DEPARTMENT OF REAL ESTATE (DRE)
DEPARTMENT OF SPATIAL PLANNING (DSP)

THE STUDY
FOR
ESTABLISHMENT OF GEOGRAPHIC INFORMATION
FOR
IMPLEMENTATION OF NATIONAL PHYSICAL PLAN
IN
THE REPUBLIC OF MONTENEGRO

Final Report

(Main)

March 2009

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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PREFACE

In response to a request from the Government of Montenegro, the Government of Japan decided to conduct a study on The Study for Establishment of Geographic Information for Implementation of National Physical Plan in the Republic of Montenegro and entrusted to the study to the Japan International Cooperation Agency(JICA).

JICA selected and dispatched a study team headed by Mr.Kazuo FURUKATA of Kokusai Kogyo Co., Ltd. between February, 2007 and March, 2009.

The team held discussions with the officials concerned of the Government of the Republic of Montenegro, and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

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

March 2009

Eiji HASHIMOTO,
Deputy Vice President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Eiji Hashimoto
Deputy Vice President
Japan International Cooperation Agency

We are pleased to submit to you the report on the Study for Establishment of Geographic Information for Implementation of National Physical Plan in the Republic of Montenegro.

This study was conducted for a little more than 2 years from February 2007 to March 2009 and this report brings together the results of the work carried out during the study to construct a spatial data infrastructure in Montenegro which is composed of 1:25,000 scale digital topographic maps and GIS databases, along with the details of technology transfer also carried out during the process.

Under the study, a spatial data infrastructure was constructed for 70% of the national land area of Montenegro, receiving cooperation from the two counterpart organizations of the Government of Montenegro: the Department of Real Estate of the Ministry of Finance, and the Department of Spatial Planning of the Ministry for Economic Development.

For the remaining 30% of the national land area, the Department of Real Estate is to construct data to complete the spatial data infrastructure with its own technological capabilities. In the process of this study, technologies were transferred to the Department of Real Estate, which are indispensable for the department to establish a stable technological base and to enhance independent development.

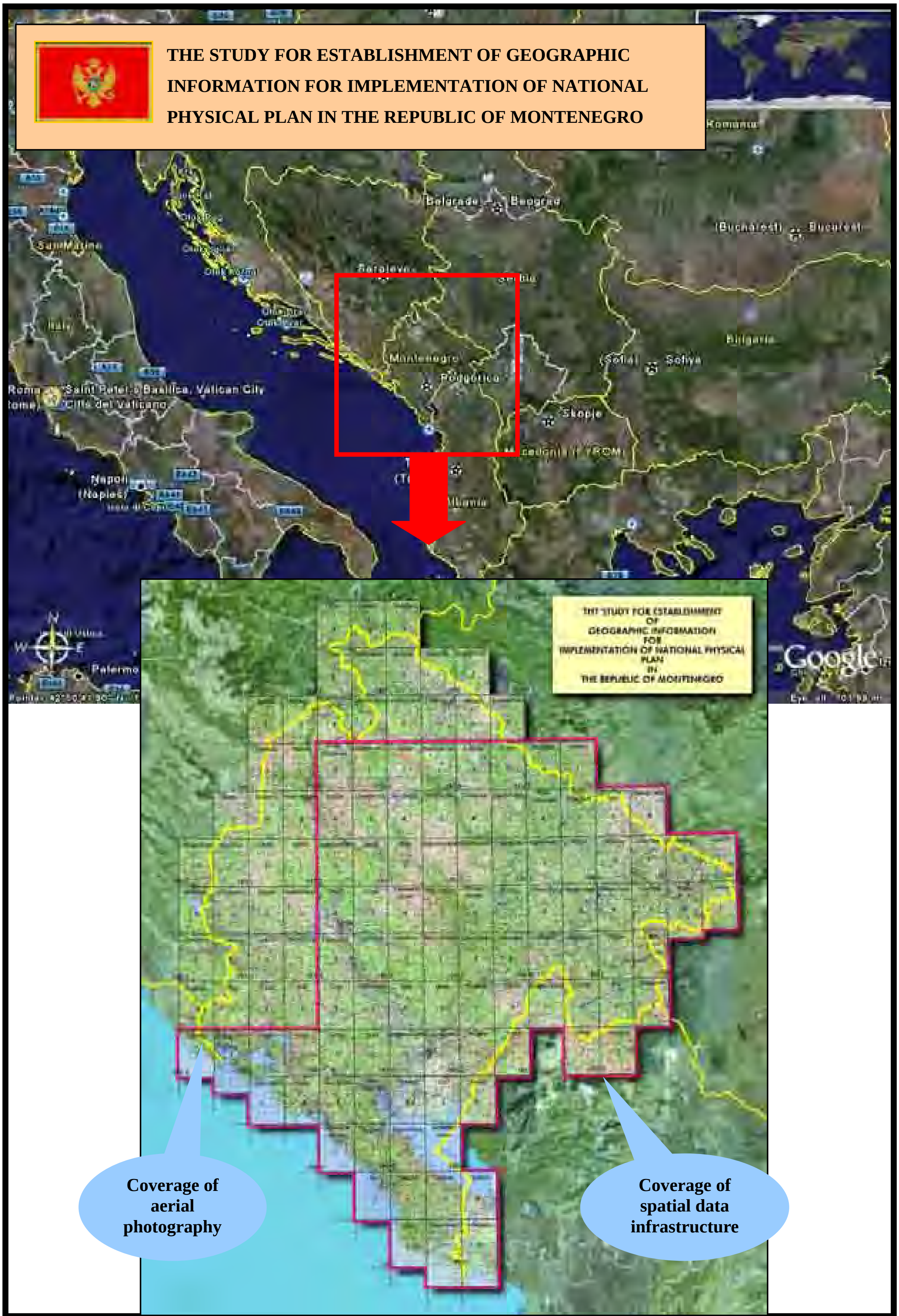
Meanwhile, also during this study, technologies related to the utilization and exploitation of GIS were transferred to the Department of Spatial Planning which is responsible for developing plans for the Government of Montenegro and has a role to play as the representative of users in need of the spatial data infrastructure. Apart from this report, an instruction manual for each technology transferred to these two departments was produced in order to clarify the details of technology transfer.

Montenegro is a country which gained independence only recently and is heading for EU membership. While the country is rapidly advancing social infrastructure construction and economic development, I sincerely hope that the data and technologies constructed or transferred during this study will be exploited effectively by the concerned organizations and utilized as the base for the country's sustainable development. At the same time, I hope that the friendly relations between Japan and Montenegro will be strengthened taking advantage of this study, the first technical cooperation project between the two countries.

Finally, let me express my sincere appreciation to the Japan International Cooperation Agency and other concerned organizations, officials of concerned organizations of the Government of Montenegro and donor organizations for their close cooperation extended to the team.

March 2009

Kazuo Furukata
Team Leader
The Study for Establishment of Geographic
Information for Implementation of National
Physical Plan in the Republic of Montenegro



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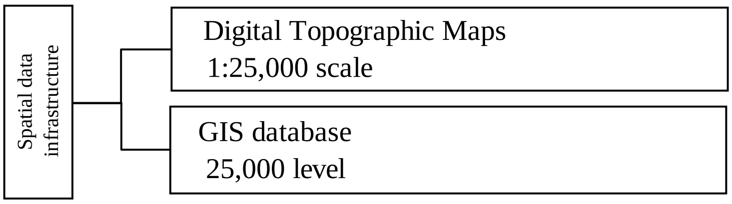
Chapter1 Outline of the Study

1.1 Aims of the Study

The targets of this study are the following three items, as well as a focus on the subordinate goals after completion of the study, in close collaboration not only with the counterpart organizations, the Department of Real Estate (hereinafter DRE) and Department of Spatial Planning (hereinafter DSP), but also with other government agencies and donors.

1.1.1 Development of spatial data infrastructure

The aims are to make digital topographic maps on a scale of 1:25,000 for about 70% (approx. 10,000 km^2) of the entire country and to develop a GIS database, and also to transfer the technologies for the creation of spatial data infrastructure in the course of the above-mentioned work.



1.1.2 Technology transfer

(1) Making of spatial data infrastructure

The technology for creating digital topographic maps and GIS database with a focus on independent development will be established in DRE.

(2) GIS Application

Technology for the application of GIS will be transferred to DRE and DSP by selecting effective and appropriate thematic geographical information with particular emphasis on the operations of DSP, where GIS is to be mainly used, in order to promote the dissemination of effective spatial data infrastructure to them and other relevant organizations.

1.1.3 Subordinate goals of the Study

Subordinate goals are those to be pursued after the aims of this study have been achieved. Namely, although these goals may seem difficult to attain through this study, they indicate the future direction in which the achievements and technologies gained through this study will be put to use. The details are given below, and attention must be given to realize technology transfer in order to approach the above mentioned goals as closely as possible.

(1) Goals utilizing the proposed plans

- Latest information of spatial data infrastructure will be created for the area covered by this study, and topographic maps will be updated more accurately than in the past.
- The spatial data infrastructure will be used as the basic data for the implementation of the national land development plan.

(2) Goals to be achieved through utilization

- Development of the spatial data infrastructure will popularize the use of new geographic information, including GIS in Montenegro.
- Technology transferred through this study will allow the DRE of Montenegro to create the remaining portion (about 30%) of the spatial data infrastructure and update all of the topographic maps unaided.
- Utilization of spatial data infrastructure for the implementation of the national land development plan will ensure the efficient implementation of planned projects for urban development, tourism development, environmental conservation, and so forth.

1.2 Details of the Study

1.2.1 Works items

The work items to be implemented in this study are classified into the establishment of spatial data infrastructure, related technical transfer, and dissemination of geographical information (GIS). Table-1 shows the work items in each category.

Table 1：Work items of the study

Development of Spatial Data Infrastructure		Technology Transfer and evaluation		Dissemination of geographical information (GIS)	
No.	Work item	No.	Tecnology transfer item	No.	Dissemination item
3.1	Establishment of specification in conformity with global standard	4.1	Setting of pricking points and measurement of eccentric elements	5.1	Dissemination of spatial data infrastructure
3.2	Photo control point survey	4.2	Photo interpretation using enlarged photographs and result summary	5.2	Workshop aimed at independent development
3.3	Aerial photography	4.3	Aerial triangulation, DEM generation and contour line generation		
3.4	Digital aerial triangulation	4.4	Digital plotting		
3.5	Photo interpretation	4.5	Digital data compilation		
3.6	Digital plotting	4.6	Field completion work		
3.7	Digital data compilation	4.7	Digital data compilation for field completion work		
3.8	Field completion work	4.8	GIS strucuring		
3.9	Digital data compilation for field completion work	4.9	Map symbolization		
3.10	GIS strucuring	4.10	Dissemination of geographic information		
3.11	Map symbolization	4.11	Counterpart training in japan		

1.2.2 Seminars/workshops and reports

Table-2 shows workshops/seminars to be held in association with the implementation of the work and the various reports to be compiled in accordance with the progress of the survey.

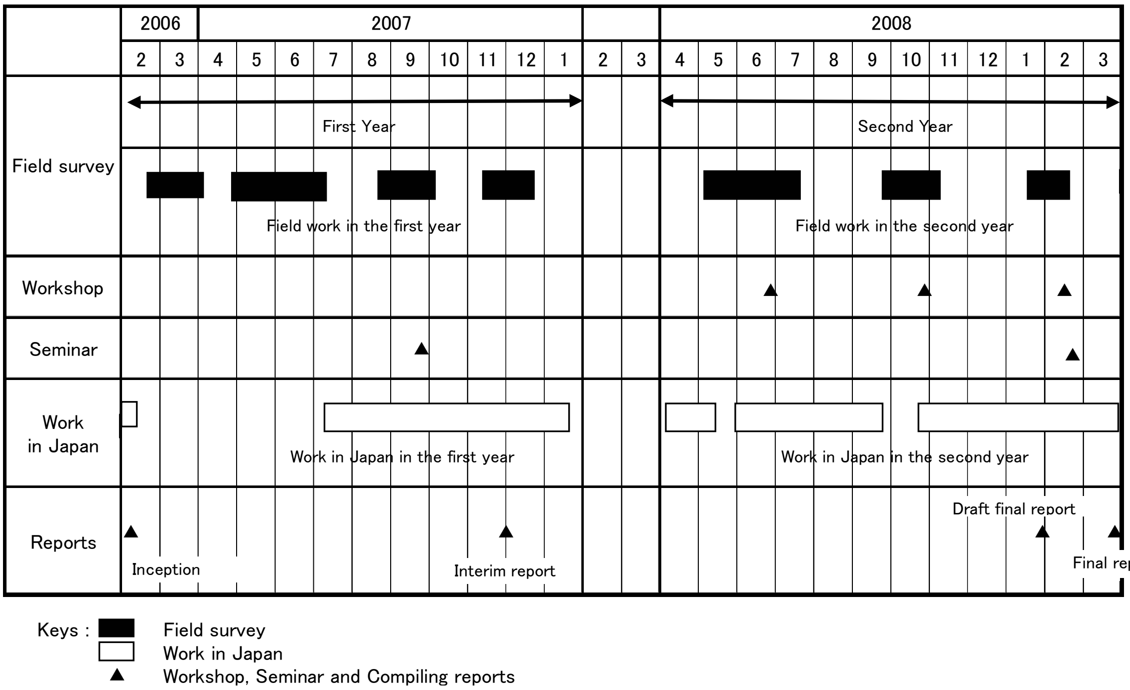
Table 2 : Contents of workshops/seminars and reports

Workshops/seminars		Reports	
Seminar 1	Announcement of the study and creation of cooperative relationship	Inception report	Implementation policy of the survey work
Workshop 1	Understanding of PCM scheme usable for implementation of the study	Interim report	Problems regarding work implementation and countermeasures against the problems
Workshop 2	Establishment of PDM for spatial data infrastructure	Draft final report	Survey work in general
Workshop 3	Evaluation of PDM for independent development	Final report	Printing and bookbinding as the final report
Seminar 2	Dissemination of the spatial data infrastructure		

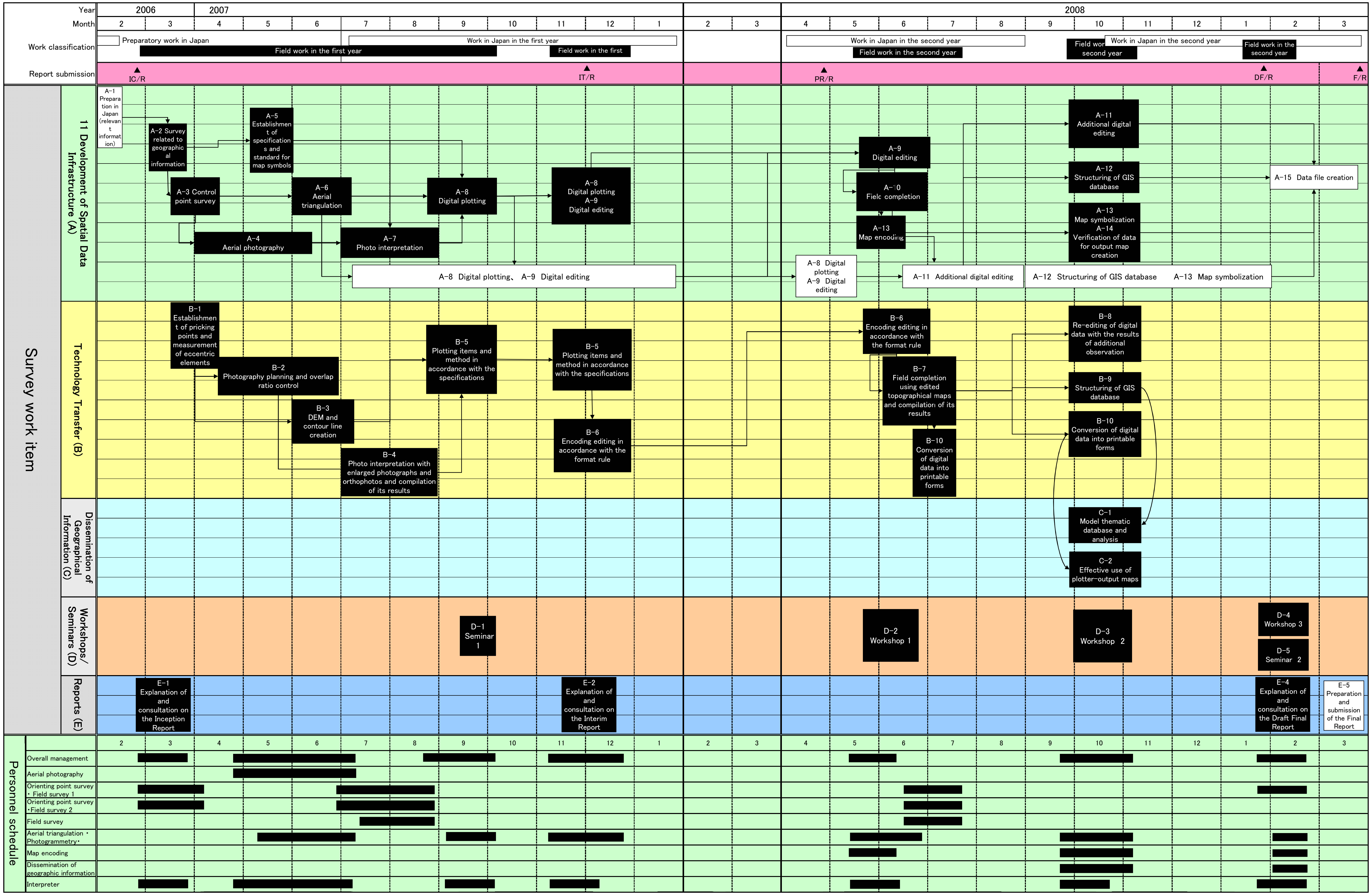
1.3 Schedule of the study and flowchart

The overall schedule of the study conducted for about two years is as follows:

Table 3 : Overall work schedule



The flow chart detailing the study conducted according to this schedule is shown on the next page.



Year
2006
2007
2008
Month
2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3
Work classification
Preparatory work in Japan
Field work in the first year
Work in Japan in the first year
Field work in the first
Work in Japan in the second year
Field work in the second year
Field work in the second year
Work in Japan in the second year
Field work in the second year
Report submission
IC/R
IT/R
PR/R
DF/R
F/R
Survey work item
11 Development of Spatial Data Infrastructure (A)
A-1 Preparation in Japan (relevant information)
A-2 Survey related to geographical information
A-3 Control point survey
A-4 Aerial photography
A-5 Establishment of specifications and standard for map symbols
A-6 Aerial triangulation
A-7 Photo interpretation
A-8 Digital plotting
A-8 Digital plotting A-9 Digital editing
A-8 Digital plotting、 A-9 Digital editing
A-8 Digital plotting A-9 Digital editing
A-9 Digital editing
A-10 Field completion
A-13 Map encoding
A-11 Additional digital editing
A-11 Additional digital editing
A-12 Structuring of GIS database
A-13 Map symbolization A-14 Verification of data for output map creation
A-12 Structuring of GIS database A-13 Map symbolization
A-15 Data file creation
Technology Transfer (B)
B-1 Establishment of pricking points and measurement of eccentric elements
B-2 Photography planning and overlap ratio control
B-3 DEM and contour line creation
B-4 Photo interpretation with enlarged photographs and orthophotos and compilation of its results
B-5 Plotting items and method in accordance with the specifications
B-5 Plotting items and method in accordance with the specifications
B-6 Encoding editing in accordance with the format rule
B-6 Encoding editing in accordance with the format rule
B-7 Field completion using edited topographical maps and compilation of its results
B-10 Conversion of digital data into printable forms
B-8 Re-editing of digital data with the results of additional observation
B-9 Structuring of GIS database
B-10 Conversion of digital data into printable forms
Dissemination of Geographical Information (C)
C-1 Model thematic database and analysis
C-2 Effective use of plotter-output maps
Workshops/ Seminars (D)
D-1 Seminar 1
D-2 Workshop 1
D-3 Workshop 2
D-4 Workshop 3
D-5 Seminar 2
Reports (E)
E-1 Explanation of and consultation on the Inception Report
E-2 Explanation of and consultation on the Interim Report
E-4 Explanation of and consultation on the Draft Final Report
E-5 Preparation and submission of the Final Report
Personnel schedule
2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3
Overall management
Aerial photography
Orienting point survey ・Field survey 1
Orienting point survey ・Field survey 2
Field survey
Aerial triangulation・Photogrammetry・
Map encoding
Dissemination of geographic information
Interpreter

1.4 Outputs of the Study

Outputs of this study are given below.

1.4.1 Study reports

In this study, the following reports will be prepared during the study period

Table 4：Study reports

Report	Language		Number of copies to be submitted			Items to be described
			JICA	Montenegro	Total	
Inception report <IC/R>	In English		5 copies	10 copies	15 copies	Study implementation schedule including the basic policy, methods, work schedule, personnel schedule, etc.
Interim report <IT/R>	In English		5 copies	10 copies	15 copies	Suggestions to the counterparts based on the results of the study and technology transfer up to this stage
Draft Final report <DF/R>	Summary	Eng.	5 copies	10 copies	15 copies	Results of the entire study and recommendations
	Summary	Jpn.	15 copies	0 copies	15 copies	
	Main	Eng.	5 copies	10 copies	15 copies	
Final report <F/R>	Summary	Eng.	10 copies	20 copies	30 copies	The report with necessary additions and corrections made in response to the counterparts' comments on DF/R
	Summary	Jpn.	10 copies	0 copies	10 copies	
	Main	Eng.	10 copies	20 copies	30 copies	

1.4.2 Study output

The reports and output items of this study are as shown in the table below. Each report will be submitted to the Montenegrin side after it has been inspected for technical validity by JICA, and agreement on the report will be reached after the report has been explained and discussed with the Montenegrin side.

Table 5：Output items

Output item	Set	Recipient
1. Aerial photographs		* Color aerial photos (1:40,000) covering entire area of Montenegro * The aerial photographs and the output obtained from them are the property of Montenegro, and thus were returned to the Montenegrin side by September 2007 at the completion of work for each item.
Film negatives	5 rolls	
Digital data files of aerial photographs	1 set	
Contact prints	1 set	
Photographs enlarged by 1.6 times	1 set	
Index map of aerial photographs	1 set	
2. Field survey results	1 set	The Government of Montenegro
3. Aerial triangulation results	1 set	The Government of Montenegro
4. Digital map data file	2 sets	The Government of Montenegro and JICA

Chapter2 Implementation method of the Study

2.1 Background of the Study

The Federal Republic of Yugoslavia was renamed Serbia and Montenegro when the new constitution was adopted in 2003 and was a federation of two republics (Republic of Serbia and Republic of Montenegro) with a limited term of existence until 2006. When the federation was dissolved in June 2006, the Republic of Montenegro (hereinafter referred to as Montenegro) came into existence.

This small country located in the midwest of the Balkan Peninsula has an area of approximately 14,000 km^2 and a population of around 620,000. The ethnic composition is as follows: Montenegrins 43.2%, Serbs 32.0%, Bosnians 7.8%, Albanians 5.0%, Muslims 3.9%, Croats 1.1%, and Other 0.5% (based on the national census conducted in 2003). The land borders on Croatia, and Bosnia and Herzegovina on the northwest, Serbia on the east, and Albania on the south, and faces the Adriatic Sea on the west.

In 2001, Japan dispatched a JICA economic cooperation study team to this country, then Yugoslavia, where the domestic economy had significantly deteriorated due to long-term economic sanctions and air strikes. The economic cooperation study, aimed at providing the citizens of this country with assistance for restoration and recovery of life and economic infrastructure, confirmed that cooperation was necessary in certain priority sectors: electric power, public transportation, health care, urban environment, agriculture, and social welfare. At the Conference of Donors for Yugoslavia held in June of the same year, Japan announced these six sectors as its priority sectors of assistance.

From 2003 to 2005, in order to bring about the recovery and economic growth of the country, the government of Montenegro, in cooperation with the UN Development Program (UNDP) and German Technical Cooperation (Gesellschaft fir Technishe Zusammenarbeit: GTZ), authored a national land development program, the pillars of which include long-term planning, urban planning, cultural heritage conservation planning, and disaster prevention planning. However, with topographic maps being the foundation of a strategic and efficient implementation of a national land development program, it became clear that the analogue topographic maps made in the 1970s were a major obstacle to the implementation of the development program, and there was a pressing need to prepare digital topographic maps which were compatible with the Geographic Information System (GIS).

Therefore, the Government of Montenegro has asked the Japanese Government for technical cooperation for the establishment of the spatial data infrastructure of the entire national land and for the related applied technologies (GIS model database development) necessary to implement the national land development program.

In response to this, the Japanese Government sent a preliminary study team to Montenegro, and on November 30th, 2006, a Scope of Work (S/W) was signed and exchanged between the concerned parties, where it was decided to carry out this study for cooperation to establish the spatial data infrastructure.

The two counterpart (C/P) organizations of this study are the Department of Real Estate (DRE), which prepares the spatial data infrastructure, and the Department of Spatial Planning (DSP), which puts to use the spatial data infrastructure.

2.2 Target area of the Study

The DRE will take aerial photographs of the entire country with the cooperation of the Japanese Government. The scope of the spatial data infrastructure to be created will be about 70% (approximately 10,000 km^2) of the entire country, excluding the mostly mountainous northwestern part, which will be covered with 92 map sheets on a scale of 1:25,000.

Spatial data infrastructure for the remaining portion, approx. 30%, will not be created through collaboration in this study. Instead, the Montenegrin side will create the spatial data infrastructure for this portion independently, using the technologies obtained from the present collaboration. The exact area to be covered by this study is the area encompassed by the blue line in Figure 1, which was prepared in accordance with the S/W.

Fig 1 : Area to be covered

2.3 Basic policies for Implementation of the study

This section describes the basic policies with regard to the aforementioned issues and approaches to their resolution, as well as technology transfer, operating methods for the study, etc. The following chart brings together the basic policies as well as the subordinate goals of this study. The methods for tackling them are laid out on the following pages.

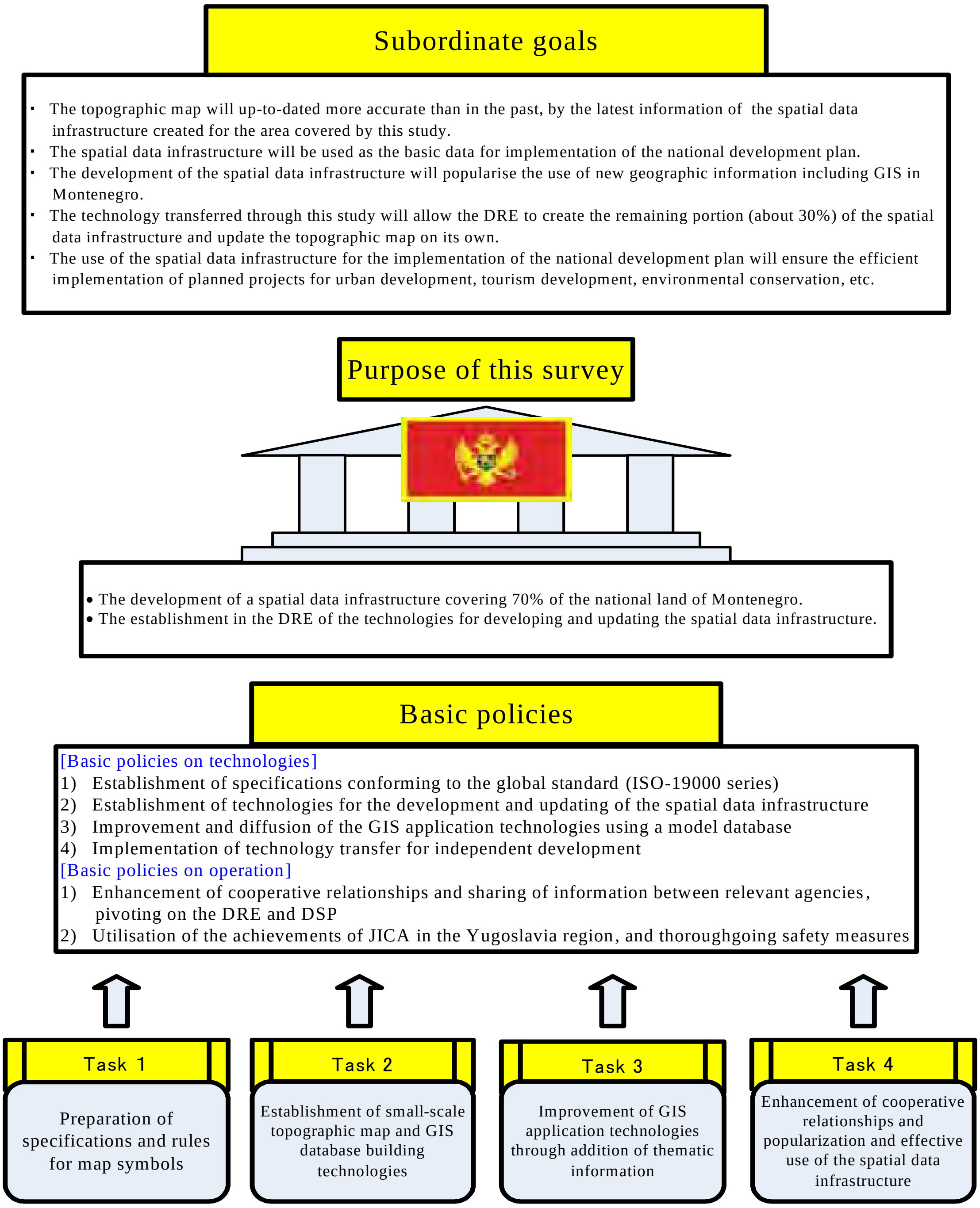


Fig 2 : Basic Policies

2.3.1 Approach to study based on the basic policies

Based on the basic policies, the following approach will be adopted in carrying out the study in order to achieve its objectives.

