The Capacity Development Project for Digital Topographic Mapping in the Federal Democratic Republic of Ethiopia

Final Report
(Summary)

September 2016

PASCO Corporation
Kokusai Kogyo Co., Ltd.

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JR
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Currency exchange rates

Unit: Ethiopian Birr (ETB)

1 JPY = 4.825 ETB (interbank rate as of August 2016)

1 USD = 105.44 JPY (interbank rate as of August 2016)

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Abbreviations

AT	Aerial Triangulation
CAD	Computer Aided Design
CODIST	Committee on Development Information, Science and Technology
DTM	Digital Terrain Model
DEM	Digital Elevation Model
EEPC	Ethiopian Electric Power Corporation
EKI	Ethiopia KAIZEN Institute
EMA	Ethiopian Mapping Agency
ENSDI	Ethiopian National Spatial Data Infrastructure
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSDI	Geospatial Data Infrastructure
GTP	Growth and Transformation Plan
GUI	Graphic User Interface
INSA	Information Security Agency
JCC	Joint Coordinating Committee
NSDI	National Spatial Data Infrastructure
M/M	Minutes of Meeting
OJT	On the Job Training
OSS	Open Source Software
PCM	Project Cycle Management
PDM	Project Design Matrix
RCMRD	Regional Centre for Mapping of Resource Development
TS	Total Station
UNCE-GGIM	UN Committee of Experts on Global Geospatial Information Management
UNECA	United Nations Economic Commission for Africa
USAID	United States Agency for International Development

Chapter 1 Outline of Project

1-1. Background and History of Project

The Growth and Transformation Plan (GTP), a five-year development plan, was launched in Ethiopia in 2010, with a particular focus on agriculture, regional development, industry and infrastructure. Accurate and reliable topographic maps are indispensable for efficient and effective implementation of the projects in each sector and provision of topographic maps to meet demand from related agencies is required.

The Ethiopian Mapping Agency (EMA) in the Ministry of Finance and Economic Development, the organization responsible for creating national maps of Ethiopia, has been engaged in medium-scale topographic mapping of the entire country since the 1970s and has created topographic maps covering 85% of the country. However, 90% of the created maps have been created based on analog technology. Also, when the topographic maps were created, there were no written and organized work specifications or accuracy control standards nor was the quality of the topographic maps controlled, so no accurate and reliable digital topographic maps that reflect the latest data such as are needed by the related agencies have been created or are available.

Against the background described above, due to the heightened need for creation and upgrading of digital topographic maps, technical assistance was requested for (1) the establishment of work specifications for digital topographic mapping, (2) technology transfer in mapping, and (3) promotion of the utilization of digital topographic map data.

In response to this request, JICA dispatched a Detailed Planning Study Team in May 2013 and held discussions with EMA, the implementing organization of the Government of Ethiopia, on topographic mapping of the area around Mojo and Adama in the State of Oromia and the related technology transfer. The Record of Discussions (R/D) was signed on July 29, 2013. Cooperation will be provided for the Project based on the above-mentioned R/D.

1-2. Project Purpose, Objectives and Priority Items

(1) Project Purpose

The overall goal of the Project and the project purpose are as described below.

Overall Goal

To create an accurate and reliable national spatial database to promote sustainable development of the economic and social infrastructure

Project Purpose

(1) To develop 1/10,000 and 1/25,000 digital topographic map data of an area of approximately 1,140km^2 around Mojo and Adama in the Regional State of Oromia

(2) To build the capacity of EMA itself to develop digital topographic maps through technology transfer, to attain a technical level at which it can perform digital topographic mapping independently based on an appropriate organizational framework, and to enable EMA to implement and manage topographic mapping projects

(2) Project Objectives

The objectives of the Project are as follows.

- To create topographic maps on a scale of 1/10,000 and topographic maps on a scale of 1/25,000 by generalization of an area of approximately 1,140km^2 around Mojo and Adama in the State of Oromia
- To enable EMA to appropriately implement and manage topographic mapping projects

(3) Project Priority Items

Based on the background and purpose of the Project, the Study Team will implement the Project with priority given to the following items.

- To create “accurate and reliable” digital topographic map data based on “uniform standards”
- To strengthen “EMA’s organizational structure” based on “improvement of the technical level of EMA staff” to enable EMA to implement and manage topographic mapping projects independently
- To provide assistance for formulation of an organizational structure that enables EMA to implement and manage utilization of geospatial information independently

1-3. Present Status of EMA

(1) Structure of EMA

The present status of EMA is as shown below.

The main departments of EMA related to technical aspects of the Project are the Mapping Directorate, Survey Directorate, GIS & Remote Sensing Directorate, IT Directorate and Quality & Standards Directorate. The Planning and Business Development Directorate is mainly engaged in providing support for the entire EMA organization.

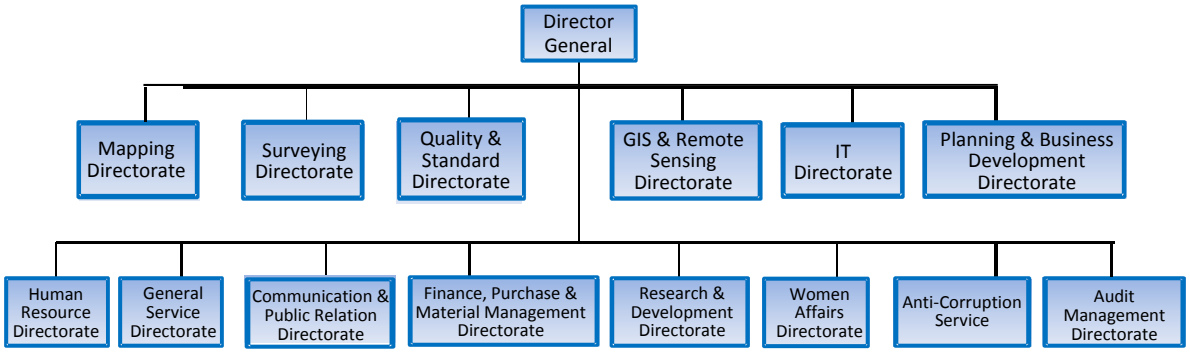


Figure 1 EMA Organization Chart

(2) Status of EMA at the Beginning of the Project

The present status of EMA was summarized to clarify the problems in "achieving a technical level where digital topographic mapping can be performed independently by EMA" and "enabling EMA to implement and manage topographic mapping projects" as stated in the project purpose.

As a result, the means of attaining the goals to be implemented in the Project with the aim of resolving the issues of EMA were decided as follows.

Table 1 Status of EMA and Goals of Each Subject at the Beginning of the Project

Item			Present Status	Goal and Means of Achievement
Equipment	Ground survey equipment	Transit EDM /Total station with accessories	EMA has a lot of equipment, but maintenance is a problem due to the lack of managers.	Attainment of reliable, high-accuracy outputs by provision of the latest GNSS receivers and analysis software for use in photo control point survey
		GPS Receiver with accessories	EMA has 4 Ashtechs and 4 Leicas (including analysis software), but they are outdated and accuracy is low.	
		Level with accessories	EMA has a lot of analog and digital equipment.	
	Photogrammetric equipment		EMA has 3 LPS, but functions and maintenance contents are limited.	Provision of digital photogrammetric system to enable implementation of processes involved in topographic mapping
	Plotting, editing, symbolization and structuralizing equipment		EMA has ArcInfo and CAD, but adequate environment is required.	Provision of the latest equipment and add-ons to enable plotting, editing, symbolization and structuration of topographic data, and provision of the hardware to run the software and improve office environment
	Website		EMA has a website, but web distribution contents and environment maintenance are required.	Creation of a website to enable distribution of topographic maps over the internet
	A0 printing equipment		EMA has analog offset equipment. EMA has 2 HP plotters, but for selling new digital topographic maps, quality and speed are required.	Provision of A0 plotter to enable distribution of high quality topographic maps
Technology	Common		Executives have a fair level of skill, but improvement of workers' level is required.	Creation of manuals and diffusion of technology for improvement of skills at worker level
	Aerial photography planning		EMA has attained a certain level, but work management and accuracy control are required.	Technology transfer in theory and software operation aiming at aerial photography planning using software
	Installation of aerial signals		Operating experience corresponding to the conditions of photo-scale and installation location is required.	Technology transfer in installation of aerial signals according to work specifications to enable work to be performed appropriately under different conditions
	Photo control point selection, survey, data management		EMA has a certain level of observation technology, but skill in photo control point surveys is required. Data management is required for efficient management of acquired data.	Technology transfer focused on photo control point survey by enabling the staff to do planning and accuracy control by themselves
	Aerial triangulation (DEM creation and editing, orthophoto creation)		EMA has a certain level of skill, but work management and accuracy control are required.	Technology transfer to improve work efficiency by raising process management and accuracy control knowledge and skill
	Field identification		Improvement in understanding of work management and quality control from a leadership position and review and organization of the field identification manual are required.	The target is to implement the supplementary field verification with leadership of EMA engineers throughout the whole process as much as possible. Quality and process control will be implemented by progress management and document checking at the time.

Item		Present Status	Goal and Means of Achievement
	Digital plotting Digital editing	Work experience in digital stereo environment is inadequate. Experience in data creation using latest CAD software is required.	Technology transfer classified by stages: theory/basic skills acquisition period, practice period, process control/efficiency improvement period, and pilot period, to achieve level that takes into account process/quality control and work efficiency
	Supplementary field verification	Work quality was inadequate due to the lack of practical experience in working independently.	As work involves arranging for vehicles and accommodation, etc. and expense burden is high, technology transfer in the form of OJT will be implemented focused on work efficiency to improve cost effectiveness when EMA does own work.
	Symbolization	The level of digital technology is low at the initial stage. There is a lack of skills at worker level.	Technology transfer to enable understanding of map symbol rules and creation of symbols and symbolization based on map symbol rules Technology transfer in pilot area
	GIS structuration	Experience in data creation using latest GIS software is required.	Technology transfer to enable structuration of topographic map data and creation of GIS model samples that will serve as utilization tools Technology transfer in pilot area
Management & Operation	Promotion of utilization	Lack of management structure with related agencies inside and outside Ethiopia for utilization of topographic maps. Little need for analog topographic maps and not much of a track record in their sale.	Establishment of JCC and holding of regular meetings, collaboration with projects in Ethiopia and abroad, advertising activities and seminars Study of needs for utilization of topographic maps by considering collaboration with related events as well as strengthening of delivery and sales management systems
		Skill in management of web distribution is required.	Technology transfer in website operation for the improvement of operation skills
	Process control	Need for establishment of management system for costs and schedule	Assistance for formulation of organizational structure for work optimization
	Quality control	EMA has materials containing quality control standards, but needs to increase universal use Need for improvement of quality control process	Consideration of work specifications in discussions Inclusion of quality control in each technology transfer item
	Topographic map management	Analog topographic maps are managed and sold by inventory control, but experience in digital distribution is required.	Assistance for formulation of organizational structure to heighten needs by promotion of utilization and improve distribution system based on needs
Establishment of work specifications		Digital aerial photography standards, 1/10,000 scale standards, 1/25,000 scale standards and topographic map sheet reference system standards have been established, but classification and definition of topography and features are inadequate	Establishment of work specifications based on existing materials for development of highly versatile data and smooth project operation and management
Financial aspect		Trend is toward growth, but percentage accounted for by personnel expenses is considerably high. Significant allocation to policy expenses and equipment purchase/replacement costs is considered difficult.	Assistance for improvement of environment by provision of equipment Assistance for cost and schedule management system, and reduction of burden by improved work efficiency through technology transfer in each field

1-4. Project Target

(1) Target Area for Creation of Topographic Map Data

The target area for creating topographic map data in this Project is the range shown in the map below. It is an area of approximately 1,140km^2 (the country covers an area of approximately 1,130,000km^2) around Mojo and Adama in the State of Oromia.

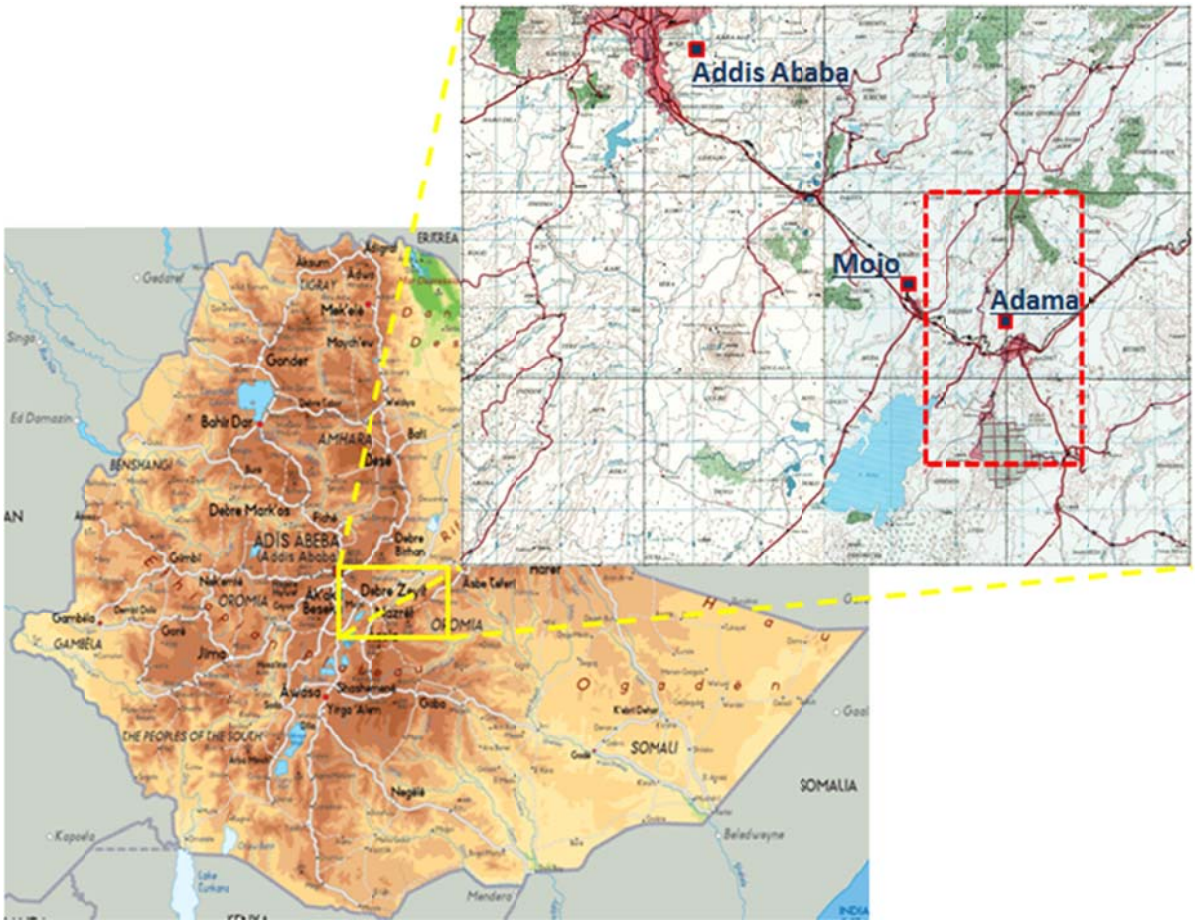


Figure 2 Target Area for Topographic Map Data Creation

(2) Process of Target Area Selection

There has been a plan in the Government of Ethiopia to construct a new highway and railway connecting Addis Ababa (the capital of Ethiopia) and the country of Djibouti.

This project area has been selected from the following conditions: The city of Adama and Mojo is existing belong the construction area; a large scale plantation area along the way has been confirmed; regarding to the 5-year GTP, high potentials of agriculture, rural development and infrastructure development can be found.

(3) Target of Technology Transfer

The figure below shows a simplified general workflow from creation to utilization of geospatial information. In view of the present status and problems of EMA described above, all the work except aerial photography is included in the technology transfer in this Project, taking into account the workflow of the entire project for topographic mapping.

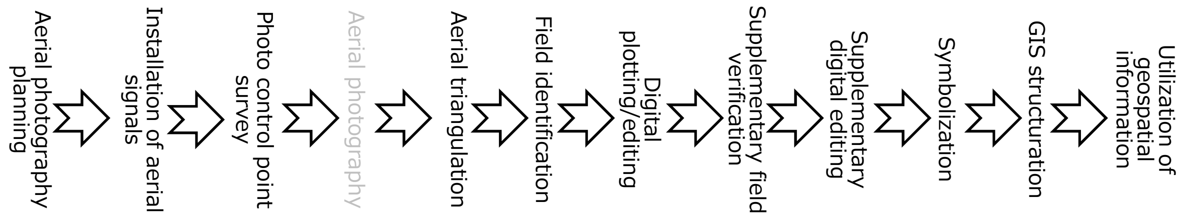


Figure 3 General Workflow Related to Geospatial Information

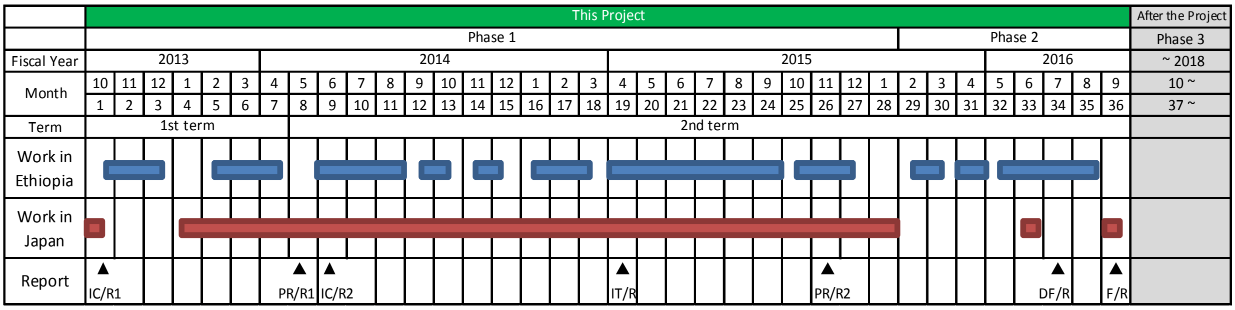
1-5. Entire Schedule, Contents, Technology Transfer and Outputs of Project

The entire process, outline and amount of each work together with the outputs of the Project are shown below.

(1) Entire Schedule

The entire cooperation period is approximately five years from October 2013 to 2018, divided into three phases. The first term of the Project ends in May 2014 during Phase 1 and the second term starts in the following June.

