Republic of Mali
Ministry of Equipment, Transport and Rural Development
Institut Géographique du Mali (IGM)

DIGITAL TOPOGRAPHIC MAPPING PROJECT
FOR THE BAMAKO METROPOLITAN AREA
IN THE REPUBLIC OF MALI

FINAL REPORT

December 2016

Japan International Cooperation Agency (JICA)

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Exchange rate

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1 EUR = 655.957 FCFA

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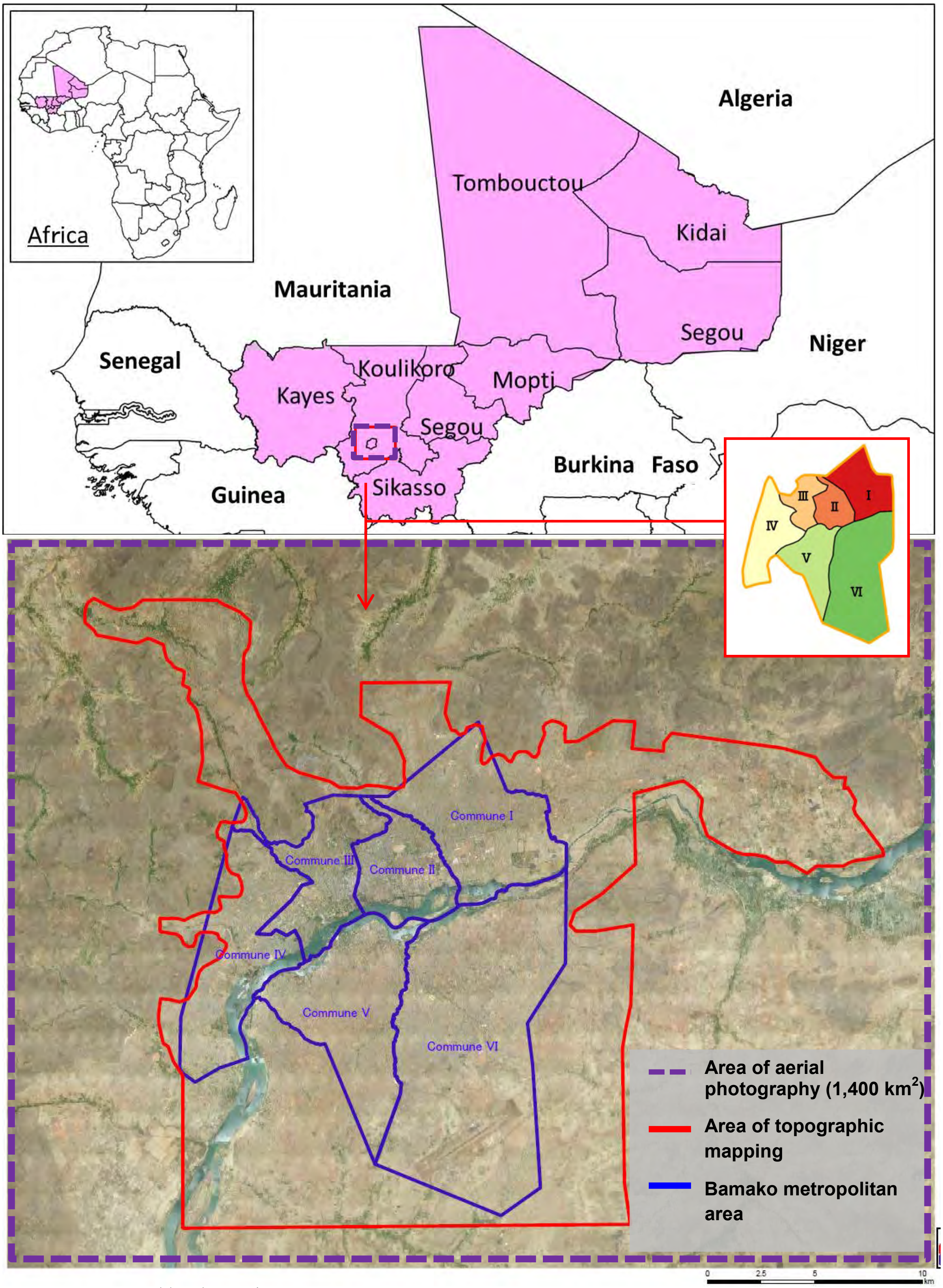
Average of August 2016

Map of the Target Area



Source: Prepared by the Project Team

Photo Album

Kick-off Seminar

Existing Geodetic Point (B-11)

GCP Survey Planning

Training on GNSS Antenna Installation

Training on Leveling

Leveling Work

Discussion on Mapping Specifications

Aircraft for Aerial Photography

Workshop for Field Identification

Training on the Use Field Survey Equipment

Field Survey Training

Field Identification



Field Completion Workshop

Technical Training on Field Completion

Scene of Field Completion



Preparation for Workshop (Facilitator Development)

Workshop for Working-level Personnel of GIS Users

Group Work by Theme



Group Presentation

Technical Training in 3-dimensional Measurement

Technical Training in Digital Compilation

GIS Training


IGM Open Forum (demonstration by staff of IGM)

List of Abbreviations

Abbreviation	Full Form
AFD	Agence Française de Développement
AGETIPE	Agence d’Exécution des Travaux d’Intérêt Public pour l’Emploi
ANAC	Agence Nationale de l’Aviation Civile
ANASER	Agence Nationale de la Sécurité Routière
CAD	Computer-Aided Design
CGIG	Centre de Gestion de l’Information Géographique
CIIG	Conseil Interministériel d’Information Géographique
CNIG	Comité National d’Information Géographique
CNPCT	Centre National de Production Cartographique et Topographique
CRIG	Comité Régional d’Information Géographique
CTAC	Cellule Technique d’Appui aux Communes
DEM	Digital Elevation Model
DGCT	Direction Générale des Collectivités Territoriales
DGPC	Direction Générale de la Protection Civile
DNACPN	Direction Nationale de l’Assainissement et du Contrôle des Pollutions et des Nuisances
DNCT	Direction Nationale de la Cartographie et de la Topographie
DNDC	Direction Nationale des Domaines et du Cadastre
DNH	Direction Nationale de l’Hydraulique
DNPD	Direction Nationale de la Planification du Développement
DNR	Direction Nationale des Routes
DNUH	Direction Nationale de l’Urbanisme et de l’Habitat
DRCT	Direction Régionale de la Cartographie et de la Topographie
DSM	Digital Surface Model
DTM	Digital Terrain Model
EO	External Orientation
EDM	Energie du Mali
GCP	Ground Control Point
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GLONASS	Global Navigation Satellite System
GSD	Ground Sample Distance
IGM	Institut Géographique du Mali
IGN France	Institut Géographique Nationale France
IMU	Inertial Measurement Unit
INT	Institut National de Topographie
ISO	International Standards Organization (International Organization for Standardization)
IT	Information Technology
JICA	Japan International Cooperation Agency
LGO	Leica Geo Office

MDB	Mairie du District de Bamako
NSDI	National Spatial Data Infrastructure
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
OJT	On the Job Training
OMATHO	Office Malien du Tourisme et de l'Hôtellerie
PDF	Portable Document Format
PNIG	Politique Nationale de l'Information Géographique
POS-EO	Position and Orientation System/ External Orientation Parameter
RD	Record of Discussion
SHP	Shape File
SD	Standard Deviation
GIS	Geographic Information System
SOMAGEP	Société Malienne pour la Gestion de l'Eau Potable
TIFF	Tagged Image File Format
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984

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Contents

List of Figures, Tables and Photos

1. Outline of the Project

1.1 Background of the Project

The population of Bamako, the capital of the Republic of Mali, is rapidly increasing because of economic development. According to the 1998/2009 census, the population increased from 1 million in 1998 to 1.8 million in 2009. Migration from other areas has resulted in the proliferation of unplanned settlement area and urban sprawl. Consequently, services such as water supply, sewerage system have deteriorated, resulting in a poor living environment. Furthermore, basic infrastructure such as roads, hospitals and schools are not sufficient, which impedes socio-economic growth of the country.

In light of the problems stated above, Bamako City, and the Department of Urban Development and Housing under the Ministry of Urban Planning and Housing of Mali (DNUH: Directeur Nationale de l'Urbanisme et de l'Habitat) prepared a master plan for Bamako urban development in 2011. The master plan also included improvement in infrastructure. However, it is imperative that the 1:50,000 base maps produced with assistance of the French government in 1988 are updated because existing maps are not suitable for urban planning, improving the changing infrastructure or managing the expanding informal sector. Taking into consideration the need for larger scale maps in order to update urban development master plan of Bamako City and its surrounding area, the government of the Republic of Mali requested the government of Japan to produce digital topographic maps of the Bamako metropolitan area at scale of 1:5,000 (including basic GIS data) as well as to transfer technology to Mali.

The Japan International Cooperation Agency (JICA) dispatched a Detailed Planning Survey Team. The Survey Team recognized the need for digital topographic maps and technology transfer for urban planning of the Bamako metropolitan area. The JICA Survey Team and the government of Mali agreed in the Record of Discussion of November 2011 to implement the study for developing basic GIS data.

The digital mapping project for Bamako was launched on 2nd March 2012. However, the project was discontinued following the coup that occurred on 21st March. This was attributed to the subsequent deterioration of security in the country. Nevertheless, the security situation stabilized in Bamako and its surrounding area. Therefore, the project was resumed from February 2015.

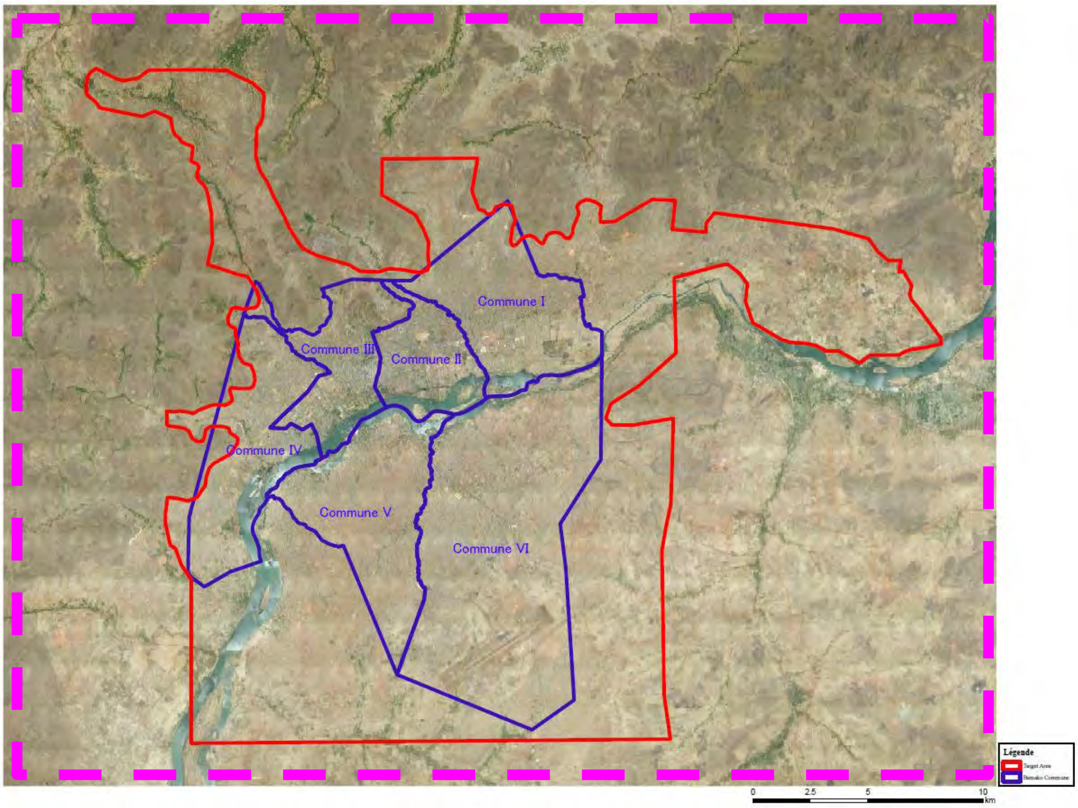
1.2 Project Objectives and Outputs

1.2.1 Objectives

In order to support the sustainable socio-economic development planning as well as improvement of urban infrastructure in the Bamako metropolitan area, the objectives of the project are to (i) produce 1:5,000-scale digital topographic maps and orthophotos, (ii) produce GIS data, and (iii) conduct technical training to IGM.

1.2.2 Target Area

Figure 1-1 shows the project area. The 1:5,000-scale topographic map covers approximately 520 km^2 (red line) in the Bamako metropolitan area, while the orthophoto map area covers approximately 1,400 km^2 (within pink colored dashed line) in Bamako and its surrounding area.



Source: Prepared by the Project Team

Figure 1-1 Target Area of Project

: Topographic map at 1:5,000 (covering approx. 520 km^2)

: Orthophoto maps covering approximately 1,400 km^2

: Bamako metropolitan area

1.2.3 Outputs

The project was implemented based on the Record of Discussion dated on November 17, 2011 in order to produce large scale digital topographic maps and GIS data in collaboration with the Geographic Institute of Mali (hereinafter called IGM). In order to achieve the objectives, the following products were produced based partly on the-job-training:

(1) Aerial photography (1,251 photos),
(2) Orthophoto maps (approximately 1,400 km^2),
(3) GCP survey results (point descriptions of GNSS observation and leveling),
(4) Result of aerial triangulation (a set of EO files),
(5) 1:5,000 digital topographic map data set (520 km^2),
(6) GIS data set (520 km^2),
(7) Topographic maps of booklet type,
(8) Technical specifications for large scale digital mapping and work manual,
(9) WebGIS Development and,
(10) Final Report (skill development of IGM in terms of creation and updating of digital topographic maps)

1.3 Counterpart Organization in Mali

IGM is the counterpart organization of this project. The counterpart organization, which is under the Ministry of Equipment, Transport and Rural Development is responsible for surveying and topographic mapping. IGM conducts surveys and produces topographic maps in response to orders or requests from other ministries and donors. IGM does not have a plan to create and update topographic maps with its own budget at present. It digitizes existing maps and creates thematic maps for clients to generate sales revenue. A detailed organization and structure of IGM is described in the next chapter.

In this project, staff members from the Map Production Department, namely, Geodetic Division, Topographic Map Division, Aerial Photogrammetry Division, Drawing Division and Printing Division implemented the assigned operations.

1.4 Content of Implemented Operations

1.4.1 Overall Composition of the Project

The project components are implemented within 21 months between late February 2015 and late October 2016. The project components focus on:

(A) Production of GIS data, and

(B) Technology transfer (see Figure 1-3).

This report has been compiled on the major operations implemented from February 2015 to October 2016 and their outcomes centered on the major activities shown in Table 1-1.

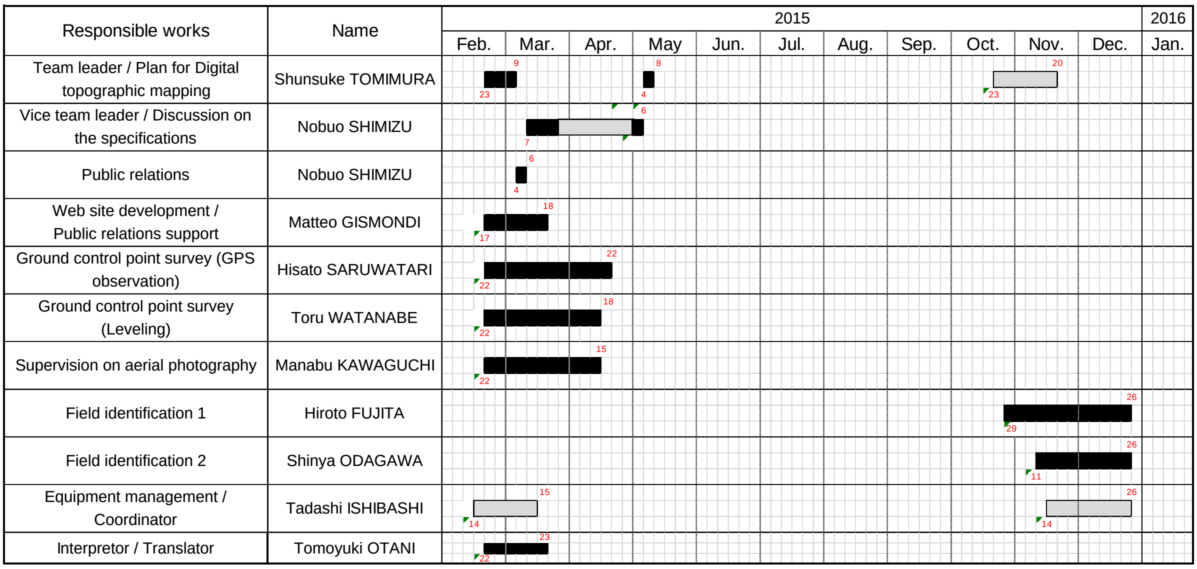
Table 1-1 Principal Activities in Mali

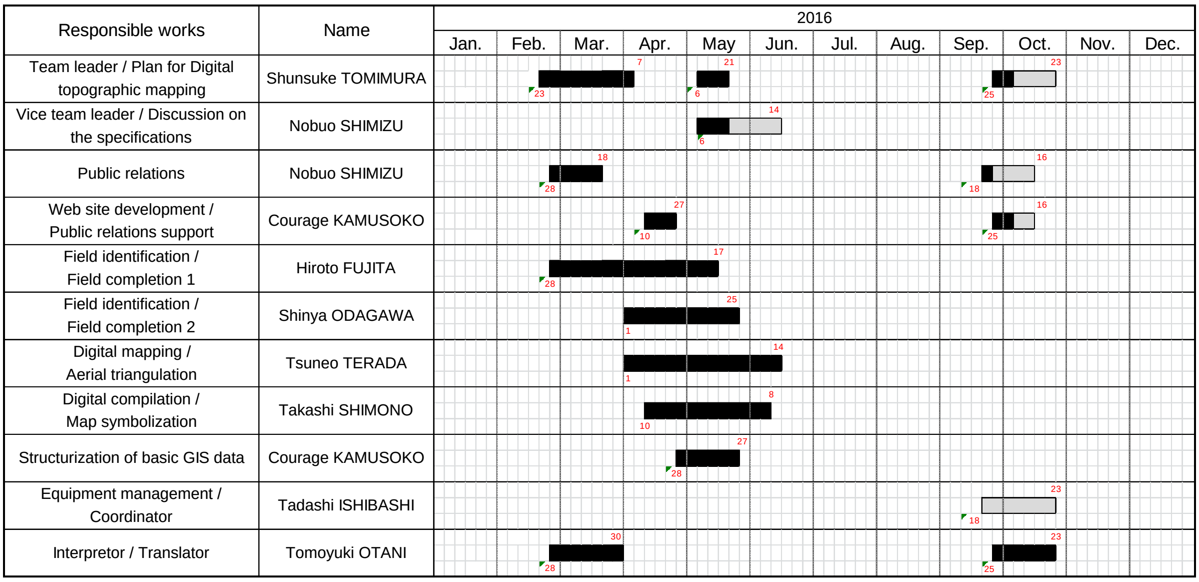
Work items		Activity period	Activities
Discussion on specifications (A)		Mar. – May 2015 Oct. – Nov. 2015 May – Jun. 2016 October 2016	Development of definition and standards of the 1:5,000 topographic features (Ver. 4.03) Development of technical specifications for the creation of 1:5,000 digital topographic maps (surveying system, marginal information, annotation and rules for the numbering of large scale topographic map sheet)
Aerial photography	(A)	Mar. – Apr. 2015	Selection of eligible bidders Completion of aerial photography (1,251 photos) in all the target areas (1,400 km^2)
	(B)		Implementation of technical training (Flight planning and quality control)
Ground Control Point survey	(A)	Feb. – Apr. 2015	Verification of existing national geodetic points needed for 1:5,000-scale digital mapping Completion of GNSS observation (27 points) Completion of Leveling (approximately 180 km)
	(B)		Implementation of GNSS observation in the form of OJT Implementation of leveling in the form of OJT Training in the quality control of observation results
WebGIS Development (A)/(B)		Feb. – Apr. 2015 Apr. 2016 Oct. 2016	Implementation of needs analysis and survey of IT environment Agreement on the basic design of WebGIS, training in the maintenance of WebGIS Installation and operation of WebGIS
Activities to promote utilization (A)/(B)		Mar. – May 2015 Feb. – Mar. 2016 May 2016 Oct. 2016	Kick-off seminar Interview to geospatial information stakeholders GIS workshop for the construction of NSDI Seminar for the promoting the utilization of data
Field identification survey	(A)	Oct. – Dec. 2015 Feb. 2016	Implementation of field identification survey in the form of OJT
	(B)		Implementation of workshop (understanding of definition and standards of topographic features and survey methodology) Implementation of field identification using simplified orthophoto maps
Field completion	(A)	Mar. – May 2016	Implementation of field completion survey using plotting manuscript
	(B)		Implementation of workshop (difference from field identification, capturing of question items)
Technology transfer program	Aerial triangulation (B)	Apr. – Jun. 2016	Instruction for implementation of aerial triangulation using aerial photos
	Creation of orthophotos (B)		Instruction for creating orthophoto maps based on the result of aerial triangulation
	Digital mapping (B)		Training in the measurement of elevation values and appropriate deciphering of features in 3- dimensional spatial model

	Digital compilation (B)	Apr. – Jun. 2016	Understanding topological structure and training in data input
	Symbolization (B)		Understanding 1:5,000 map symbolization criteria and training on symbol expression method
	GIS structurization (B)	Apr. – May 2016	Understanding database structure of digital geographic information and training in the construction of geodatabase
	Quality control (B) and partial modification (B)	Apr. 2016 Dec. 2015 Apr. – Jun. 2016	Understanding of the quality control method of captured aerial photographs Training on the quality control of observation results from ground control point survey Training on the quality control of data acquired in field identification Training on quality control including the accuracy control of each process of digital mapping (aerial triangulation, orthophoto creation, digital plotting, digital compilation, symbolization, GIS structurization) and training for the understanding of the difference between creation and updating (modification according to secular changes)

1.4.2 Project Team Member Assignment

Figure 1-2 shows the assignment of the personnel dispatched to implement the project activities. Furthermore, selected IGM technical staff members from the Geodetic Division, Topographic Map Division, Aerial Photogrammetry Division and Drawing Division of the Map Creation Department collaborated with the Project Team and also participated in the project technical training programs.





■ : Official assignment as a project member □ : Private assignment by Asia Air Survey

Figure 1-2 Assignment in Mali

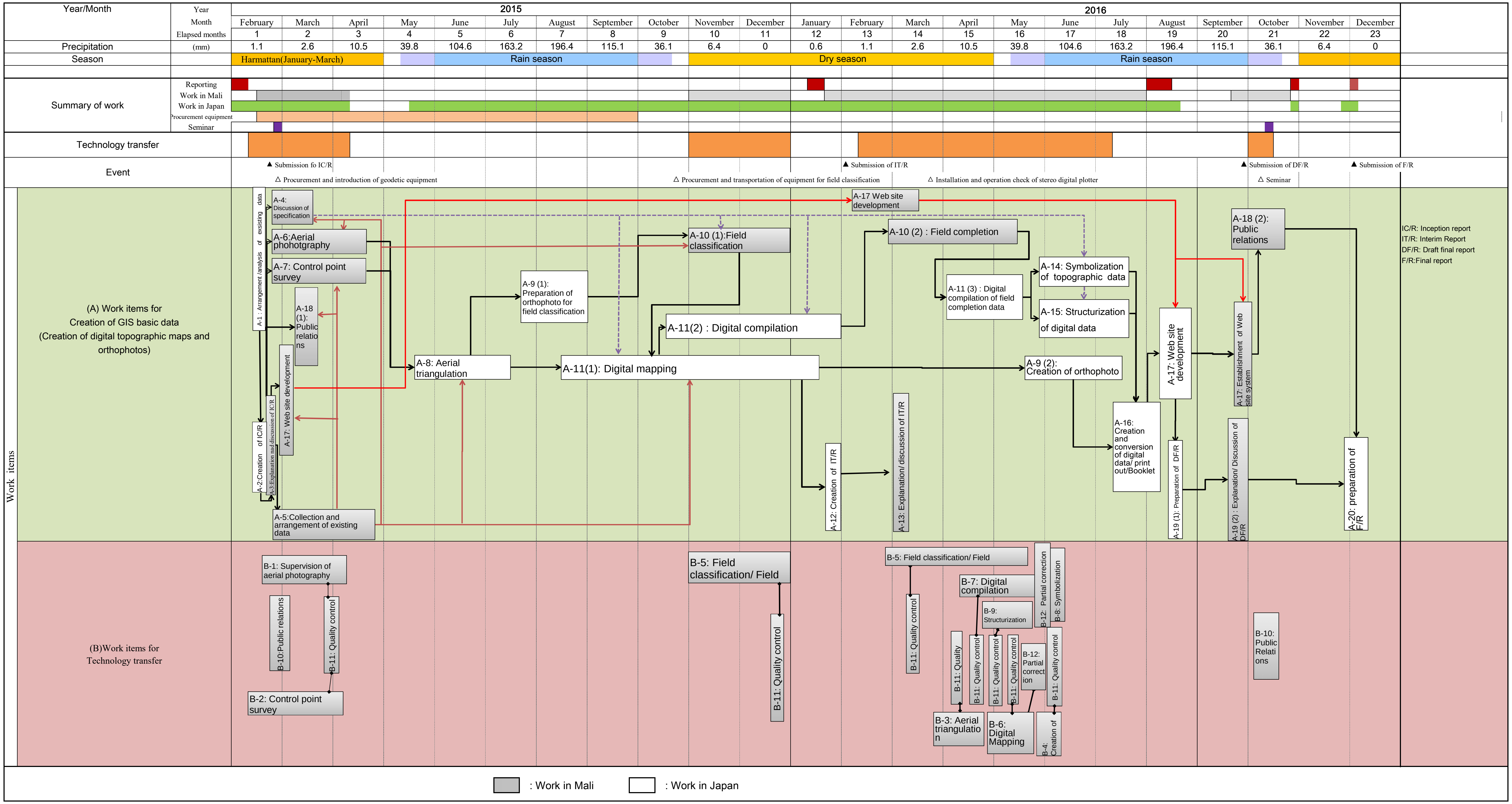


Figure 1-3 Workflow of the Project

2. Promotion of the Use of Geographic Information

It is assumed that the GIS data produced in this project will be shared by the government ministries, agencies and local governments comprising Comité National d'Information Géographique (hereinafter "CNIG") and Comité Régionale d'Information Géographique (hereinafter "CRIG"). The local government organizations were established within Conseil Interministériel d'Information Géographique (hereinafter "CIIG"), which will be described later. Therefore, it should be noted that the potential for mutual cooperation between IGM, and government ministries and agencies comprising CIIG already exists in Mali in order to upgrade and use geospatial data.

In order to promote the widespread use of the products of this project, it is important to develop a structure that will make it possible for IGM to maintain and update the content and the products of this project as their own new geospatial information in the future. In addition, geospatial information should be shared with the working level personnel of the other ministries, agencies and local governments associated with IGM. This will enable the accumulation of knowledge. Consequently, the following activities were undertaken during the implementation period of this project to promote the use of the data based on the current situation of the national spatial policy of Mali.

2.1 Previous GIS Data Development Initiatives

Geospatial information in Mali was produced before and after the independence from France, that is, in the late 1950's and early 1960's, under the technical cooperation of France. Therefore, IGM (known as DNCT in those days) has not produced geospatial information alone. However, from 1998 to 2001, JICA developed 1:50,000-scale digital topographic maps of Kita area (31,000 km^2) in the west of Bamako. Therefore, IGM used the small scale topographic mapping production technology learned during the technical training to produce thematic maps on their own. Note that only small scale topographic maps at 1:2,000,000 were available for the whole of Mali. However, National Geographical Institute of France (hereinafter "IGN France") produced 1:200,000 scale topographic maps in cooperation with IGM targeting the territory of Mali.

The four sheets of 1:20,000-scale topographic maps created by IGN France in cooperation with DNCT in the 1980's and the 10,000-scale city guide maps (thematic maps without height information) of six communes in Bamako created by IGM between 2005 and 2007 are the only available geographic information of the Bamako Metropolitan Area, the project area of this project.

Rapid influx of people in Bamako has led to expansion and development of new urban areas in recent years. However, newly developed topography and features in these areas have not been reflected in the currently available large-scale topographic maps of the city. Because of this discrepancy between the information on the maps and the actual situation, the available maps fail to satisfy the demand for geographic information of the actors in the development of the Bamako metropolitan area including government and donor organizations involved in the urban planning sector and private developers.

Large scale geospatial information is important for urban planning of the metropolitan area as well as to share data to other relevant ministries and agencies, which will enable effective planning and implementation of various development projects.

The government of Mali proclaimed an ordinance for the establishment of cabinet council and national committee on GIS data (No.02-565/P-PM) and setting-up CIIG on 16th December 2002, with the objectives of developing GIS data and actively introduces GIS to organizations. CIIG was defined as a forum of political decision-making with the ministers from different ministries as representatives and as the substructures of CIIG. In addition, CIIG was meant to serve working organizations, with the establishment of CNIG for the central government and CRIG for the local governments (Table 2-1).

Table 2-1 Major Geospatial Information Organizations in Mali

Organizations	Structure and Composition	Responsibilities
Conseil Interministériel d'Information Géographique (CIIG)	-Established in December 2002 as the supreme decision-making body concerning geographic information. -The Prime Minister serves as the chairperson of the council, which consists of 27 ministers. -A meeting is convened by the chairperson once a year.	• Strengthen the structure of governmental organizations to facilitate the creation, updating and active utilization of geographic information • Develop a geographic information database system, which is essential for implementing projects of national priority • Ensure security for procurement, management, processing, provision and utilization of geographic data as well as protect personal data and intellectual properties • Set-up prices for geographic data and related products • Determinate policies to improve administrative services and strengthen geographic information analysis and processing capabilities of research institutions • Evaluate recommendations from CNIG
Comité National d'Information Géographique (CNIG)	-The committee is composed of director generals or equivalent of 36 ministries and agencies and five experts. -The chairperson is the Minister of Transport, Equipment and Rural Development and the President of IGM serves as the secretary general. -The chairperson convenes regular committee meeting once in 6 months.	• Handles geographic information issues in order to implement CIIG national policies • Formulate geographic information guidelines • Implement decisions made by CIIG • Coordinate with CIIG • Coordinate among users of geographic information and related materials • Prepare guidelines for the production of geographic information • Recommend standard for geographic information products
Comité Régionale d'Information Géographique (CRIG)	-CRIG is mainly composed of 21 representatives of local governments and five experts. -The chairperson is the mayor of Bamako City and the president is the regional representative of IGM.	• The committee is composed of all users of geographic information and supports CNIG. • Regular meeting is held on a quarterly basis and the chairperson is able to convene ad-hoc meeting as necessary.

As the secretariat of CNIG, IGM has coordinated with 42 organizations, consisting of ministries, agencies, universities and research institutes with regard to the development of map data, code standardization, metadata and geographic information policy. The results of such coordination activities were compiled as the National Policy of Geographic Information (Politique Nationale d'Information Géographique, hereinafter "PNIG"), which was approved by the cabinet meeting in 2012. In addition, objectives to achieve the PNIG were established and a specific action plan was set up. Table 2-2 summarizes the PNIG outline and the contribution from this project.

Table 2-2 Outline of PNIG

Item	Content	Contributions from this project
General objective	Contribute to the socio-economic development of Mali through the establishment and continual updating of the national spatial data infrastructure (NSDI)	→ Support the NSDI initiative
Specific objective	1. Develop the basic structure of NSDI data 2. Strengthen capabilities of organizations in the production and management of geographic information 3. Strengthen cooperation on geographic information 4. Implement PR and promotion strategies in public and private sectors and in organizations that have interest in geographic information	→ Technical specifications of 1:5,000 topographic maps and GIS data → Promotion and awareness based on WebGIS, etc. → Hosting working-level GIS workshop → Hosting seminars and developing WebGIS
Action plan 2012-2016	• Establishment of Geographic Information Management Center (CGIG) • Procurement of the equipment of CGIG • Perusal of the ordinance concerning the installation of CIIG and CNIG • Collection of usable data • Identification of geographic information users • Training of organizations engaged in geographic information management • Creation and updating of national metadata register • Production of basic topographic map at a scale of 1:200,000 • Strengthening of cooperation concerning geographic information • Implementation of public relations strategy, and information sharing between donors or development partners and users at organizations that have interests in geographic information	→ Self-funded → Procured part of the equipment → No contribution → Implemented in this project → Support by WebGIS, etc. → Calling at the final seminar → Implemented by IGN France → Activity after this project → Support through seminars and WebGIS
Financial resources	It is expected that the various activities contributing to the implementation of the policy will be funded by the national budget, external fund, and own revenue from the sale of products.	
National budget	Special investment budget through planned contract between the national government and IGM	
Own revenue	Revenue arising from the provision and sale of geographic information deliverables and survey services. It will be transferred to the National Geographic Information Fund (FNIG)	

Because the implementation of the policy has been delayed by turmoil in the country, practical activities in the next action plan to be implemented from 2016 on have not been decided. However, budget was allocated to the preparation for the establishment of CGIG (which was scheduled for 2012 in the Action Plan) in 2015 and IGM presented a tentative plan for the operation of CGIG in the workshop and the seminar mentioned below.

2.2 Capacity and Structure of IGM in Terms of Geographic Information

2.2.1 Organizational Structure of IGM

IGM was initially established within the Ministry of Public Works in 1964 as the National Mapping Institute (Institut National de Topographie: INT).

Later, it was renamed the National Mapping and Topographic Survey Production Center (Centre National de Production Cartographique et Topographique: CNPCT) in 1977. However, the National Mapping and Surveying Bureau (Direction Nationale de la Cartographie et de la Topographie: DNCT) was merged with the Regional Mapping and Surveying Bureau (Direction Régionale de la Cartographie et de la Topographie: DRCT) in 1979. In 2000, the current IGM was established.

The national strategy of Mali concerning mapping and surveying is based on the National Strategy of Mapping and Surveying (Politique Nationale de Cartographie et de Topographie), which was adopted in September 1998.

Figure 2-1 shows the latest organization chart of IGM, which was reorganized in 2015. The key point of the reorganization is the establishment of CGIG. Following is a brief summary of the newly established departments that are connected to this project.

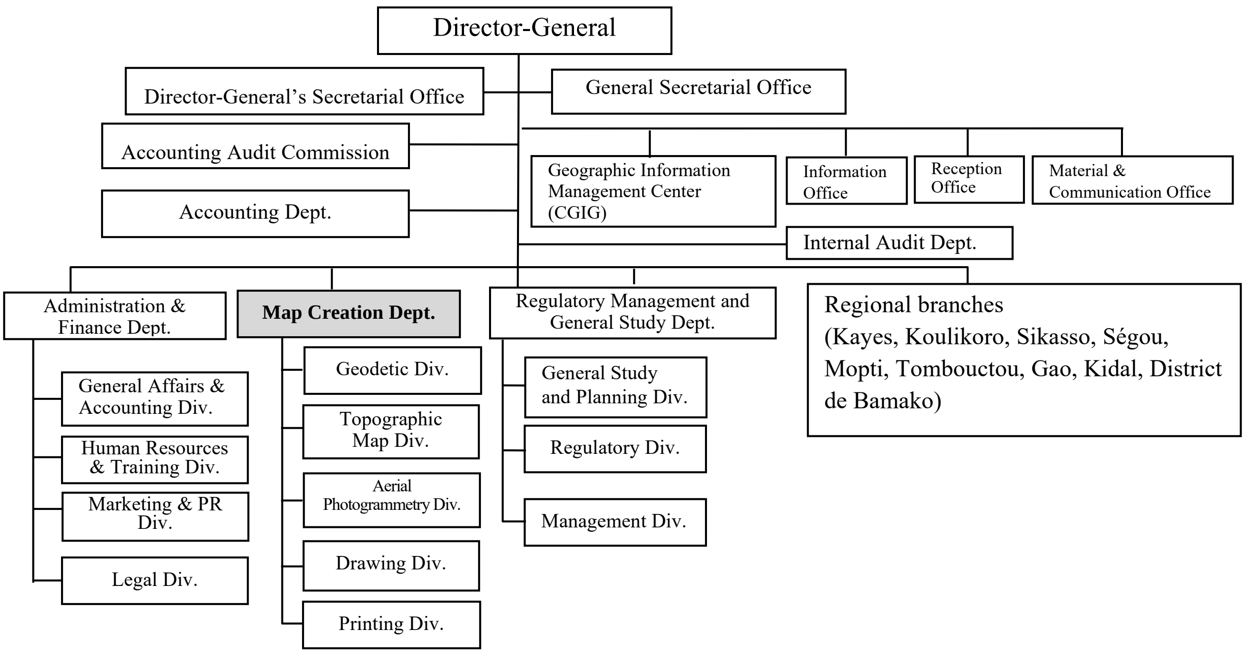


Figure 2-1 Organization of IGM

(1) Geographic Information Management Center (CGIG)

With respect to CGIG, the draft budget, which was developed in accordance with the PNIG action plan, was approved in August 2015. However, preparations for installation began in March 2016. This center which collects geographic information produced by the ministries and agencies is controlled by the president of IGM. CGIG is going to be located on the first floor of the main building of IGM.

According to the current plan, CGIG will be comprised of five people. That is the head of CGIG, two experts for GIS processing, and two experts for promoting the use and management of GIS data. However, as of June 2016, no staff has been assigned yet. The Project Team was told that CGIG will be jointly managed by IGM and the staff of other ministries and agencies. CGIG is supposed to have the following three missions.

- Centralized management of geographic information produced by other ministries and agencies. However, it will not hold the right to market the information because of the copyright issue.
- As a clearing house, consultation with customers concerning GIS data and promotion of the use of GIS data.
- Implementation of training for GIS engineers from other ministries and agencies.

(2) Printing Division of the Map Creation Department

Printing Division was newly added to the previous organization. This division will be in charge of the sale of topographic maps. Currently, printing service is provided by using a large plotter. However, IGM is considering using the offset printing in the near future when the missing parts of the offset printer are purchased. The role of this division will be printing of topographic maps and plans and printing management within IGM. Printing operations will be classified into several technical ranks in accordance with the production policy. The division is scheduled to operate with a total strength of five people, consisting of a chief officer, a geodetics expert, a map adjustment expert, a photogrammetry expert, and a topographical survey expert.

(3) Legal Division, Administration & Finance Department

The Legal Division was established under the umbrella of the previous Financial Management Department. This division is responsible for conformance monitoring of the implementation of operations of IGM, advising of legal opinions concerning disputes and supporting the management in lawsuits.

2.2.2 Human Resources and Technical Capabilities of IGM

With respect to the transition of the number of staff members of IGM, the number decreased from 204 in November 2011 to 161 and accordingly, the number of contract employees increased while that of regular employees decreased.

Table 2-3 Number of Staff Members of IGM

	Total number of staff (Total)	Engineers	Technicians	Others including assistants	Contract employees	% of technical staff
IGM Headquarters	93	25	13	20	35	62% (including others)
Bamako Branch	9	1	2	2	4	33%
Koulikoro Branch	12	3	3		6	50%
Kayes Branch	10	2	3	1	4	50%
Sikasso Branch	11	2	3	1	5	45%
Ségou Branch	6	2	1		3	50%
Mopti Branch	6	2	1		3	50%
Gao Branch	8	2	2		4	50%
Tombouctou Branch	6	1	1	1	3	33%
Total	161	40	29	25	67	Overall average 47%

Source: IGM, March 2016

The counterpart of this project is the Map Creation Department of IGM. The personnel composition of this department is as follows.

Table 2-4 Personnel Composition of Map Creation Department

	Topographic Map Division	Geodetic Division	Drawing Division	Aerial Photogrammetry Division	Printing Division
Chief engineer	1	2	5	2	1
Engineer	4	4	4	2	3
Assistant engineer	4	6	3	1	
Trainee	35 for the Map Creation Department as a whole (non-regular staff)				
Office clerk	2 for the Map Creation Department as a whole				

Source: IGM, March 2016

Through the activities implemented in this project, the following findings were obtained about the current technical capabilities of the Map Creation Department of IGM, which is the implementing organization for supplying geographic information of Mali.

(1) GCP survey skill

As a result of the baseline survey by the Project Team, it was determined that the counterpart knows the procedures for basic GPS observation, which is necessary for this project. In this project, an observation method based on a 3-dimensional network created from GPS observation according to the radiation method was introduced to enable the counterpart to perform quality control. All the four engineers belonging to the Geodetic Division of IGM have sufficient experience in leveling using analog level and one of them also has sufficient experience in leveling using digital level.

With respect to the leveling in this project, height of the newly installed ground control point was determined by using several existing benchmarks. Since such work was not new to the counterpart, it was confirmed that the counterpart has enough skills to perform leveling in this project.

(2) Technical skill in aerial triangulation and photogrammetry (digital plotting, DEM generation, orthophoto creation)

IGM has experience in digital plotting, but has not practiced aerial triangulation. Therefore, it was decided that the technology transfer should focus on the improvement of the basic technical skills. In addition, since IGM had expressed their wish to learn about the color tone adjustment of orthophotos although they have an understanding of DEM orthophotos, special care was taken in transferring such technology.

(3) Technical skills in map editing and symbolization/map reproduction and printing

The experience of IGM was limited to editing the 1:50,000 topographic map (project previously implemented by JICA) and editing the 1:200,000 topographic maps (that are being produced by IGN France). They have no experience in editing large scale maps at a scale greater than 1:5,000.

IGM provides thematic map creation services to customers. However, IGM has no systematic and consistent methodology for digital mapping, creation and registration of map symbols, map output, etc. Therefore, IGM is expected to upgrade the manuals and specification standards prepared in this project.

2.2.3 Equipment Resources of IGM

Equipment that will be needed for IGM to create and upgrade GIS data after the completion of this project is summarized.

Table 2-5 shows the measurement equipment necessary for ground survey and ground control point survey. All the equipment is stored at the IGM Headquarters. While the equipment is put into operation, it is managed by each branch.

Table 2-5 Geodetic Equipment Owned by IGM

Equipment name	Quantity	Specification/condition	Remarks
Digital Level NA3003	2	Good	With 2 Tripods
Digital Level NA2002	5	Good	With 5 Tripods
Digital Level DNA 10	1	Workable	With 1 Tripod
Digital Level DNA 03	1	Workable	With 1 Tripod
Ordinary Level NAK 2	3	Good	With 3 Tripods
GPS system 500	2		
GPS system 1200	4	GX1230, V2.12-V5.10	
Leica Geo Office (LGO) Ver8.40, Basic license	1	L1/L2 data processing for GNSS, GLONASS data processing option, Rinex import, Design & adjustment 3D, Flexible Bundle CCP	GPS analysis software Procured by JICA
Total Station	8		

Source: IGM, March 2016

Table 2-6 shows 3-dimensional measurement systems necessary for digital mapping. In accordance with the growing needs for urban planning in Bamako after the restoration of stability, development of various infrastructures will be required. This table covers the equipment for 3-dimensional measurement, which is indispensable for the measurement of height that is essential for such infrastructure development, and the equipment for creating thematic maps that are necessary for urban planning. These pieces of equipment are all managed by the IGM Headquarters.

Table 2-6 Photogrammetry Equipment Owned by IGM

Photogrammetry system	Quantity	Specification/name	Remarks
Photogrammetry software (for aerial triangulation, Mosaic, Stereo-Matching, DTM)	1	TopAero	
Photogrammetry software (for Stereo-Plotting)	1	GeoView	Software developed by IGN France
LPS Package Desktop	1	Digital plotting system basic software	Equipment procured by JICA
LPS Orima	1	Aerial triangulation software	Equipment procured by JICA
LPS PRO 600 CART	1	Digital plotting data acquisition software	Equipment procured by JICA
LPS PRO DTM	1	DTM creation software	Equipment procured by JICA
Bentley Map Enterprise V8	2	Digital plotting/digital mapping system CAD software	Equipment procured by JICA
Adobe Photoshop	1	Image conversion software	Equipment procured by JICA
ArcGIS Desktop Advanced	1	GIS software	Equipment procured by JICA
3D monitor/3D glasses (2sets/each)	2	Digital plotting system	Equipment procured by JICA
TopoMouse 3D	2	Digital plotting system	Equipment procured by JICA
Desktop Workstation Precision 3420 with 3D board	3	Digital plotting/digital compilation/GIS structurization system	Equipment procured by JICA
AutoCAD Map 3D	1	Digital mapping system	Equipment procured by JICA

Source: IGM, March 2016, including equipment procured by JICA. It should be noted that equipment used in the project of IGN France is not included in the table above, because it has not been handed over to IGM (as of June 2016).

