Republic of Djibouti
Topographic Section Department of Equipment

The Project for Managing Digital Topographic Data in Djibouti City in the Republic of Djibouti

(Technical Cooperation Project in the form of Development Study)

Final Report (Summary)

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Table of Contents

1. OUTLINE OF THE STUDY....1

1-1. BACKGROUND OF THE STUDY....1
1-2. OBJECTIVES OF THE STUDY....1
1-3. TARGET AREAS OF THE STUDY....2
1-4. WORK ITEMS AND VOLUME....2
1-5. FINAL OUTPUTS....3
1-6. ITEMS DISCUSSED....4
1-7. WORKFLOW....5
1-8. WORK ASSIGNED TO STUDY TEAM MEMBERS....6

2. STUDY OUTPUTS AND PROPOSALS....7

2-1. STUDY OUTPUTS....7
2-2. PROPOSAL ON UTILIZATION OF GEOGRAPHIC INFORMATION DATA AND TSDE....11

3. DETAILS AND RESULTS OF WORK DONE....16

3-1. COLLECTION, SORTING AND ANALYSIS OF RELATED MATERIALS AND INFORMATION [WORK IN JAPAN] 16
3-2. PREPARATION OF INCEPTION REPORT (IC/R) [WORK IN JAPAN]....16
3-3. EXPLANATION AND DISCUSSION OF INCEPTION REPORT (IC/R) [WORK IN DJIBOUTI]....16
3-4. DISCUSSION OF SPECIFICATIONS [WORK IN DJIBOUTI]....17
3-5. COLLECTION AND SORTING OF EXISTING MATERIALS [WORK IN DJIBOUTI]....18
3-6. FACT-FINDING SURVEY ON PROMOTION OF GEOGRAPHIC INFORMATION DATA [WORK IN DJIBOUTI] .18
3-7. HOLDING OF (FIRST) SEMINARS TO PROMOTE UTILIZATION [WORK IN DJIBOUTI]....19
3-8. CONTROL POINT SURVEY [WORK IN DJIBOUTI]....19
3-9. AERIAL PHOTOGRAPHY [WORK IN DJIBOUTI]....22
3-10. AERIAL TRIANGULATION [WORK IN JAPAN]....24
3-11. CREATION OF ORTHOPHOTOS [WORK IN JAPAN]....25
3-12. PREPARATION OF PROGRESS REPORT (PR/R) [WORK IN JAPAN]....25
3-13. EXPLANATION AND DISCUSSION OF PROGRESS REPORT (PR/R) [WORK IN DJIBOUTI]....25
3-14. FIELD VERIFICATION [WORK IN DJIBOUTI]....26
3-15. DIGITAL PLOTTING AND COMPILATION [WORK IN JAPAN]....27
3-16. DISCUSSION AND PROPOSAL OF METHODS FOR THE PUBLICIZING AND SUPPLY OF GEOGRAPHIC INFORMATION DATA [WORK IN JAPAN]....27
3-17. PREPARATION OF INTERIM REPORT (IT/R) [WORK IN JAPAN]....30

3-18. EXPLANATION AND DISCUSSION ON INTERIM REPORT (IT/R) [WORK IN DJIBOUTI].....30
3-19. FIELD COMPLETION SURVEY [WORK IN DJIBOUTI].....31
3-20. DIGITAL COMPILATION AFTER FIELD COMPLETION [WORK IN JAPAN].....32
3-21. MAP SYMBOLIZATION OF TOPOGRAPHIC MAPS [WORK IN JAPAN].....32
3-22. STRUCTURIZATION OF DIGITAL DATA [WORK IN JAPAN].....32
3-23. CREATION OF DRAFT FINAL REPORT (DF/R) [WORK IN JAPAN].....33
3-24. EXPLANATION AND DISCUSSION ON DRAFT FINAL REPORT (DF/R) [WORK IN DJIBOUTI].....33
3-25. PROMOTION OF UTILIZATION [WORK IN DJIBOUTI].....33
3-26. HOLDING OF SEMINARS FOR PROMOTING UTILIZATION [WORK IN DJIBOUTI].....34
3-27. CREATION OF DATA FILES [WORK IN JAPAN].....36
3-28. CREATION OF FINAL REPORT (F/R) [WORK IN JAPAN].....36

4. TECHNOLOGY TRANSFER.....37

4-1. DETAILS OF TECHNOLOGY TRANSFER.....38
4-2. OUTPUTS OF TECHNOLOGY TRANSFER.....40

5. SCHEDULE OF WORK AND DISPATCH OF PERSONNEL.....41

5-1. WORK SCHEDULE AND PROJECT FLOWCHART.....41
5-2. DISPATCH OF PERSONNEL.....44

List of Figures

Figure 1 Target Area of the Study. 2
Figure 2 Determined Topographic Map Symbols (example). 4
Figure 3 Project Workflow. 5
Figure 4 System for Updating and Utilizing Geographic Information Data (conceptual diagram) 11
Figure 5 Concept of Organizational Enhancement of TSDE (upper: current, lower: conceived). 15
Figure 6 Printed Map based on Determined Topographic Map Specifications 17
Figure 7 Scenes at the First Seminar 19
Figure 8 Flow of Control Point Survey Work 20
Figure 9 Map of Control Points 20
Figure 10 Control point survey (Left: GNSS observation; Right: Leveling) 21
Figure 11 Aerial Photography Workflow 22
Figure 12 Implementation Map for Aerial Photography 22
Figure 13 Photographic Equipment (Left: Airplane; Right: Digital camera, GNSS/IMU) 23
Figure 14 Aerial Triangulation Workflow. 24

Figure 15 Created Orthophoto Image . . . 25
Figure 16 Field Verification Workflow . . . 26
Figure 17 Field Verification Operation (Left: Pre-interpretation, Right: Result) . . . 26
Figure 18 Digital plotting (Left: Plotting work, Right: Result) . . . 27
Figure 19 Examples of Utilization (Left: ArcGIS; Right: Free GIS Software) . . . 30
Figure 20 Field Completion Survey Operation Flow . . . 31
Figure 21 Field Completion Survey Operation (Left: Marking of results, Right: Result) . . . 32
Figure 22 (Left: Symbolization, Right: Structurization) . . . 33
Figure 23 Final Seminar（Upper Left : Opening ceremony, Upper Right : Participants, Lower Left : Study Team Presentation, Lower Right : TSDE presentation） . . . 35
Figure 24 Lecture in University（Left : Lecture, Right : Q&A） . . . 36
Figure 25 Technology Transfer (Left: GNSS Installation; Right: Leveling) . . . 38
Figure 26 Technology Transfer (Left: Road width measurement; Right: Verification of features) . . . 39
Figure 27 Technology Transfer (Left: AutoCAD, Right: ArcGIS) . . . 40

List of Tables

Table 1 Work Items and Volume . . . 2
Table 2 Reports Prepared and Outputs Created in the Study . . . 3
Table 3 Discussion Topics with the Counterpart . . . 4
Table 4 Names of Study Team Members and Work Assigned . . . 6
Table 5 Geographic Information Data Developed in the Study . . . 7
Table 6 Outputs of Technology Transfer . . . 8
Table 7 Activities for Promoting Utilization . . . 9
Table 8 Relationship between Relevant Organizations and the Study . . . 10
Table 9 Middle and Long-term Goals of Stakeholder Meetings . . . 12
Table 10 Middle and Long-term Goals of Data Supply . . . 13
Table 11 Organizational Enhancement and Middle and Long-term Operation Goals . . . 14
Table 12 Proposal on technology enhancement of TSDE . . . 16
Table 13 Topographic Map Specifications Determined . . . 17
Table 14 Interview Results . . . 18
Table 15 List of Geodetic Coordinates of Control Points . . . 21
Table 16 Specifications for Aerial Photography . . . 23
Table 17 Residual Errors of Control Points . . . 24
Table 18 Items for Discussion . . . 28
Table 19 Status of Provision of Topographic Mapping Data . . . 28

Table 20 Results of User Survey 29
Table 21 Participating Organizations and Comments in First Stakeholder Meeting 31
Table 22 List of Participants for the 2nd Stakeholder Meeting 34
Table 23 List of Participants for the Final Seminar 35
Table 24 Summary of Technology Transfer 37
Table 25 Equipment and Materials for Technology Transfer 37
Table 26 Outcomes of Technology Transfer on Reconnaissance, Selection and Installation 38
Table 27 Outcomes of Technology Transfer in Field Verification 39
Table 28 Outcomes of Technology Transfer on Updating of Topographic Maps 40
Table 29 Level of Achievement in Transfer of Topographic Map Updating Technology 41

List of Abbreviations

2D	2 Dimension
3D	3 Dimension (Stereo)
CAD	Computer Aided Design
DEM	Digital Elevation Model
DF/R	Draft Final Report
EU	European Union
GIS	Geographic Information System
GNSS	Global Navigation Satellite System(s)
GPS	Global Positioning System
GRS80	Geodetic Reference System 1980
IC/R	Inception Report
IT/R	Interim Report
IGS	International GNSS Service
ITRF	International Terrestrial Reference Frame
JICA	Japan International Cooperation Agency
MET	Ministry of Equipment and Transports
MM	Minutes of Meeting
OJT	On the Job Training
PDF	Portable Document Format
R/D	Record of Discussion
SHP	Shapefile
TIFF	Tagged Image File Format
TM	Transverse Mercator
TSDE	Topographic Section Department of Equipment
UPS	Uninterruptible Power Supply

1. Outline of the Study

1-1. Background of the Study

In the City of Djibouti, the capital city of the Republic of Djibouti, the recent economic development in the Republic and advancement of desertification in the countryside have accelerated the inflow of population into the City, resulting in a concentration of 350 thousand persons, about 43% of the total population (about 820,000), in the City and infrastructure such as roads and water and sewerage systems is underdeveloped, obstructing socio-economic stabilization.

Under such circumstances, the Government of Djibouti is preparing to establish a development plan in order to address urban problems in the suburbs of the City. However, the basic data to be used for planning, *i.e.*, the existing large-scale topographic maps are outdated and do not identify the range of the urban area that is expanding year by year according to the population growth. Although donors such as the EU, World Bank, and French Agency for Development, are implementing projects for developing infrastructure such as water and sewerage systems in the suburbs of the City, the lack of topographic maps is requiring them to implement current-condition surveys and topographic surveys in each project. Therefore, there is a high need for developing comprehensive, large-scale digital topographic maps for the entire City that can be used for current-condition identification and draft planning.

Against such a background, the Government of Djibouti requested the Government of Japan for technical assistance for developing data of large-scale digital topographic maps of the City then this project was implemented for a duration of two years from March 2012 based on the R/D.

1-2. Objectives of the Study

This Study has the following objectives:

(1) To carry out aerial photography of the central city and surrounding area of Djibouti City (an area of 300km^2) in Djibouti and to create the orthophotos on the scale of 1/2,500 (with a ground resolution of 20cm).

(2) To create digital topographic maps on the scale of 1/2,500 and GIS basic data of the central area of Djibouti City (an area of about 100km^2).

(3) To carry out technology transfer to the Topographic Section, Department of Equipment (hereinafter referred to as "TSDE") of MET which is the counterpart agency in Djibouti, so as to give them an understanding of topographic mapping technology and partial correction (updating of the "geographic information data").

1-3. Target Areas of the Study

The target areas for aerial photography and developing the orthophotos and digital topographic map in this Study are shown below.

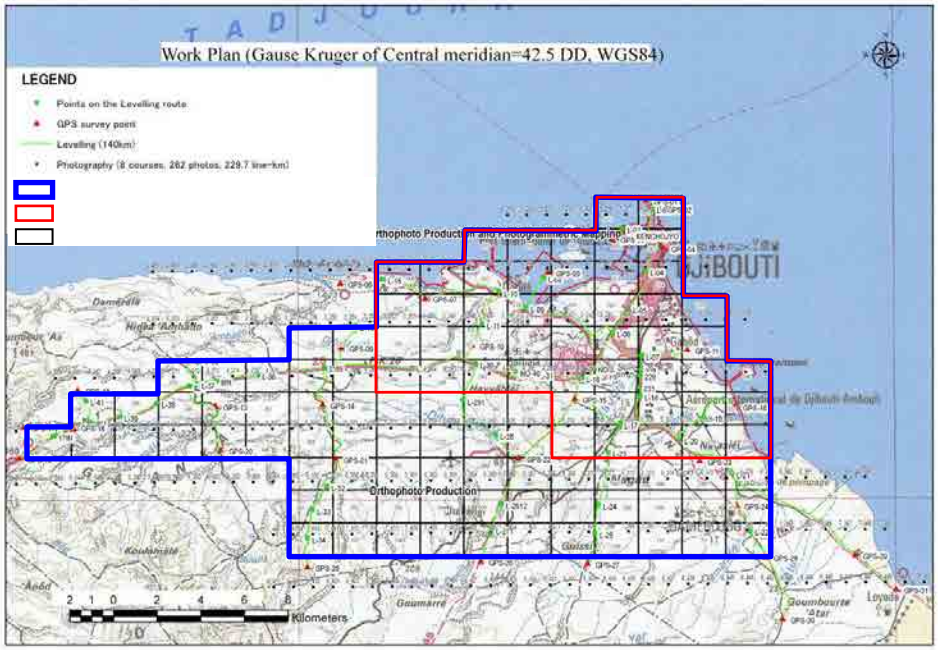


Figure 1 Target Area of the Study

1-4. Work Items and Volume

The work items and volume of this Study are shown below.