Table 2 Entire Schedule



(2) Contents of Project Implementation

Table 3 Contents of Work to be Implemented

Term	Implementation item	Qty.	Remarks
1st	Creation of work specifications	1 set	Work specifications, map symbol rules, quality/accuracy control manual, specifications of digital topographic map data
	Verification, preparation of images, etc.	1 set	Aerial triangulation, verification of orthophoto accuracy
	Field identification	1,140km^2	1/10,000 54 map sheets
	Website creation	1 set	Existing website survey
	Assistance for implementation of organizational capacity building	1 set	EMA organization management survey
	Promotion of utilization	1 each	Opening seminar, 1st JCC meeting
2nd	Digital plotting/editing	1,140km^2	1/10,000 54 map sheets
	Generalization	1,140km^2	1/25,000 6 map sheets
	Symbolization (1/10,000)	1,140km^2	54 map sheets
	Symbolization (1/25,000)	1,140km^2	6 map sheets
	Digital data structuration (1/10,000)	1,140km^2	54 map sheets
	Digital data structuration (1/25,000)	1,140km^2	6 map sheets
	Creation of data files	60 files	1/10,000 (54 map sheets), 1/25,000 (6 map sheets)
	Website creation	1 set	
	Assistance for formulation of organizational structure & utilization of geospatial information	1 set	

(3) Technology Transfer

Table 4 Technology Transfer Items and Quantities

Phase 1

Item	Work Content	Outline of Technology Transfer	Implemented Quantity
Aerial photography planning/Installation of aerial signals	Creation of photography plan	Formulation of photography plans according to photo-scale	5 practice areas
	Field reconnaissance point selection	Field reconnaissance to select installation points for aerial signals and installation of aerial signals	4 practice points
	Installation of aerial signals		
	Accuracy control	Accuracy control of photography plan and aerial signals	1 set
Photo control point survey	GPS survey	Calculation of coordinate values by measuring installed aerial signals using GNSS equipment and analysis of results	4 practice points
	GPS analysis		
	Leveling	Theoretical accuracy training	1 set
	Accuracy control	Accuracy control of photo control point survey	1 set
Aerial triangulation orthophotos/DTM	Aerial triangulation by aerial photo images	Understanding of theory of aerial triangulation and implementation of actual observation and adjustment calculation	2 blocks on scale of around 5 photo control points
	DTM creation/editing	Understanding of theory of DTM creation and ortho-creation and implementation of DTM creation and editing and orthoimage creation	Two 1/10,000 sheets
	Creation of orthoimages		

Item	Work Content	Outline of Technology Transfer	Implemented Quantity
Field identification/Supplementary field verification	Pre-interpretation	Understanding of map symbols, acquisition items and acquisition standards Pre-interpretation of target items of field identification	OJT for EMA technical staff (8 teams/16 persons) over 1,140km^2
	Field identification	Field identification and gathering of required feature information	
	Supplementary field verification	Supplementary field verification at doubtful points by plotting and editing processes, and identification and verification in the field	
	Compilation of results	Compilation of identification and supplementary verification results and creation of materials	
Digital plotting	Digital plotting using aerial photo images	Understanding of map symbols, acquisition items and acquisition standards Acquisition of position information of features by digital plotter Decipherment of feature type by digital plotter	15 1/10,000 map sheets
	Accuracy control	Accuracy control of plotting results	1 set
Digital editing/ Supplementary digital editing/Generalization	Digital editing	Understanding of operation of CAD software Addition of field identification and supplementary field verification results to plotting data and correction Understanding of data error detection and correction techniques	Two 1/10,000 map sheets
	Supplementary digital editing		
	Generalization	Generalization according to procedures	One 1/25,000 map sheet
	Accuracy control	Accuracy control of editing results	1 set
Symbolization	Allocation of symbols to topographic map data	Understanding of theory of mapping and map symbols Symbolization according to procedures	Two 1/10,000 map sheets One 1/25,000 map sheet
GIS structuration/ Website creation	Creation of GIS database	Understanding of conversion technique from CAD to GIS format and implementation of data conversion Understanding of GIS software operation Creation of number of GIS models	Two 1/10,000 map sheets One 1/25,000 map sheet
	Website operation and maintenance	Understanding of skills required for website operation and maintenance	To be negotiated with EMA
Promotion of utilization	Grasping of need for use of topographic maps	Establishment and running of JCC and liaison with related agencies	JCC: 5 times Individual interview: as appropriate
Technology transfer to enable EMA to implement topographic map creation projects by itself	Accuracy control by process Creation of accuracy control table	Implementation independently by EMA of process control, quality control and manual creation for each process	1 set per technology transfer

Phase 2

Item	Work Content	Outline of Technology Transfer	Implemented Quantity
Creation of project management manual	Creation of manual	Creation of manual from project planning to implementation and evaluation	1 set
	Updating of manual	Update of manual by EMA itself as required	
Process control	Basics of process control	Understanding of importance of process control and creation of appropriate project process sheet	1 set
	Process control	Process control based on created process sheet	
Quality control	Basics of quality control	Understanding of importance of quality control, quality standards, content and approach to quality control	1 set
	Process control	Quality control in each process	
	Product management	Quality control of products	
Strengthening of topographic map management system	Formulation of management plan	Establishment of manager, management method and operational procedures for management of map sheets and data	1 set
	Topographic map management	Topographic map management by EMA itself according to management plan	
Strengthening of topographic map sales structure	Formulation of sales plan	Establishment of prices of topographic maps, sales manager, sales outlet and terms of use	1 set
	Sale of topographic maps	Sale of topographic maps by EMA itself according to sales plan	
Website creation	Operation of website	Understanding of website operating procedures Understanding of public data update method Website operation by EMA itself	1 set
Promotion of utilization	Holding of seminars	Planning and holding of seminars on initiative of EMA	1 set

(4) Products

Table 5 Outputs etc.

Item			Quantity	Remarks
Study report	Inception Report 1		Japanese 5 copies English 15 copies	First term 10 English copies to EMA 5 Japanese copies and 5 English copies to JICA
	Progress Report 1		Japanese 5 copies English 15 copies	First term 10 English copies to EMA 5 Japanese copies and 5 English copies to JICA
	Inception Report 2		Japanese 5 copies English 15 copies	Second term 10 English copies to EMA 5 Japanese copies and 5 English copies to JICA
	Interim Report		Japanese 5 copies English 15 copies	Second term 10 English copies to EMA 5 Japanese copies and 5 English copies to JICA
	Progress Report 2		Japanese 5 copies English 15 copies	Second term 10 English copies to EMA 5 Japanese copies and 5 English copies to JICA
	Draft Final Report			Second term
		Main Report	English 15 copies	10 English copies to EMA 5 Japanese (Summary) copies and 5 English copies to JICA
		Summary	English 15 copies	
		Summary in Japanese	Japanese 5 copies	
	Final Report			Second term
		Main Report	Japanese 5 copies English 15 copies	10 English copies to EMA 5 Japanese copies and 5 English copies to JICA
		Summary	Japanese 10 copies English 15 copies	10 English copies to EMA 10 Japanese (Summary) copies and 5 English copies to JICA
		Quality Control Report		
Outputs	Field Survey Results		1 set	1 set to EMA
	Digital Data Files			
		1/10,000 and 1/25,000 topographic map data	2 sets	1 set to EMA, 1 set to JICA
		1/10,000 and 1/25,000 GIS base data	2 sets	1 set to EMA, 1 set to JICA
		1/10,000 and 1/25,000 topographic map data, PDF format	3 sets	1 set to EMA, 2 sets to JICA
		Orthophotos	2 sets	1 set to EMA, 1 set to JICA
		Final Report	1 set	
	Quality Control Report		2 sets	1 set to EMA, 1 set to JICA
	Booklet			
		A3 size	33 sets	33 sets to related agencies
		Original size	6 sets	5 sets to EMA, 1 set to JICA
	Work Manual		1 set	1 set to EMA
	Others			
		Acquisition inventory (survey equipment, etc.)	1 set	
Work report			1 set	Monthly (Submitted to JICA by 10th of following month)
Collected materials				List sorted by category is attached
PR materials			200 digital copies in English	150 copies to EMA, 50 copies to JICA
Digital files			1 CD-R	About 20 digital images (in JPEG format) and record table
Others		M/M, etc.		
		Documents for/from the Government of Ethiopia		

Chapter 2 Evaluation and Recommendation of the Study

2-1. Verification of the Achievement

(1) Input

The contents of the input from the Japanese side to the project, *i.e.* the dispatch of experts, training in Japan and provision of equipment (including that for topographic mapping), were appropriate and the input was utilized effectively in the project.

(2) Output

1) A work manual on digital topographic mapping has been created.
2) Digital topographic maps (of an area of 1,140km^2 at the scales of 1/10,000 and 1/25,000) have been created in Japan.
3) EMA has become able to plan, implement and manage digital topographic mapping and conduct trouble-shooting in it independently.
4) The digital topographic maps created in the project have been made available to the public and a system required for the provision of the maps to users has been established.
5) Technologies for digital topographic mapping have been accumulated and an organizational structure and a responsibility-sharing system required for implementing mapping projects systematically have been established in EMA.

Almost all the outputs have been achieved. It has been decided that the outputs of this project shall be made available to the public on the Geoportal of EMA free of charge.

The engineers who participated in the technology transfer in this project have become able to create 1/10,000 and 1/25,000 topographic maps at a steady pace. The technologies for the work scheduling and schedule management have been transferred to them in the project. Therefore, they are expected to be able to implement projects similar to this one in future in accordance with a pre-determined work schedule. In addition, because the training on the quality control in each stage in the mapping was provided to the staff members in the Quality and Standard Directorate of EMA as part of the technology transfer, systems responsible for both schedule management and quality control are considered to have been established.

(3) Progress in the Achievement of the Project Purposes

< Project Purpose >

1) To develop 1/10,000 and 1/25,000 digital topographic map data of an area of approximately 1,140km2 around Mojo and Adama in the Regional State of Oromia
2) To build the capacity of EMA itself to develop digital topographic maps through technology

transfer, to attain a technical level at which it can perform digital topographic mapping independently based on an appropriate organizational framework, and to enable EMA to implement and manage topographic mapping projects

During the project period, 54 sheets of 1/10,000 digital topographic maps (of an area of 1,140km^2) were created and six sheets of 1/25,000 digital topographic maps (of the same area) were created with the generalization of these 1/10,000 topographic maps.

The engineers who participated in the technology transfer have improved their technical capacity to the level at which they can at least create quality-controlled 1/10,000 and 1/25,000 topographic maps by themselves. They have become able to implement and manage topographic mapping projects of EMA through the experience in preparing the "Work Manual," "Product Specifications" and "Accuracy Control Manual" and compiling them into the "Project Management Manual."

Table 6 Outcome of the Technology Transfer in Relation to the Project Purposes

Item	Outcome
Aerial photography planning/Installation of aerial signals	Became able to formulate photography plans in according to the photography scale by using the software developed in this study.
	Became able to perform point selection according to the photography conditions and at clear locations on the aerial photograph. Became able to install aerial signals based on the work specifications.
Photo control point survey	Became able to use procured equipment (GPS receiver, analysis software) in practical work.
Aerial triangulation/ Orthophotos/DTM	Understood the theories of aerial triangulation and DTM. Understood the operation of digital photogrammetry system.
Field identification/ Supplementary field verification	Understood the operation of the equipment used. Understood the theory of field identification and became able to collect information which is difficult from photo interpretation.
Digital plotting	Understood map specifications, acquisition standards and acquisition procedures. Understood 3D interpretation. Reached the level capable of plotting on a scale of 1/10,000 and 1/25,000 by themselves and application to other scales may be expected.
Digital editing/ Supplementary digital editing/Generalization	Understood the operation of CAD software. Understood the methods of detecting and correcting errors in data and creating polygons.
Symbolization	Understood the theory of mapping. Understood map symbols and 1/10,000 and 1/25,000 map symbolization.
GIS structuration	Understood the conversion technique from CAD to GIS format. Understood the operation of GIS software.
Website creation	Understood the website operation technology.

Table 7 Outcome of the Assistance for the Formulation of Organizational Structures for the Achievement of the Project Purposes

Target	Item	Outcome
Accurate and reliable map creation by EMA	Creation of work specifications	Work specifications were created.
	Acquisition of Basic Technology	All the operators who participated in the technology transfer acquired basic skills.
Accurate and reliable map creation by EMA Development of data creation/update structure	Creation of wide use manuals	Wide use manuals were created and utilized also in the technology transfer.
	Implementation of pilot area operations	Operators who participated in the technology transfer reached the level capable of implementing the operations by themselves.
	Efficient work implementation	Joint operations across the directorates within EMA (“Planning and Business Development Directorate”, “Surveying Directorate”, “Mapping Directorate”, “GIS & Remote Sensing Directorate”, “IT Directorate”, “Quality & Standards Directorate”) were carried out through the technology transfers and creation of “Adama Tourist Map”, which clarified the roles and schemes of each directorate.
	Implementation of process control	Performance of different levels of operators was understood through the technology transfer, which laid the foundation for independent process planning by EMA.
	Implementation of quality control	EMA became able to perform quality control in accordance with the quality control manual and accuracy control table by themselves based on an understanding of quality control method.
	Development of sustainable management and operation structure of topographic map creation work	Utilization of the servers and viewers procured in this study laid the foundation for independent and sustainable management of topographic maps by EMA.
Development of easy to use environment for digital topographic maps	Information exchange and coordination with related organizations centered on EMA	Through the seminar and JCC, importance of national geographic information management was shared and the roles of stakeholders and each party were clarified.
		Direction of the analysis and utilization of the outputs of this study were shared, while the needs of potential users were grasped.
		International presence of EMA and the geographical information managed by EMA was enhanced as the presentation by EMA at an international conference was supported by the Study Team.
		At the meeting with “Djibouti City GIS Committee”, relationship for sharing information on GIS promotion was established.
	Specific proposals for utilization	With respect to the creation of “Adama Tourist Map” utilizing the output of this study, the Study Team supported EMA and obtained an outcome during the study period.
	Development, management and operation of provision method	This study led to the creation of data that can be uploaded to and downloaded from the existing geoportal and laid the foundation for independent and sustainable sale of topographic maps by EMA.

2-2. Result of the Evaluation

(1) Relevance

The project is considered to be highly relevant because of the reasons mentioned below.

The project was formulated in accordance with the “Country Assistance Policy” for Ethiopia, which stipulated the direction of Japan’s assistance to Ethiopia.

Meanwhile, “agriculture development” and “infrastructure” development, which were expected to be the main areas of utilization of the outputs of this project, continued to be priority areas in the “Second Growth and Transformation Plan (2015/16 – 2019/20)” (draft as of September 2015). In addition, geospatial information is essential for the improvement of the “tax administration” and “land

administration," which are mentioned in the draft plan as issues to be addressed. For these reasons, this project is considered to be consistent with the policy of the Government of Ethiopia.

As the Government of Ethiopia announced that the Information Security Agency (INSA) should develop National Spatial Data Infrastructure during the project period, EMA and INSA will have to coordinate in the creation and management of geospatial data.

(2) Effectiveness

This project is considered to have been highly effective for the following reason.

As mentioned in "2-1 Verification of Achievement, (3) Progress in the Achievement of the Project Purposes" above, the project purposes have been achieved with the achievement of the project outputs.

(3) Efficiency

This project is considered to have been highly efficient for the following reasons.

The quantity, quality and timing of the inputs in this project were appropriate. The project has managed to produce more outputs than planned in the assistance to the establishment of an organizational structure for the topographic mapping in the scales other than 1/10,000 or 1/25,000, the assistance in the creation of tourism maps of the project area as a way to utilize the topographic maps created in this project and the preparation of a recommendation on a viewer for the management and browsing of the data owned by EMA.

(4) Impact

No negative impact of this project has been observed so far. The three positive impacts mentioned below have emerged.

1) The equipment for the photo control point survey that has already been provided to EMA in response to a strong request of EMA is being utilized in the work of EMA.
2) EMA received an order for work including aerial triangulation, creation and editing of DEMs and orthophoto creation during this project period. EMA is implementing the work using the technologies learned and equipment provided in this study.
3) EMA began its own project of creating 1/10,000 topographic maps of the area around the study area of this project in order to increase the area coverage of 1/10,000 topographic maps while this project was in progress.

(5) Sustainability

With regard to the sustainability of the technical capacity, EMA is fully utilizing the technologies and equipment provided in this project in a project for photogrammetry and topographic mapping ordered by the Government of Ethiopia during the project period. In addition, EMA is expected to continue utilizing the technologies and equipment in the similar projects.

Greater impact on the organizational sustainability of this project is expected from disseminating the outputs transferred to EMA in this project within EMA, particularly for the training of inexperienced young staff members.

Free provision of the outputs of this project on the Geoportal is expected to lead to continuous utilization of the topographic map data, which is expected to contribute to the sustenance of the data utilization system.

2-3. Conclusion

The results of the evaluation of the implementing processes of this project and the evaluation of the project on the five DAC criteria suggest that the project purposes were achieved within the project period.

2-4. Recommendation

Recommendations on the requirements for sustaining and extending the project outcome after the completion of the project for the achievement of the overall goal, “to create an accurate and reliable national spatial database to promote sustainable development of the economic and social infrastructure” are described in the following.

(1) Requirements for the sustenance and extension of the project outcome

It is considered necessary to provide the support as described in the following table in order for EMA to continuously create, update and manage geographical information data for accurate and reliable national spatial database and for such database to be utilized for “sustainable development of the economic and social infrastructure”.

Table 8 Technical Support Required by EMA in the Future

Item	Theme	Contribution to overall goal
Strengthening of photogrammetry technology	• Development of structure suitable for large-scale operations (aerial triangulation, DEM creation and editing, orthoimage creation)	Establishment of this scheme will facilitate the creation of highly accurate and high-resolution ortho images that can be utilized for cadaster and city planning.
Strengthening of topographic map creation technology	• Extension of technology to inexperienced engineers within EMA (digital plotting, digital editing, symbolization)	By improving the EMA's productivity in the creation of topographic maps, establishment of a structure enabling the creation of geographical information of the necessary regions and at the necessary level of accuracy at an adequate cost and within an appropriate time period can be expected.
Strengthening of GIS technology of EMA and user organizations	• Development of GIS engineers capable of training users (GIS data creation and analysis, application to practical work)	Improvement of the technology for utilization of national spatial database of users and stakeholders involved in the economic and social infrastructure can be expected.
Strengthening of leveling technology	• Technology transfer in determining elevation for utilization of continuously operating reference stations (Support to planning of leveling)	Accuracy and reliability of the national spatial database in the aspect of "height" will be enhanced.
Establishment of structure for the management and operation of geospatial information	• Formulation of topographic map update plans • Strengthening of the data sharing system/promotion of data sharing • Elimination of the duplication in aerial photography, survey and topographic mapping • Training and permanent employment of human resources	Provision of the latest and easy-to-use digital data is made possible by equipping EMA with operating capacity and organizational structure required for the efficient and sustainable creation of geospatial data and by enabling the information sharing between EMA and other survey/planning organizations.

(2) Recommendations for Phase 3

In view of the results of this study, it was decided that specific initiatives should be strengthened in Phase 3 with respect to the following items.

1) Strengthening of photogrammetry technology

EMA has been receiving a growing number of requests for the creation of large-scale high-accuracy geospatial information from relevant agencies and it is considered that this work will continue to exist for a certain period to come. Accordingly, it is necessary to set up a production system to handle such requests. However, EMA does not have adequate skilled manpower and technology for large-scale high-accuracy photogrammetry.

As such, technology transfer should be implemented for the purpose of improving the creation technology and establishing the production system. Necessary equipment should be procured at the same time.

Major contents of the technology transfer are as follows.

Table 9 Support Assumed to be Necessary for the Strengthening of Photogrammetry Technology

Item	Matters requiring focus	Contents	Input (proposed)
Aerial triangulation	Work planning, progress control	Accurate planning based on adequate inspection of 4,000 to 5,000 images and understanding of the degree of difficulty in performing the work	<Japanese side> Expert (1 person) DEM editing software (2 sets) <Ethiopian side> Engineers (4 – 8 persons)
	Improvement of work efficiency	Improvement of efficiency in designing "description of control point" and photo control point observation Automatic setting of tie point observation parameters in accordance with the topography and image quality Establishment of adjustment calculation method by combining different software	
	Quality control	Improvement of efficiency in error detection and correction by combining different software Strengthening of troubleshooting capability	
DEM creation and editing	Work planning, progress control	Clarification of work method to avoid over specifications and standardization of quality among operators	
	Improvement of work efficiency	Division of work area in accordance with the processing capabilities of PC and software as well as topography	
	Quality control	Effective combination of editing tools Division of work taking advantage of the characteristics of different DEM editing software	
Orthophoto creation	Work planning, progress control	Development of a system to avoid work bottlenecks	
	Improvement of work efficiency	Understanding of appropriate mosaic line acquisition method Removal of cloud and haze	
	Quality control	Development of the line and feedback system from ortho inspection to DEM modification	

2) Strengthening of topographic map creation technology

The staff who attended the technology transfer by the Study Team should act as the instructors for technology transfer to the EMA staff to achieve the widespread use of the technology. Support should be provided for the implementation of this technology transfer. Specific details are as follows.

Table 10 Support Assumed to be Necessary for the Strengthening of Map Creation Technology

Item	Matters requiring focus	Contents	Input (proposed)
Digital plotting	Training of beginner-class engineers by skilled engineers of EMA	Development of digital plotting operators through practice in the areas with existing aerial photographs of which 1/10,000 maps have not been created	<Japanese side> Expert (1 person) <Ethiopian side> EMA instructors (5 – 7 persons) Engineers (10 – 15 persons)
	Acquisition of plotting technology for different scales	Plotting of Addis Ababa 1/5,000 topographic map data	
Digital editing	Training of beginner-class engineers by skilled engineers of EMA	Development of digital editing operators through practice in the areas with existing aerial photographs of which 1/10,000 maps have not been created	
	Acquisition of editing technology for different scales	Editing of Addis Ababa 1/5,000 topographic map data	
	Acquisition of generalization technology for different scales	Generalization from 1/10,000 to 1/25,000 and to 1/50,000	
Symbolization	Training of beginner-class engineers by skilled engineers of EMA	Development of symbolization operators through practice in the areas with existing aerial photographs of which 1/10,000 maps have not been created	
	Acquisition of symbolization technology for different scales	Symbolization of Addis Ababa 1/5,000 topographic map data Creation of 1/5,000 and 1/50,000 symbol catalogs	
	Conversion of symbols to other formats	Conversion from MicroStation (dgn) to ArcGIS (emf)	

3) Strengthening of GIS technology of EMA and user organizations

Utilization of GIS is essential in promoting the use of topographic map data in different governmental organizations. However, engineers and technological level in this field are inadequate. As such, as the first step, technology transfer to the EMA engineers should be implemented. As the second step, the staff who received the training should carry out technology transfer to other organizations.