2.2.4 Financial Situation of IGM

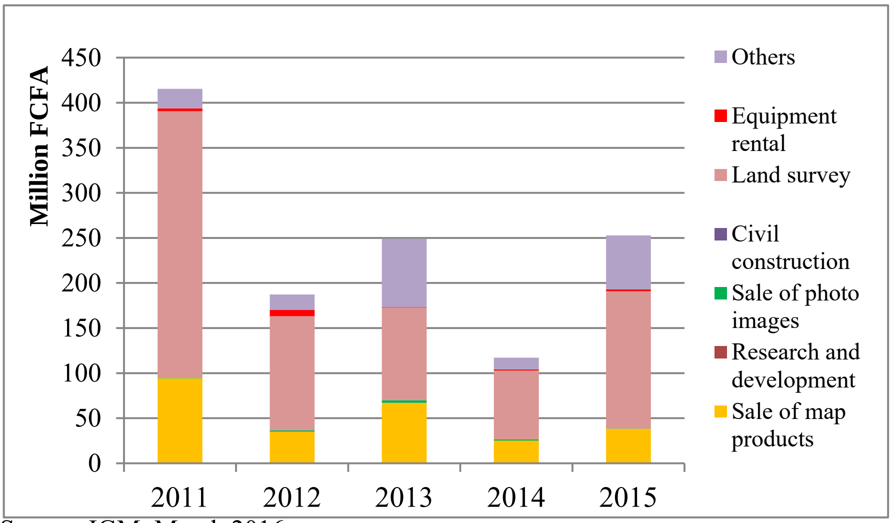
According to the financial trends of IGM in the last five years (Table 2-7), national subsidy decreased from 2011. This may be due to the transfer of the cadastral section to another section in 2011 as well as to external factors caused by the coup and the civil war against the northern forces (2013). In particular, the impact of the transfer of the cadastral section is obvious from the fact that the needs for land survey (including cadastral survey) have decreased to half (Figure 2-2) that shows the technical services provided by IGM in the last five years. However, the situation improved after 2014 as the country regained stability, and budget for the establishment of CGIG was approved.

The sale of topographic maps in 2015- the major service of IGM- decreased to about 40% of the sales in 2011 because of the worsening of security caused by the coup and the civil war in the northern region after 2011. Furthermore, development activities in both the public and private sectors became stagnant, which also resulted in the declining demands for topographic maps.

Table 2-7 Balance of Payments of IGM in the Last 5 Years (Unit: FCFA)

	2011	2012	2013	2014	2015
National subsidy	1,006,924,000	693,634,535	675,068,000	897,821,000	998,052,296
IGM Expenditures	1,006,852,000	92,011,152	659,802,724	602,906,622	934,625,948
Balance	72,000	1,623,383	15,265,276	294,914,378	63,426,348
Balance (in JPY)	12,744	287,338	2,701,954	52,199,845	11,226,464

Source: IGM, March 2016 Exchange rate: 1 FCFA = 0.177 JPY (average of August 2016)



Source: IGM, March 2016

Figure 2-2 Trends of Technical Services of IGM

2.2.5 Development Status and Selling Price of Geographic Information

(1) Development status of geographic information

IGM is responsible for the development and maintenance of existing geographic information, latest topographic maps, aerial photos, satellite images, orthophotos and ground control point results. Table 2-8 shows the archive status of the geographic information developed, maintained and managed by IGM. Other than those covered by the table, IGM has index maps of aerial photos, satellite images, orthophotos and ground control points. In the past, the geographic information archive consisted of analog information that was managed and sold as such. However, there has been an increased development of digital geospatial information in recent years as a result of JICA and IGN projects.

Table 2-8 Development Status of Geographic Information in Mali

	Map scale	Number of map sheets	Data	Remarks
Small scale	1:2,000,000	1	Analog	Covers the whole area of Mali
	1:1,000,000	12	Analog	
	1:500,000	33	Analog	Covers the whole area of Mali
	1:200,000	137	Analog Digital	Covers the whole area of Mali 118 sheets (updated by project of IGN France in 2016)
Medium scale	1:50,000	105	Analog Digital	Covers the whole area of Mali with 1,848 sheets Kita area and 5 sheets created by IGN
	1:20,000	4	Digital	Bamako City
	1:10,000	6	Digital	By 6 communes (thematic map)
Large scale	1:5,000	Nil	Analog	Former DNCT created maps at scales of 1:2,000, 1:5,000 and 1:10,000 for the Bamako metropolitan area in the 1990's. Reproductions of the original maps are stored at the DNDC branch office. As a rule, IGM is in charge of up to 1:5,000 topographic maps and does not create maps at a scale larger than that. The city office and the cadaster bureau are in charge of scales larger than 1:5,000.

Source: IGM, March 2016

(2) Selling price

The selling price of geographic information is broadly divided into printed map and digital data. The prices of printed maps were relatively low during the days of DNCT, which is a precursor of IGM, because large volume printing was possible with offset printer. However, maps are currently printed using the ink jet printer. Table 2-9 shows the standardized prices according to size and color.

IGM set new prices for the 1:200,000-scale topographic maps created by IGN France, the 1:1,000,000-scale topographic maps created by editing the 1:200,000 maps and the outputs of this project, *i.e.* 1:5,000-scale topographic maps and orthophoto maps and thematic digital data (shown in the table below). According to IGM, the prices of the maps created with the national budget used to be set to cover the cost of creating the maps (the costs of labor, materials and processing) without profit before this price revision. However, profit is included in the new prices to raise revenue in order to update the geographic data in future.

Topographic maps are marketed across Mali and within Bamako City. In addition, international organizations, embassies and private companies are major customers. Generally, topographic maps are sold at a normal price to governmental agencies of Mali upon request. Topographic maps from this project will be sold at the same price. However, digital geospatial data will be distributed to contracted parties under specified conditions because of copyright issues.

Table 2-9 List of Selling Prices of Geographic Information

Prices of the output/printed maps and digital data of the analog maps			
Designation (geographic information)	Content of geographic information	Price/Unit	Price/in JPY
Thematic map			
A0 version	Digital data	97,960 FCFA/sheet	17,339 JPY
A1 version	Digital data	50,480 FCFA/sheet	8,935 JPY
A2 version	Digital data	26,740 FCFA/sheet	4,733 JPY
A3 version	Digital data	14,870 FCFA/sheet	2,632 JPY
A4 version	Digital data	8,935 FCFA/sheet	1,581 JPY
Thematic map (Large-format plotter)			
A0 version	Output map	11,700 FCFA/sheet	2,071 JPY
A1 version	Output map	5,850 FCFA/sheet	1,035 JPY
A2 version	Output map	2,925 FCFA/sheet	518 JPY
A3 version	Output map	1,465 FCFA/sheet	259 JPY
A4 version	Output map	730 FCFA/sheet	129 JPY
Topographic map (Offset-printed maps)			
Scale 1:1,000,000 map	Printed map	5,000 FCFA/sheet	885 JPY
Scale 1:500,000	Printed map	5,000 FCFA/sheet	885 JPY
Scale 1:200,000	Printed map	5,000 FCFA/sheet	885 JPY
Scale 1:50,000	Printed map	5,000 FCFA/sheet	885 JPY
Scale 1:20,000	Printed map	5,000 FCFA/sheet	885 JPY
Scale 1:7,500	Printed map	5,000 FCFA/sheet	885 JPY
Topographic map			
All scales	Digital data	97,960 FCFA/sheet	17,339 JPY
Photo map (Monochrome, plotter)			
Scale 1:1,000,000	Output map	15,000 FCFA/sheet	2,655 JPY
Scale 1:50,000	Output map	5,000 FCFA/sheet	885 JPY
Prices of the new maps and digital data created in this project			
Designation (geographic information)	Content of geographic information	Price/Unit	Price/in JPY
1:1,000,000			
Output on ordinary paper	Output map	60,000F CFA/sheet	10,620 JPY
Output on photographic paper	Output map	75,000F CFA/sheet	13,275 JPY
Vector data	Digital data	1,000,000F CFA/set	177,000 JPY
Raster data	Digital data	300,000F CFA/set	53,100 JPY
1:200,000 (Identical size)			
Output on ordinary paper	Output map	7,500F CFA/sheet	1,328 JPY
Raster data	Digital data	30,000F CFA/sheet	5,310 JPY
Vector data	Digital data	100,000FCFA/sheet	17,000 JPY
1:5,000 (Bamako)			
Topographic map on ordinary paper	Output map	10,000F CFA/sheet	1,770 JPY
Orthophoto on ordinary paper	Output map	13,000F CFA/sheet	2.301 JPY
Topographic map on photographic paper	Output map	15,000F CFA/sheet	2,655 JPY
Orthophoto on photographic paper	Output map	20,000F CFA/sheet	3,540 JPY

Vector data	Digital data	150,000F CFA/set	26,550 JPY
Raster data	Digital data	50,000F CFA/set	8,850 JPY
Orthophoto raster data	Digital data	75,000F CFA/set	13,275 JPY
Thematic digital data			
Administrative boundary	Digital data	20,000F CFA/Group	3,540 JPY
Road	Digital data	20,000F CFA/Group	3,540 JPY
Infrastructure	Digital data	20,000F CFA/Group	3,540 JPY
Water body	Digital data	20,000F CFA/Group	3,540 JPY
Topography	Digital data	20,000F CFA/Group	3,540 JPY
Land use	Digital data	20,000F CFA/Group	3,540 JPY

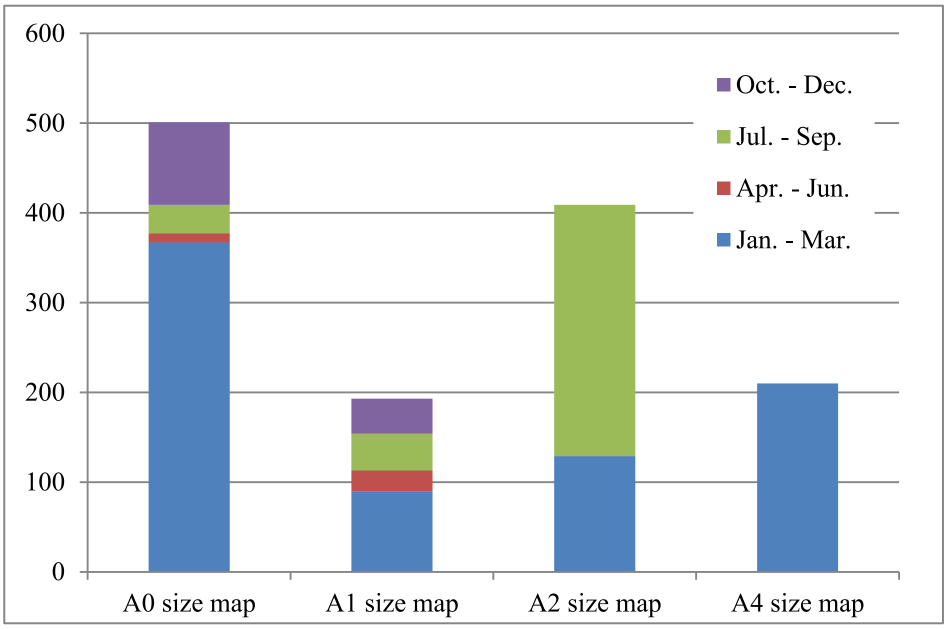
Source: IGM, October 2016 Exchange rate: 1 FCFA = 0.177 JPY (average of August 2016)

(3) Demand for geographic information

In order to capture the sales trend of geographic information at IGM, the Marketing and Public Relations Division on the first floor of the IGM Headquarters compiles the sales record in each quarter (Figure 2-3). As noted in Chapter 2.2.4, public works in Mali became stagnant after the 2012 coup. This resulted in decreased sales volume of more than 60%, which hindered the IGM operations.

Generally, there is a high demand for large-size topographic maps (A0, A1 and A2) since customers cannot print large-size maps. Therefore, it is recommended that IGM focuses on the sale of large-size maps, which accounts for 84% of map sales.

IGM informed that the sales record revealed high demand for the 1:500,000-scale maps of Regions (Kayes, Koulikoro, Sikasso, Ségou and Mopti) and certain types of thematic maps, *i.e.* 1:10,000-scale city guide maps of Bamako and road maps.



Source: IGM, March 2016 (Unit: Sheet)

Figure 2-3 Sales Record of Geographic Information in 2015

2.3 Needs and Requirements for GIS Information in the Bamako Metropolitan Area

Table 2-10 describes the information gained from 21 organizations that showed strong expectations from this project.

Requirements of high potential users of basic GIS data can be summarized to the provision of easy-to-use geographic information as well as the provision of technical training on GIS. These potential users would like to implement the GIS system to utilize different kinds of geographic information. However, they do not have many technicians who can make full use of geographic information. Therefore, it became clear that IGM needs to take the leadership in implementing activities to raise the awareness and promote the use of geospatial information.

The geographic information products from this project comprises 1:5,000 scale topographic maps, orthophoto imagery, DEM etc. complete with elevation information. Currently, ministries and agencies involved in the development of the Bamako metropolitan area create and update their own thematic maps and other maps based on the needs and requirements. However, these maps do not have elevation information. The reference elevation information for Bamako metropolitan area, which was obtained in this project, will make useful data all stakeholders. In particular, such data are required for river utilization, flood control, development of water and sewerage works, where elevation information is important.

Table 2-10 Needs Analysis for Current Stakeholders

Potential user	Contents of activity	Notes
AGETIPE (Agence d'Exécution des Travaux d'Intérêt Public pour l'Emploi)	Supervises outsourcing of public works to private sector for the purpose of employment promotion	Orthophoto map, topographic map data *Comment: The product of this project is indispensable for infrastructure development projects. It can be used for the preliminary survey in outsourcing road, housing and water system construction to private companies for the purpose of employment promotion.*
ANASER (Agence National de La Sécurité Routière)	Mainly engages in traffic infrastructure management and implements measures to prevent traffic accidents and to ensure safety (Identification of actual location, Classification of type and name of road, Confirmation of parking, Identification of risk areas)	Topographic map data, GIS data can be modified as a thematic map *Comment: It is important for the information of road condition, traffic and risk areas. Products will be contributed to road management by creating attribute information of main roads.*

DGPC (Direction Générale de la Protection Civile)	Responsible for prevention of city disasters (accidents, natural disasters, floods, fire), protection of residents affected by disaster and rescue operations	GIS data and topographic data *Comment: Creation of thematic maps using security related feature data such as hospital, fire station, police station and so on can be available.*
DGCT (Direction Générale des Collectivités Territoriales)	Engages in coordination between communes and discusses the determination of administrative boundaries, such as commune boundaries	Topographic map data, orthophoto data and GIS data *Comment: Cooperation of DGCT is necessary for determination of administrative boundaries.*
DNACPN (Direction Nationale de l'Assainissement et du Contrôle des Pollutions et des Nuisances)	Conducts surveys on the environmental impacts of development activities and for the prevention of floods, and formulates development plans of sanitary infrastructure, such as waste collection and disposal facilities	Topographic map data, aerial photograph data and orthophoto data *Comment: Information on the positional relationship between vacant land and roads is useful in designing appropriate waste collection stations, collection routes and for the construction of disposal facilities.*
DNDC (Direction Nationale des Domaines et du Cadastre)	All land in Mali is owned by the state and only the right of use is granted. DNDC is in charge of land registration procedures subject to the right of use, cadastral survey and collection of tax concerning the trading of the right of land use. Its main duty is cadastral management combined with population statistics.	Topographic map data, aerial photograph data and orthophoto data *Comment: 1 Promotes cadastral work by using 1:5,000 maps. In the rural area, such data may be used at a lower accuracy at the resolution of 50cm.* *By adding cadastral information the product will be used as basic database of cadastral management system.*
DNH (Direction Nationale de l'Hydraulique)	Develops national policies on water resources, performs monitoring of water resources and controls the development of waterworks and sewerage works of the whole country, identification of water sources and study of the arrangement of water supply facilities. Acts as a development organization and is currently monitoring water resource management. DNH currently owns hydropower and hydrological databases through the operations of SINEAU (national information system of water).	Topographic map/orthophoto data, GIS data *Comment: Land undulation information using DEM, which is a product of this project, may be utilized for facility development, flood control and measurement of the area of contiguous zones.*
DNPD (Direction Nationale de la planification du développement)	An implementing organization for the development of medium- and long-term national development plans and policies and coordination of socio-economic sector strategies between communities and regions.	Road network data, tourist map and thematic maps *Comment: The product of this project can contribute to the formulation of all kinds of development plans. In particular, 1:5,000 topographic maps, which enable identification of road network data, building names, positions and shapes, are useful for scrutinizing features. They can also be used for resident services.*
DNR (Direction Nationale des Routes)	Responsible for the road administration, development of legislation, maintenance of facilities associated with roads of the whole country. Performs operations by using LogiRoad (road management software made in France). Requested IGM to cooperate in providing and surveying data of starting points and endpoints of	Topographic map data, GIS data, orthophoto data *Comment: DNR can provide attribute data for road network, and mutual collaboration is necessary for future data update.*

	roads in the past.	
DNUH (Direction Nationale de l'Urbanisme et de l'Habitat)	An organization for policy development and implementation concerning urban planning. Develops policies for the City Planning Master Plan of Bamako City and its Outskirts (SDU) and Sector-Wise City Planning Plan (PUS) corresponding to each commune with respect to the urban planning of the outskirts of Bamako City.	Topographic map data, aerial photographic data, orthophoto data and GIS data *Comment: This product is helpful for DNUH activity regarding Bamako development.*
MDB (Mairie du District de Bamako)	Collaborates with the branch offices of the ministries and agencies in the central government to implement the development and maintenance projects and resident services in Bamako City. MDB is currently studying the master plan of Bamako City.	Topographic map data, aerial photograph data, orthophoto data and GIS data *Comment: MDB will surely utilize the product of this project in implementing the survey for the development of master plan, which is scheduled to begin around November 2016. As such, it is considered to be the most promising potential user of the product.*
OMATHO (Office Malien du Tourisme et de l'Hôtellerie)	Currently reorganized as DNTH and is mainly responsible for promotion of tourism in Mali and development of laws and regulations for tourism.	Topographic map/orthophoto data, GIS data, aerial photographic data *Comment: Tourist map can be updated by adding information of tourist spots in Bamako, such as hotels, restaurants, scenic spots and historic sites. Has a track record of publishing and selling sightseeing map for tourists called "Passport to Mali" in collaboration with IGM. The map should be displayed as one sheet map as much as possible and advertisement sponsors should be raised to earn revenue to cover the O&M costs for upgrading the map.*
AFD (Agence française de développement)	(1) Urban development MP project in Bamako and surround area: Preliminary survey: 2011 5 of 15 companies were selected Under preparation of detailed specifications Commune 2 and 5 for sanitation and sewage basic planning project (2) Project for supply of potable water at Bamako-Kabara Project (PADUB) Budget: € 200 mil. (WB, AFD, EIB) (3) Needs of topographic maps: Necessary and sharing information with IGM	For the management of the roads across the country, it is possible to develop thematic map data in Bamako and utilize road network information.

2.4 Implementation of Activities to Promote Utilization

2.4.1 Kick-off Seminar

Prior to the implementation of this project, a draft Inception Report was presented to IGM on February 27, 2015. An agreement was reached by both parties after discussions.

Following the Inception Report, a kick-off seminar targeting potential users of spatial information was held (Table 2-11) in order to publicize the expected project results. His Excellency the Ambassador of

Japan and the Honorable Minister Mamadou Hachim Koumar (Ministry of Equipment, Transport and Rural Development) attended. Both the Japanese and Malian officials expressed high expectation from Japan's technical cooperation project. Then, JICA Project Team presented an outline, overall schedule and final project results.

Table 2-11 Brief Summary of Kick-off Seminar

Date	6th March 2015
Venue	Conference Hall, Azalai Grand Hotel
Number of participants	71 participants Related institutions: 40 participants Guest: Minister of Transport, Equipment and Rural Development Ambassador of Japan IGM: 17 participants Japanese: 11 participants Press: 3 participants
Main discussion points	Methodology and expected outputs/outcomes of this project Main role and obligation of IGM for this project Discussion on digital mapping techniques Utilization of 3D data as product of this project

2.4.2 GIS Workshop

After being established as a cross-sectoral organization of different ministries and agencies, CIIG had been stagnant in terms of its activities since 2012, which was partly due to security issues. However, as the updating of small scale topographic maps was completed by IGN France project and the creation of large scale topographic maps, which is the first attempt for Mali, was started by this project, in order to ensure that the product of this project will be utilized extensively, in 2015, preparations were started to establish CGIG as a receptacle for such geographic information basic data.

The Project Team held several meetings with IGM on the promotion of the use of the products of this project under such circumstances. They reached a common understanding that making the member organizations of CIIG, the assumed users of the geographic information, recognize the usefulness of the products of this project was an effective way to promote the use of geographic information in Mali. Therefore, they decided to provide the members of CIIG with an opportunity to practice group work of visualizing the administrative problems in Bamako (creating thematic maps of the city) from the geographic information created as an output of this project.

The Project Team organized a workshop to provide working-level personnel (division managers) in various areas with such an opportunity. The aim of the workshop was to create common understanding that geographic information is a tool applicable to urban administration among the participants and raise the sense of ownership of the geographic information not only in IGM but also in the ministries and agencies concerned (those that were members of CNIG, in particular).

In this workshop, the participants were provided with an explanation on the outline and outputs of this project and an opportunity to learn the process of creating thematic maps in inter-ministerial group discussion (Table 2-12).

Table 2-12 Outline of the Workshop for Working-Level Personnel

Date	9th May 2016
Venue	Conference Hall, Equipment and Accounting Department, Ministry of Equipment, Transport and Rural Development
Number of participants	65 participants Related institutions: 32 participants from 27 ministries and agencies Guest: Technical advisor to the Ministry of Equipment, Transport and Rural Development Chargé d'Affaires ad interim of Japan in Mali IGM: 19 participants Japanese: 14 participants
Major content	• Fields of geographic information in Mali and the positioning of this project • Establishment and roles of Centre de Gestion de l'Information Géographique (CGIG) • Significance and purpose of thematic maps • Participatory workshop (creating thematic maps by theme) (1) Group work to create thematic maps (2) Presentation of the result by group (3) Workshop evaluation

Three themes, 1) security and protection of citizens, 2) water supply and health/sanitation and 3) tourism and education, among the developmental problems of Bamako described in "Bamako 2030," an urban development plan prepared by Bamako City office in 2015, were selected for the participatory workshop. The participants from 32 government ministries and agencies were divided into six groups in accordance with their areas of expertise. They had inter-ministerial group discussion and practiced the creation of thematic maps (zoning) in these groups for approx. one hour.

IGM assigned one of its staffs to each group as a facilitator to help the participants learn the ways to utilize large-scale topographic maps in general and in their specific areas of work with products of this project.

Table 2-13 below summarizes the workshop thematic map creation results for each group.

Table 2-13 Presentation Results of the Participatory Workshop (Thematic Map Creation)

Theme	Group	Content
Security and resident protection	1	Thematic map theme: Security and resident protection Purpose: Ensuring the security of critical security point SOMAGEP (Potable Water Public Corporation) Fire fighting against fires of residences and markets **Necessary data:** Detailed road information, electric light, road sign, signal and security facility information
	2	Thematic map theme: Minimizing the incidence of traffic accidents in Bamako Purpose: Importance of the maintenance of crossings **Necessary data:** Traffic signs, signals, traffic plan
Water supply, health and sanitation	3	Thematic map theme: Water and health in Commune 3 Purpose: Relationship between health and facilities (distribution of healthcare facilities and pharmacies, water and drainage channels) **Necessary data:** Waste disposal sites, detailed information of water and drainage channels
	4	Thematic map theme: Health and sanitation of Commune 2-3 Purpose: Grasping the sanitary environment of overpopulated Commune 2-3 **Necessary data:** Healthcare facility information, waste disposal sites, detailed information of water and drainage channels
Education and tourism	5	Thematic map theme: Tourist map of Mali Purpose: Tourist information of Commune 2-3 including the national museum, national zoo and football stadium **Necessary data:** Monument information
	6	Thematic map theme: Tourist map, school distribution map Purpose: Grasping the distribution of tourism resources by administration, hotels and schools **Necessary data:** Hotel information, educational facility information

Next, the results of questionnaires given to the participants after the workshop are shown in Table 2-14 as follows.

Table 2-14　Questionnaire Results of Workshop Participants

		Yes, very much	Yes	Not so much	No, not at all	No answer
a	Did you understand the importance of sharing geographic information among ministries and agencies?	13	9	1	0	6
b	Did you recognize the roles of CIIG relative to the NSDI initiatives?	13	14	0	0	2
c	Did the facilitators* run the workshop well?	13	15	0	0	1
d	Was the facilitators'* time allocation appropriate?	9	18	1	0	1
e	Did the facilitators* have knowledge about the themes?	16	12	1	0	0
f	Were the materials, etc. prepared for the workshop useful?	23	5	1	0	0
g	Did you enjoy the workshop?	22	7	0	0	0
h	Did the workshop improve your theme awareness?	16	13	0	0	0
i	Did the workshop contribute to upgrading your skills?	11	15	3	0	0
j	Will the knowledge and skills learned in the workshop help your work in your workplace?	17	11	0	0	1
k	Would you recommend this workshop to other people?	23	6	0	0	0

*: The facilitators are six members of the IGM staff who were trained in this project beforehand.

After the workshop, the participants were requested to report to their immediate superiors in order to raise awareness of CNIG, CRIG and CGIG. Furthermore, this was done to ensure that the project products would be fully understood by the working-level personnel. In addition, as a follow-up, IGM prepared a report of the results of this workshop and submitted the report to the director general or the equivalent of each department and bureau.

Source: Project Team

Photo 2-1　Scenes of the Workshop for Working-Level Personnel

2.4.3　Seminar for the Promotion of Utilization

The Project Team explained the contents of the Draft Final Report prepared as a final report of the outputs of this project to IGM on 28th September 2016. IGM conducted internal evaluation of the report and gave general consent to it later.

After the agreement had been reached on the Draft Final Report, a seminar for the promotion of the use of geographic information was held (Table 2-15). The users of the geographic information in Mali including the member ministries and agencies of CNIG and CRIG were invited to participate in the seminar. The Ambassador of Japan to Mali, Chief Representative of JICA Senegal Office and the Permanent Secretary of the Ministry of Equipment, Transport and Rural Development of Mali, the ministry supervising IGM, gave speeches on the technical cooperation by the Government of Japan in Mali. The Ambassador of Japan handed over the list of products of this project to the Permanent Secretary in a special ceremony.

After the speeches and the ceremony, members of the Project Team explained the outline of the project and officer of IGM made presentations on the basic policy on and prospect of the administration of geographic information after the completion of this project and the technologies they had acquired in the project. Staff members of the City Planning Bureau and the Civil Protection Bureau of the Bamako City Office also gave lectures on the application of the outputs of this project that they had conducted with sample data provided by the Project Team, as representatives of the data users. At the end, a question-and-answer session was held. In this session, questions were asked and discussion was held on such matters as the specifications of the products of this project and technical extension of the geographic information technologies acquired by IGM in this project, before closing the seminar.

Table 2-15 Summary of the Seminar for the Promotion of the Use of Geographic Information

Date	6th October 2016
Venue	Palais des Sports de Bamako
Number of participants	129 participants Related institutions: 57 participants from the invited organizations, Guest: Permanent Secretary, Ministry of Equipment, Transport and Rural Development, Ambassador Extraordinary and Plenipotentiary of Japan to Mali, Chief Representative of JICA Senegal Office IGM: 52 participants Japanese: 13 participants Press: 7 participants
Main discussion agenda	Impact expected of the outputs of this project Outline and products of this project (WebGIS, rules on the technical specifications) Future development for the realization of NSDI Initiative Policy on the activities of IGM after the completion of this project Utilization of products of this project (Civil Protection Bureau, Bamako City Office)

	Presentation on the outputs of the technology transfer (on aerial triangulation, digital compilation and GIS)

Source: Project Team

Photo 2-2 Seminar for the Promotion of the Use of Geographic Information

2.4.4 Open Forum

Large-scale topographic maps and GIS data (1:5,000-scale) of the Bamako Metropolitan Area were created in this project. The equipment required for the revision, including updating, of the maps and data has been provided to IGM and its staff members have acquired a certain level of technical expertise on the use of the provided equipment in the technology transfer program also implemented in this project. Meanwhile, the needs survey in this project revealed that not all the users of geographic information had an accurate knowledge. This finding confirmed the indispensability of the sharing of basic understanding of the data between the provider and users and a significant responsibility of IGM in providing technical support service in GIS and other geographic information technologies to the users.

In order to make the users of the geographic information data aware of not only the technologies that staff of IGM had acquired in the project, but also what the GIS data were and how they had been created, IGM Open Forum was held (Table 2-16). This forum was a follow-up to the workshop on the creation of thematic maps for the working-level personnel held in May this year. The Forum was expected to produce the following impact.

- Improving the understanding of the geographic information, increasing the opportunities to utilize it and increasing its potential users by providing its users, including the people engaged in providing administrative services who played an active role in the data sharing and provision in this project, and staff and students of universities, who were expected to lead the country in future, with an opportunity to watch and ask questions about the actual work conducted at IGM and its outputs;
- Making staff of IGM aware of their responsibility on the large-scale digital stereo mapping technologies transferred to them in this project and the output geographic information data to be created with these technologies by making them actively involved in the demonstration and by

making them answer questions from the guests on the contents of the technology transfer and the process of creating geographic information data in the forum.

Table 2-16 Summary of IGM Open Forum

Date	13th October 2016
Venue	Laboratory and Main Conference Room in IGM
Number of participants	151 participants Related institutions: 25 participants from the invited organizations Universities: 12 participants IGM Headquarters: 91 participants IGM local offices: 23 participants
Program	Explanation of the reasons for holding this open forum by the Project Team Staff of IGM and the Project Team members conducted the demonstration on the subjects mentioned below with actual data for the participants in several groups at four locations in the laboratory and the conference room on the 2nd floor. They also answered questions from the participants during the demonstration. (1) Demonstration (on the digital mapping technology); ・Table 1: on 3D measurement by IGM ・Table 2: on GIS database management by IGM ・Table 3: on digital topographic maps by IGM ・Table 4: on Open source GIS by Project Team (2) Demonstration (on the GIS technology); ・Table 5: on WebGIS by IGM ・Table 6: Presentation of pioneering cases of the application of geographic-information-based technologies in Japan with video images on tablet computer by Project Team

A questionnaire survey of the participants was conducted after the conclusion of the open forum. The table below shows the result of the survey (with the sample number of 54).

Table 2-17 Result of the Questionnaire Survey of the Participants of the Open Forum

		Yes, I think so very much.	Yes, I think so.	No, I do not think so.	No, I do not think so at all.	No response
1	Have you understood the importance of inter-ministerial sharing of geographic information?	33	16	1	1	3
2	Have you understood the role of CIIG in the implementation of the NSDI Initiative?	12	26	6	4	6
3	Have the lecturers managed the lectures appropriately?	18	24	8	1	3
4	Have the lecturers managed the time appropriately?	16	28	3	0	7
5	Did you have some knowledge of the subjects of the forum?	14	26	13	0	1
6	Has your understanding of the subjects improved in the forum?	34	18	0	0	2
7	Was the open forum interesting to you?	27	22	4	0	1
8	Do you think that the workshop helped improve your skills?	17	25	8	1	3
9	Do you think that the knowledge and skills you have acquired in the forum are useful in your work?	28	18	4	1	3
10	Have you understood how to use the products of this project?	21	20	6	1	6

The participants also provided valuable comments, in addition to their appreciation of and interest in this open forum, in the comment space in the questionnaire. The following is a summary of those comments.

- The forum was a good opportunity to learn QGIS and ArcGIS software. I would like IGM to prepare similar opportunities and provide technical assistance on geographic information to its partner organizations.
- Please organize an open forum like this one for university students who are expected to lead the country in future.
- Please correct the administrative boundaries on the topographic maps of Bamako as soon as possible because the maps with correct boundaries are essential for the urban planning.
- I would like IGM to be always ready to disclose geographic information to its users by providing them with technical training.
- Please consider to have a plan for updating topographic maps every 10 years. Please relocate the boundary of Commune VI on the maps to its official location.
- I would like to use the geographic information in the planning of a pipeline immediately.
- Please prepare a pamphlet including the price list and user's guide of the topographic maps.
- IGM should continue providing opportunities like this forum. However, I was not fully satisfied with this forum because the number of participants was too large. Please organize a series of opportunities like this for 10 or so people.

The responses of the participants mentioned above suggest that the forum has generally achieved its purpose, *i.e.* to publicize the role of IGM to the users of geographic information, to facilitate the improvement of their understanding of the basics of geographic information data and the method for the creation of topographic maps and to disseminate the outputs of this project to the geographic information users including staff of universities and working-level administrators through the active involvement of the staff of IGM in the dissemination of the knowledge they acquired as an output of this project in the technology transfer program to the users.

Implementation of this forum and the workshop in May has undoubtedly generated a certain level of recognition of the assistance to IGM and in the geographic information sector at the field-level. The senior officials of IGM are expected to take lead in the activities of the Government of Mali for the standardization of the geographic information and realization of NSDI (National Spatial Data Infrastructure) Initiative in cooperation with the relevant bureaus and departments of the ministries and agencies that are the members of CNIG and CRIG.

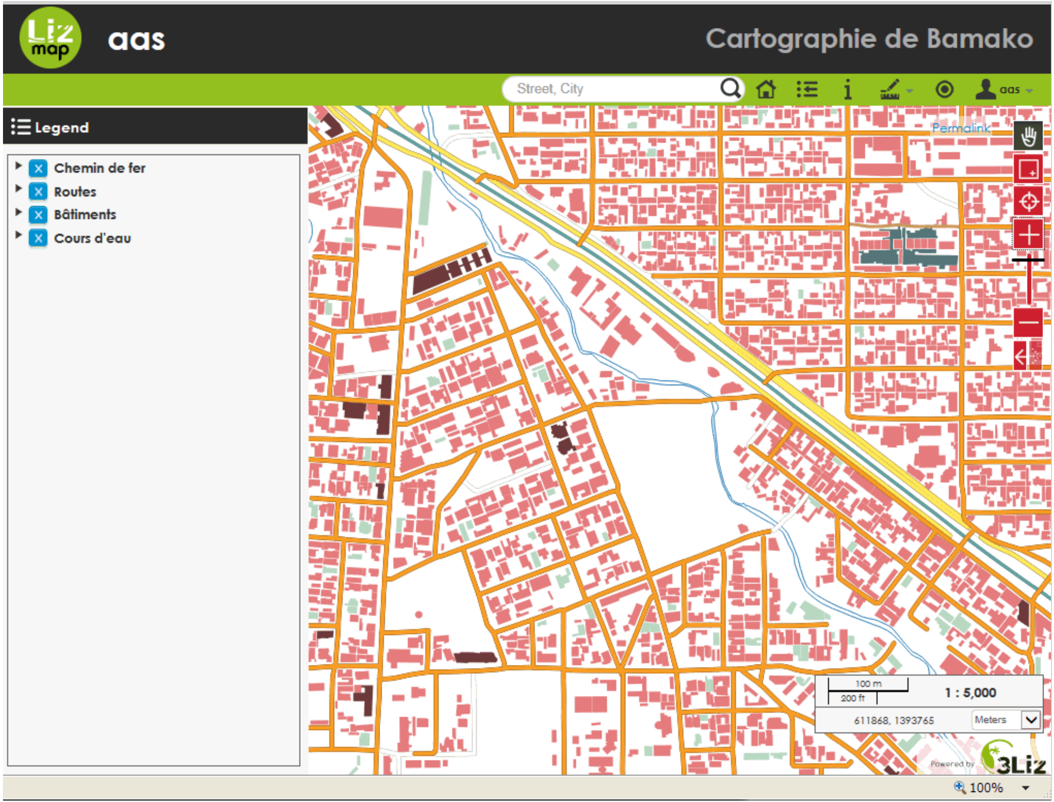
2.5 Development of WebGIS

WebGIS development was proposed in order to enable various urban development stakeholders and other potential users to visualize selected Bamako Metropolitan area GIS data from this project. The WebGIS design concept were first discussed, and then approved after much consultation with IGM

2.5.1 WebGIS Design

The WebGIS content represents selected GIS datasets that will be open to the public (that is, available on the internet) (see Figure 2-4). For security reasons, the final WebGIS content will be represented as follows:

(1) Use selected GIS vector layers without location (no coordinate information);
(2) Mask sensitive “Public facilities” layers such as embassies, international organizations, military institutions or facilities, hotels (this means users cannot see these layer information or names on the map); and
(3) Mask the “Building” layer (DataCodes 2101 – 2106) and replace it with a general “urban area/ built-up” category.
(4) Mask the elevation layer (DataCodes 6101 – 7107) in order to reduce the WebGIS data size. Note that the internet connection is in Bamako. Therefore, a reduced GIS data size will increase upload performance.



Source: Prepared by the Project Team

Figure 2-4　Sample image of WebGIS

2.5.2　Installation of WebGIS and system management

The design and implementation of a WebGIS is highly iterative process, whereby GIS data is configured and loaded using Lizmap, a QGIS plugin. The "Bamako Digital Topographic Mapping WebGIS" is an interactive spatial data platform, which allows visualization of selected GIS datasets derived from the 1:5,000 scale topographic maps.

The GIS datasets on this platform covers administrative, building, hydrography, selected public services, land use/cover, and transportation feature datasets. Note that, the WebGIS platform can be updated whenever improved topographic maps and GIS datasets are available.

In addition, GIS dataset as the contents of the WebGIS has been operated in Italian server for five years from 2016 because of accessibility and IT infrastructure weakness in Mali and procedure of operation of WebGIS was lectured to IGM officer in charge of IT field.

From 2021, IGM will have to perform maintenance of dataset in Italian server by IGM's own effort or IGM will move dataset in Italy to IGM's own server and manage WebGIS, if IT infrastructure is improved dramatically.

2.6 Future Directions

The GIS data will be shared by Conseil Interministériel d'Information Géographique (CIIG) and Comité National d'Information Géographique (CNIG). To date, no major activity has been carried out. Therefore, the following recommendations were made to IGM to encourage IGM to continue collecting information and implementing practical activities for the purpose of promoting the utilization of the project geospatial products.

(1) Additional development of GIS data

As prescribed in the map symbolization criteria, GIS data are composed of items that can be treated as common themes selected out of the features comprising topographic maps. Considering the diversified needs of GIS, the product of this project cannot satisfy all users. As shown by the results of the workshop described earlier, cross-sectoral discussions can help in clarifying the information that needs to be added to the basic GIS data to meet the needs arising from the duties of each ministry or agency. As such, IGM should assume the responsibility of coordinating among the member organizations of CNIG, etc. for each theme to avoid duplicated development of the same basic GIS data and to clarify the information to be added, thereby enabling the efficient addition and updating of the data.

(2) Expansion of the coverage of 1:5,000-scale topographic maps

The population of Bamako has been increasing in recent years. The urban population increased from was about 1 million in 1998 to 1.8 million in 2009 (1998/2009 census in Mali). The residents who have moved into the city live in the urban periphery in a disorderly manner and the city area is sprawling. As such, development actors consider that the geographic information in and around Bamako City is indispensable for the development of residential areas, sanitary infrastructure and water and sewerage facilities.

While aerial photographs cover an area of 1,400 km^2, the 1:5,000-scale topographic maps cover only 520 km^2. Therefore, remaining 880 km^2 of the outskirts of the Bamako metropolitan area need to be mapped. Note that aerial triangulation has been carried for the remaining unmapped area. It is important that IGM continues to develop data including height information, using these 3-dimensional models and the knowledge and knowhow of each work process learned from the technology transfer program.

(3) Cooperation with CGIG

The preparation for the establishment of CGIG was commenced in 2015. This is based on the action plan of PNIG. However, CGIG was scheduled to be established in 2012 according to the initial plan, which was the first year of the activity to achieve the special target (that is, the development of NSDI).

In view of this, it is essential to take this opportunity to step up the effort to implement the activities necessary for the achievement of the special target in the initial plan, namely, creation of 1:200,000 topographic maps by IGN France project, creation of metadata inventory of the product of this project and development of technical specifications and legal framework. Furthermore, it is urgently required to develop human resources capable of implementing the introductory training on basic GIS data for the member ministries and agencies of CNIG and CRIG.

3. Production of Digital Topographic Maps and GIS Data

3.1 Determination of Technical Specifications

Survey standards and digital mapping method and rules for 1:5,000-scale topographic map and orthophoto were determined with IGM before the starting the digital topographic mapping.

3.1.1 Discussion for Setting Technical Specifications

IGM did not have a systematical framework for the survey criteria and standard (method and accuracy), map symbols (acquired feature items) and applicable rules, and specification (size, language and marginal information) for producing the final products of 1:5,000-scale topographic maps.

As described in the previous chapter, the national geographic information policy of Mali, which was determined by cabinet meeting in 2012, sets forth the establishment of NSDI as the high-level goal to be achieved. Standardization of geographic information data in Mali and development of technical specifications are essential in achieving this goal. In the management of national geospatial information of Mali that IGM is implementing as the secretariat, development of unified technical specifications is as important as the 1:5,000 topographic maps that are produced by this project.

A series of discussions were held in order to prepare the 1:5,000 technical map specifications and standards, which will be adopted by the ministries and agencies of Mali. In the discussions, sufficient consultations were made to ensure consistency with the existing products and future plans of IGM.

3.1.2 Inventory Survey at IGM

Prior to the commencement of discussion for specifications, existing information listed below was collated in order to determine the survey standards.

(1) Distribution map of geodetic points at Bamako (The list and map of geodetic points, description of leveling points, leveling route map)

(2) Server system at IGM office and internet environment survey

(3) Administrative names, scopes of administrative boundaries and existence of information about urban infrastructure facilities

(4) Existing topographic maps (IGM)

(5) Capacity analysis for technical level, human resource and equipment of IGM

3.1.3 Technical Specifications

Various specifications and rules were discussed with IGM. Finally, IGM agreed to five specifications, which are shown below (for the 1:5,000-scale base map specifications).

(1) Bamako mapping project: Briefing document on UTM

(2) Bamako mapping project: Marginal information of 1:5,000 base maps

(3) Bamako mapping project: Methodology of numbering system for basic maps

(4) Bamako mapping project: 1:5,000-scale map symbols and application rules

(5) Bamako mapping project: 5,000-level specification of annotation

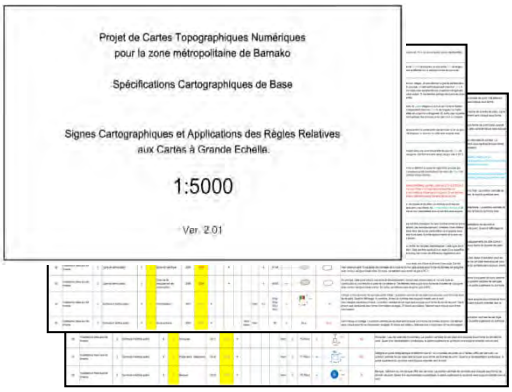


Figure 3-1 1:5,000-scale Map Symbols and Application Rules

3.1.4 Survey Standards

The following survey standard for aerial photography, GNSS observation, leveling, aerial triangulation, field identification, digital mapping and digital editing were discussed with IGM. With respect to the national standard coordinate system, as IGM had been considering transition to the world geodetic system since 2012, the survey standard to be adopted in this project was established, while checking the progress of the standard system conversion work of IGM. Table 3-1 shows survey standard, with which the basic GIS data developed in this project comply.

Table 3-1 Survey Standard

Standard items	Adopted specifications
Reference spheroid	WGS84 (World Geodetic System 84)
Projection method	UTM (Universal Transverse Mercator), Zone 29N
Coordinates system	WGS84 coordinates system
Height reference	Mean sea level of the Port of Dakar (= existing benchmarks of IGM)

Surveying specifications are essential in implementing ground control point survey for basic GIS data production was discussed with IGM. The work specifications needed for GNSS observation, leveling and aerial triangulation were determined as shown in Table 3-2.

Table 3-2 Adopted Accuracy Standards in this Project

Survey items	Standard and specifications
GNSS observation	Observation sessions: 20 sessions Observation time: 60 minutes Data acquisition interval: within 15 seconds Common satellite number: more than 5 satellites Observation method: Simultaneous observation
Direct leveling	Pricking distance: 2-4 km Closure: 40 mm√S Closure between existing point: 50 mm√S Discrepancy of round trip: 40 m√S S = observation distance (one way km)
Aerial photography (Digital camera)	Overlap: 60% standard Side lap: 30% standard Fixed point and slave point: more than 5 satellites shall be acquired as same time Photography report: Photo log, execute organization, start and end time, date of photography, camera serial number, focal length, ground sampling data, aircraft, altitude, camera calibration report, GNSS/IMU data, trajectory, quality control table, technology transfer information, aerial image data, thumbnail image

Next, tolerances regarding data acquisition and calculation from GNSS observation, leveling and aerial triangulation were adopted as shown in Table 3-3.