(1) Establishment of specifications conforming to the international standard

The very first thing to be done in this study is to "establish specifications." There is a very strong need not simply for the existing specifications to be digitized, but for them to be in conformity with the international standard, both in view of Montenegro's desire to join the European Union, and considering the potential for the effective use of the data in countries where it is compatible. The specifications will be established in a joint undertaking between the study team and the DRE in order to provide the flexibility for the DRE to be able to revise the specifications on its own in the future.

(2) Establishment of technologies for the development and updating of the spatial data infrastructure

Technological enhancement of the field survey division in charge of the photo interpretation and field completion, and of the photogrammetry division in charge of digital plotting and digital data compilation, is essential for the development of the spatial data infrastructure. The cooperation between the two divisions that will be needed after the technological enhancement will be handled is as follows:

1) Field survey division

This work is an important part of the initial stage of digital topographic map development, and the various types of information to be displayed on the digital topographic maps will be selected appropriately in line with the specifications, and displayed accurately on the survey photographs (using codes, symbols, etc.). Also, because the quality of the spatial data infrastructure is greatly affected by the results of these surveys, the aim will be to enhance technological capabilities while carrying out verification through on-the-job training.

2) Photogrammetry division

Since this operation includes the construction of the GIS database and the development of map printing data, with regard to the specifications, the technology transfer with the photogrammetry division must be done with greater precision than with the field survey division. The work in this stage includes not only the plotting of topographic features, but also data classification for points, lines, and planes, and the input of attribute information; which means that the technology for accurate plotting and data compilation must be established. For this purpose, the staff must understand the digital photogrammetric survey system, the GIS system, and the map symbolization system, etc. provided by JICA, and master the technology for their operation. Therefore a combination of lectures, tests, on-the-job training, etc., will be used to establish the technologies needed for the series of operations from plotting to data processing.

3) Cooperation between the two divisions

Since the results of the field surveys will contain a few errors, accurate judgment is essential in the plotting and compilation stages. In some cases, a follow-up survey of the content of the field survey may be needed, and so the division of roles between the two divisions involved in the development of the spatial data infrastructure and their cooperation based on mutual understanding are important. At the same time, the construction of a system to meet these requirements will be pushed forward.

(3) Improvement and dissemination of the GIS application technologies using a model database

1) GIS application technologies using a model database

The following two operations, defined in this survey as "the dissemination of spatial data infrastructure," will be carried out.

A.1 GIS technology transfer to the DSP/DRE

A.2 Dissemination activities for relevant agencies that need GIS

As the core organization for the development of spatial data infrastructure in Montenegro, the DRE should also take on the task of putting the various thematic maps into a database. In addition to transferring the GIS technologies to the DSP, the study team will transfer to both organizations the technologies for the process involved in putting thematic information into a database.

2) Use of color orthophoto maps for the development of a temporary spatial data infrastructure covering the entire land of Montenegro

The role of the DSP includes the drawing up of national land development plans, in addition to those in other spheres, such as forest management plans and tourism promotion plans. However, the development of spatial data infrastructure in this study will cover 70% of the country, and the remaining 30% is expected to be covered in order to prepare data for the entire country and drawing up national plans.

This preparation of data will be done by the DRE during or after the technology transfer, but is expected to take some time due to the current limitations of human resources and equipment.

As a workaround to this problem, it is suggested that the DRE prepare a temporary spatial data infrastructure from the orthophoto maps that the DRE has created on its own and is utilizing in its ordinary operations at present.

The study team will implement this study in collaboration with the DRE, from the aerial photography to the creation of the DEM and contour line data. The creation of orthophoto maps from the existing DEM will take significantly less time than the creation of the digital topographic maps. In particular, since color photographs are to be used in this study, the orthophoto maps themselves can be used to provide thematic geographic information with which to identify the current land usage conditions.

The preparation of the spatial data infrastructure for the remaining 30% area is not included in the S/W, but there is obviously a high demand for it from the DSP and other agencies in Montenegro. With the understanding and cooperation of the DRE as a provision, the study team will provide technical instruction regarding the preparation method. The preparation of data for this 30% within the study period can be expected to be very significant and effective from the viewpoint of the dissemination of the spatial data infrastructure and has therefore intentionally been included here in the technical policies.

(4) Implementation of technology transfer for independent development

1) Technology content

Technology transfer will not be a broad, perfunctory exercise covering all aspects of the work carried out by the DRE. Those fields in which there is sufficient technological capacity will not be covered and emphasis will be placed on the processes necessary for the preparation of the Montenegro spatial data infrastructure requested in this study, thus contributing to the sure development of human resources.

In particular, the DRE lacks experience in the spheres of ground survey with regard to photo interpretation and field completion, the creation of the medium scale of spatial data infrastructure (digital plotting and digital data compilation), and photogrammetry to create the GIS database and map printing data, and so these will be the high-priority issues in technology transfer.

2.4 Composition and Responsibilities of the Study Team

The composition of the study team and the responsibilities of each team member are determined as stated below, based on the basic policies of the study.

Table 6 : Composition of the study team

Responsibilities	Name	Main tasks
Overall management	Kazuo FURUKATA	• Overall management of the study • Planning and administration of technology transfer
Aerial photography	Tomohiko CHIBA	• Management and supervision of aerial photography, and technology transfer
Aerial triangulation / Photogrammetry / Digital plotting	Kohei ISOBE	• Consultation on specifications and standard of map symbols • Management and supervision of digital photogrammetry-related technologies, and technology transfer
Photo control survey / Field survey 1	Satoru NISHIO	• Consultation on specifications including survey specifications. • Management and supervision of photo control survey, and technology transfer • Management and supervision of photo interpretation, and technology transfer • Management and supervision of field completion, and technology transfer
Photo control survey / Field survey 2	Kazuhiro ISHIZUKA	• Consultation on specifications including survey specifications. • Management and supervision of photo control survey, and technology transfer • Management and supervision of photo interpretation, and technology transfer • Management and supervision of field completion, and technology transfer
Field survey	Akira NISHIMURA	• Management and supervision of photo interpretation, and technology transfer • Management and supervision of field completion, and technology transfer
Map symbolization	Yoshimitsu FUKUMOTO	• Technology transfer regarding editing of digital topographic map for printed-map data
Dissemination of geographic information (GIS)	Kazunori MASUDA	• Dissemination of geographic information, mainly study and analysis of GIS and technology transfer
Interpreter	Motoko KATAYAMA	• Interpreting services for explanations and discussions
	Masahiko OTSUKA	• Interpreting services relating to technology transfer

Chapter3 Development of Spatial Data Infrastructure

The development of the spatial data infrastructure included lots of tasks such as aerial photography, ground surveys, aerial triangulation, digital plotting and digital data compilation, map symbolization, and GIS database structuring. The details are given in the following sections.

3.1 Establishment of Specifications in Conformity with International Standard (ISO-19000 Series)

3.1.1 Preparation of Specifications and Format Rules

The basic policies (draft) for designing a spatial data infrastructure were established as shown below prior to the discussion between the study team and DRE regarding the specifications. The specifications were summarized as the "Spatial Data Product Specifications."

(1) Basic policies for establishing the specifications

The deliberation and discussions for the establishment of specifications were carried out based on the following four basic policies:

Photo 1：Scene of deliberation and discussions regarding specifications

1) In view of usability as GIS data, the spatial data infrastructure shall be developed in conformity with the standards for spatial data infrastructure (ISO-19000 series).
2) The spatial data infrastructure standards to be referred to shall be the standards by which the spatial data infrastructure can be expected to be used as mapping data as well as GIS data that can be distributed and used more extensively in and out of the country.
3) The spatial data infrastructure shall be established through discussion with DRE based on the assumption that the existing format rules developed in the days of the former Federal Republic of Yugoslavia are used wherever possible.
4) The specifications shall be summarized as the Spatial Data Product Specifications including "feature definitions," "spatial reference system," "quality evaluation," "meta data specifications," and "encoding specifications."

(2) Procedure of specification establishment

1) Member appointment

The basic policies for the specifications development and the structure of the specifications were explained. Based on the explanation, members in charge were selected through discussion with the leaders of the field survey division, photogrammetry division, and GIS division. Consequently, expert engineers familiar with topographic map preparation in each of the divisions were appointed to participate in the discussions.

2) Finalization of specifications

After dividing the specifications to be made into "feature definitions," "map symbols," "UML data modeling and data structures," "quality evaluation criteria," and "meta data specifications" and using the draft specifications prepared by the study team as the working draft, the process including "explanation, identifying requirements, summarization of specifications, and confirmation" was repeated until a draft was completed, which was then approved by the leaders of the divisions to establish final specifications.

(3) Outline of the Spatial Data Product Specifications

1) Compliance with international standards (ISO-19000 series)

An agreement was reached after it was advised that the data specifications comply with international standard specifications for the sake of data exchange, and distribution at present and in the future. The Product Specifications shall not only include data specifications but also define how to write the specifications, meta data, etc., comprehensively, and shall be revised to comply with international standard specifications in phases.

The Product Specifications have the character of and are positioned as a national social infrastructure similar to the international standard specifications, such as the ISO-19000 series (Geographic Information) by ISO/TC211 or the GML specifications by the Open GIS Consortium. Therefore, the Product Specifications in compliance with these specifications were established based on mutual agreement between the two parties.

This definition includes not only the data formats, but also all the items required for data exchange including application schema (such as items and attributes to be acquired), spatial schema (geometrical figure data model), graphics (format rules and expressions), and meta data profiles. However, the graphics in this list are specified to establish rules for exchanging computer-readable graphics originally as a portrayal schema. At present, there are few software applications available that implement these rules, and therefore it was decided to adopt for the specifications of existing symbols and line types dependent on individual graphics.

2) Feature definitions

The feature definitions were examined based on the format rules developed in the days of the former Federal Republic of Yugoslavia, "TOPOGRAFSKI KLJUC ZA TOPOGRAFSKI KARTU 1:25000." By eliminating many features that could be consolidated or no longer existed, the number of features was reduced, and the format rules were simplified, so that Montenegro can maintain them by itself in the future. Since no definition was provided for each of the features, the scope of applications was determined based on the size of symbols, and so forth. If these were still hard to determine, the application rules for Japanese 1:25000 maps were applied.

Fig 3：Notation in "TOPOGRAFSKI KLJUC TOPOGRAFSKI KARTU 1:25000"

3) Map symbols

Map symbols were discussed based on "TOPOGRAFSKI KLJUC ZA TOPOGRAFSKI KARTU 1:25000" and the dimensions of each symbol were created by measuring the shape of the symbol on the former topographic map. The adopted symbols are summarized in the "Definition of Graphics" which also shows the dimensions, widths, colors, etc. of lines that make up each symbol. New symbols were created where they did not exist in the former format rules (e.g., mobile phone antenna) after examining the shape. The features that were difficult to express in digital data were created based on the Japanese format rules (e.g., soil and rock cliffs).

Feature item name	Element type	Item code	Graphics	Remarks

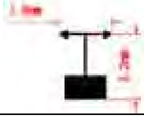
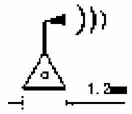
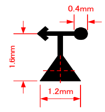
Antenna on Building	point	6083		color: black line width: 0.15 mm
Mobile Antenna	point	6084		color: black line width: 0.15 mm
Meteorological Station	point	6085		color: black line width: 0.15 mm

Fig 4 : Notation in "Definition of Graphics"

4) UML modeling and data structure

The organization of features was defined in the UML modeling, and the format of spatial data was examined in the data structure.

Fig 5 : Organization of 1:25,000 SDI expressed as a UML class diagram

A notation system for class diagrams in the UML modeling was used to group features into several classes and define the "spatial attributes," "temporal attributes," and "thematic attributes."

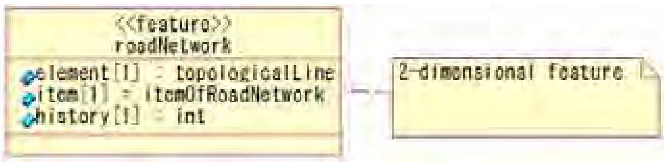


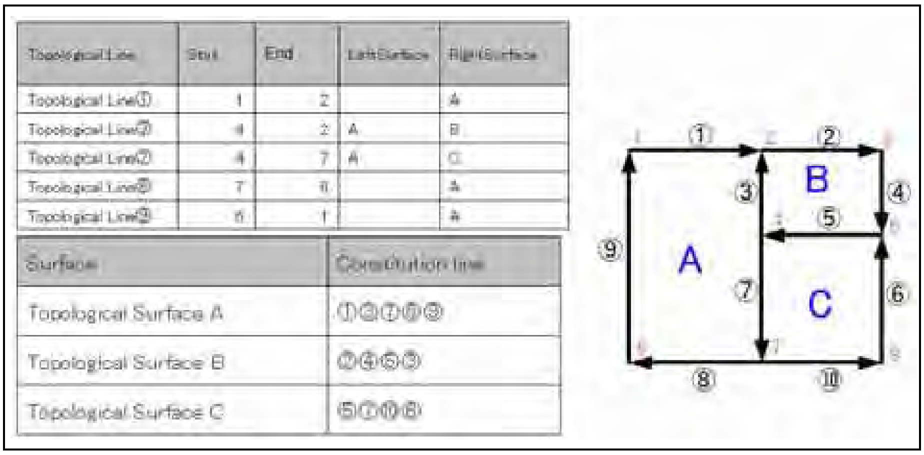
Fig 6 : Class diagram of a road network

The spatial data infrastructure is expected to bear an important role as part of the social infrastructure.

Once built, the spatial data infrastructure is required to continuously fulfill the role. Therefore, the data structure shall meet the following requirements:

- The data structure shall flexibly support an expansion or change of the specifications in the future.
- The data structure shall have sufficiently high accessibility and availability at present, and be able to comply with international standards such as ISO by way of format conversion processing in the future.
- The specifications of the data structure shall be disclosed to the public to enable data maintenance on various systems, and data processing by users.

According to the above requirements and for the effective use of the data, topological structure data was adopted. Also, in view of future compliance with ISO, data shall be created in coverage format of ArcInfo so it will be possible to simply convert the data.



Topological Line	Start	End	LeftSurface	RightSurface
Topological Line①	1	2		A
Topological Line③	4	2	A	B
Topological Line⑦	4	7	A	C
Topological Line⑧	7	6		A
Topological Line⑨	6	1		A

Surface	Constitution line
Topological Surface A	①③⑦⑧⑨
Topological Surface B	②④⑤③
Topological Surface C	⑤⑦⑩⑥

Fig 7：Structure of topological data

5) Quality evaluation

Quality evaluation was defined using five elements: completeness, spatial accuracy, logical consistency, temporal accuracy, and thematic accuracy. After the quality requirements and quality evaluation procedure were determined for each feature, the details of these five quality elements were discussed.

As for quality inspection, visual inspection and logical inspection were adopted. The former refers to final results inspected with original data and photographs, and the latter refers to data structures and other items that can be inspected by a program. Furthermore, the quality evaluation specifications were determined to prevent defects in the final products.

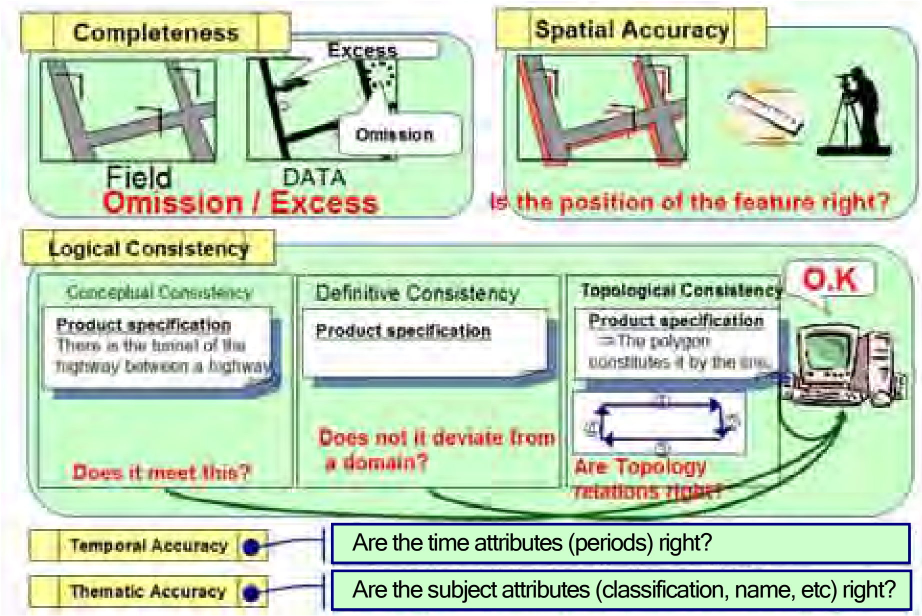


Fig 8：Explanation of five elements of quality evaluation

6) Meta data

Meta data was discussed as follows: JMP 2.0 defined in Japan was explained in detail and it was decided to modify the specifications to comply with the circumstances of Montenegro and define them as MMP 1.0.

JMP 2.0 is a set of specifications including 50 essential items (core meta data) defined as the information of meta data defined in ISO as well as an additional 20 items representing the content of quality evaluation. Montenegro agreed that no more information is required so that it was decided to define similar specifications as MMP 1.0.

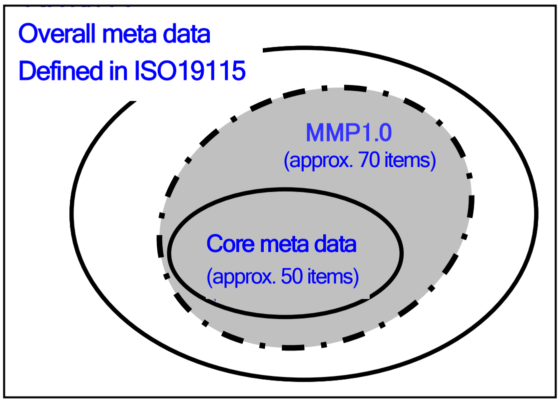


Fig 9：Scope of application of meta data

(4) Update of Spatial Data Product Specifications

After the Product Specifications were established, some problems were found in the digital topographic map expressions that led to several revisions to the Specifications. These updates of the Product Specifications were agreed upon in the memorandum exchanged between the study team and DRE.

3.2 Photo Control Point Survey

3.2.1 Photo Control Point Survey and Revision of the Survey Standard

The photo control point survey was conducted in the first and second year of the study operation period based on the conventional survey standard (hereinafter, the former survey standard). After the second-year photo control point survey was completed, however, the revision of the former survey standard took shape to produce a new survey standard (hereinafter, the new survey standard) and DRE and the study team met numerous times to determine which survey standard should be applied in the current survey. Since the coordinate system was split into two under the former survey standard, and a common coordinate system for the entire country is desirable from the viewpoint of developing and utilizing a spatial data infrastructure, it was decided to make a revision to establish the new survey standard compliant with the ITRF (International Terrestrial Reference Frame)-96, an international standard. Therefore, the coordinate results of the photo control point survey were also converted in compliance with the new survey standard.

Table 7：Survey standard used to make a digital topographic map

Item	Former Survey Standard	New Survey Standard
Survey Standard	Former Yugoslavic Standard	ITRF-96
Reference ellipsoid	Bessel 1841	GRS-80
Map projection	Gauss-Kruger Zone 6, 7	UTM Zone 34
Central meridian of coordinate syster	Zone 6: 18 degrees east longitude	21 degrees east longitude
	Zone 7: 21 degrees east longitude	
Coordinate origin	Zone 6: X=0, Y=6,500,000	X=0, Y=5,000,000
	Zone 7: X=0, Y=7,500,000	
Scale factor	0.9999	0.9996
Specifications of topographic map	Surrounding framework: 7° 30´x 7° 30´	Surrounding framework: 7° 30´x 7° 30´

3.2.2 Decision on Number of Photo Control Points

The number of photo control points required for aerial triangulation was calculated by applying the Survey Operation Manual of JICA (for National Base Maps). The formulae provided in the operation manual used for calculation were as follows:

- Nh (horizontal control points)
- =4+2[(n-6)/6]+2[(c-3)/3]+[(n-6)(c-3)/30]
- Nv (vertical control points) =[n/12]c+[c/2]

n：Average number of models per course

c：Number of courses (the fractional portion inside the brackets [ ] should be rounded up after calculation).

Fig 10：Existing GPS control points

Using the numbers in the photographing plan, n=31 and c=34, the number of control points were calculated to be

Nh=62 and Nv=119, respectively. Since vertical points (Nv) can also serve as horizontal points (Nh), the number of control points when only Nv is used was calculated as: 119-62=57.

3.2.3 Reconnaissance of Existing Control Points

In this study, a plan was established to make the most of the many GPS control points that already exist in Montenegro. Based on the coordinate results received from DRE and the results of the reconnaissance survey, the existing GPS control points to be recognized as photo control points in this study were accurate enough to be used as Nh (horizontal control points). Furthermore, the existing GPS control points came with elevation data results which, when checked through indirect leveling by TotalStation from nearby benchmarks, were in error by around 10cm. The study team, assuming that the elevations of the existing GPS control points can also be used for aerial triangulation, decided to use them as Nv (vertical control points) in the same way as benchmarks.

Photo 2：Inspection survey using benchmarks

3.2.4 Installation of Aerial Photo Signal

In principal, when installing aerial photo signals as horizontal control points, the A-type (Y-shaped), B-type (square-shaped), and C-type (X-shaped) are used. However, in this instance, the existing A-type (Y-shaped) aerial photo signals were used (see Photograph 1). Boulders on the ground were painted mainly with lime powder dissolved in water. The size of aerial photo signals was 5 meters in length and 1 meter in width in accordance with the result of the discussion on the specifications.

3.2.5 Performing the Photo Control Point Survey

The photo control point survey was conducted by three or four groups as a joint effort between the study team members and the counterparts of DRE. Each group used either a GPS receiver or TotalStation owned by DRE according to the observation conditions in the field. Furthermore, efforts were made to make the most of the observation data of GPS receivers, JICA survey equipment, and nine GPS-based reference stations installed in Montenegro, and the observation

Photo 3：Aerial marker in aerial photograph method for Real Time Kinematic survey (hereinafter, RTK GPS survey) was adopted.

This work, initially planned to be completed in March or April 2007, had to be interrupted after installation of 36Nh points (including air marking), and 39 Nv points due to an unexpected snowfall and an extensive and long power failure. Therefore, changes were made in the work plan so that the photo control survey was carried out in two separate phases.

Photo 4：Photo control point survey and air marking

Photo 5：Snowfall on March 21 in Berane

It was decided to carry out the photo interpretation survey in the second phase in late June to late August 2007. Since aerial photography was completed by then, the rest of the photo control points were handled in the pricking process instead, and the installation of 66 Nh points (62 planned) and 69 Nv points (57 planned) was completed by the end of July 2007.

In the second phase, it was possible to use the RTK GPS survey, a survey method superior in speed and accuracy, and therefore it was used on the three new photo control points, as follows:

- GCP63 (T-1) and GCP63 (T-3) were installed near the area neighboring the northern border with Bosnia and Herzegovina.
- A new photo control point (GCP64) was installed because the GPS control point planned near the northwestern border with Serbia did not exist.
- Likewise, an existing GPS control point neighboring the northwestern border that was to be used as GCP21 was missing. Therefore, a new point was installed nearby.

Consequently, the number of horizontal control points installed in the first and second phases was as shown in the following table.

Table 8：Number of horizontal control points

Photo Control Points for Horizontal Position (Nh)			
Phase	Existing Control Point Use		New Control Point Use
	Aerial Photo Signals	By Pricking	By Pricking
First Phase	36	0	0
Second Phase	0	27	3
Total	36	27	3
Grond Total	66		

The number of vertical control points of which only the elevation value is used for adjustment calculation of aerial triangulation was calculated by measuring the relative elevation difference between an existing control point or GPS control point, and a pricking point using the TotalStation. Consequently, the number of vertical control points installed in the first and second phases was as shown in the following table.

Table 9：Number of vertical control points

Photo Control Points for Vertical Position (Nv)		
Phase	Existing Control Point Use	Exsiting Bench Mark Use
First Phase	17	22
Second Phase	30	0
Total	47	22
Grand Total	69	

3.2.6 Coordinate Transformation for Control Point Survey Results

Since it was decided to develop spatial data infrastructure in conformity with the international standard ITRF-96 in this study, the plane coordinates that had been obtained as a result of the control point survey conducted using the conventional survey standard needed to be transformed into planimetrical coordinates in conformity with the specifications of the new survey standard. The program used for transformation between longitudes and latitudes with different ellipsoids was transformation software developed by the Geographical Survey Institute of Japan. Furthermore, the transformation from the former planimetrical rectangular coordinates to longitudes and latitudes, and the transformation from the longitudes and latitudes to the new planimetrical rectangular coordinates were conducted using the software owned by Kokusai Kogyo Co., Ltd. as shown in the following figure:

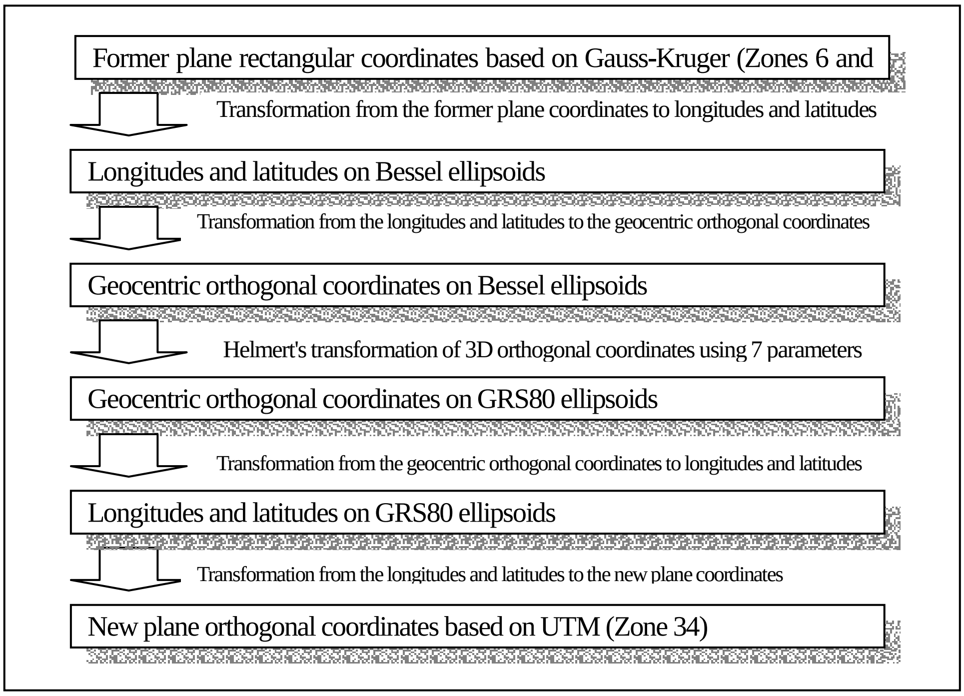


Fig 11：Flow of coordinate transformation

The results of the existing GPS control points used for the control point survey were the planimetrical coordinate values based on the Gauss-Kruger projection using zone six and seven based on the former survey standard. Therefore, the longitude and latitude results of the GPS control point survey conducted by DRE were also received.

The seven parameters used for 3D transformation of the geocentric orthogonal coordinate values on the Bessel ellipsoid to those on the GRS80 ellipsoid were the values shown in the table below, which were calculated by Prof. Blagojevic (Faculty for Geodesy, University of Belgrade) and adopted by DRE.

The ellipsoid elements adopted in the process of transformation and conversion are as shown in the table below.

Table 10 : Seven parameters used for coordinate transformation

7 Parameter	Bessel/GRS80
T1 (m)	−261.89858
T2 (m)	−221.21591
T3 (m)	−743.8768
R1 (″)	+4.99487
R2 (″)	+14.45241
R3 (″)	−15.13857
D (ppm)	−2.03665

Table 11 : Ellipsoid elements

Ellipsoid	Semi-major axis	Frattening
Bessel (m)	6,377,397.155	299.1528128156
GRS80 (m)	6,378,137.000	298.2572221010

3.2.7 Creation of Description for Photo Control Points

The descriptions for photo control points were created for each of the horizontal and vertical control points, as shown in the figures below, to be used as the control points for aerial triangulation that follows. The descriptions indicate the after-transformation coordinate values and their positions, and show aerial photographs and position diagrams.


