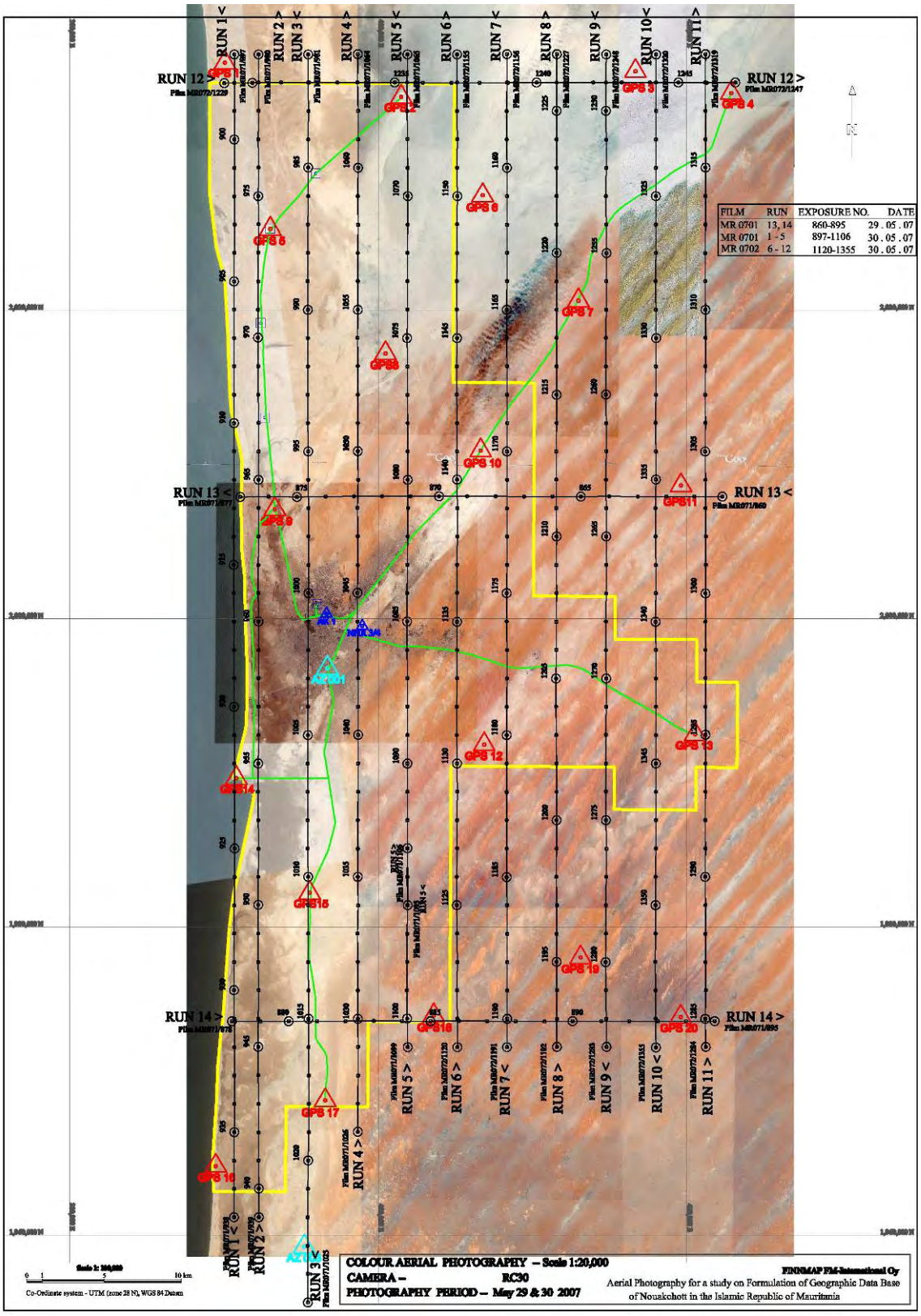


Figure 2.14 Flight index map

b) Photo scanning

In order to obtain digital data of the photographs, all the frames of film were scanned in Japan in June 2007 by the scanner shown Figure 2.15.

Figure 2.15 Scanning of a roll film by “Vexcel Ultrascan 5000”

Figure 2.16 Scanned image

2.1.3. Field identification (in Mauritania)

The field identification was conducted from August through September 2007.

The purpose of the field identification for the first phase was to obtain information for digital plotting described later according to the specifications of topographic data acquisition agreed upon between DTC and the Team. This work includes preliminary photo-interpretation, on-site check of geographical features and annotations on the maps using photo images.

In addition, for the purpose of constructing basic GIS data, on-site survey of water supply facilities was conducted.