Table 3-3 Tolerance of Topographic Map

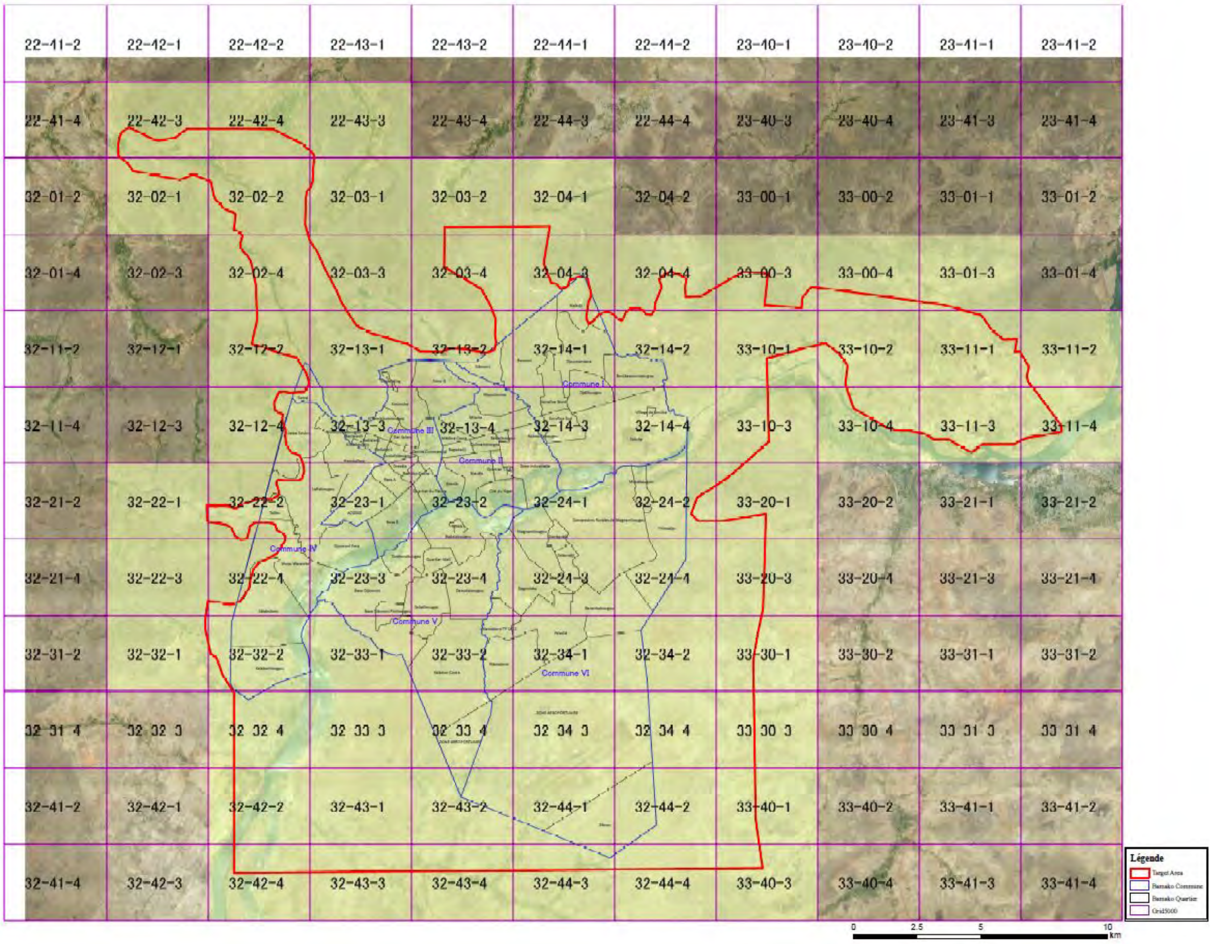
Survey items	XY position	Height
Ground control point survey	Within 0.2 m	Within 0.2 m
Proof point of aerial triangulation	Within 1.5 m	Within 1.5 m
Adjustment of aerial triangulation	Within 1.5 m	Within 1.0 m
Digital mapping	Within 1.5 m	Within 1.0 m
Basic GIS data	Within 3.5 m	Within 1.66 m (Contour lines: within 2.5 m)

Contour interval and spot height's density of the products, 1:5,000-scale basic GIS data were agreed as shown in Table 3-4.

Table 3-4 Contour Interval of Topographic Map

Map scale	Main contour	Index contour	Supplementary contour	Spot height (on the map)
1:5,000	5 m	25 m	2.5 m	4 points / 10cm^2

Finally, according to the methodology of numbering system for basic map defined respecting consistency with the small scale maps managed by IGM, the layout of 1:5,000-scale map sheet for 1:5,000-scale topographic maps and orthophoto maps was agreed as shown in Figure 3-2.



Source: Prepared by the Project Team

Figure 3-2 Index for each Sheet of 1:5,000 Topographic Maps

Red: Coverage of topographic map, Purple: All the 1:5000-scale map sheets, Blue: Commune boundary, Yellow: Map sheets of the topographic maps created in this project

3.2 Supervision of Aerial Photography

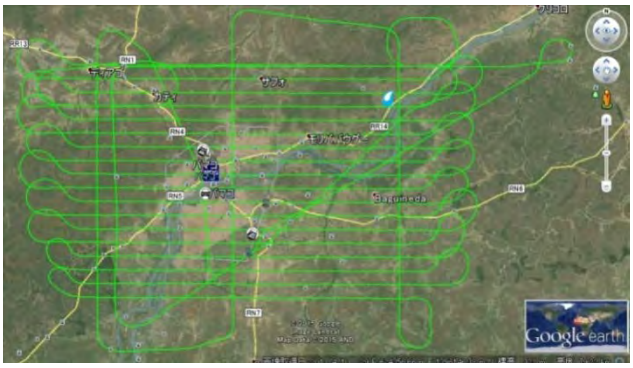
3.2.1 Aerial Photography

Aerial photography was subcontracted to a Netherlands aerial photography company since there is no aerial photography company in Mali. The subcontractor used an UltraCam Eagle (a Microsoft digital aerial camera, that is equipped with GNSS and an inertial measurement unit) to acquire digital aerial photographs with a ground resolution of approximately 20cm. The following provides an outline of the aerial photography tender procedure to aerial photo acquisition and inspection.

(1) 19th February 2015 Commencement of the tender
(2) 26th – 27th February 2015 Deadline/evaluation of the bidding documents and announcement of the bid result
(3) 3rd March 2015 Reporting to the JICA HQ about the evaluation
(4) 4th March 2015 Submission of applications for the landing and photography permits
(5) 9th March 2015 Signed on the contract document
(6) 19th March 2015 Issuance of the photography permit
(7) 20th – 21st March 2015 Arrival in Bamako of the aircraft and inspection for the aircraft, GPS and Camera
(8) 22nd March 2015 Start and Finished 100% photography
(9) 8th April 2015 Approval of the inspection for the interim results of the photography

3.2.2 Results of Aerial Photography

The flight lines comprised 18 lines in the East-West direction and 3 lines in the North-South direction. The total numbers of photographs were 1,251. The flight used existing geodetic point (B11) managed by the IGM for getting GPS/IMU data as the principal point coordinates of camera position (see Figure 3-3 and Table 3-5).



Source: Map data © 2015 GoogleEarth

Source: Prepared by the Project Team

Figure 3-3　Flight Lines and Result of Sample Image
(Upper left: Flight lines, Lower left: All exposures, Right: Sample image)

Table 3-5 Quality Control Sheet for Aerial Photography

Digital Aerial Photography Quality Control Sheet			
Client	Japan International Cooperation Agency	Aircraft	Piper Cheyenne PA31T / Piper Cheyenne IIXL
Project Name	Digital topographic mapping project for the Bamako Metropolitan Area	Camera	Vexcel Ultra CAM Eagle No.01-70512096 / Pixel size=15.1CM Focal length=100.500mm
Project Period	From : 9th March, 2015 To : 10th May,2015		La Mission d' Etude de la JICA Asia Air Survey Co., Ltd
Date	16/3/2015	Inspecter	Manabu Kawaguchi (Signature)
Date	29/4/2015	Approvrd	Nobuo Shimizu (Signature)

Flight Line No.	Photo No (Start)	Photo No (End)	Number of Photos	Date of Photography	Inspection Item / Accuracy requirement	Forward overlap 60%±5%	Laterel overlap 30%±5%	EO file Availability & condition	κ ≦5°	φ ≦3°	ω ≦3°	Deviation from planned altitude ±5% from planned altitude	Out of focus No	Halation	Shadow spot	Cloud	Smoke	Haze	Remarks ※Only adopted results are shown.
														Less than 3% in each image					
1	1217	1265	49	22-Mar-2015	21	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
2	1169	1216	48	22-Mar-2015	20	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
3	1121	1168	48	22-Mar-2015	19	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
4	2	90	89	22-Mar-2015	1	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
5	91	151	61	22-Mar-2015	2	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
6	152	212	61	22-Mar-2015	3	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
7	226	286	61	22-Mar-2015	4	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
8	287	347	61	22-Mar-2015	5	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
9	348	408	61	22-Mar-2015	6	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
10	409	468	60	22-Mar-2015	7	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
11	469	528	60	22-Mar-2015	8	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
12	529	588	60	22-Mar-2015	9	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
13	589	647	59	22-Mar-2015	10	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
14	648	707	60	22-Mar-2015	11	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
15	708	767	60	22-Mar-2015	12	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
16	768	826	59	22-Mar-2015	13	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
17	827	885	59	22-Mar-2015	14	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
18	886	943	58	22-Mar-2015	15	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
19	944	1002	59	22-Mar-2015	16	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
20	1003	1061	59	22-Mar-2015	17	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
21	1062	1120	59	22-Mar-2015	18	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
21			1,251																

3.3 Ground Control Survey

3.3.1 GNSS Observation

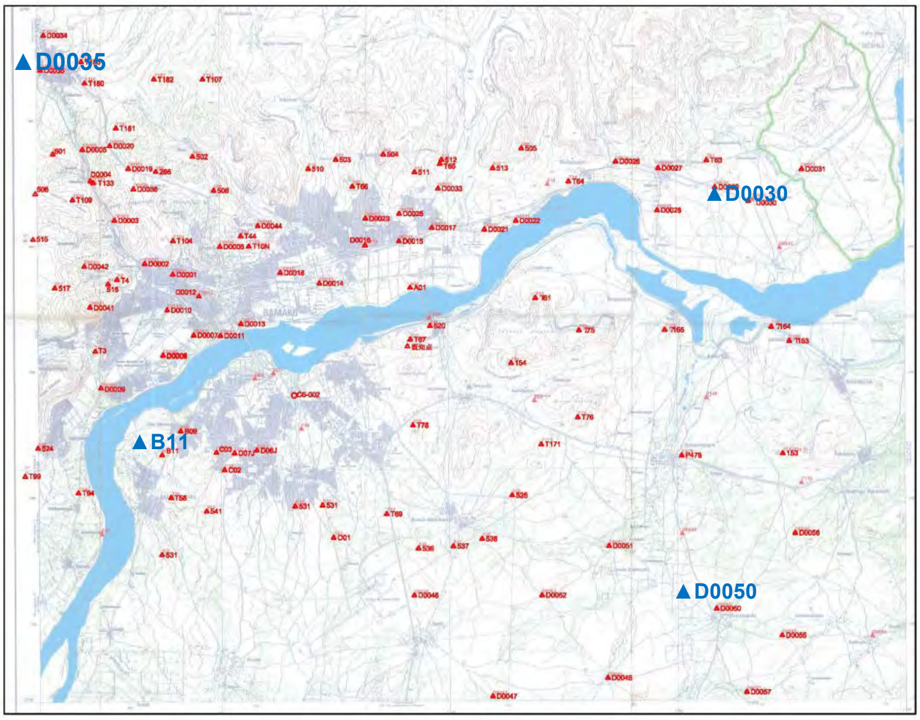
The ground control point (GCP) survey was executed to determine the planimetric position for the digital topographic mapping at scale of 1:5,000 based on the existing geodetic points managed by IGM.

(1) Preparation work

Before commencement of the ground control point survey, single positioning observation executed at the existing point located on the roof of IGM building using GNSS equipment IGM controlled.

(2) Validation of existing geodetic points

Figure 3-4 shows distribution of existing geodetic points managed by IGM in the Bamako metropolitan area. Based on this distribution map, geodetic points were selected within the target area. For the inspection of existing points, selected points were determined by GNSS observation. Then those results were confirmed within a threshold or not.



Source: Created by Project Team based on IGMs

Figure 3-4 Distribution map of geodetic points

The inspection survey was conducted using radial method based on the computation of the coordinates among D0035, D0030, D0050 and B11 as a fixed point. Table 3-6 shows the results of the observed coordinates (coordinates system adopted UTM coordinates system). After validation, the observed values were confirmed to be with sufficient accuracy to be used for this project.

Table 3-6 Observed Coordinates and Result Discrepancy

Existing point	Observed Coord. for X Observed Coord. for Y	Result Coord. for X Result Coord. for Y	Discrepancy
D0035	601333.077 1407075.274	601333.098 1407075.265	-0.021 0.009
D0030	629561.081 1401956.465	629561.054 1401956.434	0.027 0.031
D0050	628153.732 1385708.196	628153.783 1385708.276	-0.051 -0.080

All the geodetic points in the Bamako metropolitan area were not fully observed. However, reconnaissance confirmed 60% of existing points, while 40% of the points were missing or broken by the secular changes.

Source: Project Team

Normal condition of geodetic point (D0050) Broken condition of geodetic point (T58)

Photo 3-1 Actual condition of geodetic points

(3) Field reconnaissance of the selected GCPs

After preparation of selection point, 27 control points (GCP-01 to GCP-27) for the aerial triangulation work was confirmed on the sight.

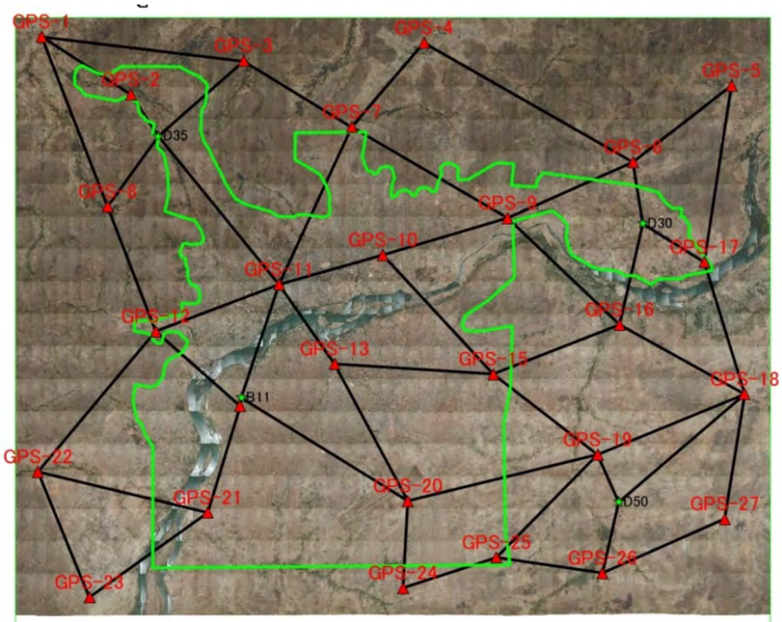
Furthermore, photographs were taken at each location and the point description of ground control points was prepared as shown in Figure 3-5.

Source: Prepared by the Project Team

Figure 3-5 Point Description of GCPs

(4) Execution of GCP survey

Four GCP survey teams were organized to observe 27 control points using 4 sets of GNSS equipment. In total, 20 sessions GNSS observations were executed (Figure 3-6). Polygonal network observation and calculation method were used for the GCP survey in this project. (Photo 3-2).



Source: Prepared by the Project Team

Figure 3-6 Index of Observation Session Planning

Source: Project Team

Photo 3-2 Snaps of GPS Observation

3.3.2 Leveling

The purpose of leveling was to determine elevations of ground control points, necessary for aerial triangulation of 1:5,000-scale digital topographic mapping. Leveling was implemented based on the existing benchmarks which are maintained and managed by IGM.

(1) Confirmation of existing benchmarks in the Bamako metropolitan area

Based on the information of the existing benchmarks on the periphery of Bamako City, the existing benchmarks, which are located along the planned leveling routes, were examined for the presence or absence of benchmark.

The inspection results and elevations of the existing benchmarks were provided from IGM are shown in Table 3-7.

Table 3-7 Confirmation of Existing Benchmarks and Height Value

BM No.	Result	Condition	Height (m)
Mle DET	Existing	Good	332.480
Mle 1	Lost		330.413
Mle 2	Lost		324.656
Mle 3	Existing	Good	324.948
CT-1	Existing	Good	322.789
CT-2	Unknown		322.199
CT-3	Existing	Good	322.130
CT-4	Lost		322.898
CT-5	Lost		322.191
CT-6	Lost		320.760
CT-12	Existing	Good	324.489
CT-16	Existing	Good	353.859

(2) Confirmation of geodetic points in the Bamako metropolitan area

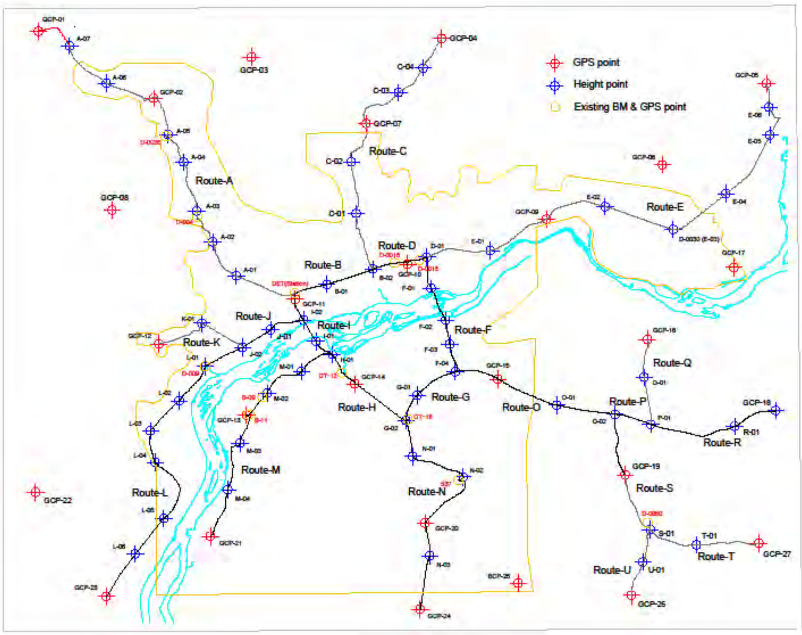
According to the information prepared by IGM, the elevations of some geodetic points, which were established by IGM were determined based on the result of past leveling work. Therefore, the existing geodetic points (the elevations were determined by leveling) were checked in the field. According to inspection result, the height of geodetic points could be used seven points of eleven points provided by IGM (A-01 could not be used in this project) as shown in Table 3-8.

Table 3-8 Confirmation of Existing Geodetic Points and Height Value

Point No.	Result	Condition	Height (m)
A-01	Existing	Broken	316.915
520	Lost		503.500
531	Lost		363.540
537	Existing	Good	361.870
B-09	Existing	Good	328.745
B-11	Existing	Good	348.776
D-002	Lost		349.034
D-004	Existing	Good	414.310
D-0015	Existing	Good	326.092
D-0016	Existing	Good	330.738
T-69	Lost		386.980

(3) Execution of leveling

Based on the leveling route plan prepared in Japan, final leveling routes was determined (Figure 3-7) taking into consideration the locations of the existing benchmarks, geodetic points (elevations were determined by leveling), road conditions and so on.



Source: Prepared by the Project Team

Figure 3-7 Index of Leveling Route

Leveling with total distance of 196.78 km (which was executed by three parties) started from March 9 and completed in April 26, 2015. In parallel with the leveling, observation notes and calculation notes were prepared and all elevations of ground control points were determined by April 28, 2015 including points that were measured again. Based on the accuracy standards determined with IGM as described earlier, leveling was carried out at the accuracy as described below.

Discrepancy between two (2) times observation	40 mm x$\sqrt{D}$
Closing error to the existing point	50 mm x$\sqrt{D}$

Note: D is the distance in km.

(5) Calculation of elevation of GCPs

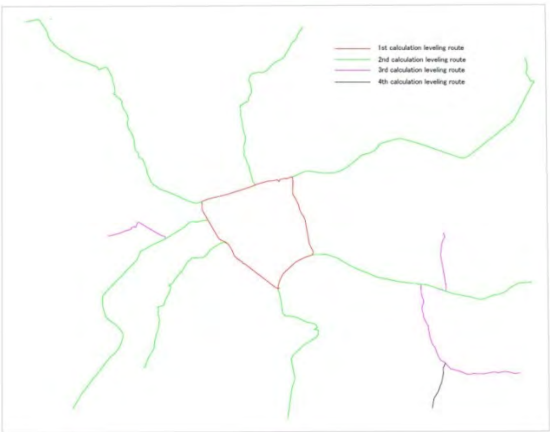
As mentioned above, validation revealed that the existing benchmarks and geodetic points have sufficient accuracy (as standard of elevation) for aerial triangulation of 1:5,000-scale digital topographic mapping. Therefore, the elevations of ground control points were determined based on the elevations of the existing benchmarks and geodetic points.

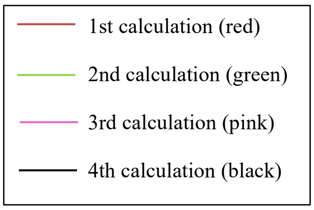
Using vertical drop between existing elevation value of the existing benchmarks and geodetic points and measured value from this leveling work, the elevation of each ground control point was calculated using the following method.

1) The elevations of the existing benchmarks and geodetic points were used as given point.
2) The closure error among the existing points was distributed proportionally based on the distance of leveling routes.
3) If there is no existing point at the end of leveling route, average value of two times (or round trip) observation was determined as a relative height.
4) Taking the location of the existing benchmarks into consideration, the loop consisting of route-B, D, F, G, H and I was calculated at the beginning and the elevations of existing benchmarks or geodetic points along Loop were defined as the 1st route.
5) Leveling route connected to the loop as the 1st route was defined as the 2nd calculation and the third calculation and the fourth calculation routes were set as appropriate as shown in Table 3-9 and Figure 3-8.

Table 3-9 Calculation Order for Elevation of Leveling Routes

Calculation order	Route name
1st calculation (red)	Loop consisting of Route B, D, F, G, H, I
2nd calculation (green)	Route A
	Route C
	Route E
	Route J & L
	Route M
	Route N
	Route O & P & R
3rd calculation (pink)	Route K
	Route S & T
4th calculation (black)	Route U





Source: Prepared by the Project Team

Figure 3-8 Calculation Order for Elevations of Leveling Routes

The final elevations of ground control points (benchmarks and ground control points) calculated based on the result of leveling are shown in Table 3-10.

Table 3-10 Calculated Elevations of GCPs

Benchmarks				GCPs	
Point No.	Elevation (m)	Point No.	Elevation (m)	Point No.	Elevation (m)
A - 01	348.588	I - 01	322.046	GCP - 01	388.394
A - 02	387.317	I - 02	321.654	GCP - 02	427.830
A - 03	419.394	J - 01	324.342	GCP - 04	386.125
A - 04	440.718	J - 02	327.427	GCP - 05	328.121
A - 05	478.747	K - 01	341.878	GCP - 07	397.827
A - 06	408.459	L - 01	325.411	GCP - 09	312.774
A - 07	404.692	L - 02	328.458	GCP - 10	328.901
B - 01	328.518	L - 03	347.914	GCP - 11	327.984
B - 02	328.354	L - 04	336.509	GCP - 12	341.197
C - 01	359.096	L - 05	326.454	GCP - 13	338.862
C - 02	368.144	L - 06	331.352	GCP - 14	327.329
C - 03	414.719	M - 01	342.840	GCP - 15	334.219
C - 04	391.953	M - 02	327.244	GCP - 16	315.578
D - 01	324.784	M - 03	330.716	GCP - 18	331.872
E - 01	316.131	M - 04	326.842	GCP - 19	344.661
E - 02	325.628	N - 01	386.081	GCP - 20	373.696
E - 03	338.379	N - 02	358.529	GCP - 21	330.397
E - 04	343.011	N - 03	363.020	GCP - 23	329.890
E - 05	315.520	O - 01	348.791	GCP - 24	365.058
E - 06	311.971	O - 02	322.470	GCP - 26	342.746
F - 01	319.351	P - 01	341.957	GCP - 27	368.854
F - 02	323.266	Q - 01	328.939	GCP - 3	416.869
F - 03	322.740	R - 01	343.986	GCP - 6	362.161
F - 04	329.963	S - 01	338.775	GCP - 8	441.896
G - 01	357.175	T - 01	361.979	GCP - 17	316.702
G - 02	351.174	U - 01	339.082	GCP - 22	345.762
H - 01	325.603			GCP - 25	376.738

3.4 Aerial Triangulation

For the area covered by the aerial photography (about 1,400 km^2), aerial triangulation was carried out in Japan according to the work process shown in Figure 3-9.

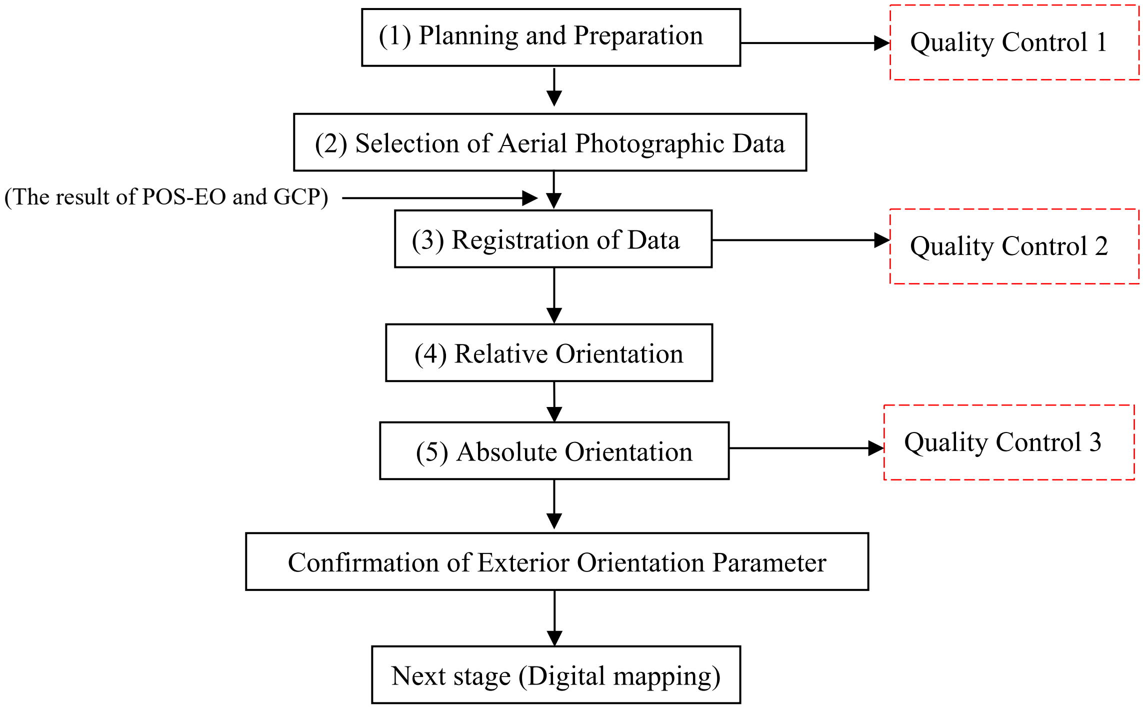


Figure 3-9 Flowchart of Aerial Triangulation

3.4.1 Inspection of Acceptance Data Using in Aerial Triangulation (Quality Control 1)

After inspection of digital data of aerial photographs and coordinates of ground control points based on results of quality control of photo image, POS-EO and ground control point survey, exterior orientation elements were determined for successive digital mapping in aerial triangulation (Table 3-11).

Accepted aerial photographs were 1,222 exposures for 21 lines and 80 Ground control points from GCP survey were used.

Table 3-11 Items for Acceptance Inspection of Each Data

Results	Categories of data	Inspection items
Results of aerial photographs	Image data of aerial photographs	Each image → Number, Data size Image quality → Sharpness and clearness Overlap → OL60%, SL30% GCP → Confirm on the stereo image
	POS-EO data	Bundle Block Adjustment → Confirm photogrammetric elements Flight height → Confirm required resolution on the ground
	Data for aerial camera reference	Aerial camera → Focal length
	Index of aerial photographs	POS-EO* Confirm coincident between POS-EO data and position
Results of GCP survey	Description	Prick point → Clearness
	Coordinates of GCP	Within the coverage of aerial photography area
	Index of GCP location	Coincident between list and XYZ coordinates from GCP survey

*POS-EO: Introduction in a system as initial value of approximate external orientation parameter

3.4.2 Selection of Aerial Photographic Data

Figure 3-10 shows the aerial photographs captured in this project. The target area of this project was photographed in a total of 21 courses, of which 3 were vertical and 18 were horizontal, and the total number of photographs was 1,222.

Source: Prepared by the Project Team

Figure 3-10 Index of Aerial Photography

Aerial photography accuracy assessment results were good since the aerial photos were acquired in one day. In addition, there were few variations of flight height from the results of POS-EO. Finally, aerial photos for triangulation were determined. In total, 1,077 aerial photos were acquired based on 18 east-west lines (Table 3-12).

Table 3-12 Photo Numbers for Aerial Triangulation

Line No.	Photo No.		Photo No.	Qty.	Line No.	Photo No.	~	Photo No.	Qty.
C-4	4-31	~	4-90	60	C-18	18-886	~	18-943	58
C-5	5-91	~	5-151	61	C-19	19-944	~	19-1002	59
C-6	6-152	~	6-212	61	C-20	20-1003	~	20-1061	59
C-7	7-226	~	7-286	61	C-21	21-1062	~	21-1120	59
C-8	8-287	~	8-347	61				Total	235
C-9	9-348	~	9-408	61					
C-10	10-409	~	10-468	60					
C-11	11-469	~	11-528	60					
C-12	12-529	~	12-588	60					
C-13	13-589	~	13-647	59					
C-14	14-648	~	14-707	60					
C-15	15-708	~	15-767	60					
C-16	16-768	~	16-826	59					
C-17	17-827	~	17-885	59					
			Total	842					

18 strips Grand Total 1,077

3.4.3 Registration of Data (Quality Control 2)

Three dimensional models were established using digital photogrammetric system based on aerial photograph data, POS-EO data and focal length and position data (X, Y, Z/ω, φ, κ) of digital aerial camera.

After confirmation of three dimensional stereo model in a system by visual inspection, registered POS-EO data (result of AEROoffice V5.3d on April 7, 2015) as shown in Table 3-13 and flight report (Flight Report on 22nd March 2015) were re-confirmed for the registration of data.

Table 3-13 Inspection Items during Registration of Photo Data

Work items	Items of registered data	Contents of inspection
Registration of aerial photographic images	The position of each photograph	Between coordinates of flight index and POS-EO coordinates
	Photographic lines	Number of lines and photos
	Flight height	Average of flight height (m)
Registration of aerial camera	Type of aerial camera	Focal length of camera (mm)
Image resolution	Photo scale	Photo scale

(1) Elements of aerial camera

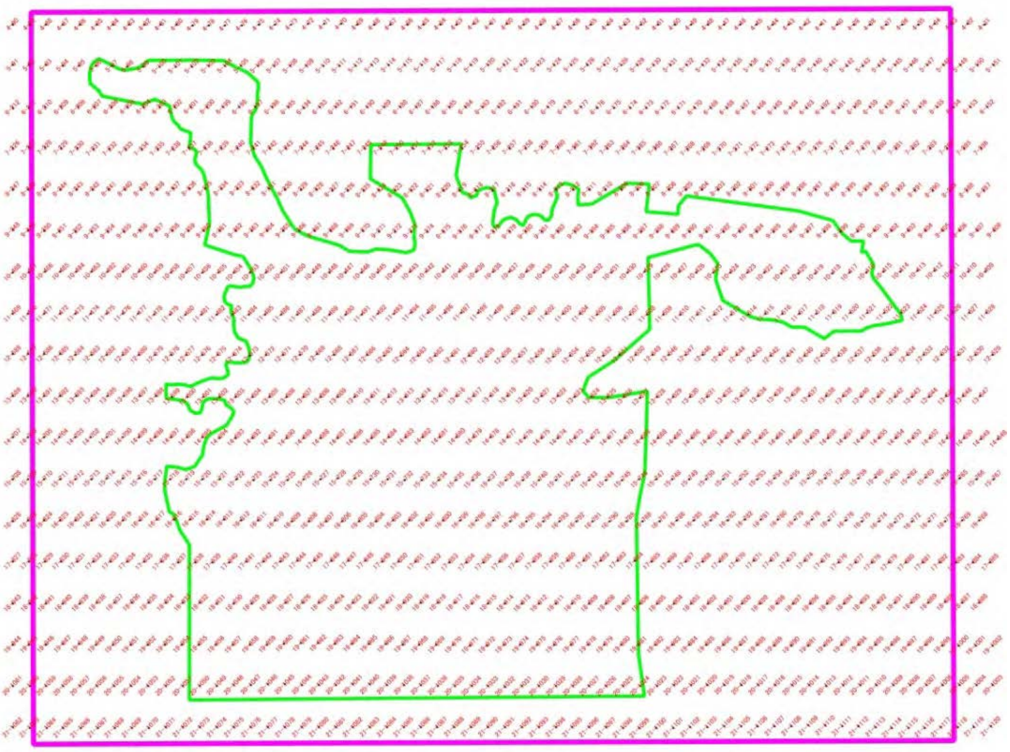
Elements of digital camera used for aerial photography are as follows.

- Camera type : UltraCam Eagle, 1-70512096-f100
- Format of image : 13080, 20010 (H,W Pixel)
- Size of CCD : 0.0052, 0.0052 (mm)
- Focal length : 100.5 (mm)

* Measurement date: 6th May 2014

(2) Aerial photographs

Figure 3-11 shows that aerial triangulation was executed using 1,077 aerial photographs with 18 lines selected from total 21 lines (1,251 photos).



Source: Prepared by the Project Team

Figure 3-11 Photo Index for Aerial Triangulation

: Coverage of 1:5,000-scale topographic map

: Coverage of orthophoto *1234*: Position of photographs and photo number

(3) POS-EO data

Approximate exterior orientation (EO) elements were computed from POS recorded data of aircraft and continuous GPS observation data by ground during aerial photography. These approximate EO were used in aerial triangulation such as sample POS-EO output below (Figure 3-12).

Figure 3-12 Sample of POS-EO Results

3.4.4 Relative Orientation

Relative orientation was executed to adjust relative connection of left and right stereo images to get tie-point and pass point as the same position of adjacent photos by automatic image matching. The total matching points were 6,451 points for 18 lines and 1,077 photos (in case of getting 5 points per 1 model as a connection points (pass-point)).

3.4.5 Absolute Orientation (Quality Control 3)

Pass-points, tie-points and pricked leveling points were observed in a stereo model. Transformation coefficient values were determined between model coordinates and observed ground control points (GCP survey and leveling) on model and ground coordinates of GCPs. This process to observe all models means absolute orientation. Final **exterior orientation parameter** of each photo were computed and confirmed.

Residual of absolute orientation (GCP coordinates by GNSS and computed GCP coordinates) and relative orientation (vertical parallax of pass-points and tie-points) were confirmed.

Adjustment results are shown in Table 3-14. Each residual was within tolerance, so exterior orientation parameters were confirmed for the next stage of digital mapping.

Table 3-14 Comparison between Tolerance and Computed Value in Aerial Triangulation

Tolerance for each parameter		Tolerance	Computed value
Exterior Orientation parameters	X (m)	0.05	0.1
	Y (m)	0.05	0.1
	Z (m)	0.08	0.1
	ω (deg)	0.005	0.005
	φ (deg)	0.005	0.005
	κ (deg)	0.008	0.008
GCP:XY (H)	SD (m)	0.64	0.198 (0.246)
	Max V. (m)	1.28	-0.369 (-0.744)
Pass point Tie point	SD (mm)	0.015	0.002
	Max V. (mm)	0.03	0.009
Flight height (m)	-	-	3,200 m

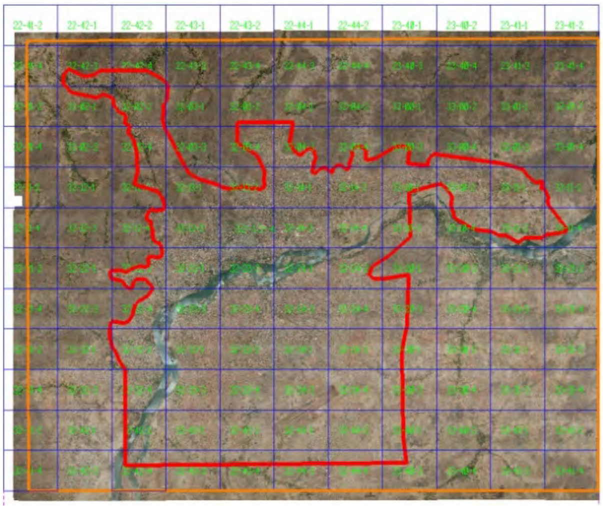
As the final result of quality control, aerial triangulation realized a positive outcome as follows:
Standard deviation (XYZ) of GCP: = 0.143m, 0.134m, 0.438m
Standard deviation of planimetric position: = 0.198m

3.5 Orthophoto Creation

An orthophoto is created by orthographically projecting an aerial photo, which is a central projection, at the correct position and correct scale by using elevation data (DEM) and breaklines indicating points of topographic changes. It is an orthographic image on which measurement of area and length can be carried out like a topographic map.

3.5.1 Coverage of Orthophoto Maps

In this project, orthophotos were created by dividing the whole area of the Bamako metropolitan area of about 1,400 km^2 (132 map sheets (1 map sheet = 4.0 km×3.0 km)) extracted from the coverage of aerial photos into the area subject to 1:5,000 digital plotting (520 km^2) and



Source: Prepared by the Project Team

Figure 3-13 Coverage of Orthophotos

(Orange: Coverage, Red: Area subject to digital plotting, Blue: Neatline)

the area not subject to digital plotting (880 km^2)
as shown in Figure 3-13.

3.5.2 Creation of Orthophoto Data

Figure 3-14 shows the procedure for producing orthophotos.

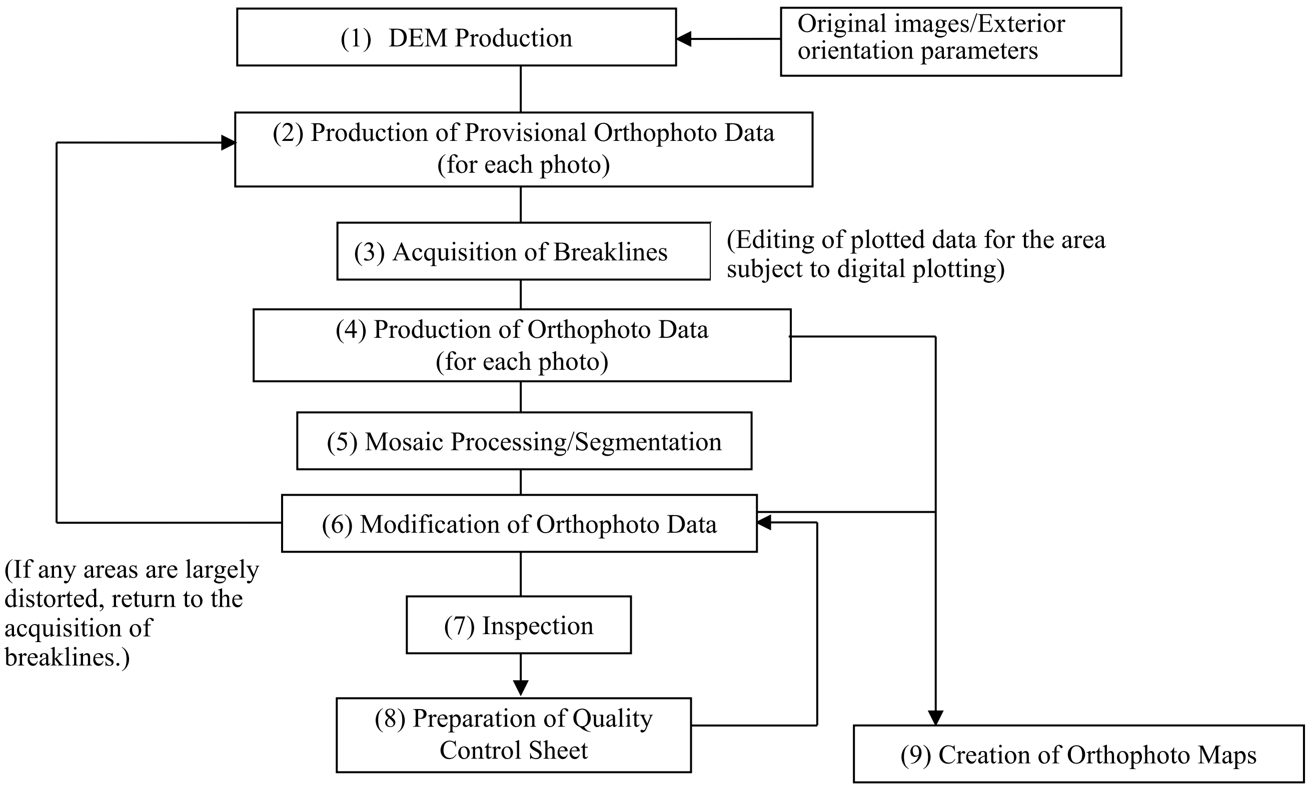


Figure 3-14 Flowchart for Orthophoto Production

(1) Production of DEM

Using the aerial photo data (original images) and exterior orientation parameters determined by aerial triangulation, DEM data were created in the automatic matching method. Inconsistent locations were manually modified to create the DEM data.

(2) Production of provisional orthophoto data

Using the DEM data that were generated, provisional orthophoto data (for each photo) were created.

(3) Acquisition of breaklines

Areas with distortions, such as roads and rivers, from the provisional orthophoto data were verified and breaklines were acquired by using stereo models. With respect to the area subject to digital plotting, plotting data were edited against feature data of roads and contours.

(4) Creation of orthophoto data (for each photo)

Using the DEM data and breakline data (plotting data that have been edited), orthophoto data (for each photo) were created.

(5) Mosaic processing

All the orthophoto data created for each photo were imported and seamline data were created by automatic mosaic processing (Figure 3-15).

In addition, by using the seamline data against the orthophoto data for each photo, ortho images that have been mosaic-processed in the units of map sheets were created.

Source: Prepared by the Project Team

Figure 3-15 Mosaic Processing (Seamline)

(6) Modification of orthophoto data

The orthophoto data were checked by monitoring checks of the overall joints, distortions and color tones. With respect to the areas with large distortions, breaklines were added (re-acquired) to create the orthophoto data again.

(7) Inspection

Images after the modification of the orthophoto data were checked to make sure that extracted errors were corrected by ortho modification to complete the orthophoto data.

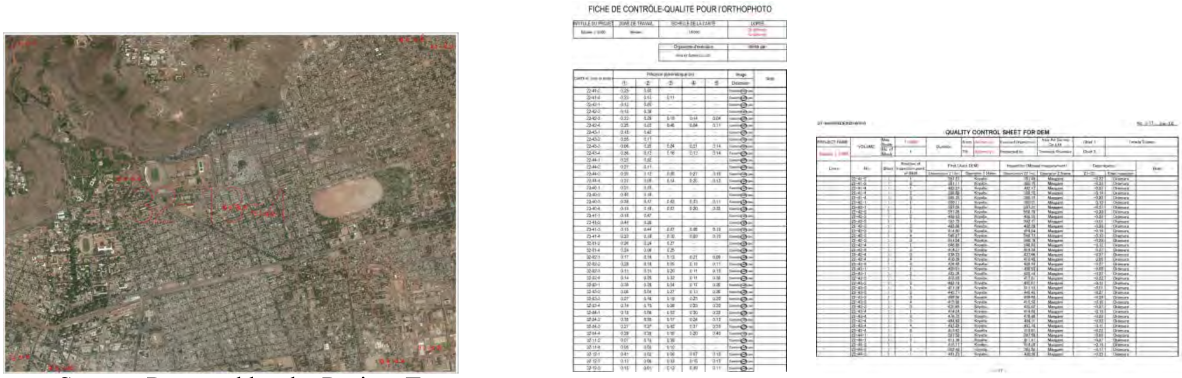
(8) Quality control

With respect to the accuracy of orthophoto data position and height of DEM, inspection was carried out in accordance with the accuracy standards shown in Table 3-15 and the results were compiled into quality control sheets.