Table 1 Work Items and Volume

Work	Work Volume	Description	Remarks
Control point survey / Installation of aerial markers	34 points	Orientation origin: 2 pts Control points: 32 pts	Work in Djibouti (Technology transfer)
Leveling	28 routes	Simple leveling Route length: 143km	Work in Djibouti (Technology transfer)
Aerial photography	8 courses, 262 images	Image resolution: 20cm	Work in Djibouti
Aerial triangulation	256 models		Work in Japan Work in Djibouti (Technology transfer)
Creation of orthophotos	112 sheets ($300km^2$)	Color images Image resolution: 20cm	Work in Japan
Field verification / Field completion	49 sheets($110km^2$)	1/2,500	Work in Djibouti (Technology transfer)
Digital plotting / compilation	49 sheets($110km^2$)	1/2,500	Work in Japan, Work in Djibouti (Technology transfer in updating)
Digital compilation after field completion			
Map symbolization			
Data structurization			

1-5. Final Outputs

The following lists the outputs from this Study.

Table 2 Reports Prepared and Outputs Created in the Study

Item		Quantity	Remarks
(1) Study report	Inception Report (IC/R)	5 copies in Japanese 15 copies in French 15 copies in English	Submit 10 copies in French and 10 copies in English to the Government of Djibouti.
	Progress Report (PR/R)	5 copies in Japanese 15 copies in French 15 copies in English	Submit 10 copies in French and 10 copies in English to the Government of Djibouti.
	Interim Report (IT/R)	5 copies in Japanese 15 copies in French 15 copies in English	Submit 10 copies in French and 10 copies in English to the Government of Djibouti.
	Draft Final Report (DF/R)		
	Main report	15 copies in French 15 copies in English	Submit 10 copies in French and 10 copies in English to the Government of Djibouti.
	Summary	15 copies in French 15 copies in English	Submit 10 copies in French and 10 copies in English to the Government of Djibouti.
	Summary in Japanese	10 copies in Japanese	
	Work manual	2 copies in French	Submit 1 copy in French to the Government of Djibouti.
	Final Report (F/R)		
	Main report	15 copies in French 15 copies in English	Submit 10 copies in French and 10 copies in English to the Government of Djibouti.
	Summary	15 copies in French 15 copies in English	Submit 10 copies in French and 10 copies in English to the Government of Djibouti.
	Summary in Japanese	10 copies in Japanese	
	Work manual	2 copies in French	Submit 1 copy in French and to the Government of Djibouti.
(2) Outputs	1) Orthophoto maps	2 sets	Submit 1 set to the Government of Djibouti.
	2) Field verification results	1 set	Submit 1 set to the Government of Djibouti.
	3) Aerial triangulation results	1 set	Submit 1 set to the Government of Djibouti.
	4) Digital data files		
	1/2,500 topographic mapping data	2 sets	Submit 1 set to the Government of Djibouti.
	1/2,500 GIS basic data	2 sets	Submit 1 set to the Government of Djibouti.
	1/2,500 topographic mapping data in PDF format	3 sets	Submit 1 set to the Government of Djibouti.
	Digital aerial photo data	1 set	Submit 1 set to the Government of Djibouti.
	Final report	1 set	
	5) Booklet	1 set	A3 size: 100 sets Original map size: 5 sets
	6) Report on quality management	1 set	

1-6. Items Discussed

The topics and details of discussion between the Study Team and TSDE of MET, a counterpart organization in this Study, are shown in the table below.

Table 3 Discussion Topics with the Counterpart

Discussion topic	Timing	Details	Remarks
Inception Report	March 2012	Work area, work amount, work policies, and final outputs	The counterpart agreed with the Study Team's proposal.
Specifications of topographic maps	March 2012	Reference coordinate system, map symbols, and GIS basic data specifications	Determined through discussion
Technology transfer	March 2012	Technology transfer items, equipment, and workers	The counterpart agreed with the Study Team's proposal.
Progress Report	October 2012	Work progress, subsequent work schedule, and utilization promotion study	The counterpart agreed with the Study Team's report and proposal.
Interim Report	September 2013	Work progress, utilization promotion, and achievement level of technology transfer	The counterpart agreed with the Study Team's report and proposal.
Draft Final Report	Scheduled for January 2014	Proposal on geographic information data utilization and TSDE enhancement	

Block Symbols

	Block Symbol Names for Object (ByBlock color)	Block Symbol Names for LEGEND (ByLayer color)	Symbols	Nom
1	221900	2219		Tunnel for Road (トンネル:車道)
2	223800	2238		Boulevard trees (並木)
3	241900	2419		Tunnel for Railway (トンネル:鉄道)
4	242100	2421		Bus stop (バス停)
5	350300	3503		Administrative Building for ministry (行政施設:省)
6	350400	3504		Tribunal (裁判所)
7	350500	3505		Police station (警察署)
8	350700	3507		Tax Office (税務署)
9	350900	3509		Post Office (郵便局)
10	351000	3510		Forest Reserve (保護林)
11	351100	3511		Meteorological weather station (気象観測所)
12	351500	3515		Police box (派出所)
13	351600	3516		Fire station (消防署)
14	351800	3518		Embassy and International organisation (大使館及び国際機関)
15	351900	3519		Other Administrative Building (行政施設:その他)

Figure 2 Determined Topographic Map Symbols (example)

1-7. Workflow

The outline of workflow in this Study is shown below.

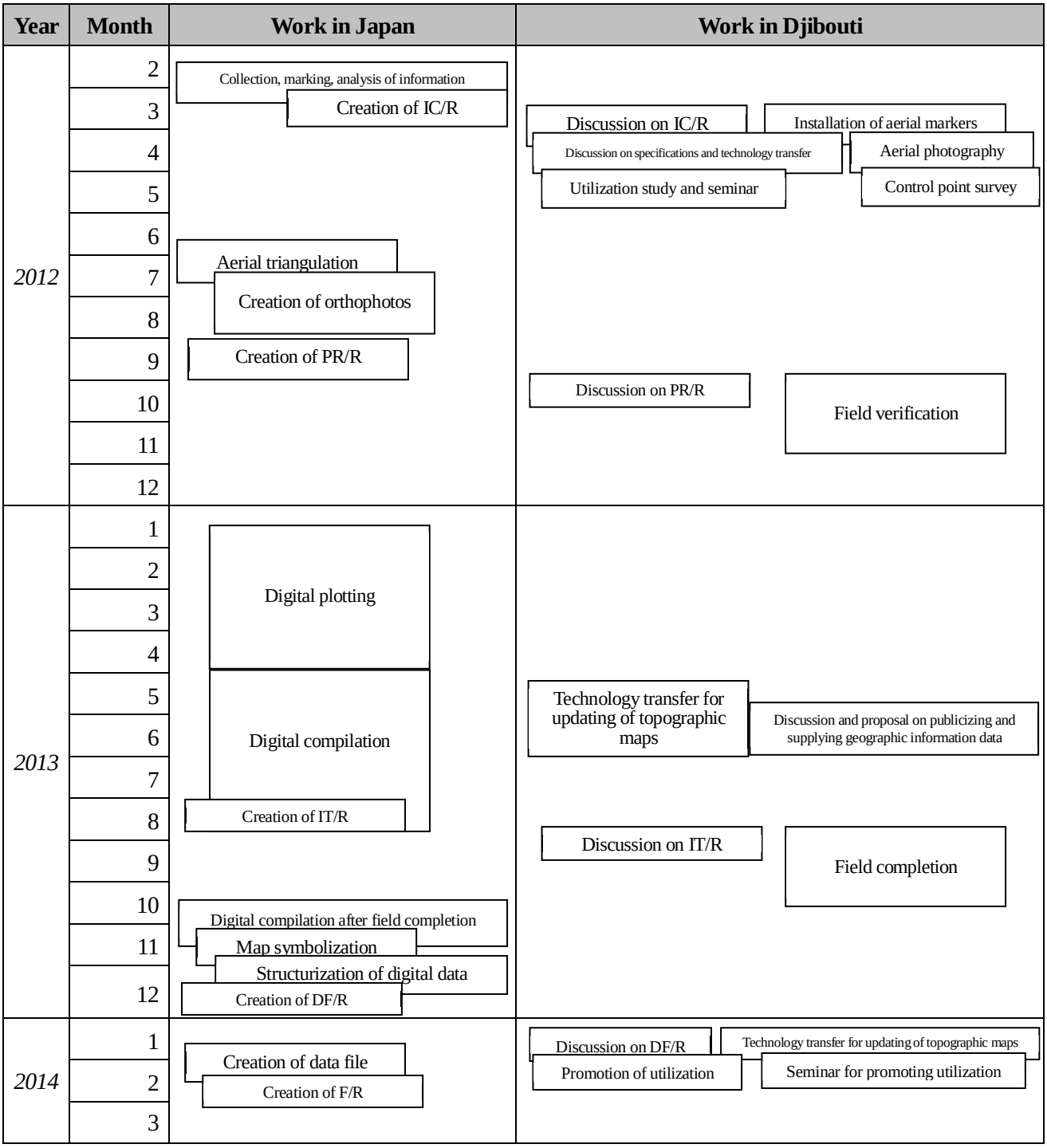


Figure 3 Project Workflow

1-8. Work Assigned to Study Team Members

The names and work assignments of the members of the Study Team are shown below.

Table 4 Names of Study Team Members and Work Assigned

Name	Survey operations under charge	Details of operations
Masakuni NAKAYAMA	Team Leader / Digital compilation	- Management and supervision on the study operations in general - Planning and evaluation of technology transfer (including holding of seminars) - Coordination with relevant organizations
Daikichi NAKAJIMA	Aerial photography	- Management of aerial photography
Atsushi MOCHIZUKI	Control point survey 1	- Guidance, management, and technology transfer on GNSS observation and leveling - Technology transfer on pricking
Tadaaki TOMITA	Control point survey 2	
Daikichi NAKAJIMA	Field verification / Field completion 1	- Guidance and technology transfer on field verification and field completion for topographic maps
Toshiyuki WAKABAYASHI	Field verification / Field completion 2	
Tadahiko SEKIGUCHI	Field verification / Field completion 3	
Daikichi NAKAJIMA	Updating of topographic maps (technology transfer)	- Guidance and technology transfer on technologies required to update topographic maps
Kaoru TSUDA	Utilization promotion	- Guidance and technology transfer on creating a system required to promote utilization (including holding of seminars)
Akira OTA		
Tomohiro KOYAMA	Interpreter	- Interpretation and translation
Tomoyuki OTANI		
Takashi SHIRAI	Operation coordination / Assistance in field verification and field completion	- Operation coordination as well as guidance and technology transfer on field verification and field completion for topographic maps
Hayato FUKUOKA		
James WATSON		

2. Study Outputs and Proposals

This section describes the outputs of this Study and the achievement levels for the study purposes. It also provides proposals on the system for using the study outputs continually after the end of this project.

2-1. Study Outputs

(1) Development of large-scale geographic information data

The following geographic information data has been developed in this Study. This information, being large-scale (meeting the 1/2,500 level specifications) and digital data, is expected to be applied to a wide range of uses for the development of the City of Djibouti and the Republic of Djibouti.

Table 5 Geographic Information Data Developed in the Study

Geographic information type	Specification	Quantity	Remarks	Common uses
Orthophotos	20 cm resolution	300 km^2 112 map sheets	See Chapter 3-11	Land use survey Vegetation survey Housing survey Land readjustment
Topographic maps	1/2,500 level	110 km^2 49 map sheets	See Chapter 3-21	Urban planning Road/railroad planning Water/sewerage system planning/management Disaster prevention/security planning GIS basic data
GIS basic data	1/2,500 level	110 km^2 49 map sheets	See Chapter 3-22	Distribution planning/management Facility planning/management Irrigation planning Afforestation planning Port planning/management River improvement planning Landscape planning Agricultural planning/management Topographic analysis analysis/survey

(2) Outputs of technology transfer

The technology transfer in this Study was provided with a focus on “partial revision (updating of geographic information data)” to allow the TSDE staff to update the above spatial

information continuously.

On the other hand, the "topographic mapping technology" was transferred with a focus on theory. The technology transfer items were determined through discussion with TSDE before the technology transfer was implemented.

The TSDE engineers were inexperienced in the basic work procedures such as the operation of equipment to be used. In consideration of this point, the technology transfer was implemented according to the goals set for each process, and the achievement levels of the technology transfer goals were evaluated as shown in the table below.

As a result of technology transfer, the TSDE staff attained a technical level with which they could conduct "partial revision (updating of geographic information data)" and understood the theory of "topographic mapping technology."