Descriptions for Ground Control Point DRE /JICA

Point No.	35	No. of 1:25,000 Map	147-3-1	Operated by	S.Stojanovic & R.Krstajic
Type of Photo Signal	Three wings	Date of Installation	17-Mar-07	Inspected by	K .Ishizuka
Coordinate Zone: UTM 34		Coordinates (m)		Elevation (m)	
		Easting (E)	Northing (N)	Pillar Ele.	Signal/Ground Ele.
Main Station (DRE96)		301,700.400	4,723,002.998	1,174.316	1,174.190
Eccentric Point (EP)		301,722.222	4,722,983.904	–	1,174.880

Site Sketch

Map 1:25,000

Surrounding Site Photo

Site Photo of Signal

Position on Aerial Photo

Notes:


Descriptions for Vertical Control Point

DRE/JICA

UTM Zone: 34	No.	Coordinates (m)		Elevation (m)	Remarks
		Easting	Northing		
VCP No:	106	316,516	4,699,319	1.062	Coordinates was measured by handheld GPS.
Reference Point:	1406	–	–	2.444	DRE's Bench Mark
Survey Date:	27-Mar-07		Operated by:	Slobo Stojanovic & Rados Krastajic	

Site Photo:

Site Sketch:

Notes:

Fig 12：Description for Horizontal control points

Fig 13：Description for Vertical control points

3.3 Aerial Photography and Photograph Data Creation

3.3.1 Aerial Photography

Aerial photography in this study was conducted in collaboration with DRE, the counterpart agency. DRE supplied airplanes and cameras as well as pilots, photographers, and mechanics, whereas JICA supplied materials such as film and processing chemicals and aircraft fuel to carry out joint work with the engineers of the study team.


Photo 6：Aerial camera

The undulating topography of Montenegro, which ranges from the coastal area on the Adriatic Sea to a mountainous area with 2,500-meter elevations, requires caution to perform aerial photography, such as adjusting the shutter intervals during the flight while checking the rapidly changing geographic features of a target area. If such caution is not taken, the required overlap rate may not be attained. To avoid this problem and acquire aerial photographs required to make the digital topographic maps, it is necessary not only to use a photographing method such as the overlapping rate control, but also to start making thoroughgoing preparations from the photographing flight planning phase.

(1) Flight planning

The flight plan map made during preparations in Japan assumed carrying out all the photography in an east-west direction, covering 34 courses in total. As a result of discussion with the DRE photography crew, however, it was decided to change the plan by reducing the courses in an east-west direction to 31 and adding 15 courses along the international borders with neighboring countries in order to cover all the areas.

The reason for this change in the photography courses was that it was expected to take a long time to obtain permission from the neighboring countries for the flights. The Republic of Bosnia and Herzegovina granted permission soon after the application was made, but there was difficulty in flying over the other neighboring countries at the start of the photographing process in early May.

Therefore, the east-west courses on the Bosnian side included the taking of one photograph beyond the border while the courses on the Serbian (including Kosovo), Albanian, and Croatian sides were stopped short of the borders. To make up for the blank areas resulting from this change, photographs were taken with new flight plans along the international borders.

The photography method and the courses along the national borders was planned by the study team and finalized through discussion with the DRE photography crew. In the end, permission for flights was given one after another by the neighboring countries, with the exception of Albania and Croatia, and photographs were taken mostly as scheduled in the plan.

The coordinates required for the actual photography flight for the start and end points of each flight plan were measured by the study team. Then, a DRE photographer transformed the measurement data into a coordinate system to be used for the navigation system, and then entered the transformed data in the photography control system, ASCOT. The DRE photographer had sufficient experience and technical skills so that there was no problem in the data entry and initial settings (setting for inserting coordinates, time, and course numbers in photographs).

(2) Photography specifications

- Photographing scale: 1/40,000
- Average overlapping rate: O/L=70%, S/L=35%
- Photography courses: L1 to L31 (east-west), L101 to L115 (along borders), a total of 46 courses
- Planned number of photographs to be taken in photographing mode specifying

Photo 7：Photographing aircraft owned by DRE principal points: 1,064

- Above-ground level for photographing: 6,140 m
- Camera focal length: 153.49 mm

(3) Photography management

The experienced DRE photographer had no problem in handling the camera and ASCOT, and took photographs while discussing with the study team about detailed settings such as exposures and altitudes.

Many of the photographs were planned to be taken in photographing mode specifying principal points (with priorities on principal point positions). However, there was a risk of extremely small overlaps due to the topographic features with significantly different elevations. Photographing was carried out, therefore, by switching ASCOT to V/H mode (with priorities on overlaps) when required by the topography of the shooting areas. The DRE photographer was well acquainted with such a procedure for complementing photography procedures with manual operations, so the operation progressed quite smoothly.

Photo 8：Identification of weather conditions

The photographer was also familiar with an efficient and economical photography method, such as not photographing areas with obstacles including clouds and re-photographing only these areas in the next flight, making the most of the advantages of ASCOT that operated in linkage with the GPS navigation system. The photographer accurately managed photography courses, areas not yet photographed, and areas to be re-photographed.

As described above, the process up to the actual flight was based on a different system than in Japan, and many of the target areas were in a distinctive region with an undulating topography, much coastline, and many lakes and rivers from which clouds tended to build up. For about 1 month from mid-May, it was sunny in the morning but cumulus-type clouds built up as the time passed. Thanks to the experienced photography crew who collected weather information and accurately determined whether or not to fly, the photography of all the target areas was completed by late June.

(4) Processing of film development, scanning, and printing

1) Data processing after film development and scanning

Exposed films were developed one by one in the DRE laboratory. Later, all the negative films were scanned and converted into digital data.

Next, a photograph number table was created based on this data, and printing data was created according to the plotter resolution.

To prevent erroneous overwriting of the original image data after scanning, the transformed digital data was saved to a 1.5-TB HDD brought from Japan. On the other hand, DRE also made a data backup on DVDs on its own to ensure this original data was saved.

2) Printing image data and printing

A management table was made for the processing and printing of this set of data. It was decided to write in this table the file names for photographs that were converted into digital data, and the numbers for photographs that were printed one by one in order to prevent any omissions in data processing and printing. Later, through collaboration with the DRE engineers, printing was done to produce one set each of 1.6-times enlarged prints for photo interpretation (scale: about 1:25,000), 1.6-times enlarged prints, contact prints covering 30% of the survey conducted by DRE, and one set of contact prints for the work in Japan.

3.3.2 Accuracy Control

The DRE photographer was well acquainted with manual operation procedures to complement photographing, and accuracy control using digital data did not turn up any problem either in drift correction or exposure, etc., except weather disturbances or in overlapping rates, which stood at around 70% of the plan regardless of topography.

Photo 9：Accuracy control using digital data

However, the study team requested DRE to retake seven of the photographs showing some clouds. These photographs did not pose significant obstacles to digital topographic mapping, but were retaken in view of effective utilization in future orthophoto maps, etc. The details are shown in the table below.

Table 12 : List of aerial photography courses and photograph numbers

Course	No – No		No – No		No – No		No – No		No – No		Total
1	3167 – 3175	9									9
2	3158 – 3166	9	3217 – 3218	2							11
3	3146 – 3157	12									12
4	3129 – 3145	17									17
5	3104 – 3128	25									25
6	3076 – 3103	28									28
7	3026 – 3054	29	3073 – 3075	3							32
8	2989 – 3025	37									37
9	2948 – 2988	41									41
10	2660 – 2676	17	2905 – 2930	26	3065 – 3072	8					51
11	2634 – 2659	26	2878 – 2904	27							53
12	2605 – 2633	29	2846 – 2877	32	*Three exposures (2875, 2876, 2877) affected by cloud to be taken						61
13	2233 – 2235	3	2575 – 2603	29	2824 – 2845	22	3058 – 3063	6			60
14	2236 – 2241	6	2542 – 2574	33	2799 – 2823	25					64
15	2506 – 2541	36	2776 – 2789	14							50
16	2461 – 2505	45	2792 – 2795	4							49
17	2405 – 2434	30	2444 – 2460	17	2790 – 2791	2					49
18	2368 – 2404	37									37
19	2328 – 2367	40	* One(1) exposure to be taken at the west end (near the border with Croatia) : lack of stereoscopic image								40
20	2104 – 2125	22	2210 – 2211	2	2214 – 2217	4	2323 – 2327	5			33
21	2079 – 2085	7	2090 – 2102	13	2206 – 2209	4	2318 – 2321	4	3226 – 3227	2	30
22	2056 – 2069	14	2071 – 2078	8	2219 – 2222	4	2677 – 2679	3			29
23	2021 – 2039	19	2195 – 2202	8							27
24	2003 – 2020	18	2203 – 2203	1							19
25	2040 – 2055	16									16
26	2126 – 2136	11									11
27	2146 – 2155	10	2194 – 2194	1							11
28	2137 – 2145	9	2193 – 2193	1							10
29	2156 – 2161	6	2192 – 2192	1							7
30	2165 – 2171	7									7
31	2172 – 2177	6									6
101	3176 – 3179	4									4
102	3180 – 3196	17									17
103	3198 – 3211	14									14
104	2931 – 2947	17									17
105	2224 – 2232	9									9
106	2242 – 2246	5	2796 – 2798	3			*Three exposures (2244, 2245, 2246) affected by cloud to be taken				8
107	2250 – 2257	8									8
108	2438 – 2443	6									6
109	2275 – 2284	10									10
110	2285 – 2293	9									9
111	2294 – 2317	24									24
112	2178 – 2190	13									13
113	2267 – 2274	8									8
114	3220 – 3225	6									6
115	2258 – 2266	9									9
46											1,094

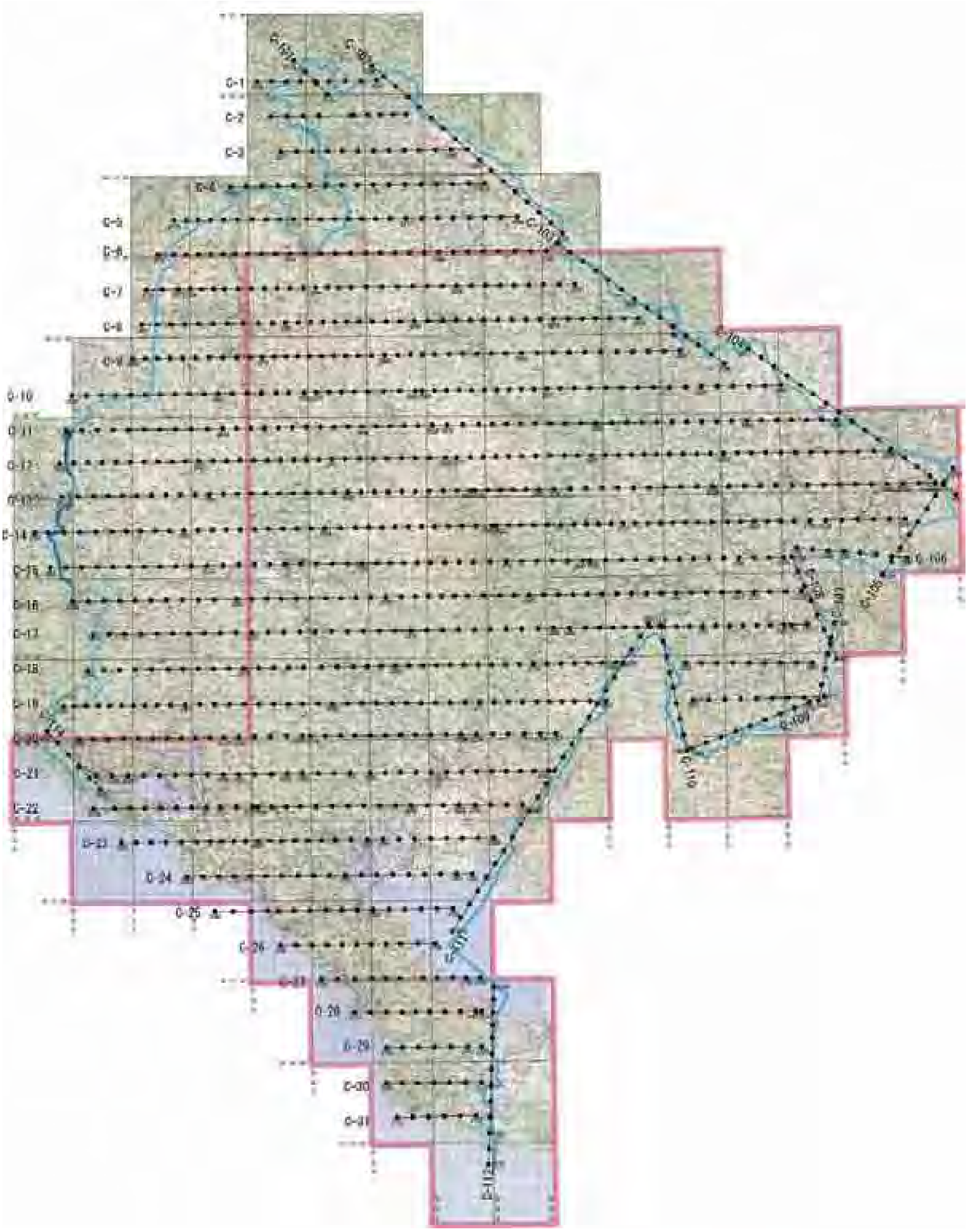


Fig 14：Index Map of Aerial Photos

3.4 Digital Aerial Triangulation

3.4.1 Description of Operation

Aerial triangulation was conducted in digital form using the digital photogrammetry system. The use of the system's automatic measurement function led to the acquisition of efficient and high-precision results. The aerial triangulation method used in the study was as follows:

Initially, it was planned that the counterpart agency DRE should conduct aerial triangulation on all the areas, but the agency responded that this was difficult to do due to the term of work. As a result of discussion between the two parties, DRE decided to take on only the amount of work it could reasonably handle, including the technology transfer (98 out of 1,048 models), and the rest of the work was carried out by the study team.

Likewise, the study team also handled making DEMs and contour line data in the areas where spatial data infrastructure was to be constructed (70% of the total area) and DRE acquired those in the remaining 30% of the area and two sheets related to technology transfer.

3.4.2 Process Methods

The equipment and methods used by DRE are as follows: Aerial triangulation was conducted in two blocks, zone 6 and 7; because control points consisted of zone 6 and 7 of local coordinates system. It was decided to ensure the consistency between the two blocks by using common photo control points.

(1) Equipment used:

Digital photogrammetry system, Leica Photogrammetry Suite9.1, ORIMA9.1 (Montenegro), and Image station SSK (Intergraph) (Japan)

(2) Adjustment calculation

Bundle method with self-calibration that can be used with RIMA9.1 (Montenegro) and Image station (Japan)

Photo 10：Leica Photogrammetry

In this operation, automatic processing based on image matching was frequently used to make the most of the advantages of digital aerial triangulation by effectively using the principal point coordinates for photographing that can be obtained from the GPS mounted on the aircraft. The measurement of photographic coordinates (images) such as tie-points was conducted mainly through automatic measurement. While analog aerial triangulation was conducted by manually measuring three to five tie-points per photograph, digital aerial triangulation enabled the measurement of a maximum of about 120 points per photograph. Since extremely numerous points were measured, stable results (solutions) can be expected in subsequent calculation or analysis processing, so that the latter method is advantageous in terms of accuracy. In contrast, the photo control points were measured manually as in the past.

(3) Creation of DEMs and contour lines

DEMs at intervals of 20m were created using the automatic elevation extraction technology, break lines were added to abnormal points and unrepresentative topographies using a stereo model, and contour lines were created based on these DEMs through automatic generation processing.

3.4.3 Executed quantities and results

(1) Executed work quantities

- Number of photographs: 1,096
- Number of photo control points (horizontal) : 66
- Number of photo control points (vertical): 136

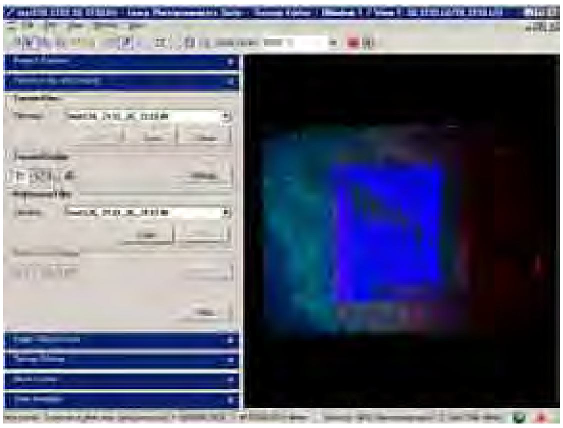


Fig 15：DEMs created through automatic elevation selection and stereo model

(2) Specifications

The limit values in the aerial triangulation adjustment calculation results applied in the survey operation comply with the Survey Operation Manual of JICA as follows:

- Bundle intersection residual error limit values: 30 µm (maximum), 15 µm (standard deviation)
- Photo control point residual error limit value: 0.04% of photographing altitude (2.4 m) (maximum), 0.02% (1.2 m) (standard deviation)

The results of the aerial triangulation were as shown in the following table and sufficiently met the accuracy requirements:

Number of reference points for control		Number of points excluded from calculation		Reference point residual error				Independent model method or bundle method Pass-point and tie-point residuals			
				Horizontal location		Elevation		Horizontal location		Elevation	
Horizontal location	Elevation	Horizontal location	Elevation	Standard deviation	Maximum	Standard deviation	Maximum	Standard deviation	Maximum	Standard deviation	Maximum
				(m)	(m)	(m)	(m)	(mm)	(mm)		
66	136	1	0	0.09	0.5	0.033	0.10	0.003	0.027		

3.5 Photo Interpretation

3.5.1 Description of Operation

The photo interpretation was conducted using aerial photographs with the same scale as the 1:25,000 digital topographic maps to be created, in order to identify the necessary features to be shown in the digital topographic maps. The feature items that could not be identified in the field or aerial photographs were supplied via DRE from the competent agencies of Montenegro. The specific operations conducted in the study are as follows:

- Preparative operation
- Reconnaissance investigation and photo interpretation
- Creation of a photo interpretation handbook
- Field confirmation

3.5.2 Implementing Method

The implementing method and procedure of operations were as follows:

(1) Preparative operations

The preparation for the photo interpretation consisted of the following operations:

1) Creation of a photo interpretation instruction

Table 13：Example of rules applied to photo interpretation

Application Rule for Field Identification at a scale of 1 : 25,000 Map Symbols (Draft)				
[illegible]	[illegible]	Boja	SIMBOLI MAPA	DEFINICIJA
	Small point			
6051	crkva sa dvije kule	[illegible]		STAVITI CRKVA SA DVIJE KULE
6052	crkva sa jednom kulom	[illegible]		STAVITI CRKVA SA JEDNOM KULOM
6053	džamija	[illegible]		STAVITI SVE VRSTE DZAMIJE
6054	sinagoga	[illegible]		STAVITI SVE VRSTE SINAGOGE
6055	kapela	[illegible]		STAVITI SVE VRESTE KRISTIANSKI KAPELA
6056	manastir	[illegible]		STAVITI KRISTIANSKI MONASTIR
6057	spomenik(religiona)	[illegible]		STAVITI RELIGIONALNIH SPOMENIK KAO KRIZ,KULA ITD
6058	Hrišćansko (individualna)groblje	[illegible]		STAVITI HRISCANSKO INDIVIDUALNA GROBLJE
6059	muslimansko (individualna)groblje	[illegible]		STAVITI MUSLIMANSKO INDIVIDUALNA GROBLJE
6060	ZIDOVSKI (INDIVIDUALNA)GROBLJE	[illegible]		STAVITI ZIDOVSKI INDIVIDUALNA GROBLJE
6061	ruševina	[illegible]		STAVITI RUZEVINA MALA KUĆA
6062	zamak	[illegible]		STAVITI SVE VRSTA ZAMAK

Based on the spatial data infrastructure specifications, the survey items were selected and their definitions and application rules were clarified. Furthermore, the usage methods of symbols and codes for showing the photo interpretation results were clarified, and the survey methods were determined through deliberation and discussions. The information thus determined was summarized into an instruction, which was prepared both in English and Serbian.

2) Collection of the existing 1:25,000 topographic maps

DRE prepared the existing 1:25,000 topographic maps (hereinafter, former topographic maps) for the study area.

3) Other preparations

On the printout aerial photographs with an approximate scale of 1:25,000, the surrounding frameworks and sheet numbers of former topographic maps were marked in red. Since the scope of one topographic map sheet is usually covered with more than one aerial photograph, joining lines were marked in red on each of the neighboring aerial photographs.

(2) Discussion with DRE

The following items were discussed with DRE in order to proceed smoothly with the photo interpretation:

- Organization of survey team
- Period of survey
- Explanation of the survey operation instructions

(3) Reconnaissance investigation

The following reconnaissance investigation was conducted according to the survey operation instructions that had been determined upon discussion. The reconnaissance investigation was conducted by comparing and checking the features in the aerial photographs for surveying against those in the collected former topographic maps.

The survey items compared and checked were as follows:

- Identification of secular change areas
- Identification of features to be checked in the field (e.g. buildings such as public facilities and factories) in the feature information based on former topographic maps
- Identification of topography and features free of secular changes which can be used as they are, in the topography and feature information based on former topographic maps
- Identification of feature information that cannot be determined in field confirmation or photo interpretation (e.g. place names and routes of transmission lines) and geographical information that needs to be confirmed in the former topographic maps (e.g. road types, administrative boundaries,

and national borders)

(4) Creation of a photo interpretation handbook

A photo interpretation handbook that can be effectively used for digital plotting and digital data compilation was created. For the handbook, 46 types of feature items, mainly vegetation, were surveyed using the following procedures:

- Selection of features as survey targets
- Identification of target features on former topographic maps
- Photography of current-status of features identified on former topographic maps
- Photography of aerial images corresponding to features identified on former topographic maps
- Specification of definitions of feature items and characteristics of aerial photograph images

Photo Interpretation Key for Land Classifications DRE/JICA

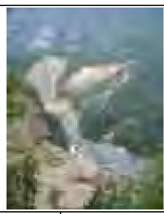
Feature Code	Category of Feature	Feature Item	
7006		Steep slope	
Index No. of Map:	130-4-4	Site Photo	
			
Scale :	1:25,000	Date Taken :	Aug, 2007
Definitions This item should be applied to steep slope topography formed from landslides and such. この項目は、地滑り等の急傾斜地形に適用する。			
Characteristics This item should be easy to decipher when mapping because of the exposed surface. この項目は、地表が露出しているため図化時の判読が容易である。			
Photo No.	2923		
			
Date Taken :	21/06/2007	Photo Scale :	1:25,000

Fig 16：Example of photo interpretation card

(5) Field confirmation

To standardize and unify the evaluation criteria used by each survey team for the feature expressions in the field confirmation, a preliminary joint field confirmation was conducted by all the survey teams. After this field confirmation, each survey team conducted field confirmation based on the results of reconnaissance investigations and photo interpretation. In parallel with the field confirmation, the current-status photographs of the identified feature items required to create a photo interpretation handbook were also taken.

Photo 11：Preliminary photo interpretation by all the survey teams

(6) Request to collect relevant materials

A request was made via DRE to relevant agencies to supply information on the feature items that could not be evaluated in reconnaissance investigation and photo interpretation or field survey. The target feature items were as follows:

- Types and location information of trunk roads (Main Roads and Regional Roads)
- Location information of high-voltage transmission lines (Power Lines)
- Curve information of a long tunnel between Vipazar and Sutomore
- Coordinate results of control points (trigonometric points, GPS control points, etc.)
- Coordinates of mobile antennas
- Data on national borders, administrative boundaries, and national park boundaries
- Annotation data
- Sea-related symbols
- Fountains, wells, water pipes, etc.

3.5.3 Results of Photo interpretation

(1) Executed quantities

The executed quantities of the photo interpretation were as follows:

- Executed area: About 10,000 km^2
- Number of sheets: 92 (1:25,000 framework)

(2) Survey results

1) Result of preparative operations

The prepared operation instructions, including the definitions and application criteria of features to be expressed based on the Spatial Data Infrastructure Specifications, indication methods for survey results, and codes and symbols, proved useful in unifying the survey results.

For the survey, a total of 547 aerial photographs and two sets of 92 former topographical maps were prepared.

2) Organization of survey teams and survey execution period

In joint work with the DRE field survey division, three survey teams, each consisting of four members in principle, were formed to conduct the survey operation.

3) Result of reconnaissance investigation and photo interpretation

The reconnaissance investigation and photo interpretation identified areas of secular change, and features to be confirmed in the field in the printout aerial photos and former topographic maps.

4) Result of photo interpretation handbook creation

The photo interpretation handbook, in the end consisted of 46 feature item interpretation cards, could be effectively utilized for subsequent digital plotting and digital data compilation.

5) Result of field confirmation

Using the aerial photographs for surveying and former topographic maps that indicated the reconnaissance investigation and photo interpretation results, the places to be confirmed in the field were clearly identified, ensuring the execution of an efficient field survey.

6) Result of collection of relevant materials

The relevant materials collected through requests to DRE, ended up as follows:

Table 14：Result of collecting relevant materials

Relevant Material	Supplied by	Description of Material
Trunk roads	DRE	1:250,000 road maps issued in 2007
High-voltage transmission lines	Power company	1:100,000 transmission line management map
Road shape in the Vipazar-Sutomore tunnel	DRE	Road shape plan map
Reference point coordinate results	DRE	List of reference point coordinates
Mobile antenna coordinate results	Mobile phone company	List of Antenna position longitudes and latitudes
National borders, administrative boundaries and national park boundaries	DRE	CAD data
Annotation data	DRE	Annotation data updated from existing maps
Sea-related symbols	DRE	Data in existing maps
Fountains, wells, water pipes, etc.	DRE	Same as above

3.6 Digital Plotting

3.6.1 Description of Operation

Digital plotting of topography and features was conducted using the results of field surveys and aerial triangulation. For the digital plotting, expressions in consideration of characteristics of Montenegro topography (precipitous landform) were adopted. The area of digital plotting was identified using the international boundary data supplied by DRE, and the coordinates in the materials were transformed based on a new ellipsoid and coordinate system before they were used.

3.6.2 Implementing Method

The digital plotting was conducted on a digital plotter using the supplied materials in accordance with the defined spatial data product specifications. The coordinate results were expressed by capturing the XYZ coordinate values on the equipment used.

Care was taken to use similar expressions and symbols for many of the features as in the former maps.

In the plotting of land use data, the data based on "boundary lines" and "representative points" was obtained so that a topological structure would be easier to make in structuring.

The following materials were used to conduct digital plotting.

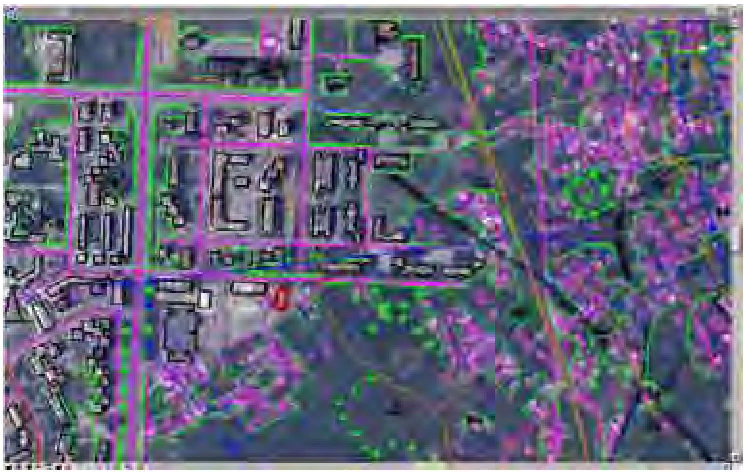


Fig 17 : Making of data on a digital plotter

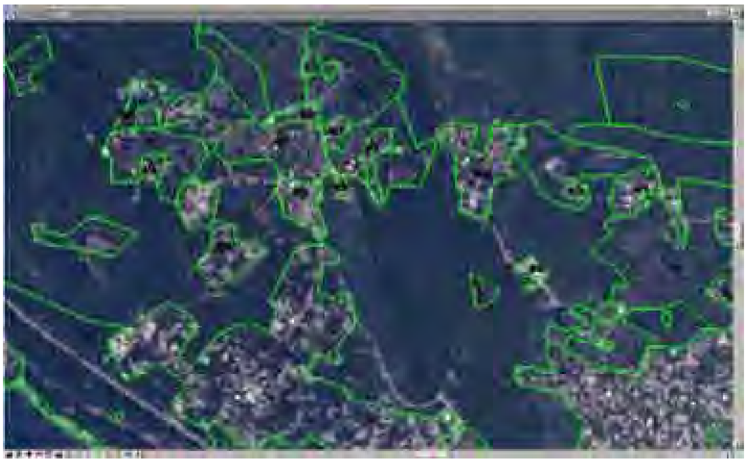


Fig 18 : Image of land use data based on boundary lines and representative points

Table 15 : List of materials

Material name	Purpose of use
Photographs taken in photo interpretation	Reflect all the indicated survey results in the plotting.
1:25,000 former topographic maps	Transcribe the information on some features shown in this material but no longer existent at the time of photo interpretation. Furthermore, refer to this material for any information not shown in other materials.
Road classification map	Refer to this map for information on the classification of main, regional, and local roads.
Tunnel design drawings	For long tunnels that cannot be interpreted, enter data while referring to the design drawings.
High-voltage power line position map	Refer to this map for the position of power lines and reflect them in the plotting.
Coordinate value results	Enter the coordinate values of triangulation points, mobile antennas, and GPS control points.
Interpretation cards	Conduct land use classification while referring to cards which consist of combinations of field photographs, topographic maps, and aerial photographs.
Data on administrative boundaries	Use this as reference material to make data on national borders and administrative divisions.