Table 3-15 Accuracy Standards of Position and Height

Map information level	Standard deviation of horizontal position	Standard deviation of elevation point
5,000	5.0 m or less	2.5 m or less

In addition, accuracy of horizontal position was controlled by focusing on the discrepancy between the topographic map and the orthophoto data, and accuracy of elevation point was controlled by measuring the residual difference between the DEM and the 3-dimensional spatial model.



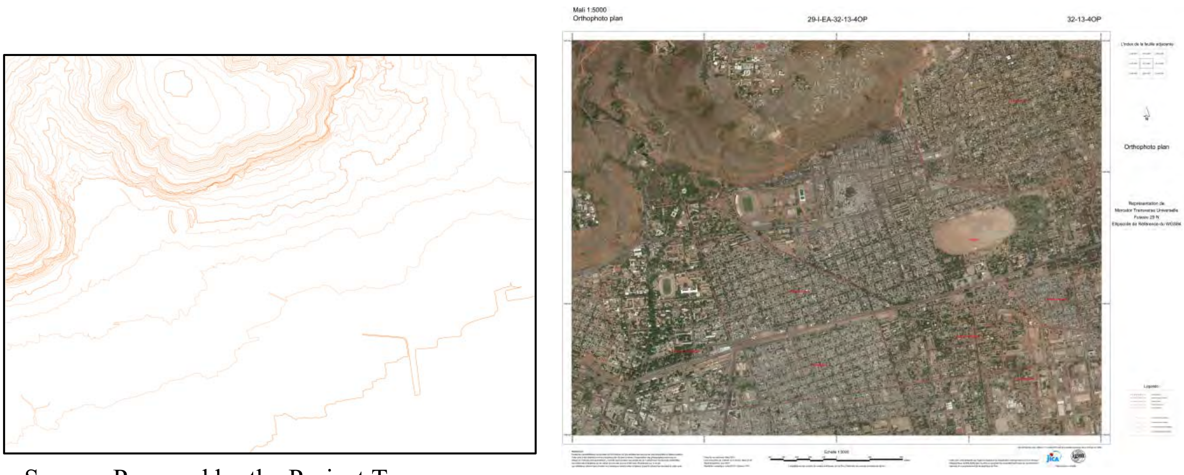
Source: Prepared by the Project Team

Figure 3-16 Output of Quality Control Sheet (Left Table) and Quality Control Sheet for Plane and Height (Right Table)

(9) Creation of orthophoto maps

For the creation of orthophoto maps, with respect to the area not subject to digital plotting, contour lines were generated based on the DEM used in creating orthophoto data and the breakline data. On the other hand, for the area subject to digital plotting, contours lines of digital editing data were edited to create the contour line data for orthophoto maps (Figure 3-17).

Marginal information for orthophoto maps was created and orthophoto maps were created with the contour line data and orthophoto data in the background.



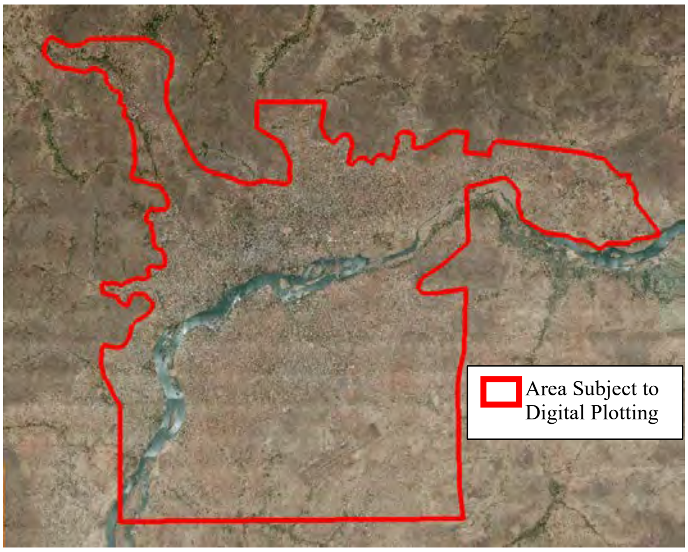
Source: Prepared by the Project Team

Figure 3-17 Contour Line Map (Left Map) and Orthophoto Map (Right Map)

3.6 Digital Plotting

3.6.1 Area Subject to Digital Plotting

Digital plotting was carried out for 73 map sheets, which measures approximately 520 km^2 for the Bamako metropolitan area (Figure 3-18). The 1:13,000-scale color aerial photo image data from C4 to C20 courses were used (See Table 3-12) based on the "1:5,000-scale Map Symbols and Application Rules" and allowable errors adopted in 2.1.



Source: Prepared by the Project Team

Figure 3-18 Area Subject to Digital Plotting

3.6.2 Production of Digital Plotting Data

In this project, digital plotting data were created in accordance with the work flow shown in Figure 3-19 as follows.

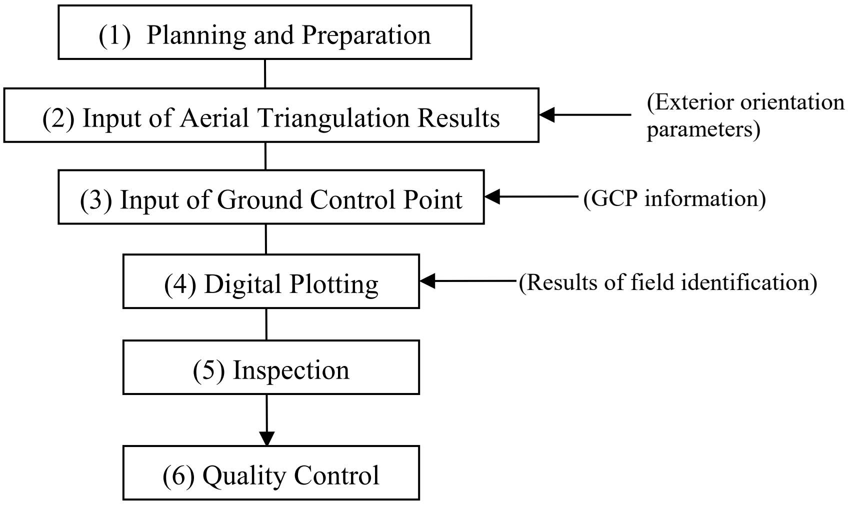


Figure 3-19 Digital Plotting Work Flow

(1) Planning and preparation

System environment for digital plotting was configured using stereo models (rectification images) necessary for the work and results from aerial triangulation (exterior orientation parameters) in 3.4 as well as the “1:5,000-scale Map Symbols and Application Rules”.

(2) Input of aerial triangulation results

Exterior orientation parameters obtained in aerial triangulation were imported to the digital plotting system and stereo models used for digital plotting were constructed and joined with the ground coordinate system. About 1,000 stereo model images, including duplications between the courses, were used.

(3) Input of ground control point

The ground control point information used in aerial triangulation (primary GPS point and leveling point) was deployed on the digital plotting data and consistency with the digital plotting acquisition items, such as contour lines, was checked on the 3-dimensional spatial model.

(4) Digital plotting

For the acquisition items other than small objects, building symbols and other feature items that are not suitable for photo interpretation, digital plotting was carried out based on photo interpretation as initial input to create plotting manuscripts and simplified orthophotos.

The plotting manuscripts and simplified orthophotos were brought to the field and field identification as described in the next section was conducted to finalize the digital plotting data by incorporating the feature attribute, position and property data acquired in the field identification in Mali (Figure 3-20).

Source: Prepared by the Project Team

Figure 3-20 Data Acquired in Field Identification

In carrying out digital plotting, properties and land use format of the target area as well as field photos supporting the interpretation of building classification were used as references for photo interpretation (Photo 3-3).

Source: Project Team

Photo 3-3　Field Photos for the Interpretation of Features

(5) Inspection

Visual inspection was implemented for each map sheet using 3-dimensional spatial models in order to (i) see if appropriate features have been acquired, (ii) make sure that all the features have been acquired and no excessive acquisition was carried out (Figure 3-21), and (iii)　check the position and property of the acquired features for abnormality.

Source: Prepared by the Project Team

Figure 3-21　Examples of Errors in Digital Plotting

(6) Quality control

With respect to the accuracy of the position of digital data and height of DEM, inspection was carried out based on the allowable accuracy shown in Table 3-16 and the results were compiled into quality control sheets.

Table 3-16 Accuracy Standards of Position, Height and Contour Line

Map information level	Standard deviation of horizontal position	Standard deviation of elevation point	Standard deviation of contour line
5,000	3.5 m or less	1.66 m or less	2.5 m or less

*: "Map information level" in this table represents the map expression accuracy of digital topographic map data and it refers to an index showing the average overall accuracy of data within a map sheet of a digital topographic map.

3.7 Field Identification Survey

As described in (4) of the previous Chapter 3.6.2, field identification was conducted in order to directly identify the feature information that was difficult to directly interpret aerial photographs (land use, road types (paved or unpaved), names and usages of major buildings, such as public facilities) in the field and to acquire feature information.

3.7.1 Field Identification Workshop

According to the initial plan, Japanese experts would accompany the IGM engineers participating in the field identification so that the field identification could be implemented in a form of OJT. However, the plan was changed because of the security problem in Bamako. Therefore, it was decided that the IGM personnel should independently acquire feature information without the Japanese experts.

Therefore, a field identification workshop was conducted to train the IGM counterparts (Photo 3-4). The workshop consisted of lectures in a conference room and practical training in the field. The details of this workshop are given in the next chapter.

Source: Project Team

Photo 3-4 Field Identification Workshop

3.7.2 Analysis of the Existing Information (1:10,000 Topographic Map)

Names of the roads and the designations of the main buildings appear on the 1:10,000-scale topographic maps published between 2005 and 2009 by the IGM. Even though the maps were developed a long time ago, such names are important source of information. A period of field identification was shortened by pre-interpreting/validating such data and updating existing data before field identification.

The 1:10,000-scale topographic map and the current topographic map have different scales, which makes the comparison of the position of planimetric features difficult. To reinforce the efficiency of the field identification, teams have divided the framings into those of the field identification, and made a map on traces paper from the same scales and framings of that of the field identification map (Figure 3-22). Features whose locations were identified on the field identification map were entered on the map and in the field notebook to update the data.

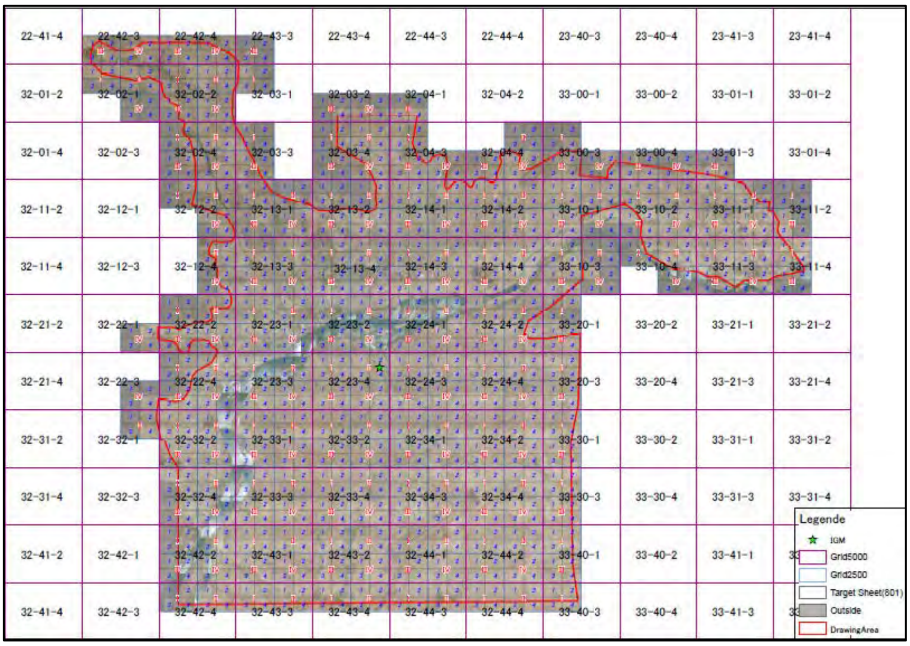
Source: Created by Project Team based on information from IGM

Figure 3-22 Utilization of the Map Scale of 1:10,000

3.7.3 Performing of Field Identification

In total six teams comprising two field personnel conducted the field identification. A3-size field identification maps (801 maps in total) were brought to the field to collect feature information (Figure 3-23).

The field identification was initially scheduled from November 16, 2015 to January 6, 2016. However, due to the worsening of security situation caused by the hotel attack that occurred in Bamako City on November 20, 2015, the field identification was temporarily suspended on December 23, 2015.Howver, the survey was resumed on 2nd March 2016.

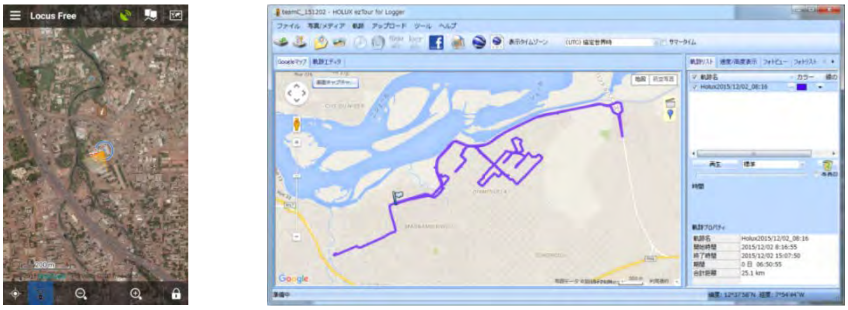


Source: Prepared by the Project Team

Figure 3-23 Map of Field Identification Area (Survey Divisions)

The following methods have been adopted to assure the precision of determination of the position during the field identification.

- The aerial photographs and corresponding field identification map were displayed on a table in order to define the position of the survey point easily (Figure 3-24, on the left).
- The name of the planimetric features and their range as well as the acquired GNSS coordinates was registered in the field notebook. The positions of the survey points were verified for subsequent digitalization works.
- The tablet tracking function allowed us to get the field identification results, and to verify its efficiency and its adaptation (Figure 3-24, on the right).



Source: Prepared by the Project Team

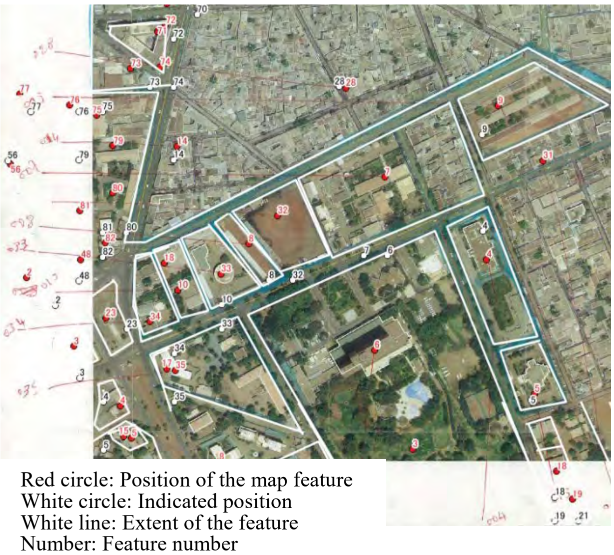
Figure 3-24 Examples of Tablet Usage

(Left: verification of the position on an aerial photo, Right: verification of the activities trajectory)

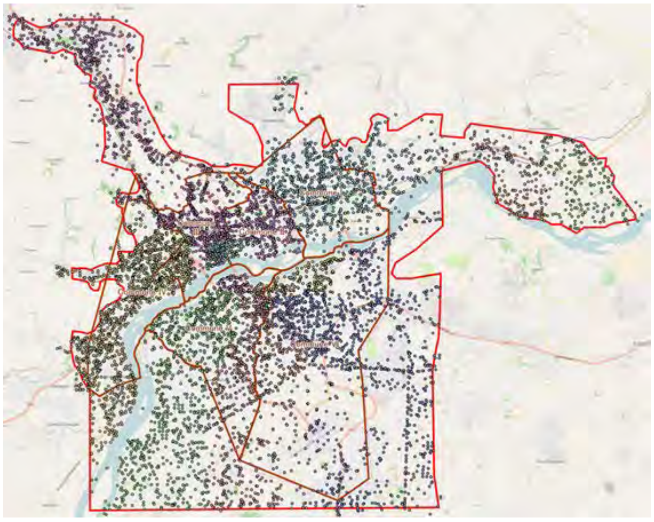
3.7.4 Ordering of the Survey Results and Digitalization

The indicated codes, names, numbers of photo, longitude-latitude of the positions of the map features noted in the field notebook have been compiled in an Excel table. The positions of the map features compiled in the Excel table have been integrated in the GIS software (Figure 3-26, on the left). Furthermore, the precision of the position of the map features was verified through the comparing of its shown position in the map and the real position of the object in the field.

The survey results are represented in Figure 3-25. In total 8,628 points were acquired in this survey.



Source: Prepared by the Project Team



Source: © OpenStreetMap contributors, Project Team

Figure 3-25 Digitalization of Field Survey Results

(Left: Ordering of Features, Right: Survey Results Development Map)

3.8 Field Completion

Field completion is a work to resolve the doubts that arose in the plotting and compilation operations by conducting field identification again. It is also a work to confirm the information that could not be identified in the field identification (road names, river names, district name, etc.) based on materials. Therefore, final field identification was conducted in Mali with regard to (1) adjustment of annotations on the maps, (2) confirmation of road and river names as well as the starting point and endpoint, (3) confirmation of transmission line connections and (4) final adjustment of administrative boundaries.

3.8.1 Field Completion Workshop

A three-day workshop was conducted for the IGM engineers who conducted the field identification. First, a lecture was given to explain the outline of field completion and the "1:5,000-scale Map Symbols and Application Rules". Then, practical training was conducted at the IGM office, which was used as a pilot study area. The study results from each team were reviewed and shared with all the members.

Source: Project Team

Photo 3-5 Field Completion Workshop

3.8.2 Preliminary Confirmation of Areas Requiring Final Field Identification

Field completion refers to clarifying unclear points that were identified in the digital plotting and digital compilation. Due to time constraints, the following two points were checked in the office work prior to the field completion.

(1) Unclear points that need to be confirmed

Unclear points that were found in the digital plotting and digital compilation were marked on the maps.

(2) Names of buildings that need to be reconfirmed

Names of buildings were acquired in the field identification. Since names are important elements of geographic information, they were reconfirmed in the final field identification. However, it is impossible to reconfirm all the buildings. Therefore, a narrowed-down list was prepared, enumerating the buildings to be reconfirmed.

3.8.3 Implementation of Final Field Identification

Final field identification was conducted by six teams for 17 days from April 5 to April 27.

Based on the result of field identification, the list for field completion (list of unclear points and names of buildings, etc.) was updated. Table 3-17 summarizes the points confirmed in the final field identification classified by content. A total of 5,997 unclear points were confirmed in the end. Many names of buildings required modification due to spelling errors during data input.

Table 3-17 Confirmation Points by Investigation Result

Confirmation content	Modification required	Deletion	No modification	Addition	Total
Investigation to confirm questionable points	695	124	320	326	1,465
Investigation to confirm names	2,231	144	2,138	-	4,513

3.8.4 Identification of Roads and Rivers

Names and sections of roads and rivers were investigated to obtain the topographic map annotations information of. After discussions with IGM, it was agreed that only the existing annotations should be used as attribute data (Table 3-18).

Table 3-18 List of Collected Materials

Type	Collected material	Format
Road	・Road management map (CTAC*) 　・Plan d'ensemble Bamako et Kalabancoro 　(within Bamako City, Kalabancoro District) 　・Sangarébougou (Sangarébougou District) 　・Kati adressage (Kati District)	Digital (DWG format) Arbitrary coordinates
	・1:10,000 city map (IGM)	Paper
	・Road network data (OCHA)	Digital (Shape format)
River	・1:25,000 Bamako metropolitan area map (created by IGM)	Digital (Shape format)

* CTAC: Cellule Technique d'Appui aux Communes (Office for Technical Support to Communes)

(1) Confirmation of names, starting points and endpoints of roads

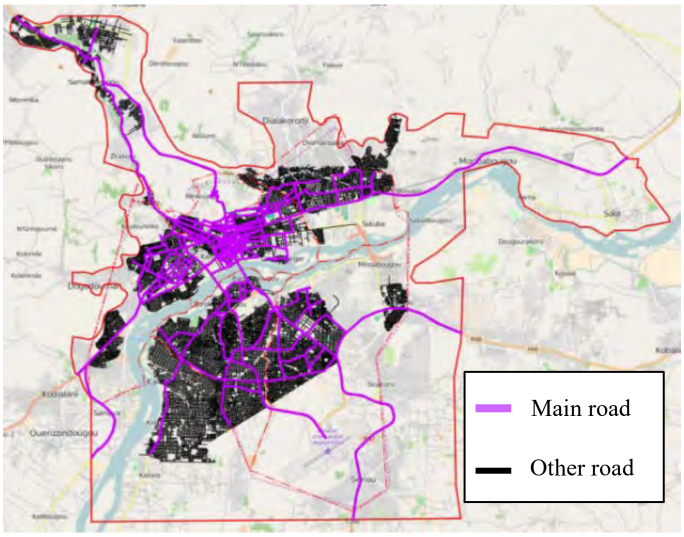
The materials collected from CTAC-which manages the roads in Bamako City-consisted of non-georeferenced digital data. Therefore, the digital data was georeferenced and overlayed with topographic maps (Figure 3-26 left).

Source: Created by Survey Team based on IGM and CTAC materials

Figure 3-26 Road Management Map after Position Orientation (Left) and Overlapping on Topographic Map (Right)

After confirming and modifying the road names and entering the starting and end positions of the roads, the road names and starting and end positions were registered to the road centerline data acquired in the digital plotting (Figure 3-26 right).

The final data output was inspected for errors and omissions, and modified as necessary. Only national highways were extracted and displayed on the maps, while other roads were retained as attribute information (Figure 3-27).



Source: © OpenStreetMap contributors, Prepared by the Project Team

Figure 3-27 Road Data Map

(2) Confirmation of river names and starting and end points

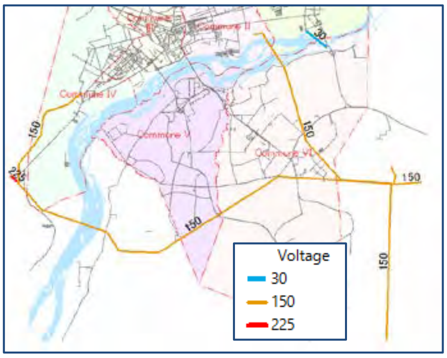
GIS data layers (in Shapefile format) -derived from the Bamako metropolitan area map (1:25,000) -were used to confirm river names as well as the starting points and endpoints. Subsequently, data codes relating to rivers namely, "4101: Cours d'eau", "4102: Ligne de côte", "4103: Canal" and "1205: Caniveau", were extracted from the topographic mapping data. Furthermore, river names were added as attribute information.

Source: Created by Project Team based on information from IGM

Figure 3-28 River Data after Extraction (Thick Blue Lines)

3.8.5 Confirmation of Transmission Line

High voltage transmission lines are one of the important infrastructures of Bamako. Therefore, EDM (Energie du Mali) which manages transmission lines- was consulted in order to confirm the direction and connection points of transmission lines on the map. Voltage information provided during the discussion was included as attribute information.



Source: Prepared by the Project Team

Figure 3-29 Transmission Lines in Bamako City (Voltage in kV)

3.8.6 Identification of Quartier Boundaries

In urban planning, names of administrative zones and districts are important information to identify locations on the map. However, the demarcation of official administrative boundaries requires an approval from the Ministry of Interior. Therefore, IGM agreed that the unofficial boundary data should be used. At the beginning of this project, commune was regarded as the minimum administrative unit. However, the commune boundary was considered too coarse for a minimum administrative unit. Therefore, a decision was made in order to use the quartier as the minimum administrative unit after holding another discussion with IGM.

Source: Created by Project Team based on information from IGM

Figure 3-30 Quartiers in Bamako Metropolitan Area

Quartier boundaries were derived from the "1:25,000 Bamako Metropolitan Area Map", which was produced by IGM. The administrative boundary data provided by IGM was overlayed on the topographic mapping data to check topographic elements, such as rivers. Then the person in charge at IGM inspected and finalized the boundary positions and names (Figure 3-30).

The quartiers outside of the Bamako metropolitan area (Kati Commune) only has names. Therefore, it was agreed with IGM to describe only the quartier names on the topographic maps without creating the boundary lines.

3.9 Digital Compilation and Symbolization

Digital compilation/completion editing and symbolization were carried out for the Bamako Metropolitan area, which covers 520 km^2 (that is, 73 map sheets in total), for which digital plotting had been completed. The acquired geographic data was organized and edited on the map based on the digital plotting data and field identification results in accordance with "1:5,000-scale Map Symbols and Application Rules". Completion editing was carried out to summarize the omissions, errors and unclear points detected in the digital compilation into a completion map. This was done in order to designate the areas to implement field completion. The compiled data will be completed based on the field identification results.

Marginal information and annotation symbols were adjusted in accordance with technical specifications, such as "1:5,000-scale Map Symbols and Application Rules" in order to produce the final maps.

3.9.1 Method of Editing

Figure 3-31 shows digital compilation and symbolization editing work flow.

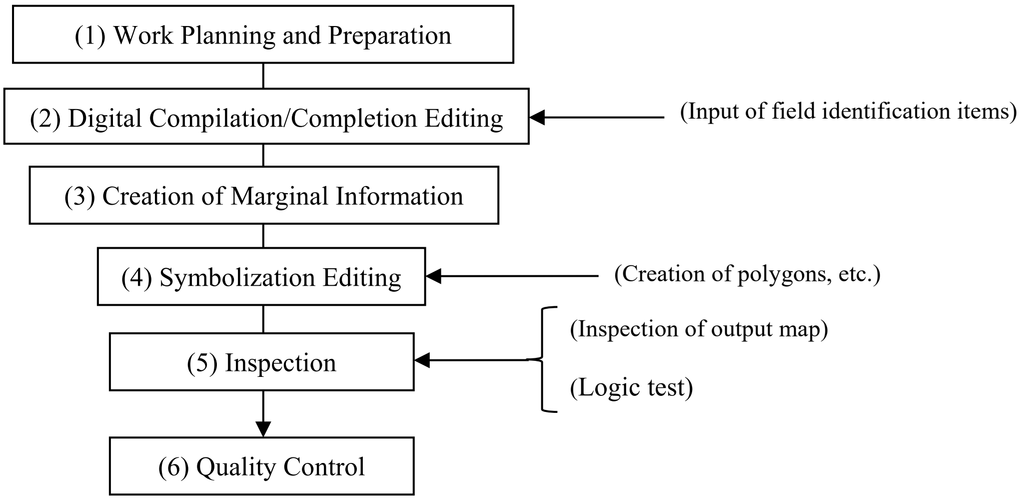


Figure 3-31 Digital Compilation and Symbolization Editing Work Flow

(1) Work planning and preparation

Digital plotting data that will be needed for digital compilation was segmented in the map sheet unit of 1:5,000 topographic maps during the preparation stage. When omissions, errors and unclear points from the field identification were detected in the digital compilation, a completion map identifying the areas requiring field identification was prepared.

(2) Digital compilation/completion editing

1) Digital compilation

For the digital plotting data, continuity and input direction were checked, attribute items were added and hidden line elimination and breaking were carried out in accordance with "1:5,000-scale Map Symbols and Application Rules".

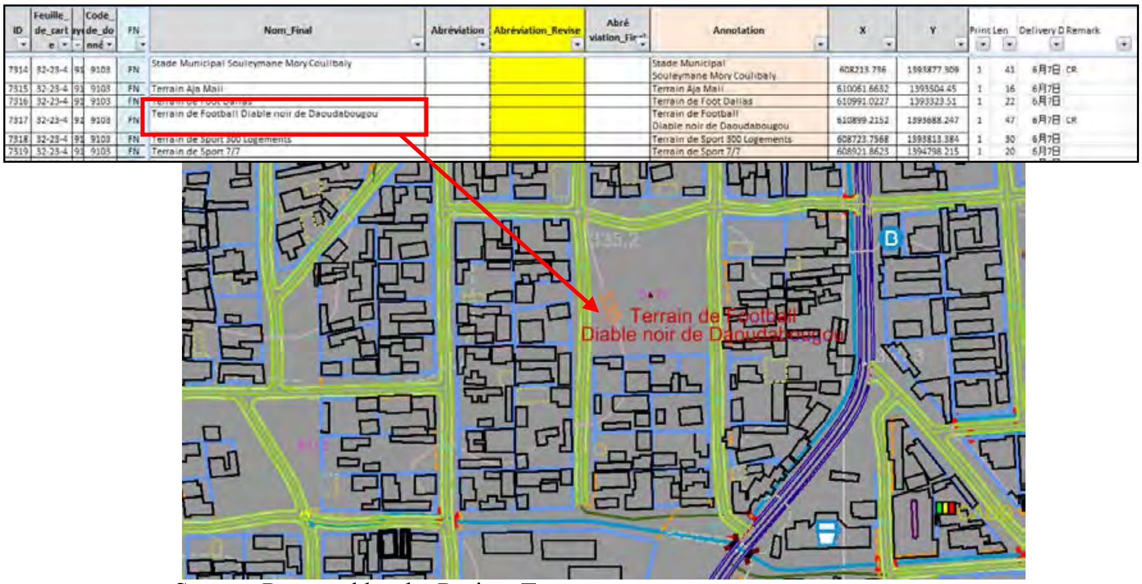
In addition, the collected field identification information, annotations and building symbols were input and modified at the same time. Field completion reference map and field completion list were prepared to check unclear and inadequate points during the subsequent completion editing process (Figure 3-32).

Source: Prepared by the Project Team

Figure 3-32　Field Completion Reference Map and Field Completion List

2) Field completion editing

Completion editing was carried out to check omissions or discrepancies based on field completion results. Furthermore, field completion editing was done to make additions and modifications to the data after the digital compilation based on field completion results in Excel format.



Source: Prepared by the Project Team

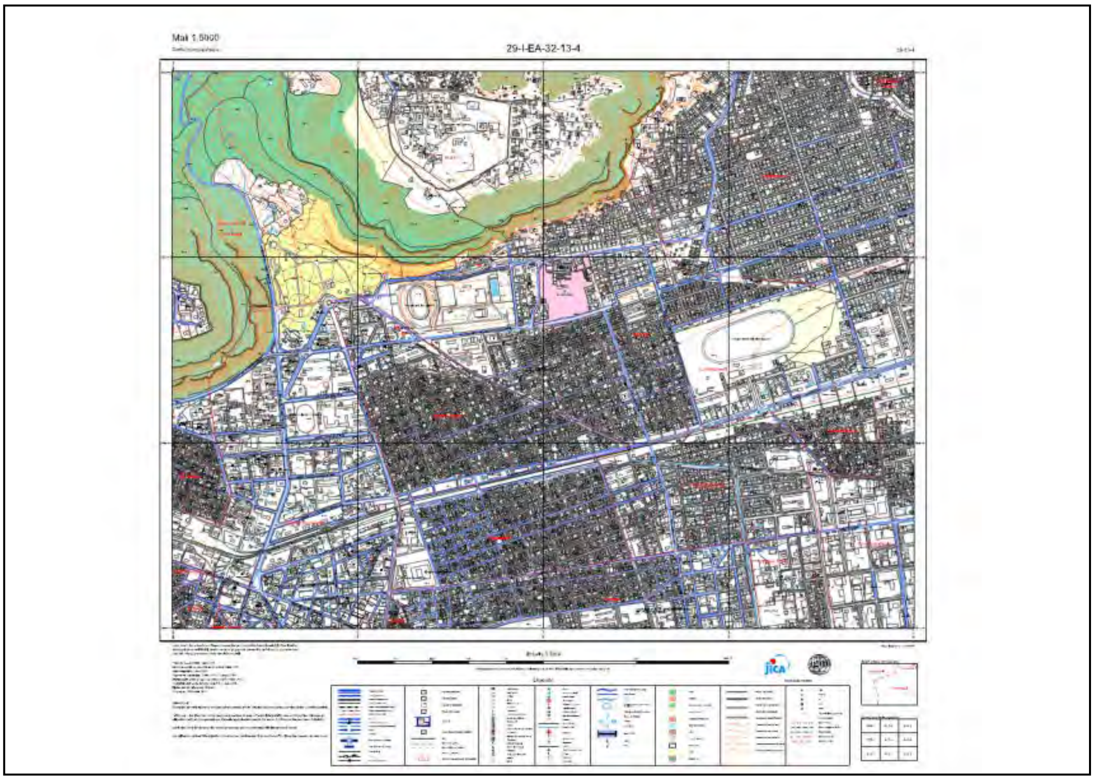
Figure 3-33　Completion Editing Data

(3) Marginal information

Marginal information was prepared for the 73 map sheets covering Bamako Metropolitan area. Marginal information comprised the 1:5,000 map sheet name, grid coordinate values, adjacent map sheet number, index map, and institutional logos.

(4) Symbolization editing

Symbolization editing was done according to the “1:5,000-scale Map Symbols and Application Rules”. After the digital compilation, input points, lines and polygon data were used to generate map symbols (Figure 3-34).



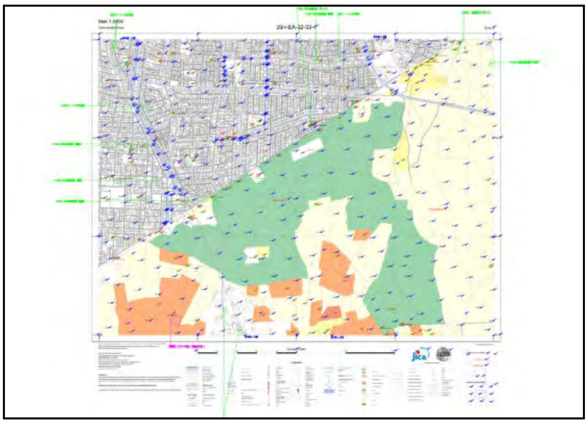
Source: Prepared by the Project Team

Figure 3-34 Symbolization Editing Data

(5) Inspection

Following digital compilation and symbolization editing, visual inspection was carried out in order to check for omissions and errors. In addition, logical testing was also carried, and corrections were made whenever data type classification, structure or topology errors were detected.

The output maps were visually inspected for consistency and form. On the other hand, symbolization editing data were combined with the marginal information data to output the raster of the final printing images. Building annotation data and road name data were compiled the digital compilation data. Those data were superimposed on a map, then executed visual checks (Figure 3-35).

Source: Prepared by the Project Team

Figure 3-35 Examples of Inspection Maps (Left: Output Inspection, Right: Monitoring Inspection)

(6) Quality control

Omissions and errors extracted from the visual inspection and logic testing were summarized in digital compilation quality control sheet.

3.10 GIS Data Structurization

In this project, GIS data structuralization refers to the procedures for creating and organizing GIS datasets, which were acquired during the project implementation. In total, 128 feature layers derived from the "1:5,000-scale Map Symbol and Application Rules" document were used for GIS data structurization.

3.10.1 GIS Data Structurization Workflow

Figure 3-36 shows the GIS data structurization workflow.

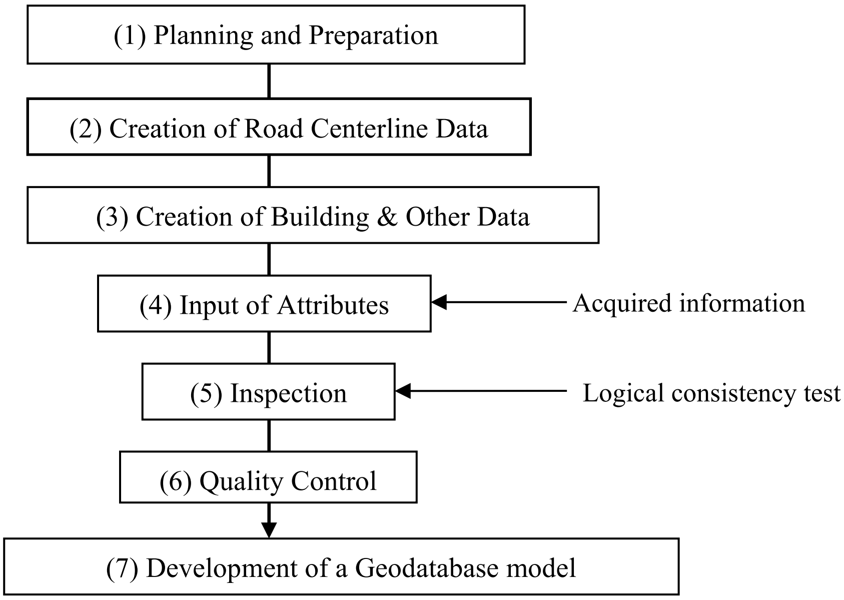


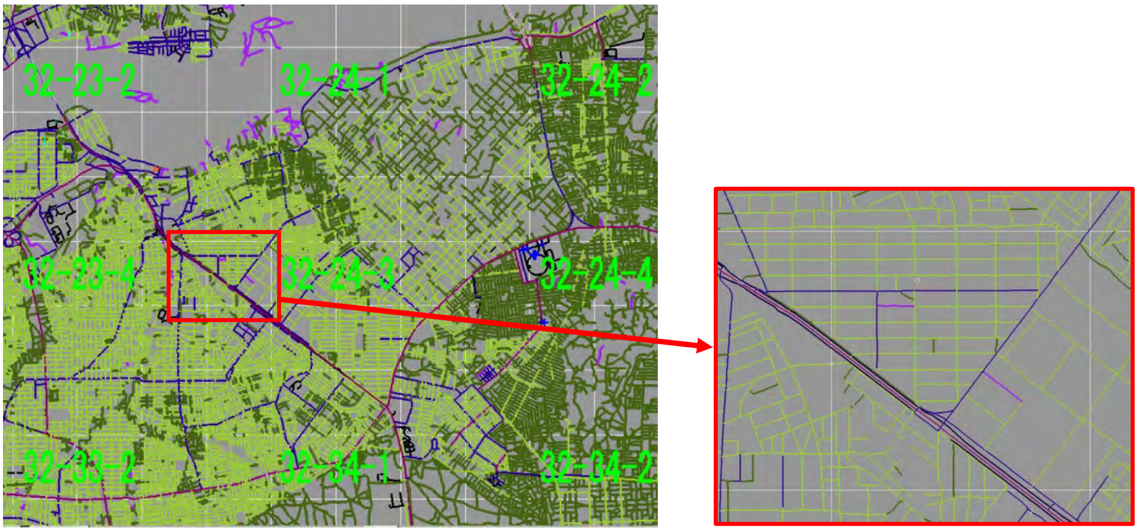
Figure 3-36 GIS Data Structurization Workflow

(1) Planning and preparation

Prior to the implementation of GIS data structurization planning was carried out.

(2) Road centerline data

Following the completion data editing, centerlines were obtained from the center of roads with 5m or more in width. In addition, single line roads were joined with the double line road centerlines in order to create a road network.



Source: Prepared by the Project Team

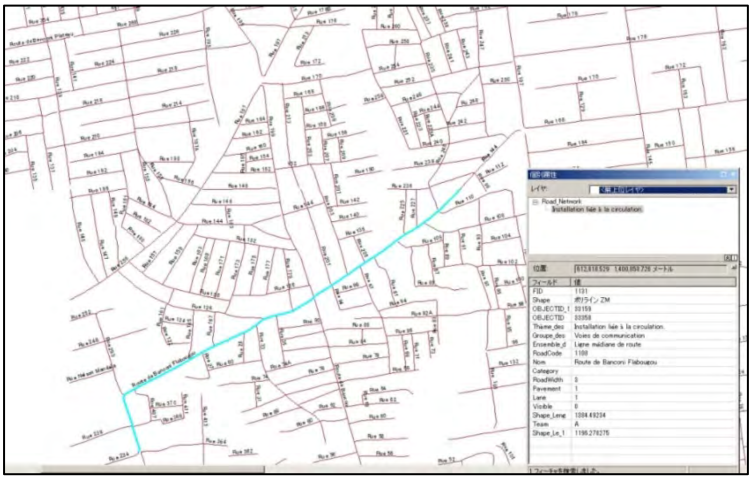
Figure 3-37　Road Centerline Input Data

(3) Building and land use features

Building features were converted to polygons. In addition, land use features were also represented as polygons.

(4) Input of attributes

Road names were added to road centerline data, while annotations and other necessary attributes were added to building point data based on collected field identification information.



Source: Prepared by the Project Team

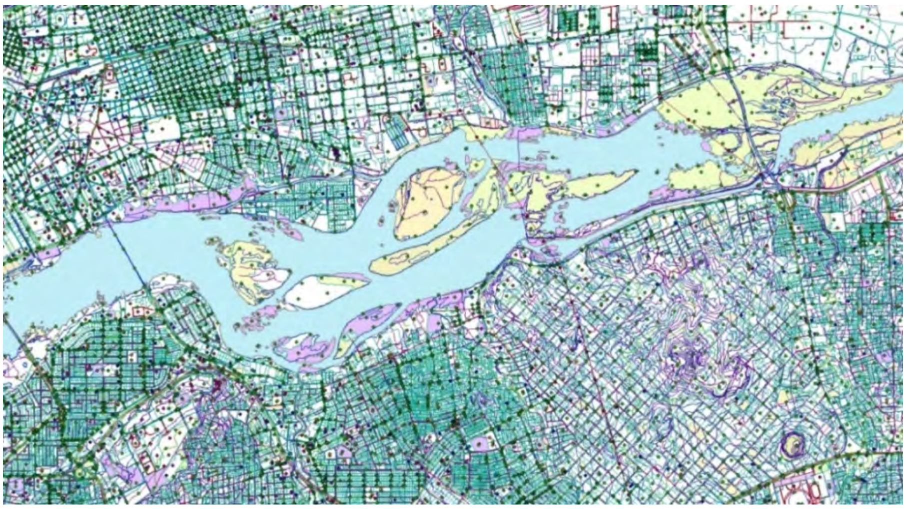
Figure 3-38 Road Name Input Example

(5) Inspection

Logical consistency testing was carried out to check data type, attribute information, classification, structure and topology errors.

(6) Quality control

Quality control was carried out by correcting the errors detected during the logical consistency testing. A quality control sheet was compiled by summarizing the quantity of the detected errors and the data subject to the computation of corrections.



Source: Prepared by the Project Team

Figure 3-39 Image of Basic GIS Data

(7) Development of a Geodatabase Model

While a Geographic information system (GIS) data is important for urban infrastructure development, its successful use depends on its quality as well as an efficient database management system. In this project, an efficient geographic information database management using geospatial data acquired during the project implementation was designed. The specific objectives of the geodatabase model was to efficiently migrate computer aided design CAD data or shapefiles into geodatabase format as well as efficiently store, manage and process GIS data.

1) Bamako Geodatabase Model

The GIS data structuralization (hereafter referred to as the Bamako geodatabase model) is based on ESRI's single-user file geodatabase model. A geodatabase is a container of geospatial and attribute data. The geodatabase, which is a native data structure of ArcGIS (ESRI 2012), organizes vector data sets into feature datasets and feature classes. Feature classes store spatial features of the same geometry type (e.g., point, line and polygon), while the feature dataset stores feature classes that share the same coordinate system and area extent (Chang, 2010; ESRI, 2012). Raster data can also be stored in a geodatabase. Below is a brief outline of the design process, which involves conceptual, logical, and physical design phases. For definition geodatabase terms and concepts, refer to the geodatabase design technical specifications and training manual.

2) Conceptual Model

The conceptual model comprise seven feature datasets, which were compiled from 128 feature layers that include spatial features and annotations. The 128 feature layers were derived from the "1:5,000-scale Map Symbol and Application Rules" document. In addition, the conceptual model includes the raster dataset (orthophoto imagery). Table 3-19 shows the main feature datasets, which are described in the subsections below.