Figure 2.17 Data input for creating CAD and spreadsheet data

Figure 2.18 Field identification for water supply facility

Figure 2.19 Result of field identification

2.1.4. Aerial Triangulation (in Japan)

Aerial triangulation was carried out for the Study area of 2,000 km^2 in September 2007 in Japan.

The Specification of the Aerial Triangulation is shown in the table.

Geodetic Datum	WGS84
Map Projection	UTM, Zone 28
Number of Models	463
Software	Match AT

Figure 2.20 The allocation of each point in Aerial Triangulation

2.1.5. Digital plotting (in Japan)

The digital plotting work was completed for the mapping area of approximately 1,200 km^2 in the first phase. This area is divided into 47 map sheets.

According to the specifications of topographic data acquisition agreed upon between DTC (DCIG) and the Team, planimetric features such as road, building, vegetation and other ground objects were plotted digitally referring to the results of Field identification with the 3 dimensional models of aerial photograph.

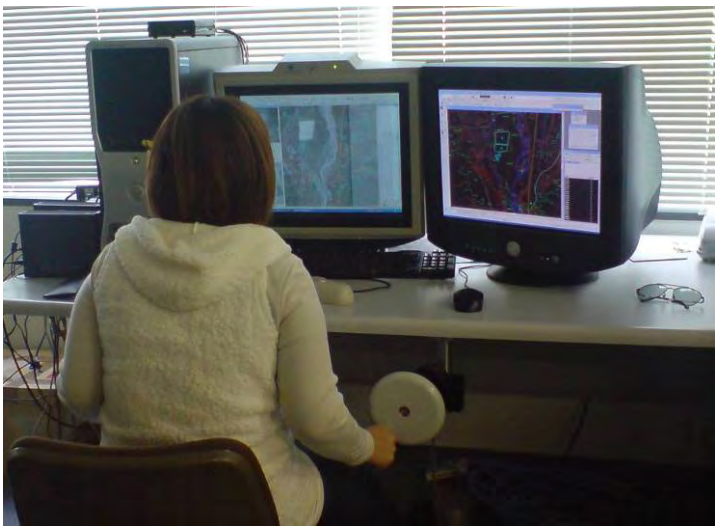


Figure 2.21 Data setting by using "SUMMIT EVOLUTION

a) Digital plotting

Data plotted is shown in Figure 2.22 and Figure 2.23 as samples.

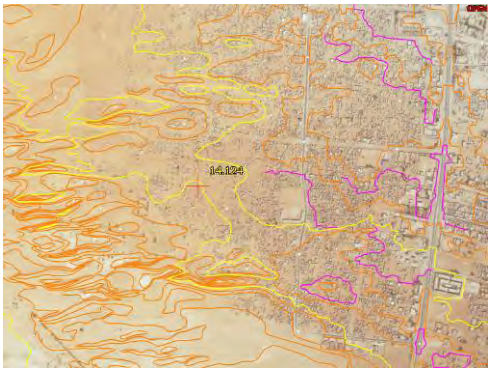
	
Planimetric features plotted	Terrain features plotted

Figure 2.22 Plotted data

Visual checking and logical checking was implemented. The visual checking conducted both on the monitor of PC and on the printed map. The logical checking was conducted by using the tool of CAD software automatically and interactively.

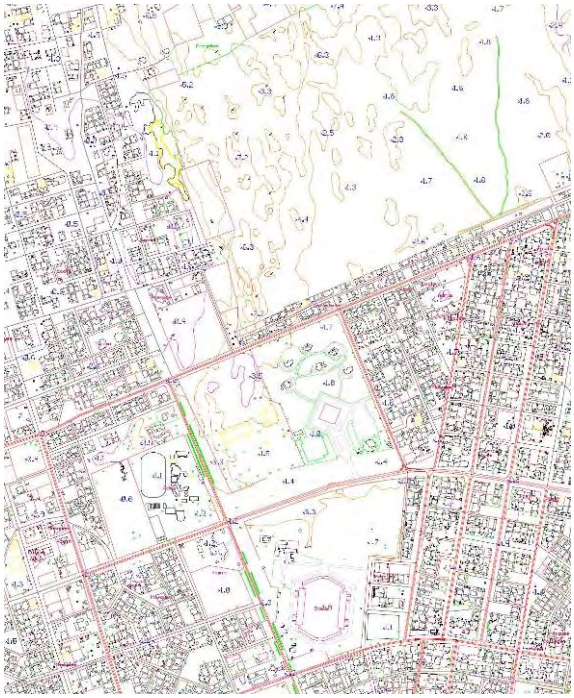


Figure 2.23 Plotted data

2.2. Works for the second phase

The second phase started in May 2008. Digital compilation, Field completion, Supplementary compilation, Map symbolization, Data structurization, and Creation of GIS model systems were carried out until March 2009. Data structurization and Creation of GIS model systems continued in the third phase.

