JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
SURVEY OF KENYA (SOK)

THE STUDY
FOR
THE ESTABLISHMENT OF THE SPATIAL DATA FRAMEWORK
FOR
THE CITY OF NAIROBI
IN
THE REPUBLIC OF KENYA

FINAL REPORT
SUMMARY

FEBRUARY 2005

JICA STUDY TEAM

KOKUSAI KOGYOU CO., LTD.

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Preface

In response to a request from the Government of the Republic of Kenya, the Government of Japan decided to conduct the Study for the Establishment of the Spatial Data Framework for the City of Nairobi in the Republic of Kenya, and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA dispatched a study team headed by Mr. Akira Nishimura of Kokusai Kogyo Co. Ltd. to the Republic of Kenya, six times between December 2002 and March 2005.

The team held discussions with concerned officials of the Government of the Republic of Kenya, including the Survey of Kenya, Ministry of Lands and Housing and Nairobi City Council, and conducted field surveys in the study area. Upon returning to Japan, the team conducted further studies and prepared this report.

I hope that this report will contribute to the establishment of spatial data infrastructure and the development of various GIS in the Republic of Kenya in the future, and to the enhancement of friendly relations between our two countries.

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

February 2005

Mr. Kazuhisa Matsuoka
Vice-President
Japan International Cooperation Agency

Letter of Transmittal

Mr. Kazuhisa Matsuoka
Vice-President
Japan International Cooperation Agency

It is a great honor to submit herewith the report of the Study for the Establishment of the Spatial Data Framework for the City of Nairobi in the Republic of Kenya. This report was prepared, incorporating the suggestions received from the Japan International Cooperation Agency (JICA) and concerned authorities, as well as the agencies concerned of the Government of the Republic of Kenya including the Survey of Kenya, Ministry of Lands and Housing and Nairobi City Council.

During the Study, spatial data infrastructure for the City of Nairobi, which forms a part of the national spatial data infrastructure of Kenya, was established, and the techniques concerned with this work were transferred to the Survey of Kenya. Furthermore, various GIS databases (public facilities, roads, water supply and sewerage, cadastral) were constructed from this spatial data infrastructure, to support administration of Nairobi City. The team also developed GIS model systems that use these databases, and provided them as a tool to solve urban problems faced by the city. Regarding the GIS model systems, techniques for GIS use, including those for database construction, were transferred to the Survey of Kenya and Nairobi City Council with successful results.

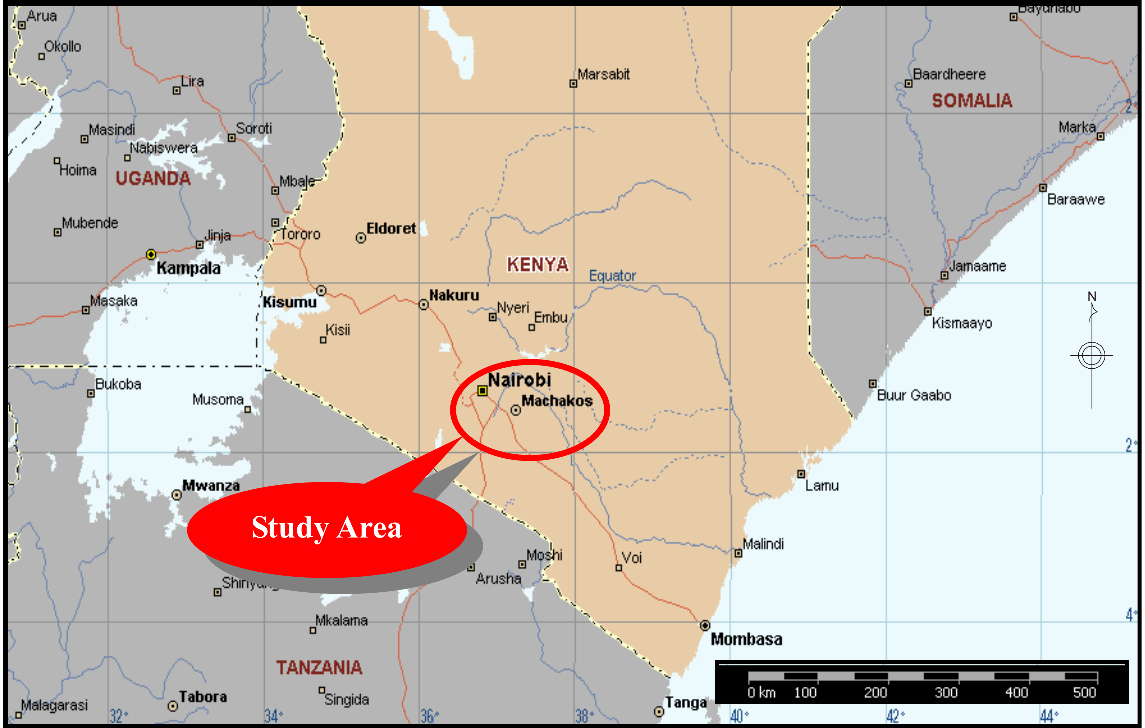
In the final chapter of this report, specific recommendations are made based on the results of the study. From the viewpoint of maintaining and developing the results of the study, I hope that these recommendations are promptly implemented by the agencies concerned of the Government of the Republic of Kenya.

On behalf of the team, I would like to express my sincere gratitude to JICA, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport, and agencies concerned for the valuable advice and cooperation they provided us during the implementation of this study. I would also like to express my deep appreciation to the agencies concerned of the Government of the Republic of Kenya, including the Survey of Kenya, Ministry of Lands and Housing and Nairobi City Council, for their generous assistance and cooperation during our stay in Kenya.

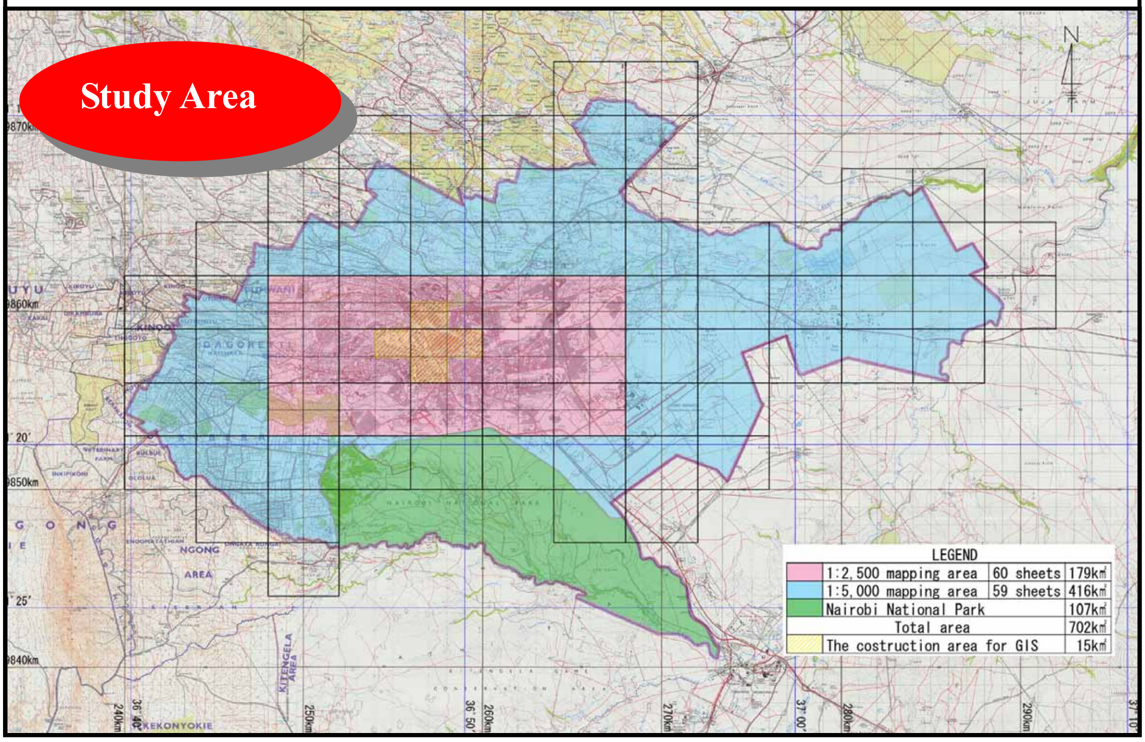
February 2005

Akira Nishimura
Team Leader
The Study for the Establishment of the Spatial Data Framework for the City of Nairobi in the Republic of Kenya

Location Map of Study Area



Republic of Kenya



Photographs

Nairobi City

Nairobi City

Nairobi City

Nairobi City

Nairobi City

Nairobi City

Photographs

Survey of Kenya

Survey of Kenya

Plotting

Plotting

Computer Room

Printing Machine

Photographs

Nairobi City Council

Nairobi City Council

Nairobi City Council

Nairobi City Council

GPS Survey

GPS Survey

Photographs

Levelling

Levelling

Aerial Photography

Aerial Photography

Aerial Photography

Aerial Photography

Photographs

Field Identification

Field Identification

Supplementary Field Identification

Supplementary Field Identification

Technology Transfer

Technology Transfer

Photographs

Technology Transfer

Technology Transfer

Technology Transfer

Technology Transfer

Technology Transfer

Technology Transfer

Photographs

Inception Report Meeting

Inception Report Meeting

Progress 1 Report Meeting

Interim Report Meeting

Interim Report Seminar

Interim Report Seminar

Photographs

Progress 2 Report Meeting

Draft Final Report Meeting

Technology Transfer Seminar

Technology Transfer Seminar

Technology Transfer Workshop

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Chapter 1 Objective of the Study

1.1 Background

The City of Nairobi in the Republic of Kenya (hereinafter referred to as "Kenya") has experienced rapid growth due to an inflow of people from rural areas. However, the city cannot effectively manage its infrastructure to meet the growing demand.

A portion of the 1:2,500- and 1/5,000 scale topographic maps required for management of such urban infrastructure was produced by the Survey of Kenya (SOK) in analogue format over 30 years ago but has not been updated or expanded since.

Meanwhile, SOK has been promoting a plan to develop National Spatial Data Infrastructure (NSDI) as part of an effort to establish geographic information in digital format.

Under the above circumstances, the Government of Kenya made a request in 2001 to the Government of Japan for technical cooperation regarding "The Study for the Establishment of the Spatial Data Framework for the City of Nairobi in the Republic of Kenya" (hereinafter referred to as "the Study").

In response to the request, the Government of Japan dispatched a preliminary study team to confirm the content of the request, implementation conditions, etc., and the Scope of Work (S/W) and Minutes of Meeting (M/M) were signed and exchanged.

The Study was implemented in accordance with the S/W and M/M

1.2 Objective of the Study

The objectives of the Study were as follows:

(1) Transfer of technology (main objective)

(2) Construction of GIS model system

(3) Establishment of spatial data infrastructure

1.3 Study Area

The areas targeted for the respective works in the Study were as follows:

(1) Target area for acquisition of aerial photo image data

Aerial photo image data was acquired for the entire City of Nairobi (702km^2).

(2) Target area for aerial triangulation

Aerial triangulation was carried out for the entire City of Nairobi, excluding Nairobi National Park, which was not to be mapped (595km^2).

(3) Target area for the establishment of 2500 and 5000 level spatial data infrastructure

a. 2500 level

The 2500-level data was established for an area of 179 km^2 in 60 sheets (2 km x 1.5 km/sheet).

b. 5000 level

The 5000-level data was established for an area of 416km^2 in 59 sheets (4km×3km/sheet).

(4) Target area for the construction of GIS databases

GIS databases were constructed for the 15 km^2 area (5 sheets) most suitable for application of the GIS model system within the area covered by 2500-level data.

Chapter 2 Basic Policies for Study Implementation

2.1 Basic Policies for Technology Transfer

The basic policies for technology transfer were as follows:

a) Technology transfer for database construction

b) Technology transfer for the operation and maintenance of GIS

c) Transfer of the latest techniques for establishing spatial data infrastructure

d) Establishment and evaluation of the objectives of the transfer

e) Preparation of regulations and manuals

f) Human resource development

2.2 Basic Policies for GIS Construction

The basic policies for GIS construction were as follows:

a) Feasible technical specifications

b) Ensuring the common use of databases

c) Introduction of a system that can be operated and maintained

2.3 Basic Policies for the Establishment of Spatial Data Infrastructure

The basic policies for the establishment of 2500 and 5000 level spatial data infrastructure were as follows:

a) Adopting technical specifications that meet user needs

b) Establishment of spatial data for general use

c) Ensuring technical sustainability

2.4 Basic Policies for Management of the Study

The basic policies for operation of the Study were as follows:

a) Detailed preparations

b) Flexible schedule

c) Close consultation with concerned agencies

d) Exhaustive safety measures

e) Thorough compliance

f) Utilization of results

g) Adequate quality control and flow control of subcontracted work

Chapter 3 Results of Implemented Work

3.1 Content and Volume of Work

(1) Technology transfer

The technology transfer implemented in the Study was divided into the following two main fields:

- Technology transfer for GIS construction
- Technology transfer for the establishment of spatial data infrastructure

a) Technology transfer for GIS construction

The transfer of technology in this field covered the following items:

- Construction of GIS databases
- Construction of topographic databases
- Operation and maintenance of GIS

b) Technology transfer for the establishment of spatial data infrastructure

The transfer of technology in this field covered the following items:

- GPS survey
- Ordinary leveling
- Pricking
- Field identification
- Aerial triangulation
- Digital plotting and compilation
- Supplementary field identification
- Production of topographic map data

(2) Construction of GIS

The contents and volume of work related to the construction of GIS are summarized in Table 3.1.