Table 3-19 Main Feature Datasets Compiled from the 1:5,000-scale Map Symbol Specifications and Rules

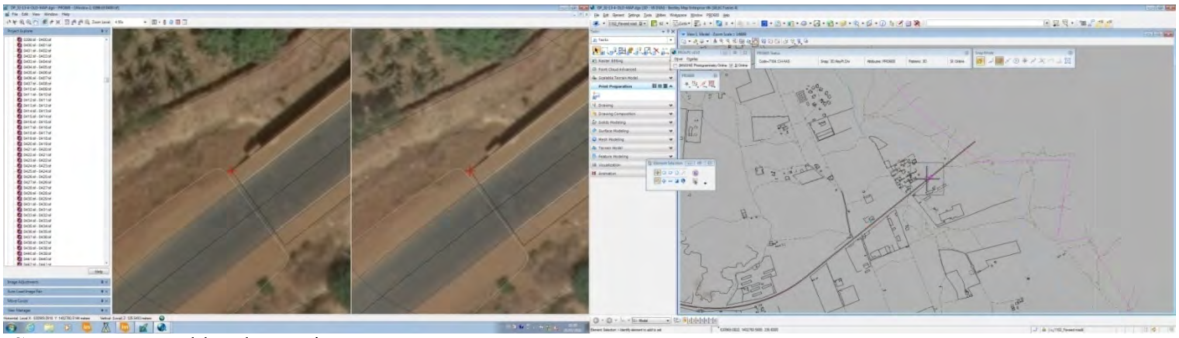
Feature Dataset	Map Use	Data Source	Representation
Administrative	Administrative and legal boundaries, national parks.	IGM	Lines and polygons
Building Infrastructure	Represents buildings, cultural, landmark features and building related facilities	IGM/ this project	Mainly polygons. Includes annotations
Public services	Represents government buildings, banks, schools, religious institutions etc.	IGM/ this project	Point. Includes annotations.
Hydrography	Represents surface water and features for moving, storing, and managing water	IGM/ this project	Points, lines and polygons. Includes annotations
Hypsography	Represents terrain	IGM/ this project	Elevation points, contour lines, DEM. Includes annotations.
Imagery	Map background and reference	IGM/ this project	Aerial photos, orthophoto imagery
Surface overlays	Represents land use/cover such as urban areas, bareland, forest	IGM/ this project	Polygons. Includes annotations.
Transportation	Represents roads, rail, and the associated infrastructure	IGM/ CTAC/ this project	Lines and points. Includes annotations.

3.11 Quality Control

As described above, inspection results at each work process were compiled into quality control sheets to prepare a report on quality control. However, this project was implemented with an emphasis on security control. Therefore, Japanese experts did not participate in the field work in most cases. As a result, the project products were produced based on field identification and verification surveys that were carried out by IGM engineers.

3.11.1 Implementation of Inspection Survey

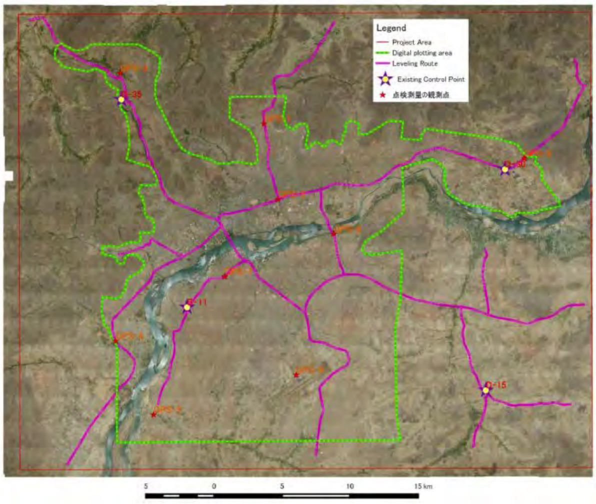
For the inspection survey, nine points arranged on both sides of the rivers in the area covered by this project with the two known points, namely B-11 and D-30, as the baseline, were simultaneously observed with four units of GNSS equipment. Nine points that are clear on the topographic map were selected, and the coordinates of the locations that are flat, whose position can be easily located and where GNSS observation can be carried out on the stereo image* were measured (Figure 3-40).



Source: Prepared by the Project Team

Figure 3-40 Stereo Image and Topographic Map (GPS-8)

Coordinate values retained by IGM were adopted for planes and elevation values determined by direct leveling in this project were adopted for heights (Figure 3-41).



Observation point	X	Y	Height
GPS-1	611,799.617	1,405,693.456	368.250
GPS-2	612,827.091	1,399,738.743	328.338
GPS-3	601,244.131	1,409,008.185	426.400
GPS-4	600,906.118	1,389,309.176	336.882
GPS-5	603,706.274	1,383,907.407	327.015
GPS-6	616,937.584	1,397,205.435	320.209
GPS-7	608,923.969	1,394,046.776	342.793
GPS-8	630,969.092	1,402,760.514	325.549
GPS-9	614,172.210	1,386,819.218	377.592
B-11	606,154.302	1,391,800.147	348.776
D-30	629,561.054	1,401,956.434	338.376
D-35	601,333.098	1,407,075.265	471.762
D-50	628,153.783	1,385,708.276	341.862

Source: Prepared by the Project Team

Figure 3-41 Inspection Survey Index Map

After carrying out the observation using the GNSS equipment at the verification points configured as described above, 3-dimensional analysis was conducted for the data acquired by the observation to determine the coordinate values of each verification location.

*: Locations whose position can be easily identified are, for example, ends of bridges and corners of manmade structures.

3.11.2 Analysis Results of Verification Points

Positional coordinates measured from the topographic maps and results of the inspection survey by GNSS observation are summarized in the table below. Based on the results, with respect to the nine verification points, the standard deviations of plane and height were: SD =±14cm for plane (X direction), SD =±25cm for plane (Y direction) and SD =±40cm for height (H).

Based on the results described above, it was verified that the comprehensive 1:5,000-scale basic GIS data set that was produced in this project, which included quality control at each process, is a product of the series of operations for the production of digital topographic maps. Totally, these digital topographic maps retains an adequate accuracy in terms of both position and height.

Table 3-20 Inspection Survey Results

2016/7/29

Points	X/Northing	Y/Easting	z	Latitude	Longitude			Remesured	Remesured	Remesured	dx	dy	dz
B11	1391800.148	606154.3031	348.776	12° 35' 17.70883" N	8° 01' 21.79025" W	348.7760 m							
D30	1401956.848	629651.5538	338.376	12° 40' 45.12930" N	7° 48' 24.60338" W	338.2916 m							
D35	1407075.267	601333.0993	471.762	12° 43' 35.49088" N	8° 03' 59.75565" W	471.7829 m							
D50	1385708.277	628153.7814	341.862										
B11	1391800.148	606154.3031											
D30	1401956.512	629561.2055											
D35	1407075.341	601333.0543											
GPS1	1405694.004	611799.7997	368.1128	12° 42' 49.24356" N	7° 58' 12.89305" W	368.1128		611799.617	1405693.456	368.250	-0.18	-0.55	0.14
GPS2	1399738.239	612825.3021	327.9379	12° 39' 35.25570" N	7° 57' 39.67938" W	327.9379		612824.946	1399738.078	328.200	-0.36	-0.16	0.26
GPS3	1409008.162	601244.5408	426.6814	12° 44' 38.41473" N	8° 04' 02.46053" W	426.6814		601244.131	1409008.185	426.4	-0.41	0.02	-0.28
GPS4	1389309.779	600906.3184	336.882	12° 33' 57.26540" N	8° 04' 15.99603" W	336.7222		600906.118	1389309.176	336.882	-0.20	-0.60	0.00
GPS5	1383909.331	603705.7226	326.9549	12° 31' 01.15297" N	8° 02' 43.88096" W	326.9549		603705.496	1383909.038	327.015	-0.23	-0.29	0.06
GPS6	1397204.828	616938.6042	319.6786	12° 38' 12.25421" N	7° 55' 23.67974" W	319.6786		616938.143	1397204.800	320.000	-0.46	-0.03	0.32
GPS7	1394047.132	608924.0332	342.8172	12° 36' 30.50806" N	7° 59' 49.72016" W	342.8172		608923.969	1394046.776	342.793	-0.06	-0.36	-0.02
GPS8	1402760.374	630969.1504	325.549	12° 41' 11.08222" N	7° 47' 37.80925" W	324,543		630969.092	1402760.514	324.543	-0.06	0.14	-1.01
GPS9	1386817.858	614172.0733	377.855	12° 32' 34.53168" N	7° 56' 56.75120" W	377.855		614171.830	1386817.691	377.592	-0.24	-0.17	-0.26
										GPS Pts. SD=	0.14	0.25	0.40

4. Technology Transfer Program

4.1 Program Implementation Background

The technology transfer program in this project was implemented with the following points.

1) Implementation of the program should improve the technology level of IGM to enable them to carry out the maintenance of the GIS information of the area covered by this project, including the addition and updating of such information, on their own.
2) The products of this project should be recognized and utilized by the ministries and agencies comprising CIIG as the GIS data of Mali and contribute to the development planning of the Bamako metropolitan area as part of NSDI.

If the spatial information data are to be provided to the ministries, agencies and local governments belonging to CNIG and CRIG, which can be the direct beneficiary of the products (geographic information user), a certain level of accuracy, supply system and responsibility based on uniform inspection criteria and technical reliability must be ensured of such data. As such, for the purpose of nurturing the ownership of IGM for the products of this project, since the beginning of this project, discussions have been conducted with IGM to exchange opinions with them on the program content and prospective participants for each technical field.

Prior to the training, baseline surveys were conducted to determine the skill levels of the IGM participants. The training program for each technical field was designed with the objective of enabling IGM to produce large scale topographic maps and upgrade geographic information after the completion of this project.

Furthermore, a workshop on utilization of the project geospatial datasets should be held for geographic information users as part of the activities to promote the utilization. This would promote a common understanding among the ministries and agencies of CIIG.

4.2 Achievement of Technology Transfer

A baseline survey was conducted to understand the technology level of IGM prior to the start of the program. After confirming the current technology level of IGM, the program content was determined with an aim of strengthening the practical skills in each field. The following table summarizes the results of the technology transfer program implemented in this project.

Table 4-1　Achievement of Technology Transfer Program in Each Field

Field	Subject of technology transfer	Baseline skill level	Achievement
Supervision of aerial photography	Achievement goal: Able to learn photography planning and process management based on the judgment of timing and weather conditions in accordance with the photography purpose	－	△
	Photography planning	×	△
	Direct orientation measurement (GNSS, IMU)	×	△
	Inspection of photographed data	×	△
	Quality control	×	△
Ground control survey	Achievement goal: Able to perform quality control of survey results using the quality control sheet based on the basic understanding of quality control	－	○
	Point selection planning	○	○
	Pricking	△	○
	GNSS observation	○	◎
	Leveling	○	◎
	Quality control	×	○
Field identification/ field completion	Achievement goal: Able to develop investigation plans in accordance with the target scale and implement investigations for field identification based on the understanding of the work content	－	◎
	Understanding of the difference in the scales of topographic maps	×	◎
	Understanding of specifications, map symbols and application rules of map symbols	×	○
	Understanding of the content of investigation (acquisition items)	○	◎
	Understanding of the difference between photograph field identification (field identification) and map field identification (field completion)	×	◎
	Implementation of field identification/completion using digital terminal	×	○
	Analysis of investigation results	×	◎
Aerial triangulation	Achievement goal: Able to perform aerial triangulation independently based on the understanding of all the processes	－	○
	Preparation	△	◎
	Determination of interior orientation	×	○
	Determination of exterior orientation	×	○
	Quality control	△	○
Orthophoto	Achievement goal: Able to learn how to create orthophotos while controlling the quality based on the understanding of the basic concept of orthophotos	－	○
	Understanding of the work process and utilization method of orthophotos	△	○
	Understanding of the relationship between the pixel size and quality	△	○
	Creation of orthophotos	△	○
	Implementation of image adjustment and mosaic processing	△	○
	Understanding of quality control	×	○
Digital plotting	Achievement goal: Able to read digital information from 3-dimensional models composed of stereo aerial photographs and perform quality control of the acquired data based on the understanding of the specification and map symbolization criteria	－	○
	Learning of elevation measurement (single point observation)	△	○
	Learning of feature interpretation accuracy (feature classification)	○	◎
	Understanding of large scale digital data content	○	◎
	Understanding of specifications and map symbolization criteria	×	○
	Learning of preparation for digital plotting (environment setting, analysis of results)	○	◎

	Drawing of topography, feature measurement, elevation point and contour line	○	◎
	Understanding of quality control method and quality control sheet	×	○
Digital compilation	Achievement goal: Able to compile digital data and perform quality control of the compiled data based on the understanding of specifications, map symbols and map symbol application rules	−	○
	Understanding of the matching of joint coordinates between map sheets	○	○
	Understanding of the data type and acquisition classification of each feature	○	◎
	Compilation of plotted data	○	○
	Understanding of topology structure	○	○
	Understanding of appropriate method to input data from the results of field identification and field completion	×	○
	Understanding of appropriate method to input data from collected materials	×	○
	Understanding of the basic concept of quality and process control	△	○
GIS structurization	Achievement goal: Able to perform GIS structurization and quality control of the basic GIS data based on the understanding of specifications, map symbols and map symbol application rules	−	○
	Understanding of point data structure	○	◎
	Understanding of line data structure	○	◎
	Understanding of plane data structure	○	◎
	Understanding of attribute data structure	△	◎
	Learning of basic operations of GIS software	○	◎
	Understanding of metadata	△	○
	Quality control and accuracy control	△	○
Map symbolization	Achievement goal: Able to perform map symbolization and quality control of the symbolized data based on the understanding of specifications, map symbols and map symbol application rules	−	○
	Understanding of map symbols and map symbol application rules	△	○
	Creation of map symbols, line types and patterns to be used	○	◎
	Understanding of map symbol expressions based on the image of final output map	△	○
	Learning of the method to create marginal information and legends	△	○
	Learning of modification method for secular changes	×	○
	Understanding of quality control	×	△
Promotion of utilization	Achievement goal: Capture the needs of potential geographic information users involved in the development of the Bamako metropolitan area and clarify the method to operate the organization able to respond in accordance with the needs	−	○
	Clarification of services and needs	△	◎
	Scope of copyright	○	○
	Policy concerning information disclosure (clarification of security policy)	×	◎
	Design and operation of website	×	○
	Checking of disclosure information and supply of topographic maps	×	○
	Holding of seminars and workshops to promote utilization	○	◎

Qualitative evaluation criteria (4 grades)
Baseline: (×: Lack theoretical knowledge or practical experience, △: Have knowledge but no experience, ○: Have theoretical knowledge and practical experience, ◎: Able to perform independently)
Achievement: (×: Underachieved, △: Learned only the theory, ○: Understood the theory and put it into practice, ◎: Able to perform independently)

4.3 Implementation of Technical Training

4.3.1 Supervision of Aerial Photography

(1) Technical level of IGM

The technical transfer focused on the theoretical and technical aspects of aerial photography since IGM does not own an aircraft and aerial cameras.

(2) Technical training

The purpose of the technical training was to train IGM staff so that they can acquire the capacities to understand as well as supervise aerial photography planning. The technology transfer focused on (see Photo 4-1).

1) Basic techniques for acquiring aerial photography (stereo photos)
2) Basic techniques for acquiring aerial photography (overlap and side lap)
3) Control points during aerial photo acquisition
4) Digital camera
5) Handling photographic data and quality control
6) Questions-answers

Source: Project Team

Photo 4-1 Technology Transfer on the Aerial Photography (on the top left: visit of observation of the aircraft, below on the left: theoretical course, on the right: camera)

(3) Assessment each work component item

The technical training focused on skills to plan aerial photography taking into account photo acquisition period, weather conditions, and quality control.

1) Plan of aerial photography

Expected aerial photogrammetry results were explained in terms of the features of the aerial camera used, and the development of the aerial photography plan. However, IGM does not have lot of experience in subcontracting or the supervising aerial photography. Therefore, the aerial photography implementation program was not sufficient for IGM to understand aerial photography. Nonetheless, IGM understood the difference between analog and digital aerial photography planning.

2) Direct measure of orientation (GNSS, IMU)

IGM understood the basic elements such as GNSS and IMU measurements, flight plans for digital photography as well as ground observations.

3) Inspection of the photographic data

Aerial photography was completed in a short time due to good weather. As a result, the quality of the aerial photograph was good. While the acquired photographic data did not have distortions or errors, the Project Team noted that IGM understood the inspection workflow for digital aerial photography.

4) Work manuals

- The aerial photography documents (images of aerial photographs, aerial photography log, aerial photography index map, etc.) and work manuals such as (i) introduction to digital photography, (ii) digital camera calibration report, and (ii) data management and quality control

4.3.2 Ground Control Point Survey

IGM ground survey technicians had experience on GNSS and leveling observations. In addition, the technical level of the technicians for topographic survey was above average. Technical transfer on GNSS and leveling observations, and ground control point survey was done through on-the-job-training (OJT).

(1) Verification of the technical level related to the ground control points

1) Management of the geodesic infrastructure of IGM

As indicated in Chapter 3, all geodesic points and the points of leveling managed by IGM around Bamako have not been verified. However, as the results of the inspection survey for the existing geodetic points, the rate of subsistence of the geodetic points managed by IGM is about 60% and that of existing leveling points is estimated to 50%.

Therefore, the Project Team recommended IGM to conduct a visual inspection periodically to know if the known points are normal or not, to take the coordinates numbers and to verify the disappearance of the points with the passing of time (construction of new buildings) in the city of Bamako, as well as to manage some precisely and without mistake on a card of distribution of the points.

2) State of management of the GNSS devices possessed by IGM

The GNSS observations were conducted using devices possessed by IGM. The devices were checked for external damages, the degree of precision of the levels, the interval of the receipt times, and the control of the battery. This inspection showed that the observation devices were managed correctly and without problems.

3) Abilities of the technicians of IGM concerning GNSS observation

During the GNSS observations, IGM technicians set up of the GNSS devices. Installation of the tripod, centering and fast leveling, and height measurements were checked. No problem was noted during observation. The setting procedures of the receiver was confirmed to be done according to the given instructions: selection of the acquisition time and the ellipsoid used in the project, selection of the device height, definition of the point names, method of starting and ending of the observation, etc.

4) Abilities of the technicians of IGM concerning the leveling

Four engineers who work in the IGM Geodetic Division have the experience of leveling with conventional method. However, one engineer has experience of using digital leveling. Table 4-2 shows the IGM's leveling experience.

Table 4-2 Experiences of IGM Concerning Leveling

Period	Project
1999 - 2000	JICA National Topographic Mapping Project in the Kita Area
2004	Kossanto Mapping Project (1:50,000 scale)
2004	Leveling of the Senegal River in the framework of OMVS
2004 - present	Road Leveling through Bamako and Mali

(2) Evaluation by item

The objective of the ground control point survey was to acquire skills for planning and conducting topographic surveys. The Project Team assessed the level of understanding by item of IGM based on the ground control point survey.

1) Development of plan for the selection of points

The development of the ground control points (GCP) plan by both the Project Team and IGM was not achieved due to the security threats, and limited time for field work. However, the Project Team explained to IGM the reasons for developing GCP selection plan. Furthermore, the Project Team concretely indicated the reasons and the bases of the distribution of the ground control points (GCP) of the project in the field. The IGM technicians understood efficient observation plan and the point measurement sites and acted efficiently with travel time/installation environment in mind. The Project

Team therefore noted that IGM understood the importance of point selection plan in consideration of efficient and minimum required number of points.

2) GNSS observations

Technical transfer on GNSS observations was done through on-the-job-training (OJT). Leica Geo Office software was used for data analysis. Technical transfer was also done for 3D analysis targeting the concerned technicians since IGM did not have experience on GNSS observations (see Photo 4-2). The following was done:

- Rigorous checking of the height of the GPS antenna
- Determining and fixing points used for the analysis of the baselines
- Checking the coordinates of the record of the observations and order of an observation session
- Error checking and accuracy control for each observed point

Source: Project Team

Photo 4-2 Technology Transfer on Installation of GNSS antenna

3) Leveling

IGM has a good experience of leveling and the Project Team did not observe any problems.

4) Accuracy control

While the ground control point survey capacity is good, IGM has to improve on data management. This is because some data input errors have been detected in the previous leveling survey data. The observation and the calculation of leveling done to define the value of elevation of the geodetic point were correct. However, the Project Team observed data input errors during creation of the table of coordinate values and elevation values of geodetic points. Therefore, the Project Team recommended IGM to check the data more rigorously.

4.3.3 Field Identification/Field Completion

4.3.3.1 Field Identification

In order to get accurate field identification results in a limited time, it is necessary to understand the field identification method according to the objectives and map scale. Therefore, the Project Team organized a workshop in order to give an orientation on basic field identification survey. This is important since it would help IGM to better understand photographic and cartographic techniques (*e.g.*, reading symbols) as well as attain the same knowledge. The training was conducted in the form of OJT.

(1) Field identification workshop

Since the field identification was performed by several teams, a workshop was conducted at IGM and in the field. The purpose of the workshop was to understand the survey content as well as to maintain consistency of the survey results (Table 4-3).

Table 4-3 Implementation Schedule of Field Identification Workshop

Work items	Lecture	Practice	November 2015					
			4	5	6	9 – 12	13	16 – 20
Overview of the field identification	○	-	Training					
Techniques of reading of map symbols and aerial photographs	○	○	Training					
Method of collection and meticulous exam of the existing information	○	○		Training		OJT		
Method of annotation on the aerial photographs	○	○		Training				
Method of recording in the field notebook	○	○		Training				
Practical exercises	-	○			Training			OJT
Operation of the support devices for the field identification	-	○					Training	
Method of ordering at the end of the survey	○	○				Training		OJT
Review	-	-			★	★		★

Training OJT

(2) Overview of field identification

Since it was the first time that IGM produced a large-scale topographic map, the Project Team explained the importance of field identification for a large-scale topographic map. This was compared to past field identification survey methodology for 1:50,000 topographic mapping. Figure 4-1 shows a sample field identification manual.

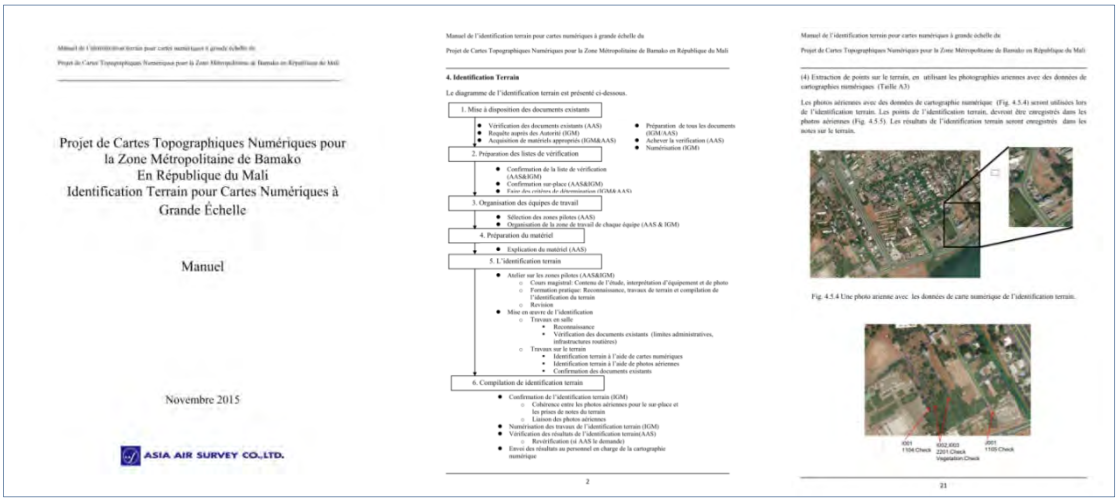


Figure 4-1　Sample of Work Manual

(3) Method of the photo interpretation

Cartographic and aerial photograph interpretation skills are required in order to achieve the objectives of field identification. Therefore, the Project Team provided explanations using the previous interpretation results as well as the 1:5,000-scale map symbols and application rules.

The Project Team provided explanations on approx. 120 map symbol elements adopted in the project. The Team also indicated the elements that should be acquired during the field identification, and the elements that can be interpreted from the photos and gave instruction using materials shown in Table 4-4.

Table 4-4　List of Map Symbol Elements to be Acquired during Field Identification (Sample)

Identification sur le terrain

Field Identification Survey ◎:Top priority ○:Low priority △:If Possible ▲:Direction ×:No Need

	Thème des Données	Groupe des Données	Ensemble des Données	Data Code	Data type						Identification sur le terrain	
					poin	ln.	pol.	txt	attr1	attr2	1st	2nd
66	Infrastructure et Etablissements	Infrastructure et Etablissements	Château d'eau	3108	●						○	▲
67	Infrastructure et Etablissements	Infrastructure et Etablissements	Monument	3109	●				Nom		◎	▲
68	Infrastructure et Etablissements	Infrastructure et Etablissements	Pipeline	3110		●					×	△
69	Infrastructure et Etablissements	Infrastructure et Etablissements	Cuve à carburant ou gaz	3111	●						○	▲
70	Infrastructure et Etablissements	Infrastructure et Etablissements	Pylône	3112			●				◎	▲
71	Infrastructure et Etablissements	Infrastructure et Etablissements	Cheminée	3113	●						△	▲
72	Infrastructure et Etablissements	Infrastructure et Etablissements	Arbre isolé	3114	●						×	▲
73	Hydrographie	Hydrographie	Cours d'eau (flueve, rivière)	4101			●		Nom		△	▲
74	Hydrographie	Hydrographie	Ligne de côte	4102		●					×	×
75	Hydrographie	Hydrographie	Canal	4103			●				△	▲
76	Hydrographie	Hydrographie	Etang/mare/bassin et/ou réservoir, marigot, tal	4104			●				△	▲
77	Hydrographie	Hydrographie	Point d'eau d'installation publique	4105			●				△	▲
77	Hydrographie	Hydrographie	Station de pompage	4108			●				△	▲
78	Hydrographie	Hydrographie	Piscine	4106			●				×	×
79	Hydrographie	Hydrographie	Cuve d'eau	4107			●				○	▲

Furthermore, the Project Team explained some difficult aerial photography interpretation cases (Figure 4-2). This also combined a session of questions-answers.

Source: Project Team

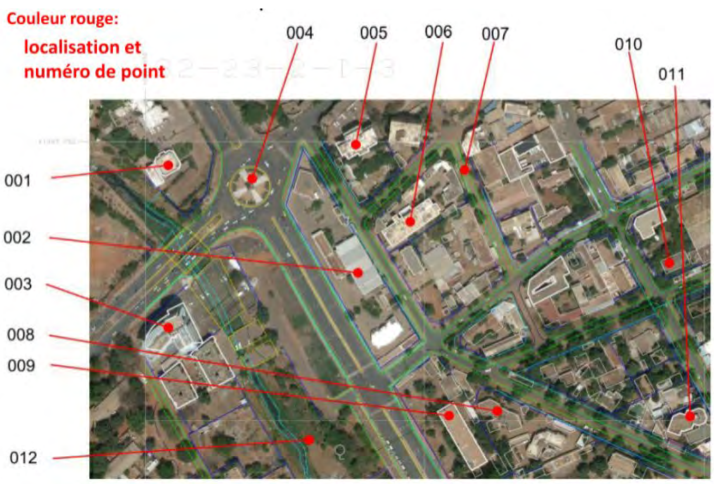
Figure 4-2 Examples of Aerial Photographs Difficult to be Interpreted

(Left: Pavement condition, Right: By type of cemetery and vegetation)

(4) Annotation of the acquired data

The Project Team explained the way to annotate the aerial photographs using existing information and field information. Generally, only the number and the position of the elements were labelled aerial photograph (Figure 4-3).

The Project Team also explained the method of recording in the field notebook, which was used by all the survey teams.



Source: Prepared by the Project Team

Figure 4-3 Aerial Photograph Annotation Procedure

(5) Practical exercises

The field training took place after the selection of the maps numbered (32-23-2-1-3), where there are various public services, school infrastructures, etc. The Project Team proposed a route survey in advance (Figure 4-4), and indicated an efficient survey method as well as the field content.

Source: Prepared by the Project Team

Figure 4-4 Survey Itinerary

(6) Review of the acquired data

The Project Team checked if all the members of field identification teams had a similar understanding of the survey methodology. In order to improve the survey methodology, the Team conducted a detailed check for all the team members as quality control, after principal processes were completed.

Table 4-5 shows that the review was made twice. The Project Team recognized that the teams understood given the active discussions during the review.

Table 4-5 Content of the Review

	Date	Content
1st review	6th Nov.	After practical exercises, review of the level of understanding of the method of the field identification, and finding of the problems of the implementation
2nd review	11th Nov.	After organizing of the results of the practical exercises, identification of the differences between the survey teams

1) Result of first review

- While some teams completed whole survey within the given time, others did not. The reason for the teams failed to complete the survey is that the Project Team provided very detailed explanations without taking into consideration of time. As the survey had to be finished in the limited period in this process, the Project Team gave them some instructions to reduce the survey time for each site.
- They mentioned that the map symbols were too detailed, and therefore it took some time to learn the map symbols. Therefore, the Project Team prepared a booklet of codes, which can be used for reference.

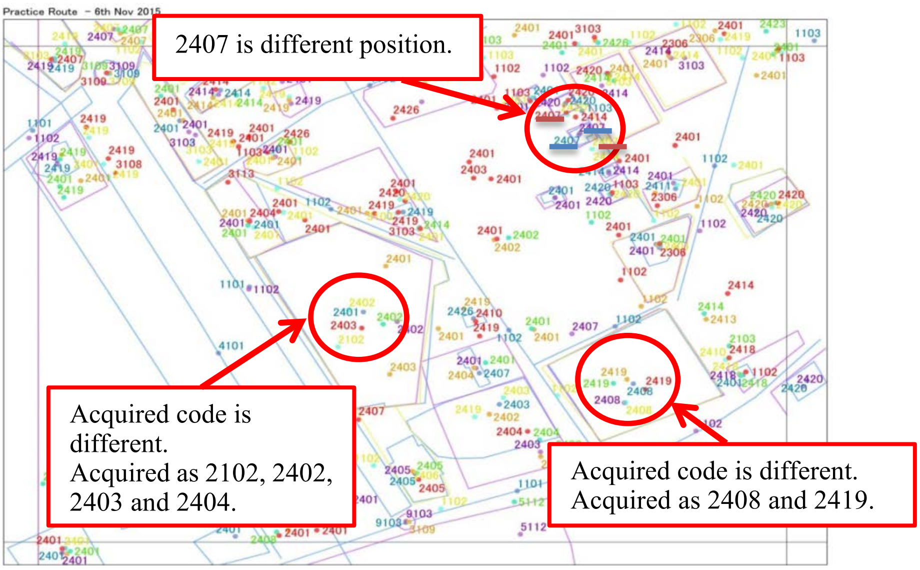
- There were some map symbols such as antenna whose acquirement applications were unclear. The Project Team reviewed such applications to assure the homogeneity of the planimetric features during field identification stage.

2) Result of second review

Table 4-6 shows survey results for each team after the field training. Teams classified on the acquired aerial photographs, and Figure 4-5 shows GIS representation samples.

Table 4-6 Numbers of Survey Sites per Team (Unit: No. of sites)

Team	Route (11xx)	Road structure (12xx)	Building (21xx)	Boundary (23xx)	Building symbol (24xx)	Facility (31xx)	Land use (51xx)	Annotation (9xxx)	Numbers surveyed
A	7	1	0	3	46	7	0	0	64
B	2	0	2	0	34	2	1	0	41
C	2	0	3	1	34	4	0	0	44
D	15	0	1	0	39	7	0	1	63
E	5	0	0	0	32	3	1	1	42
F	11	0	0	0	28	1	1	1	42



Source: Prepared by the Project Team

Figure 4-5 Representation of the Survey Results of Every Team on a Map

Based on above results, Project Team discussed with all team members about the sites for which the results acquired are different. Therefore, the team could improve their same understanding of all concerning the acquirement codes and implement the field identification.

4.3.3.2 Field Completion

Training was given in a form of OJT. A workshop was also held before starting the work.

The workshop was implemented to achieve a common understanding of the content of field completion and included practical training and repetitive training by OJT.

(1) Field completion workshop

As the field completion survey was to be conducted in several teams, the workshop was implemented to ensure that the survey results will be correctly understood and shared and that consistency of the survey results will be maintained as much as possible (Table 4-7).

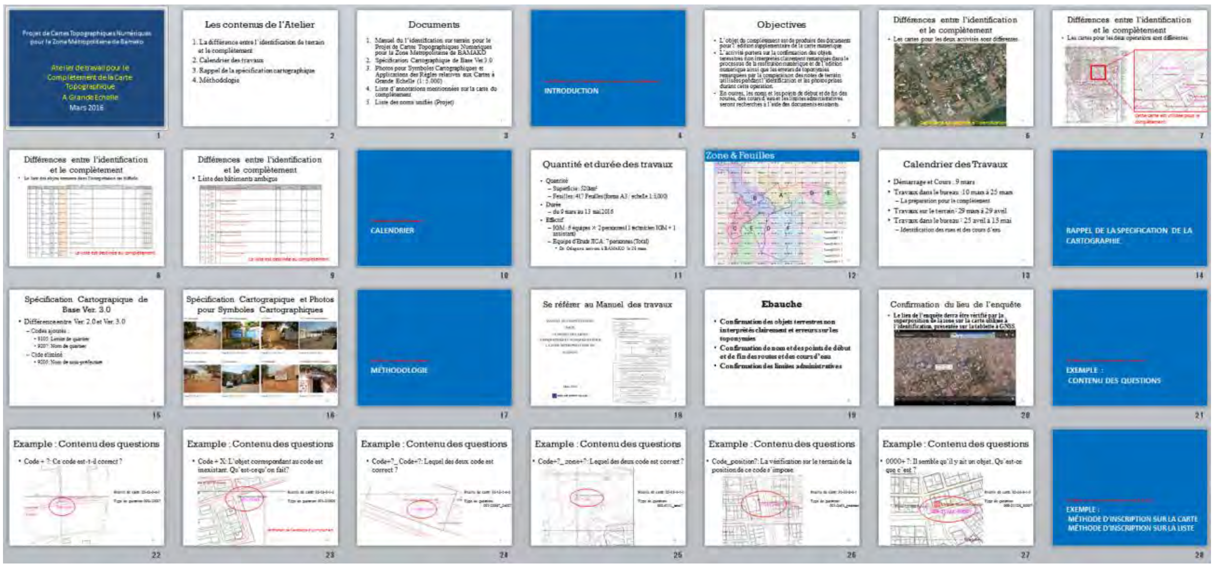
Table 4-7 Implementation Schedule of Field Completion Workshop

Work items	Lecture	Practice	March 2016							
			9	10	11	14	15–18	19	21–24	25
Outline of field completion	○	-	Training							
Method of confirmation of field completion list	○	○		Training			OJT			
Method of description on field completion map	○	○		Training			OJT			
Field training	○	○			Training		OJT			
Method of organization after the survey	○	○			Training	Training				
Method of road survey	-	○						Training	OJT	
Questionnaire survey	-	-								★

Training OJT

(2) Outline of field completion

In the beginning of the workshop, a lecture was conducted to explain the difference from the field identification that had been implemented and the survey method and to explain the map symbols again using a field completion work manual prepared beforehand (Figure 4-6).



Source: Prepared by the Project Team

Figure 4-6 Work Manual (Extracted Partly)

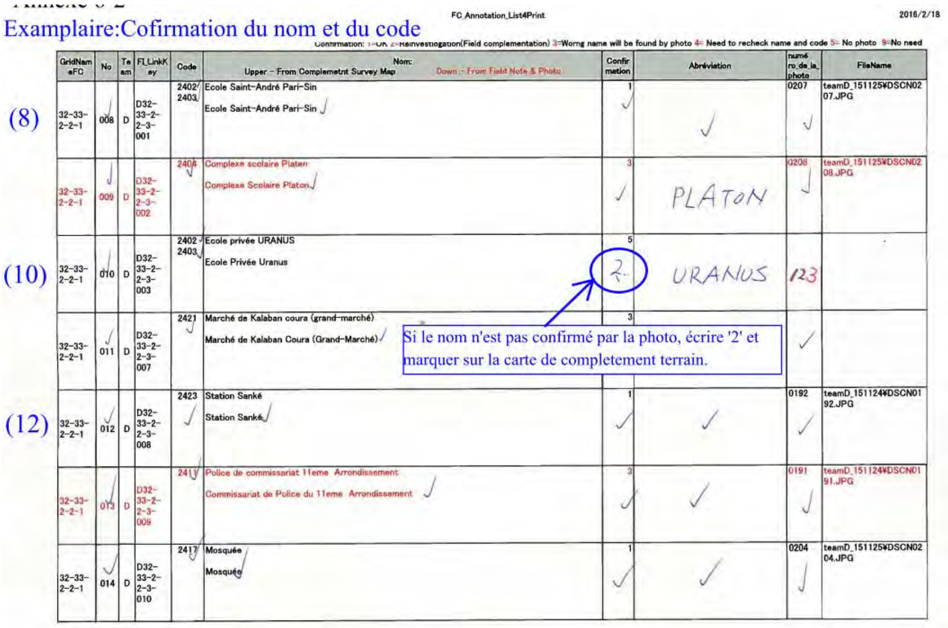
In addition, to check the comprehension of the map symbols explained during the field identification, taking out part of the compiled data, quizzes were repeatedly given to the participants of the survey to let them answer (Figure 4-7).

Source: Prepared by the Project Team

Figure 4-7 Comprehension Test of Map Symbols (Example)

(3) Method to confirm field completion list

Two types of list, one for the confirmation of unclear parts found during the digital compilation and the other for the confirmation of building names were used in this survey. As the area for practical training, survey map number "32-33-2-II-1" was used. At first, practical training was conducted for all the teams and then, each team was trained for the part allocated to them in the form of OJT.



Examplaire:Cofirmation du nom et du code

FC Annotation_List4Print 2016/2/18

Confirmation: 1=OK 2=Reinvestigation(Field complementation) 3=Worng name will be found by photo 4= Need to recheck name and code 5= No photo 9=No need

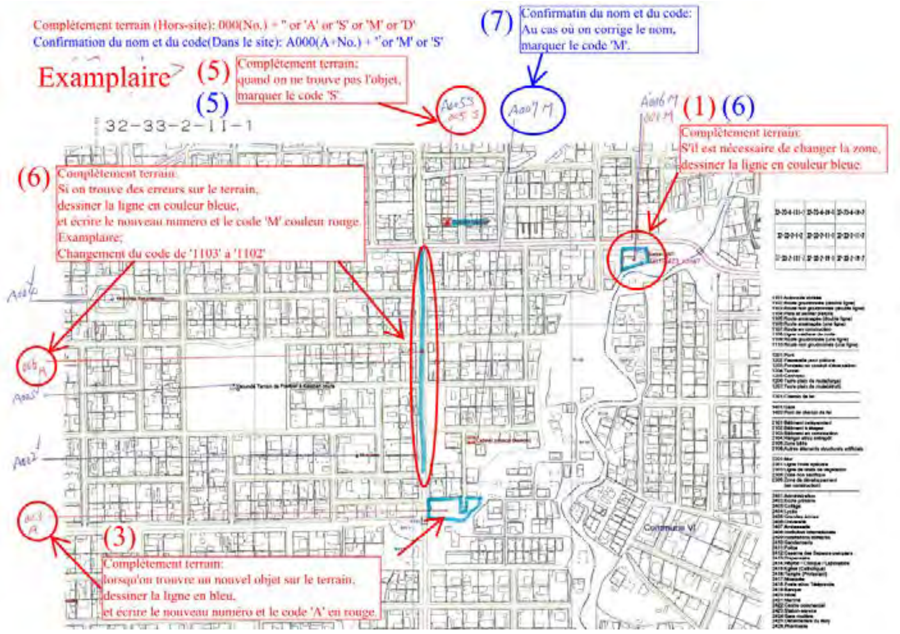
	GridNameFC	No	Team	FI_LinkKey	Code	Nom: Upper – From Complemetnt Survey Map / Down – From Field Note & Photo	Confirmation	Abréviation	numéro_de_la_photo	FileName
(8)	32-33-2-2-1	008	D	D32-33-2-2-3-001	2402/2403	Ecole Saint-André Pari-Sin Ecole Saint-André Pari-Sin	1		0207	teamD_151125¥DSCN0207.JPG
	32-33-2-2-1	009	D	D32-33-2-2-3-002	2404	Complexe scolaire Platen Complexe Scolaire Platon	3	PLATON	0208	teamD_151125¥DSCN0208.JPG
(10)	32-33-2-2-1	010	D	D32-33-2-2-3-003	2402/2403	Ecole privée URANUS Ecole Privée Uranus	5 / 2	URANUS	123	
	32-33-2-2-1	011	D	D32-33-2-2-3-007	2421	Marché de Kalaban coura (grand-marché) Marché de Kalaban Coura (Grand-Marché)	3			
(12)	32-33-2-2-1	012	D	D32-33-2-2-3-008	2423	Station Sanké Station Sanké	1		0192	teamD_151124¥DSCN0192.JPG
	32-33-2-2-1	013	D	D32-33-2-2-3-009	2411	Police de commissariat 11eme Arrondissement Commissariat de Police du 11eme Arrondissement	3		0191	teamD_151124¥DSCN0191.JPG
	32-33-2-2-1	014	D	D32-33-2-2-3-010	2417	Mosquée Mosquée	1		0204	teamD_151125¥DSCN0204.JPG

Si le nom n'est pas confirmé par la photo, écrire '2' et marquer sur la carte de completement terrain.

Figure 4-8 Example of Entry in the List for Confirmation of Building Names, etc.

(4) Method to describe field completion map

The difference between the content of description in indoor work and that after the verification in the field was explained and to ensure that the survey would be conducted based on the common understanding of all the participants, practical training on the method of description was given to all the participants.



Source: Prepared by the Project Team

Figure 4-9 Example of Entry in Field Completion Map

(5) Post- survey analysis

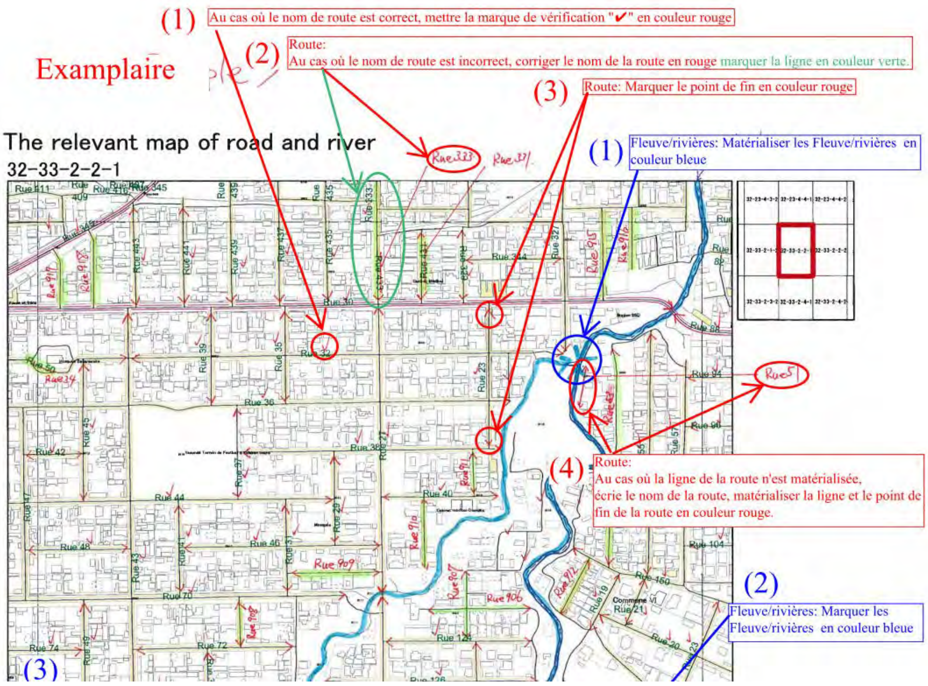
After the field training, the survey results of each team were compared with each other and the participants were instructed to review the points of discrepancy in the acquired content (Table 4-8) to achieve uniform quality of the results.

Table 4-8 Major Points of Discrepancy

Discrepancy	Cause	Action
A bank that had been relocated was not deleted.	Some teams determined that the bank still existed from the sign that remained and other teams visually confirmed that the bank had been relocated.	Instruction was given to make direct confirmation rather than judging from the sign.
The position of an antenna is different.	The position of the building was interpreted wrongly when verified in the field.	Instruction was given to understand the relative position of the target feature with one's position by taking measurement by walking in addition to checking the map, tablet, etc.
Road pavement classification is different.	Some teams did not confirm the road condition.	Since paved roads are highlighted by red lines on the field completion map, instruction was given to acquire the information of paved roads if found other than the red lines on the map.
Features that were not acquired in the field identification have not been acquired.	The participants were preoccupied with the unclear points from digital compilation and overlooked the points that the information was not acquired in the field identification.	Instruction was given to review the acquisition items to check the missing information from the field identification and the areas that underwent secular changes.

(6) Method to survey road names and river names

The participants were trained in preparing survey manuscript map (Figure 4-10).



Source: Prepared by the Project Team

Figure 4-10 Example of Entry of Road Names and River Names in Survey Manuscript Map

Since the teams that finished the preliminary preparation for the field completion started to input the survey manuscript map information to the GIS data, first of all, the Japanese experts should provide the members of the team specific guidance on the input and compilation methods on a one-on-one basis and then, the team acquired from Japanese experts should train the other team that have yet to master. This approach helps them as an instructor to increase the depth of understanding of methodology as well as enable to uniform quality among all members.