Table 6 Outputs of Technology Transfer

Item	Operation details	Goal setting	Achievement level	Current technical level
Installation of aerial markers	Installation of aerial markers	Capability of conducting the same operation as in training	The engineers understood appropriate materials, forms, and colors of aerial markers corresponding to image resolutions of photos and conditions on the ground. The installation work performance improved as they repeated the operation.	Capability of installing aerial markers required for aerial photography on their own
Control point survey and analysis	Field reconnaissance for selection of control points	Capability of conducting the same operation as in training (survey planning and GNSS observation and analysis)	The engineers understood the basic items such as coordinate systems and map projection.	Capability of making a control point installation plan using topographic maps and selecting and installing control points in the field using a handheld GPS
			The engineers understood point allocation according to the photographing plan. In the future, TSDE can plan point allocation on its own when conducting new control point survey.	
			The engineers understood the basic operations of handheld GPS receivers such as registration of points and point names.	
	GNSS observation		The engineers understood basics and basic operations of GNSS survey. They can conduct static observation of new points by themselves. Applicative operations such as kinematic survey are also possible.	Capability of planning and conducting observation in GNSS survey on their own
	GNSS analysis		The engineers understood basic operations of analysis software. They understood how to examine the analysis results and set limit values. They can conduct observation and analysis of TSDE's own new control points network.	Capability of downloading GNSS observation data and conducting baseline analysis, and 3D net adjustment calculation
Leveling and pricking	Leveling and pricking	Capability of conducting observation and calculation using digital levels	The engineers were able to conduct observation using digital levels. They were able to prick necessary points on photos.	Capability of conducting observation and calculation in leveling
Field	Pre-interpre	Capability of	The engineers understood what to do in field	Capability of conducting

verification	tation	applying the technology to updating of topographic maps	verification and the verification items (map symbols).	pre-interpretation without problems
	Field verification		The engineers learned to check the verification items without much trouble using the handheld GPS and Orthophotos.	Capability of acquiring planimetric features and reflecting them on the topographic mapping data using the handheld GPS
	Marking of field verification results		The engineers understood what to do in the check and marking process (omissions, errors, and edge matching between map sheets).	Capability of marking on digital maps
Updating of topographic maps	Updating of topographic maps	Learning of basic knowledge and computer operations required to update topographic maps	The engineers understood the procedures for digital plotting and digital compilation. They understood the method of map symbolization. They need to continue to receive training on computer operations.	Acquisition of basic understanding

(3) Outputs of promotion of utilization

To promote effective and widespread use of geographic information data developed in this Study, TSDE and the Study Team carried out the activities listed in the table below. After the study by and information exchange among stakeholder organizations and potential user organizations, the stakeholder meeting for geographic information data was launched.

Table 7 Activities for Promoting Utilization

Activity	Timing	Details	Remarks
Fact-finding survey on promotion of geographic information data	March 2012	Survey of stakeholder organizations and potential user organizations and needs survey	See Chapter 3-6
Utilization promotion seminar 1	March 2012	Explanation on project outline and utilization examples and questions and answers	See Chapter 3-7
Discussion and proposal of methods for publicizing and supplying geographic information data (Stakeholder survey)	June 2013	Individual explanation to stakeholder organizations and potential user organizations, demonstration of GIS utilization Fact-finding, discussion, etc. on publicizing and supply of geographic information data	See Chapter 3-16
Discussion and proposal of methods for publicizing and supplying geographic information data (Stakeholder meeting 1)	September 2013	Exchange and sharing of information on sharing and updating of geographic information data Fact-finding, discussion, etc. on publicizing and supply of geographic information data	See Chapter 3-18
Utilization promotion seminar (Stakeholder meeting 2)	January 2014	Proposal on data publicizing and supply system	See Chapter 3-25
Utilization promotion seminar 2	January 2014	Project output report Proposal on utilization	See Chapter 3-26

Table 8 Relationship between Relevant Organizations and the Study

Organization		Utilization promotion seminar 1	Stakeholder survey	Stakeholder meeting		Utilization promotion seminar 2
				1	2	
1	Topographic Section, Department of Equipment (TSDE), Ministry of Equipment and Transport	○	○	○	○	○
2	Department of Statistics and Population (DISED)	○	○			○
3	Djibouti Center for Research Studies (CERD)	○	○	○	○	○
4	Djibouti Electricity (EDD)	○	○	○	○	
5	Department of Cadaster		○			○
6	Djibouti National Water and Sanitation Office (ONEAD)	○	○	○		○
7	Department of Housing and Urban Planning	○	○	○	○	○
8	Department of Environment		○		○	○
9	Division of Large Construction, Department of Agriculture		○			
10	Djibouti Road Maintenance Office (OVD)		○			
11	Department of Citizen Protection, Ministry of Interior and Decentralization		○	○	○	○
12	Djibouti City Hall		○	○		○
13	University of Djibouti		○			○
14	Djibouti Ports & Free Zones Authority				○	○
15	Djibouti Social Development Agency				○	○
16	Djibouti International Airport				○	
17	Civil Aviation Authority				○	○
18	Port of Djibouti				○	○
19	National Office of Copyright and Related Rights				○	○
20	Disaster Risk Management Office				○	
21	Department of Maritime Affairs				○	○
22	Djibouti Telecom					○
23	Road Maintenance Fund					○
24	National Meteorological Agency					○
25	Office of Industrial Property and Commerce					○
26	Djibouti Railway Company					○
27	Coast Guard					○
28	Central Laboratory of Building and Equipment					○
29	UNDP Representative Office					○
30	WFP Representative Office					○

2-2. Proposal on Utilization of Geographic Information Data and TSDE

To have the geographic information data developed in this Study updated by TSDE continuously using the technology transferred in this Study and put it to continuous, widespread use in the Republic of Djibouti, it is advisable to construct and manage a system for utilizing geographic information data centered around TSDE in collaboration with organizations in and out of the Republic.

In this regard, proposals on the following items from the middle and long-term perspectives are summarized:

- Proposal on the operation of stakeholder meetings
- Proposal on development of a system for publicizing and supplying data
- Proposal on enhancement of TSDE

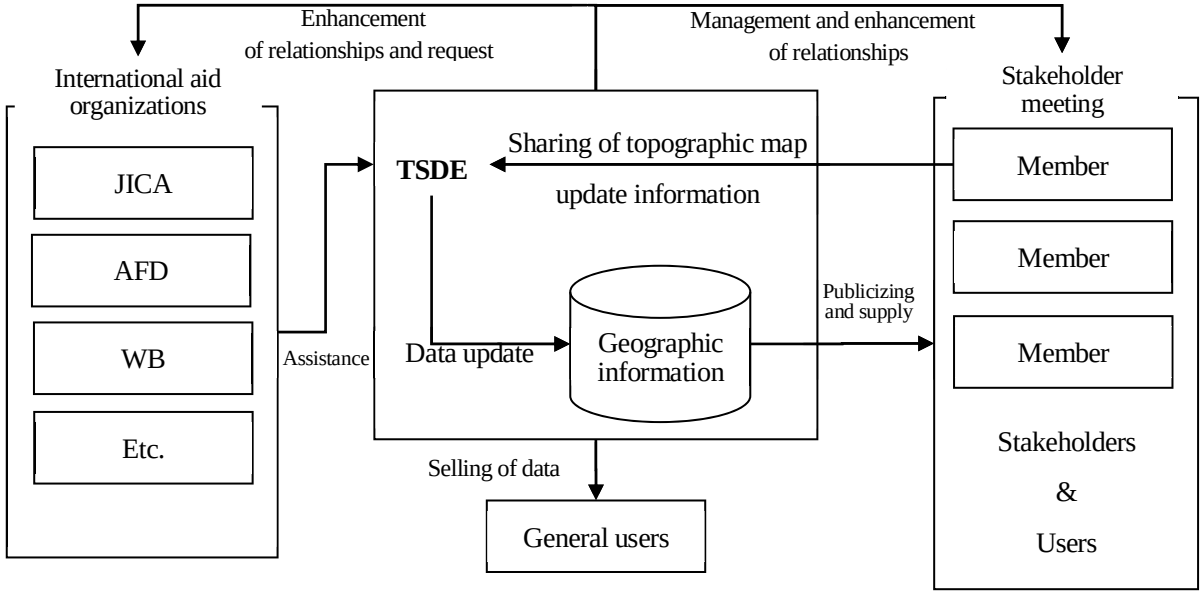


Figure 4 System for Updating and Utilizing Geographic Information Data (conceptual diagram)

2-2-1. Proposal on Holding of Stakeholder Meetings

On January 21, 2014, the second stakeholder meeting was held in succession to the first stakeholder meeting (September 2013) which was aimed at becoming Djibouti's central organization for "utilizing" and "updating" the outputs of this Study.

In the second stakeholder meeting, the participants shared information again on the overview of the Project and utilization of the outputs and exchanged opinions on the importance of continuously holding stakeholder meetings in relation to the establishment of an organization required to "utilize" and "update" the geographic information data.

In the meeting, the Study Team made the proposal shown below as the term-by-term goals for the

management of stakeholder meetings to be held in the future.

For the management of meetings in the future, the assumed leader is the "Ministry of Equipment and Transport" and the assumed permanent members are "Djibouti Electricity (EDD)," the "National Water and Sanitation Office of Djibouti (ONEAD)," "Djibouti Telecom," "Djibouti Center for Research Studies (CERD)," the "Ministry of Housing, Urban Planning, Environment, and Land Management," the "National Office **of** Copyright and Related Rights," and the "Topographic Section."

Furthermore, the immediate goal is for the stakeholder meeting to establish a basic sharing system for digital topographic maps by around April 2014 when the outputs of this Study are supplied from JICA to Djibouti. This goal was included in the speech made by the Vice-Minister of the Ministry of Equipment and Transport and is expected to be achieved.

Table 9 Middle and Long-term Goals of Stakeholder Meetings

Item	Timing	Goals
Stakeholder meeting	By the end of study (by April 2014)	Selection of the leader Screening of permanent members Decision on management rules (such as frequency of meeting) Schedule and setting of goals by term Establishment of a system for "sharing" and "utilizing" geographic information data
	Middle-term goals	Division of roles among organizations in sharing and updating of geographic information data Discussion on roles and rules in continuous holding of stakeholder meetings, extraction of problems in sharing and updating geographic information data continuously, and discussion on necessary enhancement of organizations and human resources, improvement of equipment, etc.
	Long-term goal	Continuous sharing/updating and publicizing/supply of geographic information data

2-2-2. Proposal on Development of System for Publicizing and Supplying Data

Through the utilization promotion seminars, stakeholder survey, and stakeholder meetings, the stakeholder organizations were able to share information on the content of the topographic map information data and utilization effects. However, it is considered necessary to establish and enhance rules and systems for publicizing (supplying and selling) and managing (sharing and updating) the digital topographic maps through continuous management by the stakeholder meeting. Therefore, the Study Team made proposals as shown below.

Table 10 Middle and Long-term Goals of Data Supply

Item	Timing	Goals
Improvement of sales channels	Middle-term goal	Conduct market research and estimate on geographic information to set appropriate prices at which to sell the study outputs (DJF 3,000 to 5,000 per printed map seems appropriate). Among the permanent members of the stakeholder meeting, an organization that has experience in selling topographic maps (*e.g.*, CERD) will take the initiative in managing the supply and sale of data.
	Long-term goal	Enhance the TSDE organization and improve the sales system by TSDE both on hardware and software bases.
Handling of software copies	Middle-term goal	Prevent illegal transfer to a third party using papers (Application for supply of digital topographic data) .
	Long-term goal	Make internal rules about handling of applications to the National Office of Copyright and Related Rights and digital geographic information according to the examples of neighboring countries.

2-2-3. Proposals on Enhancement of TSDE

To ensure continuous update and utilization of geographic information data, it is indispensable to enhance TSDE in terms of organization and finance. The proposals on the enhancement of TSDE are summarized in the table below.

(1) Proposals on organizational enhancement of TSDE

Even before this Study, TSDE had been considering organizational upgrade (National Directorate of Topography and Geodesy: Direction national de Topographie et de la Géodésie) and enhancement. In the September 2013 interview that the Study Team had with the Minister of Equipment and Transport, the upper organization of TSDE, the minister gave positive answers about the organizational enhancement of the Topographic Section.

If the sections of this organization (Administration Section, Geodesy Section, Mapping Section, and Topography Section) have an equivalent scale (in terms of human resources and equipment) to the current Topographic Section, Department of Equipment and gain a budget with which they can carry out the operations listed in the table below according to middle and long-term goals, there will be a higher possibility that TSDE takes the initiative of the relevant organizations to promote continuous utilization and updating of topographic mapping data.