At the end of July 2008, the Team presented the Interim Report to DCIG. Then, both sides had a series of discussions on the Report and made agreements on August 9. After a suspension of the works in Mauritania due to the political change, both sides had discussions on map symbols and other technical matters, and they attained to agreements on October 22.

2.2.1. Digital compilation (in Japan)

This process is separated into 2 main works, one is Data Cleaning and the other is Creating Topology.

Data Cleaning means to omit duplicate data, to erase meaningless lines, gaps and dangles of lines, to correct pseudo nodes, and to check connectivity and consistency of data among adjoining map sheets. Creating Topology means the preparation for creating polygons by associating between symbols and areas which should become polygons.

This work was carried out from May through September 2008 in Japan based on the specifications for topographic data acquisition, by referring to aerial photos and other relevant materials. The data that was cleaned-up, being topological, serves as the basic data for Map symbolization, Data structurization, and GIS data creation.

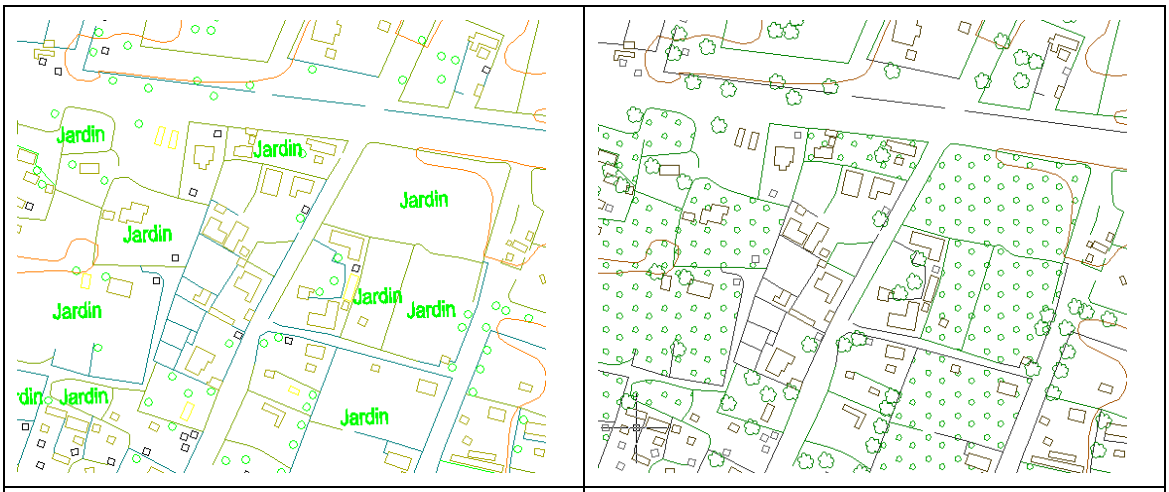


Figure 2.24 The data before & after Digital Compilation

2.2.2. Provisional map symbolization (in Japan)

This is the process to temporarily symbolize the above digitally compiled map. This symbolized map is to be used as the base map in the succeeding process, Field completion. This work was carried out from May through July 2008 in Japan.

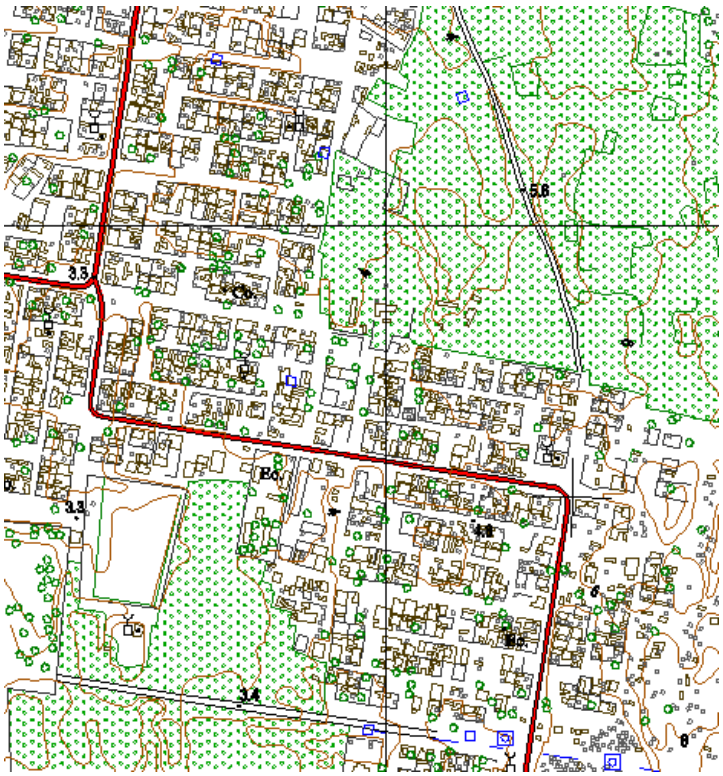


Figure 2.25 The symbolized map for Field completion

2.2.3. Field completion (in Mauritania)

This is the process to complete the contents of map, clarifying on-site all the uncertain features raised during the processes of Digital plotting and Digital compilation, and also clarifying all the objects like geographic names and administrative boundaries, which cannot be acquired from photo-interpretation.