4.3.3.3 Evaluation

The objective of the field identification and completion survey training was to learn how to conduct field identification and field completion survey based on the survey plan and the target scale. They were evaluated for the following components:

(1) Understanding of the survey content for a medium-scale topographic map and a large-scale topographic maps

The actual work, survey results and questionnaire results indicated that all the survey participants understood this component.

(2) Understanding of specifications, map symbols, and application rules

Some participants forgotten or had inadequate understanding of parts of the map symbols that were not used during the field identification in the beginning of the field completion survey. This is due to the fact that there was a three months gap between field identification and completion surveys. However, the survey results and questionnaire results indicated that most participants understood specifications, map symbols, and application rules.

(3) Understanding of the content of the survey

The participants increased their understanding of the acquisition items by confirming how the items acquired in the field identification are expressed on the map as the survey was conducted.

(4) Understanding of field identification and field completion roles

The participants recognized the difference in the survey content through the workshop and clearly understood the difference from the field identification as they actually implemented the field completion survey.

(5) Execution of field identification using a digital device or tablet

As with the field identification, the participants implemented the survey without any problems, using tablet, GNSS camera, etc. However, the preliminary preparations were made by the Japanese Project Team. It remains to be seen whether or not IGM will be able to make preparations smoothly when they make preparations independently. Therefore, IGM is recommended to continue to make practical use of such devices.

(6) Classification of survey results via the control of the accuracy

Although the final inspection of the survey results was carried out by the Japanese experts, intermediate inspections during the survey process were conducted by the participants from IGM. In particular, lists input by using Excel and road data input by using GIS software were inspected not only on the screen but also after being output to make sure that they were correctly input and updated. It was determined that by repeatedly carrying out inspections in this way, they understood the accuracy control method in addition to the importance of inspection.

4.3.4 Aerial Triangulation

The training content of aerial triangulation consists of interior orientation, exterior orientation (relative, absolute) and quality control. A preliminary questionnaire and an interview were conducted to understand the skill levels of two participants selected by IGM. Training began after initial surveys.

(1) Baseline survey to understand the skill levels

Table 4-9 shows the questionnaire used to understand the technical expertise and skill level of the participants.

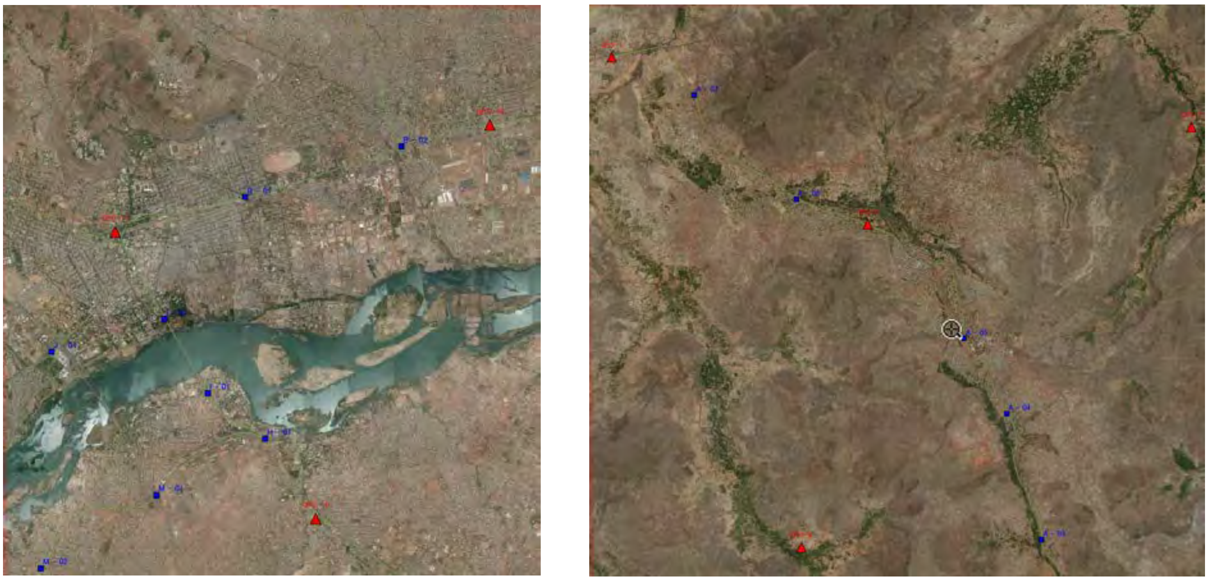
Table 4-9 Questionnaire Concerning the Skill of Aerial Triangulation

Survey item	Training content	Self-evaluation (5 grades)	
Basic knowledge	(1) Understanding of the work process of digital topographic mapping	5.0	2.0
	(2) Understanding of the work process of aerial triangulation	1.0	4.0
Technical skill	(3) Ability of stereoscopic viewing of aerial photographs	3.0	2.0
	(4) Ability to interpret features by stereoscopic viewing	3.0	4.0
	(5) Ability to measure ground control point and tie point	1.0	1.0
Technical knowledge	(6) Understanding of the default setting of LPS	0	0
	(7) Understanding of the number of ground control points when the POS/IMU results are used	1.0	2.0
Special technique	(8) Knowledge of bundle block adjustment calculation	1.0	2.0
Quality control	(9) Knowledge of quality control of aerial triangulation results	3.0	2.0

The baseline survey revealed that the participants had little experience in aerial triangulation. Therefore, repetitive training was conducted with a focus on technical skill and technical knowledge in order to improve the accuracy in stereoscopic interpretation. In particular, training on “stereoscopic viewing of aerial photographs” and “measurement of ground control point and tie point” was conducted for two participants for 14 days (5th to 22nd April 2016).

(2) Setting the target area in practical training

Simple topographic patterns were used for training to enable the participants to learn 3-dimensional measurement technique in a short period Figure 4-11 shows the area that was selected for the technical training.



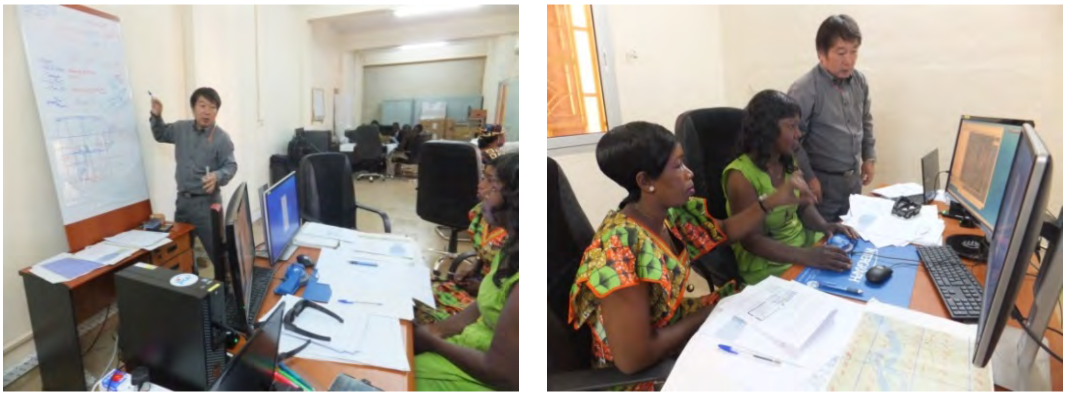
Source: Prepared by the Project Team

Figure 4-11 Areas Selected for Training: Flat Urban Area (A: Left) and Mountainous Area (B: Right)

(3) Content of technical training

Lectures on the technical content and knowhow of aerial triangulation mainly covered the work process of aerial triangulation and the basic concept of aerial photogrammetry. With respect to practical skill training based on the lectures, using the 3-dimensional plotting system provided in this project, technical training of the aerial triangulation of two points located in the target areas was implemented (Photo 4-3).

Quality control was conducted by using the actual aerial photograph data for the participants to learn the quality control method of aerial triangulation. In particular, in the practical skill training, the participants were repeatedly told to make it a mandatory practice to evaluate the result calculated from aerial triangulation and record the quality result in the quality control sheet.



Source: Project Team

Photo 4-3 Lecture on Aerial Triangulation (Left) and Training in Stereoscopic Viewing and Operation of 3D Mouse (Right)

(4) Technical training evaluation

The goal of this technical training program is to enable IGM to carry out aerial triangulation based on the understanding of the entire work process (preliminary preparation, interior orientation, exterior orientation and quality control).

1) Understanding of preparatory work

IGM had no previous experience in the operation of digital aerial camera with POS-IMU. The technical training enabled the participants to understand the difference from analog camera and the work process of using digital aerial camera with POS-IMU as well as the necessary information.

2) Understanding of work process

The participants learnt the methodology to import digital aerial photograph data and to input photography position (POS-EO) and camera information. The participants reached the level of being able to carry out aerial triangulation through measurement accuracy of control points as well as the method for eliminating tie point errors after repeated training.

3) Implementation of each process and quality control

The participants were able to set the accuracy level of ground control survey results, set the density in automatic tie point measurement, carry out large-scale aerial triangulation analysis and set the visualization display of different types of errors by themselves. In addition, it was determined that they understood the method of evaluating the analysis result to record in the quality control sheet.

4) Achievement after the training

According to the result of the baseline survey, the participants did not have experience in aerial triangulation. As such, pre-training evaluation scores were low. However, as a result of repetitive and intensive technical training, it was confirmed that the participants have reached a working knowledge level (Figure 4-12). Nevertheless, to ensure that they acquire the technical skill to reach the level of performing the work as a routine, continual training is needed for them to improve the speed and efficiency of visual interpretation.

Technical level survey of the IGM staff

<Aerial triangulation> 13-May

Item No.	Research item	Examination **before** the training (Present situation level) 04/4/2016: Korotoumou Mariko	M'Bake Toure		Examination **after** the training (The later level) 21/4/2016: Korotoumou Mariko	M'Bake Toure	
(1)	1.Knowledge of the work production process of the digital topographic map	5	2		5.0	3.5	
(2)	2.Knowledge of the work production process of the Aerial triangulation	1	4		4.0	4.5	
(3)	3.Possibility of the Aerial photography	3	2		4.0	5.0	
(4)	4.Possibility of interpretationand measurement of field features in stereovision	3	4		5.0	5.0	
(5)	5.Initial setting of the LPS is possible : Input of the exterior orientation.camera. Aerial photography image	1	1		4.0	5.0	
(6)	6.Amount of a control point necessary to a minimum of the Aerial triangulation using POS/IMU	0	0		4.0	4.0	
(7)	7.The measurement of the control point /Tie point is possible (control of the APM function)	1	2		4.0	5.0	
(8)	8.Possibility of the operation of the bundle adjustment computation (CAP-A)	1	2		4.0	3.0	
(9)	9.Possibility in accuracy management of the quality	3	2		5.0	5.0	

:Before
:After

Unaware 0 1 2 Know the basics 3 4 Well known 5

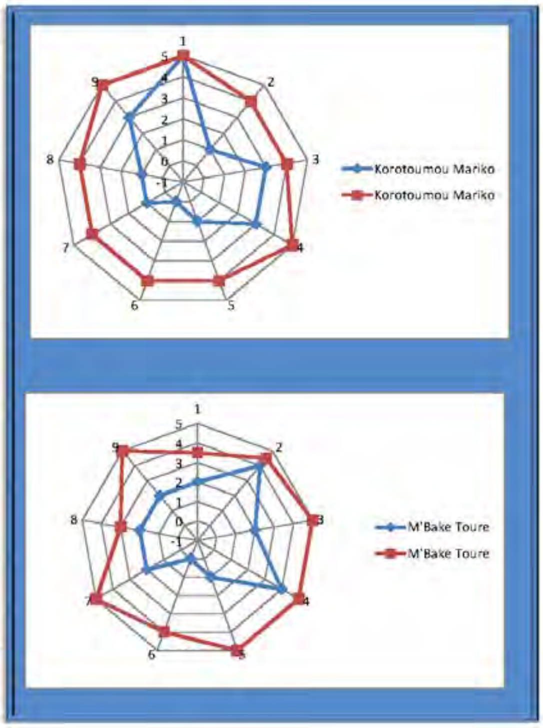


Figure 4-12 Skill Level of Two Participants from IGM in Aerial Triangulation

(Blue: Pre-Training Self-Evaluation, Red: Post-Training Self-Evaluation)

4.3.5 Orthophoto

Training was given to two participants selected by IGM (same as the participants stated in 4.3.4) with the objective of enabling them to understand the basic concept of orthophoto and learn the method of creating orthophotos, including image adjustment and mosaic processing.

(1) Baseline survey to grasp the skill level

Prior to the start of training, a questionnaire survey was conducted to grasp the technical expertise and skill level of the participants with respect to the survey items as described in the following.

Table 4-10 Content of Questionnaires about Orthophoto Creation Skills

Survey item	Training content	Self-evaluation (5 grades)	
Basic knowledge	(1) Understanding of the work process for DEM/orthophoto maps	2.0	4.0
Technical knowledge	(2) Knowledge of DEM data editing	2.0	4.0
	(3) Knowledge of orthophoto creation work	4.0	4.0
Technical skill	(4) Knowledge of orthophoto joining and editing	4.0	1.0
Special technique	(5) Knowledge of color tone correction of images	4.0	4.0
Quality control	(6) Knowledge of quality control of orthophoto products	2.0	2.0

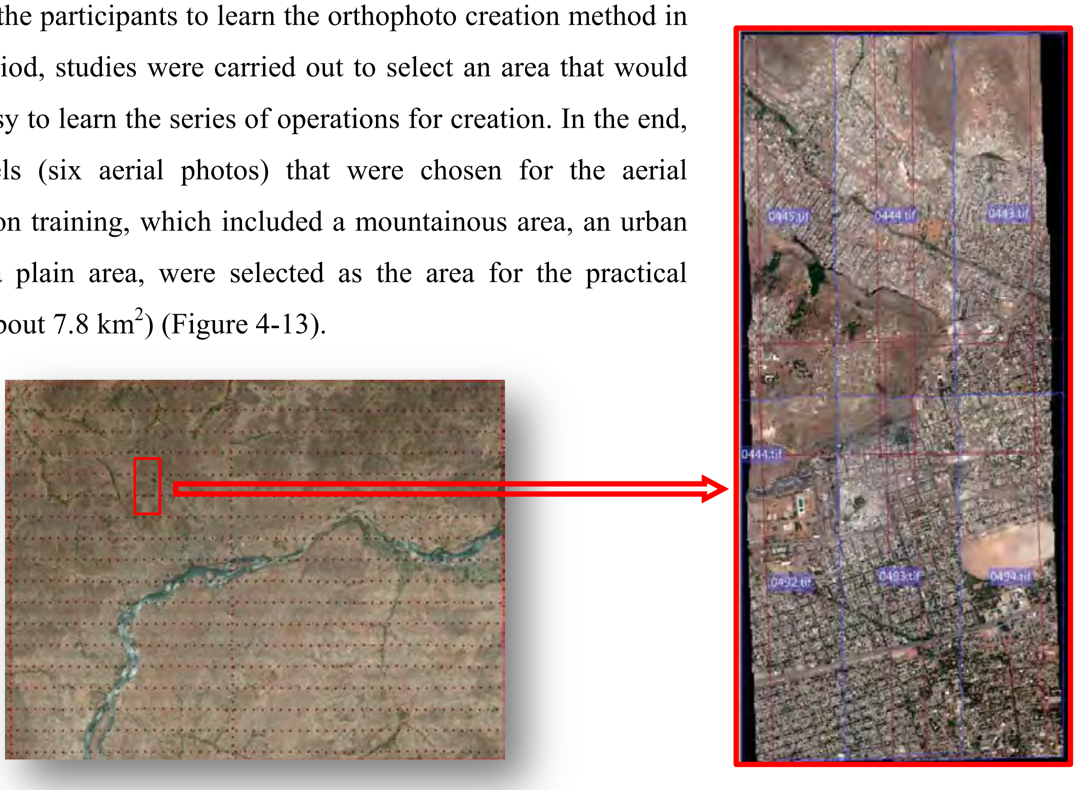
According to the result of the baseline survey and checking of existing orthophoto products created by IGM, IGM had a track record and a certain level of skills in creating orthophotos. However, in addition to the lack of experience in DEM editing, they had the following issues.

- They have little experience in creating orthophotos by using aerial photos in which the color tones are not uniform unlike satellite photos and the inclination of structures tends to be large.
- They are unable to determine the joining position of photos, which is important in aerial photo processing
- They have little experience in re-measuring ground elevation (DTM) to correct the ground elevation in editing.

In order to overcome the issues as described above, the technology transfer program was designed to implement practical training focused on the knowhow and techniques unique to aerial photo processing for seven days (June 2 to 20, 2016).

(2) Setting of the target area of training

To enable the participants to learn the orthophoto creation method in a short period, studies were carried out to select an area that would make it easy to learn the series of operations for creation. In the end, four models (six aerial photos) that were chosen for the aerial triangulation training, which included a mountainous area, an urban area and a plain area, were selected as the area for the practical training (about 7.8 km^2) (Figure 4-13).



Source: Prepared by the Project Team

Figure 4-13 Area for the Training in Orthophoto Creation

(3) Content of technical training

The process of orthophoto creation is divided into the inspection of aerial triangulation result, DEM generation and editing, seamline editing, color tone correction, generation of orthophoto images and quality control. In this program, technical training focused on the knowhow and techniques unique to aerial photo processing was implemented for the two participants from IGM and the training of each process consisted of lectures and practical training.

1) DEM generation and editing

The operations for DEM generation are divided into the inspection of aerial triangulation result, DEM generation, DEM editing and quality control. In the practical skill training, the participants were repeatedly trained in the interpretation of elevation from 3-dimensional data that was particularly difficult for them.

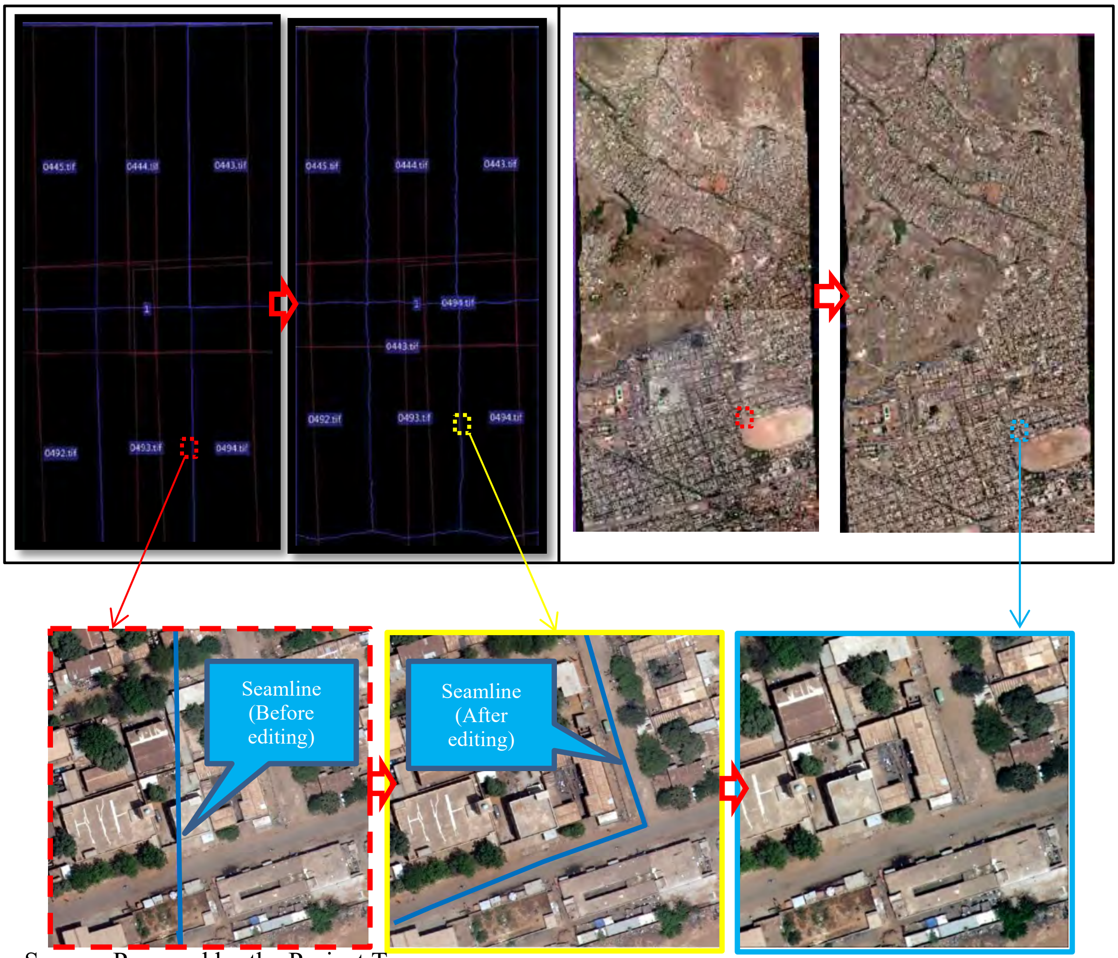
Source: Prepared by the Project Team

Figure 4-14 Stereo Images in DEM Editing (Before Editing (Left) and After Editing (Right))

2) Creation of orthophoto images and quality control

In the generation of orthophotos, color tone correction and geometric correction are carried out by using aerial photo image data and joining position of each aerial photo is edited. The work process is divided into the creation and editing of the line at the joining position (seamline), color tone correction of aerial photos (Figure 4-15) and quality control.

In the practical skill training, the participants were trained in the creation of orthophotos using the digital photogrammetry system provided in this project (IMAGINE Photogrammetry: formerly known as LPS). They were also trained with respect to the evaluation of the result and recording of quality result in the quality control sheet.



Source: Prepared by the Project Team

Figure 4-15 Seamline Processing
(Top Left: Before and After Seamline Editing, Top Right: Before and After Editing for Image Color Tone Correction)

(4) Evaluation by item

The achievement of the two participants from IGM with regard to the creation of orthophotos was evaluated as described below.

1) DEM generation and editing

In the beginning of the practical skill training, it took them a long time to learn the operation of the mouse dedicated to 3-dimensional measurement as they were not used to it. However, in the end, they became skillful enough to perform the elevation correction of automatically processed DEM on a 3-dimensional monitor by themselves.

However, it was observed that the accuracy of elevation correction tends to be poor in forest areas where the ground surface is covered with trees. To improve the accuracy of elevation correction in such areas, it is necessary to acquire the experience of performing elevation correction with diverse topographic patterns through repetitive training. As such, it is desired that they will further improve the technical skills that are considered necessary for DEM editing in the future through repetitive training and practice.

2) Creation of orthophoto images and quality control

With respect to the technical skill, since they do not have experience in using the digital photogrammetry system introduced in this project and in editing seamlines, repetitive skill training was intensively carried out and it was confirmed that they have reached a certain level (Figure 4-15).

Furthermore, the participants acquired a working knowledge level of knowledge with respect to the creation of DEM and orthophotos, definition of orthophotos (transformation into orthographic projection) and principles of other elevation models (DTM: Digital Terrain Model, DSM: Digital Surface Model). Consequently, they gained an understanding of the basic concept of digital orthophotos and quality evaluation based on accuracy control.

3) Creation of orthophoto maps

Figure 4-16 (a) shows an orthophoto image created by the participants during the training program. The orthophoto image is almost similar to the one created in Japan (Figure 4-16 (b)). Since the participants were familiar with the field conditions, they had no problem with color tone correction.

The accuracy of DEM elevation was generally good. However, the accuracy of DEM elevation worsened in steep slope areas or in the areas affected by shadow from buildings, trees and fences.

Source: Prepared by the Project Team

Figure 4-16 (a) Orthophoto Image produced by trainees, (b) Orthophoto Image produced in Japan

4) Achievement after training

As a result of implementing repetitive training in 3-dimensional interpretation, it was determined that the participants from IGM have reached a working knowledge level with respect to the creation of DEM and orthophotos, principles of elevation models and definition of orthophoto (features of transformation into orthographic projection).

Technical level survey of the IGM staff

Orthohoto

10-Jun

Item No.	Research item	Examination before the training (Present situation level) 02/6/2016			Examination after the training (The later level) 10/6/2016		
		Korotoumou Mariko	M'Bake Toure		Korotoumou Mariko	M'Bake Toure	
(1)	Possibility of the work production process of the DEM/	2	4		4.0	4.5	
(2)	Possibility of the editing method of DEM	2	4		4.5	4.5	
(3)	Possibility of the preparation method of the ortho photo	4	4		4.5	5.0	
(4)	Possibility of editing and the setting method of the ortho connection line	4	1		4.5	3.0	
(5)	Possibility of the tone collection of ortho photoimage	4	4		4.5	4.5	
(6)	Possibility of the accuracy management method of the DEM/ ortho photoimage	2	2		5.0	4.0	

:Before
:After

Unaware 0 — 1 — Know the basics 2 — 3 — 4 — Well known 5

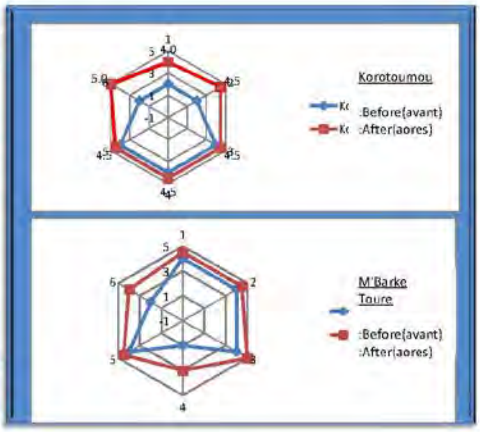


Figure 4-17 Self-Evaluation of 2 Participants from IGM for Orthophoto Creation

(Blue: Pre-Training Self-Evaluation, Red: Post-Training Self-Evaluation)

4.3.6 Digital Plotting and Partial Modification

Technical training was conducted for the participants from IGM with the objective of enabling them to interpret 3-dimensional models composed of stereo aerial photographs to acquire digital information and appropriate data based on a full understanding of the 1:5,000 map symbolization criteria and specifications, enabling IGM to independently perform modification according to secular changes in the future.

(1) Baseline survey

Prior to the start of training, a questionnaire survey was conducted to grasp the technical expertise and skill level of the participants by setting the survey items as described in the following.

Table 4-11 Content of Questionnaire about Digital Plotting Skills

Item	Training content	Self-evaluation (5 grades)	
Basic knowledge	(1) Knowledge of the work process of creating digital topographic maps	3.0	2.0
	(2) Knowledge of the work process of aerial triangulation	4.0	4.0
Technical skill	(3) Ability to view aerial photographs stereoscopically	4.0	5.0
	(4) Ability to decipher features by stereoscopic vision	4.0	4.0
Technical knowledge	(5) Knowledge of setting and changing the block (configuration) of LPS	4.0	5.0
	(6) Knowledge of configuration of PRO-600	1.0	1.0
	(7) Knowledge of setting and changing the library of PRO-600	1.0	1.0
Special technique	(8) Ability to decipher topography and features by stereoscopic vision	4.0	4.0
	(9) Experience in modifying topographic maps by using aerial photographs	3.0	4.0
Quality control	(10) Understanding of quality control and accuracy control	2.0	1.0

The baseline survey indicated that IGM had experience in analog plotting, basic aerial triangulation knowledge and had basic technical skills (visual interpretation of 3-dimensional models and interpreting features). However, digital plotting was new to IGM. Therefore, it was necessary to improve their digital mapping work process knowledge. It was noted that IGM had working experience on partial modification since they had modified existing 1:20,000 maps using satellite images.

Therefore, the technical training content focused on understanding the procedures for producing digital topographic maps, sharing technical knowledge on digital plotting and practicing accuracy control.

(2) Setting of the target area of practical training

One map sheet equivalent to 1/64 of Bamako Metropolitan project area (or 12km^2) was selected for the technical training.

(3) Content of technical training

The technical training was conducted for 25 days (from April 25 to June 1, 2016) to improve the skill level of the staff. In the training, which consisted of lectures and practical training, PRO-600 module (hereinafter “PRO-600”) of the digital photogrammetry system provided in this project (IMAGINE Photogrammetry) was used to explain 3-dimensional digital plotting and data structure, acquisition standard of the topographic map data at a scale of 1:5,000, work procedures of practical modification and reconnaissance method.

1) Understanding of digital plotting and preparatory work

With respect to the basic knowledge and technical skill, on which a special focus was placed, lectures were given on the work process of the creation of digital topographic maps and the content of data generated from each operation to ensure the understanding of the map symbolization criteria for the creation of 1:5,000-scale topographic maps. In addition, a combination of lectures and practical training was conducted on the basic configuration of digital plotting system (Photo 4-4). In particular, a lot of time was allocated for the explanation of the data structure of digital maps to ensure the participants' understanding.

Source: Prepared by the Project Team

Photo 4-4 Technical Training in Digital Plotting

(Left: Lecture on Work Process, Right: Training in Elevation Measurement Using 3D Monitor)

2) Data acquisition by 3-dimensional interpretation and quality control

In the field of special techniques, the exercise of the 3-dimensional data acquisition for terrain information including the contour line and spot heights was carried out using stereo aerial photographs. In addition, the practical training on the methods of partial modification as well as the updating due to aging (secular change) was conducted using the aerial photograph data. Moreover, the lecture on the knowledge of quality control and techniques for the management of acquired data from digital plotting was provided.

(4) Technical training evaluation

The goal of digital plotting training was to capture digital information using 3-dimensional model and to acquire accurate data.

1) Understanding of preparatory work and work process of digital plotting

Since IGM had experience in modification from secular distortions (changes) by using analog plotting method satellite images, IGM was simple to understand an approach and knowledge required for digital plotting.

Evaluation results indicated that the participants understood the preparatory work and digital plotting work procedures

2) 3-dimensional digital plotting data acquisition

Both participants had a satisfactory ability and no additional training was required. However, as they had little experience in 3-dimensional drawing, they were not accustomed to the stereoscopic vision of stereo screens. Therefore, it was necessary to repeatedly train them in the acquisition of contour line data, which took up a lot of time. Since it is difficult to acquire working level skills for the acquisition of elevation point and contour line data in such a short time, additional training is required.

At the beginning, in the middle and at the end of the training, measurement was made to determine the digital information acquisition speed of the participants. The measurement results were 1.56 points/minute, 4.86 points/minute and 11.19 points/minute, which showed that the speed had steadily increased. As such, it would be important for them to continue the practice of data acquisition by acquiring digital plotting data in the area other than the target area of this project after the completion of the project.

3) Improvement of the ability to planimetric features

The ability to interpret planimetric features requires in accordance with the map symbolization criteria and measurement of height at a high accuracy in accordance with scale 1:5,000. The participants from IGM were highly capable of determining the classification of features and the deciphering accuracy was high, but the measurement accuracy of height was inconsistent.

As technical training in the acquisition of the elevation values of target features were conducted again and again, the measurement accuracy of height gradually stabilized. However, since it still takes too long to measure digital information because of lack of interpret skill, continuous training is essential for them to become able to measure elevation instantaneously.

4) Understanding of partial modification

IGM has updated topographic maps by partial modification based on satellite photographs. Therefore, practical training was conducted by allowing the participants to modify digital plotting data that had undergone secular distortions by using aerial photographs and stereo photographs.

It was determined that the training promoted the participants' understanding of the work of updating topographic maps based on the latest aerial photographs and they learned the basic technology required for IGM to modify 3-dimensional topographic maps according to secular changes by themselves in the future.

5) Digital plotting results

The digital plotting data that the participants actually created are as shown in the top left of Figure 4-18. Comparison with the digital plotting data of the same area created in Japan (top right in the same figure) revealed that the two sets of data almost conformed to each other in terms of the measurement of features in planes and the measurement errors of the elevation single points were within the allowable limit.

However, there were some discrepancies in terms of the measurement of contour lines in the areas with flat topography. Also, the accuracy of height in some areas was not uniform and the accuracy of contour lines tends to worsen in the areas shaded by buildings, trees and fences. Therefore, it is desirable to practice repetitive training in order to acquire consistent skills in 3-dimensional interpretation.

Source: Prepared by the Project Team

Figure 4-18 Map Created by Overlapping the Plotting Data from Practical Training with Standard Plotting Data (Bottom)

(Top Left: Result of Practical Training in Digital Plotting by IGM, Top Right: Standard Plotting Data)

6) Accuracy control

Because there was no quality control record in IGM, the quality and accuracy information of the acquired results was unclear. Accordingly, based on the quality control sheet adopted in Japan, lectures and exercises were conducted about the recording format of quality results and the method of quality control.

As a result, with respect to the quality control method, that is, to evaluate the defectiveness of 3-dimensional digital plotting data in quantitative terms to take corrective measures, a certain level of understanding was achieved. Also, it is expected that the quality control sheet will be continually used after being modified by IGM to comply with the design standards and specifications of the national geographic information of Mali, which will be prescribed by CIIG in the future.

7) Achievement after training

Figure 4-19 compares the result of self-evaluation carried out by the two participants from IGM of their skills of digital plotting after the completion of the technical training in digital plotting, using the same indices as the baseline survey, with the result of the baseline survey.

As described earlier, since IGM had experience in analog plotting, they had an adequate understanding of the basic preparations and work process and had adequate abilities of stereoscopic vision and to decipher features. However, since they had little experience in digital plotting, it was necessary to promote the understanding of configuration and operation method unique to digital plotting. Also, because they had no skills in the acquisition of digital plotting data and digital information of elevation values, repetitive training was essential.

In conclusion, although the explanation of the 3-dimensional data structure and the operations to acquire topography and features (it took time to determine the plane position and height) required more time than necessary, from the evaluation of the result of practical training, it is determined that they acquired a certain level of knowledge and skills.

Technical level survey of the IGM staff

Restitution numérique

Item No	Research item	Examination before the training (Present situation level) 2016/4/25		Examination after the training (The later level)2016/6/1	
		Korotoumou Mariko	M'Barke Toure	Korotoumou Mariko	M'Barke Toure
1	Degré de compréhension sur le processus des travaux de la cartographie numérique	3	2	3.5	4
2	Degré de compréhension sur le processus des travaux de l'aérotriangulation	4	4	4.5	4.5
3	Capable d'interpréter la disposition du terrain et des objets terrestres sur une orthophoto	4	5	4.5	5
4	Capable d'interpréter des objets terrestres tridimentionnellement sur deux photos aériennes	4	4	4.5	4.5
5	Capable de configurer et modifier un ficher bloc du LPS (Configuration pour le démmerage de la restitution numérique)	4	5	4.5	5
6	Capable de configurer l'environnement du PRO600 (Ficher de projet, Paramètres Tolérance etc)	1	1	4	3.5
7	Connaissance sur la configuration de la bibiliothèque du PRO600	1	1	4	4
8	Capable de mesurer des reliefs terrestres et des objets terrestres sur une image en 3D (Degré d'expérience de la technique de l'interprètation en 3D)	4	4	5	4.5
9	Voue pouvez corriger la carte topographique en utilisant les photographies aeriennes	3	4	5	4.5
10	Connaissance sur le contrôle de qualité et de précision.	2	1	5	4

Before(avant)
After(après)

médiocre Unaware 0 — 1 — 2 — 3 moyenne Know the basics — 4 — 5

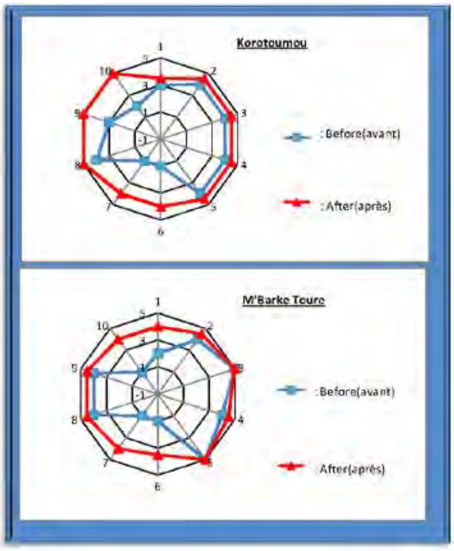


Figure 4-19　Self-Evaluation of Digital Plotting Skill Level by 2 Participants from IGM (Blue: Pre-Training Self-Evaluation, Red: Post-Training Self-Evaluation)

4.3.7　Digital Compilation, Map Symbolization and Partial Modification

Technical training was conducted for the participants from IGM so that they will be able to perform digital compilation and map symbolization independently.

(1) Baseline survey

Prior to the start of training, a document describing the outline of the digital compilation and map symbolization technologies was distributed to the four participants of this program to explain the schedule and outline of technology transfer.

After that, a questionnaire survey was conducted to grasp their skill level and requests for the technology transfer, etc. (Table 4-12). According to the result of the questionnaire and the self-evaluation table, although they use digital compilation software in their work, they have not been able to use it efficiently as a practical work tool.

Table 4-12 Content of Questionnaires about Digital Compilation, Map Symbolization and Practical Modification Technologies

Evaluation item	Self-Evaluation by 3 participants (5 grades)		
(1) Experience in creating maps	1	3	3
(2) Operation of MicroStation/AutoCAD	1	3	2
(3) Creation of symbols and lines using MicroStation/AutoCAD	1	0	1
(4) Understanding of map topology	1	2	2
(5) Operation of GIS software, such as ArcGIS	1	2	2
(6) Map updating operation	1	2	3
(7) Output mapsheet inspection	1	2	3

In view of the degree of their understanding and considering the achievement goal of this program, it was decided to focus on the repetition of basic operations.

(2) Setting of the target area in practical training

In order to let them learn the techniques and methods of digital compilation, map symbolization and quality control in a short period of time, the northwestern quarter of a map numbered “29-I-EA-32-13-4” was selected as the target area of the practical training.

Source: Prepared by the Project Team

Figure 4-20 Target Area of Digital Compilation Training

(3) Content of technical training

Lectures on the technical content and knowhow of digital compilation and map symbolization mainly covered the basic concepts and they were given by using the manuals prepared beforehand.

On the other hand, practical training was given repeatedly in accordance with the skill level of the participants and the importance of the items. More specifically, technical training covering the content as described in Table 4-13 was given to two engineers from IGM for 35 days (from 14th April to 3rd June 2016).

Table 4-13 Major Content of the Technical Training Program (Digital Compilation and Map Symbolization)

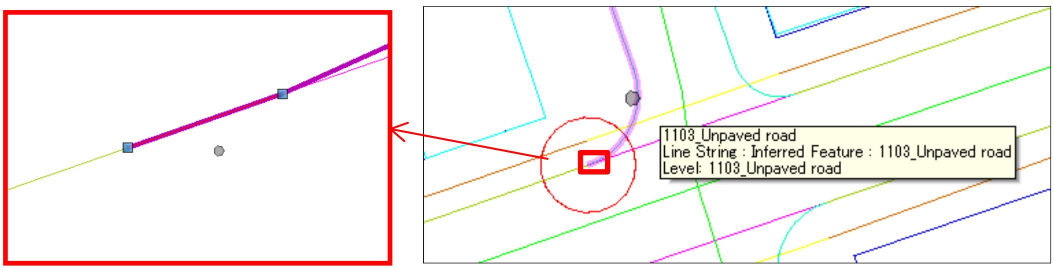
Item	Objective	Work content
Understanding of the content of basic operations for digital compilation	Understanding of the basic operations of the software	Practical training in command operations necessary for this project
Data modification in digital compilation	Understanding of data cleaning Understanding of the measures to be taken against errors	Elimination and adjustment of map lines that are unnecessary for the creation of topology, data modification by visual judgment
Understanding of map symbolization	Understanding of the basic operations of the software Understanding of symbols necessary for map expressions Understanding of judgment in mapping in accordance with the scale	Creation of symbols and line types necessary for map expressions Mapping with data composed of points, lines and planes Creation of the data for output
Modification according to secular changes	Understanding of data insertion considering the feature attributes acquired in completion survey Coordinate conversion where necessary Insertion of reference system data Quality control of mapping result	Data modification considering the consistency with existing data, reconstruction of topology, coordinate conversion, input of raster and vector, insertion of text data Inspection and modification, creation of quality control sheet

1) Understanding of work content

According to the result of the baseline survey, the participants from IGM had little experience in creating GIS data using digital compilation software and GIS. As such, exercises were conducted, giving direct instructions on the basic operations of digital compilation software, which is indispensable for performing digital compilation and map symbolization, again and again.

2) Data modification in digital compilation

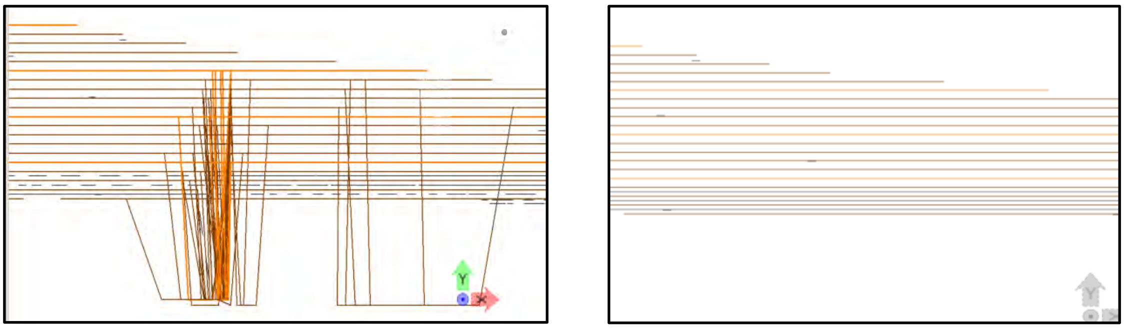
Exercises were given to the trainees in order to learn the method to deal with duplication and disconnected errors (Figure 4-21). The method to correct or deal with errors varies according to the type of errors. Therefore, advice was given on how to deal with the errors during the exercises.



Source: Prepared by the Project Team

Figure 4-21 Data Duplication Error

The trainees were explained that the compilation of contour lines as a two-dimensional processing unable to maintain height information because original is 3D data. After understanding and considering this issue, practical training was conducted.



Source: Prepared by the Project Team

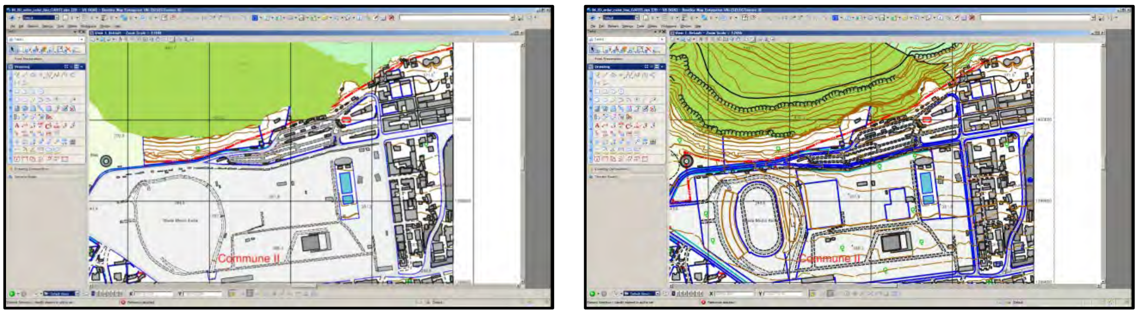
Figure 4-22 Modification of Defective Contour Lines
(Left: Defective Contour Lines, Right: Modified Section)

In the practice training, the trainees were explained the importance of the modification as described above is essential for the creation of GIS data and the modification needs to be continued until the necessary requirements are fulfilled, no matter how many modifications are needed. Also, the participants were instructed to record the situations and trends of such errors and report them to the person in charge of digital plotting because collaboration is necessary for making improvements.

3) Map symbolization

In the topographic mapping at a scale of 1:5,000, rearrangement is not commonly because map symbols are put in true position, however it should be carried out only when overlapping of symbols makes it difficult to read the map.

The trainees were lectured that the arrangement of annotations should be performed pursuant to the annotation specification and that if the arrangement rule cannot be applied, the arrangement should be made in a way to avoid overlapping with nearby symbols and annotations. In addition, practical training regarding the method to create sequence definition files was conducted because if the sequence of feature code layers is not defined before creating the output data, the data will be output with no appropriate map expressions.



Source: Prepared by the Project Team

Figure 4-23 Data without the Application of Printing and Output Sequence
(Left: Incomplete display of Contour Lines and Roads, Right: Appropriate Display)

Moreover, a lot of time was allocated for the explanation of the creation of cells (symbols) and custom lines (line types) so that IGM will be able to design original map symbols in the future.
At the request of IGM, practical training on a series of map symbols ranging from simple symbols to complicated ones (for example, from market 2421 to cliff 6105) was given to the participants from IGM in accordance with the map symbolization criteria, and exercises were repeatedly conducted for this work.