Table 3.1　Contents and volume of work for GIS construction

Category	Work Item	Description	Volume
Joint Work	Consultations on works related to GIS	A survey on work that could be targeted for GIS and a survey on requested GIS functions and database items/material were conducted.	1 set
	Discussions/determination on target works and target area of GIS	The target work and target area of GIS was discussed with the Counterpart and decided on.	1 set
	Discussions on GIS specifications	Based on the items discussed and decided on above, the functions and database items was discussed and determined.	1 set
	System/database verification 1 and 2	The constructed GIS model systems were verified to be running in accordance with the specifications.	1 set
Construction of GIS databases	Collection of administrative data　(by SOK)	Administrative data corresponding to the database items decided on were collected.	1 set
	Construction of GIS databases (by SOK)	The various GIS databases were constructed from the collected administrative data.	$15km^2$
	Construction of topographic database	The topographic database was constructed from the topographic map data.	$15km^2$
	Traffic volume survey (by subcontractor)	Three types of traffic volume surveys were conducted.	1 set
	Field verification of information on water and sewer facilities (by subcontractor)	Information (location, etc.) on water and sewer facilities (manholes, valves, etc.) were verified in the field.	$15km^2$
Construction of GIS system	System construction	Based on the results of the consultations on GIS related work, a system equipped with various functions was constructed.	1 set

(3)　Establishment of 2500 and 5000 spatial data infrastructure

The contents and volume of work related to the establishment of 2500- and 5000-level spatial data infrastructure are summarized in Table 3.2.

Table 3.2 Contents and volume of work for the establishment of spatial data infrastructure

Category	Work Item	Description	Volume
Joint Work	Preparatory work in Japan	The preparations necessary for Study implementation were made.	1 set
Establishment of 2500/5000 level spatial data infrastructure	Discussions and determination on the area targeted for the establishment of spatial data infrastructure	The area targeted for the establishment of the spatial data infrastructure were discussed and decided on with the Counterpart agency.	1 set
	Discussions and determination on the specifications for the establishment of spatial data infrastructure	The specifications for establishing the spatial data infrastructure were discussed and decided on with the Counterpart agency.	1 set
	Aerial photography (by subcontractor)	1:15000-scale color aerial photos were taken	approx. 702km^2
	Ground control point survey (by SOK)	A photo control point survey by GPS and ordinary leveling was conducted.	approx. 22 points approx. 350km
	Pricking (by SOK)	Using the aerial photos taken, pricking of photo control points and elevation points by ordinary leveling was carried out.	approx. 22 points approx. 350km
	Aerial triangulation	Using the results of the ground control point survey, the elements of orientation required for digital plotting were obtained through computer processing.	approx. 249 models
	Field identification (by SOK)	The information (place names, annotations, etc.) that could not be obtained through photo interpretation using the aerial photos taken was collected in the field.	approx. 585km^2
	Digital plotting/compilation (done in part by SOK and subcontractor)	The 2500 and 5000 level topographic and planimetric features were digitally plotted and compiled using the results of aerial triangulation and field identification.	approx. 585km^2
	Supplementary field identification (by SOK)	Any questionable items that arose during digital plotting/compilation were verified in the field	approx. 585km^2
	Supplementary digital compilation (done in part by SOK)	The results of the supplementary field identification were digitally compiled to produce digitally compiled data.	approx. 585km^2
	Establishment of topographic map data (done in part by SOK)	Topographic data suitable for producing output maps were generated from the digitally compiled data, and reproduction film for printing was made.	approx. 585km^2
	Production of printed maps (by SOK)	Printed maps were produced using the reproduction film.	118 sheets 1,025 copies
Other	Technical transfer seminar	The process and results of the Study were announced and dissemination of the products of the Study was promoted. The outcome of the technology transfer was also reviewed.	1 set

The work related to the construction of GIS and the establishment of 2500- and 5000-level spatial data infrastructure was implemented in accordance with the flowchart shown in Figure 3.1.

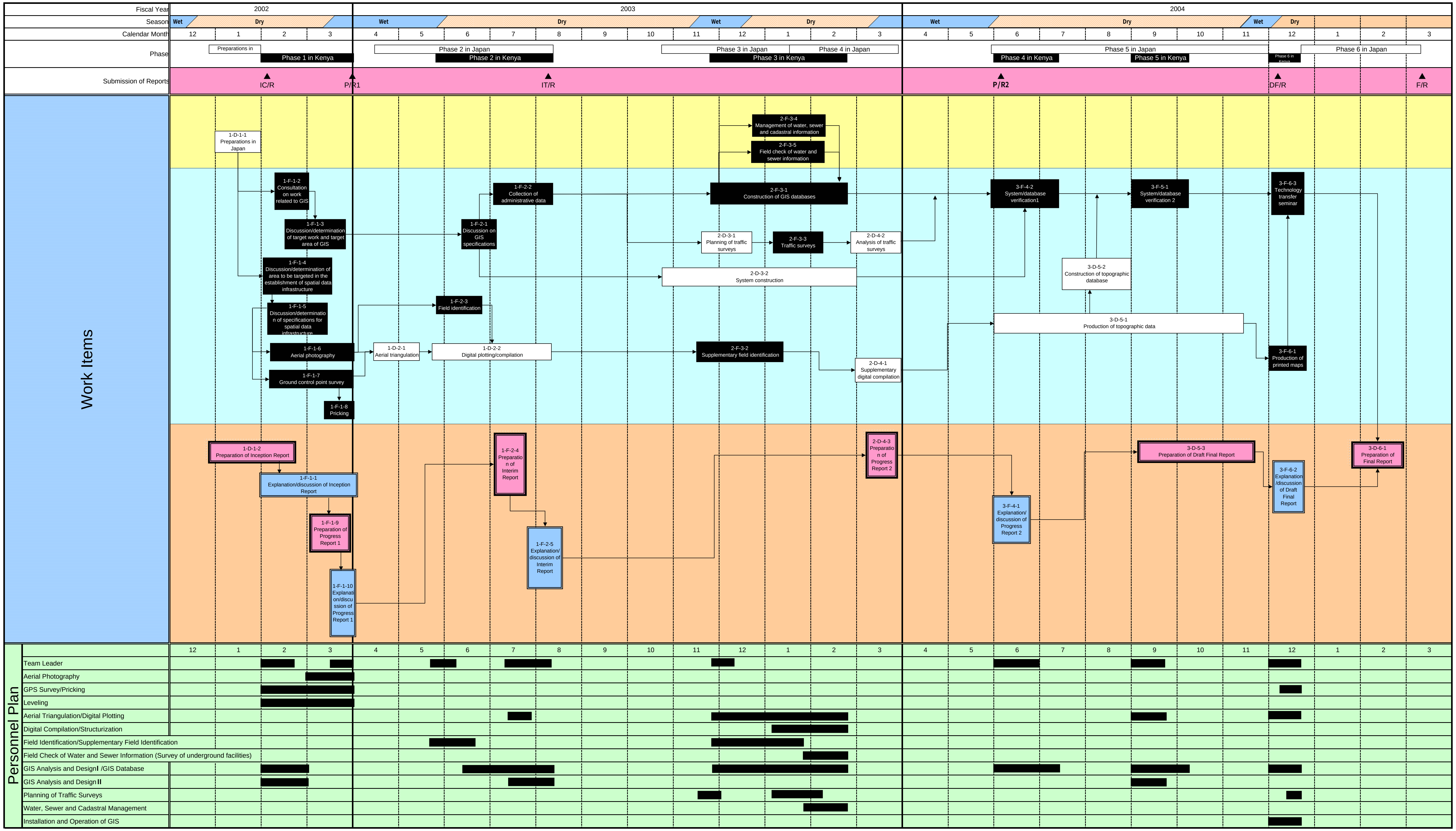
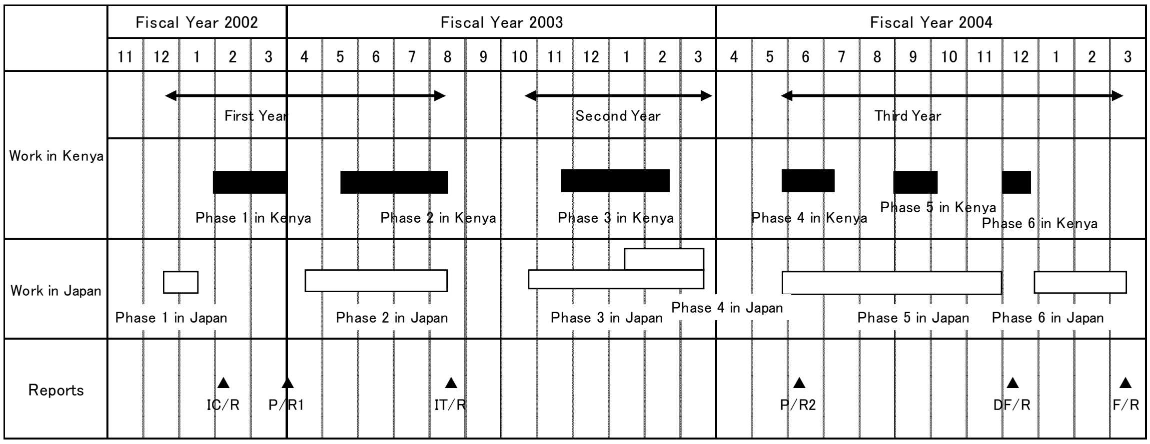


Figure 3.1 Flowchart for GIS construction and establishment of spatial data infrastructure

3.2 Implementation Schedule

(1) General schedule

The general schedule of the Study was as follows:



The Study commenced at the end of December 2002 and was completed at the end of March 2005.

(2) Detailed schedule

The detailed schedule was divided into technology transfer and GIS construction/establishment of 2500- and 5000- level spatial data infrastructure (refer to Table 3.3 Detailed schedule).

The schedule of the subcontracted work is shown in Table 3.4. The time the work was contracted out (▲) and time of quality and flow control (△) are indicated by their respective symbols.