Table 11 Organizational Enhancement and Middle and Long-term Operation Goals

Department		Middle-term goal	Long-term goal
National Directorate of Topography and Geodesy		Fostering of engineers	Unification of information regarding topography, mapping, photogrammetry, and geodesy Fostering of experts and senior engineers
	Administration Section	Administration Enhancement of relations with public organizations in Djibouti Establishment of cooperative structure with private companies and donors of developed countries	Administration Operation of selling geographic information data
	Geodesy Section Mapping Section Topography Section	Development of networks of control points and benchmarks in Djibouti and its periphery Updating of topographic maps (Secular change correction) Cooperation in creation of control maps for urban infrastructure Survey operation related to improvement of urban infrastructure	Development of networks of high-accuracy national benchmarks Creation and printing of various topographic maps Creation of ortho images Development of spatial information database Development of new road maps and creation of road management maps

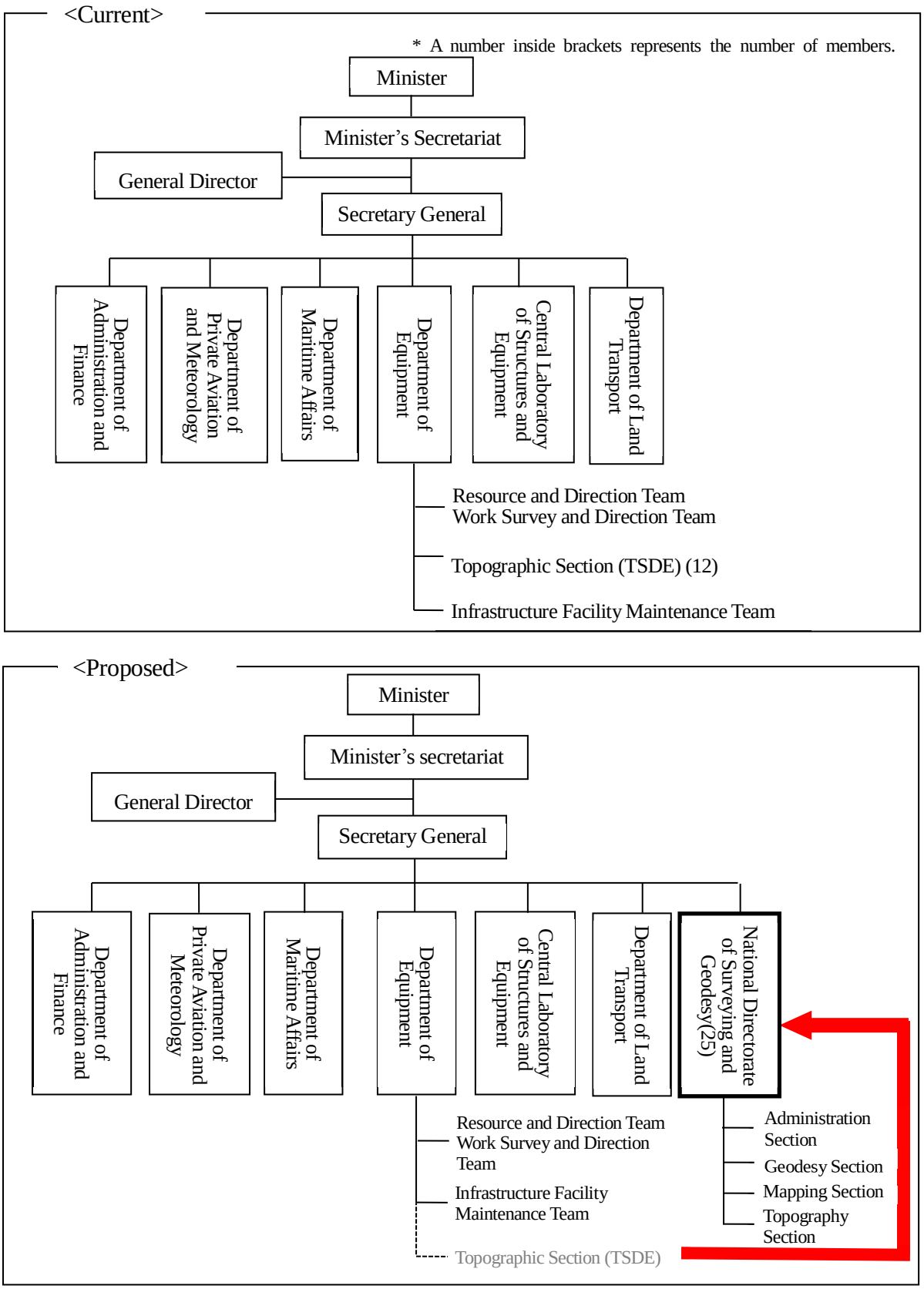


Figure 5 Concept of Organizational Enhancement of TSDE (upper: current, lower: conceived)

(2) Proposal on technology enhancement of TSDE

Proposal for utilization of the result of technology transfer in the project and sustainable data update in the future is described as below.

Table 12 Proposal on technology enhancement of TSDE

Item	Timing	Goals
Partial revision (Updating of geographic information data)	Middle-term goal	It is advisable to actually carry out updating operations using information on topographic data updating (design charts, completion charts, etc.) to be acquired from stakeholder organizations in order to brush up and learn efficient use of the technologies acquired in the technology transfer of this Study. Furthermore, opportunities for review and repeated practice should be gained through actual work regarding the practical applications and quality control using the GIS software, which remained as future tasks in the technology transfer of this Study.
	Long-term goal	About technologies related to new mapping data creation, to actual use of theories transferred in the project, it is necessary to learn new technologies such as software operation procedures, etc. When the engineers learn the 3D data acquisition technology, it is advisable to select hardware and software according to the operators' technical level and scales of work and budget. One of the possible solutions is to utilize the dispatch of experts from international aid organizations.

3. Details and Results of Work Done

3-1. Collection, Sorting and Analysis of Related Materials and Information [Work in Japan]

The map symbols (Draft) were prepared based on the materials collected by the Preliminary Study Team, the results of the study made by PASCO and the information procured in Japan.

3-2. Preparation of Inception Report (IC/R) [Work in Japan]

The Inception Report was prepared through analysis and examination of the Terms of Reference (TOR), the Report on the Preliminary Study and the above-mentioned collected materials. The issues pointed out in the meeting for discussion of the Inception Report held on March 8, 2012 were reflected in the Inception Report and English and French-language versions of the report were also prepared.

3-3. Explanation and Discussion of Inception Report (IC/R) [Work in Djibouti]

The Study Team discussed the content of the Inception Report with MET and explained the details of study,

implementation policies, etc. The contents of explanation and discussion were summarized in minutes of meeting (M/M), which were signed by both the parties on mutual agreement .

3-4. Discussion of Specifications [Work in Djibouti]

MET and the Study Team made discussions on the specifications of the 1/2,500 digital topographic maps and orthophotos to be created and determined to use the specifications of the topographic maps in this Study shown below in the discussion.

Table 13 Topographic Map Specifications Determined

Item	Matters Determined
Height criteria	As per the results of survey of existing benchmarks
Reference ellipsoid	GRS80
World geodetic system	ITRF2005
Central meridian	42°30′E
False_Easting (m)	130000.000
False_Northing (m)	0.000
Scale factor	0.9999
Items acquired for plotting	213 items
Contour intervals	Index contour: 10m; Intermediate contour: 2m
Map sheet size	1.5km × 2km
Annotation	Cette carte topographique a été réalisée conjointement par l'Agence Japonaise de Coopération Internationale (JICA) et le Gouvernement de la République de Djibouti, dans le cadre du Programme de Coopération Technique du Gouvernement du Japon.

Figure 6 Printed Map based on Determined Topographic Map Specifications

3-5. Collection and Sorting of Existing Materials [Work in Djibouti]

In addition to the information collected in the preparatory and preliminary works in Japan, related materials and information were also collected in Djibouti through the exchange of information with the counterparts and organizations related to other ongoing projects in Djibouti; information on the collected materials was incorporated into the Project under this Study and was used as reference materials for the utilization of the topographic mapping data and GIS basic data to be created in this Study.

3-5-1. Information on Existing Survey Results

The collection of existing survey results and field reconnaissance found some existing benchmarks and control points that can be used in this operation.

3-6. Fact-finding Survey on Promotion of Geographic Information Data [Work in Djibouti]

The results of interview survey on the above organizations have been summarized as basic data for future popularization methods and utilization promotion with a focus on distribution and selling statuses of geographic information data and the Djiboutian people's understanding of maps, etc. Consequently, the following problems were found as of the timing of interviews.

Table 14 Interview Results

Organization	Survey result
Ministry of Equipment and Transport (MET)	TSDE did not supply spatial information such as topographic maps and aerial photos to government organizations for a long time. Therefore, it does not exchange information nor share owned data with relevant organizations at all. To establish the Master Plan for Djibouti City, the Ministry of Housing, Urban Planning, Environment, and Land Management needs orthophotos and topographic maps, which must be provided by TSDE. Therefore, the rules for supplying spatial information (regarding duplication, storage, secondary usage, etc.) must be established promptly.
Ministry of Housing, Urban Planning, Environment, and Land Management	This ministry has started establishing master plans for five cities except for Djibouti City and already carried out aerial photography (resolution of 10 cm). This ministry, which is also going to establish the master plan of Djibouti city, intends to be supplied with topographic maps and orthophotos that will be developed in this Study. However, the scope of work in this Study does not cover the entire master plan area, and this ministry wants JICA to expand the range of orthophotos and topographic maps to be created.
Ministry of Water, Energy, and Natural Resources	The water and hygiene survey plan section is examining the improvement of water pipe network maps and pipeline ledgers. The current water pipe network maps (paper) are based on the topographic maps created by France more than 20 years ago and do not match the current status. Accurate information cannot be entered on them. Consequently, water pipes were accidentally broken during construction of roads and houses. The ministry wants to put the water pipe ledgers into an electronic form based on digital maps created in this Study and supply them to the government and parties concerned with construction.

3-7. Holding of (First) Seminars to Promote Utilization [Work in Djibouti]

A seminar to promote the utilization of topographic mapping data was held on March 24, 2012.

In the seminar, an outline of this Study and the present status / problems of the geographic information in Djibouti were explained and discussed, and a request for cooperation in this Study was made. A total of 35 delegates participated in this seminar: 29 delegates from governmental agencies, international organizations and the press, and 6 members of the Study Team. Participants included 3 Ministers in the Government of Djibouti.

A number of questions and instructive comments about the aerial photography, target range of the plotting and the method of acquiring geographic information were put forward by the participants. The Ministry of Housing, Urban Planning, Environment and Land Management expressed a desire to expand the range of development of topographic mapping data, and there were strong indications of the need for and high expectations of up-to-date and reliable geographic information.

Figure 7 Scenes at the First Seminar

3-8. Control Point Survey [Work in Djibouti]

The aerial markers were installed and the control point survey conducted in accordance with the workflow shown below. As a result of the GNSS survey and leveling, the coordinates and heights (H) of the control points in the world geodetic system (ITRF2005) were acquired as shown below.

Reconnaissance, point selection and laying of stone monuments	Carry out reconnaissance of planned candidate sites, select the control points taking into consideration the level of recognition on aerial photos and access to the points, and lay a stone monument at the center of each control point.
Installation of aerial	Install aerial markers so that the positions of all stone monuments laid are clearly recognizable on the aerial photos.
GNSS Observation	Observe the center of each control point using a GNSS receiver to acquire its relative horizontal coordinates.
48-hour Observation and Long Baseline Analysis	Acquire the horizontal coordinates of two control points through 48-hour observation and through long baseline analysis with the IGS points in neighboring countries.
Data processing	Make the net adjustment calculations to determine the horizontal coordinates and heights of all control points.
Leveling	Observe and determine the heights of all control points by means of a direct leveling survey.

Figure 8 Flow of Control Point Survey Work

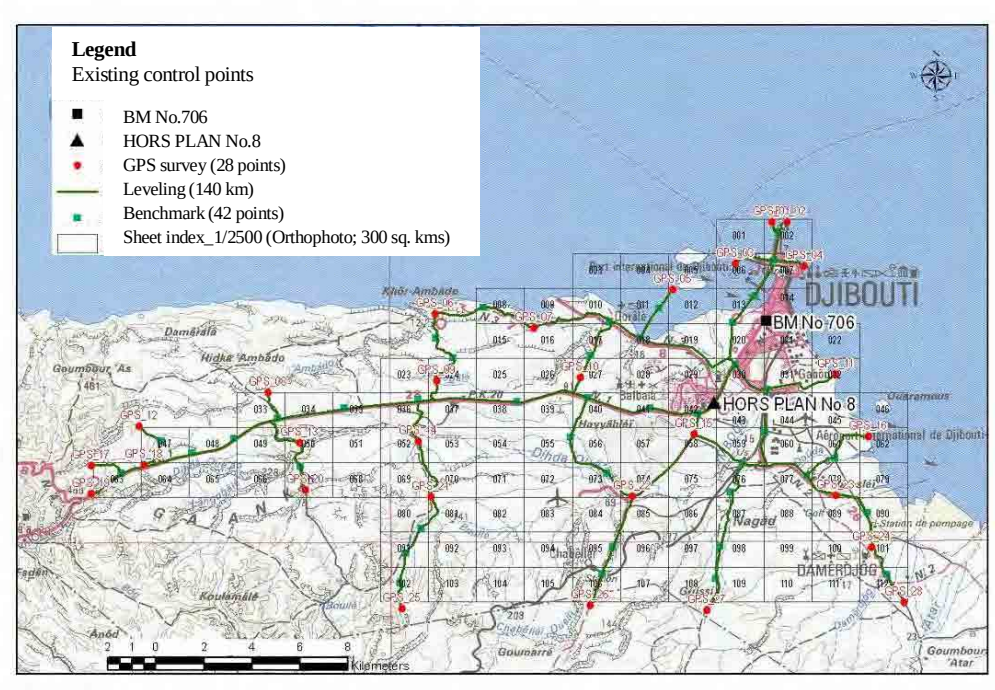


Figure 9 Map of Control Points

Figure 10 Control point survey (Left: GNSS observation; Right: Leveling)