The data used in the plotting was summarized for each map and visually checked to ensure that there was no excess or omission of data. When there was any excess or omission of data, the plotting data was corrected so that it would not be necessary to start over again in the digital data compilation.

3.6.3 Executed quantities and results

Almost all the items have been turned into data according to the spatial data product specifications. The figure below shows part of the plotting data. One problem was that there were some features for which the land use package could not be interpreted with the interpretation cards alone. This problem was solved by using the "field completion" described later to illustrate the unknown places in the field completion material.

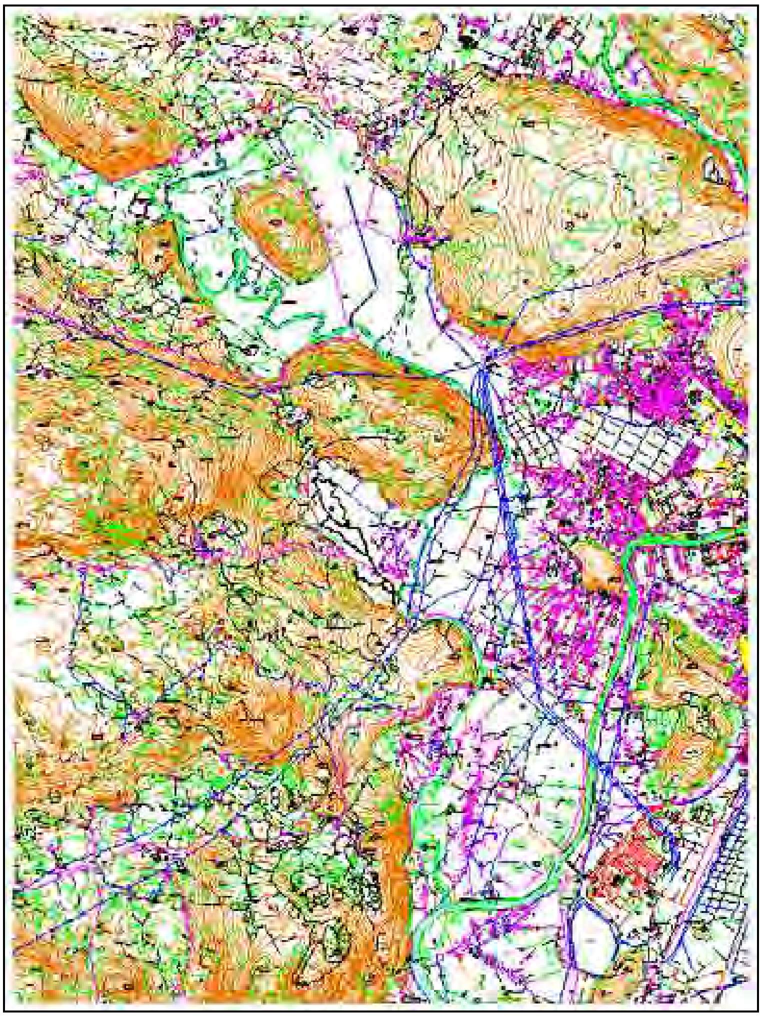


Fig 19：Plotting data (near Podgorica)

3.7 Digital data compilation

3.7.1 Description of Operation

The digital plotting data was edited to represent format rules and structured to make GIS data more efficient.

Format-rule digital data compilation included adjusting the layout and angle of symbols, displacing them, and adjusting the layout of annotations. Structuring included connecting network data, correcting the consistency of topological data of planes, and editing joining.

After digital data compilation, work sheets were created for use in field completion.

3.7.2 Implementing Method

(1) Format-rule editing

Format-rule editing was conducted using CAD software according to the following work procedure:

1) Arrangement and adjustment of symbols

Symbols were added to features obtained through plotting. Features with a direction were provided with angles in accordance with either the topography or former topographic maps.

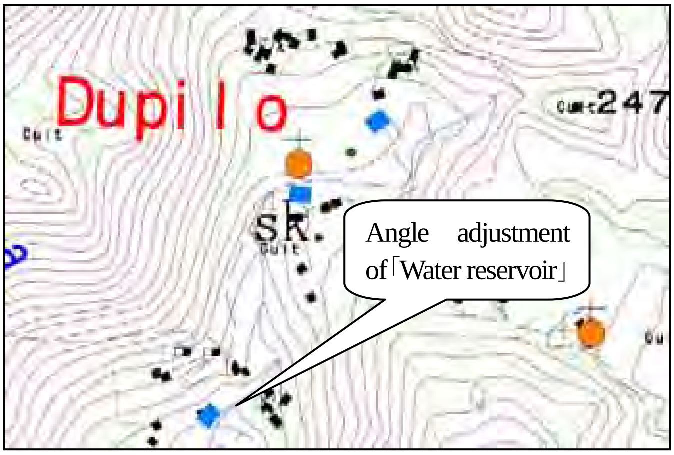


Fig 20：Symbol indication and angle adjustment

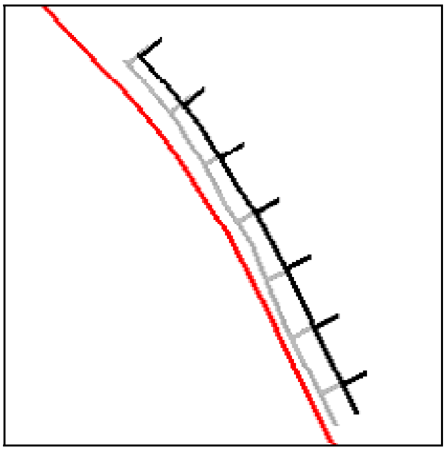


Fig 21：Displacement of slope symbol

2) Displacement

Slope symbols and small low-priority objects that overlapped road and river symbols were displaced. The position of significant features such as roads, rivers, and control points were not displaced in the editing work.

3) Arrangement of annotations

Annotations were created by the Montenegrin side as digital data using CAD software from the former topographic maps. The work in Japan was conducted to capture the annotation data and adjust the sizes and positions of the annotations.

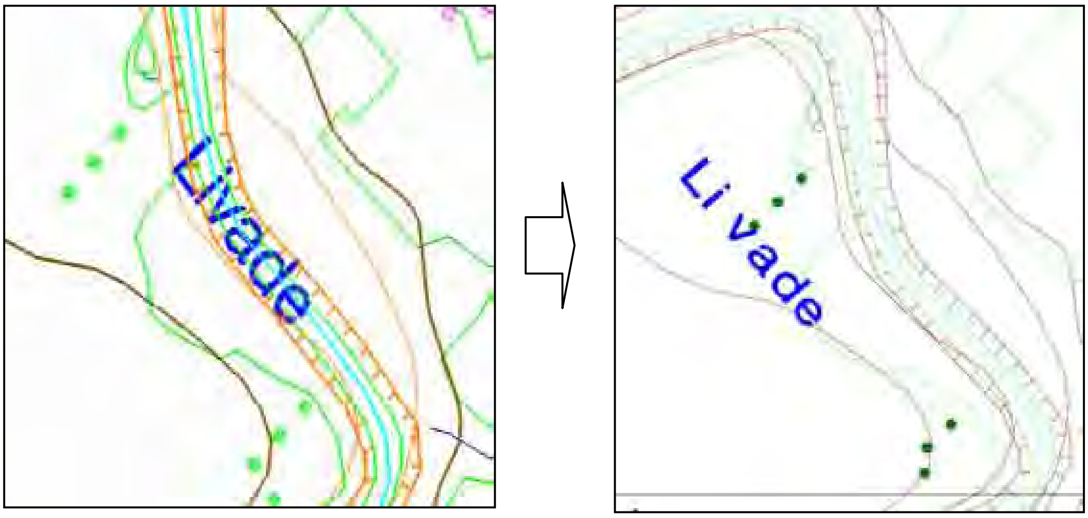


Fig 22 : Displacing an annotation overlapping a river to where it does not overlap other features

(2) Structuring

Structuring was conducted to ensure that none of the following logical errors exist.

Inspection of topological structures:

The following logical inspection of geometric figures was conducted on features defined as figures with correlations.

Item	Explanation
Joining processing	There shall be no un-joined elements.
Undershoot	There shall be no undershoot.
Overshoot	There shall be no dangle.
Areas overlapping	There shall be no impermissible overlapping (e.g. houses).
Consistency of domain classification	There shall be only one code to one domain. The classification shall be consistent between frameworks.
Twisting of lines	There shall be no self-intersection.
Twisting of domain	There shall be no twisted domains.
Data redundancy	There shall be no redundant lines.

Classification accuracy inspection:

Logical inspection was conducted on all of the following items.

Item	Explanation
Validity of feature code	There shall be no undefined code.
Validity of data type	There shall be no undefined data type.

Data editing was conducted in consideration of network data representing not only connections but also non-connections (grade crossings) of roads.

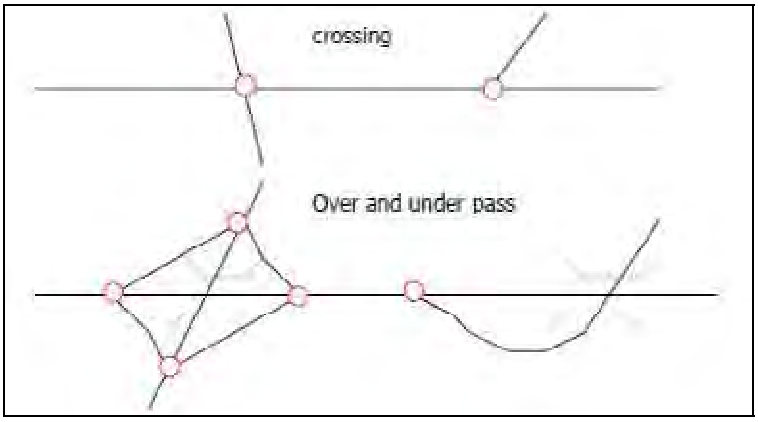


Fig 23：Network data structures

Topological data of planes was created with a structure in which there is always one representative point of a feature within a domain surrounded by boundary lines as shown in the figure below. If, as a result of inspection, there is no representative point or more than one point in the domain, or the boundary lines do not constitute a domain, data was edited to have the correct structure.

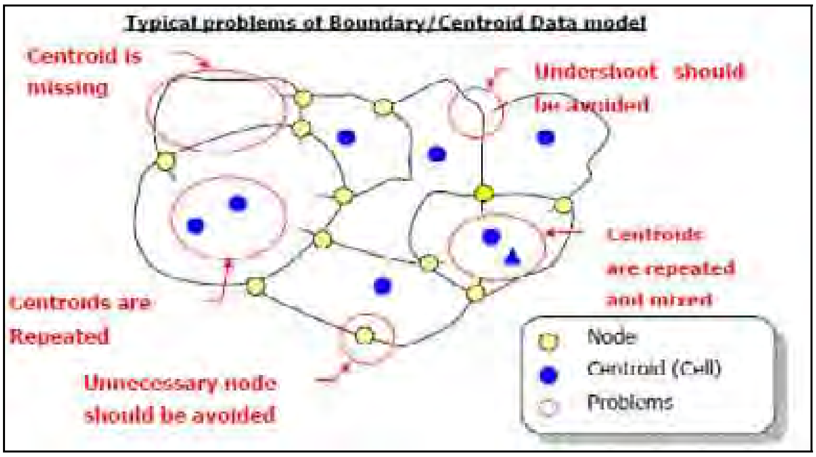


Fig 24：Data structure used to create a topology of planes

(3) Creation of field completion sheets

At the same time as logical inspection during structural editing, edited data was printed and visually inspected. The visual inspection compared the data with the original materials to ensure that there is no excess or omission of data, or defects in format rules and expressions.

The edited data that had been inspected and corrected was used to create field completion sheets. Two versions of field completion sheet were created: the topographic version with which the topography was to be checked; and the annotation version with which the annotations and administrative boundaries were to be checked. The image of a field completion sheet is shown in the following figure. Field completion sheets included questions arising during plotting and editing, and instructions to survey them during field completion.

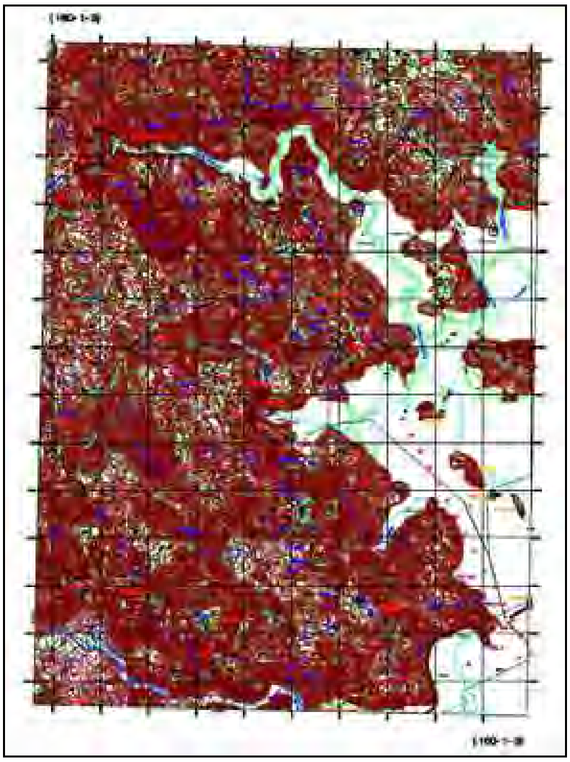


Fig 25：Image of field completion sheet (topographic version)

3.7.3 Executed Quantities and Results

(1) Executed quantities

The work volume and equipment used are as follows:

Executed quantities (Number of planes): 92 (1:25,000 framework)

Editing software: MicroStation V8 (Bentley), NIGMAS (Nihon Computer Graphic Co., Ltd.), PC-Mapping (MAPCOM), and ArcGIS 9.2 (ESRI)

(2) Results

Digital data compilation was completed according to the spatial data product specifications. One problem was that, due to a short work period before field completion, field completion sheets were created before the digital data compilation process was completed. It was decided to solve this problem by pointing out the defects of digital data compilation during field completion and making necessary corrections in the digital data compilation for field completion process.

3.8 Field completion

3.8.1 Description of Operation

Field completion is a process in which unknown and uncertain map expression items found during digital plotting and digital data compilation are additionally observed and corrected on plotted field completion maps. Furthermore, the study team requested DRE again to supply map-related materials not yet supplied at the time of the photo interpretation (annotation materials, boundary materials, coordinate results for existing reference points, location information of transmission lines, etc.). Although there was difficulty in obtaining some of the materials during the survey period, the operation was successfully completed in the end, thanks to the responses after field completion.

3.8.2 Preparation of Materials

An instruction manual in Montenegrin was prepared to facilitate understanding of the basic procedures of field completion by the counterpart agency.

Table 16 : Creation specifications for reference maps

Material map	Creation specifications	
Additional-observation map	1	Created by showing the data of all the feature items except for border data in consideration of the field survey
	2	Shows part of the vegetation symbols, etc. in a simpler form according to the purpose of additional observation
Annotation material map	1	Created by capturing the annotation data entered by DRE based on the former topographic maps and the plotted and edited feature data
	2	Created by hiding the contour line data in consideration of the inspection of annotations in the maps
	3	Shows the annotations with codes so that the annotation types are easier to see
	4	Shows each of the annotation types by the size and color in the annotation specifications

Two types of reference maps for field completion were created: field completion maps to be used mainly in the field for topography and feature survey; and the annotation reference maps to be inspected for updating annotations. Two copies each of these types were printed out. Each of the reference maps was created to meet the following specifications in accordance with the purposes of field completion.

3.8.3 Discussion with DRE

To carry out the survey smoothly and effectively, the study team discussed the following items with DRE:

- Organization of study teams (four teams consisting of three DRE members for field completion and one DRE member for annotation inspection)
- Explanation and adjustment of the survey schedule, etc. (the survey period was from mid-June to mid-July 2008).
- Methods for field completion and annotation inspection

3.8.4 Methods and Implementation of Field completion

Field completion was carried out by each of the following four categories into which the process had been classified depending on the result of the preliminary inspection of field completion maps and extraction of data after digital plotting and digital data compilation.

- Solution of questions arising during plotting and digital data compilation
- Clarification of unknown points extracted in the preliminary inspection by the field completion teams
- Update and inspection of annotations
- Update and inspection of administrative boundaries, etc.

(1) Solution of questions and unknown points

The questions arising during plotting and digital data compilation, and the unknown points in the field completion maps extracted in the inspection by the field completion teams were surveyed. While clearing up the causes and reasons for them with the counterpart agency, the study team instructed the counterpart agency in the evaluation criteria used to determine whether, photo interpretation or comparison with the former topographic maps is sufficient, or whether field completion is required for clarification.

Photo 12：Additional confirmation of feature expressions

Photo 13：Inspection of place names on annotation reference maps

(2) Update and inspection of annotations

Since annotation data created based on the annotations on the former topographical maps had not yet been inspected by DRE after the photo interpretation, a request was made to DRE to update the annotations. The inspection required for annotation update was requested based on the annotation type code table in the format rule specifications. The inspection was conducted with emphasis on the following three points:

- Checking whether the spelling and the position of annotations on the map were appropriate
- Checking whether the classification codes assigned to annotations were correct

- Checking the effectiveness of annotations after secular changes (such as the names of new or deserted villages)

(3) Update of boundary data

The latest CAD data on the administrative boundaries including national borders and national park boundaries, after being received from DRE, was plotted on the field completion maps and, after being inspected by DRE, was updated during digital data compilation for field completion.

3.8.5 Results of Field completion

In field completion, DRE and the study team acquired the following results:

- Field completion maps showing the field completion results: 92 sheets (1:25,000 framework)
- Annotation reference maps inspected by DRE: 92 sheets (1:25,000 framework)

3.9 Digital data compilation for field completion

3.9.1 Description of Operation

Digital data compilation for field completion was conducted using the digitally edited data file and field completion result. The compilation consisted of the following: addition of administrative boundaries, missing features, and control points; correction of type, annotations, and defects in digital data compilation; and visual and logical inspection.

3.9.2 Implementing Method

The implementing method is as shown in the following table:

Table 17：Implementation method for digital data compilation

Work item	Explanation
Correction of field completion sheets (topography)	Addition of lacking features: Missing features pointed out in field completion were entered on the plotter. Correction of type: Feature types pointed out in field completion were corrected in editing.
Correction of annotations	Annotations pointed out in field completion sheets were corrected regarding type and spelling.
Additional information of control points, etc.	National borders: Official maps managed by Montenegro were scanned and entered. Existing triangulation stations: The data was replaced with the official data managed by DRE.
Visual inspection	Using the output sheets, the editing items in digital data compilation for field completion were checked.

Work item	Explanation
Logical inspection	In the same way as for the inspection conducted on digital data compilation, the topological structures and the classification accuracy were inspected.

The data that underwent digital data compilation for field completion described in the above was converted into data formats optimal for "GIS structuring" and "map symbolization."

3.9.3 Executed Quantities and Results

(1) Executed quantities

Executed quantities (number of sheets): 92 (1:25,000 framework)

Equipment used: MicroStation V8 (Bentley), NIGMAS (Nihon Computer Graphic Co., Ltd.), PC-Mapping (MAPCOM), and ArcGIS 9.2 (ESRI)

(2) Results

Items specified on the field completion sheets were corrected. At this point, the defects in digital data compilation were able to be corrected. One problem was that DRE first supplied imperfect data on the triangulation points and national borders and, at this point, correct data was supplied and re-entered. This was expected to cause a delay in the start of the map symbolization process. As a solution, the map symbolization process was advanced with other data, in order to lessen any delay in the process.

3.10 GIS Structuring

3.10.1 Description of Operation

Data files that underwent digital data compilation for field completion includes all the items required for a spatial data infrastructure. This data set was converted into ArcInfo Coverage format, as specified in the spatial data product specifications, and stored. This work process consisted of input of thematic attributes, and creation of an ArcInfo geo-database, topological structures, and of ArcInfo Coverage data.

3.10.2 Implementing Method

(1) Input of thematic attributes

Annotation and history information were stored as thematic attributes in the figure data. The annotation information was entered in the attribute field of figures manually, while referring to the positional relationships with the features to be annotated.

	FID	Shape	Entity	Layer	mName	item	history
	0	Point ZM	Text	8014_hill	Petilje	8014	200903
	1	Point ZM	Text	8014_hill	Grbavac	8014	200903
	2	Point ZM	Text	8014_hill	Tor	8014	200903
	3	Point ZM	Text	8014_hill	Stepen	8014	200903
	4	Point ZM	Text	8014_hill	Pja`dol	8014	200903
	5	Point ZM	Text	8014_hill	Kapa	8014	200903
	6	Point ZM	Text	8014_hill	V.Raſ	8014	200903
	7	Point ZM	Text	8014_hill	Br"elice	8014	200903
	8	Point ZM	Text	8014_hill	Vis	8014	200903
	9	Point ZM	Text	8014_hill	Humac	8014	200903
	10	Point ZM	Text	8014_hill	M.Raſ	8014	200903
	11	Point ZM	Text	8014_hill	V.brijeg	8014	200903
	12	Point ZM	Text	8014_hill	Srednje brdo	8014	200903
	13	Point ZM	Text	8014_hill	"elo	8014	200903
	14	Point ZM	Text	8014_hill	Brdo	8014	200903
	15	Point ZM	Text	8014_hill	M.vis	8014	200903
	16	Point ZM	Text	8014_hill	Ostrik	8014	200903
	17	Point ZM	Text	8014_hill	Veljigrad	8014	200903
	18	Point ZM	Text	8014_hill	Obida	8014	200903
	19	Point ZM	Text	8014_hill	Glavoc	8014	200903

Fig 26 : Part of entered thematic attribute

(2) Creation of ArcInfo geo-database

Feature data was stored into the ArcInfo geo-database in order to create topological structures. Since a geo-database with topological structures enables various processes, it was decided to create one before creating ArcInfo Coverage data, and assign it to Coverage data in a one-on-one relationship. An ArcInfo Shape file was also created from the geo-database.

(3) Creation of topological structures

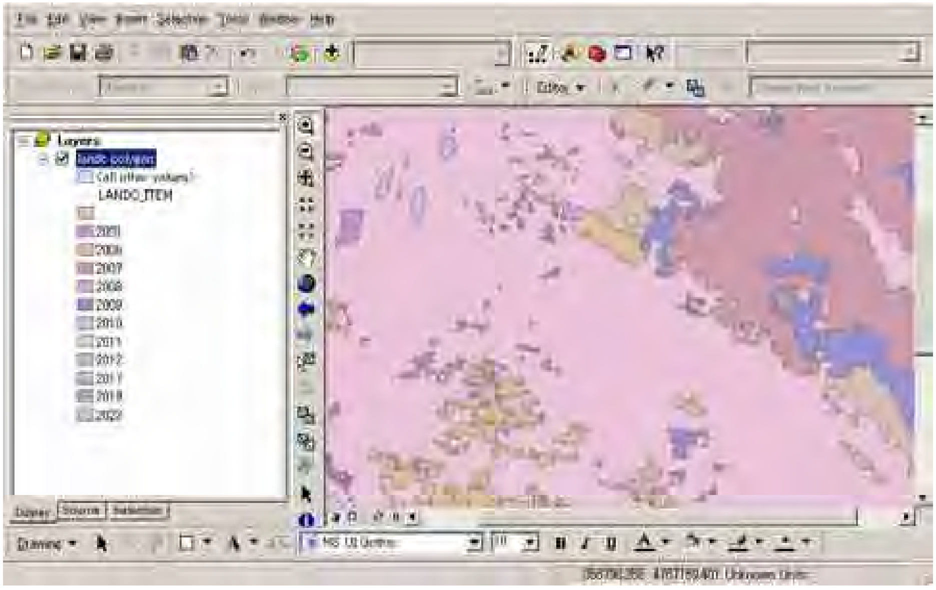


Fig 27 : Creation of topologies of land use data

Topological structures were created for features that required network structures and topological structures of planes. Errors resulting in failure to create of topological structures were corrected at this point.

(4) Creation of ArcInfo Coverage data

ArcInfo Coverage data was created from the geo-database for which topological structures had been created. After Coverage data was created, meta data was created for each data set.

3.10.3 Executed Quantities and Results

(1) Executed quantities

Executed quantities (number of sheets): 92 for Coverage data set (1:25,000 framework) and 92 for meta data

Equipment used: ArcGIS 9.2 (ESRI)

(2) Results

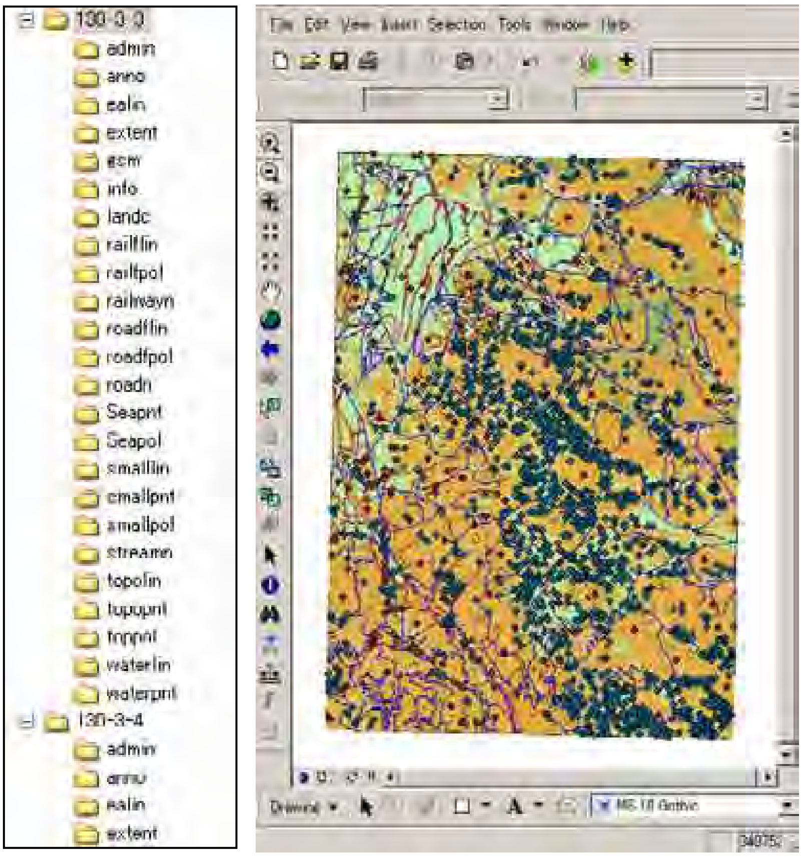


Fig 28：ArcInfo Coverage data and display on ArcGIS

A GIS database based on the spatial data product specifications was created successfully. One problem was that the GIS database had to be corrected regarding the defects discovered in the topographical maps in terms of map symbolization. However, the data was corrected relatively easily because the map symbolization work was proceeding ahead of the schedule. Part of the ArcInfo Coverage data that was created is shown in figure 28.

3.11 Map Symbolization

3.11.1 Description of Operation

In the course of GIS structural editing, map data for printing with a scale of 1:25,000 was created using digital topographic map data, for which the necessary map symbolization processing was completed. The scope of the created map data was about 70% of Montenegro and 92 map sheets.

3.11.2 Implementation Method

From the developed digital topographic map data, map printing data consisting of vector data files put into layers according to map symbol number for each map was created.

(1) Map layers

Files representing layers for each map symbol number were modified by generating and processing line widths, colors, symbols, patterns, and annotations in accordance with the format rule specifications for spatial data infrastructure. This process also included, in consideration of the map expressions: correcting the vertical relationships of layers, adding layers, and displacement and fine-tuning of objects.

(2) Marginal data

Fig 29：Marginal data

Fig 30：Synthesis of map layers and marginal data

This process used marginal data that had been determined through discussion with DRE at the time of map symbolization work in Montenegro. Map data and marginal data were synthesized, and information such as map numbers and titles were entered for each of the maps in order to complete map-by-map printing data.