Table 3.3 Detailed schedule

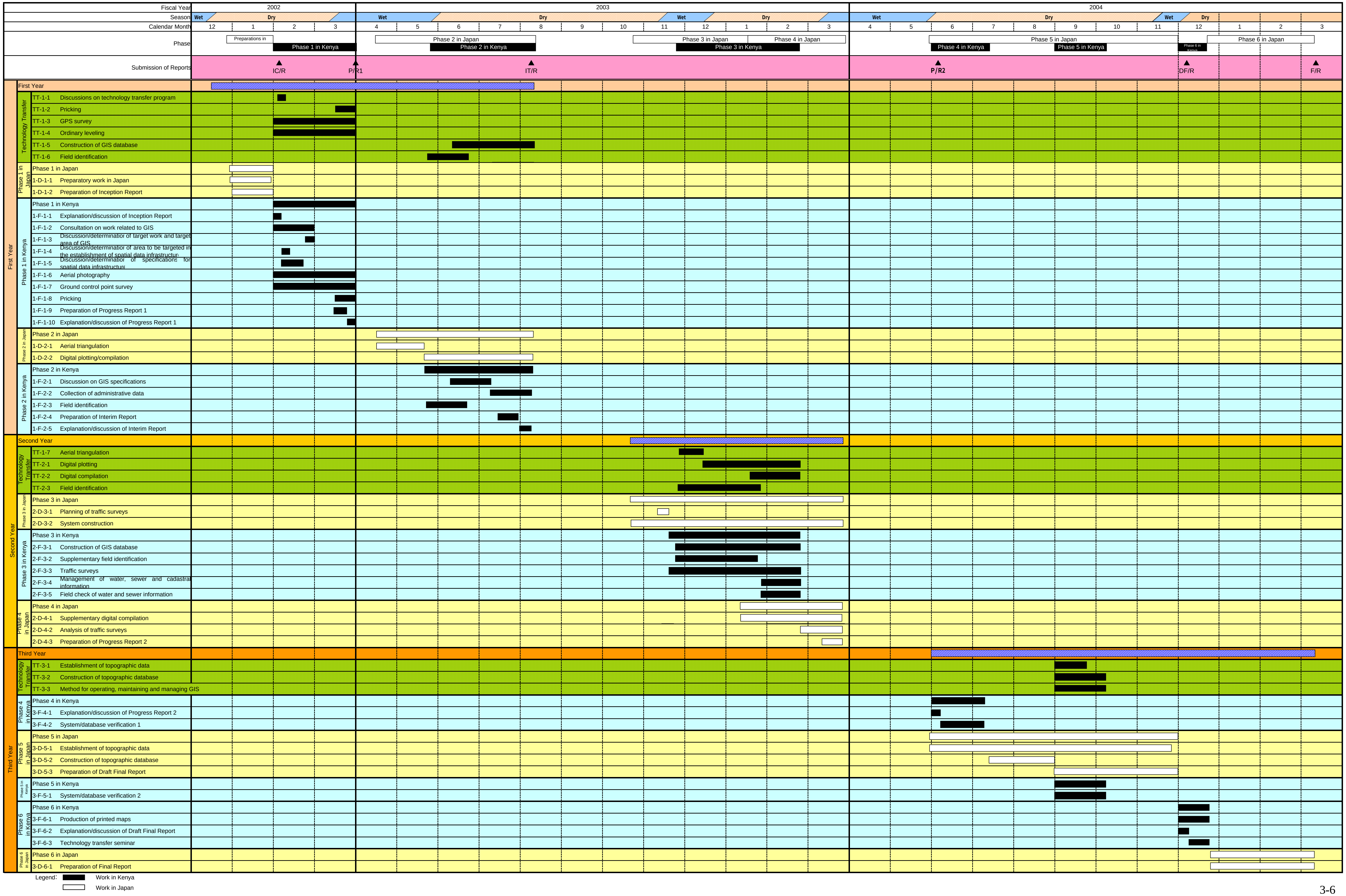
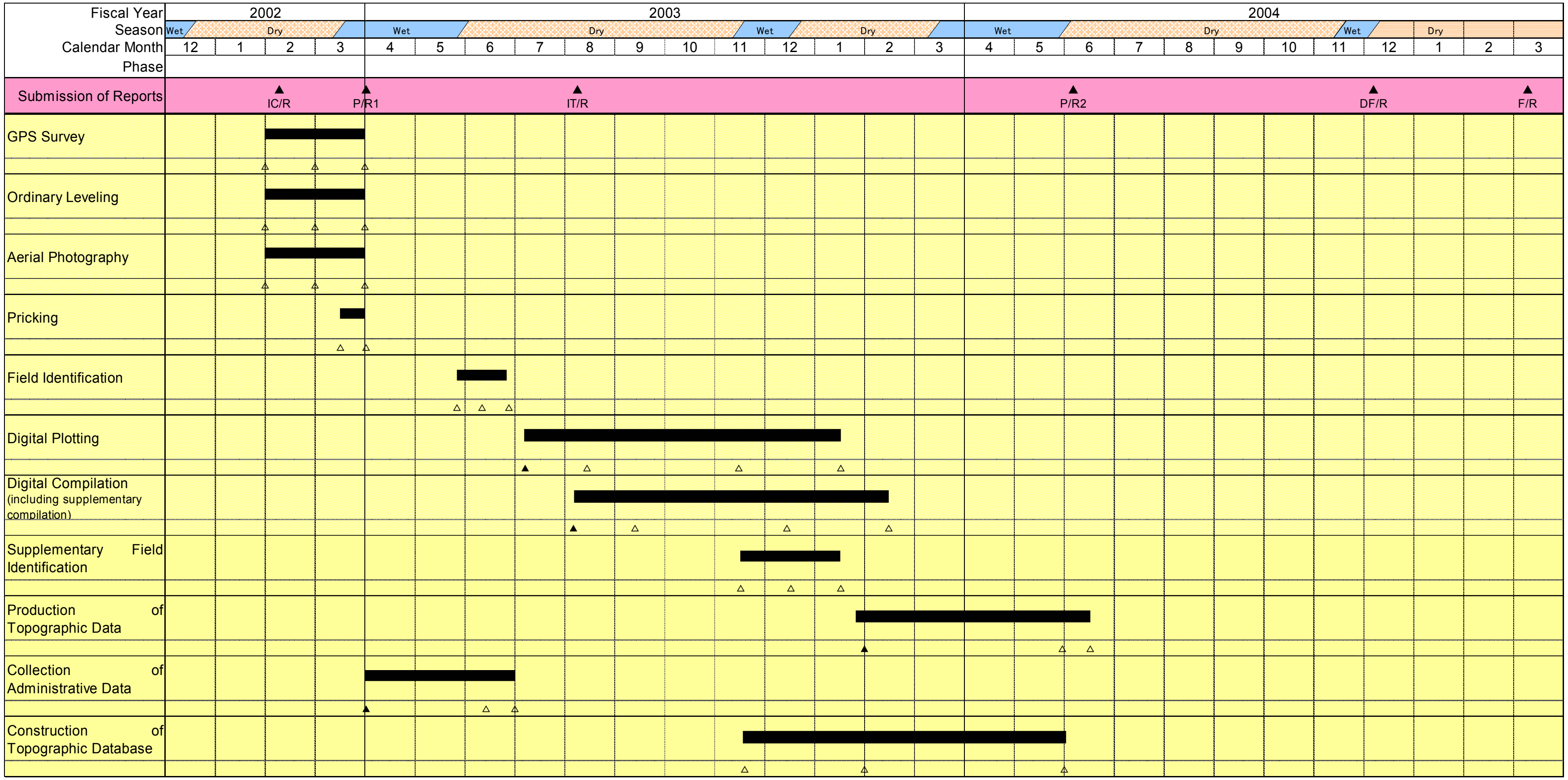


Table 3.4 Schedule of subcontracted work



Legend: ▲ Procurement of servcies , △ Quality/flow control

・The study team implemented quality and flow control of work by local subcontractor while in Kenya.
・Quality and flow control of work by SOK in the technology transfer was implemented during the technology transfer.
・Flow control by e-mail was carried out along with the execution of works .

3.3 Results of Technology Transfer

The technology transfer was divided into two fields: GIS construction and the establishment of spatial data infrastructure. Prior to implementation, the technology transfer program was discussed in respect to the following items:

- ♦ Schedule of the technology transfer
- ♦ Items targeted in the technology transfer
- ♦ Participants of the technology transfer
- ♦ Method of the technology transfer

The technology transfer was implemented based on the results of the discussions above.

3.3.1 Results of the Technology Transfer for GIS Construction

(1) Technology transfer program

The technology transfer program was discussed in line with the objectives of the technology transfer for GIS construction.

The contents, implementation period and number of participants of the program decided on are as shown in Table 3.5.

Table 3.5 Contents of technology transfer

Contents	Period of Implementation	No. of Participants
・Set up of hardware ・Installation of GIS software and other software ・Explanation of GIS software functions ・Practice with sample data	Jul - Aug 2003 (Actual Period: Jul 15 - Aug 1, 2003)	From SOK: 5 From NCC: 5
・Review of previous training ・Preparation of database specifications ・Data conversion ・Setting/conversion of projection method ・Construction of new database ・Editing of database ・Production of new graphic data ・Editing of new graphic data ・Input from external database ・Output to external database	Dec 2003 - Feb 2004 (Actual Period:Dec 8, 2003 - Feb 13, 2004)	From SOK: 10 From NCC: 10

Contents	Period of Implementation	No. of Participants
・Review of previous training ・Data display ・Geometrical correction/georeferencing ・Data conversion ・Attribute data analysis ・Spatial search ・Vector data creation ・Spatial analysis ・3D analysis	Jun - Jul 2004 (Actual Period: Jun 7 - Jul 2)	From SOK: 10 From NCC: 10
・General review ・Review of functions for ArcMap ・Review of functions for ArcCatalog ・Review of functions for ArcToolbox ・Review of spatial analysis ・Review of 3D analysis	Sep - Oct 2004 (Actual Period: Sep 6 - Oct 1, 2004)	From SOK: 10 From NCC: 10
・Review of previous training ・Method for operation and maintenance of GIS ・Exam	Dec 2004 (Actual Period: Dec 7 - 10, 2004)	From SOK: 10 From NCC: 10

(2) Implementation of technology transfer

Technology transfer in the field of GIS construction was implemented as planned with respect to contents and schedule.

As for the number of participants, technology transfer in the first period was carried out as planned (5 participants from SOK and 5 from NCC), using loaned equipment. However, from the second period onward, technology transfer was implemented using AICAD facilities targeting 10 staff from SOK and NCC respectively for effectiveness.

a) Goal

The aim of technology transfer for the various technical items was as follows:

∗ Basic knowledge and techniques of hardware and software necessary for GIS

The goal was to acquire basic knowledge and techniques concerning the hardware and software to be used in the technology transfer for GIS construction.

∗ Knowledge and techniques necessary for the construction of GIS database and topographic database

The goal was to acquire knowledge and techniques necessary for construction of the various databases.

* Knowledge and techniques for analysis using GIS software functions

The goal was to acquire basic knowledge and techniques of analysis functions of GIS software.

* Knowledge and techniques necessary for operation and maintenance of GIS

The goal was to acquire knowledge and techniques necessary for daily operation and maintenance of the GIS model systems to be introduced.

b) Method

In the first period, the technology transfer was conducted using loaned equipment. However, in order to increase effectiveness, from the second period onward technology transfer was carried out using AICAD facilities enabling each individual participant to operate equipment

The technology transfer was conducted mainly through lectures, using both the manuals that came with the hardware and GIS software and materials specially prepared for the technology transfer.

c) Evaluation of the results

* Basic knowledge and techniques for hardware and software

SOK and NCC staff were able to fully understand the physical set up of hardware by participating in the actual setting up of equipment used in the technology transfer.
The method for installing GIS software and other software was transferred by OJT through the actual installation of software, and the trainees were able to gain an understanding.

The technology transfer for the basic functions of GIS software was carried out through lectures and practice using sample data, and the trainees were able to gain a general understanding of the basic operation of GIS software

* Knowledge and techniques necessary for construction of GIS database and topographic database

Although the degree of understanding by SOK and NCC staff of the systematic concepts of ArcGIS software including Arc Catalog, Arc Map and Arc Toolbox varied, all participants were able to understand the basic concepts.

* Knowledge and techniques for analysis using GIS software

Here, the basic operation of ArcMap, ArcCatalog and ArcToolbox was reviewed, and all trainees understood the operating method and concept of these applications. The basic concept and operating method of spatial analysis and 3D analysis, which are extension programs, were also explained, and all the trainees gained an understanding of overlay analysis using various data, and the method for constructing digital topographic data (elevation, slope and aspect) using contour data.

* Knowledge and techniques for operation and maintenance of GIS

In the final technology transfer, lectures were held on the operation and maintenance of the GIS model systems constructed, and all the trainees gained a deeper understanding of the importance of this.

3.3.2 Results of Technology Transfer for the Establishment of Spatial Data Infrastructure

(1) Technology transfer program

a) Schedule of the technology transfer

The technology transfer for the establishment of spatial data infrastructure was implemented according to the following schedule.

GPS survey (including pricking, aerial photo signals:	Feb 12-Mar 27, 2003
Ordinary leveling 8including pricking):	Feb 12-Mar 27, 2003
Field identification:	May 26-Jun 13, 2003
Supplementary field identification:	Dec 8, 2003-Feb 20, 2004
Digital photogrammetry (aerial triangulation, digital plotting and compilation, other):	Dec 8, 2003- Feb 20, 2004 Sep 6-22, 2004

b) Items targeted in the technology transfer

The items targeted in the technology transfer were as follows:

- Pricking
- GPS survey
- Ordinary leveling
- Field identification
- Supplementary field identification
- Aerial triangulation
- Digital plotting

- ♦ Digital compilation
- ♦ Other digital photogrammetric techniques

c) Participants of the technology transfer

The participants in the technology transfer included four (4) for GPS survey, three (3) for ordinary leveling, five (5) for field identification, and ten (10) for supplementary field identification. For the transfer of photogrammetric techniques, there were five (5) participants and two (2) observers who attended on occasion

(2) Implementation of technology transfer

a) Goal

The aim of the technology transfer for the various technical items was as follows.

- ♦ Pricking:
  - Acquisition of techniques for pricking photo control points on aerial photos and for preparing description sheets of the pricked points
  - Acquisition of techniques for pricking elevations points while carrying out observations in ordinary leveling

- ♦ Aerial photo signals:
  - Understanding the relationship between photographic scale and the size of aerial photo signals
  - Acquisition of techniques for installing aerial photo signals and for preparing description sheets

- ♦ GPS survey:
  - Acquisition of techniques for preparing a point distribution and observation plan
  - Acquisition of techniques for observations and analysis of observation data (baseline analysis, net adjustment)
  - Acquisition of techniques for evaluation of results of analytical computations

- ♦ Ordinary leveling:
  - Method of planning for ordinary leveling
  - Method of inspecting and adjusting the level
  - Acquisition of techniques for observations, computational processing, etc.