Table 11 Support Assumed to be Necessary for the Strengthening of GIS Technology

Item	Matters requiring focus	Content	Input (proposed)
GIS technology	Development of EMA instructors	• Creation of instructor development plan • Creation of training curriculum and text • Practical training, practice	<Japanese side> Expert (1 person) <Ethiopian side> EMA instructors (5 persons) User organization engineers (about 10 persons)
	Expansion of GIS users	• Introduction and promotion of the use of GIS to other organizations and technical training • Holding of GIS seminar • Consulting with users (needs survey, joint operation)	

4) Strengthening of leveling technology

Currently, elevation data (benchmarks) in Ethiopia are significantly insufficient for the area of the country (approximately 1.13 million km^2). The placement of benchmarks is skewed and the benchmarks are not evenly distributed. As such, sufficient accuracy cannot be ensured in aerial photography because of the lack of control points for elevation necessary for aerial triangulation. Also, it is impossible to assign elevation to continuously operating reference stations (CORS). Therefore, technology transfer in leveling should first be implemented. At the same time, necessary equipment should be procured.

Table 12 Support Assumed to be Necessary for the Strengthening of Leveling Technology (Draft)

Item	Matters requiring focus	Contents	Input (proposed)
Leveling	Leveling theory and observation technology	Development of managerial-level human resources with respect to the purpose and theory of "leveling", specifications and management method of equipment and installation and observation methods	<Japanese side> Expert (1 person) Zero order Leveling equipment (2 sets) Car hire (4WD: 3 vehicles) Local workers (2 teams of 4 workers) <Ethiopian side> Managers (2 persons) Engineers (5 – 10 persons)
	Leveling planning	Laying the foundation for planning to cater for large-scale operations	
	Quality control	Implementation of error summation practice using spreadsheet software and accuracy control practice in accordance with the "accuracy control and accuracy control table creation manual"	
	Observation practice	Implementation of practice in the leveling between the existing benchmarks and the zero-order control points in the suburbs of Addis Ababa	

5) Strengthening of geospatial information management and operation

Recommendation for the establishment of structure for development of geospatial information in Ethiopia

Table 13 Support Assumed to be Necessary for the Strengthening of Geospatial Information Management and Operation

Item	Matters requiring focus	Contents	Input (proposed)
Strengthening of geospatial information management and operation	Formulation of a topographic map update plan	Decision on a policy on the formulation of a medium- to long-term plan on topographic mapping to be required in Ethiopia in future (a work schedule, personnel assignment planning and budget planning for them appropriate for the productivity of EMA to be included in the medium- to long-term plan) Example: Topographic mapping of areas in which national projects (for the construction of dams, airports, roads and railways) are to be implemented	<Japanese side> Experts (2 persons) <Ethiopian side> EMA managers (10 persons)
	Strengthening of the data sharing system/ promotion of data sharing	Assistance in drafting a geospatial information policy	
		EMASDI (discussion on and documentation of the categorization of the data owned by EMA and disclosure/non-disclosure of data and the rules on data disclosure)	
		Assistance in the web and Geoportal operation	
		Development of a scheme in which an organization that has conducted a survey shares the survey results with EMA	
		A study on a scheme for a regular information sharing for data sharing, update and distribution among the major organizations (submission of survey plans and results and update and distribution of geospatial information)	
	Elimination of the duplication in aerial photography, survey and topographic mapping	Recommendations on the creation of a survey plan form and a scheme in which surveying organizations share their survey plans with EMA	
		Presentation of the actual outputs of aerial photography, surveys and topographic mapping	
	Training and permanent employment of human resources	Creation of a guideline on the career path for the staff members	
		A study on the introduction of a qualification system (making reference to the qualification systems in neighboring countries)	
		Strengthening of the training center of EMA	

Chapter 3 Works in the First Term

[1] Collection, Sorting and Analysis of Related Information and Materials《Work in Japan》

The Terms of Reference, Detailed Planning Study Report and materials collected in Ethiopia have been sorted and analyzed.

[2] Preparation of Inception Report 1《Work in Japan》

The policies for implementation of the Project, work schedule, implementation system and technology transfer plan have been compiled to prepare Inception Report 1. The contents are shown below:

- Survey target area
- Setting of survey work amount and issues, items and quantities of the products of the Project
- Basic policy of works
- Technology transfer plan
- Work schedule
- Table of man-months required for the survey

[3] Explanation and Discussion of Inception Report 1《Work in Ethiopia》

Explanation

The Inception Report was explained to EMA directorates at a management meeting. During the explanation, emphasis was placed on the schedule, the relevant departments for each work item, strengthening of the organization, etc.

Discussion

The work policy and content of the surveys, etc. described in Inception Report 1 were explained to EMA. The survey implementation system based on the implementation policy was discussed with EMA, and minutes of the meeting were prepared and agreed by both parties.

[4] Discussions on Specifications《Work in Ethiopia》

Discussions Regarding Surveying Standards

Regarding the surveying standards, the Study Team proposed the following standards taking into consideration facilitation of data sharing with domestic and foreign organizations, aid agencies, etc., and after discussion with EMA, the standards were agreed by the two parties.

Table 14 Surveying Standards

Item	Standard
Reference ellipsoid	Clarke 1880 mod a=6378249.1453 f=1/293.4663
Projection method	UTM (Universal Transverse Mercator) Zone 37
Coordinate system	Adindan
Central meridian line	Longitude east 39°
Correction factor	0.9996 (on central meridian line)
Origin of coordinates	Intersection of central meridian line and equator E=500,000.000m N=0.000m
Annotation	The following annotation will be displayed in the data files. This digital map was prepared jointly by the Japan International Cooperation Agency (JICA) under the Japanese Government Technical Cooperation Program and the Ethiopian Mapping Agency (EMA) of the Government of the Federal Democratic Republic of Ethiopia.

Discussion Regarding Topographic Map Symbol Regulations (1/10,000, 1/25,000 Topographic Maps)

In the first term survey, the Study Team held discussions mainly with the EMA Quality and Standard Directorate while referring to the relevant regulations of EMA, and prepared draft topographic map symbol regulations (map scale level 10,000 and 25,000).

[5] Collection and Sorting of Existing Materials《Work in Ethiopia》

Existing data that will serve as basic information or that can be utilized in the Project, such as topographic maps and future plans, etc. owned by related Ethiopian agencies or EMA were obtained through individual interviews with EMA staff related to the various works in this Project and EMA management meetings, seminars and JCCs, and the data were organized.

[6] Preparation of Work Specifications on Digital Topographic Mapping《Work in Ethiopia》

The Study Team held a discussion on the preparation of the work specifications with EMA. The table below shows the details of the discussion. The team described the outcome of the discussion in the work specifications.

Table 15 Discussion on the Work Specifications

Item	Contents of the Survey and Discussion
Preparation method	Existing work specifications of EMA Work specifications required by EMA and the contents to be included Procedures for the preparation of work specifications
Quality control	Quality control in the topographic mapping practiced by EMA Presentation of the quality control methods used in actual mapping known to the Study Team Explanation of actual use of the quality control methods presented above Explanation of the concept and implementation of the quality evaluation provided in the ISO geographic information standards
Accuracy control at each process	Practical method for accuracy control of the outputs of plotting and editing Explanation of the accuracy control table and preparation of the accuracy control table (draft) for 1/10,000 topographic maps
Product specifications	Explanation of the outline of the concept, composition and contents of the product specifications Explanation of the quality evaluation (including the concepts of the five data quality elements and 15 data quality sub-elements) Explanation of the procedures for quality evaluation in accordance with the map symbol regulations for 1/10,000 digital topographic maps and a trial partial data quality evaluation using the product specifications

[7] Verification and Preparation of Images and Other Information《Works in Ethiopia/ Japan》

Verification was made whether the aerial photographs owned by EMA (taken in May 2011) and the outputs of the aerial triangulation (conducted in May 2011) were accurate enough to satisfy the required specifications of the Project by inputting them in a digital photogrammetric system in Japan. Although some problems were found regarding a ground control point, it was concluded that the outputs of the aerial triangulation were accurate enough for their use in the subsequent processes including plotting.

[8] Field Identification and Supplementary Field Verification《Work in Ethiopia》

1) Field Identification

The actual work was conducted by 18 engineers from the EMA organization under the instruction of members of the Study Team as a part of the technology transfer (in the form of OJT), with field identification maps sampled from the orthophotos owned by EMA.

Purposes

The purposes of the field identification were to verify features/buildings, changes in the features over the years, annotations, etc., which are difficult to interpret on photographs in the subsequent plotting stage, in the field and to collect document-based data such as power transmission lines and administrative boundaries.

Table 16 Method of the Field Identification

Work items	Actual work
Preparation of Field Identification Map Sheets	The team created an orthophoto image on a scale equivalent to 1/10,000 of each map sheet area in the plotting area and one for the additional area around Mojo mentioned above, using the aerial photographs and orthophotos owned by EMA, and prepared field identification map sheets using the orthoimages.
Preparation of Map Symbol Rules for the Field Identification	Prior to the field identification, map symbol rules for the field identification were prepared based on the (draft) map symbol rules prepared in the Discussion on Specifications with EMA. The preparation was conducted in Japan, by the engineers in charge of the field identification who verified the identification items and unidentified locations.
Composition of the Field Identification Teams	Ten field identification teams, each with two members, were formed from a total of 20 engineers (two from the Study Team and 18 from EMA). As the entire area had to be studied within a limited Project period, the study area was divided into ten small areas, each including urban and suburban areas, and each team conducted the field identification in one of those small areas.
Explanation of the Outline of the Work	Guidance was given on the details and method of the field identification to the engineers who were to participate in the work using the Field Identification Manual. The details of the map symbol rules prepared in the Discussion on Specifications were clarified and the items to be identified in the field identification and those to be identified with reference materials were specified.
Pre-interpretation	Prior to the field identification, pre-interpretation was carried out using the existing topographic maps in the office. Each team identified the locations and data on mountains, rivers, roads, railway lines and names of places in its study area in advance using the existing 1/50,000 topographic maps.
Trial work	Acquisition of outputs of a standardized quality requires implementation of the identification work by all the engineers based on the same understanding. Therefore, trial work was conducted in two different environments, semi-urban and suburban areas, for standardization of the understanding of the identification work.

Work items	Actual work
Identification of Topography and Features	Topography and features, the targets of the identification, were identified in the field. All the topography and features excluding those which the operators could interpret in the photo-interpretation and plotting, as classified in the map symbol rules, were identified in the field.
	Digital cameras with GPS and/or handheld GPS devices were used for verification of unidentified locations and positioning in the field identification.
	Findings in the identification were recorded on the field identification maps at any time with the description of the corresponding feature codes specified in the map symbol rules on the sheets.
	The field identification teams held weekly meetings to monitor the progress of the work, verify unidentified locations and exchange information between the teams for work process control and quality control.
Study on annotations	The study of annotations was conducted for identification of names of buildings which could serve as landmarks. The topography and annotations of place names shown on the existing topographic maps were also reconfirmed in the field identification. The position of the annotation data obtained in the field identification and from the existing topographic maps and other reference materials were clearly marked on the field identification maps and the annotation data were sorted on the Annotation Table forms used by EMA. The annotation data sorted on the forms in the local language were translated into English and the data in English were digitized with the use of PCs. The digitized annotation data were inspected again by all the members of the field identification team for errors and omissions in data entry.
Compilation of the Outputs of the Field Work	After the completion of the field identification, office work was conducted in order to organize the annotation list and inspect the data for consistencies between different map extents and omissions in the identification. Since inconsistencies in the matching and omissions in the identification had been detected at several locations, the team conducted supplementary identification to complete the field identification.
Outputs of the Field Identification	In order to reduce the complication in handling of outputs, the field identification outputs were compiled in the identification maps and annotation data. These data and the other relevant reference materials were digitized for convenience of use in the subsequent stages.

2) Supplementary Field Verification

An overview of the supplementary field verification in 1,155km^2 including the area around Adama City and the entire urban area of Mojo City is given below.

Purposes

The supplementary field verification was aimed at re-verifying, adding and correcting the locations, details and codes of all the topography, features and annotations represented on the editing manuscripts with a focus on the unidentified topography, features, etc. including ambiguous features at 1,138 locations. Field verification was also conducted in areas where changes over the years in topography and features were observed. The work procedures used in the supplementary field verification were as follows:

- To prepare supplementary field verification sheets from the topographic map data created in the digital editing

- To bring the printed supplementary field verification sheets and handheld GPS receivers to the field and verify the locations where data ambiguity and questionable annotations were detected in the digital plotting and digital editing
- To compile what was verified in the field on the printed topographic maps for data correction in the subsequent supplementary digital editing

[9] Website Creation《Work in Ethiopia / Japan》

A system in which the existing data and newly created data will be disclosed to allow anyone to easily access the geospatial information will be built by the use of the Web Mapping System that will be newly developed in this Project.

Reports of study in the 1st term

The following is a summary of the existing website survey results, explanation of the web system required for this Project (software, hardware), and details of the technology transfer.

Table 17 Existing Website Survey Results

Item	Result
Operation	Operation has been outsourced to Peer 1 Network Enterprises Limited of UK, but at present the contract has been cancelled.
Server hardware and software owned by EMA	Dell PowerEdge Server R710 2 No, RAM (4GB), HDD capacity 14.4TB, Windows Server 2008, CPU (3.0MHz), maximum number of PCs that can be connected (200) Dell PowerEdge Server R310 1 No, RAM (4GB), HDD capacity 9.6 TB、OS is Windows Server 2003, CPU (3.0MHz) Dell PowerEdge T610, HDD: 0.5TB, RAM (8GB), CPU (3.0MHz), Windows Server 2008 Dell PowerEdge 2800, HDD: 1.0TB, RAM (4GB), CPU (3.0MHz), Windows Server 2003
Server management staff	Managing department: Information Communication Directorate Database Administration: 5 persons System Administration: 6 persons Technical Instrument Maintenance: 5 persons At present 3 teams are responsible for daily server operation, but there is no software for operating and managing large scale data on the server side, therefore they have not accumulated experience in management and operation of GIS data.
Web communication speed	Only 2MBPS (theoretical value) both up and down, which makes operation of the website difficult.
Website	From June 2013 EMA has commissioned the national Information Network Security Agency (INSA) to produce the website, and the final report was submitted at the end of October. The site is composed of 2 parts, the internet part and an intranet part. The hardware and software from which the system is composed are not disclosed, but Oracle's MySQL Database Server is scheduled to be used, and the development language is Java. Regarding the GIS function, small size (1 page maximum 13MB) map images can be released, but they do not have the function to release and download large size raster data such as orthoimages, satellite images, map images, etc., or vector data such as points, lines, polygons, and annotations. Some existing data contained military information, so INSA issued instructions to suspend the EMA's website. Regarding to this issue, EMA is now planning to request INSA to reopen the website under condition by excluding the military data.

[10] Assistance for Formation of Organizational Capacity Building/Utilization of Geospatial Information《Work in Ethiopia》

The following issues became clear from the interviews at EMA during the first dispatch survey in November 2013. As a result of their evaluation, activities (draft) were extracted as per the figure below.

Table 18 Issues for EMA Identified in the First Dispatch Survey

Current Issue	Factor		Expectations
Effectively usable digital topographic maps are not prepared	Quality and applications are not defined	Preparation method is not unified	Preparation of map symbol regulations and specifications
		Quality control method is undefined	Technology transfer of quality control method
	Map creation and updating system have not been developed	Work management method (process/cost management) is undefined	Technology transfer of work management method
		Lack of manuals and turnover make it harder to exchange and spread technology	Technology transfer and preparation of manuals for the creation of topographic maps
			Discuss with Planning and Business Development Directorate to improve work environment
	Environment for easily using digital topographic maps is not developed	Mechanism to distribute digital topographic maps has not been developed	Discussion in JCC (held twice)
		The preparation of hardware for distribution has not been developed	Technology transfer of web server procurement and operation

The capacity building of the EMA organization was determined to be through the preparation of “Map Symbols” and “Specifications” and by technology transfer in digital topographic mapping work and manipulation of equipment, and capacity building in work management to be enforced by technology transfer with open source software.

Other issues identified consist of improvement of staff retention and development of a topographic map provision system easily accessible for many users.

These issues were addressed in the second term (see Chapter 4 [11]).

[11] Promotion of Utilization《Work in Ethiopia》

Implementation of First Seminar

A seminar was held on Thursday, November 21, 2013 and was attended by 54 persons from 20 organizations. The content of the seminar was as follows, and the Study Team gave presentations on “Outline of the Project”, “Examples of Utilization”, “System and Issues Concerning Utilization”, etc., and EMA gave a presentation regarding the “Present Status of EMA”.

The following table shows the seminar content, the effects and the issues identified through the seminar.

Table 19 Contents of the First Seminar

Objective	Explanation of Project outline and technical cooperation by JICA in the field of geographical information for smooth project implementation and effective utilization of the results from a better coordination with other organizations	
Content	Outline of the Project (introduction of Study Team members, introduction of EMA, outline of the work, training in Japan, outputs, technology transfer, etc.) Present Status and Issues regarding Geographical Information in Ethiopia Present Status of EMA Introduction of Technical Cooperation on Geographical Information by JICA in Africa Examples of Use of Geographical Information Cooperation Items Requested for this Project (document collection, interview surveys, request for participation in JCC, etc.)	
Method of Presentation	Extensive use of technical terminology was avoided, and images and graphics were used, so that the presentations could be understood by persons who were not geographical information specialists. The presentation on "Present Status and Issues regarding Geographical Information in Ethiopia" was presented by EMA staff.	
Q&A	1. EMA's response to the issue of turnover of human resources: This is a common issue within other governmental organizations, due to the wage differential between agencies and ministries. The Government of Ethiopia is now on the move to solve this problem. EMA is trying to prevent turnovers by sending staff to university training as an incentive. 2. Possibilities and structure for internet distribution of soft copies: This Project is target to upload and provide data view function. Distribution and the system for this will be discussed with EMA for the final results. 3. Standard of open source GIS software and results of the Project: We have received few questions about open source GIS. The Study Team has explained the strong points and weak points by comparing with general GIS software. Also, there was question about the accuracy of the results; the Study Team has answered this by explaining the data formats and quality standards.	
Effects	Information about the Project outline, objectives and outputs was shared with at least ten Ethiopian government agencies and regional agencies. From comments by the participating agencies, it was clear that there have been major changes over time in many areas due to urban expansion, infrastructure development, etc. accompanying development of the country, and the importance of updating the topographic maps was shared anew. The interest of donor organizations (projects related to land management) in Europe and the US was obtained. It was found that many agencies have knowledge of GIS data and software. It was found that there are many domestic agencies with common concerns and common interest in strengthening the EMA organizational structure including turnover measures.	
For the future	Establishing JCC	To grasp user's needs related to geo-spatial information and distribution method Discuss and decide the rules and system for internet distribution.
	Points for the final seminar	Define information (discrimination, range, quality, spatial definition, time definition and distribution method) and reference method, so that many users will be able to easily understand and use the results. Add activities for improvement of the human resource turnover issue as a key aspect in the formulation of the EMA organization structure.

Results of First JCC

As a result of the first Joint Coordinating Committee meeting held on March 3rd, 2014 which was attended by 14 persons from four organizations, the following information was obtained. Also, during the discussions an "Activity Plan (Draft)" for this Project was prepared and agreed by those involved.