(3) Correction

The completed map printing data was printed with a plotter, and the printouts were inspected for topographies, annotations, etc. When the inspection found that something needed to be revised, it was immediately corrected in the printing data. This correction process was repeated three times per map on average until flawless printing data was available.

3.11.3 Executed Quantities and Results

(1) Executed quantities

Map data for printing (topographic maps + marginal data): 92 sheets

(2) Results

1) Details of results data

- File format: PostScript file (Adobe Illustrator CS3 format)
- Colors used (Map layer): 10 (Black, Gray, Red, Orange, Blue, Light Blue, Green, Light Green, Yellow, and Brown)
- Color mode: CMYK (four-color printing mode)
- Finished size (including marginal data): 700 mm vertical × 700 mm horizontal (partly 800 mm × 700 mm expanded map)

Chapter4 Technology Transfer and Evaluation

This study, as described in Chapter 3, "Development of Spatial Data Infrastructure," does not require the Japanese study team to develop a spatial data infrastructure for all the areas, but assigns the responsibility for developing for 30% of the area to DRE. The technology transfer required for implementation of the survey on this 30% and for independent development in the future, is an important element in this study. To ensure the technology transfer, JICA provided the necessary equipment such as GPS receivers, digital photogrammetry system, map symbolization and GIS software, etc., and carried out a series of technology transfers related to the development of a spatial data infrastructure.

The technology transfer operation was conducted mainly as joint work (on-the-job training: OJT) and also as training (lectures and practical training).

Since the field survey division of DRE already owns nine advanced GPS-based reference stations, and has a high level of technology in the control point survey and cadastral survey sectors, the technology transfer was focused on the utilization of these GPS-based reference stations and the sectors required for spatial data infrastructure development, for which the organization has had little experience in the past. Lectures and other training were limited to the initial step of each operation, and most of them were provided by the Japanese experts on an OJT basis. The operations, as shown below, were limited to ground surveys needed in the survey process for the spatial data infrastructure development, such as how to install pricking points in the control point survey, measure eccentric elements, and conduct photo interpretation and related field completion.

On the other hand, the photogrammetry division carries out the main operations in the creation of the digital topographic maps and GIS database, using the ground survey results obtained as described above and the aerial photographs. This division was provided with technology transfer programs consisting of lectures and practical training for the entire set of operations and, using the technology obtained in this process, created two sheets of spatial data infrastructures in the study area on an OJT basis.

The DRE photogrammetry division already has abundant experience in creating background maps required for cadastral management, and large-scale maps such as 1:5,000 and 1:2,500 required by relevant government agencies and local authorities to establish development plans, and therefore had the basic technology for developing a spatial data infrastructure. However, there are few engineers experienced in the creation of small-scale topographic maps, which was consigned to the former Yugoslavia Government until independence in 2006. Additionally, the construction of a GIS database is included in the technology for a spatial data infrastructure. Therefore, many hours were spent on the technology transfer in this sector, as it is important and indispensable technology for independent development in the future.

To further enhance the effect of this technology transfer, four engineers (two from DRE and two from DSP) received training in Japan for about four weeks from August to September, 2008. This training had a significant effect in deepening the understanding about the applications of advanced technology promoted by Japan, the necessity of spatial data infrastructures used for them, their effective utilization, and so forth.

On the other hand, DRE has its own aircraft, cameras, and photo processing laboratories, and took aerial photographs to be used for this study using the materials supplied by JICA, and conducted joint work with the study team. Since the photographers and other crew members had sufficient experience in these tasks, emphasis was not put on technology transfer, but on accuracy control.

Technology transfer to the field survey and photogrammetry divisions, and its evaluation are described in the following sections.

4.1 Setting of Pricking Points and Measurement of Eccentric Elements (Photo Control Point Survey)

4.1.1 Description of Technology Transfer

Aerial photographs in this survey were taken with cameras not equipped with three-dimensional positioning equipment such as POS (Position and Orientation System). Therefore, the accuracy of the photo control point survey depends on the ground survey and largely affects the quality of spatial data infrastructure.

In particular, the most important technology in the first step of photogrammetry is to interpret aerial photographs that have been taken, and identify clear features that can be used as photo control points. Technology transfer in this study was conducted on an OJT basis after the study team and DRE discussed the following items, and both the parties understood each other.

(1) Target technologies in technology transfer

Since the engineers of DRE had a sufficient technical level in consideration of DRE's experience in cadastral and road surveys, the technology transfer conducted in the actual work of photo control point survey included, how to select spare points using aerial photographs, and how to observe eccentric elements.

The technology transfer in the first phase was conducted in a period after the installation of aerial photo signals at GPS control points, and before the start of aerial photography, by explaining the necessity of working around failures of aerial photo signals, and instructing through joint work based on OJT the importance of spare points to be installed in case aerial photo signals could not be clearly identified in photographs, and how to measure their eccentric elements. In the technology transfer, the following three observation methods were used due to constraints of DRE survey equipment.

1) Observation method through DGPS survey

The observation method of Differential GPS (DGPS) was instructed on an OJT basis by using the two

GPS receivers owned by DRE, installing one at an existing ground control point, and the other at its eccentric point, which is a spare point. In this operation, the geometrical coordinates of the spare point were measured in simultaneous GPS observation for about 15 minutes, and then the planimetrical coordinates were calculated using DRE's GPS analysis software.

2) Observation method through RTK GPS survey

This is the latest survey method based on GPS-based reference stations installed in Montenegro using one of the RTK GPS survey receivers supplied to DRE as survey equipment. With nine GPS-based reference stations already installed in Montenegro, and the transmission of positional compensation data started, observation for about 20 seconds was conducted based on the compensation information. As a result of the initial inspection survey of 16 existing GPS control points, a high accuracy in terms of standard deviation of 15 mm in horizontal location. and 29 mm in elevation was confirmed. The application of this observation method in the photo control point survey in the second phase of this study will achieve a significant effect in enhancing the operations of DRE in the future.

Photo 14：GPS-based reference station on the roof of Pljevja city office

Photo 15：Inspection survey of existing control point using RTK GPS

3) Observation method using TotalStations

This is a conventional survey method using TotalStations owned by DRE. This method can be used if the main ground control point and another ground point required to determine the azimuth are both visible by observing the eccentric elements (horizontal angle, horizontal distance, and relative elevation difference) to obtain the coordinates of a spare point. In Montenegro, where an azimuth marker (reference point) is installed on most of the major mountaintop towers, churches, and antennas, the eccentric elements of a spare point can be easily measured for any of these reference points. The technology transfer progressed smoothly thanks to the necessary conditions, such as those above, being already met, and the counterpart organization had abundant experience in this kind of operation from cadastral surveys, etc.

4.1.2 Evaluation

The DRE engineers have abundant experience in ground surveys, and quickly understood the observation methods for eccentric elements of spare points in aerial photographs, showing a high level of capability for ground surveys. However, it turned out that there was room for improvement in the GPS analysis, calculation, and other tasks after observation, which became apparent when there was a delay in obtaining some of the coordinate results because different groups were in charge of them.

From the results of the technology transfer in this study, it is desirable to reconfirm the technical capability in each of the planning, observation, and calculation processes, promote further efficiency and quality control of the ground survey operations, and improve them as tasks of the field survey division.

4.2 Photo Interpretation Using Enlarged Photographs and Result Summary

4.2.1 Description of Technology Transfer

Photo interpretation requires the field survey division and photogrammetry division to be in close collaboration, so it is extremely important that accurate and reliable survey results are confirmed in the field, and successfully conveyed to the plotting operators in the photogrammetry division, which they then use as elements for creation of spatial data infrastructures. Therefore, the technology transfer was conducted taking into consideration the following items, to guarantee that they were acquired:

- Understanding of new spatial data product specifications established for the implementation of this study
- Mastering the method of implementing photo interpretation according to the specifications
- Mastering the method of summarizing the results of photo interpretation

The actual operations of the technology transfer were conducted after the study team and DRE discussed and agreed upon the following items.

(1) Target technologies in technology transfer

- Method for accurately indicating on aerial photographs the area of survey including joining with adjacent photographs
- Survey method using symbols and code numbers
- Method for displaying the survey results on aerial photographs
- Method for summarizing the survey results

(2) Methods

OJT was selected as the main method for technology transfer because it was to be conducted in parallel with the actual survey operations during the field survey period. Before the start of the actual operation and technology transfer, lectures on the following items were given and then discussed:

- Format rule specifications for photo interpretation
- Process control for photo interpretation
- Method of photo interpretation

Photo 16：Scene of technology transfer in field survey

4.2.2 Evaluation

The survey engineers who participated in the OJT-based technology transfer were middle-ranking engineers who had much experience in cadastral and boundary surveys, etc., and were quick to understand the photo interpretation method that was the subject of the technology transfer, and are considered to have attained the initial goal. Based on the experience of the technology transfer and the survey results, they will be fully capable of carrying out photo interpretation work on the 30% of the country for which DRE is responsible.

Their future tasks will be to deepen the technical collaboration between the ground survey and photogrammetry divisions, to standardize the photo interpretation and survey results among engineers, and to disseminate the transferred technologies to other engineers to enhance the photo interpretation method based on the spatial data product specifications.

4.3 Aerial Triangulation, DEM Generation, and Contour Line Generation

4.3.1 Description of Technology Transfer

The final goal of the technology transfer is that DRE is capable of constructing 1:25,000 spatial data infrastructures independently. Its accuracy largely depends on aerial triangulation, whose goal is to conduct the processes from preparation to obtaining results and, based on the results, DEM generation, editing, and contour line generation without problems. The following items were discussed between the study team and DRE.

The technology transfer was targeted at two middle-ranking engineers so that DRE could carry out the operations by itself after the technology transfer was completed. However, other members of the organization were also allowed to attend the lectures for technology transfer, and the evaluation of the technology transfer was confirmed by testing the two engineers that were selected. Thus, an environment was provided in which other members could acquire the technologies when they wished.

(1) Target technologies in technology transfer

- Operation procedures for the digital photogrammetry system (LPS_CORE, LPS_ORIMA, LPS_ATE, and LPS_TE)
- Aerial triangulation
- DEM generation and editing
- Contour line generation

(2) Methods

The technology transfer was conducted in the form of lectures and practical training on areas with optimal allocation of reference points selected from the photography results completed at the start of technology transfer. For the scope of work of which DRE was in charge, the effects were evaluated by having the DRE members conduct aerial triangulation for 98 models and DEM and contour line generation on two sheets as OJT.

Photo 17：Technology transfer on aerial triangulation

(3) Executed items and descriptions

- Method of capturing control point data required for aerial triangulation and creating index maps
- Method of creating aerial triangulation projects, setting up software, and of conducting interior orientation
- Method of stereographic-view observation of coordinates such as control points and automatic mutual orientation
- Method of bundle adjustment, error correction, report reading, etc.
- Method of setting up DEM generation for various topographies and making large-scale DEMs
- Method of correcting DEMs on stereo models and entering break lines
- Method of generating contour lines from a DEM and outputting data in a data file format of editing software

4.3.2 Evaluation

DRE conducted aerial triangulation by itself in the two months between the end of the first-phase technology transfer and the start of the second-phase technology transfer. As a result, DRE was considered to have the technical capability required to carry out aerial triangulation independently.

Additionally, fact-finding surveys (questionnaire and test formats) on aerial triangulation were conducted in DRE, which showed that many staff members were capable of carrying out aerial triangulation (see charts (1), (2), and (3)). From this result, the technical level of DRE was found to be high enough to carry out the operations. However, it also turned out that the staff members had little experience in using the new equipment supplied by JICA (see charts (4) and (5)).

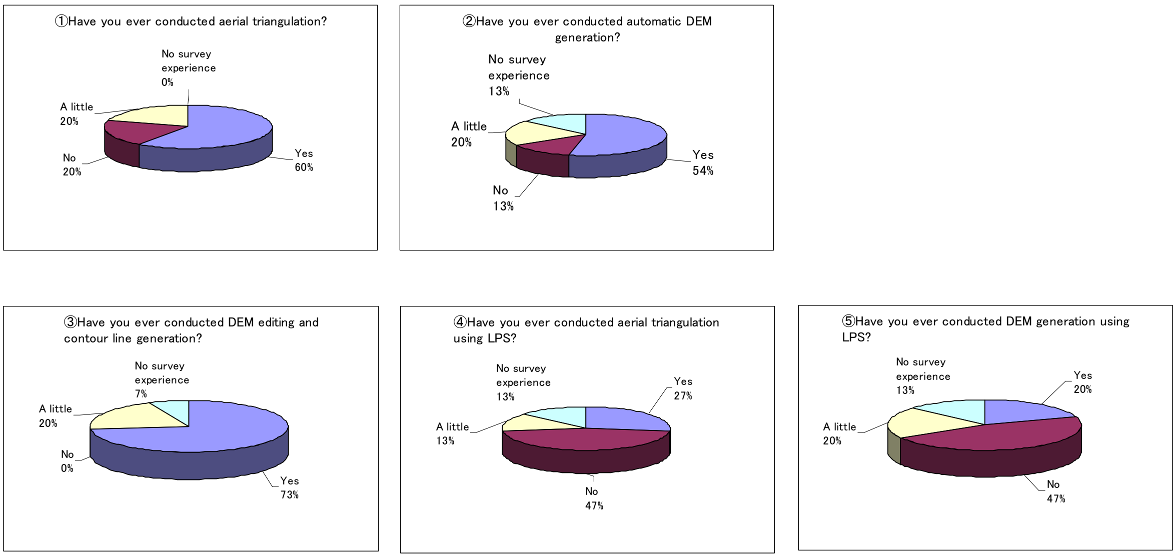


Fig 31 : Results of questionnaire survey and test on aerial triangulation and DEM contour line generation

4.4 Digital Plotting

4.4.1 Description of Technology Transfer

The technology transfer was targeted at two plotting operators so that DRE could carry out the operations by itself after the technology transfer was completed. However, other members of the organization were also allowed to attend the lectures for technology transfer, the results of which were evaluated by testing the chosen two operators. Thus, an environment was provided in which other members could acquire the technologies when they wished.

(1) Target technologies in technology transfer

- Digital plotting
- Inspections (logical and visual inspections)

(2) Methods

The technology transfer was conducted in the form of lectures and practical training using models used in the technology transfer for aerial triangulation. OJT was adopted for the digital plotting and data compilation regarding the scope of work of which DRE was in charge (two sheets).

(3) Executed items and descriptions

- Method of using stereo models, index maps, and materials required to conduct digital plotting, and using digital plotter applications and feature tables
- Method of plotting road facilities and railroad facilities based on understanding of the importance of agreement of end points and other items important for the creation of a network structure
- Method of plotting rivers, lakes, and marshes, and sea features (particularly on the importance of continuity for rivers because network structuring is adopted for them in the same way as for roads and railroads)
- Techniques for plotting topographic expression items other than contour lines with an emphasis on the expression of rock cliffs of which there are many in Montenegro
- Method of plotting small objects such as buildings
- Method of expressing with symbols the small features difficult to identify in photo interpretation while referring to materials and former topographic maps
- Method of printing plotted data and visually inspecting them for omissions and excessive plotting using materials and aerial photographs
- Method summarizing and managing survey results in accuracy control sheets

4.4.2 Evaluation

The technology transfer was conducted, as in the technology transfer for aerial triangulation, mainly in the form of lectures and practical training using actual data. However, the persons in charge had experience in digital photogrammetry and were quick to understand the operations without problems. Fact finding surveys (questionnaire and test format) into the state of numerical plotting within DRE, found that many members have numerical plotting experience (see charts (3), (4) and (5)). As the make up of participants when the questionnaires were held may not have been entirely appropriate, there may be some discrepancies in the results, but the evaluation was that there were few employees with an understanding of the specifications of products used in this field (see charts (1) and (2)). Knowledge of specifications is indispensible for preparing a 1:25,000 spatial data infrastructure, but it is difficult to teach this to all of the employees carrying out this work.

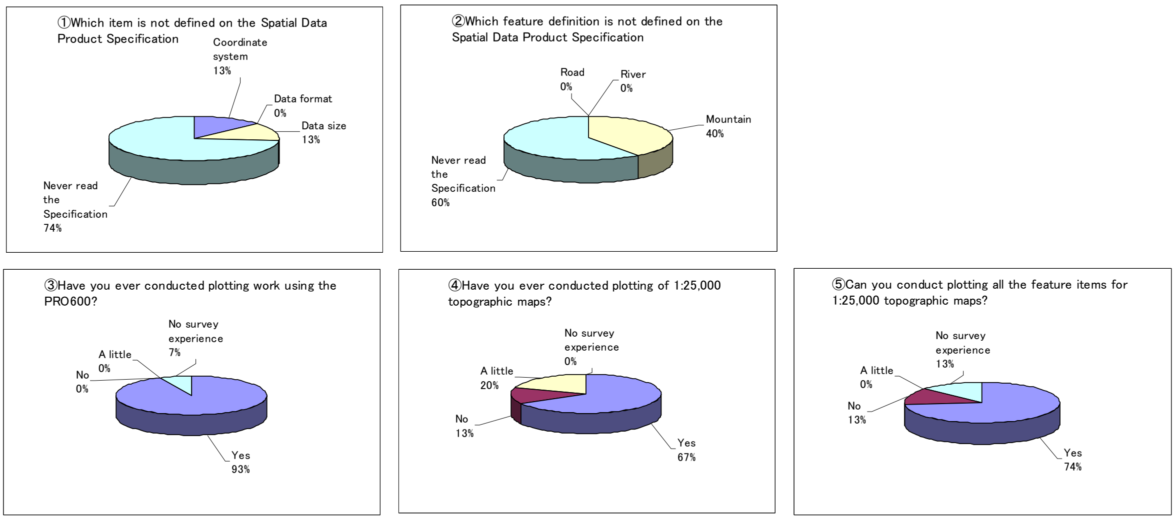


Fig 32：Results of questionnaire survey and test on digital plotting

4.5 Digital Data Compilation

4.5.1 Description of Technology Transfer

The technology transfer was targeted at two young engineers who understood the spatial data product specifications, because consideration must be given not only to editing for symbolization, but also structuring. However, these engineers had little experience in symbolization editing, so the counterpart organization members specializing in digital plotting also participated as supporting personnel.

(1) Target technologies in technology transfer

- Digital data compilation
- Inspections (logical and visual inspections)
- Creation of field completion sheets

(2) Methods

The technology transfer was conducted in the form of lectures and practical training actually using the system. OJT was adopted for the digital data compilation regarding the scope of work of which DRE was in charge (two sheets).

Photo 18：Technology Transfer of digital data compilation

(3) Executed items and descriptions

- Handling of substandard data and excessive data

- Displacement of features related to roads and railroads (such as slopes), transfer of symbols in case of overlapping, editing the orientation of features with orientations
- Method of editing data of network structures such as roads, railroads, and rivers, for which it is necessary that the lines consisting them should be connected with each other
- Method of editing data that needs topological structures of planes such as land uses, which requires that there should be boundary lines and only one representative point within a domain surrounded by the boundary lines
- Method of joining with other maps
- Method of editing contour lines created from DEMs
- Method of entering and editing annotations and control point values to be created during editing
- Method of logical inspection of data types (plane, line, point, and annotation), logical inspection of network data and land uses (topological data of planes), and other general logical inspection (self-intersection of lines, etc.)
- Method of visually inspecting digitally edited data by printing and comparing it with original materials
- Method of creating field completion sheets by printing digitally compiled data and writing on the printouts survey instructions of unknown points identified up to this process
- Method of summarizing and managing survey results in accuracy control sheets

4.5.2 Evaluation

The digital data compilation was completed mostly without problems regarding the two sheets on which DRE worked in the technology transfer. In order to complete the remaining 30% accurately, it is necessary to appoint staff, besides the operators as inspectors, and to prepare a work environment where they can inspect separate from the other operators. As a result of a questionnaire survey and a test, it was found that few staff members were capable of carrying out digital data compilation for a GIS database (see charts (1), (2), and (3)). Furthermore, it also turned out that the staff members had little experience in conducting inspections, such as visual and logical inspections, on the created data (see charts (4), (5), and (6)).

The suggested solution is often conducted in Japan and does not imply that there is anything special about DRE. Inspections conducted by persons other than the operators are considered to ensure elimination of defects in data.

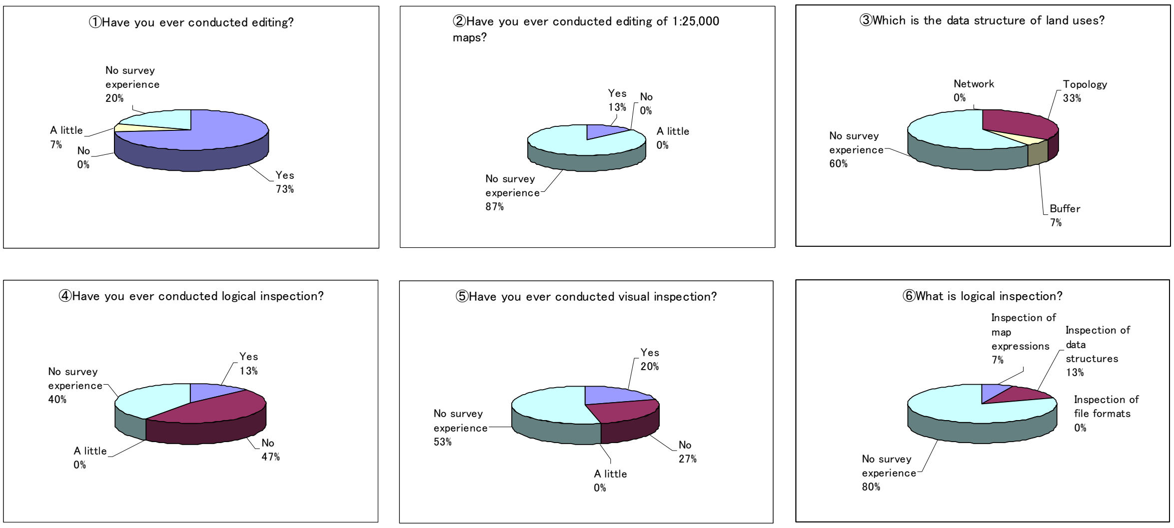


Fig 33：Results of questionnaire survey and test on digital data compilation

4.6 Field completion

4.6.1 Description of Technology Transfer

The main goal of the technology transfer was that the counterpart organization members specializing in ground survey improve their capability for reading basic topographic maps, improve the understanding of feature items to be surveyed, and deepen their understanding of the surveys in the entire field completion.

The characteristics of secular changes in feature information on the former topographic maps developed about 30 years ago, and the map expressions used in those times were checked and utilized for the technology transfer. On the other hand, the field completion required that the uncertain and unknown points on the maps for field completion must be cleared quickly and effectively. The technology transfer was conducted by instructing the required survey and inspection procedures on an OJT basis.

(1) Target technologies in technology transfer

- Method of extracting unknown and uncertain expression items on maps for field completion and inspecting them
- Characteristics of target feature items in field completion
- Method of putting map symbols and code numbers on maps for field completion
- Method of inspecting annotation reference maps by comparing them against annotations on former topographical maps

(2) Methods

The technology transfer was conducted on an OJT basis to improve the understanding of the survey manuals and format rules and carry out technology transfer to counterpart organization members in each team.

4.6.2 Evaluation

Through the OJT-based field completion conducted on topography and features, the method of inspecting field completion maps and field confirmation are considered to have been understood. The future tasks of DRE will be to devise by itself common specifications and methods based on the spatial data product specifications and the survey manual, and to make improvements in the organization, including the photogrammetry division. Furthermore, it is desirable for the engineers who were engaged in the operation to pass on the experience of this operation to other engineers.

Photo 19：Technology transfer on the feature inspection method

On the other hand, the inspection on annotations was conducted through discussion based on the annotation reference maps and the survey manual. The engineers in charge had a good knowledge of place names, geography, and history throughout Montenegro so that the technology transfer was more effective than otherwise. However, the annotation reference maps used in the inspection, created by the photogrammetry division based on the existing maps, had not been fully checked and therefore had to be re-inspected by the field survey division during the field completion.

Their future tasks will be to enhance the collaborative survey and inspection system between the two divisions in order to improve the efficiency of field completion and the quality of the digital topographic maps.

4.7 Digital data compilation for field completion

4.7.1 Description of Technology Transfer

The practical skills used to enter the results of field completion in the digitally edited data and complete it as a product and the digital data compilation for field completion regarding the creation of input data for map symbolization were instructed in the OJT-based technology transfer. The technology transfer of this operation, being mostly the same work as digital editing, was targeted at two persons who had conducted digital editing, and the counterpart members specializing in digital plotting also participated as supporting personnel.

(1) Target technologies in technology transfer

- Digital data compilation for field completion
- Creation of input data for map symbolization
- Creation of input data for GIS structuring

Photo 20 : Technology Transfer on digital data compilation for field completion

(2) Methods

The technology transfer was conducted in the form of lectures and practical training. OJT was adopted for the digital data compilation for field completion regarding the scope of work of which DRE was in charge (two sheets).

(3) Executed items and descriptions

- How to read field completion sheets
- Digital editing in accordance with the instructions on field completion sheets
- Method of creating digital editing data on which field completion is completed before passing the data to the next process
- Method of writing and managing survey results in accuracy control sheets
- Method of creating input data for "map symbolization" and "GIS structuring"

4.7.2 Evaluation

Surveys in the questionnaire and test formats were conducted, and the results showed that the operation of digital data compilation for field completion had never been conducted in DRE (see charts (1) and (2)). Likewise, it also turned out that the DRE staff had little experience in conducting the operation using GIS software (see charts (3), (4), and (5)).

When the GIS structuring or map symbolization process was started, some defects, although minor ones, were found in the data created in the technology transfer. However, the digital field completion process was completed without problems regarding the two map sheets which DRE was in charge of in the technology transfer. Although these kinds of errors may occur in the future, it is considered that it is easy to deal with them if the operators collaborate with each other in the process.

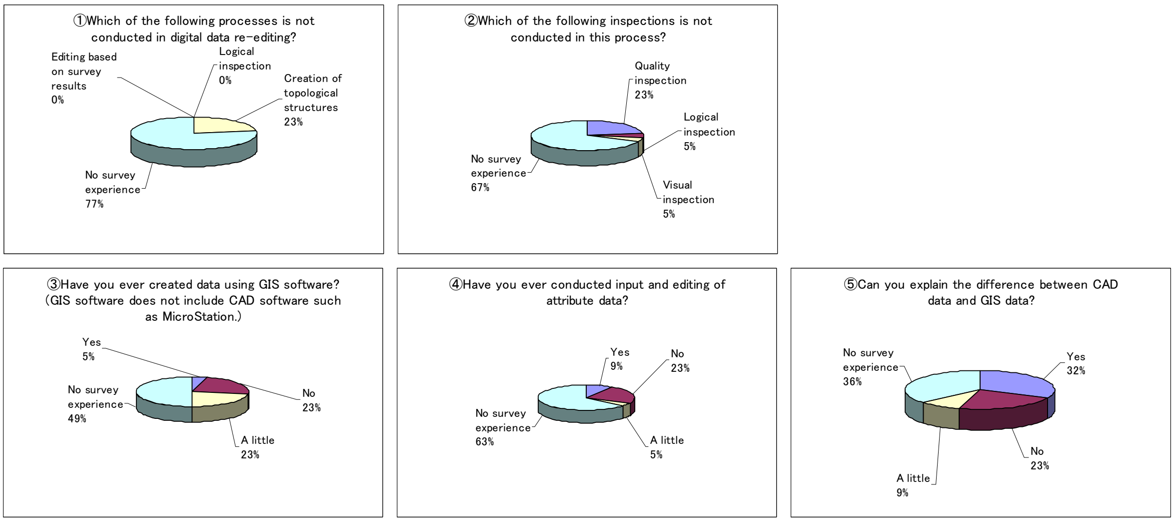


Fig 34 : Results of questionnaire survey and test on digital data compilation for field completion and structuring

4.8 GIS Structuring

4.8.1 Description of Technology Transfer

The technology transfer was conducted regarding the process of capturing digitally edited data into GIS software and adding attributes, generating topological structures, and registering data to a GIS database. The technology transfer was targeted at three engineers, including both middle-ranking and young ones, who understood the structure of a GIS database.

(1) Target technologies in technology transfer

- Capturing of CAD data into ArcGIS
- Input of attribute information
- Logical inspection and topological structure generation
- Creation of geo-databases
- Creation of ArcInfo Coverage data

Photo 21 : Technology transfer on GIS structuring

(2) Methods

The technology transfer was conducted in the form of lectures and practical training. OJT was adopted for this process regarding digital editing data on which field completion was completed in the scope of work of which DRE was in charge (two sheets).