- Field identification:
  - Method for conducting field identification using aerial photos enlarged to the plotting scale
  - Acquisition of techniques for arranging the results of field identification on the aerial photos

- Supplementary field identification:
  - Understanding of the aim and procedures of supplementary field identification
  - Understanding of the method of planning/preparing for supplementary field identification
  - Acquisition of the method of using the handbook for aerial photo interpretation
  - Acquisition of the method for conducting supplementary field identification
  - Acquisition of techniques for arranging the results of supplementary field identification

- Aerial triangulation (digital method):
  - Acquisition of techniques for operating a film scanner
  - Acquisition of techniques for digitization of aerial photos using a film scanner
  - Acquisition of techniques for carrying out digital aerial triangulation
  - Acquisition of the method for evaluating the results of digital aerial triangulation

- Digital plotting
  - Acquisition of techniques for operating a digital plotter
  - Acquisition of techniques for carrying out digital plotting
  - Acquisition of techniques for handling digitally plotted data

- Digital compilation
  - Acquisition of techniques for operating a digital compiler
  - Acquisition of techniques for carrying out digital compilation
  - Acquisition of techniques for handling digitally compiled data

- ♦ Other digital photogrammetric techniques
  - Acquisition of techniques for operating a map scanner
  - Acquisition of techniques for digitizing topographic maps
  - Acquisition of techniques for producing orthophotos
  - Understanding of a network system
  - Understanding of ISO standards

b) Method

Each technology transfer was carried out through lecture style training at the start, followed mainly by OJT. However, techniques for setting up the level and for observations were transferred through simulated practice followed by OJT.

Furthermore, the technology transfer for digital photogrammetric techniques was divided into four modules, i.e. basic operation, practice, applied techniques and other relevant techniques, as shown below.

c) Evaluation of the results

The results of each technology transfer were evaluated as follows:

∗ Pricking

The pricking of photo control points and elevation points in locations where many features were clearly identifiable in the photos was carried out with sufficient accuracy. However, the counterparts still need to enhance their capacity for pricking in locations with few identifiable features.

Based on these results, it is determined that SOK has acquired ordinary pricking techniques but needs to build on their experience.

∗ Aerial photo signals

Regarding the relationship between photographic scale and size of aerial photo signal, although SOK's theoretical understanding was not adequate, they were able to grasp the size of aerial photo signals corresponding to the photographic scales.

As for the installation of aerial photo signals and the preparation of description sheets, these techniques were successfully transferred to SOK through OJT.

∗ GPS survey

Techniques for point selection and for preparing a new point distribution map and observation plan were transferred to SOK based on the point distribution map prepared.

Through this process, SOK adequately acquired the techniques for preparing a point distribution and observation plan in consideration of the equipment it possesses。

SOK also acquired techniques for carrying out observations and various analytical computations, such as baseline analysis, check calculations and net adjustment, through OJT.

Based on these results, it is clear that SOK is capable of carrying out general baseline analysis, check computations, and net adjustment independently.

* Ordinary leveling

SOK was able to gain an adequate understanding of the significance of ordinary leveling in photogrammetry through lecture-style training.

SOK acquired the method for inspecting the level and observation techniques using an electronic level through OJT.

They also acquired techniques for analysis and calculation of observation data and net adjustment through OJT.

* Field identification

SOK gained an understanding of the method of preparing for field identification and for the application of symbols through lecture style training.

SOK did not have experience in carrying out field identification using aerial photos so the relevant techniques were transferred to SOK through OJT. As a result, it is determined that SOK gained a fair understanding of the method of field identification using aerial photos However, SOK is still not capable of arranging the results of the field study so that it can be effectively utilized in subsequent works.

* Supplementary field identification

SOK was able to understand the objective and procedure of supplementary field identification, which was mainly explained through lecture style training. However, planning for supplementary field identification was a completely new task for them, so they need to obtain practical experience in the future.

Regarding the technology transfer for using the Aerial Photo Interpretation Handbook in the supplementary field identification, the technical experience of the participants had a big effect on the outcome. Participants from the Photogrammetric Section were able to master the technique while those from the other sections need further practical experience.

In the technology transfer for supplementary field identification, which was conducted through OJT, the level to which the objectives were achieved varied among participants. Those from the Mapping Section acquired the technique for confirming administrative names and boundaries and for arranging the results of the supplementary field identification to an adequate degree. However, those from the other sections need additional training and further practice.

* Digital photogrammetric techniques (aerial triangulation, digital plotting and compilation, other)

  Regarding techniques for the digitization of aerial photos and subsequent digital aerial triangulation, the work by the counterpart was found to be of equal quality to that of the Study Team. Therefore, it is determined that SOK has reached a level where they can carry out such works independently.

  The data plotted and compiled by SOK was visually compared to that done by the Study Team. As a result, the difference in horizontal positions and code numbers of the topographic and planimetric features plotted were found to be within the permissible level. Therefore, it is determined that the counterpart has reached a level where they can carry out such work independently.

Based on the evaluation above, it is judged that SOK has achieved a technical level where they are capable of carrying out work from digital aerial triangulation to digital compilation on their own.

3.4 Results of GIS Construction

3.4.1 Current Situation of GIS at NCC

For construction of the GIS model systems, consultations on work related to GIS were conducted in order to assess the current situation of GIS at NCC.

(1) Objective of consultations on work related to GIS

Consultations on work related to GIS were conducted to determine the work content, problems, maps produced/utilized, etc. of the various departments and agencies of NCC.

(2) Implementation of consultations on work related to GIS

a) Departments visited

Consultation on work related to GIS were to be conducted at 10 departments in NCC

b) Contents of consultations on work related to GIS

The consultations on work related to GIS consisted of the following:

- ♦ General understanding of the main duties of each department
- ♦ Understanding of the relationship among NCC departments and with external organizations
- ♦ Understanding of the use conditions of geographic information
- ♦ Identification of problems in the execution of duties
- ♦ Understanding of the thematic maps each department would like established
- ♦ Understanding of the plan for GIS use of each department

(3) Results of consultations on work related to GIS

The results of the consultations on work related to GIS were as follows:

a) Outline of main duties of each department

Through the consultations, the main duties of the various departments were clarified.

b) Relationship among departments and with external organizations

- ♦ In NCC, City Planning works in coordination with all other departments, The Town Clerk (Land Valuation), Water & Sewerage and City Engineer work in coordination with many other departments.
- ♦ Few departments work in coordination with SOK, mainly because up-to-date topographic maps are not available.
- ♦ NCC expects to build a cooperative relationship with private companies that provide public services in order to share information with them.

c) Geographic information and conditions of use

The geographic information that is commonly used by many of the departments are the topographic maps and thematic maps shown below.

Topographic maps: general topographic maps - Entire Nairobi City (1:50,000)
City of Nairobi (1:20,000)
Topographic maps of various scale

Thematic maps: cadastral related - Cadastral Map (1:10,000)
Valuation Map (independently produced and used by Land Valuation section)
Deed Map (provided by SOK)

Survey Map (provided by SOK)
Registry Index Map (provided by SOK)
Zoning Map (independently produced by City Planning section)
Constituency Map (1:50,000-scale map sheets produced by SOK, indicating the boundaries and names of the election districts within the city)

The departments that often use topographic and thematic maps for carrying out their duties are City Planning, Town Clerk (Land Valuation), Water & Sewerage and City Engineer (Road).

d) Problems in the execution of duties

The four problems that are in greatest demand for improvement are the up-dating of topographic maps, the computerization of work (introduction of computers), the building of networks (including not only computer networks but also telephone and wireless networks and networks to coordinate between departments), and improvement of the system for managing registers and maps.

e) Thematic maps that the various departments would like established

The thematic maps that the various departments would like established are as follows:

- The thematic maps that most departments would like established are those related to natural resources such as land use maps, vegetation maps, soil maps, geological maps, and river and lake maps.
- The thematic maps desired by most departments also include population distribution maps. This because they recognize that information on population density and population structure is essential in the planning and construction of urban facilities and in the management of existing municipal facilities.
- The departments responsible for maintaining, managing, and expanding urban facilities, that is City Planning, Water & Sewerage, and City Engineer, recognize the need for maps of underground facilities possessed by the private companies, Kenyan Power and Telecom.

f) Plan for GIS use

In the plan for GIS use put forward by each department, the one point that many departments have in common is the plan to utilize GIS to interlink the records and relevant maps held by each department.

3.4.2 Basic Policies and Target Area for the Construction of GIS Model Systems

(1) Basic policies

The basic policies for the construction of GIS model systems were determined based on the results of consultations on work related to GIS. The three basic policies decided on are as follows:

- ♦ To construct a GIS database of spatial data infrastructure
- ♦ To construct a GIS database to support the tasks of NCC
- ♦ To construct a GIS model system to solve urban problems in Nairobi

(2) Selection of target Area

a) Target area for construction of GIS database for spatial data infrastructure

This database shall cover the same area targeted for the construction of spatial data infrastructure, which is the entire city of Nairobi excluding Nairobi National Park (595km^2)

b) Target area for construction of GIS database to support the tasks of NCC

This GIS database is to cover the following five sheets of the 1:2,500 topographic map to be produced in the Study: 69-III, 78-II, 79-I, 79-II and 79-III (37-III-EG). The total area covered was 15km^2.

c) Target area for construction of GIS model systems to solve urban problems in Nairobi

The GIS model systems are to be constructed using the GIS database to support the tasks of NCC mentioned in b). Therefore, the GIS model systems shall cover the same area targeted in the construction of that GIS database.

3.4.3 Construction of Database for GIS Model Systems

(1) Discussions on GIS database specifications

Based on the basic policies in 3.4.2, the following two types of GIS databases were constructed.

- ♦ GIS database of spatial data infrastructure
- ♦ GIS database to support the tasks of NCC

The final specifications for the GIS databases mentioned above were discussed and decided on with NCC and SOK

a) GIS database of spatial data infrastructure

The GIS database of spatial data infrastructure is composed of 11 layers (i.e. administrative boundary, transportation, buildings, small objects, water areas, surround, open spaces, vegetation, topographic features, and control points). Furthermore, each layer contains sub-layers and stores the various feature data.

This GIS data is defined in the form of polygon data, line data or point data based on the characteristics of the target feature. The feature code number is added as attribute data.

b) GIS database to support the tasks of NCC

The GIS database to support the tasks of NCC is composed of 15 layers (i.e. administrative boundary, road network, intersection, property boundary, water lines, chamber, meter point, sewage line, manhole, educational facility, medical facility, social facility, vegetation, wetland and land use).

This data is constructed in the form of polygon data, line data or point data depending on the shape of the feature, and the information concerned with these data is added as attribute data.

(2) Collection of administrative data

The necessary information (maps, records, etc) for construction of the GIS database to support the tasks of NCC was collected with the cooperation of NCC and SOK.

a) Collection of information on water and sewer facilities

Positional information and attribute information of water and sewer facilities, including lines, manholes and so on, was collected with full cooperation from NCC.

b) Collection of cadastral information

Attribute information of properties were to be obtained from the Valuation Book and the positional information from the “Valuation Map”. However, the property boundaries on the Valuation Map were found not to be consistent with actual land boundaries. Therefore, verification work was carried out based on the “Topo-Cadastral Map” (1:2,500, produced by SOK) and input maps reflecting the positional information of property boundaries were produced (5 sheets covering the entire target area of the model systems).

c) Field check of information on water and sewer facilities:

In order to upgrade the quality of the information (particularly positional information) on water and sewer facilities, the information was verified in the field by a subcontractor.

d) Traffic surveys

Traffic surveys were conducted as part of the collection of administrative data.

- ♦ Objective

  The aim of the traffic surveys is to gain an understanding of current traffic conditions and causes of congestion in Nairobi in order to obtain basic data for planning measures to alleviate congestion.

- ♦ Type of surveys

  In order to achieve the objective, the following three types of traffic surveys were planned. Each type of survey was for a 12-hour period (weekday, 7:00 –19:00) and was to be carried out twice.

- ♦ Implementation of traffic surveys

  The following surveys were carried out twice, for a period of twelve hour on a weekday. The surveys targeted the number of points shown below.

  Survey1: Traffic flow survey → 21 intersections
  Survey2: Survey of turning movement at intersections → 21 intersections
  Survey3: Survey of turning movement at intersections → 6 intersections

(3) Construction of GIS database

The GIS databases were constructed in accordance with the database specifications. The constructed databases are as follows.

- ♦ GIS database of spatial data infrastructure
- ♦ GIS database to support the tasks of NCC
- ♦ Databases of the four GIS model systems to be constructed

a) GIS database of spatial data infrastructure

This database was constructed by structuralizing the topographic map data.

b) GIS database to support the tasks of NCC

- Graphic database

  This database was constructed from the graphic data of the other two databases to be constructed, and the graphic data (land use) specific to this database, which was produced from the provided analogue data.

- Attribute database

  The attribute information specific to this database was produced from the collected information, and then used to construct the database according to the specified format.

c) Databases of the four model systems to be constructed

- Graphic database

  The databases of the graphic information (pipe, facility, property boundary, etc.) specific to the four model systems were constructed from the information collected, according to the database specifications.

- Attribute database

  The databases of the attribute information (diameter and type of pipe, type of facility, etc.) specific to the four model systems were constructed from the information collected, according to the database specifications.

3.4.4 Construction of the GIS Model Systems

The four model systems shown below were constructed as a tool to solve or improve urban problems.