Table 20 Results of JCC Discussions and Collected Information

Item	Details
Main topics	Outline explanation of the Project, confirmation of the constituent members, distribution of data, activity plan, utilization
Permanent organizations	< At present (apart from EMA, Embassy of Japan in Ethiopia, JICA Ethiopia Office) > Ministry of Urban Development & Construction Ministry of Agriculture Ethiopian Road Authority Oromia Urban Development Office < Planned to be added > Ministry of Finance and Economy Ministry of Transport Information Network Security Agency Geological Survey of Ethiopia
Present status of sharing of map information data	Information is provided through the existing website and workshops, etc., but analog maps are only sold through the EMA sales office. There is no experience of distribution of digital data. EMA owns the copyright to most of geographic information within Ethiopia.
Issues regarding sharing of map information data	It is necessary to prepare a distribution policy for the digital data produced in this Project, and specific schemes for the methods, setting of the cost, etc. Also, it is necessary to have specific measures for utilization of the digital map data produced. Disclosure of the data possessed by each organization is entrusted to the judgment of each organization.
Directionality for utilization	The aim is for "Easy to Use" data that can be simply obtained by users.
Agenda for the next JCC	Anticipating future utilization not limited to the Project area but in the whole of Ethiopia, selection of the participants is discussed with EMA. To improve the participants' understanding of the Project outputs and works for the Study, sample data is created and shared with them in the next JCC meeting. The aim is to develop a utilization system through a tie-up with the Ethiopia KAIZEN Institute (EKI)

[12] Preparation of Progress Report 1《Work in Japan》

Progress Report 1 was prepared, describing the results of the study conducted after the submission of the Inception Report and the progress in technology transfer and in topographic mapping.

Chapter 4 Work and Implementation Plan for the Second Term

[1] Preparation and Discussion of Inception Report 2《Work in Japan/Ethiopia》

Based on the results of study in the first term, the policies for implementation of the Project in the second term, the work schedule, implementation system and technology transfer plan were summarized to prepare Inception Report 2 and the contents of the Report were discussed with EMA.
The results of the discussions were recorded as the minutes of discussion, which were agreed upon by both parties.

[2] Digital Plotting/Editing and Generalization《Work in Japan/Ethiopia》

Digital plotting / Digital editing

In accordance with the decisions reached in the discussions on specifications, digital plotting was completed using the data obtained from aerial triangulation and the results of the field identification. The digital editing work was also completed based on the decisions reached in the discussions on specifications. Data requiring supplementation (missing field identification results, data difficult to interpret in the aerial photographs, etc.) was noted on 56 supplementary field verification sheets as target items in the supplementary field verification and used in the supplementary field verification survey.
The digital plotting and digital editing of 1/10,000 topographic maps in Japan were entirely completed.

Digital supplementary editing / Generalization

Any error data will be corrected or removed, and the data will be polygonized, and data such as administrative boundaries and annotations will be added to create the topographic map data. The created topographic map data will undergo generalization to create the 1/25,000 topographic mapping data. This work will be executed with the use of CAD software.
Supplementary digital plotting of 1/10,000 topographic maps and generalization to 1/25,000 mapping data have been 100% completed.

[3] Symbolization of Topographic Maps《Work in Japan/Ethiopia》

The digitally edited data will undergo symbolization for 1/10,000 and 1/25,000 topographic maps in accordance with the map symbols as agreed upon through the discussions on specifications. To avoid complicated work, the symbolization will use the CAD software used for digital plotting/editing. In this case, consideration will be given to ensuring that the symbolized data is easy to see as a line map and can also be used as a printed output map. 100% of the symbolization work in Japan was completed.

[4] Digital Data Structuration《Work in Japan/Ethiopia》

The digitally edited data will be structured into data with phase relations in a format which is usable on GIS software. This work will be executed in accordance with the specifications agreed upon with EMA and other related agencies. The file division will not be in units of map sheets, but determined taking into consideration convenience of use. 100% of the digital data structuration work in Japan was completed.

[5] Creation of Data Files《Work in Japan/Ethiopia》

The digital data and GIS data of the created topographic maps will be recorded in appropriate recording media in accordance with the specifications as discussed and agreed upon with EMA.

[6] Preparation of Interim Report《Work in Japan》

The results of the study and the progress of technology transfer and topographic mapping carried out after Inception Report 2 has been compiled to prepare the Interim Report.

[7] Explanation and Discussion of Interim Report《Work in Ethiopia》

The prepared Interim Report was submitted to EMA and the contents were explained and discussed with EMA. The results of the discussions were recorded as the minutes of discussion, which were agreed upon by both parties.

[8] Website Creation《Work in Japan/Ethiopia》

Procedure for website creation

As a result of discussions on website creation with EMA, it was decided to maximize the existing materials and equipment and create the website according the following procedure.

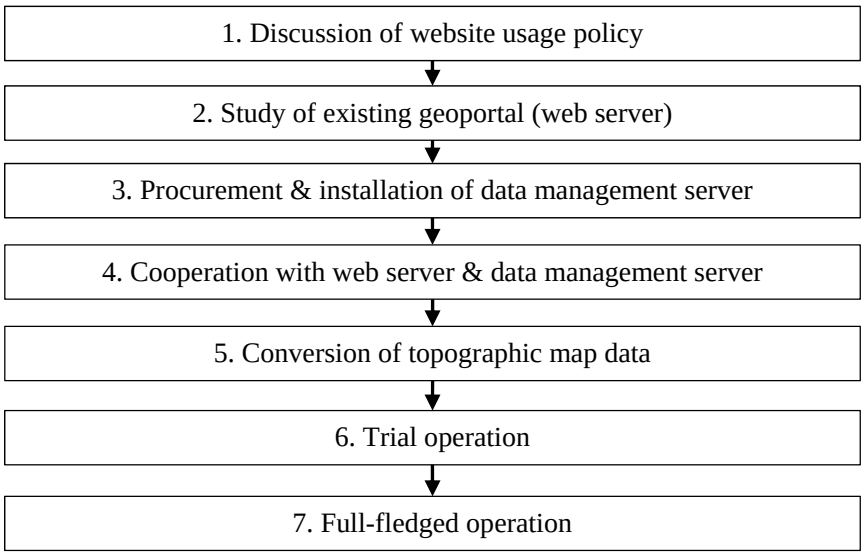


Figure 4 Procedure for Website Creation

The website-related work content to date is as shown below.

Table 21 Current Work Related to Website Creation

Period	Work Content	Result
June 2014	Discussions with EMA on management of website (installation of existing server, connection environment, role of server) Check of existing server capacity	As EMA had a geoportal procured from RCMRD in July 2014, as a result of discussions, it was decided to provide web services in cooperation with EMA's existing server (RCMRD). The existing geoportal has a function for uploading shape files and geotif.
November 2014	Procurement and installation of server for data management (database), installation of software	The necessary SQL Server 2012 and ArcGIS Server 10.2.2 software was installed in the server, and connection and cooperation with ArcGIS Server and ArcGIS Desktop was performed. Storing of sample data in the SQL database was completed.
August 2015	Connection and cooperation with data management server and web server, provision of sample data, display test of sample data on web	Updating of the necessary software to the latest version was completed. Data was stored in the data management server. Sample data was provided and stored in EMA's web server and the web display test was completed.
July 2016	Uploading and disclosure of topographic map data created in this Project on the web	The outputs of this survey in the PDF data format were uploaded to the Geoportal of EMA and an environment in which they could be downloaded free of charge was established.

*RCMRD = Regional Centre of Mapping for Resource Development

Image of Cooperation with Server Procured by RCMRD and Work Process

Besides the server provided in this Project, EMA procured a web server from RCMRD and installed it as the new web server. As a result, the initial plan was altered. The server provided in this study is functioning mainly in an intranet environment, sharing the roles of configuring linkable settings with the RCMRD server as the back-end server and providing web services with the IIS8 as the front-end web server.

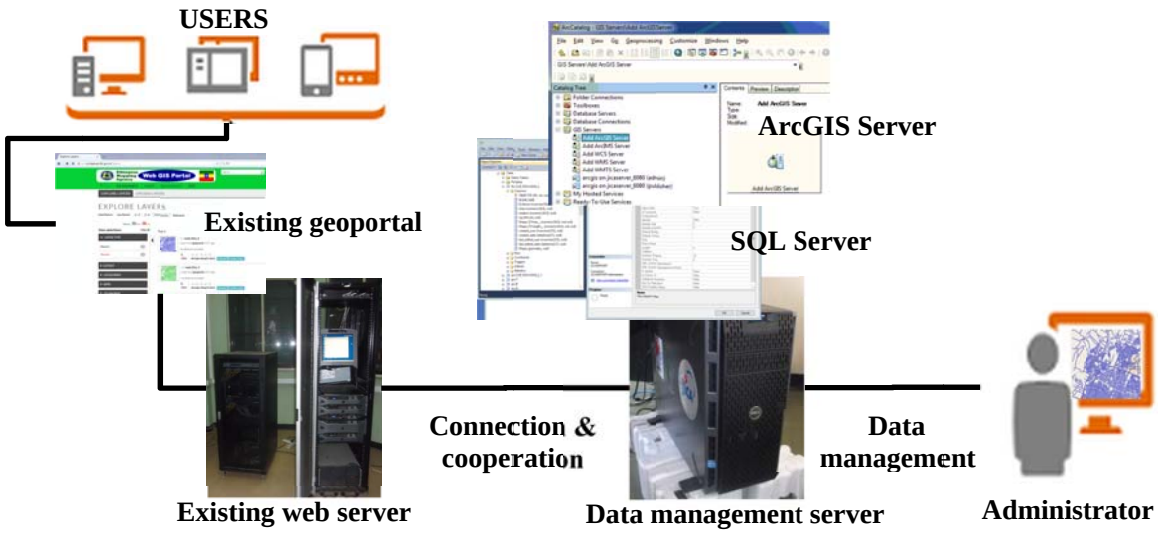


Figure 5 Conceptual Diagram of Web Environment

Types of Data and Storage Method

There are two types of data and data formats provided in this Project, File Geo-database and SQL Server Geo-database. Plotted/edited CAD data is converted to the two data formats by the Python tool and stored. The procured server has already been installed and is ready to be connected to EMA's network.

[9] Preparation of Progress Report 2《Work in Japan》

The results of the study and technology transfer and the progress of topographic mapping conducted after preparation of the Interim Report has been compiled to prepare Progress Report 2.

[10] Explanation and Discussion of Progress Report 2《Work in Ethiopia》

The prepared Progress Report 2 has been submitted to EMA and the contents was explained and discussed with EMA. The results of the discussions were compiled as the minutes of discussion, which was agreed upon by both parties.

[11] Assistance for Implementation of Organizational Capacity Building/Utilization of Geospatial Information《Work in Ethiopia》

In the second term, assistance for implementation of organizational capacity building and utilization of geospatial information was decided to be continually enforced using the PCM (Project Cycle Management) method as shown below.

Based on the issues that became clear from the interviews at EMA in the first term, it was decided that the Study Team would continuously hold consultations with EMA on creating an action plan to clarify the terms, targets and activities for organizational capacity building and would implement such activities in accordance with the plan.

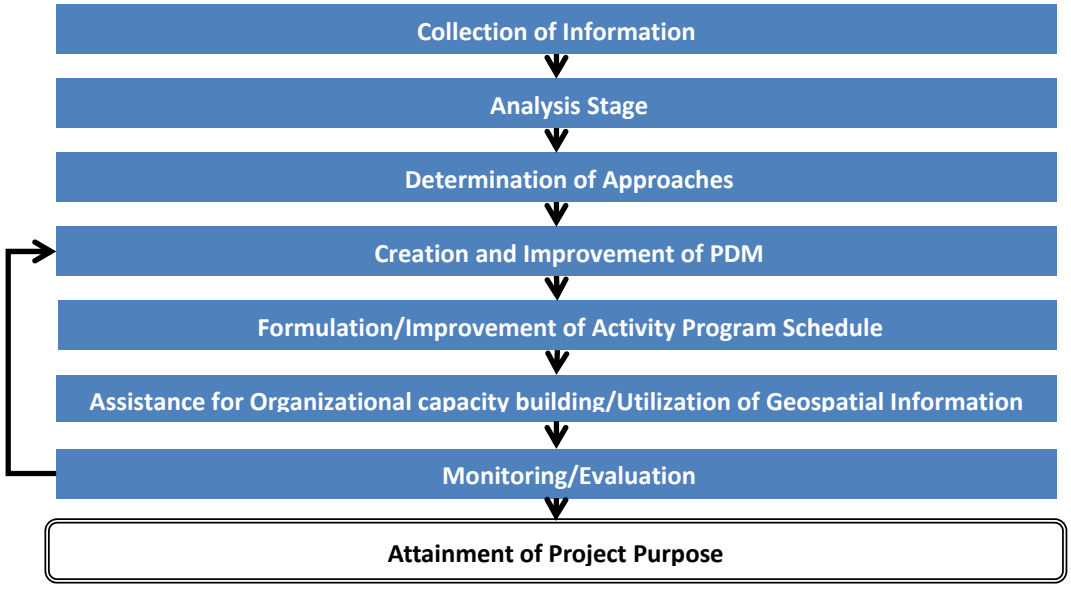


Figure 6 Formulation of Operation Plan and Flow of Implementation/Evaluation

Table 22 Example of Road Map (Operation Plan)

Target	Activities/output	Schedule		
		Phase 1		Phase 2
		2013-2014	2015	2016
	Gather/analyze information			
	Create action plans			
Accurate and reliable map creation by EMA	Creation of work specifications			
	Acquiring basic skills			
	Creation of wide use manual			
	Individual work in pilot area			
	Efficient work flow			
Development of data creation/update structure	Process management/Quality control			
	Management/operation structure for continuous mapping work			
Development of easy to use environment for digital topographic maps	Organize and exchange information with related organizations centered around EMA			
	JCC meeting			
	Development and management of data distribution			
	Monitoring / evaluation			

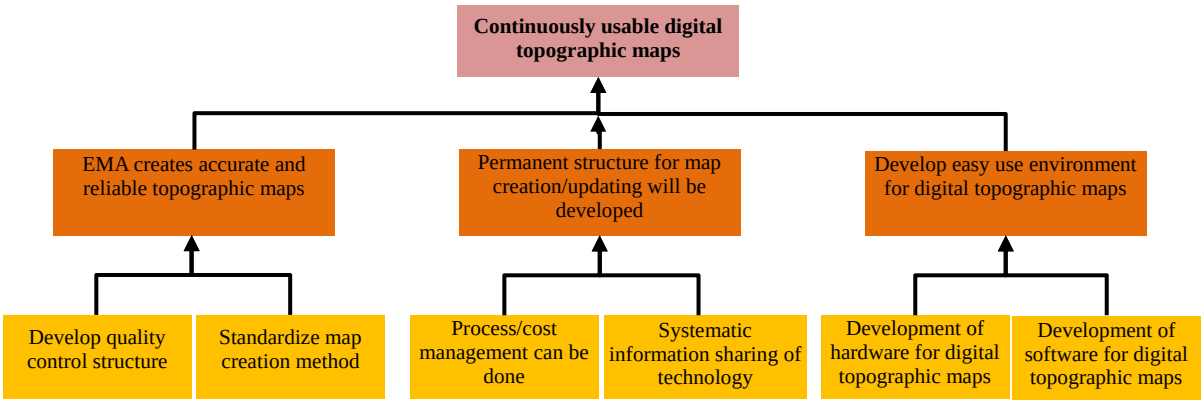


Figure 7 EMA's Evaluation Results and Assumed Activities (draft)

Table 23 Activities for Organizational Capacity Building in EMA

Period		Activity	Outcome	Issue
Develop quality control structure	November 2014 – August 2016	Establishment of a network between the departments responsible for mapping and quality control in the technology transfer Transfer of technologies for quality control in the technology transfer in each process (The C/Ps inspected and corrected the data plotted by the C/Ps in the technology transfer in digital plotting.)	The C/Ps was able to understand the quality appropriate at the scale of 1/10,000, in particular.	None in particular
Standardize map creation methods	June 2014 – November 2014	Discussion and development of topographic map symbols and work specifications	Discussions are being held in EMA on strategies for data updating in future based on the developed map symbols and specifications	None in particular
Process and cost management can be carried out	April 2016 – August 2016	Creation of work schedules with spreadsheet software	The C/Ps became able to formulate work schedules according to the capability of the operators.	Work implementation based on the work schedule and improved reliability
Systematic sharing and transfer of technologies	July 2014 – August 2016	Creation of manuals in the technology transfer	The C/Ps are quick to remember the work that they did previously and are able to maintain the equipment unassisted.	Unassisted revision of the manuals by the C/Ps and transfer of technologies to unexperienced operators
Development of hardware for the distribution of digital topographic map data	November 2014 – August 2016	Installation of a data server	The preparations for storing the geospatial data to be created in this Project have been completed.	Establishment of policies for data transmission outside EMA and data sharing within EMA
Development of software for the distribution of digital topographic map data	September 2015 – August 2016	Creation of “Adama Tourist Map” utilizing the results of this study and relevant consultation Holding of a ceremony inviting relevant people	The C/Ps acquired know-how on application development and sustainable operation of developed applications.	Sustainable operation and expansion of “tourist map creation” to other major areas
	February 2016 – August 2016	Development of “viewer (proposed)” for the management of geospatial information owned by EMA	Visualization of geospatial information owned by EMA to users can be attempted.	Operation on existing geoportal

Consultation for utilization of Adama Tourist Map

Utilizing the results of this study, EMA started to create a tourist map of Adama District on their own around April 2015. The Study Team provided technical support with respect to the design and operation of the map. Also, in July 2015, on the sustainable operation of the tourist map was discussed by JICA tourism project experts of national parks in Ethiopia at the request of the Study Team.
As a result, the first version was created in April 2016.

Meeting with the Djibouti City GIS Committee

A meeting attended by EMA, Djibouti City GIS Committee, JICA Ethiopia Office and the Study Team was held at EMA for two days on December 19 and 20, 2015.

EMA shared information on the development, updating and distribution of geographical information with the Djibouti City GIS Committee, which shared information on the issues of organization to promote the utilization of GIS with EMA. As a result of the meeting, it was decided to continue the sharing of information and study the system for technical supplementation among the parties.

Results of the Training Course in Japan

A training course has been implemented from September 28 to October 11, 2014 (Including moving days), to EMA managers. Details of the course are as follows:

Trainees:	Mr. Sultan Mohamed (Director General) Mr. Ayele Teka (Mapping Director) Mr. Karlos Latebo (Quality Control Director) Mr. Girma Giorgis (Survey Director)
Target:	To acquire knowledge of NSDI, national geodetic frame work, surveying and digital mapping activities
Items to accomplish:	1. The theoretical method for the establishment and utilization of NSDI 2. The establishment method of national geodetic frame work 3. The understanding of organization structure, activities, technical guidance, general duties of national surveying and mapping organization 4. Overviewing government / private surveying mapping agencies 5. Overviewing digital mapping work of the ongoing project

During the training course, the trainees were able to grasp the NSDI and CORS implementation status and the utilization method in Japan. Therefore this acquired knowledge will be highly useful for formulating NSDI in Ethiopia. Also the expectation in the formulation of national geodetic

frame work in Ethiopia is realizable with regarding the Japanese national geodetic frame work as a model.

[12] Promotion of Utilization《Work in Ethiopia》

Coordination with and Assistance to Related Agencies

Unless the visibility of geospatial information is enhanced by voluntary disclosure and proposals for its utilization are produced, the new information to be created will be kept within EMA and utilized by limited users. For the effective utilization of the project outputs, it was decided to enhance the efforts for holding JCC, participating in international conferences and coordinating with events concerning geospatial information.

Table 24 Coordination with Related Agencies

Term		Content
2nd JCC	July 2014	Outline explanation of the Project and confirmation of the constituent members Distribution of data and utilization
3rd JCC	June 2015	Discussion on data utilization management Discussion on data policy, Decision on the utilization theme
4th JCC	November 2015	Data process and analysis, Utilization samples from Project outputs
5th JCC	July 2016	Introduction of final outputs, Future issues and proposal for the next step
Final seminar	July 2016	Introduction of project implementation outline, outputs and details of the implementation of technology transfer, Future issues and proposals
RCMRD Conference	November 2014	Introduction of the work of EMA and the JICA project
UN-GGIMC Conference	April 2016	Introduction of the work of EMA and the JICA project

Results of the Second JCC Meeting

The second Joint Coordinating Committee meeting was held on July 15, 2014 and was attended by 20 persons from five organizations. The committee was informed that a system will be created for storing the outputs of the Project in the server provided in this Study and disclosing them in a timely manner.

Table 25 Outcomes of the Discussion and Information Collected in the Second JCC Meeting

Item	Content
Main subjects	The Project was outlined, the constituent members were confirmed, the status of website creation and data distribution, activity plans and utilization (cases of agricultural development using GIS and elevation data, infrastructure development, urban development, cases of data utilization in Japan) were described, and the selection of appropriate pilot areas was discussed.
Permanent member organizations	< At present (apart from EMA, Embassy of Japan in Ethiopia, JICA Ethiopia Office) > Ministry of Urban Development & Construction, Ministry of Agriculture Ethiopian Road Authority, Oromia Urban Development Office Ministry of Finance and Economy, Ministry of Transport, Geological Survey of Ethiopia < Plan to be added > Information Network Security Agency
Current status of the sharing of map information data	The will to begin discussion of the rules on the distribution of digital data was seen when the presentation of the website to be created in this project was made. However, the only activity for data distribution at present is the sale of analog maps at EMA. Thus, there is no facility for digital data distribution.