(3) Executed items and descriptions

- Method of converting CAD data into a shape file that can be processed on ArcGIS
- Method of creating an attribute field in a shape file and entering a thematic attribute
- Methods of logical inspection and error correction on network and topological data
- Methods of storing a shape file into an ArcInfo geo-database and creating a topology
- Methods of creating ArcInfo coverage data, a final product defined in the spatial data product specifications

4.8.2 Evaluation

Since DRE conducted structuring using GIS software for the first time, many simple mistakes due to lack of understanding were encountered during the technology transfer. However, the two sheets of maps of which DRE was in charge were completed without problems.

In the future operations, it is considered necessary for DRE to check the result of each procedure to ensure that it is executed without mistakes before going on to the next procedure because the study team will not be able to inspect the operation results. Since it is considered that this problem will be solved if DRE creates GIS data many times, it is desirable for DRE to create GIS databases in other operations than for the development of GIS databases in order to gain more experience.

4.9 Map Symbolization

4.9.1 Description of Technology Transfer

In the development of spatial data infrastructures in this study, map symbolization is the operation for publishing conventional topographic maps in an analog version. The technologies for modifying the data on which digital data compilation and GIS database structuring is completed by adding marginal data such as line type, line thickness, and color in accordance with the newly established specifications as well as adjusting the transfer of symbols and inclination of annotations must be acquired. The technology transfer was targeted at two staff members of DRE.

(1) Target technologies in technology transfer

- Basic operation of graphic software Adobe Illustrator CS3
- Creation of objects required to create map data for printing (such as the custom color, pattern, symbol brush, and line brush)
- Creation of map data for printing through editing of actual data

(2) Methods

The technology transfer was conducted in the form of lectures and practical training on an OJT basis; the former using the manuals prepared by the study team on its own regarding the basic operations of Adobe Illustrator and the map editing process, and the latter using actual data created by DRE.

Photo 22：Technology transfer on map symbolization

(3) Executed items and descriptions

1) Lectures on printing environments

Lectures were provided to nurture the understanding of the counterpart members about the necessary conditions of map printing data to be supplied in Desk Top Publishing (DTP), an international-standard technology, which constitute important elements required to print data exactly in accordance with the image such as "data resolution," "overprint," "four-color separation plates (including printing using characteristics)," and "link file (image data) conditions."

2) Basic operations of graphic software Adobe Illustrator CS3

The technology transfer was conducted to nurture the understanding of the functions and basic operations of Adobe Illustrator CS3 and its applied functions to be used to create map data for printing by having the trainees actually operate the software. The understanding of important technologies was deepened by giving an assignment to the counterpart members each time to have them operate the software by themselves.

Fig 35：Vegetation pattern

Fig 36：Symbol brush

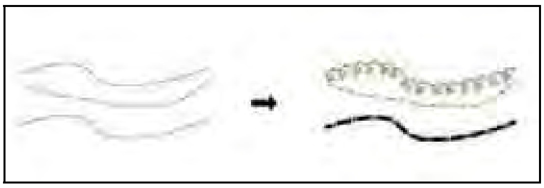


Fig 37：Line brush

3) Creation of objects required to create map data for printing

The objects required creating map data for printing such as vegetation patterns, symbol brushes (marks), and line brushes (cliffs, boundary lines, etc.) were created in accordance with the format rules and registered to a symbol (swatch) library and a brush library. This enabled batch conversion of line and polygon data that has been entered.

Fig 38：Completed map from map data for printing (Map number: 160-3-2)

4) Creation of map data through editing of actual data

The technology transfer for the map editing process was conducted using topographic data such as line data, annotation data, and vegetation polygon data developed through digital data compilation and GIS database structuring processes. Many files classified by map symbol number are superimposed on each other at a scale of 1:25,000 using Adobe Illustrator. After layers were put in order, map data for two sheets were completed through coloring of objects according to format rules, change of line type and thickness, change of font, color, etc. of annotations, conversion of indicating points into symbol brushes, and conversion of part of line data into line brushes, etc. (Map number: 160-3-1 and 160-3-2).

5) Correction

The created map data was printed in color on the plotter supplied as survey equipment and, using the printouts, the counterpart members learned the method for the correction process through visual inspection on the line types, line thicknesses, and colors, annotation font types and sizes, and annotation inclinations.

6) Creation of map data for printing through synthesis of map data and marginal data

The counterpart members of DRE learned the basic flow of operations for publishing digital maps by synthesizing the created map data and marginal data, entering information such as the map number, attainment, and title in each map, and thus completing map printing data for each map.

7) Correction of secular changes

The counterpart members understood through lectures and OJT the methods for correcting secular changes in 1:25,000 map data for printing, which will be required in a few years to come, such as replacing the layers to be updated and correcting individual data manually.

4.9.2 Evaluation

(1) Agreement on input of DXF data

Under the current operation environment of DRE, the scaling factor of artwork must be reduced by 40% in order to enter the DXF-format output data to Adobe Illustrator to obtain 1:25,000 scale data.

(2) Handling inconsistencies

When batch attribute conversion is conducted by applying a line brush to the supplied DXF data consisting of one line such as a cliff or a railroad line, a partial inconsistency may occur in the data. In such a case, the inconsistency must be handled by either dividing the line segment and correcting part of it manually, or using a command for path simplification (simplify) that decreases the number of segments (points) without changing the form of the line segment. As a result of confirming such workarounds through practical training, the counterpart members themselves became able to use a combination of more than one command to handle an inconsistency, demonstrating that they learned the skills for correcting inconsistencies without problems. In the future, the counterpart members are expected to acquire more experience in this operation to discover even more efficient workarounds.

(3) Handling of specification changes

During the operation period, some changes in the specifications were decided on, such as changes in the line width and color of vegetation polygons and the color of two-lane roads. However, the map data created in the technology transfer had already been registered to libraries, and these registered colors (swatch colors) and the registered patterns based on them had to be changed. However, the specification changes by the counterpart members themselves were completed relatively easily because batch conversion of objects was possible. Therefore, they learned the technologies for handling any specification change required due to a change in the theme, etc., in the future by changing the registration to libraries.

(4) Evaluation of the two maps created by DRE

Although map data errors were found in the processing stage of the created map data for printing, they were checked with the counterpart members in charge of digital plotting and editing in order to solve the problems. The digital topographic maps were thus completed as printing data with the technologies of the counterpart members themselves.

(5) Evaluation of counterpart organization

The two counterpart members trained in technology transfer, having never used graphic software Adobe Illustrator, learned to conduct by themselves all the processes from creation of objects to be used in maps and input of actual data (DFX data and vegetation polygon data) up to verification, editing, and correction of the data. Although the maps created in the technology transfer consisted of only two sheets which covered the scope of work of which DRE was in charge, the counterpart members have attained levels of understanding and achievement mostly sufficient for creating map printing data by themselves. If they not only maintain the skills acquired in the technology transfer, but also convey them to other staff members to enhance their productivity, it is considered possible for the DRE staff to create the planned remaining 30% of map data for printing, by themselves and without any problems.

4.10 Dissemination of Geographic Information (GIS))

4.10.1 Description of Technology Transfer

To promote effective utilization of the digital topographic maps (scale 1:25,000), the product of this study, technology transfer related to the utilization of GIS was conducted involving three staff members each of DRE and DSP. The details are as follows:

(1) Description of executed technology transfer

Week 1 (common to DRE and DSP)

- Basic operation of ArcCatalog and ArcMap
- Technique for displaying data
- Layout display

- Addition of map reference systems
- Editing of attribute tables

Week 2 (common to DRE and DSP)

- Linkage of attribute tables and external data tables
- Display of image data and geometric correction
- Conditional search
- Creation of GIS data

Week 3 (common to DRE and DSP)

- Construction of topologies
- Creation of buffer areas
- Re-classification of attribute data
- Analysis of superimpositions

Week 4 (common to DRE and DSP)

- Generation of topographic data (inclinations and slope azimuths)
- Analysis for selection of appropriate locations through spatial analysis and other items

Week 5 (only DSP)

- Overall review
- Review and quiz on spatial analysis
- Questionnaire survey related to GIS training

Second half of week 5 (only DRE)

- Creation of land-coverage polygon data
- Creation of Coverage files from DXF files
- Creation of Illustrator files for map symbolization

The technology transfer was conducted for DRE with an emphasis on the part related to GIS data structuring for the digital topographic maps, and for DSP with an emphasis on the part related to spatial analysis. The trainees of DRE and DSP received training at the same time basically in accordance with the description of the technology transfer provided above.

The training on the construction of a GIS database for the digital topographic maps was provided regarding the creation of GIS data with a topological structure in the coverage format of ArcInfo required for DRE. Then, to create printed maps from the created GIS data, the staff received training on the creation of data (layers) used to symbolize land use data.

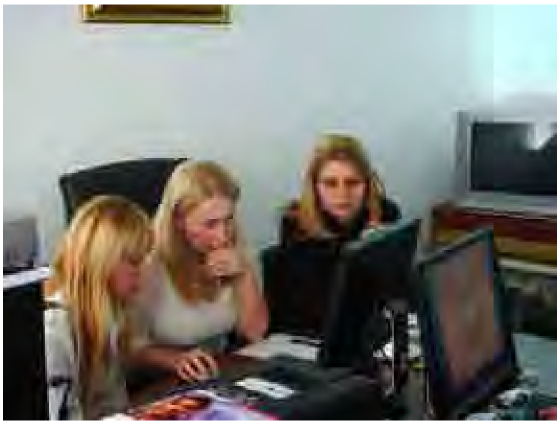


Photo 23：Scenes of technology transfer (DRE and DSP)

On the other hand, the DSP staff received training on the basic operations of ArcGIS and the methods for utilizing spatial analysis. Since model GIS databases are required at this time, the following data sets were prepared for this training.

- Administrative boundary data for all the areas of Montenegro
- Populations of men and women and populations by age group in each administrative area (2003 census data)
- Road, river, land use, elevation, inclination, and slope azimuth data for two sheets of 1:25,000 maps (near Podgorica)

Using these GIS model databases, the GIS training was provided on the analysis of regional characteristics for all the areas of Montenegro, and analysis for a selection of appropriate locations for land development near Podgorica.

4.10.2 Evaluation

The results of this technology transfer were evaluated using two methods: (1) Giving several assignments during the training period and having the counterpart members create data and maps in accordance with the assignments, and (2) conducting questionnaire surveys on the technology transfer and having the counterpart members conduct self-evaluation. The evaluation results for DRE and DSP are provided respectively in the following two sections:

(1) Evaluation for DRE

After the GIS training for about one month, the DRE staff mastered the basic operations of ArcGIS and learned to edit and process digital topographic map data as circumstances demand. They are considered to have an extremely high level of capability in this regard. They also mastered approximately all of the spatial analysis functions, and learned to create a desired map by superimposing various data on each other. They also acquired skills to conduct GIS data structuring and create data for map symbolization by capturing DXF data created on a digital plotter into GIS.

In sum, the DRE staff members who received GIS training are considered not to have a major problem in knowledge of GIS and operating skills for ArcGIS. However, the result of the questionnaire survey conducted at workshops showed that only 35% of all the participants that did not take the training understood GIS.

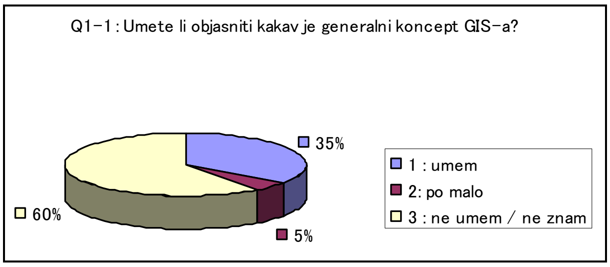


Fig 39 : Questions about GIS in general

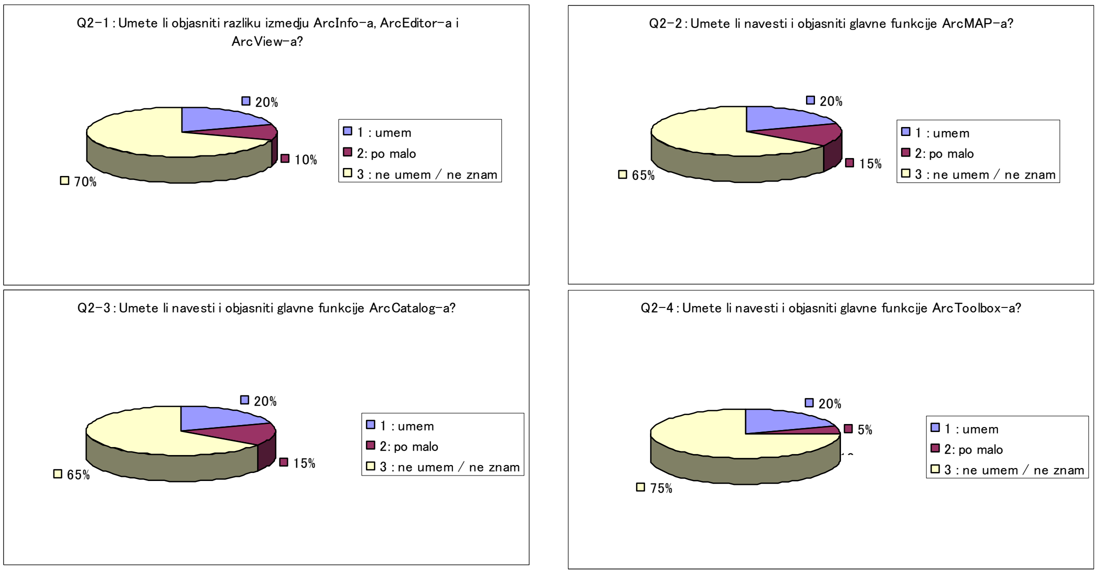


Fig 40 : Questionnaire survey result about ArcGIS functions

GIS is a well established technology, used as a tool for needed analysis in the process of projecting and making plans, so it is considered to be a necessary technique in DRE. Therefore, the general level of knowledge and skills of DRE needs to be improved, mainly by the trainees who received this GIS training.

(2) Evaluation for DSP

DSP so far conducted its major operations using CAD and the staff members had little experience in using GIS. In the initial stage of training, therefore, they were slow to create the desired data or map for an assignment, and often needed assistance each time. Since this resulted from a general lack of experience, they mostly mastered the analysis of regional characteristics using census data (refer to the figure below) and the technique for spatial analysis using various data (roads, rivers, elevations, inclinations, and slope azimuths) through practical training provided in the training period.

In the self-evaluation by the DSP staff in the questionnaire survey, they said they had not fully understood the operations of GIS or ArcGIS. As this evaluation shows, they have not yet attained a sufficient level for the operations.

In summary, continued GIS training will be necessary for DSP. In particular, the staff members need to acquire the skills for constructing GIS databases for national development plans and conducting spatial analysis required to establish development plan maps.

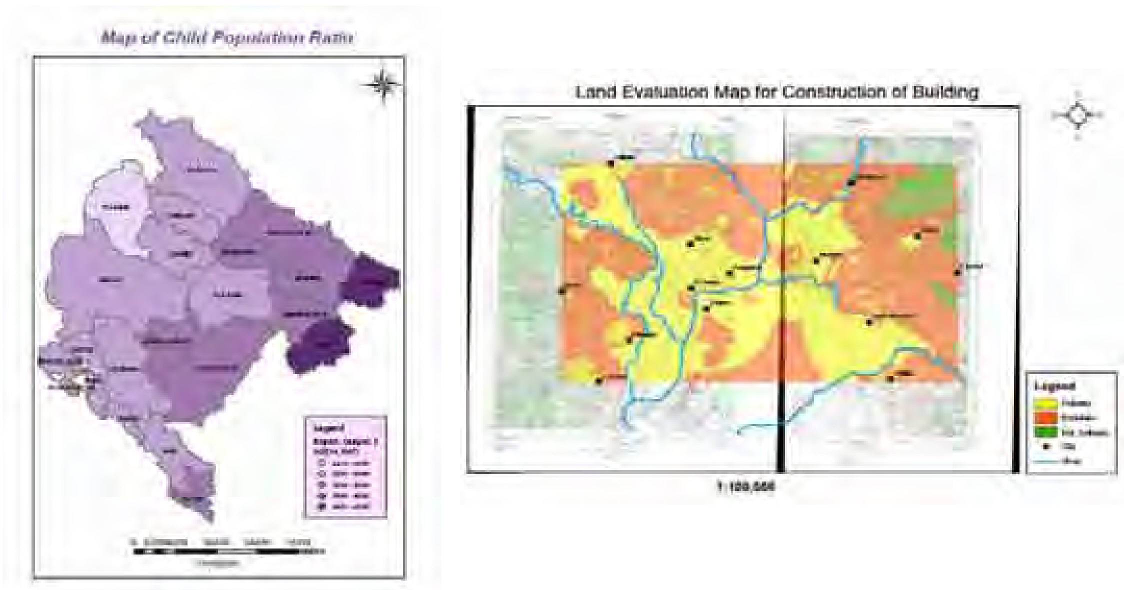


Fig 41：Regional characteristic map (left) and planned construction land evaluation map created using census data and the spatial analysis function (right)

4.11 Counterpart Training in Japan

Training conducted in Japan, upon a request from Montenegro, proved very useful for the understanding of technologies required for the future of Montenegro, including not only training on development of spatial data infrastructures, but also training on application of data obtained from GIS reference stations to the disaster prevention sector, and deployment of various service operations using combinations of GIS and information networks

Table 18 : Schedule of training in Japan

No.	Date	Day	Time	Schedule	
1	8/17	Sun	–	Arrival in Japan	
2	8/18	Mon	9:40–14:40 15:00–17:00	Briefing Orientation to the program	
3	8/19	Tue	11:00–16:00	Courtesy visit to Geographical Survey Institute	Courtesy visit to Geographical Survey Institute and facility tour(Explanation of roles and organizations of Institute)
4	8/20	Wed	10:00–16:00	Training at Geographical Survey Institute(Infrastructure map information, Denshi Kokudo system, Japanese Standards for Geographic Information, and Clearing House)	
5	8/21	Thu	10:00–12:00	Visit to National Institute for Land and Infrastructure Management(Study on social capital inprovement)	Moving
6	8/22	Fri	10:00–12:00	Visit to National and Regional Planning Bureau (Supply of national land information)	Kokusai Kogyo Head Office(Training on GIS policies)
7	8/23	Sat	–	Summary and day off	
8	8/24	Sun	–	Day off (Tour in Tokyo)	
9	8/25	Mon	10:00–12:00 14:00–16:00	Association of Precise Survey & Applied Technology	Setagaya ward
10	8/26	Tue	10:00–12:00 14:00–16:00	Infrastructure Development Institute	Japan Association of Surveyors – Survey Technology
11	8/27	Wed	10:00–12:00 14:00–16:00	Japan Map Center	Kokusai Kogyo Head Office(Training on GIS standaedization and public survey)
12	8/28	Thu	10:00–12:00 14:00–16:00	Keio University – Fukui Laboratory	Kokusai Kogyo Head Office(Training on advanced research)
13	8/29	Fri	10:00–12:00 14:00–16:00	Kokusai Kogyo Head Office(Training on markets)	Non-political organization Bigmap
14	8/30	Sat	–	Summary and day off	
15	8/31	Sun	–	Day off (Tour in Tokyo)	
16	9/1	Mon	10:00–12:00 14:00–16:00	Kokusai Kogyo Tokyo Office	Kyoritsu Air Co., Ltd.
17	9/2	Tue	10::00–16:00	Kokusai Kogyo Tokyo Office(Training on production technology)	
18	9/3	Wed	10::00–16:00	Kokusai Kogyo Tokyo Office(Training on advanced technology examples)	
19	9/4	Thu	10::00–16:00	Kokusai Kogyo Tokyo Office(Training on applied technology examples and summary)	
20	9/5	Fri	10:00–14:00 16:00–17:00	Kokusai Kogyo Tokyo Office(Training on applied technology examples and summary)	Evaluation meeting : JICA Economic Infrastructure Development Department
21	9/6	Sat	—	Departure from Japan	

Chapter5 Dissemination of Spatial Data Infrastructure and Independent Development of DRE

This study was conducted in accordance with the subordinate goals and project purposes defined by JICA. The subordinate goals were defined in expectation of effective utilization of the new spatial data infrastructure for the development of the nation. In other words, the achievement of this goal will depend on such elements as the advertisement, public relations, and dissemination activities regarding the content of the spatial data infrastructure, i.e., the product of this study, purposes and scope of its usages, specific utilization and acquisition methods, etc.

On the other hand, the project purposes for which technical elements account more significantly can be attained with certainty, although with a varying degree of understanding, through the technology transfer in which the experts of the study team provide training to a few counterpart members who have been selected. However, DRE is required not only to meet these project purposes, but also to disseminate and establish the technologies in the division to assure independent development is attained.

The counterpart organizations and the study team collaborated over the past two years not only to achieve the basic technical aspects contained in the project purpose of promoting development and bringing about the economic effects expected from effective utilization of the spatial data infrastructure, but also in terms of auxiliary activities to realize the independent development of DRE to surpass the output of this study and be able to satisfy new demands.

5.1 Dissemination of Spatial Data Infrastructure

As described earlier, the spatial data infrastructure to be developed in this study consists of digital topographic maps and a GIS database.

As shown in the figure on the right, the digital topographic map and the GIS database have significantly different contents and usage methods.

Fig 42：Comparison of topographic map (left) and GIS database

Effective utilization methods in accordance with the content of these products are described in the following sections.

5.1.1 Application of GIS (in Japan and elsewhere)

The GIS technology which has been making significant progress and development in recent years, mainly in the form of the database to be developed in this study, will certainly become an essential tool for many of the national-government, local, donor, and non-government organizations in Montenegro. Until now, paper-based maps created manually and subjectively to no small extent were used to plan or analyze and review various projects. The use of GIS will allow the users to obtain objective decisions and conclusions quickly, based only on the attribute data or analysis conditions that have been entered, and therefore achieve profound effects in the formulation of policies or decision-making stage of all kinds of plans, which have already been proved in many countries in the world.

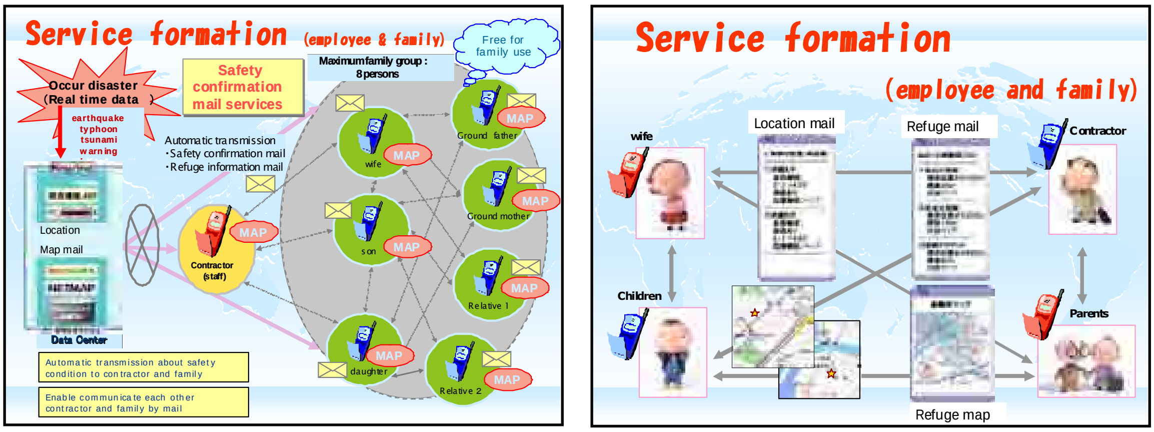


Fig 43：Emergency information service

In addition to such administrative services, in recent years general citizens have developed a close relationship with spatial data infrastructure which they use in their everyday lives. One of the most popular examples of using GIS is car navigation systems, which are widely used throughout the world. In Japan, services to assist citizens should a major natural disaster occur, such as the provision of escape routes, home return routes, and family member contact systems, are becoming common services provided by multiple private companies. However, there have been many instances in the event of a natural disaster in Japan where critical services such as gas and water supply and sewerage systems have failed along with the all-important electric power and communication networks when the electric poles or power transmission lines

Fig 44：Medical facility search system

were damaged. Japan is struck every year by natural disasters such as earthquakes, typhoons, and floods, and the general trend to base many of the emergency services on a system using a special radio band belonging to mobile phones has led to some bitter lessons. This is because even these general band mobile phone systems do not function since, as can be expected, there is a concentration of phone calls at the time of a disaster.

Furthermore, GIS is used not only in the emergency situations described above, but also in many service sectors such as public transport search systems for railroads, aircrafts, buses, etc., tourism and restaurant navigation systems, and medical facility search systems using PCs and mobile phones as media. It is beginning to take root as an important tool in citizens' everyday lives with the aim of bringing about more safety and comfort in society. In other words, GIS is a technology for conventional special applications such as planning and analysis, but has also obviously become an unseen and omnipresent element of our society, and this has already become a global trend.

One major requirement of such systems and services is that they should be able to display accurate and up-to-date geographic information. In the case of Japan, many private companies are updating the geographic information required on their systems approximately once per year in order to maintain its reliability. Maps have lives of their own, so-to-speak, and are required to constantly show the changes, such as growths and declines in society.

5.1.2 Utilization of GIS through Dissemination of Geographic Information (Montenegro)

This study was focused on future effective utilization and dissemination of the spatial data infrastructure as described above. The technology transfer in this study was thus focused on fostering the understanding not only of geographic information but also the importance of various survey results, which serve as attribute information required for GIS. By disclosing useful information owned by various departments of the government, consolidating the information for each sector, and constructing a common database, including the spatial data infrastructure, this technology transfer will lead to finding commonality among different operations conducted by each of the departments independently up to now. In other words, the technology transfer was aimed at economic effects through elimination of many redundancies and awareness raising that would improve the reliability of plans.

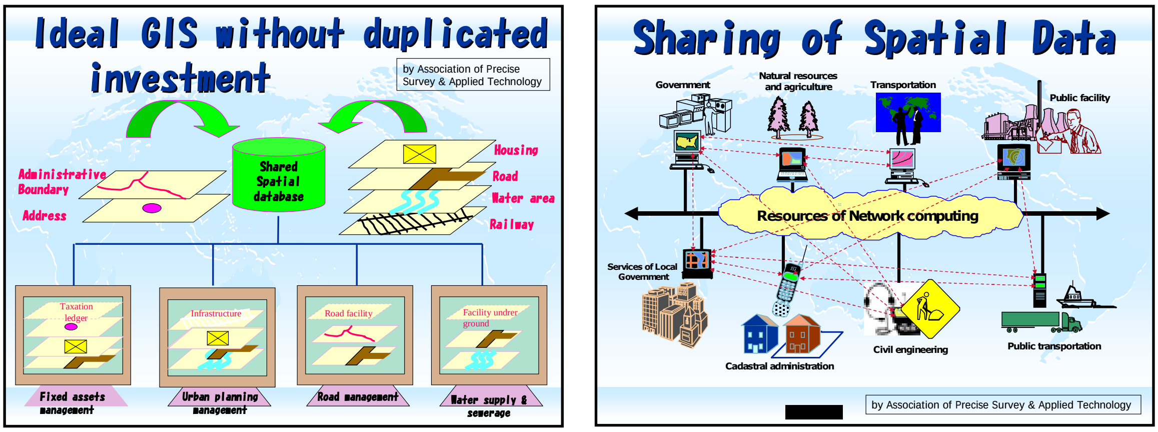


Fig 45：Ideal utilization of GIS

The technology transfer drew attention to the data of natural and social conditions, the former represented by spatial data infrastructure and the latter by available population census data, and nurtured understanding of data analysis using the software functions as well as the construction of a database including various social and economic elements and the usefulness of data when it is shared among the relevant departments and agencies.

The subordinate goals of this study were defined by JICA as "creating a spatial data infrastructure in order to disseminate new geographic information including GIS, and efficiently implement planned projects for urban development, tourism development, and environmental conservation." The efforts for stepping closer to this goal and realizing various ideas and further developing the technologies owned by Montenegro was entrusted to the two counterpart organizations, DRE and DSP, which are expected to exercise leadership by serving as an engine for the development and modernization of Montenegro.

Fig 46：Public service system

5.1.3 Effective Utilization of Digital Topographic Maps

The digital topographic maps, another product of this study, consist of raster and vector data. There has been no major change, with raster data being used as in the past, which is either output to paper or used directly on PCs via CAD. However, the previous topographic maps in circulation up to now were developed in the 1970s in the days of former Yugoslavia and is more than 30 years old, not representing the current status of things. When it was used for planning and other purposes, a field survey had to be conducted to confirm its accuracy.

Of course, the new digital topographic maps are significantly revised and contain information that shows the current status of things in detail. Therefore, there is no longer the trouble of field confirmation before it is used for planning or implementation of construction so that the reliability and ease of use will be dramatically improved.

Furthermore, these digital topographic maps come with vector data that can be modified as desired. If the original data is compiled at reduced scales, topographic maps with scales of 1:50,000, 1:100,000 and 1:200,000 can be easily created. Undoubtedly, these digital topographic maps can be utilized in more sectors than before.