- GIS model system to support road management
- GIS model system to support water and sewerage management
- GIS model system to support cadastre management

(1) Definition of required functions for the model systems

a) Definition of required functions for the GIS model system to support road management

The main functions required in the GIS model system to support road management were as follows:

- Various search functions by road name, width, etc
- Search, display and print out function for digital land register
- Display function indicating the traffic congestion

- ♦ Overlay analysis function for various data (spatial analysis function)
- ♦ Counting function coupled with conditional expressions
- ♦ Function for outputting display and analysis results
- ♦ Data import function
- ♦ Data export function
- ♦ Editing function for graphic data (add, edit, delete)
- ♦ Editing function for attribute data (add, edit, delete)

b) Definition of the required functions for the GIS model system to support water management

The main functions required in the GIS model system to support water management were as follows:

- ♦ Digital mapping function (editing of graphic data)
- ♦ Search function of various types of information (location, material of pipe, diameter of pipe, etc.)
- ♦ Map output function
- ♦ Clipping function
- ♦ Edit function for attribute data
- ♦ Function to zoom in/out
- ♦ Scroll function
- ♦ Output function for digital forms

c) Definition of the required functions for the GIS model system to support sewerage management

The main function required in the GIS model system to support sewerage management were the same as those in the system to support water management

d) Definition of the required functions for the GIS model system to support cadastre management

The functions required in the GIS model system to support cadastre management were as follows:

- ♦ Input function for cadastral boundaries
- ♦ Edit function for cadastral boundaries
- ♦ Search function by cadastral information (lot number, address, owner, etc)
- ♦ Search function by map sheet number, etc.
- ♦ Map output function

- ♦ Clipping function by address
- ♦ Edit function for cadastral attribute data (add, edit, delete)
- ♦ Function for overlay analysis
- ♦ Search and analysis function by conditional expression

(2) Construction of GIS model systems

a) Constraints in system construction

The hardware and software that could be utilized in the system design and database design of the four GIS model systems mentioned above were as follows:

- ♦ Hardware
  - Desktop PC
  - TFT monitor
  - A0 color plotter
  - A0 black and white scanner
  - A4 black and white printer

- ♦ Software
  - OS : Windows XP Professional
  - GIS engine : ArcGIS 9.0 (ArcInfo, Spatial analyst, 3D analyst)
  - Microsoft Office XP Professional
  - Anti-virus software

b) System design

The design of the GIS model systems consisted of a function design and a database design.

- ♦ Function design

  The required functions defined by the GIS model systems were divided into “common basic functions”, “common analysis functions” and “ specific functions” and then designed.

- ♦ Database design

  The databases required for the four GIS model systems and the database to support the tasks of NCC consist of graphic data and attribute data. The respective data items were designed based on the system functions and existing information.

c) Construction of GIS model systems

- Customized functions

  The existing functions in the GIS engine to be used were not sufficient to meet the requirements of the four GIS model systems . Therefore, some of the required functions were customized using “Arc/Info”.

- Common basic functions

  The basic functions required for the four model systems were analyzed and those common to the four respective systems were identified. The basic functions required when starting the model systems, such as display, reading of data, etc., were also determined.

  The common basic functions are shown below and were established with existing “Arc/Info” functions and customized functions.

- Common analysis functions

  As with the basic functions, the analysis functions required for the four model systems were analyzed and those common to the various systems were identified.

  The analysis functions were established with mainly existing “Arc/Info” functions.

- Specific functions of the model systems

  Of the required functions of the model systems, those that could not be classified as common basic functions or common analysis functions were constructed as specific functions for each model system.

  The specific functions were established with existing “Arc/Info” functions and customized functions.

d) Verification of systems/databases

The systems constructed were verified with users using the databases constructed.

In the verification process, whether the defined functions were functioning properly, whether the users were satisfied with the various displays, and whether the operational procedures were simple and convenient were checked.

Based on the verification results, the model systems were modified and improved and the flaws in the databases were corrected. After that, a final verification was carried out and the four GIS model systems were completed.

3.5 Results of the Establishment of Spatial Data Infrastructure

3.5.1 Target Area and Specifications for the Establishment of Spatial Data Infrastructure

(1) Target area for the establishment of spatial data infrastructure

a) Target area for the establishment of 2500 and 5000 scale level spatial data infrastructure

- ♦ Target area for 2500 scale level spatial data infrastructure

  The target area was approximately 179.22km^2 covered by 60 sheets as shown in Figure 3.2.

- ♦ Target area for 5000 scale level spatial data infrastructure

  The target area was approximately 416.60km^2 covered by 59 sheets as shown in Figure 3.2.

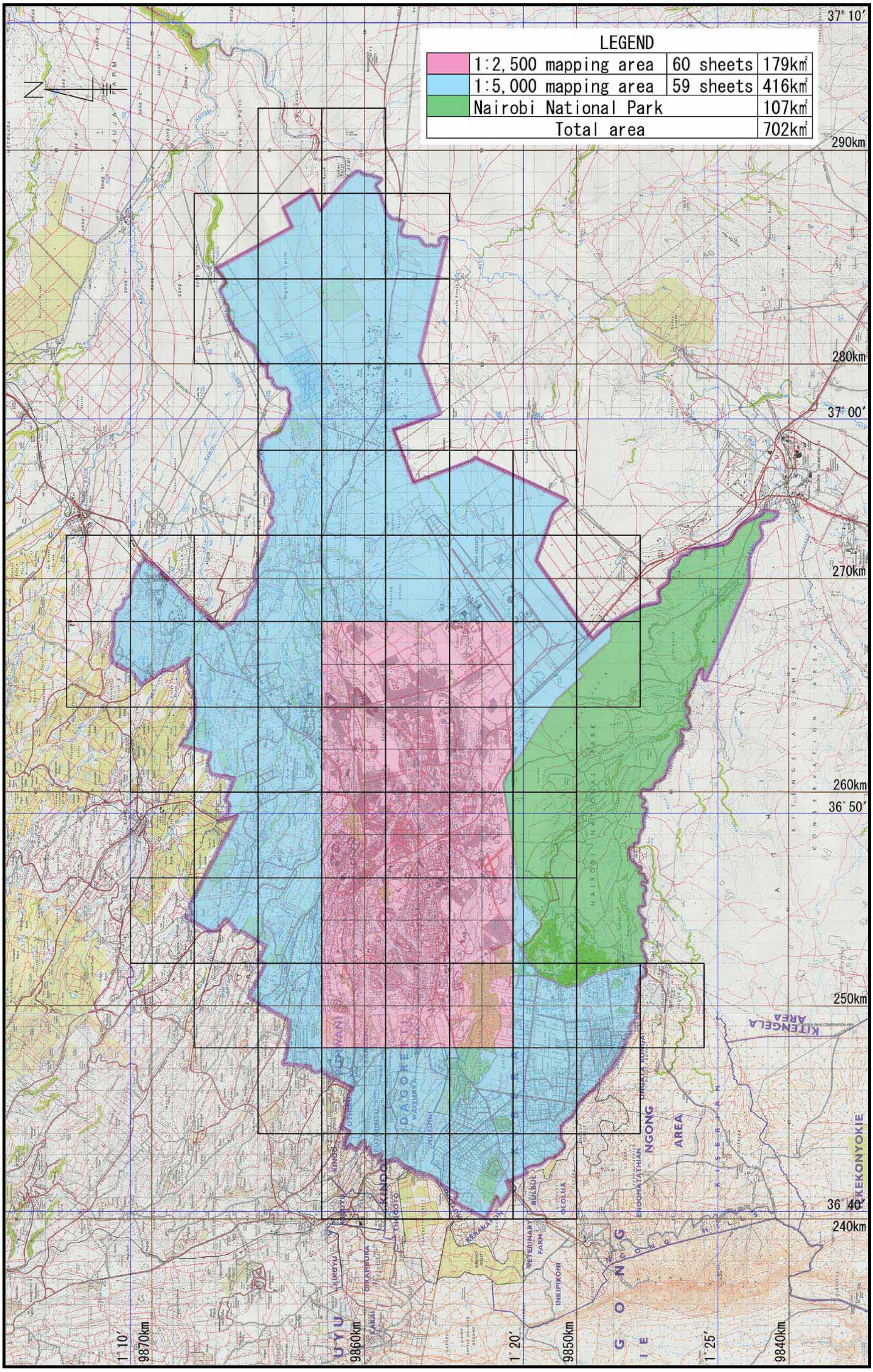


Figure 3.2　Scope of digital mapping/sheet division

(2) Specifications for the establishment of spatial data infrastructure

a) Survey standards

Reference ellipsoid: Clarke 1880(modified)

Projection method: U.T.M.(Universal Traverse Mercator) Zone37

Point of origin: Intersection point of 39° east longitude (central meridian) and the equator

Scale factor at the central meridian: 0.9996

b) Work specifications for the establishment of spatial data infrastructure

The work specifications for establishing spatial data infrastructure include a wide range of techniques. Therefore, the specifications were to be discussed and decided on as the Study progressed. The "Work Specifications for the Establishment of Spatial Data Infrastructure (Draft)" were to be prepared in the final stage of the Study.

3.5.2 Aerial Photography

(1) Preparation of specifications

Specifications for the local subcontractor were prepared based on the section in the "Work Specifications for the Establishment of Spatial Data Infrastructure (Draft)" on aerial photography, and approval by JICA was obtained.

(2) Selection of local subcontractor

A tender was held using the specifications prepared, and the following company was selected as the local subcontractor.

Digital Topographical Mapping Services (DTM) (South Africa)

(3) Permission for aerial photography

After the local subcontractor was selected, applications for photography permits were submitted to the concerned agencies with full cooperation from SOK. As a result, the various photography permits were obtained by February 17, 2003.

(4) Implementation of aerial photography

All preparations were made by February 20, 2003. The aerial photos were shot on that same day (February 20) and the film was developed.

(5) Results of aerial photography

After developing and printing the film, the color photographs were inspected.

All the aerial photographs were found to be acceptable. The aerial photography used consisted of 305 photographs (contact prints) taken in 15 flight strips.

3.5.3 Land Surveys

(1) Pricking of photo control points

Twenty-two (22) photo control points selected at locations that would appear clearly in the aerial photos were pricked on the contact prints. Description sheets for all the pricked points were also prepared.

(2) Pricking of elevation points

The pricking of elevation points is normally carried out while conducting observations in ordinary leveling. However, on this occasion, the following two methods were adopted in view of the period of aerial photography.

1. Sketches of the elevation points to be pricked are to be prepared and used for the pricking the contact prints.
2. As usual, elevation points are to be pricked while performing observations.

Using the two methods mentioned above, elevation points were pricked on the contact prints at a standard interval of approximately 500m.

(3) GPS photo control point survey

a) Field reconnaissance of existing triangulation points

A field reconnaissance of existing triangulation points was conducted based on the GPS photo control point survey plan.

Of the 13 points targeted, only three points were verified.

b) Selection and monumentation of photo control points

Photo control points were selected based on the photography flight plan and the planning map for the GPS photo control point survey.

In selecting the positions of photo control points, objects that could be clearly identified in the aerial photos (bridges, corners of large manholes, roofs of houses, etc) were targeted.

After point section was complete, the photo control points were monumented using metal markers.

c) Observations

The observation plan was determined taking into account the draft plan prepared in advance, the results of the field reconnaissance on existing triangulation points, the results of photo control point selection, and the number of GPS receivers available for observations.

The observations were carried out in 14 sessions using four GPS receivers (Leica SR520) and there were a total of 12 common sides.

d) Analytical computations of observation data

The analytical computations performed on the observation data included baseline analysis, check computations, and net adjustment. As a rule, Leica's processing software "SKI-PRO" was used for all the work.

All of the computations were carried out successfully. The standard deviation of all the newly installed photo control points' final coordinates was within the limit set in discussions with SOK (standard deviation of longitude and latitude: 15cm, standard deviation of height: 30cm).