Item	Content
Issues to be addressed for the sharing of map information data	It is necessary to create a practical plan including the policy, method and fee setting for distribution of the digital data to be created in this Project. It is also necessary to propose a practical plan for utilization of the digital map data to be created. Each organization which owns map information data is to make a decision on the disclosure of the data that it owns.
General policy for data utilization	To aim at creating “easy-to-use” data that are readily available to users
Matters to be discussed in the next meeting	The permanent member organizations shall discuss how to extend the cases of data utilization in this project to the entire country. As the number of organizations participating in JCC is small, efforts shall be made to make them understand the importance of the discussions at the JCC in order to facilitate the holding of JCC meetings, and to urge the members to participate in the meetings on a regular basis.

Results of the Third JCC Meeting

The third Joint Coordinating Committee meeting was held on June 9, 2015 and was attended by 23 persons from nine organizations.

Table 26 Outcomes of the Discussion and Information Collected in the Third JCC Meeting

Item	Content
Main subjects	The Project outline and progress report, utilization (Adama sightseeing map using the Project data), status of website creation and data distribution were explained and discussed.
Permanent member organizations	< At present (apart from EMA, Embassy of Japan in Ethiopia, JICA Ethiopia Office) > Ministry of Urban Development & Construction Ministry of Agriculture, Ethiopian Road Authority, Oromia Urban Development Office Ministry of Finance and Economy, Ministry of Transport Geological Survey of Ethiopia
Current status of the sharing of map information data	From the fact that INSA has requested EMA to extract military facility image for security reasons and a new server was provided by RCMRD, efforts to create regulations pertaining digital data distribution policy are gradually observed.
Issues to be addressed for the sharing of map information data	As it was found that INSA is responsible for NSDI framework, project based on further discussion the approach will be adopted of enabling approval of disclosure of the data created in the Project. However, this will be confined solely to the outputs of the Project and INSA will be in charge of policies for the whole of Ethiopia.
General policy for data utilization	The aim is to make available to the public the outputs of the Project and create easy-to-get easy-to-use data. The aim is to promote utilization of the technology by diffusing the skills acquired in the technology transfer to other organizations.
Matters to be discussed in the next meeting	It is necessary to speed up the NSDI framework policy for data sharing, so that every stakeholder understands the digital data distribution policy and understanding of disclosure of the output data. As the meeting will be held at the end of Phase 1, a report will be given on the results of the technology transfer and the tasks that EMA can perform independently. As the sample output data will be ready, trial operation on the website will be carried out and the report reviewed.

Results of the Fourth JCC Meeting

The fourth Joint Coordinating Committee meeting was held on December 3, 2015 and was attended by 27 persons from nine organizations.

Table 27 Outcomes of the Discussion and Information Collected in the Fourth JCC Meeting

Item	Content
Main subjects	Progress report of the project Proposal of utilization examples of the outputs of this study Development status of geospatial information owned by EMA and future plans Actual situation of EMA
Permanent member organizations	< At present (apart from EMA, Embassy of Japan in Ethiopia, JICA Ethiopia Office) > Ministry of Urban Development & Construction Ministry of Agriculture, National planning Commission Ethiopian Road Authority, Oromia Urban Development Office Ministry of Transport, Geological Survey of Ethiopia
Outcome of technology transfer in this study	Technology transfer is necessary not only to the target participants but also to all the staff of EMA and other governmental agencies.
Utilization example of the outputs of this study	Creation of tourist map by EMA on their own
Current status and direction of the development of geospatial information by EMA	The outputs of this project will be released free of charge on the web portal.
Matters to be discussed in the next meeting	Specific proposals for utilization

Interview to potential user organizations

In addition to collecting information at the JCC meetings, individual interviews were held with potential users to collect information on the specific details of their work, demonstrate concrete explanations and analysis examples concerning the outputs of this study and discuss specific methods of utilization after the completion of this study. At the interview to the Waterworks Design & Supervision Enterprise implemented on April 11, 2016, the Enterprise commented that 1/10,000 digital topographic maps are very useful to the feasibility design of irrigation facilities and plantations and EMA provided information about the areas where 1/10,000 topographic mapping data have been created. Also, a discussion was held on the scheme to utilize the data while sharing information with EMA when a new plan is formulated about irrigation facilities and plantations in such areas.

Holding of the Fifth JCC Meeting

The Fifth Joint Coordinating Committee is scheduled to be held on July 26, 2016. Questions on the conditions for the disclosure of the outputs of this study and a future plan of EMA for the creation of small-scale topographic maps from the large-scale ones were raised in the discussion at the JCC meeting.

Table 28 Contents of the Discussion and Information to be collected at the Fifth JCC Meeting

Item	Content
Main subjects	Report of the project outputs Introduction of the outputs of this study and proposal of utilization examples of the study outputs (Adama Tourist Map, etc.) Outcome of technology transfer and future geographical information development plan of EMA, Future issues and proposals
Participated organizations	National Planning Commission Ethiopian Road Authority Oromia Rural Land Administration Bureau Geological Survey of Ethiopia Ethiopian Mapping Agency Japan International Cooperation Agency JICA Study Team
Current status of mapping data sharing	Data sharing in the intranet environment in EMA A method to share the outputs of this study on the Geoportal of EMA A method to share the geospatial information owned by EMA using the Geoportal of EMA
Issues of mapping data sharing	Recommendation on the digital copy distribution Recommendation on the operation of the organizations concerning geospatial data
Direction of utilization	The Director General of EMA announced that the outputs of this study should be available to the public free of charge.
Issue	Introduction of Phase 3 (follow-up phase)

Final Seminar

A seminar was held on July 28, 2016. It was intended to be an opportunity to make the outputs of the project known to and fully utilized by not only Ethiopian organizations interested in geospatial data but also international organizations and donors. Eighty-six people from 31 organizations participated in the seminar. Interest of many participants was on geospatial information to be disclosed by EMA, cooperation among the organizations creating and using geospatial information and the policy of EMA for the creation of geospatial information in future.

The results of the seminar were reported on TV and radio programs, the Internet and newspapers by the collaborating members of the press.

Table 29 Contents of the Final Seminar (tentative)

Objective	Outputs of the Project and Recommendations
Time	July 28, 2016
Contents	Final report (Outline of the achievement of the Project and recommendations, outcome of the technology transfer and the methods for distribution of the outputs) Reports on the subject-specific training course held in Japan by the course participants Activities of the JCC and their outputs Outline and utilization of the newly created website (for web-mapping) Examples of definitions, quality and utilization of digital topographic maps Recommendations for development of geospatial information in future Capacity building activities for EMA organization and their effects
Method of presentation	Presentations on the technologies and experience acquired by EMA engineers in the Project will be made by those engineers who have acquired them. Demonstration of the web-mapping site will be shown to map users who are interested in data distribution to introduce them to the newly configured web-mapping system. Differences between the new work specifications to be prepared in the Project for digital topographic mapping and existing EMA work specifications will be presented in an easy-to-understand way using a comparison between the two.
Documents distributed	Project outline, pamphlet, Adama tourist map
Location	Hilton hotel, Addis Ababa
Participants	86 attendances from 31 organizations, including Ministries, Agencies, international donor organizations, local government and media

On the date of the seminar, the team distributed documents outlining the Project (in English and Amharic) to TV stations and newspaper publishers to explain the details of the seminars and ask them to carry articles on them.

Tie-up with International Conferences and Events Related to Geospatial Information

Cooperation with international conferences in which a number of delegates from various countries were expected to gather was examined to widely disseminate information on the outputs of the Project. Consideration was also given to presenting such information positively to donors and conferences related to geospatial information.

As the events related to geospatial information described below were held in the city of Addis Ababa, participation in such events that offer the chance of presenting the outputs of the Project was discussed with EMA. The effects and costs of such participation (participation fees and cost of exhibition space) were examined and sorted, and the results of the examination were reported to JICA.

- Africa GIS2013 and GSDI 14 (Global Spatial Data Infrastructure Association)

  These events were held at UNECA headquarters in November 2013, and some EMA staff participated in the exhibition.

- Participation in the Regional Centre for Mapping of Resources for Development (RCMRD) Conference

  The RCMRD Conference was held in Addis Ababa from November 10 to 18, 2014. The objectives of the conference were presentation of the annual activity report for the year 2013 to 2014, review of the overall activities carried out between 2011 and 2014 and discussion of the strategic plan of RCMRD between 2015 and 2018. A total of 52 people from 17 member countries, including UNECA, advisors, observers and the secretariat of the conference, participated in the conference.

*RCMRD: RCMRD was established in 1975 for the development of geospatial information for sustainable development in Africa. It has 20 member countries. It is headquartered in Nairobi, Kenya.

◆ Participation in the Fourth High Level Forum on United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM)

Chaired by the Director General of EMA, this Forum was held in Addis Ababa from April 18 to 22, 2016. It is a global forum to facilitate joint and collective dialogues concerning the management of geospatial information with all the related governmental organizations, non-governmental organizations and private sector and was attended by about 300 persons from 57 countries around the world.

The Study Team attended the forum with the EMA staff to introduce the study in part of the EMA booth and exhibit the viewer of geospatial information owned by EMA, which was developed in this study.

[13] Preparation and Discussion of Draft Final Report《Work in Japan/Ethiopia》

The works that have been done so far will be compiled as the Draft Final Report, which will be submitted to EMA for discussion of its contents. The results of the discussions will be recorded as the minutes of discussion, which will be submitted to EMA for agreement. In the Draft Final Report, the following items will be stated:

- Challenges in technology transfer and organizational system
- Potential for utilization of developed topographic maps
- Achievement level of the Project and remaining challenges after the end of the Project
- Technical sustainability after the end of the Project

[14] Preparation of Final Report 《Work in Japan》

The Final Report will be prepared by making additions and corrections based on the comments made by EMA on the Draft Final Report and submitted to JICA.

Individual work manuals for creation of various types of data, operation and maintenance procedures, structured data, system operation and other necessary items will be prepared and attached to the Final Report. For the work processes and results of the quality control work, a separate report will be prepared.

[15] Work Related to Technology Transfer《Work in Ethiopia》

In this Project, the transfer of topographic mapping technology in which emphasis was placed on EMA's capacity for independent development was conducted. The details are described in the next section.

Chapter 5 Technology Transfer

5-1. Content of Technology Transfer

The technology transfer for creation of topographic mapping data will be implemented with emphasis placed on EMA's independent development as detailed below.

Table 30 Overall Schedule of Technology Transfer

	Phase 1								Phase 2			Target Work
	2014				2015				2016			
Month	Jan – Mar	Apr – Jun	Jul – Sep	Oct – Dec	Jan – Mar	Apr – Jun	Jul – Sep	Oct – Dec	Jan – Mar	Apr – Jun	Jul – Sep	
OJT	■						■					Photo control point survey Field identification/Supplementary field verification
(Stage 1) Acquisition of Basic Technology			■									Aerial triangulation Digital plotting, digital editing, symbolization GIS structuration
(Stage 2) Independent Work Execution						■						Aerial triangulation Digital plotting, digital editing, symbolization GIS structuration (including process control and quality control)
Implementation of Pilot Work										■		
Utilization										■		Website creation

Phase 1 (Stage 1: Acquisition of Basic Technology; Stage 2: Independent Work Execution

As the EMA staff members lack sufficient experience in digital topographic mapping, the technology transfer will be conducted by dividing Phase 1 into "Stage 1: Acquisition of Basic Technology" and "Stage 2: Independent Work Execution".

In Stage 1, the "technical level", "experience in target work", and "experience in operation of related equipment" of EMA staff will be studied to grasp the technical capability of each staff member of EMA. The Technology Transfer Plan is drawn up based on that concept.

In Stage 2, a training area for technology transfer will be set up within the scope of the Project to conduct technology transfer that allows EMA to reach the technical level for conducting pilot work independently. The EMA staff members will review the technology transferred in Stage 1 through the work at the individual level of the trainees in the training area, and process control and quality control technologies will also be transferred.

The results of the work in the training area will be quantitatively evaluated by work item to examine

the priority items to strengthen the capabilities of the trainees for the work in the pilot area in Phase 2.

Table 31 Concept of Technology Transfer Plan (Phase 1)

Item	Phase 1 (Stage 1: Basic Technology)		
	Goal	**Means of Attaining Goal**	**Evaluation Method**
Aerial photography planning/Installation of aerial signals	Capable of drawing up plans to meet the photographic scale using software	Lectures and exercises using software	Evaluation of whether each item of the work specifications is satisfied
	Capable of doing photo control point selection work Capable of installing aerial signals in accordance with the work specifications	Lectures and field work	Evaluation of selected photo control points Test of work specifications
Photo control point selection and survey	Capable of operating digital equipment	Field work and exercises using analytical software	Evaluation of GNSS analysis and results of leveling Evaluation of results of 3D net adjustment analysis
Aerial triangulation orthophotos/DTM	Understanding of theories of aerial triangulation and DTM Understanding of operation of digital photogrammetric system	Lectures and exercises using digital photogrammetric system	Position/ condition of tie-point observation Evaluation of speed and accuracy of photo control point observation Evaluation of results of adjustment calculations
Field identification/ Supplementary field verification	Understanding of operation of equipment used Understanding of theory of field identification work	Field identification (OJT)	Evaluation of sorted results of field identification
Digital plotting	Understanding of map specifications, acquisition criteria and procedures Understanding of basis of 3D interpretation	Exercises in stereo plotting using CAD	Evaluation of stereoscopy Evaluation of plotting results of 20km^2 (Data and printed maps)
Digital editing/ Supplementary digital editing/Generalization	Understanding of CAD operation Understanding of data error detection and correction, and polygon creation techniques	Exercises using CAD	Evaluation of results of editing of 20km^2 (Data)
Symbolization	Understanding of mapping theory Understanding of map symbols	Creation of marginal information Exercises using CAD	Evaluation of created symbols (points, lines, polygons)
GIS structuration/ Website creation	Understanding of CAD to GIS format conversion method Understanding of GIS software operation	Exercises using GIS and CAD	Evaluation of results of created exercise data

Item	Phase 1 (Stage 2: Independent Work Execution)		
	Goal	**Means of Attaining Goal**	**Evaluation Method**
Aerial photography planning/Installation of aerial signals	EMA can independently draw up aerial photography plans including photo control point distribution.	Execution of exercises	Evaluation of input values and outputs using photography planning tools
Photo control point survey	EMA can independently carry out photo control point surveys.	Testing	Evaluation of GNSS observation work around EMA and analysis practice, and evaluation by comprehension test based on correct/incorrect answers
Aerial triangulation orthophotos/DTM	EMA can independently perform aerial triangulation, create and compile DTMs and create orthophotos.	Testing	Evaluation of practice results for 40 models on three flight courses
Field identification/Supplementary field verification	EMA can independently execute the supplementary field verification work.	OJT	Evaluation of sorted results of supplementary field verification
Digital plotting	The works in the training area are completed	Execution of works in training area	Evaluation of results of plotting practice in approx. 15 map sheet areas
Digital editing/ Supplementary digital editing			Evaluation of results of practice in approx. 4 map sheet areas
Generalization			Evaluation of results of practice in approx. one map sheet area
Symbolization			Evaluation of results of practice in approx. 2 - 4 map sheet areas
GIS structuration/ Website creation	The works in the training area are completed. Capable of creating several GIS models	Execution of works in training area	Evaluation of structuration data
	Understanding of website operation	Lectures	Execution of simple test on related operations
Promotion of utilization	Able to set up and run JCC Able to coordinate with related agencies and organizations	Joint work by EMA and Study Team	Evaluation by goal attainment level at initial stage of the Project
Technology transfer to enable EMA to implement topographic map creation projects by itself	Execution of technology transfer in “Process Control”, “Quality Control” and “Creation of Manuals” in the mentioned processes as described above		

Phase 2 (Execution of Pilot Works and Utilization of Results)

In Phase 2, EMA will formulate a work schedule for the pilot area for which they will independently develop topographic maps, and will develop the topographic maps while implementing progress control and quality control under the work schedule. The pilot area will be an area with high utilization potential and within the range in which EMA can work independently and will finally be determined through discussions with EMA.

The strengthening of the EMA system including management and sale of topographic maps and tie-ups with other organizations will also be included in the technology transfer plan. The concept of the technology transfer plan in Phase 2 is shown below.

Table 32 Concept of Technology Transfer Plan (Phase 2)

Item	Phase 2		
	Goal	Means of Attaining Goal	Evaluation Method
Creation of project management manual	Understanding of the Project Management Manual	Creation of the "Project Management Manual" jointly by EMA and the Study Team	Evaluation of the "Project Management Manual"
Process Control	EMA can independently conduct process control and grasp the progress of works.	Formulation and updating of process sheet	Evaluation of process sheet
Quality Control	Understanding of quality control procedures	Execution of quality control under the work specifications	Evaluation of level of understanding of the work specifications
	EMA can independently conduct quality control.	Preparation of accuracy control report	Evaluation of accuracy control report
Strengthening of topographic map production system	A system to allow EMA to independently implement sustainable topographic map management is established.	Strengthening of the system under the activity schedule	Evaluation of "technical aspect" and "organizational aspect" in accordance with PCM
Strengthening of topographic map sales process	A system to allow EMA to independently carry out sustainable sales of topographic maps is established.	Strengthening of the system under the activity schedule	Evaluation of "organizational aspect" in accordance with PCM
Website creation	Understanding of website operation technology	Technology transfer in website operation	Evaluation of website system maintenance capacity
Promotion of utilization	EMA can independently set up and coordinate JCC. EMA can independently coordinate with related agencies. EMA can hold seminars.	Joint work by EMA and the Study Team	Evaluation by goal-attainment level for the goals set after the end of Phase 1

5-2. Necessary Equipment for Technology Transfer

The following equipment required for the technology transfer has all been procured and installed and verification of operation has been completed.

Table 33 Equipment and Materials for Technology Transfer

1st Term		
Equipment	**Qty.**	**Target Work**
GNSS Survey Equipment Set	4	Photo control point survey
Laptop and software for GNSS analysis	1	Photo control point survey
Digital Camera	8	Field identification/Supplementary field verification
Handheld GPS receiver	8	Field identification/Supplementary field verification
Color Laser Printer	1	All
Aerial Triangulation/Plotting Integrated Software	1	Aerial triangulation, Digital plotting
Plotting/Editing Linking Software	1	Digital plotting
Plotting/Editing CAD Software	2	Digital plotting/editing/Compilation, Symbolization
Map Editing Software	1	Aerial triangulation, Digital plotting
Workstation	1	All
USB Hardware Key	1	Aerial triangulation, Digital plotting
Stereoscopic Display	1	Aerial triangulation, Digital plotting
Photogrammetry Mouse	1	Aerial triangulation, Digital plotting
Desktop Computer for Editing/Structuration	1	Digital plotting/editing/Compilation, Symbolization
Editing Monitor	2	Digital plotting/editing/Compilation, Symbolization
Uninterruptible Power Supply (UPS)	3	All
Anti-virus Software	2	All
Office 2010	2	All
2nd Term		
Equipment	**Qty.**	**Target Work**
Project Management Software for Photogrammetry	2	Aerial triangulation, Digital plotting
Stereoscopy Software	2	Aerial triangulation, Digital plotting
Plotting/Editing Linking Software (Cooperation with stereo environment and CAD)	2	Aerial triangulation, Digital plotting
Plotting/Editing Software (DEM Creation)	1	Aerial triangulation
Plotting/Editing Software (DEM Editing)	1	Aerial triangulation
Plotting/Editing CAD Software	3	Digital plotting/editing/Compilation, Symbolization
Map Editing Software	1	Digital editing/Generalization
GIS Structuration Software	1	GIS structuration/Website creation
GIS Utilization Software	1	GIS structuration/Website creation
Workstation	2	Aerial triangulation, Digital plotting
USB Hardware Key	2	Aerial triangulation, Digital plotting
Stereoscopic Display	2	Aerial triangulation, Digital plotting
Photogrammetry Mouse	2	Aerial triangulation, Digital plotting
Desktop Computer for Editing/Structuration	2	Digital editing/Compilation, Symbolization
Editing Monitor	4	Digital editing/Compilation, Symbolization
Data Server (HDD capacity: 4TB or equivalent)	2	Website creation
Map Output Printer	1	All
Uninterruptible Power Supply (UPS)	7	All
LAN Cable	10	All
Switch Hub	2	All
Anti-virus Software	4	All
Office 2010	4	All
Website Creation Hardware	1	Website creation
Website Creation Software	1	Website creation

5-3. Outputs of Each Technology Transfer

(1) Technology Transfer in Field Identification

The technology transfer was implemented in the form of OJT in the series of work for "field identification" in the Work in Ethiopia between February and April 2014.