5.1.4 Dissemination of Geographic Information through Utilization of Seminars

In March 2007, a seminar was held for the relevant organizations in and out of Japan for the purpose of dissemination and public relations regarding the details of this study started based on the inception report agreed and concluded between DRE and DSP and the study team. This seminar was intended to widely publicize the description of this study and the details of the products through the participants, to inform that this study not only concerned making a spatial data infrastructure in accordance with a request from Montenegro, but also contained the technology transfer aimed at future independent development as an important element, that the up-to-date equipment required for the technology transfer was supplied by JICA, and how useful the spatial data infrastructure to be developed will be for the newly established nation, Montenegro.

The seminar was attended by Minister Lukšić of the Ministry of Finance to which DRE belongs, and Minister Gvozdenovic of the Ministry of Economic Development to which DSP belongs, showing a high level of interest on the part of the Montenegrin government. The two ministers expressed messages that this was the first technical cooperation project for Montenegro, as an independent nation, with Japan, that extremely important information would be developed for the formation of many development plans required of the new nation, and that they hoped for the establishment of closer relationships of friendship and cooperation with Japan after this study.

In response, Mr. Tsubota, First Secretary of Japanese Embassy in Serbia, representing the government of Japan in this seminar, spoke about the usefulness of this study, the economic cooperation conducted by the Japanese government, and the possibility of new development cooperation. Next, Mr. Shikano, Director of the JICA Balkan Office, delivered a speech calling for disclosure of spatial data infrastructure and establishment of technologies required for effective utilization and promotion of such information. In sum, this seminar successfully deepened the participants' recognition and understanding of digital topographic maps and GIS, extremely important elements as basic information of a nation.

Photo 24：Presentation by DRE engineers

Photo 25：Seminar attended by the parties concerned from the two countries

The participants of the seminar were the members of the relevant organizations of the Montenegrin government such as the Ministry of Agriculture, Forestry and Water Management, Hydrometeorological Institute, road planning department, electric power department, Seismological Observatory, Geologic Survey, statistical department, and Ministry of Tourism and Environmental Protection, and many other personnel considered as the users of the results of this study such as UNDP, which is implementing a GIS capacity development project regarding such themes as GIS-based forest and environment conservation, meteorology and hydrology, and geological survey. This seminar is considered to have deepened the understanding of the usefulness of the digital topographic maps and GIS.

Photo 26：Congress co-hosted by DRE, World Bank, and GTZ

In the seminar, presentations were given with a focus on public relations. These were mainly related to the description and utilization methods for the GIS database because it is one of the products of this study and, given the current state of GIS usage in Montenegro, an area which is required to be more effectively utilized. Consequently, the participants came to share with each other the recognition of the necessity and importance of the spatial data infrastructure, the nation's basic information that is a key element common to all the independent operations carried out by each of the organizations. Even a new concept such as a "national GIS center" was heard, which may become possible if each of the organizations bring together their valuable survey results in addition to the spatial data infrastructure. As a result, high expectations for early development of the remaining 30% of the spatial data infrastructure were placed on

DRE, the organization responsible for creating spatial data infrastructure.

On the other hand, an executive officer of DRE gave a presentation in a seminar co-hosted by DRE, the World Bank, and GTZ at the start of a project on cadastral survey and real estate registration and management, on which DRE was going to work with assistance from the World Bank and GTZ, and referred to this study implemented with cooperation from JICA. This seminar was attended not only by relevant organizations in Montenegro, but also by organizations from many of the European Union members. A description, products, and other items of this study were explained, and not only the effective utilization of the results of this study in the future operations, but also the elimination of waste such as redundant investments were discussed with optimism. This was certainly considered to be an effective seminar with an effective presentation.

5.2 Workshop Aimed at Independent Development (DRE)

This study started with the establishment of specifications in conformity with a global standard (ISO19000 series) for the first time in Montenegro, and proceeded through wide-ranging operations such as aerial photography, control point survey, aerial triangulation, photo interpretation, digital plotting and digital data compilation, field completion, digital data compilation for field completion, database structuring, map symbolization, and utilization of GIS. At the same time, technology transfer was conducted so that DRE can continuously conduct independent development based on these technologies.

Photo 27：Workshop (PCM)

5.2.1 Creation of PDM

A workshop was held to clarify how high a technical capability had been acquired by DRE, which must develop the spatial data infrastructure for the remaining 30% of the area by itself, to smoothly and quickly attain the project purpose defined by JICA as "being able to create, maintain, and update digital topographic maps using its own technology in the future" and to allow the participants to understand the actual conditions at the same time.

Photo 28：Discussion for extracting problems

The participants of the workshop numbered 25 to 30 in total, and mainly consisted of the staff of the photogrammetry division participating in the technology transfer as well as the engineers and people concerned in the field survey division who were in a collaborative relationship required to create the digital topographic maps and all the members of the study team.

The workshop was conducted using the Project Cycle Management technique, and incorporated many opportunities for discussion to allow all the participants to share problems from the same point of view and find clues to problem solutions and development.

(1) Extraction of problems faced by DRE

A good amount of time was spent discussing the problem extraction process, which allowed the division managers and other participants to talk at length about issues from technical as well as organizational and social viewpoints regardless of the positions they held, and thus identify problems actually faced by DRE.

Almost all of the DRE staff members took this rare opportunity to give their opinions on problems, voice complaints, and ideals that they had held for a long time, regardless of organizational distances or difference of rank. This led to a lively discussion and, consequently, many problems were identified, such as the following.

- Low motivation
- Insufficient management to maintain quality (Process and accuracy)
- Insufficient digital plotting software
- Obsolete PCs and peripheral devices
- Insufficient security system (such as anti-virus protection)

Photo 29：Workshop

(2) Creation of PDM for accomplishing objectives

This study was conducted in accordance with the project purposes as well as the subordinate goals defined by JICA as "creating a spatial data infrastructure in order to realize wide-spread use of a new geographic information system including GIS in Montenegro."

This workshop enabled all the participants to a share common recognition regarding not only the project purposes with a focus on technical aspects, but also the necessity and feasibility of the above-mentioned subordinate goals, and the workshop resulted in the creation of a project design matrix (PDM) indicating the activities including solutions to many of the problems that were extracted and objective verifiable indicators, etc., as shown on the following page.

Table 19 : P DM

Name of Project : **The study for Establishment of Geographic Information for Implementation of National Physical plan in Montenegro**

Period II-2007 ~ III- 2009

Ver. No. :

Target groups : Department of Real Estate (DRE), Sector for Spatial Planning and Development, Ministry of Economic Development

Target area : Montenegro

Issue : 03, 06, 2008

Concise description	Objective indicators to be checked	Material for checking	Important assumptions
Long-term goals			
- Development of infrastructure of spatial data will popularise the use of new geographic information including GIS in Montenegro	The map of the rest of territory (30%) will be created so that the map of total area will be published for selling by the end of 2009.	Register about selling maps in archive section in DRE	Continuity of policy of Government of Montenegro to DRE
Goals of Study			
- Establishing technology for development and updating of infrastructure of spatial data in DRE	The map of 20% from the rest of area (30%) will be symbolized by February 2009.	Register about renewing maps and about its correction according to new data in DRE, by surface	Continuity of surroundings related to map creating in Montenegro
Outputs			
1 Capacity of implementing digital aerial-triangulation	1 Three engineers will be available till February 2009.	1 Results of examination led by expert in charge of technical transfer	Continuity of position of DRE as the responsible agency in Montenegro
2 Capacity of digital plotting, editing and changing national base map 1:25000 with new data	2 20% of engineers will be available till February 2009.	2 Results of examination led by expert in charge of technical transfer	
3 Capacity of editing and GIS database structuring	3 20% of engineers will be available till February 2009.	3 Results of examination led by expert in charge of technical transfer	
4 Capacity of map symbolizing and publishing for selling purpose	4 20% of engineers will be available till February 2009.	4 Results of examination led by expert in charge of technical transfer	
5 Capacity of surveying and photogrammetry for national base map 1:25000 according to new standard and specification	5 The results of surveying and photogrammetry according to new standard and specification will satisfy 90% of the required standard by February 2009.	5 Results of common evaluation of expert in charge of technical transfer and engineers for photogrammetry in DRE	
6 Capacity of changing existing hardwares and softwares with new system	6 20% of the equipment will be renewed	6 Book / register about basic capital in archive section in DRE	
Activities	**Resources**		
1-1 to adopt the manual for digital aerial-triangulation to DRE needs	Japan	Montenegro	Continuity of work of engineers who passed the training
1-2 to carry out training for digital aerial-triangulation in DRE	people	people	
2-1 to adopt the manual for digital plotting, editing, changing with new data according	experts from Japan	engineers from specific fields	
2-2 to carry out training for digital plotting, editing, changing with new data in DRE			
3-1 to adopt the manual for GIS database structuring according to DRE needs	equipment	office space	
3-2 to carry out training for GIS database structuring in DRE	GPS	offices for lectures and training	
4-1 to adopt the manual for symbolizing to DRE needs	LPS		Continuity of basic assignments of DRE as the agency in charge of cadastre survey and National base map creation
4-2 to carry out training for symbolizing in DRE	printer		
5-1 to adopt the manual for the field survey to the needs of engineers from field secto	plotter		
5-2 regularly collecting information from field and changing data with new informati	GIS-softwares		
6-1 to install anti-virus software in all computers in DRE	software for symbolization		
6-2 regularly upgrading anti-virus software			

5.2.2 Acquisition of Technologies with Certainty and Development of Nation-wide Spatial Data Infrastructure

This workshop was conducted to directly evaluate the level of understanding of essential elements for sustained development by engineers, who participated in the technology transfer, and also to survey and evaluate how much the technologies had been conveyed to other persons in the same division and had taken root as the technologies of DRE.

The results were announced on the spot to allow all the participants to turn their attention to the problems found in the evaluation, and have further discussion on them regardless of organizational distances and difference of positions. This process successfully clarified the methods of correction and enhancement.

Furthermore, this workshop was also conducted so that evaluation of achievements could be made until its end and appropriately correct the outputs, activities, and indicators listed in this PDM, and check the conditions of internal technology conveyance so that, even after the end of the study, DRE could continue to conduct evaluations by itself using the PDM-based evaluation method as guidelines for conducting appropriate operation, while continuing to keep track of the status quo.

It will be necessary to discuss how the organization can be structured after the end of the study in order to review the essential elements (technical and organizational) for independent development each time as circumstances demand, share among the DRE members the techniques acquired through this study and possessed by few people, and allow more people to carry out their tasks at will and with ease.

If Montenegro, a newly born nation, intends to take strides forward in social, economic, and technical aspects, and join the European Union as early as possible, the creation of basic materials required as the basis of all kinds of operations, i.e., the enhancement of the capability to develop a spatial data infrastructure, is indispensable. This operation has been assigned to DRE, the only organization that can carry out the cadastral survey, its principal duty, and supply such information essential to the nation. It is desirable for DRE to continuously make independent development while utilizing as the foundation the experience of a great deal of collaborative operations and technical transfer conducted in this study.

Photo 30：Questionnaire and test

Photo 31：Announcement of results

Chapter6 Relevant Organizations and Status Quo of Montenegro

The organizations considered major users of the spatial data infrastructure in Montenegro—apart from two counterpart organizations: DRE, which develops spatial data infrastructure, and DSP, which utilizes the resultant data to make regional and urban plans, etc., as its principal operations—are the Montenegro Seismological Observatory, Geologic Survey of Montenegro, and Public Enterprise for National Parks, etc. The following describes the status of their current activities that have been confirmed.

Furthermore, based on the statistical information obtained from the Statistical Office of Montenegro (Monstat) and the result of field surveys actually conducted by the study team, the problems faced by the new nation of Montenegro pursuing EU membership and tourism development are described in terms of the correlation with the spatial data infrastructure as follows:

6.1 Status Quo of Relevant Organizations

6.1.1 Department of Real Estate (DRE)

DRE is the only organization responsible for the operations from cadastral survey to settlement and registration of real estate in Montenegro. They have already installed nine GPS-based reference stations uniformly in the country in order to improve the speed and accuracy of various surveys in the ground survey in pursuit of modernization of its operations.

On the other hand, the photogrammetry division has a long history of creating plans and orthophoto maps required for cadastral surveys, and is seeking to modernize its equipment and use more sophisticated technologies.

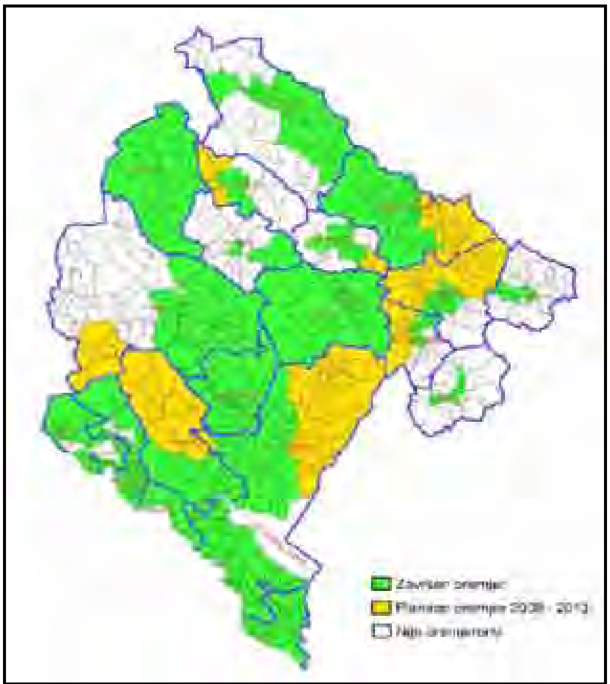


Fig 47：Five-year plan of DRE

This year, DRE defined twelve tasks in the medium-term plan (2008-2013) established for itself, and is working toward the implementation of the plan.

Montenegro is seeking membership to the European Union, and must establish a stable financial foundation. Tax revenue from real estate, which forms part of the financial foundation together with tourism, is apparently a large revenue source for the nation and therefore necessitates quick survey. Unlike before, however, the survey and registration methods in accordance with EU standards must be adopted, so Montenegro is working on the modernization of operations extending from the understanding of the legal system to the actual detailed clerical work with cooperation from the World Bank and GTZ.

In addition, while DRE used to conduct almost all its operations on its own, some of them are gradually being switched to private contractors in an effort to improve the efficiency and speed of the operations for the sake of implementation of the medium-term plan.

This outsourcing allows DRE to assign many engineers to sectors such as the creation of digital topographic maps, and thus enhance the previously understaffed development operations for various spatial data infrastructures. Hence, both the early development of the National Spatial Data Infrastructure (NSDI) and the early implementation of the "e-Government" initiatives set forth in the strategies of the medium-term plan can be expected.

DRE, currently discloses the status quo of GIS-based real estate ownership in detail through its own web service as part of its regular operations, is one of the most advanced government organizations in terms of GIS.

6.1.2 Department of Spatial Planning (DSP)

DSP is an organization responsible for making many of the plans to be implemented by the Montenegrin Government regarding, for example, urban and regional development, tourism development, and environmental conservation. They are mainly engaged in the following operations based on the national budget and with cooperation from donor organizations:

1. Creating and deciding on state plans and promoting them in order to realize them.
2. Participating in passing, laws and other regulations about spatial organization and marine resources.
3. International and regional collaboration related to state plans, as well as cooperation with NGOs (Non-governmental organizations).
4. Analyzing and publishing current state plans.

Fig 48：Long-term plan established by DSP

5. Work relating to publishing town planning and technical matters from state plans.
6. Keeping, classifying, and systematizing state plan documentation.

The aims in creating these state plans are equal economic development in the areas where effective and national spatial development is being undertaken, conservation of nature and biological diversity, promoting residential infrastructure respecting sustainable environmental development principles, and placing particular importance on the growth of tourism.

The following are some representative examples of the state plans that DSP is currently in charge of implementing.

(1) Potential survey aimed at tourism development of 17 seaside cities

At present, survey operations are in progress on 17 of 48 candidate areas. All of these selected areas meet the conditions that they are located along the coastline on the Adriatic Sea and already have accommodation facilities. The potential survey required for future development with thematic focus on tourism is being conducted on the budget specifically allocated to this operation.

(2) Environmental conservation and tourism development for Skadarsko Lake National Park

Skadarsko Lake, a beautiful lake near the capital city of Podgorica, is split by a border line approximately in the center and half the lake belongs to Albania, the neighboring country. It is one of the four national parks designated in Montenegro with a trove of wild animals and plants, many of which are specified as endangered species. DSP is conducting, with the assistance from GTZ, a survey aimed at tourism development at three selected places in the lake while preserving the environment. Many of the operations are executed by contracted private consultants under the guidance of plan establishment experts dispatched from GTZ.

(3) Supervision of comprehensive regional development plan

DSP is designated as a supervisor in the comprehensive regional development plan being implemented by 21 municipalities in Montenegro with the assistance of UNDP, and is supporting the establishment of the best plan for each of the municipalities in a manner consistent with the national plans.

(4) Comprehensive development plan in the mountainous area

At present, the majority of tourists visiting Montenegro come to the coastal areas on the Adriatic Sea, and are not much attracted by another natural world heritage site and the area surrounding it. Consequently, the accommodation facilities and road and traffic networks are underdeveloped. To ensure stable revenue from tourism, it is necessary to develop this area as soon as possible. DSP has started conducting surveys in collaboration with the Ministry of Tourism and Environmental Protection.

For planning operations, DSP mainly employs AutoCAD at present, but is working on the introduction of GIS using the equipment acquired and the technology transfer conducted in this study with a focus on establishing more accurate plans.

6.1.3 Montenegro Seismological Observatory

(1) Main operations (Interviewee: Mr. Seizmoloski Zauod)

- Balkan region and Montenegro: Seismic monitoring, seismic wave analysis, seismic phenomenon study, plate tectonics analysis, forecast of seismic damage, maximum ground acceleration, and maximum seismic intensity, study of models of seismic wave propagation in the earth's crust, evaluation of impacts on buildings, etc.
- Montenegro and surrounding areas: Quick and high-quality information supply for press reports at the time of a major earthquake and web-based information disclosure, etc.
- For architectural designs and plans: Supply of information from the viewpoint of anti-earthquake measures regarding seismic intensity coefficient, disaster prediction information, and ground stability at the target points and surrounding areas
- Report to the competent agencies and the Montenegrin government

(2) Status quo of operations using geographic information

- For the display of regional seismic data, analog topographic maps with scales 1:25,000 and 1:100,000 are used.
- From the viewpoint of anti-seismic and anti-disaster measures in urban areas, analog topographic maps with scales from 1:1,000 to 1:10,000 are used for area classification.

(3) Spatial data infrastructure

- Digital topographic maps are basic information for all the fields, including seismology, geophysics, and geology. Furthermore, DEMs are required for spatial analysis.
- Spatial planning conducted by the national government, municipalities and private sector also need information on river systems, road networks, and boundary lines between municipalities.

(4) Collaboration and information sharing with other organizations

- Anti-seismic measures have many adjoining and related fields such as spatial planning, civil engineering and construction planning, and risk management so that the Observatory should enhance cooperation with organizations specializing in such fields.

- The Observatory serves as an organization of a representative nation (under a rotation system) in the Western Balkan region for regional planning under the NATO Partnership for Peace.

(5) Utilization of GIS

- The Observatory is not utilizing GIS but has sent four staff members to the GIS training course of UNDP.
- The Observatory highly evaluates the spatial data infrastructure project of JICA.
- The tasks for the time being are the development of a topographic map database, the construction of a seismic monitoring system, and the creation of hazard maps.
- It is desirable to create both a monitoring system and hazard maps not only for Montenegro, but for the entire Balkan region in accordance with the common specifications (pursuing the EU standard).
- Observation data acquired at ten meteorological stations installed in Montenegro is being transmitted to the Observatory and managed on computers, but has not been associated with GIS yet.
- Technology transfer on the hazard map analysis using GIS is required.
- Active information exchange with the neighboring countries is in progress regarding seismic monitoring, hazard maps, GIS, etc.
- A plan is in progress to introduce software appropriate for the purpose such as ArcGIS, ArcView, and MapInfo using the budget of the Observatory.

6.1.4 Geological Survey of Montenegro

(1) Main operations (Interviewees: Mr. Nikora Cadjenovic, Mr. Dragon Radojevic, and Mr. Slobodan Radusinovic)

- Development of comprehensive geological maps, geotechnical and hydrogeological survey, and regional geologic survey
- Geological census for construction plans that require authorization by the Ministry of Economic Development and hydrogeological audit on mineral resource exploration

(2) Status quo of operations

- Analog topographic maps are used in daily operations.
- Although the institute has abundant materials, many of which are analog-based, deterioration and loss is unavoidable, and quick searches are not possible.

(3) Spatial data infrastructure

- It is urgently required to create comprehensive geological maps based on the latest geographical information.
- It is desirable to develop digital geological maps for all the land of Montenegro and link them to the geology-related information on planning and design of individual buildings.

(4) Collaboration and information sharing with other organizations

- There is little collaboration with other organizations because the materials and information are analog-based.
- It is desired to construct a freely accessible database center (such as geological survey, hydrology and geology, and geotechnology).

(5) Utilization of GIS

- The staff participated in the OSS-based GIS training courses (each two weeks long) offered by UNDP.
- Conversion from raster data to vector data and plotting of data using CoralDraw is in progress.
- No digital data except raster images is owned.
- Although the institute has a history over 60 years, all the maps are paper-based. It is desirable to convert them into digital data using GIS.
- It is desirable to use GIS mainly to create 1/500 mineral resource distribution maps.
- There is a high expectation for the 1:25,000 GIS data and digital topographic maps to be developed in this study for such uses as future field surveys and database construction.
- It has already been determined to introduce GIS to the Geologic Survey field in order to observe the principles of completeness and diversity of survey.

6.1.5 Public Enterprise for National Parks of Montenegro

(1) Main operations (Respondent: Mr. Slobodan Stijepovic)

- This public enterprise manages the four national parks: Durmitor, Biogradska Gora, Lake Skadar, and Lovćen. It carries out operations such as protection and development of these parks and expansion of the designated natural and cultural assets.
- It also manages information on these parks and other designated natural and cultural assets as well as information related to tourism expansion.

(2) Status quo of operations

- Information on the conservation, development, evaluation, usage, and expansion of the natural and cultural assets in the national parks in Montenegro is made available to all the users who need it.

(3) Spatial data infrastructure

- In the area-specific and comprehensive conservation of natural and cultural assets, which is required by law, the geographic information plays an important role, but the problem is that the map information is obsolete and inappropriate.
- It is desired that some types of information are completely converted into electronic form. However, there is only little data that has been converted into electronic form.

(4) Collaboration and information sharing with other organizations

- There is little collaboration with other organizations because most of the data is analog-based.
- Through the construction of a network between the national parks, the public enterprise will pursue sharing of the same information between the center and the field.

(5) Utilization of GIS

- Modernization of information through collaboration with UNDP
- The top priority is placed on the construction of a natural and cultural asset database.
- Spatial plan
- It is desirable to use the spatial data infrastructure as the foundation to ensure an effective and modern use of the existing and future data in order to attain protection and expansion of the national parks.

6.2 Status Quo of Montenegro

The nation of Montenegro came into existence when it gained independence in 2006 from what was formerly Serbia and Montenegro based on the result of the national referendum, and has an area of around 13,812 km^2 and a population of around 620,145 (2003 census shown in the table below).

Since Montenegro is literally “a small nation with a small government,” these advantages should be made the most of by realizing prompt decision-making and quick responses, which are considered to be important elements for Montenegro to make dramatic advances as an independent nation.

As shown in the table 20, a large part of the population in Montenegro is currently concentrated in the capital city and its suburbs, with about 40% of the people living in about 25% of the total area, as in any other country. This heavily populated area is positioned as the center of politics, economics, and commerce and industry. While the other areas, rural and farming and stock raising zones and seaside tourist-business zones have low population densities.

Table 20：Populations, areas, and population densities of municipalities (Source: Census 2003)

No.	Municipality	Population		Area		P.Density
		Total	Percentage	Area	Percentage	P/km2
1	Andrijevica	5,785	0.9%	283	2.0%	20
2	Bar	40,037	6.5%	598	4.3%	67
3	Berane	35,068	5.7%	717	5.2%	49
4	Bijelo Polje	50,284	8.1%	924	6.7%	54
5	Budva	15,909	2.6%	122	0.9%	130
6	Danilovgrad	16,523	2.7%	501	3.6%	33
7	Zabljak	4,204	0.7%	445	3.2%	9
8	Kolasin	9,949	1.6%	897	6.5%	11
9	Kotor	22,947	3.7%	335	2.4%	68
10	Mojkovac	10,066	1.6%	367	2.7%	27
11	Niksic	75,282	12.1%	2,065	15.0%	36
12	Plav	13,805	2.2%	486	3.5%	28
13	Pluzine	4,272	0.7%	854	6.2%	5
14	Pljevlja	35,806	5.8%	1,346	9.7%	27
15	Podgorica	169,132	27.3%	1,441	10.4%	117
16	Rozane	22,693	3.7%	432	3.1%	53
17	Tivat	13,630	2.2%	46	0.3%	296
18	Ulcinj	20,290	3.3%	255	1.8%	80
19	Herceg Novi	33,034	5.3%	235	1.7%	141
20	Cetinje	18,482	3.0%	910	6.6%	20
21	Savnik	2,947	0.5%	553	4.0%	5
Total	Montenegro	620,145	100.0%	13,812	100.0%	45
*	Japan	127,419,000		377,835		337

It is a well-known fact that "tourism" is an important element in the financial foundation of Montenegro at present. In the Balkan region that historically experienced numerous disturbances of war, Montenegro with its natural scenic beauties called "black mountains" has retained abundant natural and historic spots. The steep mountains covered with deep forests, after which this nation may have been named, and the peaceful Durmitor National Park that expands at the foot of these mountains has been designated as a World Natural Heritage site.

Table 21 : Current state of tourism (Source: Census 2003, Monstat Web site)

Country	Year							*Rate of Increase*		
	2001	2002	2003	2004	2005	2006	2007	2004–2005	2005–2006	2006–2007
Total	555,040	541,699	599,430	703,484	820,457	953,928	1,133,432	117%	116%	119%
Domestic tourists :	446,232	405,539	457,643	515,424	548,452	576,130	149,294			
Foreign tourists from :	108,808	136,160	141,787	188,060	272,005	377,798	984,138			
Serbia	0	0	0	0	0	0	389,428			
Albania	0	0	5,068	8,853	13,234		37,801			
Austria	978	1,393	1,509	2,062	3,193					
Belgium	556	1,179	1,479	2,970	1,179					
Bosnia and Herzegovina	32,403	25,887	29,559	32,706	46,838		101,394			
Bulgaria	525	935	4,612	1,953	1,571					
Greece	355	561	714	665	669					
Denmark	377	411	457	399	630					
Italy	2,479	3,633	3,295	5,642	11,435		37,211			
Luxembourg	41	47	157	101	99					
Hungary	1,875	1,957	3,917	4,425	6,243					
Germany	2,517	11,789	14,328	19,873	18,352		17,891			
Norway	1,216	1,770	1,816	2,152	3,801					
Poland	1,339	3,977	1,898	2,394	3,040					
Republic of Macedonia	4,206	5,266	5,415	10,187	14,940		22,543			
Romania	1,316	747	1,097	1,190	896					
Russian Federation	10,054	11,742	10,115	16,270	41,011		102,350			
Slovakia	5,973	12,703	9,080	6,707	8,442					
Slovenia	6,189	6,491	6,813	10,114	13,659		20,663			
United Kingdom	1,060	1,673	2,597	5,462	7,817					
Finland	133	177	249	169	1,192					
France	981	1,370	1,510	2,047	11,300		30,279			
Netherlands	634	1,229	1,687	1,852	2,477					
Croatia	4,420	4,352	3,952	5,368	7,543					
Czech Republic	9,672	19,763	16,842	24,356	23,517		33,100			
Switzerland	747	1,181	1,061	1,653	1,820					
Sweden	902	1,029	889	5,116	4,994					
Other Europen countries	13,664	8,229	5,213	5,600	9,704					
Australia	198	245	250	425	592					
Canada	411	617	501	590	870					
USA	1,853	2,389	2,156	2,764	3,432		7,426			
Japan	135	196	177	257	381					
Other non-Europen countries	1,599	3,222	3,374	3,738	7,134		184,052			

On the other hand, the coastline that extends along the Adriatic Sea with incomparable beauty in any other part of the Balkan region is dotted with many historic sites, including the fortress city of Kotor, designated as a World Cultural Heritage site and constitutes the most important area for Montenegro as a tourism-oriented state.

Furthermore, this area, centered on large resort facilities complete with deep blue sea and beautiful beaches, allows visitors of all ages to enjoy themselves in wide-ranging ways, such as marine sports and sightseeing in historic sites, and is visited by numerous tourists every year from Russia and East European countries in addition to the neighboring countries. As shown in the table 21, the total number of tourists, which exceeds the population of this country, and the year-on-year growth rate, are increasing steadily.