Table 15 List of Geodetic Coordinates of Control Points

Control point	ITRF2005				Elevation	
GPS01	Lat.	11° 37' 22.20349" N	Lon.	43° 08' 42.23573" E	H	2.951 m
GPS02	Lat.	11° 37' 10.29375" N	Lon.	43° 09' 03.01778" E	H	2.350 m
GPS03	Lat.	11° 36' 25.23043" N	Lon.	43° 07' 51.93154" E	H	2.579 m
GPS04	Lat.	11° 36' 10.65139" N	Lon.	43° 09' 08.46440" E	H	6.864 m
GPS05	Lat.	11° 35' 35.46806" N	Lon.	43° 06' 14.28054" E	H	3.621 m
GPS06	Lat.	11° 35' 19.24176" N	Lon.	43° 00' 59.60672" E	H	58.500 m
GPS07	Lat.	11° 34' 56.75284" N	Lon.	43° 03' 08.18751" E	H	47.688 m
GPS08	Lat.	11° 33' 25.62816" N	Lon.	42° 57' 07.29129" E	H	210.184 m
GPS09	Lat.	11° 33' 43.25365" N	Lon.	43° 01' 01.28183" E	H	146.157 m
GPS10	Lat.	11° 33' 46.19489" N	Lon.	43° 04' 18.83725" E	H	89.197 m
GPS11	Lat.	11° 33' 38.90705" N	Lon.	43° 09' 44.62980" E	H	2.934 m
GPS12	Lat.	11° 32' 40.22756" N	Lon.	42° 54' 22.05384" E	H	318.523 m
GPS13	Lat.	11° 32' 15.96879" N	Lon.	42° 57' 50.59293" E	H	226.525 m
GPS14	Lat.	11° 32' 18.28128" N	Lon.	43° 00' 32.76661" E	H	150.439 m
GPS15	Lat.	11° 32' 26.25348" N	Lon.	43° 06' 54.34260" E	H	39.595 m
GPS16	Lat.	11° 32' 14.06704" N	Lon.	43° 10' 56.50237" E	H	1.298 m
GPS17	Lat.	11° 31' 45.12826" N	Lon.	42° 52' 59.54991" E	H	466.112 m
GPS18	Lat.	11° 31' 45.17624" N	Lon.	42° 54' 14.79385" E	H	358.238 m
GPS19	Lat.	11° 30' 58.37569" N	Lon.	42° 52' 54.11585" E	H	463.161 m
GPS20	Lat.	11° 31' 10.88254" N	Lon.	42° 57' 58.55375" E	H	234.873 m
GPS21	Lat.	11° 30' 57.18780" N	Lon.	43° 00' 52.36456" E	H	153.054 m
GPS22	Lat.	11° 30' 57.87367" N	Lon.	43° 05' 29.56040" E	H	53.338 m
GPS23	Lat.	11° 30' 53.31414" N	Lon.	43° 10' 02.90515" E	H	38.778 m
GPS24	Lat.	11° 29' 46.78964" N	Lon.	43° 10' 58.79726" E	H	7.550 m
GPS25	Lat.	11° 28' 15.99326" N	Lon.	43° 00' 09.40944" E	H	233.839 m
GPS26	Lat.	11° 28' 23.87734" N	Lon.	43° 04' 32.91991" E	H	176.307 m
GPS27	Lat.	11° 28' 20.32328" N	Lon.	43° 07' 13.18170" E	H	100.792 m
GPS28	Lat.	11° 28' 29.85544" N	Lon.	43° 11' 42.71470" E	H	14.540 m
GPS29	Lat.	11° 28' 32.63250" N	Lon.	43° 13' 57.91054" E	H	4.243 m
GPS30	Lat.	11° 26' 57.22700" N	Lon.	43° 12' 07.97330" E	H	71.319 m
GPS31	Lat.	11° 27' 41.14292" N	Lon.	43° 14' 59.81272" E	H	2.642 m
No.22	Lat.	11° 34' 44.70669" N	Lon.	43° 09' 31.92113" E	H	9.624 m
No.40	Lat.	11° 33' 06.22425" N	Lon.	43° 05' 24.90712" E	H	127.190 m
No.8	Lat.	11° 33' 11.38572" N	Lon.	43° 07' 22.53912" E	H	38.721 m

3-9. Aerial Photography [Work in Djibouti]

In this Study, aerial photography was conducted by means of the digital aerial camera using the most up-to-date GNSS /IMU technology in the following workflow:

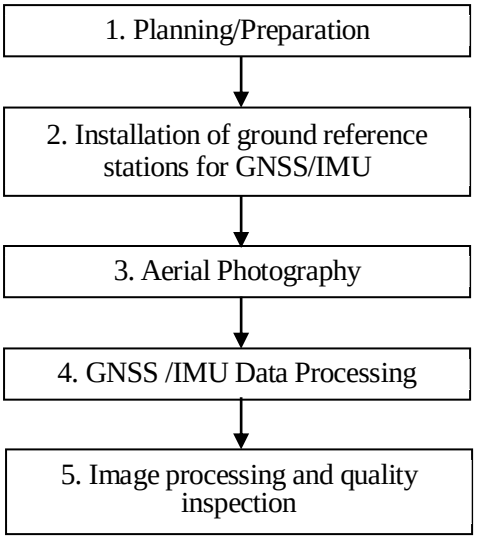


Figure 11 Aerial Photography Workflow

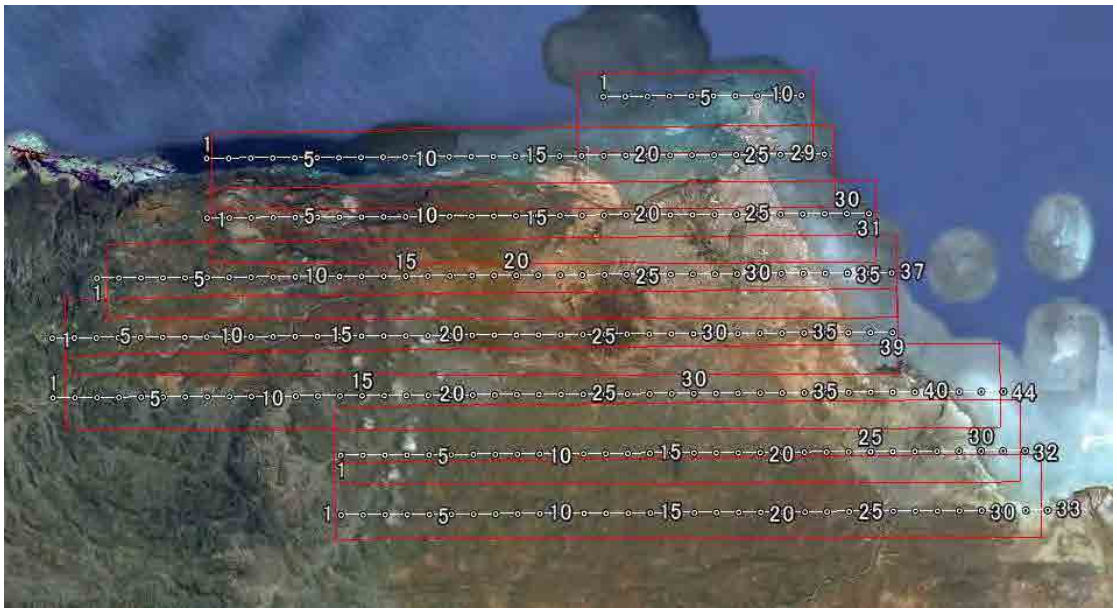


Figure 12 Implementation Map for Aerial Photography

Table 16 Specifications for Aerial Photography

Item	Specifications
Ground resolution	20cm
Type of photography	Digital color photography (TIFF format)
Photographic courses	8 courses; Total flight length: approx. 229.7km
Number of photo images	Approx. 262 sheets
Aircraft used for photography	Piper PA-23 (Aztec) Reg. F-GORP
Camera	Digital camera for aerial photography (Vexcel UCXp*)
Altitude above ground level	3,400 – 3,650m
Overlap	Overlap rate : 60±5% Side lap rate: 30±5%
Tolerable cloudiness	Less than 3% over 5 continuous photo sheets
Requirements for photography	The coordinates of the principal point of a photo were obtained by DGPS* and the elevation angle was obtained by IMU*.

*UCXp: UltraCam-Xp, Airbone digital camera by Vexcel
*DGPS: Differential GPS using technology to enhance the measuring accuracy of GPS.
*IMU: Inertial Measurement Unit using the principle of inertia

Figure 13 Photographic Equipment (Left: Airplane; Right: Digital camera, GNSS/IMU)

3-10. Aerial Triangulation [Work in Japan]

The aerial triangulation was conducted using aerial photo image data that had undergone image processing, exterior orientation elements calculated in the GNSS/IMU data processing, and coordinates of control points as shown in the flowchart below and the result satisfied the specification.

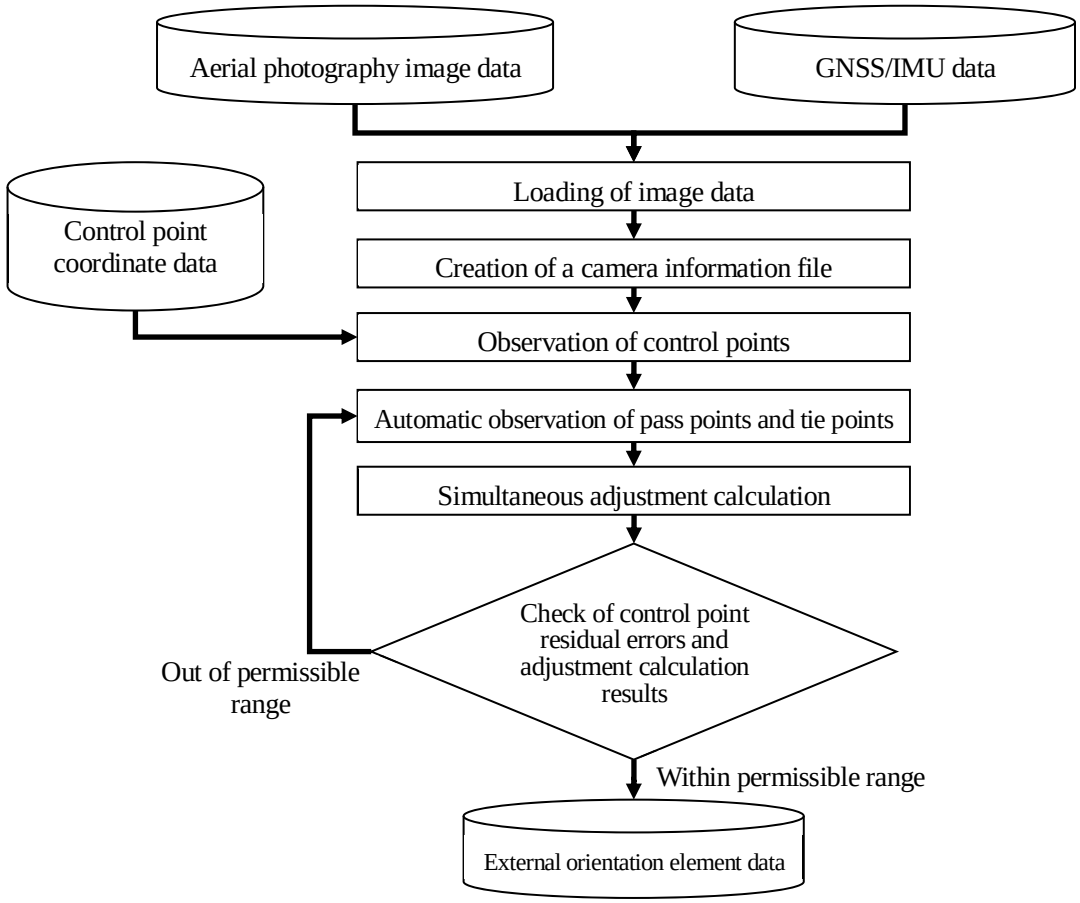


Figure 14 Aerial Triangulation Workflow

Table 17 Residual Errors of Control Points

Block		Resolution 20cm	
		Residual Error	Limit Value
Standard Deviation (m)	Horizontal Position	0.05	0.50
	Elevation	0.04	0.50
Maximum (m)	Horizontal Position	0.10	1.00
	Elevation	0.12	1.00

3-11. Creation of Orthophotos [Work in Japan]

Orthophotos were created using the digital aerial photo image data and data on the external orientation elements obtained from the aerial triangulation. In creating the orthophoto images, the method of using 20m-grid DEM (digital elevation model), which was automatically extracted and corrected by correlation of stereo model images, to correct the heights in the digital aerial photos and to transform the orthophotos into a horizontal coordinate system was used. As an orthophoto image was created for each model unit, the work of edge matching between models (mosaic processing) was carried out to create an ortho-image of the entire area of work. After that, the map sheets were divided into the 1/2,500-scale map sheets.