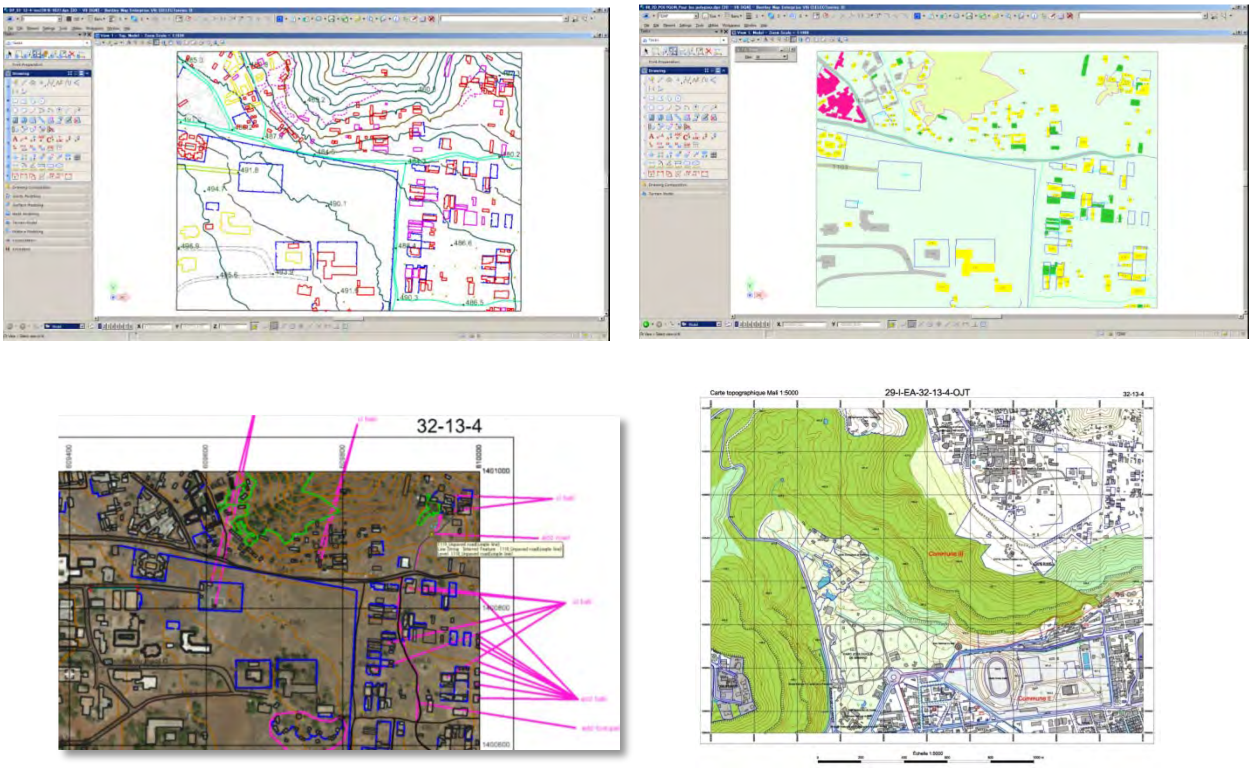
4) Modification according to secular changes

It was thoroughly explained to the participants that responding to secular changes is an important task for IGM to carry out the maintenance of geographic information after the completion of this project and that it must be regarded as a mission of IGM which needs to be operated independently.

It was also explained in the lectures that materials subject to modification according to secular changes include aerial photographs, satellite photographs, facility design drawings, layout diagrams and equipment information and that areas subject to modification are those that underwent changes, such as the enlargement and demolition of roads, bridges, railways, topography and public facilities caused by large-scale development and natural disasters.

The importance of drawing the true locations of buildings instead of the roofs in digitizing orthophotos and the necessity of collaboration with the photogrammetry engineers were explained and stereoscopic screens during the technical training in digital plotting as stated in 4.3.6 were shown to the participants to promote their understanding.

Finally, as the OJT of modification according to secular changes, the participants performed joining and insertion after creating polygon data using the data obtained from the OJT about secular changes in the plotting technology transfer so that they could understand the importance of joining with existing map data. Areas marked with red bold lines were assumed to be the areas that underwent secular changes and they were merged with the existing map with the ortho image as the background. Then, the areas marked by magenta leader lines were modified.



Source: Prepared by the Project Team

Figure 4-24 Results of the Training to Respond to Secular Changes
(Top Left: Practical training result, Top Right: Polygonized Data,
Bottom Left: Secular Change Recording Map, Bottom Right: Final Result)

(4) Evaluation by item

The goal of the technology transfer program concerning digital compilation and map symbolization is to acquire data at the accuracy suitable for compilation from digital plotting data based on an understanding of the specifications and map symbolization criteria. The achievement of the three participants from IGM with respect to the skills of digital compilation, map symbolization and partial modification confirmed from the technical training described above is evaluated for each item as follows.

1) Digital compilation

It was determined that through repeated exercises in the training, the participants from IGM understood the operations necessary for digital compilation and the commands and functions of the digital compilation system. However, additional training needs to be provided on a continuous basis to enable them to perform appropriate checking of data based on understanding and to take appropriate actions in an instant with respect to modification (data cleaning), creation of topology and modification according to secular changes.

2) Symbolization

It was determined that they fully understood map symbolization and acquired the knowledge and knowhow of the procedures for creating symbols and line types. It is desired that they will apply the acquired skills in their work.

3) Achievement after training

Figure 4-25 compares the result of self-evaluation carried out by the two participants from IGM of their skills of digital plotting after the completion of the technical training in digital compilation and map symbolization, using the same indices as the baseline survey, with the result of the baseline survey.

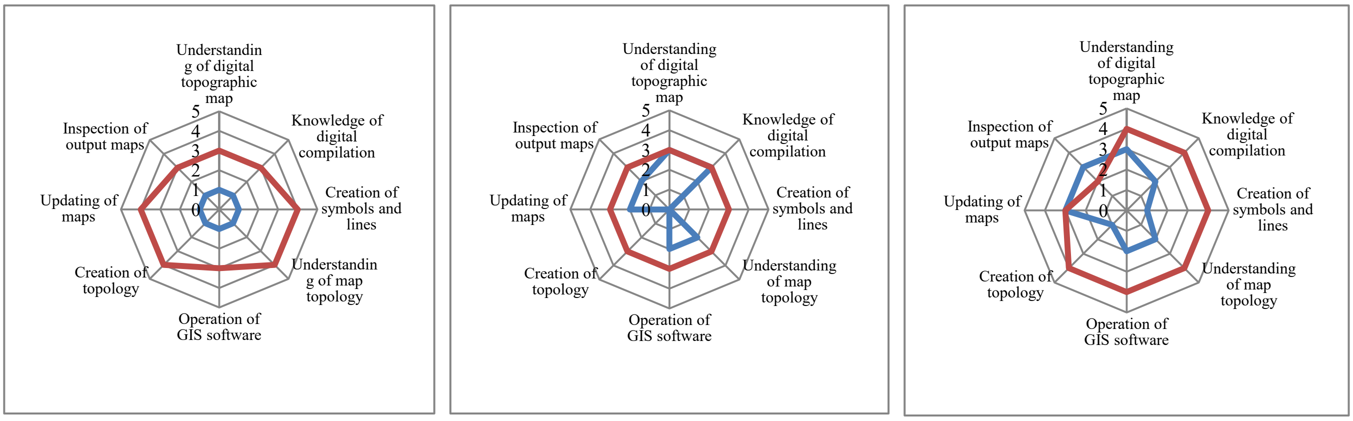


Figure 4-25 Evaluation of Digital Compilation and Map Symbolization Skill Levels of 3 Participants from IGM (Blue: Pre-Training Self-Evaluation, Red: Post-Training Self-Evaluation)

As described earlier, IGM had little experience in the digital compilation of GIS data including 3-dimensional data and as such, it was necessary to promote their understanding of the basic operations and configuration. Consequently, it took them more time than necessary to acquire the knowledge needed for basic operations, such as cleaning of 3-dimensional data and creation of topology.

It was expected that the participants from IGM perform the work by applying the basic operations and knowledge that they learned in the training, but their skills did not reach the working level. By giving repeated explanations to them in the latter half of the program, a certain level of understanding was achieved, but they were advised that continuous training was necessary.

4.3.8 GIS Data Structurization

(1) Baseline survey

The purpose of the pre-training questionnaires was to capture baseline information such as previous experience in GIS and database management, participants' perspectives on GIS and expectations on geodatabase training. The results of the survey are summarized as follows.

1) One of the participants had sufficient knowledge of information system as well as relational and object-oriented database management concepts. This participant was also well-versed with Microsoft Access, PostgreSQL and MySQL. However, the participant had no experience using CAD software.
2) The other two participants had little knowledge of information system and database management, but were well-versed with CAD software.
3) All the participants had no working experience in GIS. However, they had heard of such software as ArcGIS and QGIS and had attended GIS training.
4) They knew that GIS and geodatabase management training was urgently necessary for their work in order to improve the GIS data of IGM.

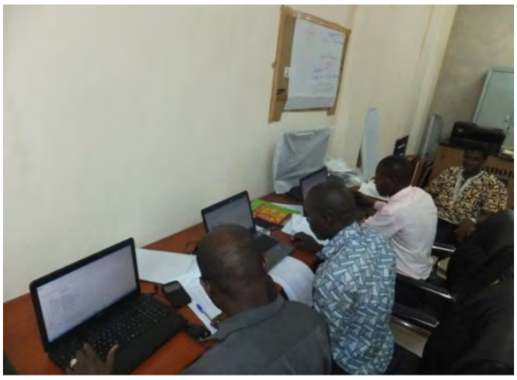
(2) Content of technical training

A training workshop was organized on geodatabase management systems. The specific objectives of the training were to:

1) develop an understanding of geodatabase design concepts;
2) design geodatabase schemas to efficiently model and store data;
3) create and modify geodatabase components including subtypes, and topology; and
4) migrate and load the project GIS data into a designed geodatabase.

The training workshop comprised approximately 10% lectures and 90% hands-on laboratory exercises using ArcGIS 10.3 (Advanced version) and sample Bamako mapping project datasets. Three selected staff members from IGM participated in the training for two weeks (Photo 4-5).

The results of practical exercises were used to evaluate the participants. In addition, the trainees were asked to evaluate themselves in order to identify their strengths and weaknesses during the training program.

Source: Project Team

Photo 4-5 Lecture about GIS Structurization and Geodatabase

1) Design and management of geodatabase

The geodatabase management training focused on five core components, namely (i) designing a simple geodatabase schema, (ii) building and populating a geodatabase, (iii) creating subtypes, (iv) importing raster dataset into a geodatabase, and (v) creating topology. Laboratory exercises and assignments were used to evaluate the trainees.

2) Topology for GIS data

The trainees were trained in the creation of polygon topology. After the lecture on the type of each topology as well as essential requirements and/or exception of point (including text), line and polygon topology, the practical training was conducted in the form of OJT (Figure 4-26).

The practical training was conducted for sufficient time because topology data creation is an important work of IGM to maintain, manage as well as create the GIS data in near the future. In particular, it was emphasized in the training that the trainees should make efforts for self-improvement as well as learn the approach of determining the reason for the errors.

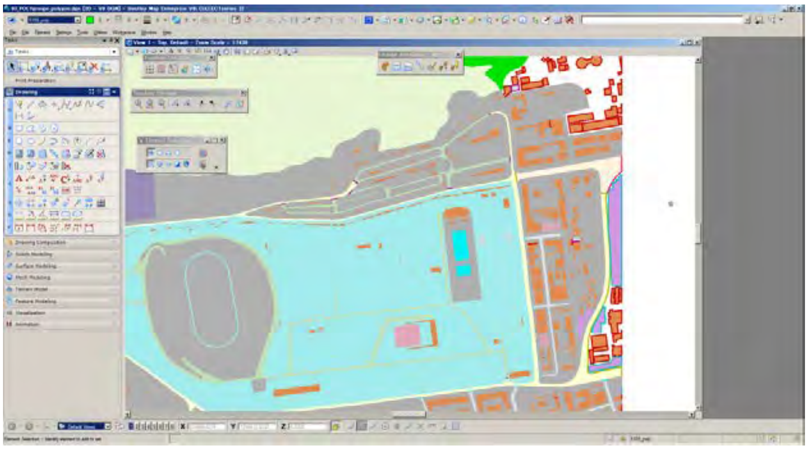


Figure 4-26 Result of Practical Training

Source: Prepared by the Project Team

3) Training evaluation

Figure 4-27 shows similarity between the trainees and instructor's evaluation. The overall performance was relatively good taking into consideration that it was the first time the trainees used GIS software (Figure 4-27). Two participants performed relatively well in (i) designing a simple geodatabase schema, (ii) building and populating a geodatabase, (iii) creating subtypes, and (iv) following the training manual. However, one participant had difficulties in (i) designing a simple geodatabase schema, and (ii) building and populating a geodatabase. This is because he was not following the steps outlined in the training manual. Nonetheless, the participant improved on the "creating subtypes" component when he started following the training manual steps. In general, all the participants encountered problems with components five and six (that is, importing raster dataset into a geodatabase, and creating topology). This is partly attributed to lack of understanding of GIS data models (that is, raster versus vector data models). In order to resolve these problems, the consultant explained again basic GIS concepts and data models, and assisted the participants in performing topology, and raster processing. Following that, the trainees were given additional assignments using administrative boundary data from IGM and free online GIS data. While difficulties concerning geodatabase design and management components such as topology and importing raster data were noted, the participants worked very hard. Generally, the participants are confident of managing GIS data at IGM. Although the participants have great potential, the following are recommended:

(i) all participants are recommended to undertake more training programs in intermediate geodatabase management. Therefore, IGM is recommended to organize follow-up hands-on training workshop programs to consolidate geodatabase knowledge and skills;

(ii) IGM is recommended to facilitate dialogue with other relevant stakeholders in order to promote more training programs on GIS; and establish a GIS laboratory at IGM, where all GIS datasets are stored. This will ensure high standards for maintaining GIS data and proper GIS data sharing protocol.

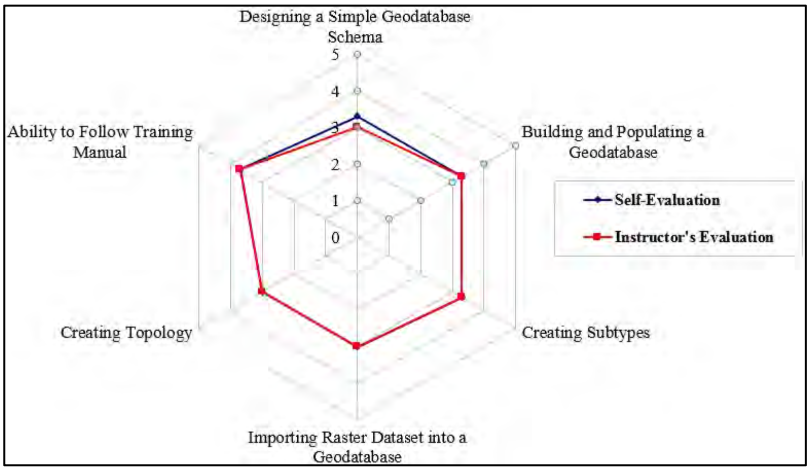


Figure 4-27 Self-evaluation (Participants) and Expert's Evaluation

4.3.9 Quality Control

4.3.9.1 Ground control point survey

The accuracy and quality control of the ground control points were based on four points outlined below. Note that the results were compiled as point description of ground control points, and used for the subsequent aerial triangulation.

(1) Accuracy control of existing geodetic points

In collaboration with IGM, the Project Team checked the quality of the geodetic points so that it does not affect GNSS observation.

The Project Team used GNSS observation to check if the ground control points coordinates (X, Y, Z) maintained their precision so that they could be used as ground control points. The Project Team observed if IGM staff members could set up the observation instrument as well as perform the initial calibration in order to receive GNSS data from the satellites.

Later, the Project Team compared the observed results with the existing control points in order to check for differences.

The Team observed four points; D0035, D0030, D0050 and B11, and then evaluated the results of the adjustment calculation of the network as resorting to four existing geodetic points. These accuracy control works allowed the Team to judge that these points can be adopted as control points of the skeleton in the ground control point survey.

(2) Accuracy control of the GNSS observations

IGM used to conduct some GNSS observations to this day by means of radiation observation. However, traverse observation was used in this project. The Project Team gave some instructions to the staff members of IGM since this method uses four GNSS devices for observation.

Before the work, the Project Team prepared an observation work plan (sessions plan) with the staff members of IGM who know traffic conditions and geography of the region well. The Team confirmed the execution of observations according to the plan.

(3) Accuracy control of the leveling

The accuracy control of technology transfer on leveling was carried out based on OJT (data management and accuracy control). IGM had enough leveling experience and observation accuracy of a leveling route was within standards. However, a considerable number of errors were found in the data management method which had adverse effects on the final results.

This is believed to be because there is no system in place to check of input errors and those in calculation at each stage of preparing intermediate results of leveling. Therefore, the Project Team provided thorough instructions on quality control through technology transfer on data management method and accuracy control at each stage in the form of OJT.

(4) Accuracy control of baseline analysis

A 3D analysis was executed for the results of the GNSS observations using software for ground control point analysis, Leica Geo Office (LGO) procured in the Project. The results showed the standard deviation of 18cm, and the subsequent aerial triangulation was conducted using this value.

4.3.9.2 Field Identification/Field Completion

Quality control of the field identification and the field completion was carried out with a focus on the following two points.

(1) Understanding of working criteria and map symbolization criteria

With regard to the positioning of field identification and field completion survey in the creation of large-scale topographic maps, the participants understood the significance of surveying in accordance with work manual and map symbolization criteria through repetitive learning by OJT.

In particular, during the field completion survey, at the end of the survey of the day, a survey was conducted on each team to see if the survey results have any inconsistency, omission or insufficiency. By checking the results repeatedly, it was confirmed that the survey was conducted in accordance with the work manual.

(2) Implementation of inspection, correction of errors and control of quality and process (creation of quality control sheet and process chart)

For process control, the progress of each team was shown on a graph (Figure 4-28), which was posted at the office of the Project Team so that everyone could see it. This made it possible to compare the progress of each team at a glance and let them recognize the importance of daily control and progress control.

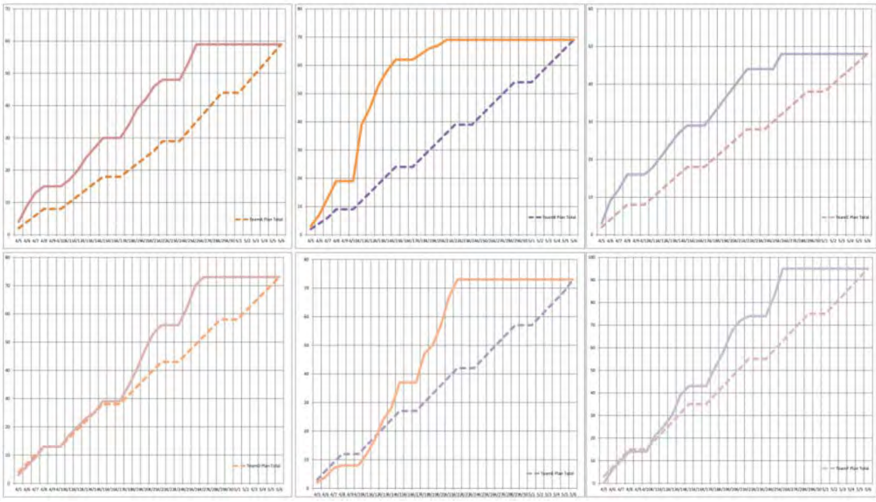


Figure 4-28 Graphic Representation of the Progress of Survey Teams (On-Site Checking)

In addition, with respect to inspection and correction of errors, the responsibilities of the Japanese experts and the IGM survey teams were determined for each process to implement inspection and corrections. The content of major inspections and corrections in each process is as shown in Table 4-14.

Table 4-14 Content of Inspection and Correction of Errors

Process	Inspection content	Corrections, etc.
Organization of surveyed points	If all building names have been verified	After verification by survey teams, Japanese experts inspected the survey results and if there were any omissions and unclear points, instructed the survey teams to make corrections.
	If the information input in the Excel sheet has been correctly updated by survey team members after the verification of building names, etc.	After the information is input by the survey teams, Japanese experts output a list indicating the history before and after corrections and survey teams collated the list with the corrected manuscript. Final inspection was carried out by Japanese experts.
	If surveyed points have been organized on the field completion maps	After survey teams organized the points on the field completion maps, Japanese experts checked the result and pointed out omissions, if any, and instructed the survey teams to make corrections.
Field verification	If all the points to be surveyed have been verified and if the survey content has any deficiencies	As soon as survey teams returned from the field, Japanese experts checked the survey results and pointed out omissions and deficiencies, if any, and if there were any issues that could not be resolved on the spot, instructed the survey teams to conduct the survey again on the follow day.
Organization of survey results and conversion to data	If the survey results in the field notebook have been input to the Excel sheet correctly	Japanese experts input the results in the Excel sheet and then, they compared the sheet with the original material and instructed survey teams to correct errors.
	If the number of survey results on the map match the number of results in the field notebook input in the Excel sheet	After Japanese experts input data to the Excel sheet and GIS, Japanese experts checked the data and instructed survey teams to make corrections if there were any problems.
Adjustment of annotations to display on the maps	If all the contents described in the annotation adjustment list have been verified	Lists checked by IGM personnel in charge were visually inspected by Japanese experts and omissions were pointed out for correction.
	If the contents changed to abbreviations have been correctly input to the Excel sheet	After input to the Excel sheet by Japanese experts, Japanese experts output the results, inspected for omissions and errors and instructed to make corrections as appropriate.

Verification of names, starting points and endpoints of roads and rivers	If the content of the original material for road survey has been correctly entered to the input manuscript	The input manuscript prepared by survey team members was checked by Japanese experts and omissions and errors were pointed out for correction.
	If the input results of GIS are consistent with the original material for road survey	The GIS data input by survey teams were output in the unit of survey map sheet and survey teams collated them with the manuscript map as primary inspection. Data corrected after the primary inspection were inspected by Japanese experts as secondary inspection.
Verification of transmission line connections	If the connections of transmission lines are correct	The map was checked with the personnel in charge at EDM that manages the transmission lines and one error was corrected.
Creation of quartier boundaries	If the original material data have been developed correctly	The result of development by Japanese experts was checked by the IGM personnel in charge and inconsistencies with vacant land and other layers (commune boundaries) were corrected.

4.3.9.3 Aerial Triangulation

With respect to the calculation of aerial photogrammetry, with the coordinates of the ground control point as the verification point, principal point position (X, Y, Z) and inclination (rotation angle of the X, Y and Z axes, namely, omega, phi and kappa) of the camera in photography were determined, and at the same time, based on the value that quantitatively represents the degree of defectiveness (sigma) and the control point residual error of the ground control point, acceptance or rejection of the calculation result was determined. By lectures and practical skill training, it was taught to the technical training participants that the acceptance criteria are determined by the photography scale of the aerial photographs used and the CCD size of the aerial camera. The IGM staff became able to perform quality control based on the acceptance criteria.

The results were recorded on the "aerial triangulation quality control sheet" and saved. As described in 4.3.5, in this project, a general format for accuracy control was prepared and the quality control sheet was prepared after the quality evaluation of the digital plotting data created by the IGM staff in the practical skill training. It is desired that IGM will continue to use the quality control sheet by improving the format to comply with the design standards and specifications of the national geographic information of Mali that CIIG will prescribe in the future.

4.3.9.4 Orthophoto

Generally, for the quality control of DEM, elevation points randomly extracted from a part of DEM are inspected and recorded. However, the quality of DEM currently created by IGM is partly inconsistent and as such, the product quality will be varied if the DEM is inspected in this way. Therefore, in this technology transfer program, training was conducted on the method of visually inspecting the elevations of the DEM by using a 3-dimensional monitor (100% inspection).

As a result of evaluation, it was determined that the participants fully understood the quality control method of inspecting the elevation points of the DEM automatically generated from each model and using the "DEM quality control sheet", which is signed by the person who performed the inspection.

4.3.9.5 Digital Plotting and Partial Modification

For the quality control of 3-dimensional plotting data of digital plotting and partial modification, since these operations are performed in series, quality control sheets of the same format were used. Quality evaluation was carried out by comparing the digital plotting data acquired in the lectures and practical training with 3-dimensional images to check for "excessiveness, omission and 3-dimensional position" of the digital plotting data and "errors and quantitative attributes" of classification. It was taught to the participants that errors found in quality evaluation should be corrected and features should be added to complete the digital plotting data to be transferred to the next process.

4.3.9.6 Digital Compilation and Map Symbolization

It was explained that topographic maps are inspected on the computer screen or by using the output map. If inspected on the computer screen, it is possible to scrutinize minute data structures by zooming in on the screen, but there is a limitation that only a part of the data is inspected by expanding on the screen. On the other hand, in analog inspection using output map, it is possible to check a wide area at one time and as such, this method is suitable for inspecting the whole area of a topographic map for uniformity.

Figure 4-29 Inspection Map and Quality Control Sheet of Training Area

Source: Project Team

It was repeatedly explained to the training participants that, since IGM has the technology for creating analog topographic maps because of past experience, advice from skilled engineers can be easily obtained and in this respect, implementation of the inspection of output, in addition to the inspection on the computer screen, has a significant meaning as it enables cross checking by several people.

Moreover, the participants were advised to record the result of inspection on the quality control sheet not only during this training but after the training and that this will help them understand the error situation and make improvements to the next project.

5. Future Prospects and Expectations Going Forward

Some challenges were observed with respect to the results of the baseline surveys and activities in IGM conducted in this project. It is expected that IGM will tackle the following challenges to develop as an organization responsible for the national geographic information and demonstrate its leadership to the ministries and agencies, which are prospective users of basic GIS data, as a service provider of geographic information technology and GIS data.

(1) Definition of the operations of the new organization and the services to be provided

In addition to providing geographic information, such as aerial photographs, satellite images and topographic maps, it is necessary to clearly define the operations of and technical services to be provided by the newly established CGIG and promote the products of IGM and technical services to be provided on the website.

(2) Management and redevelopment of ground control points

One of the missions of IGM is the management of the national geodetic points which make up the skeleton of the land of Mali. However, currently, the national geodetic points (triangulation points and benchmarks) in Bamako City have been destroyed and lost.

As such, it is essential that IGM survey all the ground control points in Bamako as soon as possible and redevelop new ground control points (including the installation of electronic control points) as necessary before providing support to other ministries and agencies in the development of geographic information.

(3) Updating the product of this project

1) Method of updating information concerning roads and rivers

With respect to road information, it is expected that it will be created upon receiving the road management map used by Cellule Technique d'Appui aux Communes (CTAC) for the management of road facilities, updated to be basic GIS data with accurate positional information and provided back to CTAC to be utilized in road administration. However, the road management map does not cover the entire metropolitan area and road names are not registered in some districts. Moreover, since the provided data are not subject to coordinate management, some areas have a low positional accuracy, and as such, areas that could not be identified were regarded as unregistered.

It is considered that providing the large scale topographic map data that were developed in this project to CTAC and establishing a system for CTAC to update the data and make feedback to IGM will make it possible to develop the road information, while maintaining unified accuracy, thereby contributing to improved efficiency in road administration in the future.

With regard to the names of rivers and water channels, because the topographic map data were created by using only the information stored on the existing 1:25,000 data, the names other than those of major rivers are not registered. Since some rivers and water channels are also used as drainage channels, it is expected that IGM will closely collaborate with the ministries and agencies managing them so that the large scale topographic maps will be utilized for the management of rivers and water channels.

2) Improvement of the accuracy of administrative boundaries (commune and quartier boundaries)

Administrative boundaries, such as commune and quartier boundaries, are basic information for the formation of communities and such information is frequently used for grasping the current situation and issues of communities.

In developing the basic GIS data in this project, commune boundaries were developed from 1:20,000-scale topographic maps created in the 1980s and quartier boundaries were developed from 1:25,000 metropolitan area map and accordingly, high positional accuracy cannot be expected. Moreover, with regard to Kati Commune, since boundaries could not be drawn because of the lack of materials, only the community names were registered. Going forward, it is necessary to finalize the administrative boundary information based on the data that were created in this project, while coordinating with the Ministry of Interior and relevant agencies.

3) Data development for the area outside the area subject to the creation of topographic maps

Using the results of aerial triangulation conducted in this project, 3-dimensional stereo models have already been constructed. As such, it is expected that topographic map data will be developed for the area of 880 km^2, which is not covered by the topographic maps created in this project, to provide for the requests that may arrive in connection with the development plans of other ministries and agencies and the master plan of Bamako City Office.

4) Modification according to secular changes for the area subject to the creation of topographic maps

The 1:5,000-scale topographic maps (520 km^2), which are the product of this project, were developed by using the aerial photographs captured in March 2015. The selling point of this product is that it extensively includes ground height information which did not exist in previous maps and for the time being, it can be sufficiently used as reference data for height. On the other hand, since some parts of the Bamako metropolitan area are being developed rapidly, freshness of the data is gradually declining. As such, when there is any change in the structure or topography, it is necessary to perform plane modification according to the change by using orthophoto images.

5) Cooperation with DNDC (Direction Nationale des Domaines et du Cadastre)

The orthophotos and 1:5,000-scale topographic maps from this project are accurate enough to be used by DNDC in developing the cadastral survey plan. Accordingly, cooperating with DNDC and supporting their cadastral survey services will indirectly contribute to the improvement of administrative services in Bamako City.

(4) Technical specifications of geographic information

In this project, technical specifications for the creation of 1:5,000-scale digital topographic maps and geodatabase of basic GIS data were developed. Considering the concept of shared geographic basic data, such specifications should not be applicable only to IGM, but they should be the technical specifications of the basic information of Mali. It is necessary for IGM to fully understand this point and make effort to publicize the specifications to all geographic information users by developing guidelines, etc.

Also, it is expected that the various technical specifications developed in this project will be revised or updated so that they will be also applicable to the ministries and agencies.

(5) For the construction of NSDI initiatives

Geographic information is merely one of the basic pieces of information of the national land spatial and it does not directly resolve the various issues of Bamako or promote urban development. For this reason, issues concerning the utilization of geographic information are caused by the vulnerability of horizontal collaboration and.it is important to establish mutual understanding and communication between IGM, which is the supplier of geographic information, and users of such information with respect to the sharing of responsibilities.

In this regard, efforts must be made to study the overall framework of Mali and develop operational guidelines so that geographic information will extend across all the ministries and agencies as well as all the sectors using such information. This is already clearly indicated in PNIG and all the geographic information that is needed (or lacking) to meet the needs of the geographic information users will be developed and managed on the basic GIS data (base map) to be created by IGM and ultimately, each geographic data (thematic information) will be shared among the ministries and agencies.

Looking back on the findings from the workshops, IGM recognized the basic concept of NSDI, that is, IGM prepares the base map from its duties and other user organizations develop thematic data on it and on the other hand, member ministries and agencies of CNIG, etc., that are the user organizations, also mostly understood this concept. As such, immediate challenges that IGM needs to tackle firstly, considering the fact that preparations have begun for the development of CGIG, which is the receptacle of the geographic information, are provision of easy-to-use (user friendly) data, GIS technical support and dissemination of information, which were clarified as a result of the attempt to unearth the needs described in Chapter 2.

(6) Conclusion

This project was jointly implemented by the Project Team and the IGM counterparts for about 21 months from February 2015 to October 2016. In the first half of the project, due to the worsening of the security situation of Bamako City, IGM took the initiative in the ground control point survey and the field identification/field completion survey. With respect to the activities in the latter half of the project, technology transfer program was developed on 1:5,000-scale digital mapping based on the aerial photogrammetry using the equipment procured in this project and technical training was

IGM had experienced small scale analog mapping in the past and had created 1:200,000 digital topographic mapping data in a recent project of IGN France, but they experienced the creation of large scale topographic maps for the first time in this project. For this reason, it took a lot of time for the IGM participants to understand and learn the difference in approaches and creation methods due to the difference in scales.

The 1:5,000-scale topographic maps developed in this project are digital data that can be easily added or modified. It is important that IGM will update the data in accordance with the changing situation of Bamako in the future based on the skills and experience acquired in this project. Of course, the technology transfer program that IGM went through in this project must not be enough for them to acquire complete technology.

However, IGM is now equipped with the materials and equipment necessary for the creation of large scale topographic maps and the work manual of each process. In addition, they also have the aerial photographs captured in this project and orthophotos (1,400 km^2) from the result of aerial triangulation. As described earlier, IGM must be ready to start the work for the area of 880 km^2, which is outside the area subject to the creation of topographic maps in this project (520 km^2).

Therefore, the Project Team expects that after the completion of this project, IGM will independently develop 1:5,000-scale topographic maps of the area that such maps have not been created and establish the method of creating large scale topographic maps in Mali through trial and error in the process of this attempt.

This project, which was executed against the unstable security situation of Mali, was supported by a great many people. In conclusion, the Team would like to express their deepest appreciation to the president of IGM and IGM counterparts, the Japanese embassy in Mali, JICA Senegal Office and experts dispatched to Mali for their kind consideration to ensure safety as well as their tremendous support and cooperation to the Team, whose members had to work under constraints during the stay in Bamako, having to perform operations smoothly in a short period of time.

Annex

1. Record of Discussions
2. Kick-off seminar report
3. UTM System Ver.1.0
4. Marginal information 1 :5000 Ver.2.3
5. Bamako Numbering system Ver 2.1
6. Bamako 1 :5000 map symbols and their application Ver4.0
7. Annotation rule Ve2.4
8. Explanation of information for utilization and promotion of the results
9. Workshop
10. Final Seminar
11. Handover

11-1 Certification to receive three (3) leveling equipments

11-2 Request of handover JICA equipments to IGM

11-3 Agreement for handover of JICA equipments between JICA and IGM

11-4 Inspection and agreement of delivered equipments

11-5 Reception letter of equipments from IGM

1. Record of Discussions

RECORD OF DISCUSSIONS

ON

PROJECT FOR ESTABLISHMENT OF GEOGRAPHIC

INFORMATION SYSTEM (GIS) FOR THE CITY OF BAMAKO

AND SURROUNDING

IN

REPUBLIC OF MALI

AGREED UPON BETWEEN

GEOGRAPHIC INSTITUTE OF MALI

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Bamako, 17 November, 2011

Ando Enko GUINDO
Director General
Geographic Institute of Mali

Akihito SANJO
Leader
Detailed Planning Survey Team
Japan International Cooperation Agency

In response to the official request of the Government of Mali (hereinafter referred to as "the GoM") to the Government of Japan (hereinafter referred to as "the GoJ"), the Japan International Cooperation Agency (hereinafter referred to as "JICA") held a series of discussions with Geographic Institute of Mali of the GoM (hereinafter referred to as "IGM") and relevant organizations to develop a detailed plan of the Project for establishment of Geographic Information System (GIS) for the city of Bamako and surrounding (hereinafter referred to as "the Project").

Both parties agreed the details of the Project and main points discussed as described in the Appendix 1 and the Appendix 2, respectively, and to request their respective governments to proceed with the necessary procedures for implementation of the Project.

Both parties also agreed that IGM, the counterpart to JICA, will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of the Mali.

The Project will be implemented within the framework of the Note Verbales to be exchanged between the GoJ and the GoM.

The effectiveness of the Record of Discussions is subject to the approval of JICA.

Appendix 1: Project Description
Appendix 2: Main Points Discussed

Appendix 1

PROJECT DESCRIPTION

I. BACKGROUND

Republic of Mali (hereinafter referred to as "Mali") is a landlocked country surrounded by Senegal and Mauritania on the west, Algeria on the north, Niger on the east, Burkina Faso and Cote d'Ivoire on the south, Guinea on the southwest. In recent years, the population of the capital city of Bamako has been increasing from about 1 million people in 1998 to about 1.8 million people in 2009 because of the economic growth.

Increased people live in the periphery of the city disorderly. Then, it leads the problem called suburban sprawl. In such areas, there are not enough roads, water supplies, infrastructure facilities, hospitals, and schools. At the same time, the residential environment and the security situation are deteriorating. Such problems become barriers to social and economic development.

Under these circumstances, the city of Bamako and the Ministry of Urban Planning has formulated a master plan (prepared from 1995 through 2005, established in 2011), proposing a plan for infrastructure construction. However, this plan is based on a topographic map on the small scale of 1/50,000 (one to fifty thousands) with the assistance of France in 1988. Therefore some problems arise as follows;

1) the map needs updating,
2) the master plan does not take account of information about gradient and detailed building placement,
3) the master plan limits the scope only in the city center, and does not include expanded settlements.

Based on the background above, the GoM has requested the GoJ for assistance in the production of a topographic map on the large scale of 1/5,000 (one to five thousands) to cover not only the central area of the city of Bamako but also its surrounding, which will be needed for the formulation of the development program, the development of infrastructure, and the management of water and environment.

II. OUTLINE OF THE PROJECT

1. Title of the Project

In order to be correspondent to the scope of the Project mentioned above, both side agreed to change the title of the Project from "Project for establishment of Geographic Information System (GIS) for the city of Bamako and surrounding" to "Digital topographic mapping project for the Bamako metropolitan area"

2. Expected Goals which will be attained after the Project Completion

(1) Goal of the Proposed Plan

The digital topographic maps as shown in Annex 1 at the scale of 1:5,000 (one to five thousands) are prepared.

(2) Goal which will be attained by utilizing the Proposed Plan
The sustainable and efficient socioeconomic development plan in the city of Bamako and its surrounding is formulated and implemented.

3. Outputs
(1) Production of the digital topographic map of Bamako city and its surrounding
1) One (1) set of aerial photo
2) One (1) set of digital orthophoto data of the project area
3) One (1) set of result of ground control point survey
4) One (1) set of result of aerial triangulation
5) One (1) set of 1/5,000 (one to five thousands) scale digital topographic maps
6) One (1) set of 1/5,000 (one to five thousands) scale digital topographic data
7) One (1) set of technical specification

(2) Capacity development of counterpart personnel

4. Activities
(1) Review of Existing Conditions
Existing conditions relevant to the Project including organization structure, mapping system, facilities management and control points shall be reviewed.

(2) Map Production
1) Discussions on the specification
2) Control Point Survey
3) Aerial Photography
4) Aerial Triangulation
5) Field Verification
6) Plotting of Digital Topographic Data
7) Editing
8) Field Completion
9) Symbolization
10) GIS Structurization

(3) Publication of the digital topographic maps
In order to accelerate practical use of the digital topographic map, the digital topographic map shall be posted on website, and widely announced to the public.

(4) Technology Transfer
In order to facilitate technology transfer, part of the above-mentioned items (II-4 (2), (3)) including publication skills of the digital topographic maps shall be undertaken by the counterpart personnel under the technical supervision of the JICA missions.

(5) Dissemination of the Final Products
Recommendations for the wide and effective use of the digital topographic maps produced under the Project shall be prepared.

5. Input

(1) Input by JICA

For the implementation of the Project, JICA shall dispatch, at its own expense, the members of the JICA missions to Mali.

Input other than indicated above will be determined through mutual consultations between JICA and IGM during the implementation of the Project, as necessary.

(2) Input by IGM

IGM will take necessary measures to provide at its own expense:

(a)Services of IGM's counterpart personnel and administrative personnel as referred to in II-6;

(b)Suitable office space with necessary equipment;

(c)Supply or replacement of machinery, equipment, instruments, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than the equipment provided by JICA;

(d) Information as well as support in obtaining medical service;

(e) Credentials or identification cards;

(f) Available data (including maps, GIS data, photographs) and information related to the Project;

(g) Running expenses necessary for the implementation of the Project;

(h) Expenses necessary for transportation within Mali of the equipment as well as for the installation, operation and maintenance; and

(i) Necessary facilities to members of the JICA missions of the Project for the remittance as well as utilization of the funds introduced into Mali from Japan in connection with the implementation of the Project

6. Implementation Structure

The roles and assignments of relevant organizations are as follows:

(1) IGM

(a) Project Director

Director General of IGM will be responsible for overall administration and implementation of the Project

(b) Counterpart Personnel

Members of IGM will be counterpart personnel of the Project

(2) JICA

The members of the JICA missions will give necessary technical guidance, advice and recommendations to IGM on any matters pertaining to the implementation of the Project.

(3) Joint Coordinating Committee

Joint Coordinating Committee (hereinafter referred to as "JCC") will be established in order to facilitate inter-organizational coordination. JCC will be held whenever deems it necessary. Members of JCC shall be appointed prior to the commencement of the Project

7. Project Site(s) and Beneficiaries

The Project will cover the area shown in Annex 1. The direct beneficiaries of the Project will be people who inhabit the city of the Bamako and its surrounding and indirect beneficiaries of the Project will be around people living in Mali.

8. Duration
The Project will be carried out for approximately twenty (20) months as shown in Annex 2. The schedule is tentative and subject to change when both parties agreed upon any necessity that will arise during the course of the Project.

9. Reports
JICA will prepare and submit the following reports to IGM in English and French

(1) Inception Report
Twenty (20) copies (ten (10) copies in English and ten (10) copies in French) at the commencement of the first work period in Mali

(2) Interim Report
Twenty (20) copies (ten (10) copies in English and ten (10) copies in French) at the time about twelve (12) months after the first work period in Mali

(3) Draft Final Report
Twenty (20) copies (ten (10) copies in English and ten (10) copies in French) at the end of the last work period in Mali

(4) Final Report
Twenty (20) copies (ten (10) copies in English and ten (10) copies in French) within two (2) month after the receipt of the comments on the Draft Final Report

10. Environmental and Social Considerations
IGM agreed to abide by "JICA Guidelines for Environmental and Social Considerations" in order to ensure that appropriate considerations will be made for the environmental and social impacts of the Project.

III. UNDERTAKINGS OF IGM

1. IGM will take necessary measures to:

(1) ensure that the technologies and knowledge acquired by the Republic of Mali nationals as a result of Japanese technical cooperation contributes to the economic and social development of the Republic of Mali, and that the knowledge and experience acquired by the personnel of the Republic of Mali from technical training as well as the equipment provided by JICA will be utilized effectively in the implementation of the Project

(2) grant privileges, exemptions and benefits to members of the JICA missions referred to in II-5 (1) above and their families, which are no less favorable than those granted to experts and members of the missions and their families of third countries or international organizations performing similar missions in the Republic of Mali

(3) permit members of the JICA missions to enter, leave and sojourn in the Republic of Mali for the duration of their assignments therein and exempt them from foreign registration requirements and consular fees.

(4) exempt members of the JICA missions from taxes and any other charges on the equipment, machinery and other material necessary for the implementation of the Project;

(5) exempt members of the JICA missions from income tax and charges of any kind imposed on or in connection with any emoluments or allowances paid to them and/or remitted to them from abroad for their services in connection with the implementation of the Project; and

(6) meet taxes and any other charges on the equipment, machinery and other material, referred to in II-6 above, necessary for the implementation of the Project.

2. IGM will bear claims, if any arises, against members of the JICA missions resulting from, occurring in the course of, or otherwise connected with, the discharge of their duties in the implementation of the Project, except when such claims arise from gross negligence or willful misconduct on the part of members of the JICA missions.

IV. EVALUATION

JICA will conduct the following evaluations and surveys to mainly verify sustainability and impact of the Project and draw lessons. IGM is required to provide necessary support for them.

1. Ex-post evaluation 3 years after the project completion, in principle
2. Follow-up surveys on necessity basis

V. PROMOTION OF PUBLIC SUPPORT

For the purpose of promoting support for the Project, IGM will take appropriate measures to make the Project widely known to the people of Mali.

VI. MUTUAL CONSULTATION

JICA and IGM will consult each other whenever any major issues arise in the course of the Project implementation.

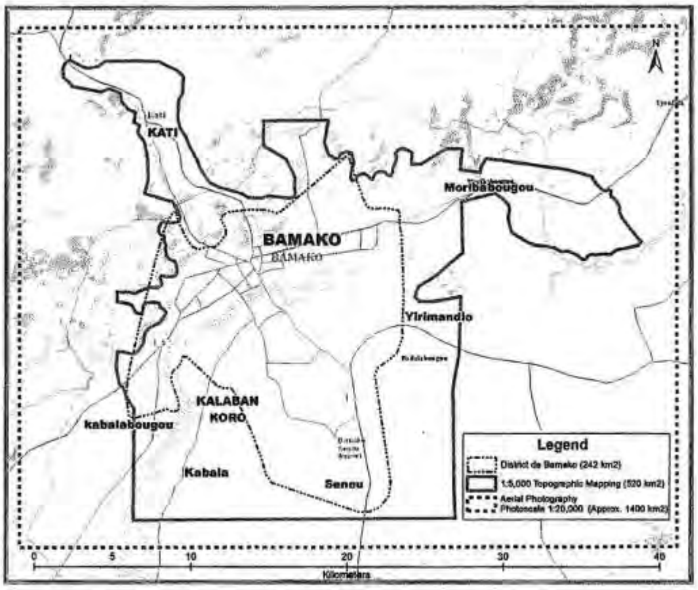
VII. AMENDMENTS

The Record of Discussions may be amended by the minutes of meetings between JICA and IGM.