Field work was carried out in October and November 2008 in collaboration with technical staff members of DCIG. It was an on-the-job training for the members under the Technology Transfer Program agreed on between the Team and DTC.

2.2.4. Supplementary compilation (in Japan)

This is the process to add the results of the above-mentioned field completion into the primary data and to conclude the contents of map. The items which were cleared from the field

completion were modified and the information such as geographic names and administrative boundaries were added.

It was carried out from December 2008 through January 2009 in Japan. It was performed with CAD software. The final results were sent to the processes of Map symbolization and Data structurization.

2.2.5. Map symbolization (in Japan)

This is the process to give map symbols to the digitally compiled map on screen and complete visual map sheets.

It was carried out from February through March 2009 in Japan.

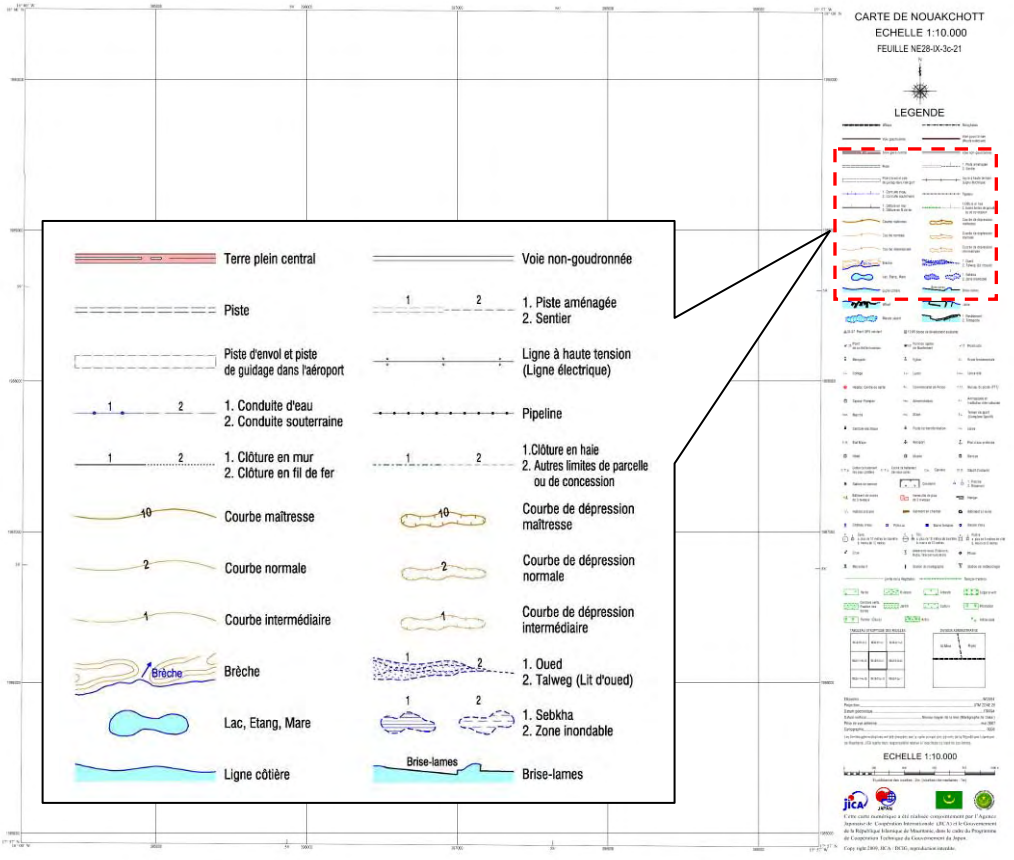


Figure 2.26 Marginal information of map sheet

2.3. Works for the second and third phases

2.3.1. Data structurization (in Japan)

This is the process of converting the digitally compiled map data to GIS data. The converted GIS data mainly included those required for the creating GIS Model Systems. This was carried out by using ArcGIS software and the GIS data files were saved as Shapefile (*.shp*) format, which is supported by wide range of GIS software.

2.3.2. Creation of GIS model system (in Japan)

Creation of GIS model systems was investigated and designed in the second phase. GIS model systems were created in Japan in the second and third phases.