Table 34 Impact and Problems of the Technology Transfer

Item	Contents	Impact and Problems	Countermeasure
Understanding of the purposes and contents of the work	Role in the entire process, purposes and methods of the work, understanding of the items to be identified	The team members were able to provide practical technical explanations and practices relevant to the actual work to the trainees and the trainees were able to fully understand the purposes and contents of the work and practiced it.	The quality of the work output shows that the level of understanding of the trainees of the work is so high that they can implement the work without problems.
Process control	Implementation of the work in conformity with the work schedule	The trainees were able to carry out the work aware of the deadline and work load and prioritizing the work contents. It is necessary for them to improve their understanding of "work management" as staff in a "leadership position."	The goal of the supplementary field verification will be for the EMA engineers to take as much initiative as possible in the entire process from planning, through preparation, field work and verification to data sorting. Each team is to execute the work while implementing quality and process control utilizing the progress confirmation sheets and check sheets.
Quality control	Implementation of the work in conformity with quality standards	The trainees were able to pay attention to the work quality in the data sorting and checking. It is necessary for them to improve their understanding of "quality control" as staff in a "leadership position."	
Level of self-learning in EMA	Understanding of the work and revision of the manuals	A new method different from the methods which had been used in EMA was presented. The trainees were able to review the work anew and digest it by revising the manual. EMA's immediate action in planning individual topographic mapping work using the new method shows us the positive effects of the experience of technology transfer.	The implementation of supplementary field verification is to be used as an opportunity to use the experience mentioned on the left to transfer the work to independent implementation by EMA engineers.

Evaluation of Technology Transfer

- The trainees were able to recognize and solve the questions and problems concerning the work in the meetings and implement the work smoothly.
- The engineers who carried out the work with the Study Team members had improved their technical capacity to a level at which they could perform the work independently thanks to the direct guidance from the team members.
- The trainees were able to collect required reference materials from the relevant organizations in accordance with the map symbol rules.
- The trainees observed the work schedule and were able to complete the work within the specified period.
- The trainees were able to ensure data quality by conducting data sorting and inspection after the completion of the field work.
- The trainees were able to revise the manual with full understanding of the purposes and details of the work and experience acquired in the actual work.

(2) Technology Transfer in Supplementary Field Verification

Supplementary field verification is the final field verification before the creation of topographic maps. It consists of field verification of the questions raised and ambiguities identified by the plotting operators, field verification of the plotted topographic maps and field surveys of other relevant information.

As 16 of the 18 participants in the work in Ethiopia between February and April 2014 were engineers involved in the field identification, the objective of the technology transfer was for them to use the experience gained in the field identification effectively to implement the supplementary field verification as independently as possible.

Table 35 Details of the Technology Transfer in Supplementary Field Verification

Item	Objective	Form
General explanation	Understanding of the work	Lecture
Trial work	Understanding of the work, map interpretation, compilation of the survey results, operation of the equipment	Practice
Supplementary field verification in the field	Interpretation of maps, compilation of the survey results, operation and maintenance of the equipment	Practice, meeting
Data compilation in the office 1 (on inspection and accuracy control of the survey results)	Compilation and management of the survey results	Lecture, practice
Data compilation in the office 2 (compilation of the survey results and data entry)	Compilation of the survey results, operation of the equipment	Lecture, practice
Revision of the work manual	Manual	Working group

Evaluation of Technology Transfer

The participants were able to understand the work procedures and implement the supplementary field verification smoothly by implementing daily time management, responding to questions and exchanging information in the OJT. Their technical level has reached a level at which they can utilize equipment such as handheld GPS receivers for acquisition of new information without problems. They still need to accumulate experience in activities concerning data quality, such as inspection and compilation of data, intensively to improve the quality of the actual work.

Table 36 Criteria for Evaluation in Supplementary Field Verification

Item	Criteria
Capacity to understand and answer questions	The participants are able to understand the contents of the instructions for supplementary field verification (questions and requests given by plotting operators) and provide appropriate responses to the instructions on the basis of the results of the field verification.
Capacity to verify features in the field	The participants are able to verify the locations, types and required information of the subjects of supplementary field verification in the field.
Capacity to understand the work	The participants are able to implement the supplementary field verification with an understanding of its purposes and methods.
Data compilation	The participants are able to describe the verification results correctly, sort and inspect the collected data and digitize them.
Time management	The participants are able to prepare a plan for the supplementary field verification in order to implement and complete it within a limited time period.

(3) Technology Transfer in the Installation of Aerial Signals and Photo Control Point Survey

The photo control point survey consists of installation of photo control points on the ground and observation of these points to locate aerial photographs and satellite images with accurate coordinate values. An aerial signal is a marker installed at the location of a control point in the photo control point survey before the aerial photography is conducted.

The technologies for the installation of aerial signals and photo control point survey were transferred to a total of 12 EMA engineers of the Geodetic Survey Team in March 2015.

Table 37 Details in Installation of Aerial Signals and Photo Control Point Survey

Item	Outline	Form
Outline (of the photo control point survey, installation of aerial signals and pricking), specifications	Understanding of the work, specifications	Lecture
Introduction to GNSS surveying outline and the equipment used	Understanding of the work, specifications, operation of the equipment	Lecture, practice
Practical work in GNSS surveying (planning and observation)	Specifications, planning, operation of the equipment	Lecture, practice
Practical work in GNSS surveying (analysis and calculation)	Specifications, operation of the equipment, accuracy control	Lecture, practice
Accuracy control	Specifications, accuracy control	Lecture, practice
Installation of aerial signals	Specifications, planning, operation of the equipment	Practice

Table 38 Evaluation in Installation of Aerial Signals and Photo Control Point Survey

Content	Evaluation method and result
Lecture using the Photo Control Point Survey Manual and draft work specifications (hereinafter, work specifications) on the roles of the photo control point survey, installation of aerial signals and pricking in topographic mapping and the methods provided and the accuracy required in the work specifications	• The participants were able to improve their understanding of the methods, inspection and accuracy control provided in the specifications that they had not practiced in their ordinary work.
Lecture on the theories of GNSS surveying at introductory level, types of GNSS surveys, methods used in different types of surveys and method to determine locations on the ground using satellites	• The participants improved their understanding of the differences in accuracy of different observation methods. • They improved their understanding of the necessity to determine distances from satellites which were investigated at the stage of analysis and calculation after the observation. • They were able to understand that the basic composition of the new equipment was the same as that of the equipment that they had been using at EMA and they understood the new functions of the new equipment by actually operating it
Lecture and practice in the planning of an actual GNSS survey (reconnaissance, point selection and observation planning) and observation in the survey to follow up the	• The participants were able to recognize the differences between the method described in the work specifications and the plan actually adopted and understand the “advantages and disadvantages” of the two.

lectures mentioned above	• They were able to understand the necessity to develop an observation plan taking into consideration inspection and evaluation. • They were able to develop a work schedule and personnel assignment schedule with limited personnel and equipment. • They were able to respond to the problems that occurred in observation (including poor reception of satellite signals and erroneous settings) under the leadership of their leader and complete the observation.
The participants practiced input of GNSS observation data in the PC for calculation and analysis and calculation using the customized software. Their level of understanding of basic matters was sufficient because of their experience in ordinary work. However, as they had not performed inspection and evaluation in the calculation process, the focus of the practice was put on inspection and evaluation.	• The participants were able to perform the inspection and evaluation required in observation planning and understood their importance. • The young engineers, in particular, were able to understand the flow and procedures for analysis and calculation by repeated self-training. • The participants were able to understand that the quality of the observation planning affects the quality of the inspection and evaluation and the final results of the analysis and calculation process.
Lecture on various inspection methods and accuracy control in the planning, observation and calculation processes using the work specifications and (draft) Accuracy Control Manual	• The participants were able to understand that implementation of planning, observation, inspection and calculation in compliance with the work specifications ensured the quality of the results and kept the accuracy of the results within the set limits.
The participants practiced installation of aerial signals in the field. They created actual aerial signals with the sizes and forms in compliance with the work specifications and installed them on existing control points.	• The participants understood the need to change the sizes of the aerial signals depending on the scales of the topographic maps to be created.

Evaluation of Technology Transfer

The participants were able to perform basic works in the photo control point survey, GNSS survey and installation of aerial signals as they had performed them already in their work. However, they had not performed inspection, evaluation and accuracy control in either of these processes in their work. They understood that poor inspection and evaluation results required re-observation (implementation of new field observation at locations where the quality of the observation results was poor). They were also able to improve their understanding of the process of preparing an observation plan taking into consideration inspection and evaluation, performing inspection and evaluation at various stages and making a final decision on the observation using the final results which had passed such inspection and evaluation, instead of simply evaluating the observation only by the final calculation results.

The Study Team considers that the participants will have to apply the accuracy control learned in this technology transfer in their ordinary work on a daily basis to ensure the quality of the work.

(4) Technology Transfer in Aerial Triangulation/Aerial Photography Planning

1st Term

Prior to the implementation of the technology transfer (in aerial photography planning, aerial triangulation, creation of orthophotos and creation and editing of DTMs) in the second term, the Study Team surveyed the current status concerning the above-described technology transfer items. The Study Team also implemented part of the technology transfer concerned in the first term.

Table 39 Impact and Problems in Aerial Triangulation/Aerial Photography Planning

Item	Contents	Impact and Problems	Countermeasures
Aerial triangulation	Explanation of the principles was partly implemented in the form of lectures	Technology transfer in the second term will be implemented smoothly by explaining the principles and examining the level of knowledge of EMA staff at the same time	Improve the understanding of the principles of aerial photogrammetry of the trainees by practice in practical work using the system to be introduced and train them to be able to implement the work independently by having them master operation of the system at the same time
Aerial photography planning	Explanation of the principles was partly implemented in the form of lectures	Technology transfer in the second term will be implemented smoothly by explaining the principles to EMA staff and examining the level of their knowledge at the same time	

2nd Term

The table below shows the schedule of the technology transfer in aerial triangulation, aerial photography planning and creation of digital orthophotos (DTMs).

Table 40 Schedule in Aerial Triangulation/Aerial Photography Planning

Period (2014)		Content (lecture and practice)	Outcome
(2nd technology transfer) July to August 2014	Week 1	Geometric principles of photogrammetry	The participants were able to diagram the geometric relationship when an aerial photograph is taken between the lens, camera and object (ground surface) and to understand the relationships between the focal length, elevation above the ground, image sensor, resolution at ground level, map sheet size, photo scale and photographed area, etc.
	Week 2	Coordinate systems for analytical photogrammetry	The participants were able to diagram the geometric relationship between a pair of stereo images (left and right) and define multiple coordinate systems (photograph, model and ground coordinate systems) linking a monaural photograph, pair of stereo images and the object of photography (ground surface)
	Week 3	Procedures for aerial triangulation	The participants were able to perform aerial triangulation of the area covered by the forty models on three flight courses near Adama City selected as the sample data for the practice on a trial basis and to understand the procedures for aerial triangulation.
	Week 4	Analysis procedures using the LPS System	The participants were able to understand the procedures for creation of DTMs and orthophotos using the outputs of aerial triangulation.
	Week 5	Theories relevant to quality control	Regarding the outputs of aerial triangulation, the participants were able to acquire the knowledge at introductory level of the “least-square method,” a method to estimate the true values from data containing errors.
	EMA’s own training course (sharing of the contents of the technology transfer within EMA and training in data exchange between the existing photogrammetry software and the photogrammetry software procured in this Project)		

(3rd technology transfer) July to August 2015	Week 1	Aerial triangulation practice and quality control	The participants were able to perform aerial triangulation of the area covered by the 40 models on three flight courses near Adama. They were also able to evaluate the outputs based on the Quality Control Manual and create an Accuracy Control Table.
	Week 2	DEM creation and DEM editing	DEM could be automatically created based on the results of aerial triangulation. The participants were able to create and edit DEM after attending a theoretical lecture on trends in automatically generated DEM errors and corrections and practicing DEM editing.
	Week 3	Orthophoto creation	The participants were able to create orthophotos after creating orthophotos using the results of aerial triangulation and edited DEM.
	Week 4	Orthophoto quality control ORIMA software operation	The participants could evaluate the created orthoimages based on the Quality Control Manual and create an Accuracy Control Table for the corrected final results.
	Week 5	Evaluation of technology transfer	The level of understanding of the EMA trainees and the operations and quality were evaluated and the results compiled.

Evaluation of Technology Transfer

Through the lectures and practice, the trainees understood the basic theory and could perform basic software operations at the same level (speed, accuracy) to a certain extent. They could also perform applied operations such as aerial triangulation of satellite images as well as aerial photographs, exchange of outputs with other software and correction of the quality control results.

Table 41 Evaluation in Aerial Triangulation/Aerial Photography Planning

Item		Objective	Evaluation method and result
Understanding of theory	Aerial photography planning	The participants are able to prepare a plan appropriate for the photo scale using the software.	The participants were given the task of drawing a photography plan map with given specifications (including photo scale and ratios of overlapping and side-lapping) in the lecture. They were able to improve their understanding by correction of errors in the elevation above the ground, etc.
	Aerial triangulation	The participants are able to understand the theories of aerial triangulation.	After an explanation of the pattern of rotational transformation of coordinates was provided in the lecture, the participants were given the task of finding another pattern of transformation. They reached the correct answer while discussing the task among them.
	Creation of orthophotos and DTMs	The participants are able to understand the theories for the creation of DTMs and orthophotos	The participants were given the task of creating orthophotos and DTMs in the practice with given sample data after instruction in the procedures used in the LPS System. Supplementary theoretical explanation was given on the products of the task (both correct and incorrect) to improve their understanding.
	Application	The participants are able to use data between different types of software.	In EMA's own training, the participants were given the task of manipulating data between the photogrammetry software used by EMA and the photogrammetry software procured in this Project after which they were able to perform the task themselves, so there will be no third technology transfer for this item.
Performance	Aerial triangulation	Improvement of processing skills	In the second technology transfer, processing of 40 models on three flight courses took 35 hours by a fast operator, but in the third technology transfer processing by even the slowest operator took only 20 hours.
	Creation of orthophotos and DTMs	Improvement of understanding and practical skills in orthophotos and	In the second technology transfer, creation of orthophotos/DTMs of 10 aerial photos on two flight courses required three days, but in the third technology transfer, the participants were able to create

Item		Objective	Evaluation method and result
		DTM processing	orthophotos/DTMs of 40 aerial photos on three flight courses in two days.
Quality	Aerial triangulation	Adjustment of position of tie-point observation	In the second technology transfer, as the participants did not understand the ideal position of tie-point observation and inappropriate observation locations adversely affected the calculation results, a second placement of all the tie-points was unavoidable. In the third technology transfer, the participants built on their experience in the second technology transfer and succeeded in doing the calculations with the first tie-point placements.
	Creation of orthophotos	Improvement of quality control capability	The participants were able to do the work based on the quality control manual. They were able to carry out efficient checks taking into consideration DTMs and seam lines and create an appropriate accuracy control table.

(5) Technology Transfer in Digital Plotting

The table below shows the schedule of the technology transfer in digital plotting.

Table 42 Schedule of the Technology Transfer in Digital Plotting

Period		Content	Outcome
(1st) July to August 2014	Week 1	Installation of the equipment Introduction to the technology transfer Questionnaire and interview surveys Basic operation of the CAD software (MicroStation) Practice in symbol creation for digital plotting	PowerPoint presentation on the outline of digital plotting Questionnaire Manual for Basic Operation of the CAD Software (MicroStation) (draft)
	Week 2	Practice in symbol creation for digital plotting	Manual for Symbol Creation for Digital Plotting
	Week 3	Practice in configuration of the stereo viewing software (PRO600)	PRO600 Configuration Manual
	Week 4	Practice in 3D digital plotting Evaluation of the technology transfer	
(2nd) September to November 2014	Week 1	Installation of the equipment	Software Installation Manual
	Week 2		
	Week 3	Review of the outcome of the technology transfer in the first term (symbol creation for digital plotting and basic operation of the CAD software)	Manual for Basic Operation of the CAD Software (MicroStation)
	Week 4	Understanding of the map symbols of 1/10,000 maps Lecture on how to capture features at a scale of 1/10,000 Practice in capturing planimetric features	Digital Plotting Work Manual
	Week 5	Practice in capturing spot elevations and contours	
	Week 6	Practice using the data of the training area	Digital plotting data of two map sheet areas
	Week 7		
	Week 8	Evaluation of the technology transfer	
(3rd) April to May 2015	Week 1	Theory of contour mapping suitable for 1/10,000 maps	Contour check maps of two map sheet areas
	Week 2	Correction of contours at a scale of 1/10,000	Contour correction data of two map sheet areas
	Week 3	Planimetry suitable for 1/10,000 maps and correction of planimetric features	Planimetric feature check sheets of two map sheet areas
	Week 4	Practice in digital plotting at a scale of 1/10,000	Start of practice in digital plotting with the southern and eastern areas of the plotting area as the training area
	Week 5		

EMA's Independent Practice Period (June – July 2015)			
(4th) July to September 2015	Week 1	Practice in digital plotting at a scale of 1/10,000	Work in Ethiopia and digital plot sheets of the adjoining southern and eastern areas consisting of 16 map sheet areas
	Week 2		
	Week 3		
	Week 4	Digital plotting quality control and data correction at a scale of 1/10,000 Digital plotting and joining at a scale of 1/10,000	Check sheet of one map sheet area
	Week 5	Digital plotting quality control and data correction at a scale of 1/10,000 Discussion of specifications for other map scales	Check sheets of two map sheet areas
	Week 6	Practice in correcting changes over time using satellite images Application to other map scales	Correction of changes over time of one map sheet area 1/5,000 topographic map symbols (draft)
	Week 7	Outline of process control	Samples of process control tools
	Week 8	Evaluation of the technology transfer	
(5th) January to February 2016	Week 1	Practice in digital plotting at a scale of 1/10,000 (quality control)	Digital plotting work for evaluation (one map sheet per operator)
	Week 2		
	Week 3		
	Week 4	Evaluation of digital plotting at a scale of 1/10,000 Lecture on specifications of digital plotting at a scale of 1/5,000 (Addis Ababa) Practice in digital plotting at a scale of 1/5,000 (Addis Ababa)	Work speed and quality were evaluated for two operators.
	Week 5		
	Week 6		
(6th) March to April 2016	Week 1	Practice in digital plotting at a scale of 1/10,000 (quality control)	Digital plotting work for evaluation (one map sheet per operator)
	Week 2		
	Week 3		
	Week 4	Evaluation of digital plotting at a scale of 1/10,000 Practice in digital plotting at a scale of 1/5,000 (Addis Ababa)	Work speed and quality were evaluated for three operators.
	Week 5		
	Week 6	Evaluation of the technology transfer	

Evaluation of Technology Transfer

An average of five operators participated in the technology transfer from May 2015 to April 2016. Three of them had experience in analog plotting and two had almost no experience.

As a result of training, the participants mostly understood necessary software operation and the work speed of all the five participants improved by the end of the training. With respect to quality, a reducing trend of errors was observed for the work of all the five participants (see tables below). In particular, it is considered that in addition to the elimination of obvious mistakes, such as "unconnected roads, rivers and contour lines" and "inconsistency between contour lines and rivers", reduction of inappropriate excessive acquisitions at a scale of 1/10,000 (both in terms of shape and size) led to the improvement of speed as well as quality.

As the subsequent training in digital editing helped the participants understand the content of errors that turn out to be logic errors in digital editing and which inhibit the creation of polygons, they became able to perform data acquisition in digital plotting based on the awareness of digital editing.

Also, in the latter half of this training, practice in digital plotting at 1/5,000 for Addis Ababa was started based on the newly procured satellite images. This enabled them to work while comparing the specifications and acquisition standards with those of the scale of 1/10,000 and promote the understanding of the difference in scales.

The final evaluation confirmed that digital plotting at 1/10,000 can be carried out at an average speed of 103km/day. Since the average total length of features generated on 1/10,000 map sheets is about 1,100km, the work can be completed in slightly more than 10 days, considering the time required for inputting symbols, etc.

As the average work speed of each operator was understood, practice in process control using bundled software (Microsoft Excel) was also implemented to enable progress control prior to the work.