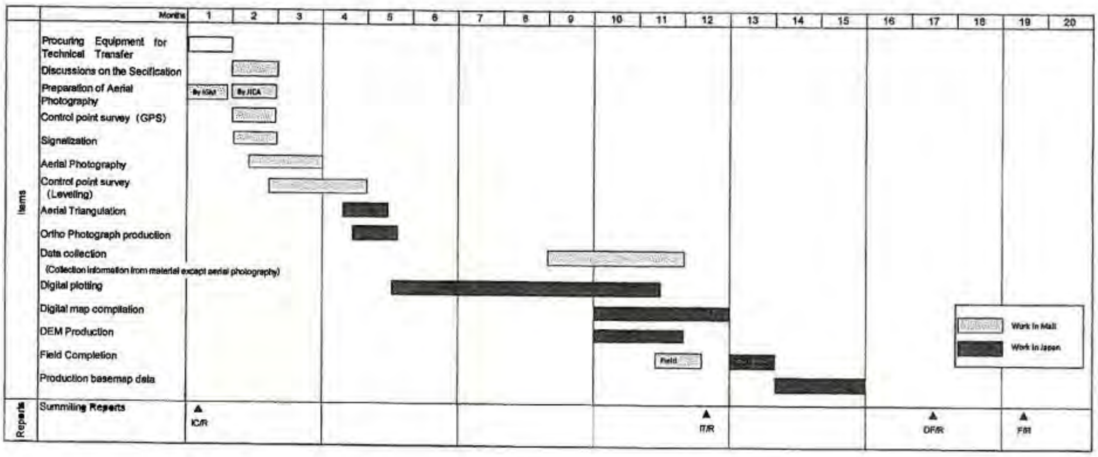
The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the Record of Discussions.

Annex 1: Project Area
Annex 2: Tentative Project Schedule
Annex 3: A List of Participants

Annex 1: Project Area



Annex 2: Tentative Project Schedule



Annex 3: A List of Participants

<Malian Side>

Mr. Ando Enko GUINDO	Director General
Mr. Aliou Adama COULIBALY	Deputy Director General
Mr. Modibo CAMARA	Technical Director
Mr. Oumar MAIGA	Financial and administrative Director
Mr. Brahima KATILE	General Survey, regulation and follow-up Director
Mr. Amadou DIALLO	Chief of topography section
Mr. Mahamadi S. TOURE	Chief of Aero-spatial survey section
Mr. Joseph OUKOGUEM	Aero-spatial survey section
Mr. Boubacar TRAORE	Chief of computer system section
Mr. Issiaka DEMBELE	Chief of cartography section

<Japanese Side>

Detailed Planning Study Team

Mr. Akihito Sanjo	Leader
Mr. Hidekatsu Saito	Precision Management
Mr. Sho Takano	Cooperation Planning
Mr. Takashi Shimono	Digital Topographic Mapping / GIS Planning
Mr. Yoshiteru Matsushita	Machinery Planning / Technical Transfer planning
Ms. Keiko Tsutsumi	Interpreter

JICA Senegal Office

Ms. Ayumi Takagi	Representative

Appendix 2

MAIN POINTS DISCUSSED

1. Project Area

IGM requested the digital topographic maps at the scale of 1:5,000 (one to five thousands) by the Project which cover approximately 439 square kilometers including the city of Bamako and its surrounding. In this survey, JICA confirmed that the developing area is expanding outside the requested area. Therefore, JICA proposed the digital topographic maps which cover approximately 520 square kilometers as shown in Annex 1, and this proposal was accepted by IGM.
JICA also confirmed that there is further potential development outside this Project's digital topographic maps area. IGM mentioned that they will develop the digital topographic maps by themselves outside this Project's digital topographic maps area based on the further development potential after technology transfer of the Project.

Both sides also confirmed that the area for the aerial photograph is approximately 1400 square kilometers in the city of Bamako and its surrounding as shown in Annex 1.

2. Import of Equipment

Both sides agreed that IGM shall act as consignee of the equipment, and shall carry out all the necessary procedure, such as duty-free clearance, etc., and if duty is not exempted, IGM shall pay all the necessary expenses for import procedure of the equipment.
Both sides also agreed that the equipment thus imported shall be used exclusively for the implementation of the Project under the supervision of the JICA mission.

3. Publicity of the Final Report and Products

JICA requested IGM that the final report and products to be prepared by the Project shall be released to the public immediately after completion. JICA requested IGM that all products, which will be produced in the course of the Project, shall be shared to projects of other donors. IGM understood the request and agreed to take full responsibility for necessary procedure.

4. Copyright

Both sides agreed the followings about the copyright on Digital Topographic Map Data and Ortho-photo Data (hereinafter referred to as "the Product").

4-1 The Product produced in the Project belongs to both IGM and JICA.
4-2 IGM and JICA keep the master-copy of "the Product" in each.
4-3 JICA agreed to allow IGM to modify, update or convert "the Product". Copyright on updated, modified or converted "the Product" belongs to only IGM.
4-4 JICA agreed to allow IGM to sell "the Product" for appropriate price.
4-5 IGM agreed to allow JICA to provide "the Product" to person or organization in

Japan who agreed below condition.

1) Not use the Product in any profitable purpose
2) Not transfer the Product to any other people or organization
3) Only use for the purpose in applied to JICA

5. Geodesic Reference System

JICA confirmed that IGM uses local geodesic reference system at present, and proposed that the Project will make use of "world geodesic reference system" from the point of utilization among related organizations. Then, IGM agreed that they will adopt this system.

6. GIS Database Center

In order to manage base-map totally and enhance utilization among related governmental agencies and private sector, IGM revealed the idea of establishment of GIS database center.
JICA had positive concern about the idea, and recommended Malian side to establish the center with the initiative of IGM as soon as possible.

7. Project Schedule and Aerial Photography

In order to implement the Project as shown in Annex 2 "tentative project schedule", it is desirable to complete aerial photography during the dry season, from November to May. If the work of aerial photography were forceful to carry out during the rainy season, JICA mission and IGM would discuss and find optimum measures for the smooth and quick implementation.

2. Kick-off seminar report

Rapport de la cérémonie de lancement

(1) Date et lieu de tenue du séminaire
Date : Le vendredi 6 mars 2015, de 9 h 00 à 11 h 00
Lieu : Azalaï Grand Hotel

(2) Programme
Allocutions de la cérémonie de lancement (Monsieur Ando Guindo, Directeur de l'IGM)
Discours de l'Ambassadeur du Japon au Mali (Son Excellence Monsieur Akira Matsubara, Ambassadeur extraordinaire et plénipotentiaire)
Discours du Ministre de l'Equipement, des Transports et du Désenclavement (Monsieur Mamadou Hachim Koumaré)
Présentation générale du Projet (Monsieur Shunsuke Tomimura, mission d'étude JICA)
Questions-Réponses
Prise de photographies

(3) Contenu du séminaire
1) Allocutions de la cérémonie de lancement (M. Ando Guindo, Directeur de l'IGM)

Il a expliqué les projets de cartes topographiques antérieures de la JICA et commenté sur les attentes concernant le présent projet.

Voici un abrégé de ses propos.

Dans le cadre de l'aide financière de la JICA, une étude sur la carte de base de la République du Mali dans la zone de Kita a été menée en 1998, et la création d'une carte à l'échelle de 1 :50.000 dans la zone de Kita et Bafing-Makana ainsi que le transfert de technologie ont été réalisés.

Le présent projet prévoit, en plus de la réalisation d'orthophotocartes couvrant une superficie environ 1.400 km^2, incluant Bamako et Kati, et de cartes topographiques couvrant une superficie environ 520 km^2, le transfert de technologie à l'IGM, dans le but de renforcer ses capacités de création des cartes topographiques numériques.

On attend beaucoup des cartes topographiques créées dans ce projet qui permettront de développer nos plans d'urbanisme, d'aménagement des routes et d'autres domaines.

2) Discours de l'Ambassadeur du Japon au Mali (Son Excellence Monsieur Akira Matsubara, Ambassadeur extraordinaire et plénipotentiaire)

L'Ambassadeur a adressé ses remerciements à l'IGM pour sa collaboration jusqu'ici et exprimé ses attentes concernant le présent projet.

Voici un abrégé du contenu de son discours.

Le projet de cartes topographiques numériques de la zone métropolitaine de Bamako a commencé en 2012, mais a été soudain interrompu par un coup d'Etat. Je remercie d'IGM de la coordination qu'il a assurée entre le Mali et le Japon pendant cette période.

Les cartes qui seront créées dans ce projet sont nécessaires dans des secteurs tels que l'urbanisme, la gestion de l'eau, l'environnement et d'autres ; outre la réalisation des cartes, ce projet prévoit un transfert de technologie à l'IGM, qui permettra une amélioration de ses capacités techniques. De plus, la diffusion des données SIG produites via l'Internet est également prévue.

Les cartes topographiques créées dans ce projet devraient contribuer à l'amélioration des conditions de vie des populations maliennes et de leur cadre de vie et de travail.

3) Discours du Ministre de l'Equipement, des Transports et du Désenclavement (M. Mamadou Hachim Koumaré)

Il a donné des explications sur les projets de cartes topographiques exécutés antérieurement par la JICA et un aperçu détaillé du présent projet et des attentes à son égard. Ses propos peuvent se résumer comme suit.

Les cartes créées dans ce projet sont essentielles pour le développement des infrastructures économiques et sociales, en particulier efficaces pour la définition des limites administratives, les mesures de lutte contre les sinistres, le cadastre et l'environnement. Les données spatiales seront de plus en plus utilisées dans des domaines tels que le cadastre, l'agriculture et l'urbanisme.

Actuellement, le gouvernement malien est en train de signer à Alger un «accord de paix et de réconciliation» avec une partie des groupes armés du nord du pays, si le conflit s'achève par la signature d'un accord, les cartes produites dans ce projet auront une importance encore plus grande.

Dans le cadre de l'étude sur la carte de base de la République du Mali dans la zone de Kita menée par la JICA en 1998, outre la réalisation des 48 feuilles de carte, un transfert de technologie et la fourniture de véhicules et de matériels informatiques ont eu lieu. Et des cadres de l'IGM ont suivi une formation au Japon. Dans le présent projet également, un transfert de technologie aura lieu à l'égard de l'IGM parallèlement à la création des cartes topographiques, ce qui permettra au Mali de poursuivre ses progrès techniques grâce à la coopération japonaise.

Le Ministère de l'Equipement, des Transports et du Désenclavement soutient de toutes ses forces la concrétisation de ce projet.

4) Présentation générale du Projet (M. Shunsuke Tomimura, chef de la mission d'étude JICA)

M. Shunsuke Tomimura, chef de la mission JICA du Projet de cartes topographiques numériques pour la zone métropolitaine de Bamako, a donné des explications centrées sur les points suivants en vue de la réalisation du Projet.

Arrière-plan du Projet
Objectifs et arrière-plan du Projet
Procédure des différents travaux
Programme des différents travaux
Rubriques du transfert de technologie

5) Questions-Réponses

Q : L'équipe japonaise pour la réalisation du projet a été présentée, mais le rôle de la partie malienne n'est pas clair.

R (Directeur de l'IGM) : Comme l'a déjà indiqué Monsieur le Ministre, ce projet sera réalisé non pas seulement par la partie japonaise, mais en collaboration par les parties japonaise et malienne.

R (Mission d'étude JICA) : Le projet de coopération technique du Japon est un projet qui a pour mécanisme l'exécution conjointe du projet par des experts japonais et les homologues maliens, et les apports de la partie malienne, qui ne sont pas visibles dans le contenu expliqué tout à l'heure, sont plutôt considérables.

Q : Le nivellement, l'observation GPS et la prise de photographies aériennes auront lieu, mais comment des données 3D sont-elles créées à partir de ces données ?

R (Directeur de l'IGM) : Le nivellement permet d'obtenir les hauteurs et l'observation GPS les coordonnées. Et des données 3D sont créées en combinant ces données et les données des photographies aériennes.

R (Mission d'étude JICA) : Il me semble assez difficile d'expliquer ces choses jusqu'à ce que la compréhension totale soit obtenue. Des équipements pour le transfert de technologie permettant de créer des données 3D seront fournis en janvier 2016. Nous voulons donc vous proposer de prendre contact avec l'IGM à ce moment-là pour une visite d'observation de ce travail.

Q (Mohamed Ali, Direction Nationale du Patrimoine Culturel) : Les cartes topographiques créées dans ce projet seront-elles aussi utilisables pour l'exploitation minière, l'archéologie, etc. ?
R (Directeur de l'IGM) : Les cartes topographiques sont utilisables dans des domaines très variés, et bien sûr pour l'exploitation minière et l'archéologie.

R (Mission d'étude JICA) : Merci de votre avis précieux. L'objectif véritable de ce projet n'est pas seulement de créer une carte topographique, c'est un projet qui exploite la création d'une carte topographique comme moyen. Nous pensons que la carte topographique sera utile pour la planification urbaine qui contribuera à l'amélioration des conditions de vie des habitants de Bamako et de ses environs, et à des activités diverses dans d'autres domaines, ce qui la rend significative. La promotion de l'utilisation étant aussi un des thèmes de ce projet, nous espérons pouvoir compter sur votre aide lors des enquêtes verbales que nous allons faire pour étudier les conditions d'utilisation réelles des cartes.

Scènes du séminaire 1

Cérémonie de lancement

Discours de Son Excellence Monsieur Akira Matsubara, Ambassadeur extraordinaire et plénipotentiaire du Japon

Scènes de la présentation

Question-Réponses

Photo de groupe avec les participants

1. Remettre 1

Projet de Cartes Topographiques Numériques
pour la Zone Métropolitaine de Bamako en République du Mali
Cérémonie de lancement du projet – 6 Mars 2015

Programme de la cérémonie de lancement

8.30 – 9.00	Mise en place
9.00 – 9.10	Mot du Directeur Général de l'Institut Géographique du Mali
	M. Ando GUINDO
9.10 – 9.20	Allocution de son Excellence Monsieur l'Ambassadeur du Japon au Mali
	M. Akira MATSUBARA
9.20 – 9.30	Discours de lancement de Monsieur le Ministre de l'Équipement, des Transports et du Désenclavement
	M. Mamadou Hachim KOUMARE
9.30 – 9.50	Pause café
9.50 – 10.30	Introduction et présentation du projet par le chef d'équipe de l'Agence Ja ponaise de Coopération Internationale
	M. Shunsuke TOMIMURA
10:30 – 10.45	Photos officielles
	Fin de cérémonie

1. Participants list

Projet de cartes topographiques numériques pour la zone métropolitaine de Bamako

Séminaire de lancement du projet – 6 Mars 2015

Fiche de présences

NOM Prénom	Structure	Email	Téléphone
Oumar A Maiga	IGM		
Harouna Guindo	IGM		
Lassine Camara	IGM		
Mme Toure Jeane	IGM		
Modibo Camara	IGM		
Hawa Sow	IGM		
Salif Demdele	IGM		
Hawachluti	IGM		
Brahima Owologem	JICA		
Brahima Diegeni	IGM		
Ando Guindo	IGM		
Ousmane Daou	Journaliste		
Hamadou B Sanogho			
Abdoulaye M Seck			
Mamoutou Traore	DNTTMF		
Mohamed Alamizialy	Inerprete		
Siriki	IGM		
Aliou Adama Coulibaly	IGM		
Traore Boubacar	IGM		
Harouna Soumana	Chef du service de		

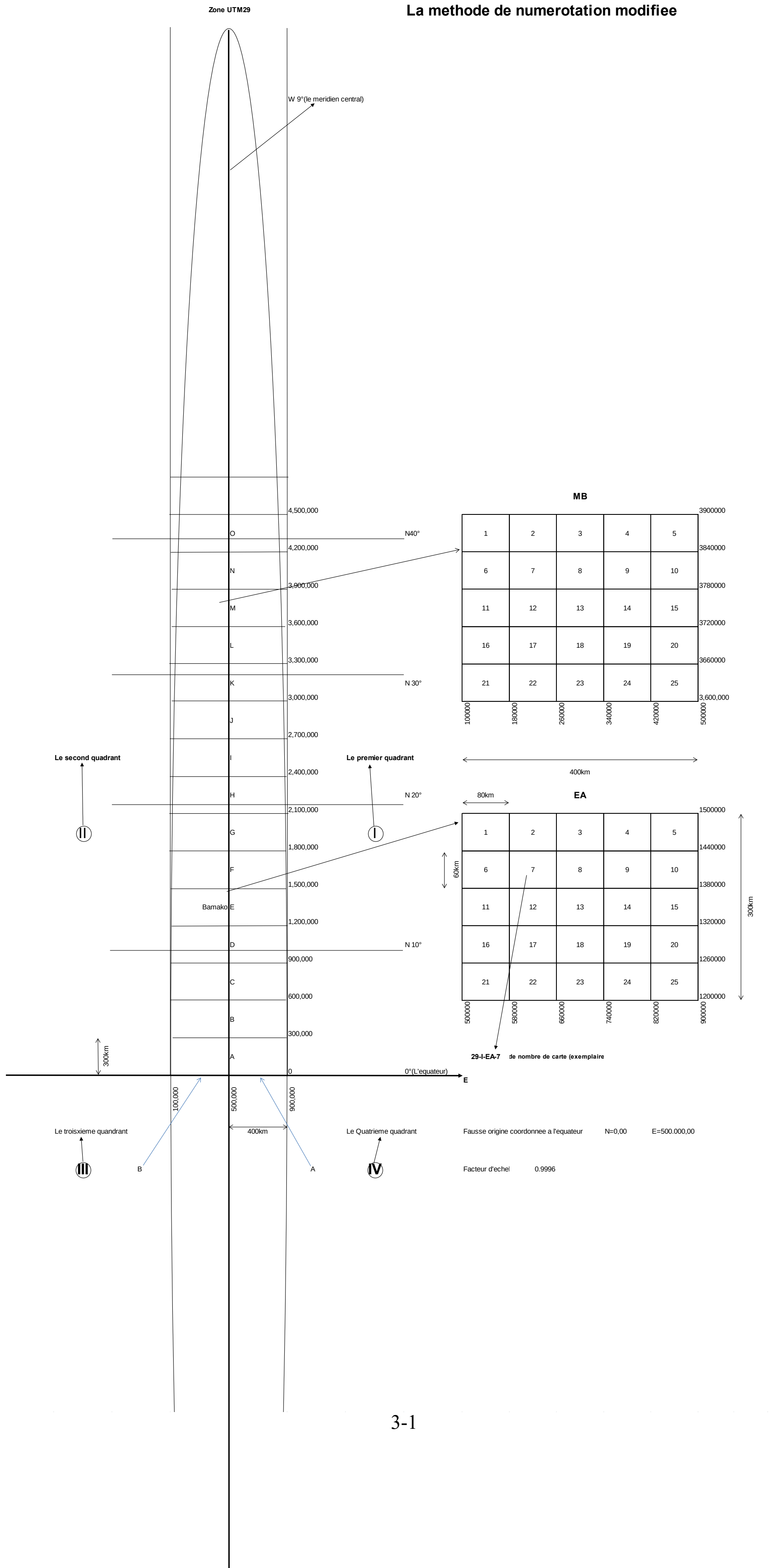
	reglementation		
Mohamed Lamine Toure	Archive IGM		
Mahamadi S Toure	IGM		
Omou Taore	IGM		
Coulibaly Adama A	DNDC		
Zhao Ahmed A Bouba	CM/CCOM/MED		
Sangho Ibrahima Papa	DNISH (representant)		
Diallo Salif	ANAG		
Boubacar Diakite	PNR		
Mamadou L Ouatara	M.Affaires etrangeres		
Ould Aly Mohamed	DNCP		
Toure Mahamane			
Dembele Bouba	Autorite Routiere		
Keita Abdoulaye	IGM (kkoro)		
Berete Habib	AMAP		
Adama Coulibaly	ORTM		
Abdoulaye diawa			
Dao Harouna	CMTK		
Sow Boubacar	AGETIPE		
Kassambara Ousmane	DGI		
Fane Siriman	DNI		
Lougaya Almaouloud	L'ESSOR		
Maiga Bintou Aliou	ANAZER		
Konate Karounga	ORTM		
Amadou Male			

Maiga Djibrilla	MALI METEO		
Sekou Camara			
Mamadou Sidiki Konate	ANAZER		
Cheickna Dembele			
Cheick Oimar Diallo	CNREX BPT		
Bourama Coulibaly	Ambassade du Japon		
Akira Natsubara	Ambassade du Japon		
Idrissa Kante	Gendarmerie		
Abdou Yehia	DNPD		
Konate Lassine	Kabako		
Moahamed O Cisse	DNH		
Seydou Sidibe	DNDS		
Traore Kalilou	Cellule Sida /METD		
Ousmane Sgore	DNACPN		
Vinima Traore	INSTAT		
Sanogo Mamoutou	AEDD		
Modibo Siriman Keita	AGE ROUTE		
Oumar Alassane Maiga	DNE		

3. UTM System Ver.1.0 -1

Ref. JICA-IGM Numbering system 20150319

La methode de numerotation modifiee



3

UTM System -2

Rapport sur la compatibilité concernant Bamako project figure and explanation of UTM_EN_20150319.xls
Exécuté le 19/03/2015

Les fonctionnalités suivantes de ce classeur ne sont pas prises en charge dans les versions antérieures d'Excel. Celles-ci risquent d'être perdues ou dégradées si vous enregistrez le classeur dans un format de fichier antérieur.

Perte mineure de fidélité	Nb d'occurrences
Certaines cellules ou certains styles de ce classeur contiennent une mise en forme qui n'est pas prise en charge par le format de fichier sélectionné. Ces formats seront convertis au format le plus proche disponible.	3

4. Marginal information 1 :5000 Ver.2.3

Projet de Cartes Topographiques Numériques pour la zone Métropolitaine de Bamako

Spécifications Cartographiques de Base

Renseignements Marginaux

1:5.000

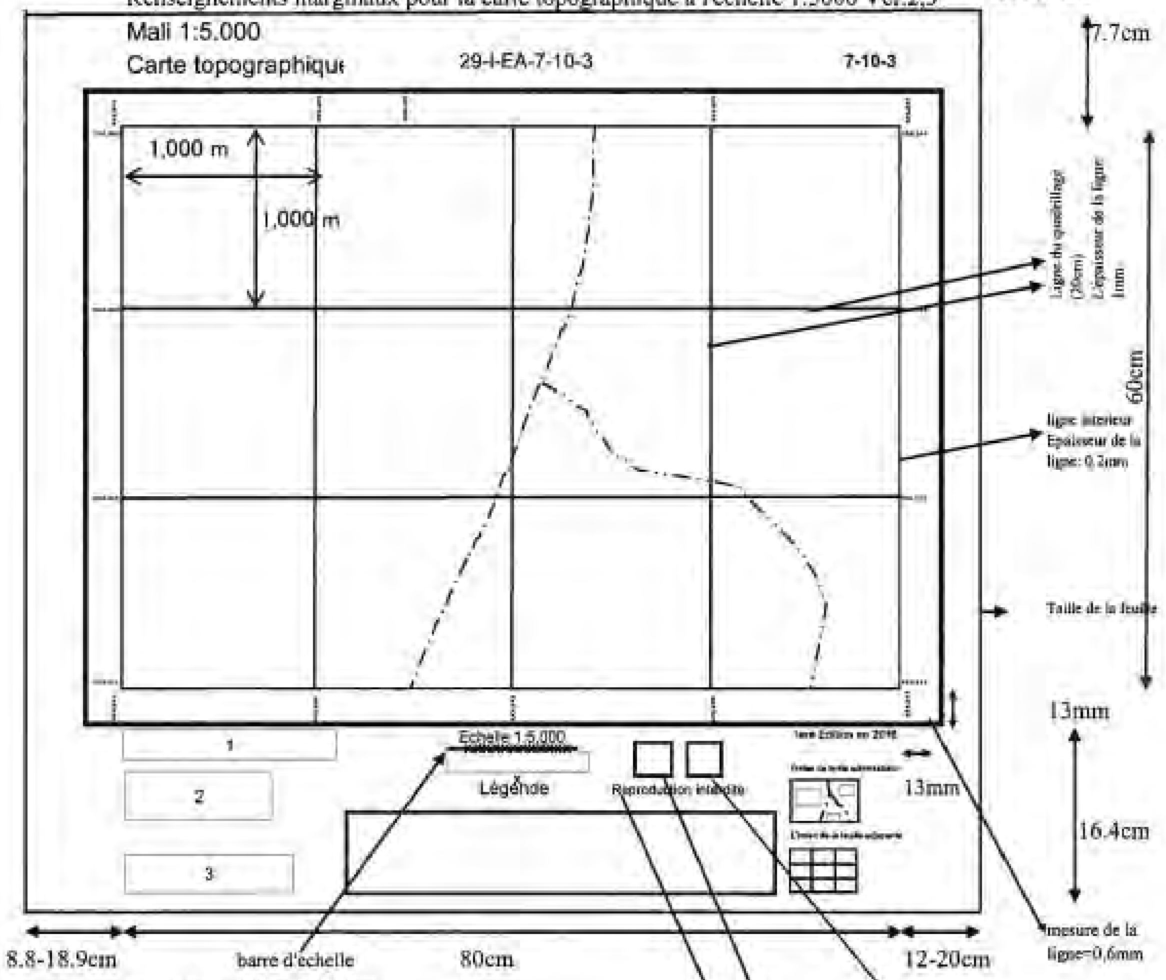
Ver. 2,3

le 03/06/2016

03/June/2016

20/06/2016
2016/6/3

Renseignements marginaux pour la carte topographique à l'echelle 1:5000 Ver.2,3



Taille de la feuille: 84.1cm*118.9cm

Ligne interieur: 60cm*80cm (3kmx4km)

Ligne de quadrillage chaque 20cm (l'equivalent a 1,000m sur le terrain)

De l'index a la feuille (exemple)

logo JCA

logo IGM

L'index de la feuille adjacente

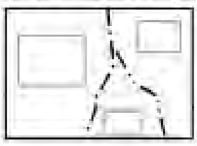
7-19-2	7-10-1	7-10-2
7-19-4	7-10-3	7-10-4
7-29-2	7-20-1	7-20-2

1,5cm

6cm

Reproduction interdite

l'index de limite administrative



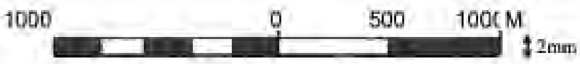
La police du texte est Arial et Gothic

Taille de police Font est approprieté.

L'espace standard es adopté pour les polices

La valeur des coordonnés (m)

Barre d'echelle



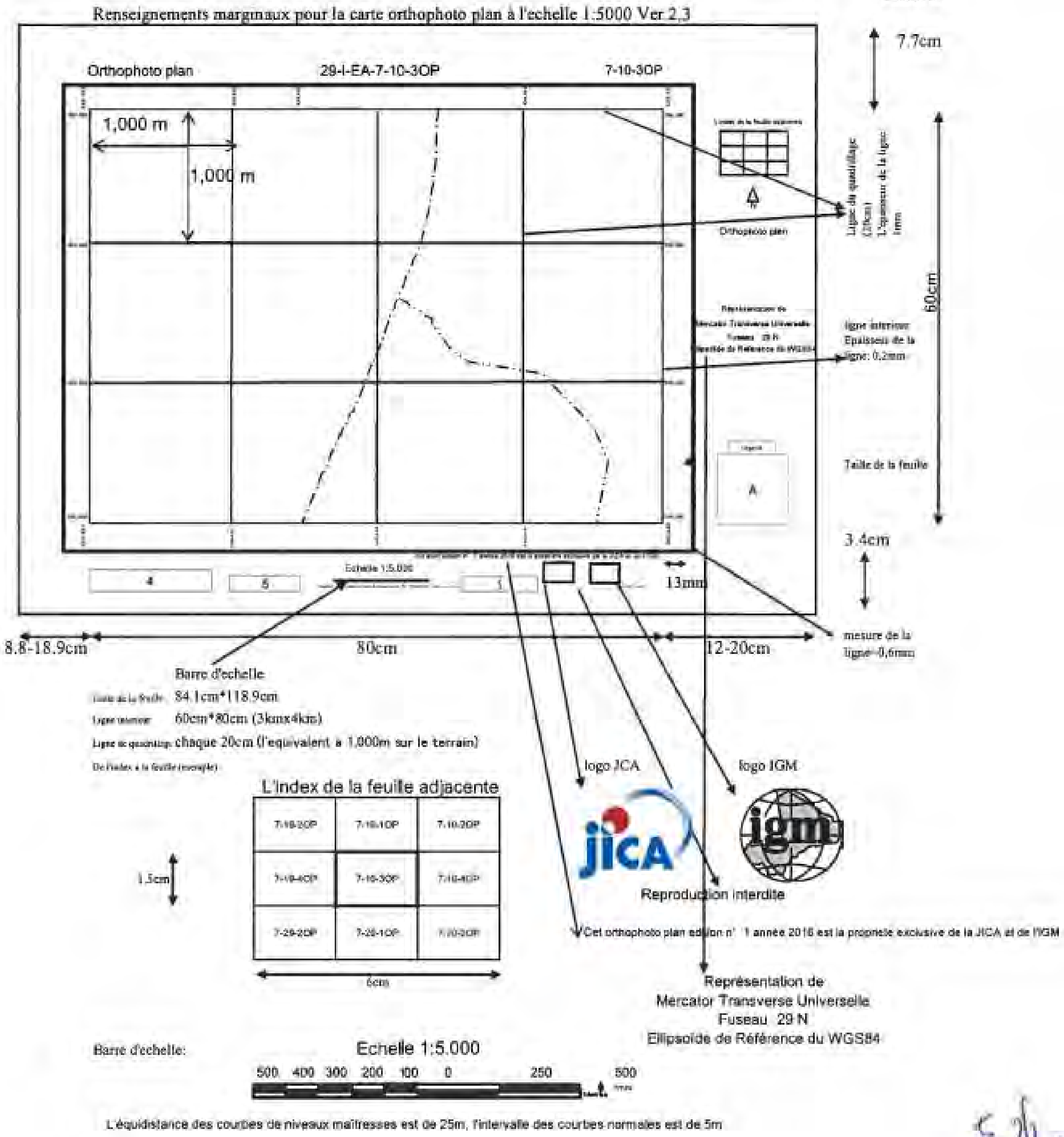
L'équidistance des courbes de niveaux maitresses est de 25m, l'intervalle des courbes normales est de 5m

2

2016/6/3

2/06/2016

Renseignements marginaux pour la carte orthophoto plan à l'echelle 1:5000 Ver 2,3



Ver.2,3

JICA Logo

IGM Logo

Reproduction interdite

Reproduction interdite

A Légende

Légende

+ + + + + + + +	Limite nationale
—·—·—	Limite de région ou district
—··—··—	Limite de cercle
—·—·—	Limite de commune
—·—·—	Limite de quartier
	Courbes de niveau maîtresse
	Courbes de niveau normale
	Courbes de dépression (maîtresse)
	Courbes de dépression (normale)

Carte topographique de base Ver.2,3

1 Cette carte a été préparée par l'Agence Japonaise de Coopération Internationale (JICA) et l'Institut Géographique du Mali (IGM) dans le cadre du programme cooperation technique du gouvernement Japonais et le gouvernement de la république de Mali.

2 Prise de vue aérienne: Mars 2015
Levé des points de contrôle sur le terrain: Mars 2015
Aérotriangulation: Juin 2015
Restitution numérique: Juillet 2015 - Octobre 2015
Identification sur le terrain: Novembre 2015 - Mars 2016
Complètement sur le terrain: Avril 2016 - Juin 2016
Ellipisoide de Référence: WGS84
Projection: UTM zone 29 N

3 REMARQUE
Toutes les caractéristiques de données et informations ont été extraites des sources les plus disponibles et fiables
Cette carte a été élaborée comme carte topographique de base à travers l'interpretation des photographies aériennes en utilisant la methode photogrametrique. L'echelle approximative des photos est de 1:20000 avec les donnees
Les limites administratives sur les cartes ne sont pas encore confirmées officiellement sur le terrain.
Les utilisateurs doivent faire attention aux remarques mentionnées ci-dessus, lorsqu'ils utilisent les données de cette

Orthophoto Plan

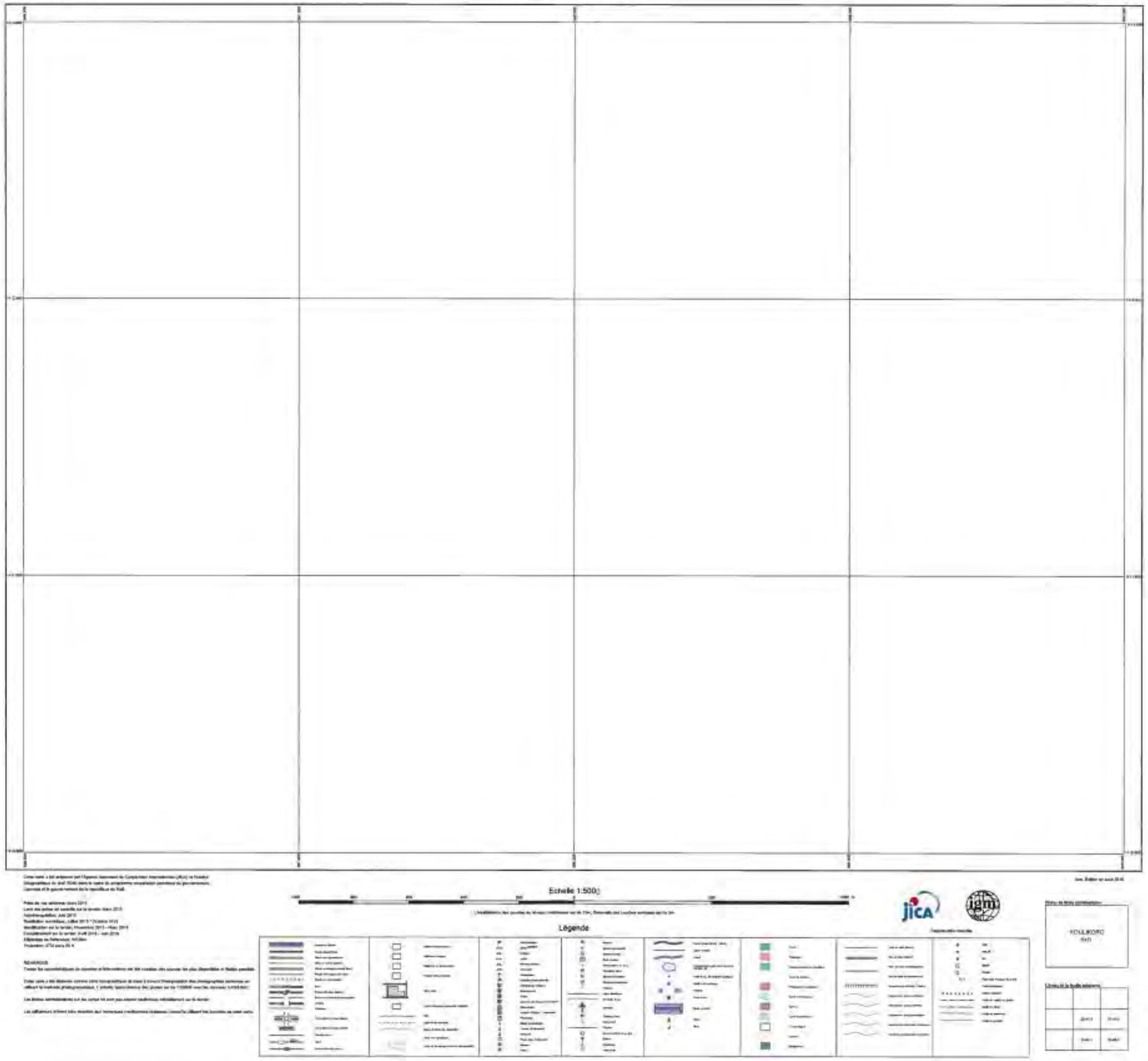
4 REMARQUE
Toutes les caractéristiques de données et informations ont été extraites des sources les plus disponibles et fiables
Cette carte a été élaborée comme orthophoto plan à travers l'interpretation des photographies aériennes en utilisant la methode photogrametrique. L'echelle approximative des photos est de 1:20000 avec les donnees GNSS/IMU.
Les limites administratives sur les cartes ne sont pas encore confirmées officiellement sur le terrain.
Les utilisateurs doivent faire attention aux remarques mentionnées ci-dessus, lorsqu'ils utilisent les données de cette

5 Prise de vue aérienne: Mars 2015
Levé des points de contrôle sur le terrain: Mars 2015
Aérotriangulation: Juin 2015
Restitution numérique: Juillet 2015 - Octobre 2015

Mali 1:5000

Carte topographique

29-I-EA-22-42-3



03/06/2016

3/June/2016

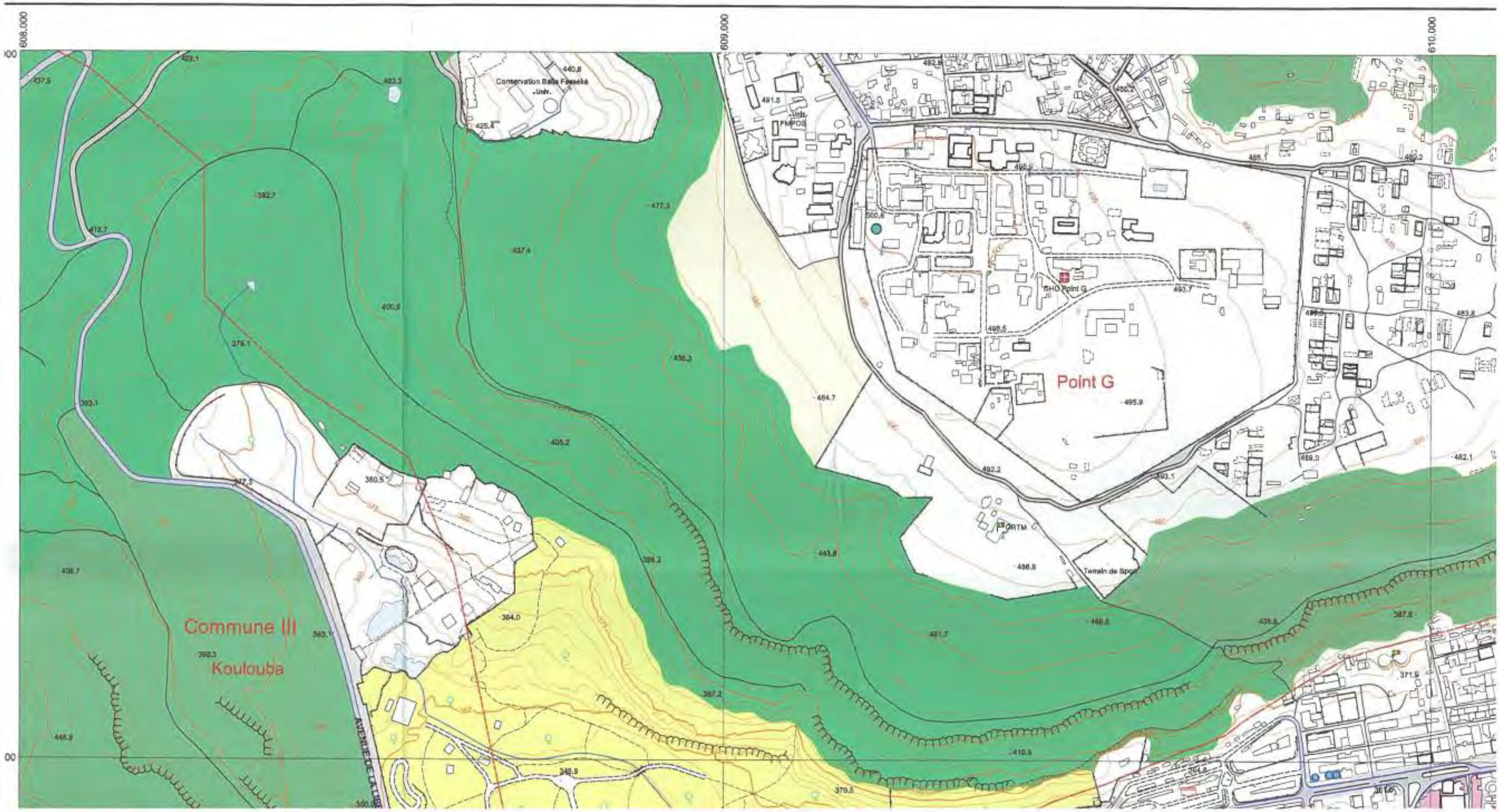
le 11/06/2016

2016年6月11日

Mali 1:5000

Carte topographique

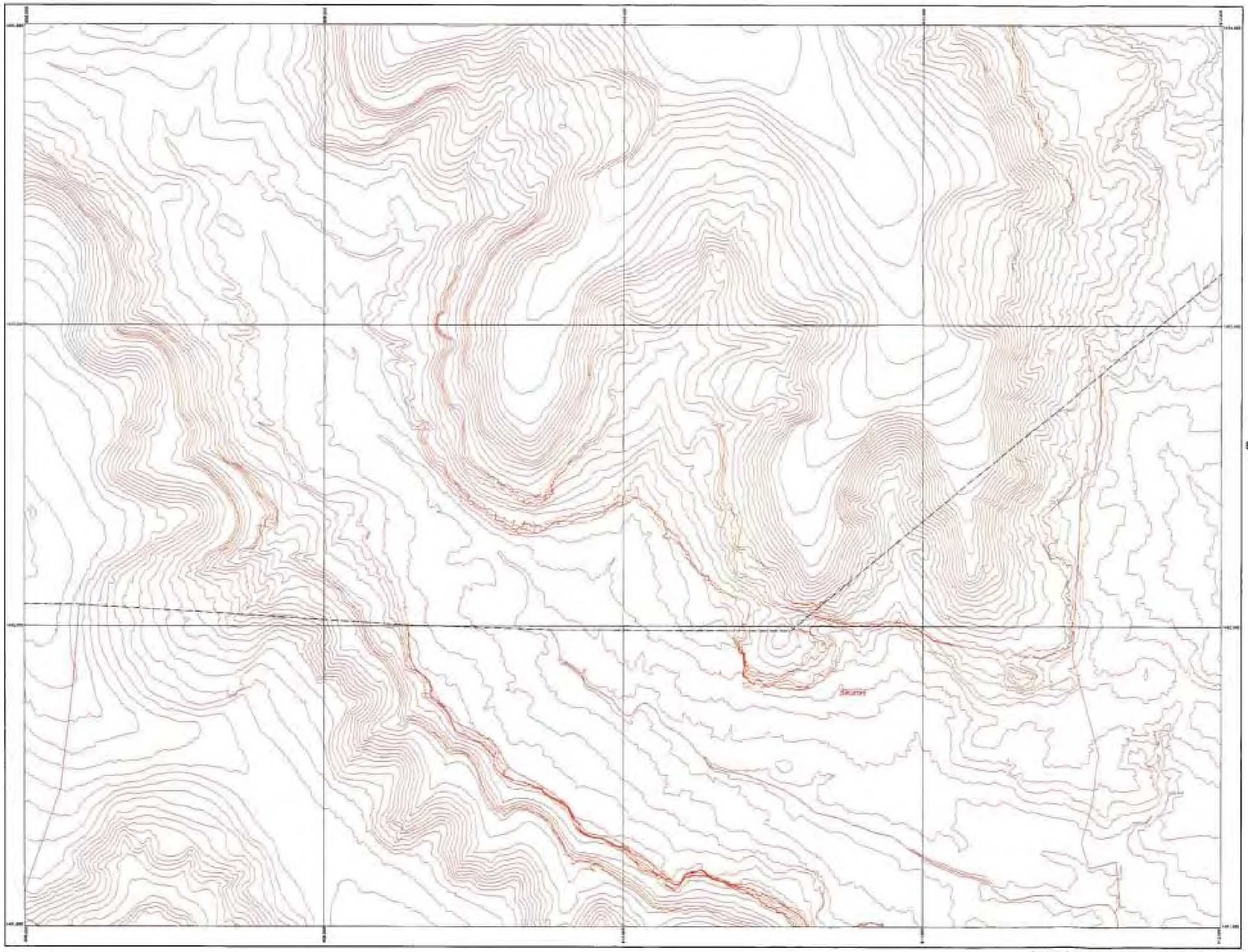
29-I-EA-32-



Mali 1:5000
Orthophoto plan

29-I-EA-32-13-2OP

32-13-2OP



L'index de la feuille adjacente

N

Orthophoto plan

Représentation de
Mercator Transverse Universelle
Fuseau 29 N
Ellipsoïde de Référence du WGS84

Légende

Echelle 1:5000

03/06/2016

3/June/2016