Table 3.6 List of newly installed photo control points

Point ID	B	L	X	Y	Ell(m)	Alt(m)	Geoid H.(m)	Remark
148ST5	1° 29' 17.70455" S	36° 37' 01.93966" E	9,835,375.070	234,861.940	1,751.642			
149S2	1° 06' 01.51548" S	37° 06' 44.49970" E	9,878,315.023	289,949.592	1,389.794			
149S3	1° 28' 07.08874" S	37° 03' 44.64762" E	9,837,592.787	284,419.100	1,727.096			
KJ01	1° 08' 53.64349" S	36° 53' 53.69124" E	9,873,011.157	266,117.332	1,454.634	1,564.493	109.859	
KJ02	1° 10' 38.75232" S	36° 56' 19.18118" E	9,869,785.482	270,618.912	1,429.742	1,539.473		Calculation by the interpolation
KJ03	1° 11' 18.23361" S	36° 47' 25.83794" E	9,868,559.858	254,126.032	1,646.087	1,755.926	109.839	
KJ04	1° 11' 24.58187" S	36° 51' 32.45660" E	9,868,370.837	261,753.130	1,518.012	1,627.743		Calculation by the interpolation
KJ05	1° 12' 52.94674" S	36° 58' 03.03261" E	9,865,665.450	273,833.428	1,407.386	1,517.117		Calculation by the interpolation
KJ06	1° 15' 14.07097" S	37° 00' 38.43740" E	9,861,333.871	278,642.179	1,387.763	1,497.649	109.886	
KJ07	1° 12' 05.67685" S	37° 03' 54.68593" E	9,867,125.458	284,706.218	1,363.585	1,473.010	109.425	
KJ08	1° 14' 32.80888" S	37° 05' 52.12847" E	9,862,608.535	288,340.853	1,377.832	1,487.417	109.585	
KJ09	1° 15' 23.26364" S	36° 41' 01.85797" E	9,861,021.492	242,256.828	1,834.370	1,943.979	109.609	
KJ10	1° 14' 12.26252" S	36° 44' 01.97427" E	9,863,207.837	247,825.540	1,703.072	1,812.803		Calculation by the interpolation
KJ11	1° 16' 21.43488" S	36° 48' 39.80047" E	9,859,246.533	256,421.085	1,561.377	1,671.208	109.831	
KJ12	1° 15' 21.16614" S	36° 54' 56.97341" E	9,861,107.686	268,083.412	1,473.976	1,583.897	109.921	
KJ13	1° 18' 49.21307" S	36° 59' 05.44134" E	9,854,722.673	275,771.774	1,471.391	1,581.122		Calculation by the interpolation
KJ14	1° 16' 38.51834" S	37° 02' 11.71732" E	9,858,741.974	281,528.489	1,386.312	1,496.106	109.794	
KJ15	1° 18' 23.61464" S	37° 04' 56.57494" E	9,855,517.537	286,628.400	1,365.482	1,475.109	109.627	
KJ16	1° 18' 59.41044" S	36° 39' 33.64896" E	9,854,377.754	239,534.745	1,782.569	1,892.106	109.537	
KJ17	1° 21' 03.48035" S	36° 42' 44.30843" E	9,850,571.212	245,434.915	1,752.437	1,862.168		Calculation by the interpolation
KJ18	1° 23' 35.16717" S	36° 45' 42.90531" E	9,845,915.976	250,962.559	1,624.835	1,734.577	109.742	
KJ19	1° 20' 24.79077" S	36° 45' 56.42869" E	9,851,765.427	251,375.325	1,684.073	1,793.781	109.708	
KJ20	1° 20' 08.02429" S	36° 53' 39.89564" E	9,852,293.211	265,707.212	1,525.040	1,634.834	109.794	
KJ21	1° 22' 56.55056" S	36° 56' 00.62238" E	9,847,119.741	270,063.268	1,507.525	1,617.329	109.804	
KJ22	1° 21' 05.76944" S	36° 57' 57.59399" E	9,850,526.016	273,677.291	1,495.617	1,605.348		Calculation by the interpolation
						Ave.	109.731	

(4) Ordinary leveling

a) Field reconnaissance of established benchmarks

A field reconnaissance of established benchmarks in and around Nairobi City was conducted using the point description data for first and second order benchmarks available at SOK and other agencies.

As a result, 11 benchmarks were verified in and around the city.

b) Deciding on routes for ordinary leveling

The routes for ordinary leveling were determined based on the planned routes, the photography flight plan map, 1:15,000 scale aerial photographs and the results of the field reconnaissance mentioned above. It was also decided that the heights of 15 of the 22 newly installed photo control points would be determined by leveling. The total length of the routes was approximately 247km.

c) Observations

After deciding on the routes for ordinary leveling, three groups were organized to perform observations.

Prior to performing observations, the levels were inspected and adjusted (collimation axis, etc.).

Observations were carried out according to specifications.

d) Computational processing and arrangement

Computational processing: Computational processing of observation data was carried out for all leveling routes.

Then, for the routes with adequate observation data, the heights of fixed points and pricking points were determined using Leica's processing software "Level Pack Pro" (refer to accuracy control table).

Arrangement: The heights of the pricking points determined by computational processing were arranged in meters on the contact prints to the second decimal place.

Table 3.7 Accuracy control table

Project name	Nairobi Mapping	Area	Nairobi City	Planning agency	JICA and Kokusai Kogyo	Executing agency	SOK	Project leader	(Signature) A. Nishimura
Objectives	Mapping	Period	from 1st Feb. 2003 to 1st Apr. 2003 (60 days)			Work quantity	Approx. 247km	Responsible engineer	(Signature) K.Ishizuka

Route No.	Distance	Error of closure limit	Error of closure	Comments
	km	cm	cm	
Link routes between known points				
V/6 → IN/11	7.0	13.2	7.4	within limit
IN/11 → MT3	5.7	11.9	4.5	within limit
MT3 → LXI/7	7.0	13.2	0.6	within limit
IV/10 → V/6	10.5	16.2	2.9	within limit
LXI/4 → IV/10	27.0	25.9	1.9	within limit
V/6 → V/20	21.0	22.9	5.5	within limit
Loop route from known point				
IN/11 → IN/11	16.0	16.0	8.0	within limit
Link routes between fixed point and known point				
OUTA22 → LXI/4	2.5	6.3	0.6	within limit
V/6 → 132	14.0	14.9	3.5	within limit
Link routes between fixed points				
37 → EMBA20	11.7	13.6	8.8	within limit
IN/37 → KJ11	17.0	16.4	1.7	within limit
Loop route from fixed point				
DADO117 → DADO117	35.0	23.6	4.3	within limit

Route No.	Distance	Error of closure limit	Error of closure	Comments
	km	cm	cm	
Going/Backing routes				
FIX → KJ01	10.3	12.8	0.2	within limit
100 → KJ03	5.0	8.9	0.7	within limit
UTHIRU → KJ09	5.5	9.3	0.2	within limit
FIX132 → KJ16	6.0	9.7	3.0	within limit
KJ19 → KJ18	6.5	10.1	2.4	within limit
IV/10 → KJ21	8.0	11.3	2.5	within limit
RUAI165 → KJ15	4.0	8.0	0.3	within limit

Name of instrument
LEICA DNA10
(S/No. 331026)
(S/No. 331020)
(S/No. 331110)

Error of Closure Limit

- Route between known points: within 50mm$\sqrt{S}$
- Loop route: within 40mm$\sqrt{S}$
- Going/Backing route: within 40mm$\sqrt{S}$

(S: Distance in Km)

(5) Field identification

a) Scope

Field identification targeted the central urban area of Nairobi City, the wealthy residential area, the slum area, the new residential area, and various vegetative areas. Because the objective of this field identification was to transfer technology and the period was short, only a small portion of the target area was covered.

b) Field Identification

The aerial photographs covering the target area were enlarged to the same scale as that of the spatial data infrastructure to be established, and used in field identification. In field identification, the topographic items in line with the map symbols regulations were surveyed and the results were arranged on the aerial photographs.

c) Aerial photo interpretation handbook

During the field identification, information was collected in line with the topographic features in the map symbols regulations to prepare the aerial photo interpretation handbook.

d) Acquisition of existing information

All available information such as old topographic maps containing administrative boundaries, administrative names, names of roads, etc., required for the establishment of spatial data infrastructure was collected.

(6) Supplementary field identification

Supplementary field identification was conducted on the 179 km^2 area of the 1/2500-scale topographic map and the 417 km^2 area of the 1:5000-scale topographic map, using output maps of the compiled data.

a) Planning/preparations

A detailed plan of the procedures and schedule of supplementary field identification was prepared. Relevant materials such as output maps and existing maps, necessary for the field survey were also prepared.

b) Implementation of supplementary field identification

In supplementary field identification, the following works were implemented.

- Revision of administrative names and boundaries based on existing materials and information

- Recording and checking of names of places, roads, rivers, etc. of existing materials and information
- Verification of uncertainties during plotting and compilation
- Implementation of supplementary field identification
- Verification of interpretation of vegetation by aerial photo

c) Arrangement of results

The results of the supplementary field identification were arranged on the overlay of the supplementary field identification map using a drawing pencil, in accordance with the simplified symbols produced for the survey based on the symbols regulations.

3.5.4 Digital Photogrammetry

(1) Digitization of aerial photos

The negative film was scanned to produce image data of the aerial photos. The specifications for scanning were as follows:

- ♦ Resolution: 1270dpi
- ♦ No of aerial photos: 305

(2) Aerial triangulation

Aerial triangulation was carried out by the analytical method. The results satisfied the required accuracy for producing 1: 2,500 and 1: 5,000 topographic maps. The work volume was as follows:

- ♦ No. of flight lines: 15
- ♦ No. of models: 250

(3) Digital plotting

Spatial data infrastructure, on which the topographic and GIS databases are based, was established using a digital plotter and an analytical plotter. The data established was stored in a layer structure and file structure suitable for the processing and updating of data in accordance with the "Spatial Data Infrastructure・Data Specifications".

(4) Digital compilation

The various files by layer structure and by sheet unit obtained in digital plotting were processed using a digital compilation system.

(5) Logical check

A complete check was conducted on the digitally compiled data for topological consistency and the correctness of classification, using a logical check program. The discovered errors were corrected, compiled and rechecked for assurance.

(6) Accuracy control

In addition to the logical checks, visually checks were performed using output maps.

(7) Supplementary digital compilation

According to the output map of digitally compiled data and the supplementary field identification results arranged on the overlay, final digital compilation covering the entire scope of plotting was implemented.

“Logical checks” and “accuracy control” were also implemented in the last stage of supplementary digital compilation.

3.5.5 Production of Printed Topographic Maps

(1) Production of data for printing

Data for printing topographic maps was produced by deleting the data thought to be unnecessary for printed maps from the topographic database constructed.

Specifically, line width, color, symbols, annotations, etc. was adjusted based on the symbols specifications and converted to a Macintosh application format for producing printed maps. Then, the positional relationship of the layers was revised according to the appearance of a topographic map.

The marginal information was produced using Macintosh application software. Then, the topographic map was inserted and the sheet numbers and coordinate values were input in each respective sheet.

(2) Production of reproduction film

After the data for printing was completed, the films were output. For the final check, the output films were individually overlaid on an output map and inspected for defects. As no problems were found, the reproduction film for printing was produced.

3.6 Outputs of the Study

3.6.1 Reports

a. Inception Report	20 copies (prepared in February 2003)
b. Progress Report 1	20 copies (prepared in March)
c. Interim Report	20 copies (prepared in August 2003)
d. Progress Report 2	20 copies (prepared in March 2004)
e. Draft Final Report (prepared in December 2004)	
Main Report	20 copies
Summary	20 copies
f. Final Report (prepared in March 2005)	
Main Report	20 copies
Summary	20 copies
CD-ROM	2 sets

3.6.2 Outputs of Technology Transfer

In the technology transfer, the following two types of manuals were produced.

a. GPS survey manuals	1 set
b. Ordinary leveling manuals	1 set

3.6.3 Outputs of GIS Construction

In GIS construction, four model systems for administrative support were constructed. The outputs include the following:

a. GIS model system and database to support traffic management	1 set
b. GIS model system and database to support water management	1 set
c. GIS model system and database to support sewerage management	1 set
d. GIS model system and database to support cadastre management	1 set
e. Topographic database	2 sets
f. Guidelines for the various GIS model systems (User's manual)	10 sets ea.

3.6.4 Outputs of the Establishment of Spatial Data Infrastructure

The outputs of the establishment of spatial data infrastructure are as follows.

a. Aerial photography

Negative film	1 set
Diapositive film	1 set

Contact prints of aerial photos	1 set
Photo index map	1 set
b. Results of ground control point survey	1 set
c. Results of aerial triangulation	1 set
d. 1/2500 and 1/5000 topographic maps	
Reproduction film for printing	1 set
1:2500 and 1:5000 printed topographic maps	1,000 sets
1:2500 and 1:5000 digital topographic map data	20 sets

Chapter 4 Current Situation and Issues

4.1 Assessment of Current Situation

4.1.1 Technical Capacity

(1) Ground survey

The various techniques for ground survey, such as the installation of aerial photo signals, pricking, GPS survey, ordinary leveling, field identification and supplementary field identification, were transferred to SOK staff. The current technical capacity of SOK is judged to be as follows:

- ∗ Immediately after the technology transfer, SOK staff were determined to have acquired the techniques for the installation of aerial photo signals, pricking, ordinary leveling, field identification and supplementary field identification. However, as they have not had practical experience since then, there is no assurance that they have maintained these techniques
- ∗ As for GPS survey techniques, SOK staff have carried out actual work even after completion of the technology transfer and have maintained the acquired techniques from observations to analysis. However, they still lack experience in planning and implementing large-scale and high precision GPS surveys and need guidance.

(2) Photogrammetry

The various digital photogrammetric techniques such as film/map scanning, digital aerial triangulation, digital plotting and compilation, orthophoto production and ISO standards were transferred to SOK staff. The current technical capacity of SOK is determined based on the outcome of these technology transfers.

a. It is determined that SOK staff acquired the techniques for film scanning, digital aerial triangulation and orthophoto production through the lectures and hands-on training. However, as they have not carried out actual work since the technology transfer, there is no assurance that they have maintained these techniques.
b. The technology transfer for digital plotting and compilation was conducted through OJT and SOK carried out such works independently on a specified area. Based on the results, it is determined that SOK staff have maintained the specific techniques for digital plotting and compilation.

(3) GIS

The transfer technology concerning GIS was conducted for SOK and NCC staff through lectures and hands-on training. The current technical capacity of each organization in regard to GIS is described in the following table.