Table 43 Evaluation and Issues of the Technology Transfer in Digital Plotting

Item	Objective	Content	Evaluation method and result	Issues for the next term
Understanding of the purpose and details of the work	To understand the specifications for 1/10,000 topographic maps	Training in the creation of the map symbols described in the specifications with CAD software	The participants became able to create symbols at a scale of 1/10,000 without any problems.	Self-training from large scale to small scale
	To understand the criteria for capturing features for 1/10,000 scale digital plotting	Provision of lecture Practice using the training area consisting of two map sheet areas	Introduction of the inspection of printed map sheets enabled the participants to understand excessive acquisitions inappropriate for the scale of 1/10,000.	Nothing in particular
	To understand the procedures for capturing features for 1/10,000 scale digital plotting	Provision of lecture Practice using the training area consisting of 16 map sheet areas	The participants were able to reduce excessive acquisitions inappropriate for the scale of 1/10,000.	Extension of technology to untrained operators
	To understand the basics of 3D interpretation	Practice using the training area consisting of 16 map sheet areas	Implementation of matching in the digital editing training with feedback enabled the operators to work based on the awareness of standardization.	Continuation of training for standardization to achieve higher work efficiency
Performance	Japanese Operator level	Aggregation of the training area consisting of 16 map sheet areas	Although the work speed at this point is about a half of the speed of Japanese operators, it is considered adequate in view of the balance with quality.	Continuation of training to increase the speed and overall improvement
Quality	To implement quality control themselves	Results of inspection of map sheet areas for quality control	Critical errors have almost been eliminated and excessive acquisitions also decreased. The participants became able to perform data acquisition in consideration of the efficiency in subsequent digital editing.	Overall improvement to the level of the operator with fewest errors

(6) Technology Transfer in Digital Editing

The table below shows the schedule of the technology transfer in digital Editing.

Table 44 Schedule of the Technology Transfer in Digital Editing

Period		Content	Outcome
(1st technology transfer) November to December 2014	Week 1	General explanation of digital editing and understanding of the basic operation and functions of the CAD software	Understanding of the details of digital editing Acquisition of how to operate the software
	Week 2	Understanding of the map symbols and map editing functions	Understanding of the rules on data creation in compliance with map symbol regulations implemented separately Mastering of the basic and advanced commands of the editing functions
	Week 3	Practical lesson on data cleaning and creation of polygons (using sample data) Acquisition of how to edit contours	Acquisition of how to display data by category and detect and correct errors Acquisition of how to edit contours, inspect contour data for errors and correct errors
	Week 4	Review by individual participants Practice in editing using actually plotted data	Improvement of the level of understanding of software operation and editing work through repeated practice
(2nd technology transfer) August to October 2015	Week 1	Correction of contours and review of data cleaning process	Review of work content of technology transfer in first year of Project
	Week 2	Confirmation of entire digital editing workflow Mastery of digital editing preparations	Understanding of entire digital editing workflow Understanding of meaning of application of common data settings for digital editing and mastery of procedures
	Week 3	Mastery of annotation input settings and work procedures Mastery of administrative boundary input work	Mastery of annotation input and administrative boundary input work procedures
	Week 4	Practice in digital editing processes using training area data	Understanding of flow of series of work using actual plotting data
	Week 5	Mastery of data check procedures for each data layer Mastery of error data correction procedures	Mastery of data check procedures Mastery of error correction procedures Feedback to quality control of digital plotting work based on understanding of error content
	Week 6	Training in recovery work by themselves	Improvement of operation and understanding of work by repeated practice
(3rd technology transfer) November to December 2016	Week 1	Review of the work schedule and procedures	
	Week 2	Practice in digital editing	Map data for evaluation (4 sheets)
	Week 3		
	Week 4		
	Week 5	Evaluation of the practice in digital editing	Evaluation of the speed and quality of the work of four operators
(4th technology transfer) May to June 2016	Week 1	Practice in digital editing	Map data for evaluation (4 sheets)
	Week 2		
	Week 3	Accuracy control in digital editing	Explanation and practice of the method to evaluate quality of the edited data
	Week 4	Evaluation of the practice in digital editing	Evaluation of the speed and quality of the work of four operators

	Week 5	Lecture on and practice in generalization	Thinning of contours Thinning of plotting single points
(5th technology transfer) August 2016	Week 1	Lecture and review on generalization	List of processing methods by layer
	Week 2	Practice in generalization	Understanding of the generalization methods
	Week 3		
	Week 4	Practice in generalization and evaluation of the practice	Improvement of the understanding of generalization work

Evaluation of the Technology Transfer and Tasks to be Performed

Approx. 10 operators participated in each of the five technology transfer sessions conducted between November 2014 and August 2016. After implementation of the first technology transfer, the participants understood basic CAD software operations and the data cleaning workflow. Through the second technology transfer, they understood data editing of each layer and the data cleaning procedures as well as understanding the entire digital editing workflow. In the third and fourth technology transfer, the participants understood the procedures used in the entire digital editing process and improved the work speed and accuracy with repeated practice. In the latter half of the fourth technology transfer and in the fifth technology transfer, the participants learned the generalization procedures.

None of the participants of the technology transfer had experience in using the editing software (MicroStation). However, as the participants used the same software they had used in the technology transfer in digital plotting and symbolization implemented concurrently, their technical capacity in operating the software improved significantly. The evaluation of the technology transfer revealed the improvement in the work speed of all the four evaluated participants. The quality of their work was also improved as the evaluation revealed a reduction in the numbers of errors. The repeated practice is believed to have been the cause of such improvement. Although the levels of understanding differed among the participants, they acquired general understanding of the setting of thresholds of the data cleaning tool, which had been a problem for them, and each of them became able to set a threshold appropriate for the data contents.

The focus of the technology transfer in generalization was on the understanding of the map specifications. The participants prepared a generalization manual while each of them considered how to edit each type of features in the generalization. They managed to conduct the generalization independently by following this manual.

Table 45 Evaluation and Issues of the Technology Transfer in Digital Editing

Item	Objective	Content	Evaluation method and result	Issues for the next term
Understanding of the purposes and contents of the work	Understanding of theory and standards for editing 1/10,000 topographic maps	Lecture	The results of qualitative evaluation of the level of understanding showed that the trainees who attended the technology transfer in digital plotting had a good understanding of the elements targeted for editing. The trainees from the Mapping Directorate who participated had a good understanding of the quality required for the final outputs. Significant progress was achieved based on the results of the lecture and information sharing by both parties.	N/A
	Understanding of acquisition procedures for digital editing at a scale of 1/10,000	Lecture Practice using sample data of one map sheet area	The results of qualitative evaluation of the level of understanding showed that the trainees who attended the technology transfer in digital plotting had a good understanding of software editing operations. In addition, the technology was appropriately communicated to the participants from the Mapping Directorate.	
	Understanding of theory and procedures for polygon creation	Lecture Practice using sample data of one map sheet area	The results of qualitative evaluation of the level of understanding showed that it was the first time for all the trainees, therefore, in the early stage of the technology transfer, the Japanese experts explained the theory and procedures and the participants tried to learn them by imitating what the experts did. In the later stages, their initiatives began to emerge in the practice. For example, they gained a better understanding of the thresholds by processing data with different thresholds set by themselves.	
	Independent execution of digital editing at a scale of 1/10,000	Practice in the training area consisting of two map sheet areas	The results of qualitative evaluation of the content of editing work and data being edited showed that several of the trainees had a good understanding of the theory of editing and the work procedures. The other trainees performed digital editing themselves while checking the work procedures with trainees with a higher level of understanding. When a problem arises, increasingly the trainees discuss it and solve it themselves. Major progress was made towards performing the work independently.	N/A
	Understanding of theory and standards of reduction (from 1/10,000 to 1/25,000 scale)	Lecture Practice using sample data of one map sheet area	The participants conducted a comparative study of the map specifications for the two types of topographic maps and completed the compilation of the generalization manual based on the results of the study independently. The result of qualitative evaluation revealed that they had understood the theory of the generalization and become able to implement it independently.	Further improvement in the work speed with repeated practice and actual work experience
	Quality control	Lecture Practice with data of two map sheet areas in the training area	The participants have understood the theory and procedures of the quality control and become able to control the quality of edited data mutually.	Improvement of awareness to the quality through the implementation of quality control and further improvement in the quality of the work itself

(7) Technology Transfer in Symbolization

The table below shows the schedule of the technology transfer in symbolization.

Practice data prepared by the Study Team were used in the training in the first technology transfer because the processing of data of the pilot area in the preceding stage had not been completed yet. Because the digital editing of data of a map sheet area in the pilot area had been completed, the data of the map sheet concerned were used in the training in the second technology transfer.

Because the digital editing of data of multiple 1/10,000 map sheet areas had been completed, these edited data were used in the training in the third technology transfer. The 1/25,000 map data prepared by the Study Team for the practice were also used in the training.

Table 46 Schedule of the Technology Transfer in Symbolization

Period		Content	Outcome
(1st technology transfer) July to September 2015	Week 1	Investigation of the engineers' level and formulation of the technology transfer plan	Grasp of experience and technical level of C/Ps
	Week 2	○ Team 1 Understanding of theory of symbolization Understanding of how to create map symbols Understanding of how to operate symbolization software	Understanding of theory of symbolization Mastery of how to create map symbols Mastery of how to operate symbolization software
	Week 3	○ Team 1 Understanding of theory and procedures of transfer Understanding of how to adjust annotations Understanding of how to adjust the positional relation between features according to the priority level of the features	Understanding of theory and procedures of transfer Mastery of how to adjust annotations Mastery of how to adjust the positional relation between features
	Week 4	○ Team 1 Understanding of the theory and procedures of hidden line removal Understanding of how to remove hidden contours Understanding of how to remove duplicated hidden feature lines	Understanding of the theory and procedures of hidden line removal Mastery of how to remove hidden contours Mastery of how to remove duplicated hidden feature lines
	Week 5	○ Team 2 Understanding of the theory of symbolization Understanding of how to create map symbols Understanding of how to operate symbolization software	Understanding of the theory of symbolization Mastery of how to create map symbols Mastery of how to operate symbolization software
	Week 6	○ Team 2 Understanding of theory and procedures of transfer Understanding of how to adjust annotations Understanding of how to adjust the positional relation between features according to the priority level of the features	Understanding of theory and procedures of transfer Mastery of how to adjust annotations Mastery of how to adjust the positional relation between features
	Week 7	○ Team 2 Understanding of the theory and procedures of hidden line removal Understanding of how to remove hidden contours Understanding of how to remove duplicated hidden feature lines	Understanding of the theory and procedures of hidden line removal Mastery of how to remove hidden contours Mastery of how to remove duplicated hidden feature lines

	Week 8	Evaluation of technology transfer	Results of questionnaire on level of understanding
(2nd technology transfer) November to December 2015	Week 1	○ Team 1 Refresher training on the training items in the previous training using the data of the pilot area	Reminding forgotten training items in the previous training by practicing the training items in the previous training again
	Week 2	○ Team 1 Understanding of how to create polygon data Understanding of the order of display of map symbols Understanding of how to make a polygon transparent	Mastery of how to create polygon data Understanding of the order of display of layers Mastery of how to make a polygon transparent
	Week 3	○ Team 1 Understanding of how to create marginal information Understanding of how to create a map sheet to be printed ○ Team 2 Refresher training on the training items in the previous training using the data of the pilot area	Mastery of how to create marginal information Mastery of how to create a map to be printed Reminding forgotten training items in the previous training by practicing the training items in the previous training again
	Week 4	○ Team 2 Understanding of how to create polygon data Understanding of the order of display of map symbols Understanding of how to make a polygon transparent	Mastery of how to create polygon data Understanding of the order of display of layers Mastery of how to make a polygon transparent
	Week 5	○ Team 2 Understanding of how to create marginal information Understanding of how to create a map sheet to be printed	Mastery of how to create marginal information Mastery of how to create a map to be printed
	Week 6	○ Teams 1 and 2 Understanding of the quality control method Understanding of how to complete the accuracy control table	Mastery of the quality control method Mastery of how to complete the accuracy control table
(3rd technology transfer) May to July 2016	Week 1	Inspection of the data of the training area created by the counterparts	Symbolized map sheets of the training area (3 sheets)
	Week 2	Correction of the data of the training area	Symbolized map sheets of the training area (3 sheets)
	Week 3	Correction of the data of the training area	Symbolized map sheets of the training area (3 sheets)
	Week 4	Evaluation of the outputs of the symbolization	Results of the evaluation of the speed and quality of the work of the three teams
	Week 5	Transfer of the technologies for the symbolization of 1/25,000 maps	Understanding of the theory of and procedures for the symbolization of 1/25,000 maps
	Week 6	Transfer of the technologies for the symbolization of 1/25,000 maps	Mastery of how to symbolize 1/25,000 topographic maps

Evaluation of the Technology Transfer and Tasks to be Performed

The results of the questionnaire inquiries and quizzes conducted several times during the technology transfer have confirmed that most of the counterparts have understood “the theory of symbolization,” “how to create map symbols,” “the theory and method of the transfer processing,” “the theory and method of processing hidden lines,” “the theory on the order of display of map symbols,” “how to create marginal information,” “how to create map sheets to be printed” and “the quality control method.”

The results of the inspection of the output of the initial training, the three map sheets of the training area symbolized by the counterparts independently and the three map sheets of the training area symbolized by the counterparts at the time of the measurement of the work efficiency were compared for the evaluation of the quality of the outputs. The number of errors identified on a map sheet, which was approximately 40 per sheet in the initial training (implemented between August and December 2015), was reduced to less than 20 and less than 15 at the time of the independent symbolization (between January and May 2016) and the evaluation of the work efficiency (in May and June 2016), respectively. This observation shows that the repeated practice reduced the numbers of errors. The difference in the number of errors between the teams does not relate to the difference in their capacities because the difference was mainly derived from the difference in the difficulty in symbolizing map sheets. (The difficulty increases as the number of features on a map sheet increases.) Because map sheets displayed on a computer screen and printed on paper look a little different, the inspection was conducted with the maps printed on paper as final outputs. Since no serious problem is expected to emerge from the existence of 15 errors per map sheet, the counterparts are considered to have conducted the quality evaluation appropriately.

Table 47 Evaluation and Issues of the Technology Transfer in Symbolization

Item	Objective	Contents	Evaluation method and result	Issues for the next term
Understanding of the purposes and contents of the work	Understanding of the theory and standards of 1/10,000 map symbolization	Lecture	• As a result of qualitative evaluation, the trainees were judged to understand the basic theory of symbolization. • Five of the trainees answered all ten questions in the test in the qualitative evaluation correctly and the remaining three trainees got nine answers right.	N/A
	Understanding of procedures for creating 1/10,000 map symbols	Lecture Practice with a number of sample symbols	• As a result of qualitative evaluation, the trainees were judged to understand the basic method of creating map symbols. • From the fact that they were able to complete the training practice within the assigned time, they were judged to understand the procedures.	N/A
	Understanding of theory of transfer and hidden line removal of 1/10,000 topographic maps	Lecture Creation of symbolization data using sample data	• As a result of qualitative evaluation, the trainees were judged to understand the basic methods of transferring, removing hidden lines and creating map symbols. • From the fact that they were able to complete the training practice within the assigned time, they were judged to understand the procedures.	N/A

Item	Objective	Contents	Evaluation method and result	Issues for the next term
	Understanding of display order of map symbols	Lecture Practice using data of (a map sheet area in) the pilot area	The trainees are considered to have understood the procedures because they managed to complete the practice in the training in a given time period. It has been concluded that they have understood the importance of the display order because they proposed a way to improve the order presented by the experts in the training.	Dissemination of the technologies to operators who have not taken the training
	Understanding of procedures for creation of marginal information	Lecture Creation of marginal information using data of (a map sheet area in) the pilot area	The trainees are considered to have understood the procedures because they managed to complete the practice in the training in a given time period. It has been concluded that they have understood the procedures to create marginal information because they gained a better understanding of the procedures by repeating the practice of the procedures by themselves.	Dissemination of the technologies to operators who have not taken the training
	Understanding of procedures for creation of printed map data	Lecture Creation of a map sheet to be printed using data of (a map sheet area in) the pilot area	It has been concluded from the result of the qualitative evaluation that the trainees have understood how to create a map sheet to be printed. The trainees are considered to have understood the procedures because they managed to complete the practice in the training in a given time period.	Dissemination of the technologies to operators who have not taken the training
	Understanding of quality control methods	Lecture Quality control using data of (a map sheet area in) the pilot area	It has been concluded from the result of the qualitative evaluation that the trainees have understood the quality control method. The trainees inspected the outputs independently, compared the inspection results and studied the difference in the results. Because they managed to correct errors identified in the inspection and compile the results of the correction in an accuracy control table, they are considered to have understood these procedures.	Quality control of the work conducted independently by EMA with the data of the pilot area
	Understanding of the theory of the creation of 1/25,000 maps and the map symbols for these maps	Lecture	The procedures to create 1/25,000 topographic maps are almost the same as those to create 1/10,000 maps. Therefore, the trainees managed to understand the procedures to create 1/25,000 maps only by providing supplementary explanation on the differences in the two procedures.	1/25,000 topographic mapping of the pilot area to be implemented independently by EMA
	Symbolization of 1/25,000 maps following predetermined procedures	Practice of the symbolization of a combined map created from the generalized data of the three map sheet areas in the training area	The trainees managed to practice the symbolization of 1/25,000 maps only with the provision of the explanation on the differences in the symbolization procedures for 1/10,000 and 1/25,000 maps and complete the symbolization in a given time period.	Symbolization of maps of the pilot area to be implemented independently by EMA

Item	Objective	Contents	Evaluation method and result	Issues for the next term
Performance	Two-fold improvement in the efficiency of the symbolization with the data of the training area compared with the efficiency of the work at the time of the lecture	Compilation of the data of three map sheet areas in the training area	Comparison of the time required for the trainees to perform the symbolization confirmed that they were able to symbolize maps approx. three times more efficiently than they could have at the time of the lecture.	Further improvement of the efficiency with EMA's own initiative
Quality	Capacity to implement quality control of the outputs of the control area independently	Evaluation of the six map sheets of the training area	The counterparts managed to inspect map sheets and complete an accuracy control table by themselves. However, errors created in the preceding process were detected.	Strengthening of the quality control in each stage of the project coordination between stages

(8) Technology Transfer in GIS Structuration and Website Creation

A survey conducted in the first term revealed the need for technology transfer in the items listed below for realization of creation, structuration and distribution on the website of GIS data (raster and vector data).