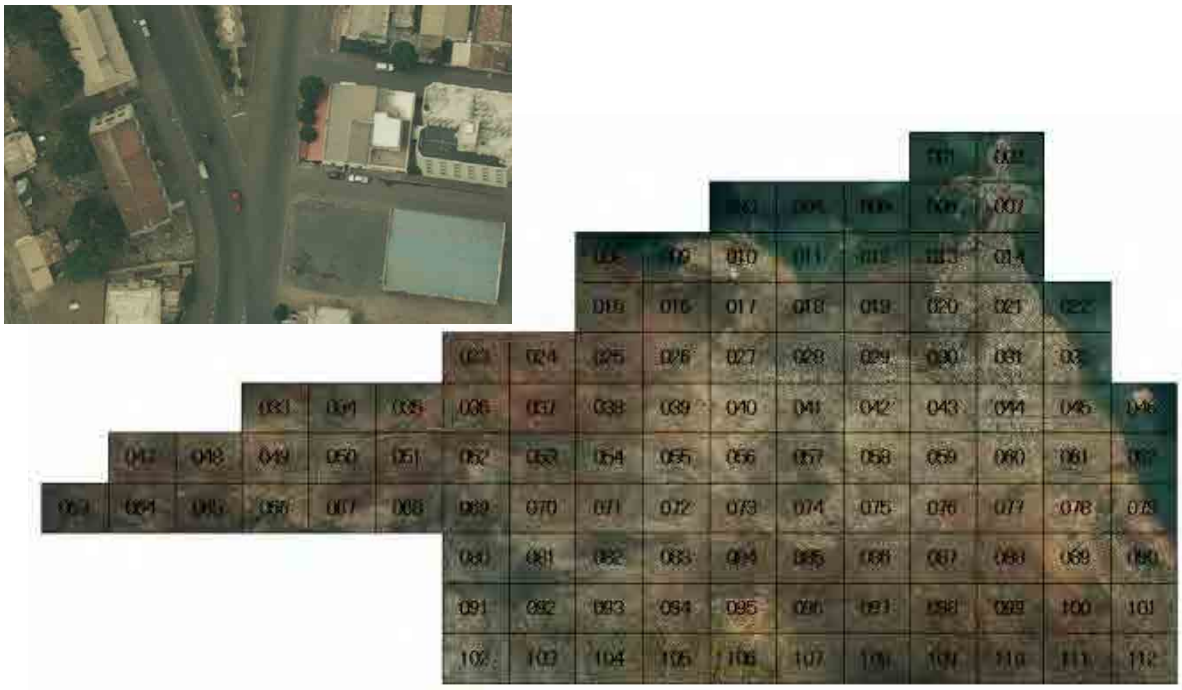


Figure 15 Created Orthophoto Image

3-12. Preparation of Progress Report (PR/R) [Work in Japan]

The details and results of works done so far and the progress of those works were summarized to prepare the Progress Report. The created report was explained to and approved by JICA before it was brought to Djibouti.

3-13. Explanation and Discussion of Progress Report (PR/R) [Work in Djibouti]

The explanation of the Progress Report was made to MET so that discussions could be held with them on a series of processes, from the control point survey and aerial photography to aerial triangulation and orthophoto creation, the results of the promotion of the utilization of the outputs in this Study, and future plans. In the meeting for the explanation and discussions, the presentation of the details of the PR/R was

provided using PowerPoint. The discussions were recorded as the minutes of proceedings, which were signed by both parties.

3-14. Field Verification [Work in Djibouti]

The objects not easily identifiable in aerial photos such as planimetric features and buildings, linear objects (electric transmission lines and pipelines), public facilities (including water places), road types, administrative boundaries, annotations, etc. were identified and checked in the study area using photo maps, *i.e.*, outputs of orthophoto images. Regarding these target objects, existing materials were collected and an interview survey was conducted at MET and other public organizations. The flowchart of the field verification is shown below.

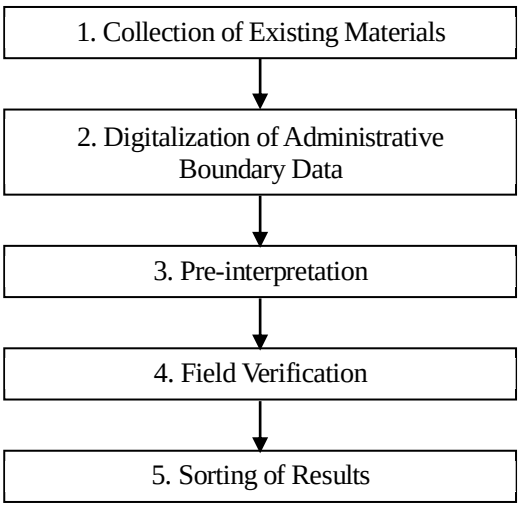


Figure 16 Field Verification Workflow

Figure 17 Field Verification Operation (Left: Pre-interpretation, Right: Result)

3-15. Digital Plotting and Compilation [Work in Japan]

The aerial photo image data was imported into a digital plotter based on the aerial triangulation results to create stereo models. The created stereo images were seen in stereoscopic view on the digital plotter to carry out the digital plotting operation in which 3D coordinates of topographic and planimetric features were obtained.

While referring to image data of the field verification results, the forms and positions of topographic and planimetric features were entered as coordinate data to create blank digital plotting map data.

In the digital compilation, the data after the digital plotting was processed in the connection processing, closure processing, joining processing between neat lines, etc. and was added with annotation data to develop compiled topographic mapping data. For the digital compilation operation, AutoCAD Map3D, CAD software, was used to unify the application with digital plotting and thus improve the operation efficiency.

Questions asked during the digital plotting and digital compilation operations and points that could not be easily identified in photo interpretation were selected as targets of field completion.

Figure 18 Digital plotting (Left: Plotting work, Right: Result)

3-16. Discussion and Proposal of Methods for the Publicizing and Supply of Geographic Information Data [Work in Japan]

The draft plan for data disclosure and dissemination methods was formulated. Based on this draft plan, discussions on the mapping data dissemination method, how to keep mapping data up to date and future PR activities were held at meetings with the persons in charge from ministries of Djibouti related to geographic information data.

Table 18 Items for Discussion

Category	Work Items (and Information to be Acquired)
Means of Distribution	➢ Types, selling methods, amounts, purchasers, etc. of geographic information (both paper and data forms) sold or procured at present ➢ Measures to protect copyright in the case of digital sales ➢ Examination, problems, etc. of distribution channel organizations for output data of this Study
Users	➢ Simple GIS demonstration using the output data of this Study (from the Study Team to the related Djiboutian agencies) ➢ Quantities of hardware and software in possession of relevant agencies ➢ Specific ideas for utilization of the output data of this survey by the relevant organizations ➢ Implementation of technology transfer and participation in the final seminar in this Study for the engineers of the relevant organizations

3-16-1. Review of Methods of Providing Geographic Information

Summarized below are the results of past and present interview surveys of related agencies regarding the provision of geographic information (both paper and data forms). Agencies experienced in handling or marketing topographic maps and thematic maps in the past and at present were the Djibouti Center for Research Studies: Centre d'Études et de Recherche de Djibouti (CERD), the Department of Statistics and Population: Direction de la Statistiques et des Études Démographiques (DISED), and the Department of Housing and Urban Planning.

Table 19 Status of Provision of Topographic Mapping Data

	Name of Agency	Materials Handled (Topographic and Thematic Maps)	Price (DJF/Sheet)	Remarks
1	Djibouti Center for Research Studies (CERD), Ministry of Higher Education	Various types of thematic map (1/100,000: Vegetation maps, topographic maps, geological maps, etc.)	6,000	Currently on sale All printed maps (printed by IGN, France) The data may be purchased, but is limited to academic or public use.
		Topographic maps (1/100,000)	1,500	
		Topographic maps (1/200,000)	2,500	
2	Department of Housing and Urban Planning, Ministry of Housing, Urban Planning, Environment and Land Management	Topographic maps (1/5,000)	2,500	All printed maps Out of stock and currently not on sale.
		Topographic maps (1/10,000)	2,500	
3	Department of Statistics and Population (DISED), Ministry of Higher Education	Various types of land boundary map		Distributed free of charge (with the permission of the Director General of the Department of Statistics)

3-16-2. Survey of Topographic Mapping Data Users

In order to discuss and review methods of updating and the wider utilization of topographic mapping data, interview surveys, including demonstrations of the data created in this Study, were carried out of those

public agencies that could be expected to be users, based on the results of past surveys of related agencies.

Table 20 Results of User Survey

Name of Agency		Equipment Owned	Materials Owned	Utilization to be Expected
1	Department of Statistics and Population (DISED)	ArcGIS: 2 sets	Census data (Text)	Relation of census results to positional information Detailing and updating of land boundary information
2	Djibouti Center for Research Studies (CERD)	ArcGIS: 3 sets	Various types of thematic data	Creation and analysis of hazard maps (floods and earthquakes) of Djibouti City
3	Electricité de Djibouti (Electricity of Djibouti)	AutoCAD: 5 sets	Electrical facility data (transmission lines, towers, etc.)	Planning and management of electrical facilities Efficient construction and rehabilitation works through shared use of underground facility information (ONEAD, Djibouti Telecom)
4	Cadastral Division	INFOCAD: 3 sets Conversion to ArcGIS is under consideration	Land boundary data	Detailing and updating of boundary information
5	Djibouti National Water and Sanitation Office (ONEAD)	ArcGIS: Several sets AutoCAD: Several sets	Positional data of wells; Service water and sewer data	Management of facilities such as wells, and service water and sewage works; Digitalization of rainwater gutter maps; Efficient construction and rehabilitation works through shared use of underground facility information (Electricity of Djibouti and Djibouti Telecom)
6	Department of Housing and Urban Planning	ArcGIS: 1 set AutoCAD: 1 set	Basic urban planning maps	Detailing of basic urban plans
7	Department of Environment	ArcGIS: 1 set	Forest distribution data; Mangrove distribution data	Updating of forest and mangrove distribution
8	Division of Large Construction, Department of Agriculture	ArcGIS: 1 set AutoCAD: 1 set	Embankment data (shared use with other agencies)	Management, analysis and planning of embankment data
9	Office de la Voirie de Djibouti (OVD) (Djibouti Road Maintenance Office)	None		Retrieval of garbage collection routes; Waste volume control; Control of illegal dumping sites
10	Department of Citizen Protection, Ministry of Interior and Decentralization	None	Register of accidents (Traffic accidents, diseases, fires, etc.)	Management of information on buildings with fire risk, route retrieval, fire history management, and retrieval of areas problematic for fire engine activity
11	Djibouti City Hall	ArcGIS: 1 set Illustrator: 1 unit		Detailing of basic urban plans
12	University of Djibouti	ArcGIS: 32 sets		Use as educational tools

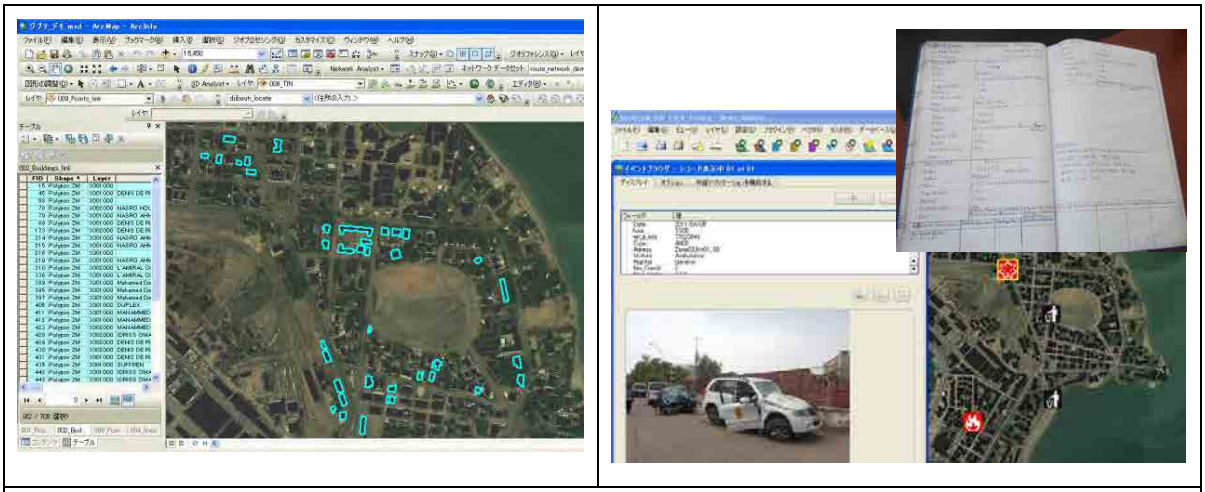


Figure 19 Examples of Utilization (Left: ArcGIS; Right: Free GIS Software)

3-17. Preparation of Interim Report (IT/R) [Work in Japan]

The details, results and progress of the work done were summarized to prepare the Interim Report. The created report was explained and examined in a meeting with JICA, modified to reflect the examination results, translated into English and French, and bound into book form.

3-18. Explanation and Discussion on Interim Report (IT/R) [Work in Djibouti]

3-18-1. Explanation and Discussion on Interim Report

The created interim report was explained to and discussed with MET. For the explanation and discussion, a PowerPoint slide that summarized the contents was prepared and used in the presentation. The contents of discussion were summarized in minutes of meeting (M/M), which were signed by both the parties.

3-18-2. First Stakeholder Meeting

A stakeholder meeting on the utilization of topographic data was held, attended by the current and future relevant organizations as stakeholders and users. The agenda and comments made by participating and other organizations are shown below.

All the participating organizations gave positive responses about the importance of data update and sharing. About the operation, however, there were many topics that needed continued discussion after the end of this study period, such as enhancement of expert staff and equipment and establishment of a department in charge. Therefore, the discussion will be continued in the second stakeholder meeting to be held at the time of explanation and discussion on the Draft Final Report.