Current situation regarding GIS in SOK and NCC

Item	SOK	NCC
Set up of hardware (connection)	Since SOK staff have many opportunities to handle hardware such as computers and plotters in their daily work, the majority of those who participated in the technology transfer were able to understand how to set up the hardware.	Because there are almost no computers in any of the NCC departments, the majority of NCC staff who participated in the technology transfer had no experience in setting up hardware. However, they were able to acquire this technique through the technology transfer so there should be no particular problems.
Installing/uninstalling of software	At the present time, SOK does not seem to have any particular problems with the installing and uninstalling ArcGIS software.	Although this was the first time for the majority of NCC staff to install and uninstall software, because of the interface, there were no significant problems. Therefore, there does not seem to be any cause for concern regarding this skill.
Items concerning Windows	Although there were differences in the individual level of SOK staff, there were no particular problems concerning the techniques and know-how for operation of Windows (start, shut down, copying of files).	Because many of the NCC staff do not use computers in their daily work, there were still a few participants who could not adequately operate Windows (start, shut down, copying of files) at the time the technology transfer was completed.
Items concerning ArcGIS	Overall, SOK staff were able to acquire basic techniques such as data display, layout creation, georeferencing、data conversion, spatial search, 3D analysis and spatial analysis. However, their understanding of logical operations that require mathematical elements is still insufficient.	Unlike SOK, many NCC staff do not have a background in mapping and survey techniques so their technical capability for georeferencing and data conversion in particular seems to be inadequate. However, they had a basic understanding of data display, layout creation, 3D analysis and spatial analysis techniques. In addition, like SOK, NCC staff's understanding of logical operations that require mathematical elements is still insufficient.

4.1.2 GIS Model Systems

(1) Database

The databases established in the construction of GIS model systems only covered a 15km^2 (1:2,500 x 5 sheets) area in the center of Nairobi. In addition, although the maps and other source materials collected in order to construct the databases were used daily in the various departments in NCC, they were not regularly updated so the accuracy of the information is uncertain. As for the database design, only data that could be implemented within the scope of the model systems were included. However, when it is actually used, there are items that need to be added and items, content, and structure that need to be modified.

(2) System

The basic policies for system development were as follows:

- ♦ User friendliness
- ♦ Compatibility with GIS databases
- ♦ Consideration for expansion in the future

As for the development environment, the COM (Component Object Model) components created using Visual Basic were embedded in ESRI's ArcInfo and the added functions are activated upon startup.

(3) GIS software and hardware

The GIS software procured is of ESRI's ArcGIS9.0 series and is shown below. This software was introduced together with the hardware (PC, plotter, scanner) required for the GIS related work.

- ♦ ArcInfo 1 license
- ♦ Spatial Analyst 1 license (additional module)
- ♦ 3D Analyst 1 license (additional module)

(4) GIS operators

Only the 11 staff members from NCC who participated in the technology transfer training.

(5) Operational plan for GIS

At present, there is no department specializing in GIS, and budget for O&M has not been secured.

4.1.3 Spatial Data Infrastructure

In the Study, 2500 and 5000 scale level spatial data infrastructure covering Nairobi City was established, in accordance with specifications prepared based on the results of discussions with SOK (represented items, etc.) and ISO standards. The specifications have been released to the public.

4.2 Issues

4.2.1 Technical Capacity

(1) Ground survey

The issues concerning technical capacity for ground survey are considered to be as follows.

* Ground survey techniques for establishment of spatial data infrastructure covered in the technology transfer

  As mentioned in the previous section, considering conditions after completion of technology transfer, there is a great need for SOK staff to build on their experience with the various techniques, excluding GPS survey, through actual work. Effective use of the manuals used in technology transfer and dissemination of techniques to others are also issues.

* Ground survey techniques necessary for building a national geodetic network

  SOK intends to build a national geodetic network in conformance with global standards. Therefore, how they will acquire techniques for network planning and long baseline analysis necessary for that task is a matter of great importance.

(2) Photogrammetry

The issues concerning technical capacity for photogrammetry are considered to be as follows:

a. There are few opportunities to practice film scanning, digital aerial triangulation and orthophoto production techniques. Therefore, SOK must make an effort to maintain those techniques by deliberately making opportunities to use those techniques.
b. As for digital plotting and compilation, SOK needs to continue education and training activities using the results of the Study (digital imagery, digital aerial triangulation) with the aim of maintaining those techniques.
c. In resolving the above-mentioned issues, diffusion of the respective techniques is also an

important factor and needs to be realized.

(3) GIS

a) Survey of Kenya (SOK)

The future tasks of SOK include the following two points:

* Sound acquisition of basic GIS techniques

In order to fully master basic GIS techniques, SOK needs to acquire basic techniques through GIS training on a day-to-day basis.

* Acquisition of GIS application techniques (3D analysis,, spatial analysis)

SOK needs to acquire techniques for 3D analysis and spatial analysis applications to produce new types of topographic maps (3D topographic maps, etc.) and thematic maps (poverty maps, etc.).

b) Nairobi City Council (NCC)

The future tasks of NCC include the following three points:

* Sound acquisition of basic GIS techniques

In order to fully master basic GIS techniques, NCC needs to acquire basic techniques through GIS training on a day-to-day basis.

* Acquisition of techniques for the operation and application of GIS model systems

NCC needs to acquire operation and application techniques to make full use of the four GIS model systems constructed.

* Acquisition of techniques for operation and maintenance of GIS

NCC needs to acquire techniques for operating and maintaining hardware and software so that they are able to carry out routine maintenance of the GIS model systems and version upgrading of GIS software.

4.2.2 GIS Model Systems

The databases established for the GIS models systems only cover a 15km^2 area of the city. They are not adequate for work and thus need to be expanded. In addition, field surveys and the arrangement of information are essential to ensure the accuracy of the data. Unless a source of revenue for human resources development, the operation and maintenance of GIS equipment, etc., is secured and a plan for operation of GIS is developed, sustained use of the GIS model systems will be difficult.

4.2.3 Spatial Data Infrastructure

As mentioned in the assessment of current conditions, spatial data infrastructure covering Nairobi City was established in the Study. However, the specifications for the spatial data were determined based only on the experience of the Study Team and discussions with SOK. Generally, specifications for spatial data are determined after adequate consideration by concerned institutions and organizations and thorough understanding of ISO standards.

Meanwhile, in Kenya, NSDI activities have begun with SOK playing a central role. Based on that fact, SOK needs to use its experience in the process of determining specifications for spatial data for Nairobi City to facilitate the consideration and determination of specifications by NSDI.

Chapter 5 Recommendations to Counterpart Agency

5.1 Future Vision and Plans

5.1.1 Technical Capacity

(1) Ground survey

* Future vision

Ground survey techniques for establishing spatial data infrastructure will be used on a daily basis. At the same time, SOK staff will also carry out OJT in order to expand the number of engineers according to plan.

Work will begin to establish the national geodetic network in accordance with the International Terrestrial Reference Frame and the standard geodetic reference frame in East Africa, which are to be established in the near future, gradually moving from the establishment of high order control points to low order control points. Coordinate conversion of existing points will also be carried out using the parameters obtained in the establishment of the new national geodetic network.

As for the biggest task, coordinate conversion will begin on the vast amount of cadastral data accumulated, aiming at management of such data under a common coordinate system.

* Future plan

Possible future plans to realize the future image mentioned above are “implementation of ground surveys along with the establishment of spatial data infrastructure”, “establishment of the national geodetic network based on the new geodetic reference frame”, and “standard management of cadastral data”.

(2) Photogrammetry

* Future vision

Photogrammetric techniques will be widely understood and regularly used in every day tasks. The dissemination of technology will be implemented and the potential for photogrammetric techniques in SOK will be enhanced.

* Future plans

Possible future plans are to establish spatial data infrastructure in major cities and 1:50,000 national base maps of uncovered areas by digital photogrammetry.

(3) GIS

a) Survey of Kenya (SOK)

* Future vision

All SOK staff concerned with GIS will master the techniques for basic operation and application of ArcGIS and will make full use of these techniques in performing their daily tasks. In addition, GIS techniques will be disseminated to all SOK staff from the bottom up through regular technology transfer trainings.

Next, in the Study, a GIS topographic database was constructed for the entire city of Nairobi (excluding Nairobi National Park). This topographic database will be expanded to cover all major cities in Nairobi and in addition, a database covering the entire country will be constructed.

Regarding cadastral information, as SOK manages the cadastral maps, they will utilize the GIS techniques they acquired to develop GIS cadastral databases for major cities in Kenya and for the entire country.

* Future plan

Based on the future image of SOK mentioned above, possible future plans for establishing GIS topographic databases and GIS cadastral databases are as follows:

- ♦ Construction of GIS topographic database for each major city (1:5,000 - 1:10,000 level)
- ♦ Construction of GIS topographic database for the entire country (1:250,000 - 1:500,000 level)
- ♦ Construction of GIS cadastral database for each major city (1:5,000 - 1:10,000 level)
- ♦ Construction of GIS cadastral database for the entire country (1:250,000 - 1:500,000 level)

b) Nairobi City Council (NCC)

* Future vision

Staff of the various departments in NCC will completely master the techniques for basic operation and application of ArcGIS and utilize GIS in performing their daily tasks. NCC will also utilize the GIS techniques they have acquired to expand the coverage and functions of the four GIS model systems constructed in this Study, as well as to develop new GIS systems to solve other urban problems (environmental pollution, hygiene issues, poverty, etc.).

* Future plan
  - ♦ Set up of GIS center

    NCC will set up a GIS center within its organization to carry out GIS related works such as development of GIS databases and management of GIS data.

  - ♦ Implementation of regular technology transfer training

    NCC will conduct regular technology transfer training utilizing facilities that have ample GIS equipment, such as AICAD and RCMRD.

  - ♦ Acquisition of techniques to expand the function of GIS model systems

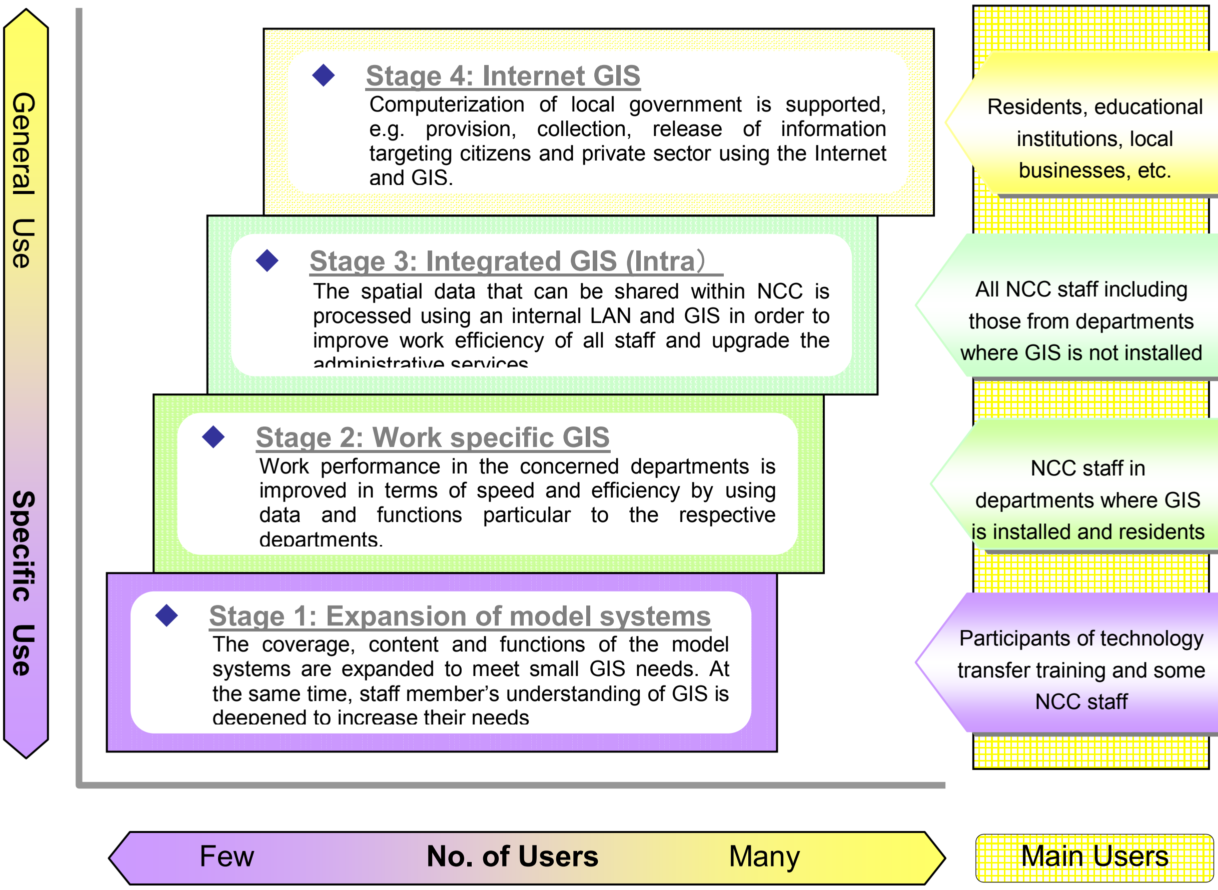
    In order to expand the functions of GIS model systems, NCC needs to acquire programming techniques for customization. Therefore, technology transfer training for this will be conducted by an expert.