Table 48 Technology Transfer Items Related to GIS Structuration and Website Creation

Item	Contents
GIS Structuration	Detailed design of the database
	Creation of schema of feature classes
	Storage and structuration of vector data
	Inspection of vector data for logical errors
	Correction of the errors in vector data
	Automatic creation of mesh data of map sheet areas in all the scales
	Optimization of the vector data display
	Automatic vector data segmentation and integration by mesh of map sheet area
	Data conversion between databases
	Coordinate conversion of GIS data
	Spatial analysis and spatial selection of vector data
	Creation, extraction, statistics and inspection for errors of attribute data
	Utilization of the SQL language for database
	Automatic image segmentation and integration by mesh of map sheet area
	Automatic mapping
Website creation	Utilization of the SQL language for database
	Design of database structure for storage of images
	Optimization of image display
	Coordinated operation of ArcGIS Catalog, ArcGIS Server and SQL Server databases

Table 49 Schedule of the Technology Transfer in GIS Structuration and Website Creation

Period		Content	Outcome
(1st technology transfer) June to July 2014	Week 1	Automatic creation of mesh data by map sheet area at all mapping scales	Acquisition of technologies for automatic processing of mesh data by map sheet area at each standard mapping scale in Ethiopia
	Week 2	Automatic vector data segmentation and integration by mesh in map sheet area	Acquisition of technologies for segmentation and integration of the image data created above
	Week 3	Detailed database design Creation of schema of feature classes	Acquisition of knowledge of design, creation and management of databases in different data formats
	Week 4	Data conversion between databases	Acquisition of knowledge for data conversion between databases in different data formats with a customized tool and improvement of the efficiency of routine work
(2nd technology transfer) November to December 2014	Week 1	Storage and structuration of vector data Inspection of vector data for logical errors	Acquisition of skill in use of tools for the creation, analysis and inspection of errors in vector data
	Week 2	Correction of erroneous vector data Optimization of vector data display Spatial analysis and spatial selection of vector data	Acquisition of skill in use of tools for the creation, analysis and inspection of errors in vector data
	Week 3	Creation, extraction, statistics and inspection of errors in attribute data Automatic mapping	Acquisition of skill in creation, processing and inspection of attribute data associated with vector data Acquisition of knowledge of automatic processing and creation of a large quantity of maps
	Week 4	Coordinated operation of ArcGIS Catalog, ArcGIS Server and SQL Server databases	Use of the web server (SQL Server) for data management
(3rd technology transfer) July to September 2015	Week 1	Discussion of web management with IT Directorate	Confirmation of technology content related to web management
	Week 2	How to convert sample CAD data to geodatabase and how to use tools	Acquisition of skill in conversion to geodatabase using ArcGIS and Python tools
	Week 3	Error check of GIS data and error output	Acquisition of skill in identification and output of errors in GIS data by topology rules
	Week 4	Definition, discussion and structuration method of GIS data structuration	Approval of definition of GIS data structuration and acquisition of skill in sample data structuration
	Week 5	How to store structured GIS data in SQL database	Acquisition of skill in storage of structured data in SQL database
	Week 6	How to provide and display GIS data on the web server	Acquisition of skill in provision and display of data on web server
(4th technology transfer) July to September 2016	Week 1	Discussion on the GIS data and web management with EMA and confirmation of the status of the networks and server operation	It was decided to disclose PDF files with Index on the Geoportal of EMA. It was confirmed that the EMA server was operating normally.
	Week 2	Conversion of 1/10,000 and 1/25,000 CAD data to Geodatabase data and inspection of GIS data for error detection	The participants were able to convert data format using the tool developed by the Study Team during this study, understood the details of the errors detected during the conversion and rectified the errors.
	Week 3	Discussion on the method to provide GIS data to the web server and supply of PDF map data to the web server	
	Week 4	Preparation for the JCC meeting and the Final Seminar	
	Week 5	Conversion of 1/10,000 and 1/25,000 CAD data to Geodatabase data and inspection of GIS data for error detection	
	Week 6	Storage of the structured GIS data in a SQL database, management of the SQL database	The participants were able to store all the data created in this study in the SQL database correctly and manage the data.
	Week 7	Provision of GIS data and PDF map data to the server and configuration and display of the data	The participants were able to upload all the data created in this study and share the data in EMA.
	Week 8	Provision of PDF map data to EMA Geoportal and configuration and display of the data	The participants were able to download all the PDF data created in this study on the Geoportal of EMA.

Evaluation of the Technology Transfer and Tasks to be Performed

An ArcGIS Python Script tool developed by the Study Team was used in the technology transfer in GIS structuration. The use of this tool made it possible to detect errors occurred in the structuration by examining log files as the rules on data input, output and definition written in the Python Script code were included in the tool and the tool had a function to record output results in a log file automatically.

The participants practiced in the conversion of the data format from dgn to Geodatabase and the examination of detected errors using sample data (in the dgn format) that had been digitally compiled after field completion.

Then they also practiced the storage of error-corrected final data in a SQL database.

The participants have fully understood the contents of the technology transfer and become able to perform the GIS structuration independently as the tool developed for the technology transfer has significantly simplified and automated the data conversion process for the GIS structuration including the error detection in the structuration.

In the technology transfer on WebGIS, the participants took a lecture on the rules for data storage in the existing Geoportal site of EMA and the website on the intranet of EMA established in this study and practiced the data storage in accordance with the rules and the display of the stored data on the Web.

A website on the intranet of EMA was designed with ArcGIS for Server and JavaScript in Japan and established by installing the design on the server.

It has become possible to share the final data stored on the existing Geoportal and the website on the intranet of EMA and display and download GIS data both within and outside EMA.

Because the IT engineers of EMA had the knowledge and technical capacity to store data in the Geoportal, they have fully understood the contents of the technology transfer concerning the data format developed in this study and become able to use the transferred technologies independently.

The table below shows the results of the evaluation of the technology transfer in GIS structuration and website creation.

Table 50 Evaluation of the Technology Transfer in GIS Structuration and Website Creation

Item	Objective	Contents	Evaluation method and result	Issues for the next term
Understanding of the purposes and contents of the work	Understanding of the GIS data structure	Storage, creation, editing and updating of databases	The participants were able to record the processes of data manipulation, analyze the outputs of data creation and create data consistent with the GIS data structure.	N/A
	Data conversion (from CAD format to SHAPE format	Use of ArcGIS conversion tool Use of customized ModelBuilder tool	The participants were able to convert data from the CAD format to the Shape format after repeatedly practicing conversion with sample data and the customized ModelBuilder tool. Improvement in work efficiency by the use of automatic conversion was observed	N/A
	Operation of GIS software	Assistance in advanced operation and tool creation	The participants were able to record the progress of a series of complicated works and perform automatic execution of the works using customized tools created with ModelBuilder.	N/A
	Operation of the server	Creation and management of server users	The participants were able to use the server tools to create and manage server users and create, edit and delete data.	N/A
	Conversion from sample dgn data to GIS data	Conversion of dgn data to geodatabase by ArcGIS and Python tools	The participants were able to perform conversion after practicing conversion of sample dgn data to the geodatabase using ArcGIS and Python tools.	N/A
	Detection of errors in GIS data	Output of GIS data error identification by topology rules	The participants were able to identify and output errors in GIS data after repeatedly practicing with sample data and the ArcGIS tools. Improvement in work efficiency by the use of customized tools was observed.	N/A
	Approval of definition of GIS data structuration	Approval of geodatabase, Feature Dataset, Feature Class, and Field definitions	The participants explained and discussed the definitions of geodatabase, Feature Dataset, Feature Class and Field. The definition of GIS data structuration was understood and approved after practicing using the structuration tool.	N/A
	Storage in SQL database	Storage of structured GIS data in SQL database	The participants were able to store the structured GIS data in the SQL database after practicing storing sample data in the SQL database using the ArcGIS tools.	N/A
	Establishment of a website in the intranet of EMA	Sharing, display and downloading of structured GIS data on a website in the intranet of EMA	The participants were able to share, display and download data after practicing the operation and management of a website using a website on the intranet of EMA.	Sustainable operation and management of the intranet website
	Display and downloading of the latest data on the website	Method to upload the final map data to the existing Geoportal site of EMA and management of the data on the site	The participants were able to upload and manage the final map data after practicing the uploading of multiple sets of the final map data to the web server.	N/A

5-4. Level of Achievement and Total Evaluation of Technology Transfer

The Study Team has comprehensively evaluated the achievement level from the initial target in each technology transfer item.

Table 51 Achievement Level of the Technology Transfer

Technology	Goals		Points by Achievers / Attendance (%)				Score (point)/100	
			0~24	25~49	50~74	75~100	by goal	SUM
Field Identification / Field Verification	1	Comprehension of “Theory” and “Specification”	0	3	6	9	9	82
	2	Able to operate equipment properly	1	4	7	10	10	
	3	Work implementation in correct procedure	2	5	8	11	11	
	4	Work implementation with stable quality and speed	3	6	9	12	9	
	5	Basic work implementation with “Quality Control”	4	7	10	13	10	
	6	Basic work implementation with “Work Management”	5	8	11	14	11	
	7	Independent implementation on similar work	6	9	12	15	12	
	8	Independent work implementation of similar work with stable quality and speed	7	10	13	16	10	
Installation of Aerial Signals/ Photo Control Point Survey	1	Comprehension of “Theory” and “Specification”	0	3	6	9	9	94
	2	Able to operate equipment properly	1	4	7	10	10	
	3	Work implementation in correct procedure	2	5	8	11	11	
	4	Work implementation with stable quality and speed	3	6	9	12	12	
	5	Basic work implementation with “Quality Control”	4	7	10	13	13	
	6	Basic work implementation with “Work Management”	5	8	11	14	14	
	7	Independent implementation on similar work	6	9	12	15	12	
	8	Independent work implementation of similar work with stable quality and speed	7	10	13	16	13	
Aerial Triangulation/ Aerial Photography Planning	1	Comprehension of “Theory” and “Specification”	0	3	6	9	9	85
	2	Able to operate equipment properly	1	4	7	10	10	
	3	Work implementation in correct procedure	2	5	8	11	11	
	4	Work implementation with stable quality and speed	3	6	9	12	9	
	5	Basic work implementation with “Quality Control”	4	7	10	13	13	
	6	Basic work implementation with “Work Management”	5	8	11	14	11	
	7	Independent implementation on similar work	6	9	12	15	12	
	8	Independent work implementation of similar work with stable quality and speed	7	10	13	16	10	
Digital Plotting	1	Comprehension of “Theory” and “Specification”	0	3	6	9	9	79
	2	Able to operate equipment properly	1	4	7	10	10	
	3	Work implementation in correct procedure	2	5	8	11	11	
	4	Work implementation with stable quality and speed	3	6	9	12	9	
	5	Basic work implementation with “Quality Control”	4	7	10	13	10	
	6	Basic work implementation with “Work Management”	5	8	11	14	8	
	7	Independent implementation on similar work	6	9	12	15	12	
	8	Independent work implementation of similar work with stable quality and speed	7	10	13	16	10	

Technology	Goals		Points by Achievers / Attendance (%)				Score (point)/100	
			0~ 24	25~ 49	50~ 74	75~ 100	by goal	SUM
Digital Editing /Digital Compilation	1	Comprehension of “Theory” and “Specification”	0	3	6	9	9	82
	2	Able to operate equipment properly	1	4	7	10	10	
	3	Work implementation in correct procedure	2	5	8	11	11	
	4	Work implementation with stable quality and speed	3	6	9	12	12	
	5	Basic work implementation with “Quality Control”	4	7	10	13	10	
	6	Basic work implementation with “Work Management”	5	8	11	14	8	
	7	Independent implementation on similar work	6	9	12	15	12	
	8	Independent work implementation of similar work with stable quality and speed	7	10	13	16	10	
Map Symbolization	1	Comprehension of “Theory” and “Specification”	0	3	6	9	9	79
	2	Able to operate equipment properly	1	4	7	10	10	
	3	Work implementation in correct procedure	2	5	8	11	11	
	4	Work implementation with stable quality and speed	3	6	9	12	12	
	5	Basic work implementation with “Quality Control”	4	7	10	13	10	
	6	Basic work implementation with “Work Management”	5	8	11	14	8	
	7	Independent implementation on similar work	6	9	12	15	9	
	8	Independent work implementation of similar work with stable quality and speed	7	10	13	16	10	
GIS Structuration / Website Creation	1	Comprehension of “Theory” and “Specification”	0	3	6	9	9	85
	2	Able to operate equipment properly	1	4	7	10	10	
	3	Work implementation in correct procedure	2	5	8	11	11	
	4	Work implementation with stable quality and speed	3	6	9	12	9	
	5	Basic work implementation with “Quality Control”	4	7	10	13	10	
	6	Basic work implementation with “Work Management”	5	8	11	14	11	
	7	Independent implementation on similar work	6	9	12	15	12	
	8	Independent work implementation of similar work with stable quality and speed	7	10	13	16	13	

Chapter 6 Project Implementation System

6-1. Work Assignments of Study Team Members

The members of the Study Team and the work items assigned to them are shown below.

Table 52 Work Assignments of Study Team Members

Name	Assignment	Work Items
Akira Suzuki	Team Leader/ Planning of Digital Topographic Map Development Project	2nd Term [1] Preparation and discussion of Inception Report 2
		2nd Term [6] Preparation of Interim Report
		2nd Term [7] Explanation and discussion of Interim Report
		2nd Term [9] Preparation of Progress Report 2
		2nd Term [10] Explanation and discussion of Progress Report 2
		2nd Term [13] Preparation and discussion of Draft Final Report
		2nd Term [14] Preparation of Final Report
Akira Ota	Deputy Team Leader/ Assistance for Formulation of Organizational Structure/ Utilization of Geospatial Information	2nd Term [1] Preparation and discussion of Inception Report 2
		2nd Term [6] Preparation of Interim Report
		2nd Term [9] Preparation of Progress Report 2
		2nd Term [11] Assistance for formulation of organizational structure/ utilization of geospatial information
		2nd Term [12] Promotion of Utilization
		2nd Term [14] Preparation of Final Report
		2nd Term [15] Work related to technology transfer
Akira Nishimura	Preparation of Work Specifications	2nd Term [15] Work related to technology transfer
Yoichi Oyama	Digital Aerial Photography Planning/ Aerial Triangulation /Orthophotos (DTM)	2nd Term [15] Work related to technology transfer
Satoru Nishio	Installation of Aerial Signals/ Field Identification/ Supplementary Field Verification	2nd Term [15] Work related to technology transfer
Takeo Sugimoto	Photo Control Point Survey/ Analytical Calculations/ Field Identification/ Supplementary Field Verification	2nd Term [15] Work related to technology transfer
Akira Ota	Digital Plotting	2nd Term [2] Digital plotting/digital editing
		2nd Term [5] Creation of data files
		2nd Term [15] Work related to technology transfer
Ryusuke Nakatani	Digital Editing/ Generalization	2nd Term [2] Digital plotting/digital editing
		2nd Term [5] Creation of data files
		2nd Term [10] Explanation and discussion of Progress Report 2
		2nd Term [13] Preparation and discussion of Draft Final Report
		2nd Term [15] Work related to technology transfer
Wentao Che	GIS Structuration/ Website Creation	2nd Term [4] Digital data structuration
		2nd Term [8] Website creation
		2nd Term [13] Preparation and discussion of Draft Final Report
		2nd Term [15] Work related to technology transfer
Kohei Isobe	Symbolization	2nd Term [3] Symbolization of topographic maps
		2nd Term [10] Explanation and discussion of Progress Report 2
		2nd Term [15] Work related to technology transfer
James Kazumori Watson	Work Coordination / Assistance for Utilization of Geospatial Information	2nd Term [1] Preparation and discussion of Inception Report 2
		2nd Term [11] Assistance for formulation of organizational structure/ utilization of geospatial information
		2nd Term [12] Promotion of utilization
		2nd Term [13] Preparation and discussion of Draft Final Report
		2nd Term [14] Preparation of Final Report

6-2. Project Implementation System

The system of the Study Team to implement this Project is shown below.

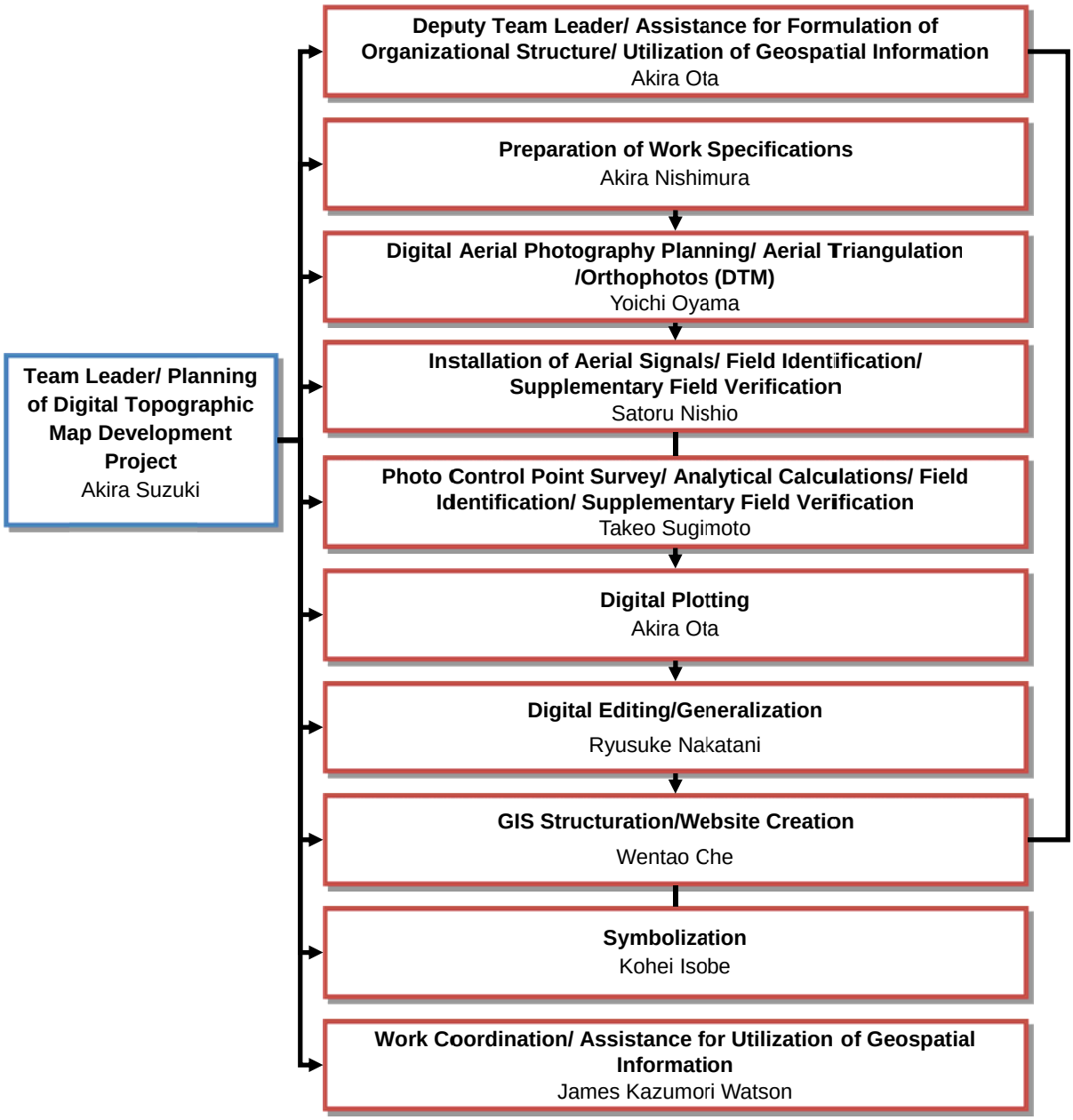


Figure 8 Formulation of Operation Plan and Flow of Implementation/Evaluation

6-3. Personnel Plan for the Study Team

The personnel plan for implementation of the Project is shown below.

Table 53 Personnel Plan

	Assignment	Name	Phase 1 (1st term + 2nd term)	Phase 2	M/M 1st term ET	M/M 1st term JP	M/M 2nd term ET	M/M 2nd term JP	M/M Total ET	M/M Total JP
Work in Ethiopia	**Team Leader/Project Planning**	**Akira SUZUKI**	30, 21, 21, 15, 15, 14, 24, 25, 30		**1.70**		**4.80**		**6.50**	
	Deputy Team Leader/Organization Formulation Assistance/Geospatial Information Utilization	**Akira OTA**	30, 38, 22		**1.00**		**2.00**		**3.00**	
	Preparation of Specifications	Akira NISHIMURA	45, 60, 30, 30		**3.50**		**2.00**		**5.50**	
	Digital Aerial Photography Planning/ Digital Aerial Triangulation/ Digital Orthophoto (DTM)	**Yoichi OYAMA**	20, 35, 35		**0.67**		**2.33**		**3.00**	
	Installation of Aerial Signals/ Field Identification/ Supplementary Field Verification	Satoru NISHIO	45, 60		**1.50**		**2.00**		**3.50**	
	Photo Control Point Survey/ Analytical Calculations/ Field Identification/ Supplementary Field Verification	Takeo SUGIMOTO	60, 60		**2.00**		**2.00**		**4.00**	
	Digital Plotting	Akira OTA	30, 60, 40, 60, 40, 40		**0.00**		**9.00**		**9.00**	
	Digital Editing/ Generalization	Ryusuke NAKATANI	30, 45, 45, 45, 45		**0.00**		**7.00**		**7.00**	
	GIS Structuration/ Website Creation	Wentao CHE	30, 30, 30, 60, 60		**1.00**		**6.00**		**7.00**	
	Symbolization	Kohei ISOBE	45, 45, 45		**0.00**		**4.50**		**4.50**	
	Work Coordination/ Geospatial Information Utilization Assistance	James K. WATSON	30, 21, 21, 27, 14, 18, 46		**1.70**		**4.20**		**5.90**	
			Total work in Ethiopia		**13.07**		**45.83**		**58.90**	
Work in Japan	Team Leader/Project Planning	Akira SUZUKI	4, 3, 3, 3, 3, 3, 3			**0.35**		**0.75**		**1.10**
			Total work in Japan							
	Reports	Submitting period	△ IC/R, △ PR/R, △ IC/R2, △ IT/R, △ PR/R, △ DF/R, △ F/R							
					Total		13.42		46.58		60.00	

Legend: Work in Ethiopia; Work in Japan