Table 21 Participating Organizations and Comments in First Stakeholder Meeting

Organization name		No. of participants	Comments
1	Ministry of Equipment and Transport	5 including cabinet chief	Will support the operation by making the most of the information owned by the organizations. As for the establishment of an organization for updating and utilization of data, the stakeholders should take time to establish a system.
2	Department of Citizen Protection, Ministry of Interior and Decentralization	1, deputy chief	This organization takes charge of construction permits for structures and disasters. It is positive about technical improvement of expert staff and data sharing.
3	City of Djibouti	2 including deputy mayor	Wants to consider positively human resource development, establishment of a department in charge of topographic maps, and cooperation with the stakeholder committees.
4	Department of Housing and Urban Planning (DHU)	2 including director	To provide coordination in the topographic mapping operation including data update, it is necessary to open a department in charge, which must have two or three experts and required equipment. This organization agrees to share data owned by it.
5	Djibouti Electricity (EDD)	2 engineers	Supplies the owned data.
6	Djibouti Center for Research Studies (CERD)	1, secretary general	The establishment of an information sharing network is important. To manage and update the result of this study, it is necessary to establish an organization in charge. For this purpose, the needs and scope of investment (securing of budget and equipment) must be identified. The utilization of existing telecommunication tools can be examined.
7	Djibouti National Water and Sanitation Office (ONEAD)	1, section chief	Supplies the owned data.
8	JICA Djibouti Office	1, advisor	
9	JICA Study Team	5 including team leader	

3-19. Field Completion Survey [Work in Djibouti]

In the field completion survey, unknown places found in the digital plotting and digital compilation operations and important items for user organizations are checked after the pre-interpretation operation using 1/2,500 maps created using the data that had undergone digital plotting/compilation as shown in the flowchart below.

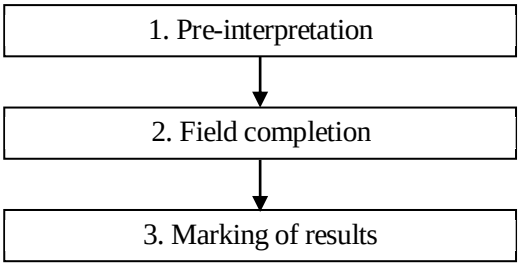


Figure 20 Field Completion Survey Operation Flow

Figure 21 Field Completion Survey Operation (Left: Marking of results, Right: Result)

3-20. Digital Compilation after Field Completion [Work in Japan]

After the field completion survey, the digital compilation was conducted to correct and modify digital compilation data based on the survey results.

3-21. Map Symbolization of Topographic Maps [Work in Japan]

Map symbols were added to the topographic mapping data that had undergone digital compilation after field completion based on the map symbol specifications determined in the Discussion of Specifications. The map symbolization processing was conducted using the AutoCAD software on the above topographic mapping data to create 1/2,500 printed map data. A check list (accuracy control table) that listed map symbolization targets and map symbols was created to ensure that there would be no omission in map symbolization.

3-22. Structurization of Digital Data [Work in Japan]

The topographic mapping data created in the digital compilation after field completion underwent the structurization of digital data based on the data structurization specifications determined in the discussion of specifications so that it can be used for GIS. The GIS basic data created in the structurization has been converted into the Shape data format, which is practical, user-friendly, and highly versatile. Based on the discussion with C/P, the data for the target area in this operation has been saved to one file.

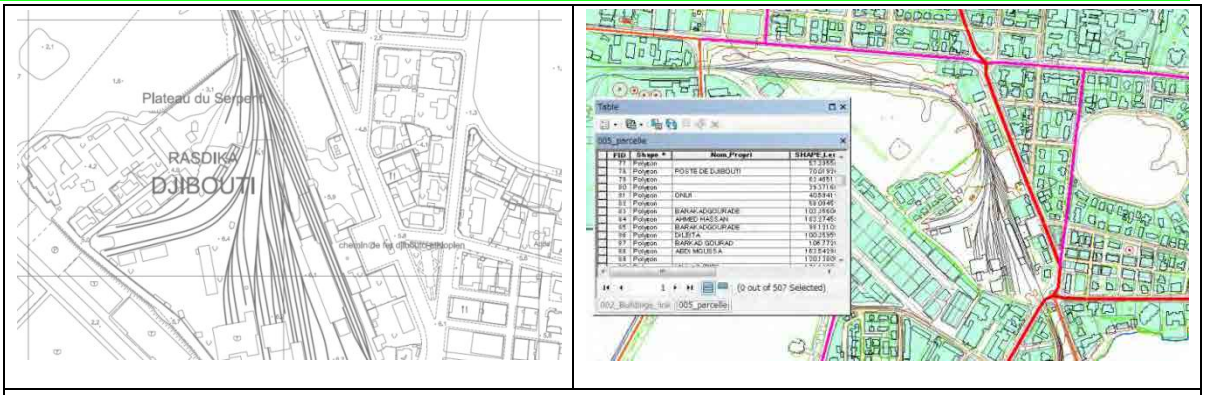


Figure 22 (Left: Symbolization, Right: Structurization)

3-23. Creation of Draft Final Report (DF/R) [Work in Japan]

A Draft Final Report was created to summarize the operations conducted so far, and was approved after the discussion meeting with JICA. The work manuals created in the process of technology transfer were included in the report. These work manuals are provided as a separate volume in consideration of the convenience in the future.

3-24. Explanation and Discussion on Draft Final Report (DF/R) [Work in Djibouti]

The content of the Draft Final Report was explained to the Djiboutian side, and the creation of the Final Report will be discussed. The contents of discussion were summarized in minutes of meeting (M/M), which were signed by both the parties.

3-25. Promotion of Utilization [Work in Djibouti]

The second stakeholder meeting was held on January 21, 2014 to give a final presentation and an opportunity for opinion exchange on utilization promotion to mainly the engineers in the stakeholder organizations that participated in the seminars, discussions, and the first stakeholder meeting (see the table below) so far. The meeting was attended by about 30 persons from 17 organizations and concerned the study outputs and proposals on how to distribute and maintain the geographic information data to be created.

For the distribution of geographic information data, the first goal was set to establish a system consisting mainly of permanent members of the stakeholder meeting by around April 2014 when the outputs of this Study are provided from JICA to Djibouti. For the handling of digital data, creation of rules about application/registration to the "National Office of Copyright and Related Rights," a member organization, and handling of them were set as urgent tasks.

This meeting was covered in TV programs on the same day and newspapers on the next day, and thus became widely known throughout Djibouti. The newspaper articles also mentioned the final seminar to

be held at a later date and served as good advertisements of the seminar.

Table 22 List of Participants for the 2nd Stakeholder Meeting

Organization		Number of participants
1	Department of Equipment	2
2	Djibouti Center for Research Studies (CERD)	1
3	Djibouti Ports & Free Zones Authority	1
4	Department of Housing and Urban Planning (DHU)	2
5	Department of Environment	2
6	Department of Citizen Protection	1
7	Djibouti Electricity (EDD)	2
8	Djibouti Social Development Agency (ADDS)	1
9	Djibouti International Airport	3
10	Civil Aviation Authority	1
11	Port of Djibouti	1
12	National Office of Copyright and Related Rights	1
13	Disaster Risk Management	1
14	Department of Maritime Affairs	1
15	Topography Section, Department of Equipment (STDE)	1
16	JICA Djibouti Office	1
17	JICA Study Team	5

3-26. Holding of Seminars for Promoting Utilization [Work in Djibouti]

3-26-1. Final Seminar

On January 26, 2014, a seminar for promoting popularization and utilization of geographic information was held. The seminar was attended by about 60 persons from 29 organizations listed below, including the "Minister of Equipment and Transport," "Minister of Housing, Urban Planning, Environment, and Land Management," "Secretary of State on National Solidarity of Djibouti," and "Commissioner on Policies".

At the seminar, presentations on the following themes were given to widely inform attendees of the Project and make proposals on information sharing on utilization and update of geographic information after the Project completion and development of a system in Djibouti for this operation.

- Final report of this Study and utilization of GCP outputs (Study Team)
- Example of utilization of digital topographic maps and GIS data (Study Team and CERD staff)
- About TSDE (Topographic Section, Department of Equipment) (TSDE chief)
- Report on OJT outputs and how to update the outputs (TSDE staff)
- How to supply outputs and maintain geographic information in the future (Deputy Vice-Minister, Ministry of Equipment and Transport)

This seminar was also covered in TV programs on the same day and newspapers later and thus became

widely known throughout Djibouti.




Figure 23　Final Seminar（Upper Left：Opening ceremony, Upper Right：Participants, Lower Left：Study Team Presentation, Lower Right：TSDE presentation）

Table 23　List of Participants for the Final Seminar

Participating Organization			
1	Department of Equipment	16	Port of Djibouti
2	Djibouti Center for Research Studies (CERD)	17	Civil Aviation Authority
3	University of Djibouti	18	National Office of Copyright and Related Rights
4	Djibouti Ports & Free Zones Authority	19	Office of Industrial Property and Commerce
5	Department of Housing and Urban Planning	20	Djibouti Railway Company
6	Department of Environment	21	Coast Guard
7	Mayor of Djibouti	22	Department of Maritime Affairs
8	Department of Citizen Protection	23	Central Laboratory of Building and Equipment
9	Department of Statistics and Population (DISED)	24	Djibouti Maritime Training Center
10	Department of Lands and Land Conservation	25	UNDP Representative Office
11	National Water and Sanitation Office of Djibouti (ONEAD)	26	WFP Representative Office
12	Djibouti Telecom	27	Embassy of Japan
13	Djibouti Social Development Agency	28	JICA Djibouti Office
14	Road Maintenance Fund	29	JICA Study Team
15	National Meteorological Agency		

3-26-2. Lecture in Djibouti University

On January 26, 2014, a lecture was delivered at the University of Djibouti, regarding the overview of this Study, examples of utilizing geographic information, and handling of digital data. About 40 students who majored in geodesy, topography, cartography, and GIS-related courses attentively listened to this lecture. In the second half of the lecture, questions and answers were exchanged actively.

The students belong to an information-literate generation. Since the time when they become active members of society is close to the time when the utilization of the outputs of this Study gets under way, they are expected to contribute to promoting the utilization, further accelerating the utilization of geographic information data in Djibouti in the future.

Figure 24 Lecture in University（Left：Lecture, Right：Q&A）

3-27. Creation of Data Files [Work in Japan]

The following digital data files were created as outputs of this study such as topographic maps.

i. 1/2,500 topographic mapping data (DGW file)
ii. GIS basic data (Shape file)
iii. 1/2,500 topographic mapping data (PDF file)
iv. Digital aerial photo data (TIFF file)
v. Orthophoto map data (TIFF file)

The created digital data files will be saved to a HDD or DVD-R for delivery.

3-28. Creation of Final Report (F/R) [Work in Japan]

The Draft Final Report was expanded and corrected based on the comments on it made by the Djiboutian side and completed as a Final Report, which is to be delivered to JICA.

4. Technology Transfer

So far technology transfer in this Study has been carried out on the control point survey, installation of aerial markers and updating of topographic maps for the following items , ranges, equipment and materials.

Table 24 Summary of Technology Transfer

Item	Matter Determined	Target Range
Workers in Djibouti	TSDE provided at least 8 technical personnel and one full-time technical coordinator.	All the field work and indoor work for control point surveys and field verification
Item of Technology Transfer	Installation of aerial markers (OJT)	32 sites within about 300km^2 in all study areas including the range of orthophoto development
	Control point survey and analysis (OJT)	32 points within about 300km^2 in all study areas including the range of orthophoto development
	Leveling and calculation processing (OJT)	32 control points in the total length of 142km
	GNSS analysis and leveling calculation processing (OJT)	32 control points
	Field verification (OJT)	About 110km^2 in the areas for 1/2,500 digital topographic map development
Updating of Topographic Maps	Technical guidance necessary for updating of topographic maps	About 110km^2 in the areas for 1/2,500 digital topographic map development

Table 25 Equipment and Materials for Technology Transfer

Name of Equipment	Q'ty	Remarks
Software for GIS data updating ArcGIS (ArcInfo)	1	Procurement in Kenya by the Study Team
Software for map updating AutoCAD Map 3D	1	
Desk-top personal computer (PC)	2	Procurement in Djibouti by the Study Team
Liquid crystal monitors	2	
Uninterruptible power supply (UPS)	2	
Hard disk for data management	1	
Set of consumables for the network, LAN cable (5) and hub (1)	1	
Color laser printer and consumables (A3)	1	
Plotter-cum-scanner and consumables for map printout (A0)	1	Procurement by JICA
GNSS surveying material and equipment (including accessories)	4	Procurement in Japan by the Study Team
Digital camera (including accessories)	4	
Simple stereoscope	8	
Medium-sized stereoscope with a reflective mirror	1	
Handy GPS	4	
Leveling equipment (digital)	4	

4-1. Details of Technology Transfer

4-1-1. Technology Transfer on Control Point Survey and Installation of Aerial Markers

The technology transfer on control point survey was conducted taking into consideration the main points shown below.