  - ♦ Acquisition of spatial analysis and 3D analysis techniques

    Training in application techniques for spatial analysis and 3D analysis should be conducted for NCC staff by an expert so that they are capable of constructing GIS systems to solve new urban problems.

5.1.2 GIS Model Systems

The proposed plan for the model systems in NCC and the development of GIS is as follows.



5.1.3 Spatial Data Infrastructure

* Future vision

Based on the experience and outputs of the Study, specifications for national spatial data infrastructure in accordance with ISO standards will be determined by NSDI and made available to the public. Then, based on these specifications, work will begin on the establishment of national spatial data infrastructure at every scale level.

* Future plans

Based on the experience and outputs of the Study, plans will be formulated for the establishment of specifications for national spatial data infrastructure by NSDI, establishment of regulations, educational and training activities, and dissemination activities and they will be approved for implementation.

At the same time, a plan for establishing national spatial data infrastructure at every scale level, covering the entire country of Kenya will be formulated, and will progress steadily according to its annual plan. In particular, plans for priority projects to establish spatial data infrastructure in major cities where urban problems are concentrated will be prepared and implemented.

5.2 Recommendations to NCC

5.2.1 Overview of Plan for Priority Projects

In the future vision and future plans of the model systems, recommendations were made on the phased introduction of GIS in NCC. Here, priority projects for the first stage, i.e. to expand the coverage and functions of the model systems, are proposed based on the results of interviews with NCC staff.

1) Cadastre model system

Expansion of coverage:	To 105 km^2
Additional attributes:	Information on leaseholds, contract start time
Additional layers:	Urban planning zone (polygon), outdoor advertising points (point)

2) Road model system

Expansion of coverage:	To 400 km^2
Additional attributes:	Traffic capacity of roads, no. of lanes, no. of parking lots
Additional layers:	Road appurtenances (street lights) (point)
Additional functions:	① Function to show road congestion conditions, ② function to show necessary number of lanes for road planning

3) Water model system

Expansion of coverage:	To 588km^2
Additional attributes:	Water supply zones
Additional layers:	Intersection nodes (points) of water lines
Additional functions:	Cost simulation function for laying water lines (also, a function to allow input of pipe size)

4) Sewerage model system

Expansion of coverage:	To 376km^2
Additional attributes:	Sewerage protection class, manhole design material
Additional layers:	Intersection nodes (points) of sewer lines

Additional functions: ①Cost simulation function for laying sewer lines (also, a function to allow input of pipe size), ②function to search for the nearest manhole in a sewer line to the point of an on-site drain

5.2.2 Improvement Measures for Realization of Plan

In order to realize the above-mentioned priority projects, consideration must be given to the following.

- Set up of GIS Center

  A room shall be set up in the City Planning Department for use as a GIS center, and the equipment procured and GIS model systems developed shall be installed there. This GIS center shall be open to all NCC staff, regardless of the department they work in, to carry out necessary works such as data editing, map production and output, etc. The GIS Center shall play a leading role in expanding the coverage, content and functions of the model systems to meet the small needs of other users, and will actively implement activities to deepen NCC staff's understanding of GIS and increase their need for GIS data.

- Development of Operation and Management Plan

  The computer will be used by a number of staff members who access data for various purposes using GIS and other software. Therefore, the duties and responsibilities of the managers and users of GIS should be clearly established so that the GIS is operated according to a plan.

- Securing of funding

  It order to realize the priority projects, it is necessary to secure funding to cover the cost of system maintenance, data production, etc. This can be done as follows:

  ①Obtain revenue by providing small services (output, thematic map, and information search services) to various departments in NCC,

  ②Each department that has benefited from the expansion of data provides a share of the cost.

  ③NCC should allocate funding for the GIS center as an "administrative" section in its total budget (as with the Computer Section in the City Treasure Department)

5.3 Recommendations to SOK

The general outline of the priority projects recommended to SOK is as follows:

* Establishment of national control network based on International Terrestrial Reference Frame

  From the results of the technology transfer in the Study and the future image and plans, the priority project that SOK needs to address is to change the standard geodetic reference frame for survey work from the existing one based on Clark 1880 to one based on the International Terrestrial Reference Frame. The first step in achieving that purpose is to prepare and implement a plan for establishing a zero order control network.

  When that task is completed, SOK should be able to cope with any technical problems in establishing first order control points and lower using the results of the technology transfer implemented in the Study.

* Establishment of spatial data infrastructure

  In addition to establishing a new geodetic system, another priority project that SOK needs to tackle is to establish spatial data infrastructure for major cities in Kenya, following Nairobi City. In this case, it is recommended that spatial data infrastructure be established based on specifications determined by NSDI. However, in the event that such specifications are not yet determined, the specifications for spatial data infrastructure established for Nairobi City in the Study should be used. Mombassa, the second largest city of Kenya, is thought to be a possible priority area.

* Construction of topographic database for GIS

  While establishing spatial data infrastructure as mentioned above, a topographic database for a specific objective (cadastral management) should be established. Specifically, a topographic database applicable in a cadastral GIS for Mombassa, of which spatial data infrastructure is to be established, should be constructed

In implementing the above-mentioned works, based on the assessment of the current situation and problems of SOK, the following improvements are recommended.

- Formulation of a rational plan
- Showing strong initiative for implementation of the plan
- Raising of necessary funds for implementation of the plan
- Establishment of technical infrastructure (including preparation of equipment, etc.)

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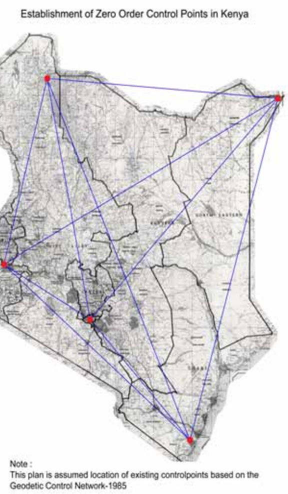
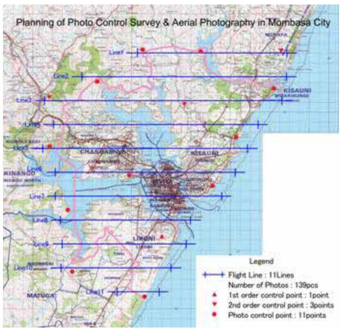
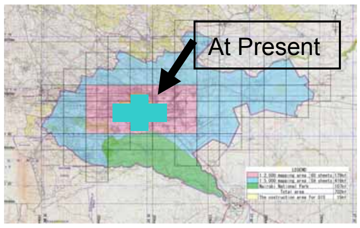
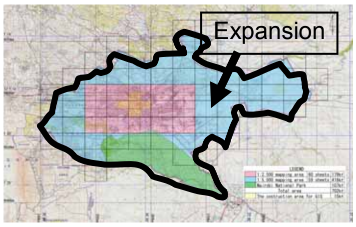
5.4 Summary of Recommendations to SOK and NCC

5.4.1 Summary of Recommendations

The recommendations made to SOK and NCC in 5.2 and 5.3 are summarized in the table below in respect to their priority, costs and required equipment.

	Establishment of national geodetic network	Establishment of spatial data infrastructure in Mombassa City	Expansion of the GIS model systems in Nairobi City
Summary of Recommendation	 • To establish a new national geodetic network based on the World Geodetic System • To establish five 0 order control points based on the World Geodetic System within Kenya	 • To establish spatial data infrastructure covering all of Mombassa City based on the same specifications as Nairobi City • To produce printed maps	  • To expand the database coverage and data items of the existing GIS model systems (4 systems) • To strengthen the functions of the existing GIS model systems (4 systems)
Main equipment Required	• GPS receivers: 5 units • Analytical software BERNESE: 1 set • Personal computers for analysis: 2 units	• Aerial photos (scale: 1:15,000) covering all of Mombassa City • Film scanner 1 unit • Plotter 2 units • Compiler 3 units	• Map scanner 1 unit • Digitizer 3 units • Compiler 3 units • Personal computer 4 units
Cost	Approx: US$67,000	Approx: US$292,000	Approx: US$21,000
Priority	1st priority	3rd priority	2nd priority

5.4.2 Contribution to the Development of Economic Infrastructure

(1) Establishment of spatial information

Topographic maps and land-related information, that is to say spatial information, are basic information essential for the development of economic infrastructure. However, Kenya is not in a situation where this spatial information can readily contribute to such development. Under such circumstances, the establishment of spatial data infrastructure for the City of Nairobi helped to meet this need. Moreover, the plan for establishing spatial data infrastructure for the City of Mombassa based on the same specification, as proposed in the previous section, will further the establishment of spatial information necessary for the development of economic infrastructure.

It is also important that the geodetic system, on which the spatial information is based, is in accordance with global standards or the Africa geodetic system. Thus, the establishment of a national geodetic network, as proposed in the previous section, is an urgent task.

The recommendations up until the previous section do not include specific mid and long term plans for the establishment of spatial information (including the training of human resources). From the standpoint of developing economic infrastructure, the formulation of such mid and long term plans is a matter that cannot be overlooked.

(2) Contribution to poverty reduction

Considering the development of economic infrastructure in respect to poverty reduction, water and sewerage, which are closely related to the daily lives of the citizens, are important factors.

The establishment of adequate water and sewerage facilities is indispensable to improving the living standards of the citizens, and formulation and implementation of a rational water and drainage plan is one policy for poverty reduction. From this point of view, the GIS model system constructed in the Study to support management of water and sewerage and the plan for its expansion are significant.

Also, the GIS model system constructed in the Study to support cadastral management can enable the rational management of certain land-related information. The clarification of land use and ownership in poor regions can help those regions to formulate policy for eradicating poverty. Therefore, the plan for expansion of the system proposed in the previous chapter will contribute to poverty reduction.

In addition to the above, if a study on the system for sales and registration of land in Kenya can be conducted, and taxation on properties can contribute to tax revenues, which is the basis of national finances, an adequate financial base for poverty reduction can be secured. In respect to that, the expansion of the GIS model system constructed to support cadastral management and the establishment of a land information system through the development of that system, can be used not only as a tool to formulate poverty reduction policy, but also as a tool to support the equitable taxation of property, which will serve as a revenue source for poverty reduction.

(3) Coordination of SOK with AICAD and KISM

The organization responsible for the extensive spatial information in Kenya is considered to be SOK. Therefore, SOK must play a leading role in realizing the establishment of spatial information to contribute to the development of economic infrastructure, as mentioned above.

However, SOK, which has enhanced its technical capacity through the technology transfer in the Study, cannot carry out the task of establishing the vast amount of spatial data infrastructure and cadastral information on its own. This task must be realized through coordination with KISM, which has great technical potential in this field, and AICAD, which has an abundance of equipment and is responsible for its use and training activities. In addition to contributing to the rational establishment of spatial data infrastructure and cadastral information, it is expected that such coordination, through the participation of many concerned institutions, will help raise public awareness of its importance.

5.5 Need for Strengthening Cooperation

5.5.1 Survey of Kenya and Nairobi City Council

Prior to commencement of this Study, there was no point of contact between SOK and NCC other that the sale and purchase of topographic maps. However, it is important that they strengthen cooperation in the future in regard to the following

- ♦ Provision of geographic information such as the latest topographic maps, aerial photos, and orthophotos
- ♦ Provision of Topo Cadastre Map reflecting changes in property boundaries consequent upon the division of plots
- ♦ NSDI activities for standardization of geographic information and promotion of advanced use

5.5.2 NSDI

In the Study, specifications for spatial data infrastructure were decided on in discussions with SOK. Furthermore, spatial data infrastructure was established for Nairobi City based on those specifications.

SOK is expected to report their experience in determining these specifications and establishing spatial data infrastructure at activities of NSDI working groups in order to strengthen such activities. It is also expected that the decisions made by NSDI committees will be reflected in the spatial data infrastructure already established. Through this process, the results of the Study will contribute to the establishment of national spatial data infrastructure in Kenya.

SOK needs to play a leadership role in NSDI activities and maintain regular communication with concerned institutions and organizations. Therefore, it is necessary for SOK to conduct regular NSDI activities while strengthening cooperation with concerned institutions and organizations through such activities.

5.5.3 Concerned Organizations

(1) AICAD (African Institute for Capacity Development)

AICAD currently possesses 11 licenses for the latest ArcGIS 9.0 and all extensions, as well as a GIS computer lab. Therefore, there is no doubt that AICAD is an important organization for the training of SOK and NCC staff in the latest GIS technologies and it is essential to maintain and continue cooperation and relations with AICAD.

A short term expert has been dispatched to AICAD from February to March 2005, to provide assistance in “the formulation of a utilization plan for GIS facilities”. At present, the expert is collecting information (implementing agency, description and instructors of the training, curriculum, etc.) on existing GIS training programs and institutions using GIS in Kenya, Tanzania and Uganda, together with the counterpart and the long term expert in the second phase of the AICAD project, in order to formulate a plan for AICAD to launch its own activities, while transferring the technical skills and knowledge concerned with such work to the counterpart.