Table 26 Outcomes of Technology Transfer on Reconnaissance, Selection and Installation

Main Points		Outcomes for TSDE
Reconnaissance, Selection and Installation	Understanding of the basic knowledge of control point survey	Application to other work
	Control point distribution to match the photographic plan	Application to other work
	Operation of handy GPS terminals	Application to other work (Finding planimetric features and registration of their positions)
	Selection of points that are easily recognizable on images	Application to other works (Improvement of photo interpretation capacity, etc.)
GNSS survey	Installation of GNSS antenna Operation of GNSS receiver	Control point survey by GNSS observation Utilization of GNSS data analysis and results
	Operation of analysis software Understanding of analyzed results	
Leveling	Operation of digital level Confirmation of survey procedure	Leveling by means of digital level Examination of computed results and accuracy control
	Inspection of measured data Examination of computed results	
Aerial marker	Understanding of aerial photography	
	Selection of materials	Improvement in photo interpretation capacity
	Selection of size, form and color	

Figure 25 Technology Transfer (Left: GNSS Installation; Right: Leveling)

4-1-2. Technology Transfer in Field Verification

The TSDE engineers were not experienced in field verification or in working with aerial photos. Therefore, technology transfer was carried out focusing on their understanding of basic work procedures, photo interpretation and the digitalization of outputs.

Table 27 Outcomes of Technology Transfer in Field Verification

Main Points	Outcomes for TSDE
Pre-interpretation	Higher understanding of field verification items
Field verification	Familiarization with effective methods of utilization of handy GPS; Interpretation of orthophotos; Application in digital plotting Process control
Arrangement of field verification results	Understanding of digitalization; Improved quality

Figure 26 Technology Transfer (Left: Road width measurement; Right: Verification of features)

4-1-3. Technology Transfer on Updating of Topographic Maps

In the first technology transfer about aerial triangulation and digital plotting was carried out mainly through lectures, with an emphasis on the buildup of basic theoretical understanding and capacity. The second technology transfer, carried out, concentrated on practical exercises using the software.

The software used for topographic map updating was Autodesk's "AutoCAD" for data compilation and ESRI's "ArcGIS" for GIS modeling.

Table 28 Outcomes of Technology Transfer on Updating of Topographic Maps

Item	Main Points	Outcomes for TSDE
Updating of Topographic Maps	Understanding of digital plotting and digital compilation procedures	Acquisition of basic capacity for updating of topographic maps
	Understanding of map symbolization method	
	Familiarization with computer operation	

Figure 27 Technology Transfer (Left: AutoCAD, Right: ArcGIS)

4-2. Outputs of Technology Transfer

In this Study, the technology transfer for the field works such as the installation of aerial markers, control point survey and leveling and the analysis and calculation processing work was carried out through OJT.

As a result of technology transfer through a series of survey works, data analysis and calculation, the TSDE survey engineers achieved a certain level of understanding though they were inexperienced in those works, and became familiar with the flow of field work and the operation of survey equipment.

In the technology transfer for updating of topographic maps, the basic work flow, including digital plotting and compilation procedures and map symbolization method, was understood; but with respect to some items of applied operations such as GIS application, quality control and meta data creation, computer

operation using software did not necessarily reach the required level, because for some participants this Study was their first experience of operating a personal computer.

Technology transfer in aerial triangulation, DSM creation, creation of orthophotos and 3D plotting for which no software was procured was carried out by means of theoretical lectures only, but these theories appeared to have been fully understood.

Table 29 Level of Achievement in Transfer of Topographic Map Updating Technology

Item		Trainee 1	Trainee 2	Trainee 3	Average
1	Planning and preparation for GIS data creation	△	△	◎	○
2	Creation of symbols	△	○	◎	○
3	Creation of 2D polygon lines	○	△	◎	○
4	Control point survey Field verification	○	○	○	○
5	Aerial triangulation DSM Creation of orthophotos	△	○	○	○
6	3D data creation (Points, lines, polygons and texts)	△	△	△	△
7	Pre-interpretation of existing topographic maps	◎	△	◎	◎
8	Georeferencing	◎	△	◎	◎
9	Definition of topographic map projection	◎	△	◎	◎
10	2D data acquisition (Points, lines, polygons and texts)	△	△	◎	○
11	Quality control of acquired DWG data	△	△	○	△
12	Data compilation	△	◎	◎	◎
13	Symbolization of 1/2,500 topographic maps	△	◎	◎	◎
14	Data conversion from DWG to Shape	◎	◎	◎	◎
15	Transformation of coordinate system	△	◎	◎	◎
16	Meta data	△	△	◎	○
17	Preparation of attributes table	△	◎	○	○
18	Various types of data	△	△	◎	○
19	GIS applied operations	△	△	○	△

Note: Legends for achievement levels - △: Understanding of theory, ○: Understanding of theory and contents of practices, ◎: Attainment of application level

5. Schedule of Work and Dispatch of Personnel

5-1. Work Schedule and Project Flowchart

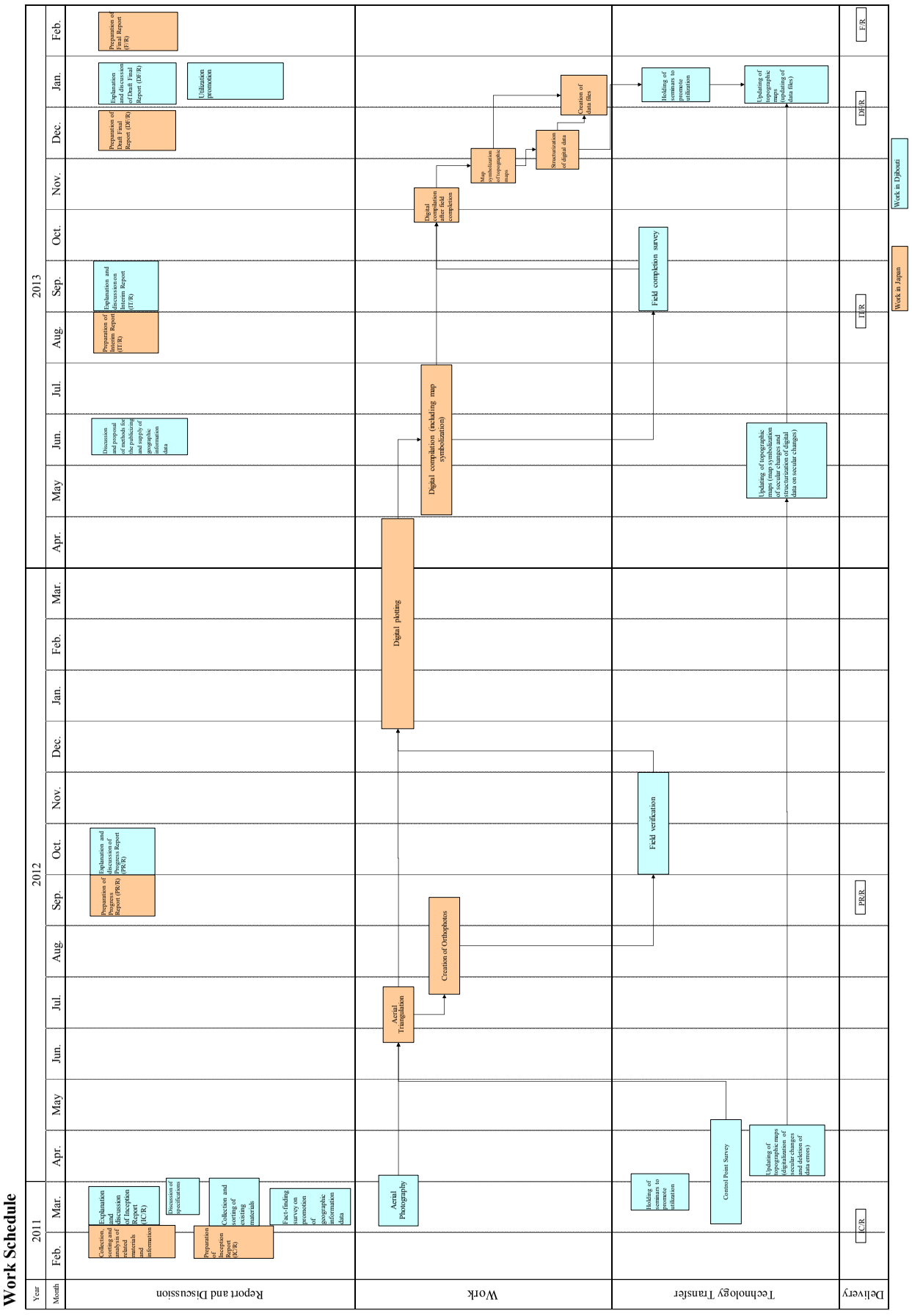
The work schedule in this study and a project implementation flowchart are shown on the next page.

Form-5 Work Plan

Work item \ FY / Month	2011 Feb.	2011 Mar.	2012 Apr.	2012 May	2012 Jun.	2012 Jul.	2012 Aug.	2012 Sep.	2012 Oct.	2012 Nov.	2012 Dec.	2012 Jan.	2012 Feb.	2012 Mar.	2013 Apr.	2013 May	2013 Jun.	2013 Jul.	2013 Aug.	2013 Sep.	2013 Oct.	2013 Nov.	2013 Dec.	2013 Jan.	2013 Feb.	2013 Mar.
Collection, sorting and analysis of related materials and information																										
Preparation of Inception Report (IC/R)																										
Explanation and discussion of Inception Report (IC/R)																										
Discussion of specifications																										
Collection and sorting of existing materials																										
Fact-finding survey on promotion of geographic information data																										
Holding of seminars to promote utilization																										
Aerial Photography																										
Control Point Survey																										
Aerial Triangulation																										
Creation of Orthophotos																										
Preparation of Progress Report (PR/R)																										
Explanation and discussion of Progress Report (PR/R)																										
Review of the surveying administration for the promotion of geographic information data																										
Field verification, field completion survey																										
Digital plotting																										
Digital compilation																										
Digital compilation after field completion																										
Discussion and proposal of methods for the publicizing and supply of geographic information data																										
Preparation of Interim Report (IT/R)																										
Explanation and discussion on Interim Report (IT/R)																										
Map symbolization of topographic maps																										
Structurization of digital data																										
Creation of data files																										
Utilization promotion																										
Holding of seminars to promote utilization																										
Preparation of Draft Final Report (DF/R)																										
Explanation and discussion of Draft Final Report (DF/R)																										
Preparation of Final Report (F/R)																										
Updating of topographic maps																										
Report		IC/R							PR/R											IT/R				DF/R		F/R
Delivery																										A set of outputs

: Work in Japan : Work in Djibouti

Work Schedule



5-2. Dispatch of Personnel

The dispatch of personnel in this Study was as shown in the table below.

Personnel Plan

	Survey operations under charge	Name	Agency	Rank		2012 Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	2013 Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	2014 Jan.	Feb.	Mar.	Total Djibouti	Total Japan
Work in Djibouti	Team Leader / digital compilation	Masakuni NAKAYAMA	PASCO	2			3/12	30	4/10					10/2	20	10/21																	**3.70**	
	Supervisor of Aerial Photography	Daikichi NAKAJIMA	PASCO	4			3/13	30	4/11																	9/1	40	10/0					**1.00**	
	Control point survey (1)	Atsushi MOCHIZUKI	PASCO (Advance)	3			3/13	60		5/11																							**2.00**	
	Control point survey (2)	Tadaaki TOMITA	PASCO (Kyoritsu Setsubi)	4			3/13	60		5/11																							**2.00**	
	Field verification and field completion (1)	Daikichi NAKAJIMA	PASCO	3										10/2	60	11/30										9/2	45	10/16					**3.50**	
	Field verification and field completion (2)	Toshiyuki WAKABAYASHI	PASCO	4										10/2	60	11/30										9/2	45	10/16					**3.50**	
	Field verification and field completion (3)	Tadahiko SEKIGUCHI	PASCO	5										10/2	60	11/30										9/2	45	10/16					**3.50**	
	Updating od topographic maps (technology transfer)	Daikichi NAKAJIMA	PASCO	4				4/12	30	5/11								5/10	45	6/23										21			**3.20**	
	Utilization promotion	Kaoru TSUDA	PASCO	4	Before change		3/12	17	3/28										16											21			**1.80**	
		Kaoru TSUDA	PASCO	4	After change			17													6/10	16	6/25										**0.60**	
		Akira OTA	PASCO	4	After change																6/10	16	6/25							21			**1.20**	
	Interpretation	Tomohiro KOYAMA	PASCO (Technostaff)	4	Before change		3/13	30	4/11					10/4	30	11/2											30			21			**3.70**	
		Tomohiro KOYAMA	PASCO (Technostaff)	4	After change			30																		9/2	30	10/1		21			**2.70**	
		Tomoyuki OTANI	PASCO (Technostaff)	4	After change										30																		**1.00**	
	Operation coordination / assistance in field verification and field completion	Takashi SHIRAI	PASCO	4	Before change		3/13	30	4/11						60															21			**3.70**	
		Takashi SHIRAI	PASCO	4	After change			30																									**1.00**	
		Hayato FUKUOKA	PASCO	4	After change									10/2	60	11/30																		
		James WATSON	PASCO	6	After change																									21			**0.70**	
																																25.90	
																																27.90	
Work in Japan	Team Leader / digital compilation	Masakuni NAKAYAMA	PASCO	2			2/28	9	3/9																					12			**0.70**	
	Control point survey (1)	Atsushi MOCHIZUKI	PASCO (Advance)	3			3/2	6	3/9																								**0.20**	
	Field verification and field completion (1)	Daikichi NAKAJIMA	PASCO	3											6																		**0.20**	
																																	1.10	
	Report	Submission term (Shown with △ and names of the report)						△ IC/R						△ PR/R												△ IT/R			△ DF/R	△ F/R			
		Work in Japan																																
		(Man/Month Total)																																
Stage/Total																																		

Legend: Work in Djibouti; Work in Japan