However, the actual status of tourism is as follows: About 90% of the tourists are concentrated on this coastline and less than 4% of the tourists visit the mountainous area where there is a World Natural Heritage site. When attention is paid to the places of accommodation and stay for these tourists (refer to the right column of the table 22), the concentration on the coastal area becomes even more obvious.

In other words, most of the tourists who visit the mountainous area do not stay in the area and the majority of them are based in the coastal area, and come to the mountains on a one-day tour or so. What's more, these numerous tourists visit the country mostly in summer in a concentrated way and hardly provide a stable source of revenue throughout a year. This is the current problem to be solved for Montenegro.

Table 22：Main places of accommodation for tourists in 2007 (Source: Monstat website)

Arrivals			Structure of Total Arrivals %	Type of Tourist Resort	Structure of Total Nights %	Nights		
Foreign	Domestic	Total				Foreign	Domestic	Total
984,138	149,294	1,133,432	100.00	Total	100.00	6,443,485	851,045	7,294,530
40,200	5,388	45,588	4.02	Repulic's Capital	1.44	80,200	24,786	104,986
901,229	109,513	1,010,742	89.18	**Coastal Resort**	95.43	6,263,434	698,010	6,961,444
21,377	17,781	39,158	3.45	Mountain Resort	1.45	45,167	60,725	105,892
21,040	16,602	37,642	3.32	Other Tourist Resort	1.67	54,357	67,514	121,871
292	10	302	0.03	Other Resort	0.00	327	10	337

Chapter7 Conclusions and Recommendations

7.1 Conclusions

As stated above, Montenegro is striving to become a tourism-oriented nation, and the nation is making efforts to develop and enhance the infrastructure along its coastlines, and the efforts are picking up speed currently. In order to establish a stable fiscal base, however, it is a prime task for Montenegro to develop its abundant natural environment in the northern mountainous region, where a UNESCO-designated World Natural Heritage site is located, while giving consideration to environmental conservation. In other words, it is important to develop tourism and the social infrastructure indispensable to attract tourists: roads, water and sewerage systems, power supply, and telecommunications. Also, DSP is the organization in charge of formulation of plans in this field in Montenegro. The spatial data infrastructure constructed in this study will play an important role in the planning process to achieve this goal.

Color aerial photos covering the nation's entire area were converted into digital data as basic data to support the construction of the spatial data infrastructure, and these aerial photos can be utilized for various purposes. In this study, a digital elevation model (DEM) at intervals of 20m was also developed for the targeted area (70%), enabling DRE to produce orthophoto maps easily. In short, in addition to the digital topographic maps and GIS databases which are the output products of this study, different types of geographic information such as aerial photos and orthophoto maps have become available in Montenegro.

These output products of this study developed in a digital format can also be arranged and converted into different forms of geographic information (changing contents and scales) and, in that sense DRE, as the nation's only organization that creates and provides maps, needs to respond appropriately to users who want to find geographic information most suitable to their purposes.

If technologies transferred for about 2 years since February 2007 are disseminated widely, and if such technologies are established as the technological base of DRE, DRE will be able to develop new geographic information on their own and will be able to respond to a range of requests coming from concerned organizations. Therefore, great expectations are placed on DRE's future efforts.

7.2 Recommendations

Based on the above conclusions, recommendations for each area and for DRE are developed as follows.

7.2.1 Recommendations on National Policy Position

In Japan there is an organization similar to Montenegro's Department of Real Estate (DRE), the Geographical Survey Institute, of the Ministry of Land, Infrastructure and Transport.

The Geographical Survey Institute is responsible for formulating the national survey law to promote survey policy, land register surveys, surveying excluding real estate administration, development of geographical information, and so on, and is currently operating under the following policies. (The following main points were taken from the Geographical Survey Institutes homepage)

****

(1) *Role of the Geographical Survey Institute (Mission)*

- *To provide to the whole of society an infrastructure of basic geographic spatial information, prepared and administered through national and international cooperation, for the purpose of clearly specifying and of administrating national territory, disaster prevention, and other matters of national responsibility.*
- *To promote geographic spatial information policy as the government agency for national surveying and mapping.*

(2) *Matters of importance*

- *Making a safe and secure society through national safety management, risk management, disaster prevention and so on.*
- *To accelerate the use of geographic spatial information in improving the standard of living and for regional revitalization.*
- *To promote international service by making good use of technical capability.*

****

Meanwhile in Montenegro, based on the 'Law on State Administration' in July 2004, DRE, under the finance ministries oversight, is the only state run agency responsible for cadastral surveys, real estate registration and administration, surveying, aerial photography, geographic information, and GIS. DRE and Japan's Geographic Survey Institute carry out all the same tasks as mentioned above, bar disaster prevention and land register surveys, and fulfills a role indispensible to national development. Thus DRE is in a position where it is responsible for a very important role in Montenegro, so I make the two following recommendations regarding state policy in order that it can easily implement this role.

(1) DRE's position regarding the development of basic spatial data

Formerly DRE's main tasks were cadastral surveys, real estate registration and administration; however with independence in 2006 and the above mentioned decree, it now has a new task to develop and provide geographic information in the same way as Japan's Geologic Survey Institute. Regarding cadastral surveys and real estate administration which it has a long history in, a technology base has been established with modern GPS electronic datum points that make highly precise and efficient surveys possible.

On the other hand, as the development of topographic maps was the charge of former Serbian Federation, there was insufficient technology for making small to medium scale maps.

In recent years, not only topographic maps, but GIS is now the mainstream of geographic information, and for this a high level of skill is necessary when compared with the analog days. This Study has transferred to DRE technicians the skills and new technology over the last two years to make the spatial data infrastructure, which is a combination of the digital topographic maps and GIS database, establishing a technology platform.

As mentioned before, within a spatial data infrastructure that can be used seamlessly throughout the country, one can expect an increase in demand in various fields, such as social and economic development, foreign investment, citizens, and in all government agencies.

Considering this, DRE has a major responsibility to expediently complete the remaining 30% that was not part of this studies scope, and we hope that they tackle it as a number one priority. Further, it is also important to make changes to keep the completed spatial data infrastructure up to date; and so it is hoped that the updating work can be implemented systematically, such as in the following way.

1. Every 4 to 5 years in economically active cities
2. Every 8 to 10 years in mountainous areas and surrounding areas

(2) DRE's position within state policy

A spatial data infrastructure is a major and indispensible factor in among others 'making a safe and secure society, and improving the standard of living,' and as discussed above, this is the same in Montenegro and in Japan. DRE understands this, and has started working toward the expeditious completion of goals set out in a mid-term plan it made in 2008 and its plan for the 2009 fiscal year. However it cannot be said that its personnel or equipment are sufficient. Because a spatial data infrastructure is important and indispensible information for national development and improving citizens' lifestyles, the most essential task for the Montenegrin government to ensure that the timely completion of the remaining 30% is possible, is to provide the sufficient environment such as the budget, systems, personnel, and infrastructure to DRE, the only agency designated to make maps.

These measures will make possible the provision of a variety of geographic information, such as, the high precision spatial data infrastructure and real estate information that society constantly requires of DRE, and also the precise location information obtainable from GPS datum points, which is why it is a matter that needs to be advanced with state policy.

7.2.2 Recommendations on Survey Standard (DRE)

Cadastral surveys and the creation of topographic maps are DRE's main responsibilities and these tasks were previously conducted based on the Gauss-Kruger Projection. As this covers both the coordinate systems zone 6 and 7, which divide the nation into two in the east-west direction, impeding the planned development of a spatial data infrastructure, new specifications were established in this study based on the global standard ITRF-96, and a spatial data infrastructure complying with the UTM system 34 was constructed. These specifications are based on the new Law on State Land Survey and Real Estate Cadastral enacted in May 2007, however under the transition period the old specifications, Bessel ellipsoid and Gauss-Kruger, are allowed to be used.

In DRE's policies, it is planned that a large amount of data accumulated at DRE, including results of past cadastral surveys and associated data such as topographic maps and plans, will be integrated and converted into the UTM format in the near future. In the meantime, however, the above 2 methods will coexist, and therefore DRE needs to pay close attention in performing any of its responsibilities.

What the advances in the leading VLBI surveying techniques have revealed about the dimensions of the earth, namely more accurate ellipsoid parameters that are being adopted in many countries around the world, and it is widely know that they are starting to replace the old specifications.

To ensure that Montenegro keeps up with this change, this study took this opportunity to establish the spatial data infrastructure based on the world standard, ITRF-96. However, until the necessary technical infrastructure and system are in place to change over the massive amount of topographical maps and survey results, including real estate cadastral, there will be a transition period where, as in the past, the two systems will continue to be used.

In particular, as the results of real estate cadastral determine the area of land, this is clearly linked to the owner's assets. More specifically, the upmost attention needs to be paid when undertaking all kinds of surveying in the future when there are two datum point results being used at the same time. It cannot be denied that there is a risk of it leading to a major social issue.

These two specifications, which have this sort of problem, need to be integrated as soon a possible, and it is best to convert the survey results from the past, and confirm the land area under the new specifications.

7.2.3 Recommendations on Ground Surveys (DRE)

In Japan, where many precious lives and assets are sacrificed in natural disasters every year, programs for accurate meteorological observation and weather forecast, crustal movement surveys, and natural disaster prediction and warning systems have been rapidly advancing. In particular, to prepare for earthquakes that can cause extensive damage, approximately 1,200 GPS-based reference stations have been set up throughout Japan to improve anti-earthquake measures, by observing and recording real-time movement of faults to understand the mechanism of how disasters occur as well as developing advanced surveying technologies to enhance the prediction accuracy. Those GPS-based reference stations employed in Japan are used also in a number of other public surveys in addition to the surveys for disaster prevention, and they are contributing to the acquisition of uniform and highly accurate information and to an improvement in efficiency of public service operation. Data collected from these stations will be combined using advanced technologies in various fields, not limited to technologies of disaster prevention and survey fields, to realize a safer and more comfortable social environment in Japan in the future.

Meanwhile, although in Montenegro, a nation that gained independence only recently, risks of natural disasters are not so high, it is a well-known fact that, as already stated, the nation needs to urgently advance development and environmental preservation. One of the important factors playing an important role in making plans for these purposes is a spatial data infrastructure, and the responsibility to construct such infrastructure has been delegated to DRE.

DRE already has nine GPS-based reference stations, and can conduct RTK GPS surveys (virtual reference station method: VRS) using GPS supplied by JICA as study equipment. Although, when compared to the static method, it is less accurate (error of ±2 to 4cm) and has a disadvantage that it requires data communication expenses, the VRS method also has a number of advantages, for example, it can shorten the time necessary for observation and can save labor as it can be managed with fewer personnel.

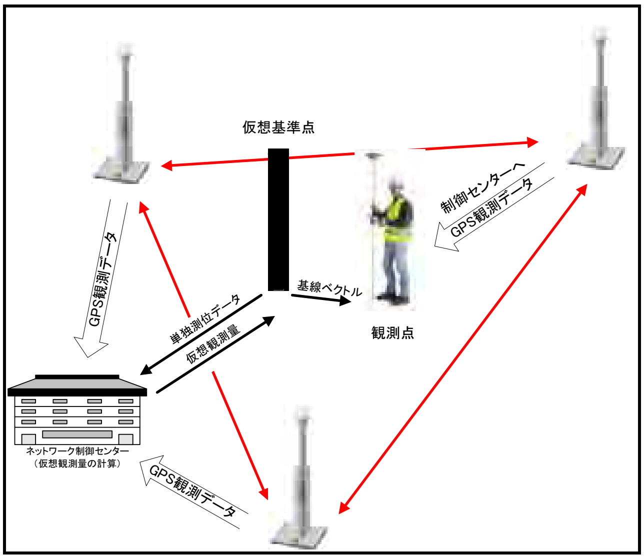


Fig 49：VRS method

The VRS method has already been put to practical use in public surveys in Japan and it is often used in GPS surveys such as engineering surveys for which the accuracy requirement is not extremely strict. In this study, technology was not transferred to many staff members and, therefore, it is necessary to disseminate the transferred technologies widely within DRE so that the base of its technological capabilities will be expanded.

7.2.4 Recommendations on Digital Photogrammetry in General (DRE)

Digital photogrammetry is the most important technological factor in technology transfer conducted in this study and it is also important for DRE's independent development. As there are different elements in the different processes of digital photogrammetry, recommendations are provided for each process as follows. Elements for which recommendations are made are selected based on the results of tests and reviews made by Japanese staff during OJT and questionnaire surveys conducted during workshops.

(1) Digital aerial triangulation

Through workshops and questionnaire surveys, it was found that there are a total of 6 staff members who can conduct aerial triangulation. Based on this fact, it seemed that the technology transfer made to C/Ps would be dissemninated adequately to other staff members. Most of the staff members, however, have experience in aerial triangulation using conventional software and it was revealed that they have not much experience in handling the new type of equipment provided by JICA. It is desirable, therefore, that DRE actively use the new equipment also in works other than the development of the 1:25,000 scale spatial data infrastructure in order to accumulate experience.

(2) Digital plotting

Although there are quite a large number of staff members who have experience in digital plotting, there are few staff members who can understand the product specifications established in this study. It is vital that those in charge of digitizing maps in the photogrammetry department understand the specifications in order to construct a 1:25,000 scale spatial data infrastructure in the future.

In order to construct a spatial data infrastructure accurately, therefore, it is considered that the best solution is to let the C/Ps who were the recipients of the technology transfer organize and offer study sessions on both the product specifications and the work methods at DRE. And, these C/Ps' workload of offering such sessions can be reduced if they are charged with different parts of the study sessions depending on their knowledge and skill.

(3) Digital data compilation

Many staff members have some experience in digital data compilation to create digital topographic maps, but only a very small number of them can conduct digital data compilation for GIS databases. It was also found that they have only a little experience in verification of the created data, such as visual inspection and logical inspection.

It is necessary for other staff members to master technologies required for "digital data compilation with structuring in mind," under the guidance of C/Ps who were the recipients of the technology transfer. Concerning "inspection," it is considered necessary to set up a division specialized in inspection and to establish a system to conduct inspection accurately, not just making staff members master how to conduct inspection.

(4) Digital data compilation for field completion and structuring

At DRE, there have not been many cases in which digital data compilation for field completion and structuring were conducted, and as a result DRE staff members are also virtually inexperienced in using the GIS software necessary for this work. The content of digital data compilation for field completion is almost the same as that of digital data compilation, and if the issues found in digital data compilation can be resolved, digital data compilation for field completion will be carried out without a problem. As far as graphic editing is concerned, there are no large differences between the CAD software familiar to DRE's engineers and the GIS software used in structuring.

When inputting attribute data, however, it is also necessary to understand the structure of GIS data, and although it is best to have as much experience as possible in work in which GIS software is used, the number of software available is limited. It is considered, therefore, that one of the solutions is to introduce GIS software available free of charge via the Internet to promote understanding of the GIS database structure.

(5) Application of fundamental materials (aerial photos)

At present at DRE, work is underway on 1:10,000 scale orthophoto maps covering the whole country using the aerial photos taken by this study, in response to requests from various government agencies beginning with the Department of Statistics and the police. The use of these orthophoto maps for the foreseeable future will be for the population census planned for this year. As the census covers all citizens living in all corners of the country, it is clear that the orthophoto maps based on the aerial photos taken in 2007 will greatly increase the accuracy, and lead to a highly reliable population census.

Even if this is the extent of its use within government for some time to come, by undertaking field surveys on a similar scale as with digital topographic maps, and adding public buildings, landmarks such as ruins, administrative names, roads, rivers, lakes and such, so that the orthophoto maps can be used by anyone, they will be able to be sold. Orthophoto maps like these produced with digital data, such as digital topographic maps, can be adapted to suit specific needs by adding content or reducing the scale, and can be used in many different fields; one of DRE's tasks is to keep developing products to meet the market needs.

7.2.5 Recommendations on Map Symbolization (DRE)

(1) Technology

1) Establishment of a strong technological base

In order to maintain and further develop the know-how of map symbolization for map publishing that has been acquired through the technology transfer, it is important to gather experience while being engaged in actual work. The technologies transferred are basic and typical that will allow the users to perform the work without fail, and if the users are to learn how to put these technologies into practice they need to keep acquiring experience through actual work. Also, it is indispensable for the C/Ps to upgrade their skills in this way, so that through self-help efforts they can find solutions to the issues they encounter.

That means, it is best to implement the development of the spatial data infrastructure for the remaining 30% of the national area immediately and, at the same time, it is desirable that digital plotting and data completion be continuously conducted.

2) Productivity

Currently, there are only 2 C/Ps at DRE who are skilled in map symbolization for map publishing. In order to improve productivity, it is essential either to promote dissemination of the technology widely within DRE by these 2 C/Ps or to employ new personnel. Meanwhile, it is necessary to implement capital investment in both hardware and software.

(2) Effective utilization of output products

1) Development of compilations of reduced scale maps

By editing the latest data obtained through this study, maps similar to 1:250,000 scale print maps that DRE currently owns can also be updated or converted into other forms. One such example is the 1:50,000 scale topographic maps of the western coast area of Montenegro, which were delivered to participants of the second seminar, and these topographic maps now can be created by DRE on their own by utilizing know-how acquired through technology transfer. The work procedures are summarized below:

Fig 50：Road map owned by DRE

- To change specifications and to select items to display
- To reduce the scale of data based on the scale ratio
- To create composite maps (by trimming each map to compose or by joining objects in adjacent areas to create new maps)
- To organize annotations
- To prepare new marginal information

2) Utilization in maps of Montenegro's entire area (print maps) owned by DRE

DRE-owned maps of Montenegro's entire area are vector data in the CoralDraw format and they are compatible with data developed in this Study. Because of this, this existing data owned by DRE can be updated using the latest information, if reduced-scale data is incorporated from the spatial data infrastructure.

3) Printing and publishing

Data of the digital topographic maps developed in this study were created on the assumption that they will be printed as high-quality print maps and, therefore, it is recommended that this data is not just printed on a regular computer printer, but be widely offered and sold in the form of printed maps. In doing so, however, since this data is currently set for 4-color printing (CMYK), it is best to designate additional plates selecting Gray (mainly for roads) and Brown (mainly for contour lines) from pre-registered colors (swatch colors) to print maps in a total of 6 colors.

4) Preparation of various thematic maps

Data of 1:25,000 scale print maps can be altered or reduced to compile a variety of thematic maps.

Even hazard maps or mountain maps can be created by linking with GIS databases and simulation. Whether excellent quality print maps can be created or not depends on the design, and it is highly expected that DRE will generate good design ideas in the future.

7.2.6 Recommendations on Dissemination of Geographic Information and GIS (DRE & DSP)

(1) DRE

1) Continuation of GIS training

As clearly indicated in the results of questionnaire surveys conducted by study team during workshops, GIS has not necessarily been dissemninated widely at DRE, apart from the GIS Division. In order for DRE to effectively utilize the digital topographic maps constructed in this study, however, GIS technology will no doubt play an important role.

Therefore, it is desirable that GIS training be held within DRE regularly, mainly offered by engineers who have already attended the GIS technology transfer training course held as part of this study, and that GIS-related technologies and knowledge be dissemninated among all concerned staff members at DRE. It is recommended that DRE review the annual schedule for GIS training and develop sample data and manuals for this training.

2) Quality control

It was found through the GIS training that engineers at DRE have a fairly high level of GIS technology. Understanding of the various functions taught in the technology transfer was high, and work was extremely smooth and fast, however, sometimes there were errors.

As it is expected that GIS data constructed at DRE will be the most important basic data for Montenegro, and this data will be used by a large number of domestic and international organizations, quality control is a very important issue at DRE.

Taking the above situations into account, it is necessary to prepare a checklist for each step and to construct highly reliable data when developing GIS data.

(2) DSP

1) Continued utilization of GIS

At DSP, the utilization of GIS has just begun and GIS-related technologies and knowledge owned by DSP are not at a high enough level. As DSP is a key organization responsible for planning, it is desirable that GIS be utilized at DSP as a tool to create a range of maps (future planning maps, laws and regulations maps, natural resource protection maps, forest conservation maps, etc.).

It is recommended, therefore, that GIS technology and manuals obtained through the technology transfer in this study be utilized effectively and such utilization of GIS be promoted in day-to-day operation. It is also recommended that DSP staff members attend the GIS training offered by UNDP to improve GIS-related skills.

2) The role of spatial data infrastructure in DSP

- The scale 1: 25,000 digital topographic maps will be indispensable to DSP in the already underway documentation in the field of spatial land-use planning
- These maps will represent a base for creating a GIS database for the field of planning, space organization and construction.

3) Construction of national-level GIS databases for the National Development Plan

At the GIS technology transfer in this study, data composed of 2 digital topographic map sheets of a suburb of Podgorica were used to construct a model GIS database of major roads, major rivers, elevation, inclination, aspect, current state of land cover, etc. In addition, training was offered to link nationwide administrative boundary data and the 2003 Census results.

In order to work out national-scale development plans, it is necessary for DSP to expand data sequentially, including data on national roads, rivers, schools, medical facilities, conservation areas, and laws and regulations, based on technologies obtained through this study. It is also recommended that DSP construct a database of attribute information of these roads, rivers, and other facilities, along with a database of geographic information. Although technologies required for implementing these tasks have already been transferred to DSP, it is desirable that DSP keep refining their skills, because their level of technological capabilities is not high enough.

(3) Entire nation of Montenegro

1) Dissemination of geographic information

As part of this study, questionnaire and hearing surveys were conducted to understand the status of GIS utilization at concerned organizations in Montenegro. A hearing survey was conducted at the Geological Survey of Montenegro and the Montenegro Seismological Observatory, and it was found that at these two organizations GIS had not been utilized on a full scale. But, currently, they are active to send staff members to GIS training courses offered by UNDP to improve their technological capabilities.

The Geological Survey of Montenegro plans to digitalize valuable geological maps they have stored for more than 60 years and to produce maps of materials and resources distribution utilizing GIS. At the same time, they recognize that the digital topographic maps to be constructed in this Study are highly important.

Meanwhile, urgent issues for the Montenegro Seismological Observatory are the construction of a GIS-based system to monitor earthquakes in the Balkan region and the production of hazard maps that cover both Montenegro and its neighboring nations. In order to achieve these, it is clear that the spatial data infrastructure, or digital topographic maps contained in it, be utilized as the base data and, therefore, it is desirable that the output products of this study be exploited extensively.

Accordingly, if the digital topographic maps constructed in this study are to be utilized effectively by the concerned organizations in Montenegro, DRE needs to lead the way in promoting the utilization of this data through seminars and workshops or through its website.

2) Sharing information

In order to work out strategic national development plans for the entire nation of Montenegro and to effectively and efficiently construct GIS databases indispensable for that purpose, information and data owned by different organizations needs to be shared. For promoting the utilization and exploitation of GIS in Montenegro, it is highly important to establish a "GIS exploitation and utilization promotion committee" (tentative name) to be composed of various concerned organizations to discuss how to construct a GIS data set required by the nation. It is anticipated that efforts like these will promote the sharing of information. It is also possible that participants in UNDP's GIS training courses and this study's GIS technology transfer will be utilized in common by concerned organizations, and new GIS training courses will be developed in which those experienced participants act as resource persons.

7.2.7 Recommendations on PC and Database-related Safety Measures

During this study, a number of computer viruses were found in computers at DRE including those provided by JICA. Although the level of threat was rather low at the beginning, and at one point the situation got to the point where the plotting system for the technology transfer would not even start-up, and as a result, work often had to be discontinued. After conducting inspection within DRE, it was found that viruses were widespread not only among computers used for the study, but also among virtually all of the DRE's computers connected through its

LAN.

For avoiding the risk of being exposed to the threat of viruses that can corrupt data or cause important information leaks, it is necessary to take highly reliable security measures.

DRE understood the importance of this problem and it took measures from the second half of 2008, at the same time as investing in equipment such as computers and software. Thanks to that, at the time of writing this report, antivirus programs had already been installed in each computer in DRE, and that helped in establishing a good base for further system protection.

However, computer viruses have become a global problem, mainly because they spread very fast, so it is expected that every employee take care of their own computer. Regarding the fact that not only the engineers participating in this Study, but the entire DRE staff use computers, it is hoped that, adequate measures will be taken, such as making updating virus software compulsory and ensuring that each DRE employee understands the importance of taking antivirus measures.

7.2.8 Recommendations on Information Disclosure

As aerospace technology advances rapidly, less than 1-meter high-resolution satellite images can be obtained freely by any individual from around the world. As a result, confidentiality of topographic maps has been diminishing and, not surprisingly, information such as topographic maps is increasingly disclosed in many nations around the world.

In Montenegro, diverse laws and regulations have been revised following the nation’s gaining of independence and in preparation toward EU membership and, as a result of the “Law on Free Access to Information’ enacted in 2005, geographic information such as topographic maps and aerial photos formerly controlled by the military sector has been put in the hands of DRE. As a result, at present such information can be utilized freely by any individual. However, only a limited amount of geographic information was offered for sale in the past and information contained in the spatial data infrastructure constructed through this study is positioned as the first geographic information to become a product for sale. If the information is offered at reasonable market prices, it is expected that investment in diverse fields will be promoted, not only domestically but also from various countries-mainly from Europe and the U.S., and that such information will be utilized effectively also by a total of 1 million tourists visiting Montenegro every year, who are one of the major income sources for Montenegro.

In Montenegro moving toward EU membership, compliance with EU standards is imperative in a range of areas and the nation’s diverse organizations including DRE are also required to comply. Specifically, DRE aims at improving its operations such as cadastral surveys and registration service, receiving support from the World Bank and GTZ. In this sense, it is desirable that the spatial data infrastructure and aerial photos developed and technologies transferred under this study be effectively exploited to generate synergies.

Meanwhile, UNDP's project for forest and environmental preservation is currently implementing its second phase and receiving a partnership fund of the Japanese government. In the project, mainly capacity development of GIS technology is promoted using open-source GIS software, and various natural condition information that will be needed in the future are compiled as a database. It is said that UNDP is also planning to implement another project to address natural disaster prevention in the next phase. UNDP will disclose this information and database through its website in the near future, targeted at enabling various organizations in Montenegro to utilize the information effectively.

In addition to these natural condition databases, information that has been collected by various organizations is extremely useful as social condition information, including information gathered through the population census conducted by Monstat. For this reason, it is clear that more extensive utilization will be possible if such information is linked with a 3-dimensional spatial data infrastructure. At the same time, it is anticipated that in the near future, the need to set up a national information center will come up as a topic of discussions in Montenegro.

Taking these situations into account, it is also desirable that DRE make efforts to inform the public of the spatial data infrastructure and other information constructed through this study seizing every opportunity, so that the infrastructure will be exploited effectively as a base for the nation's further development.

Whether this information can be freely accessed or not boils down to the precision and high reliability of the information and products. In the recommendation 7.2.9 below, in the same way as the aerial surveying department, appropriate accuracy management is indispensible in the land surveying department as well.

At the start of this study original specifications for Montenegro were established based on the Japanese specifications shown at the beginning of this study and various European countries' specifications, so it is hoped the survey department in charge of this work is improved soon, and also the inspection process to ensure the precision of each stage of the survey process can be maintained, including planning, surveying, calculating. If this is improved, the credibility of the many different results of land surveys and topographic maps obtained through aerial photography will increase, and will be used in many more fields than they currently are.

7.2.9 Recommendations on Strengthening of DRE's Organizational Structure toward Independent Development

(1) Field survey division

DRE has a total of nine GPS-based reference stations, which can be viewed as advanced technology. By also utilizing 2 total stations equipped with GPS receivers provided by JICA to implement this study, it is possible to increase the speed and accuracy not only of control point surveys, but also of cadastral surveys—the most important task of DRE. It is expected there will be no problem here as DRE has a high level of technology in place.

However, an extremely large amount of valuable data accumulated by the field survey division, including various ground control points and benchmarks and results of cadastral surveys, has not been organized appropriately. It is recommended that the digitalization and database compilation of such data be accelerated.

It is also necessary not only to maintain this valuable data using database software, but also to organize them appropriately so that they can be linked with the spatial data infrastructure. As a result, users will be able to retrieve data freely, and even third party users' requests for data will be efficiently fulfilled.

(2) Photogrammetry division

1) Dissemination of technology

During the 2-year period of this study, technology transfer was conducted to only a limited number of engineers because there is limited equipment. It is desirable that those engineers disseminate the acquired technologies to other members to further improve the production base of the DRE. In particular, for constructing the spatial data infrastructure, it is required not just to acquire conventional CAD data, but to enable practices such as digital plotting, digital data compilation, and data alignment targeted at GIS database construction and digital printing. Accordingly, a top priority is to enhance the technical capabilities of the photogrammetry division.

2) Establishment of a new Cartography Division

It may be said that in the pre-independent days, Montenegro's topographic maps were totally in the hands of Belgrade and DRE had virtually no technological capabilities to create and publish maps. Amongst others, the know-how of desk top publishing (DTP) transferred through this study, which is a mainstream of modern day publishing solutions, was totally new to DRE. The creation of the remaining (30%) of spatial data infrastructure and updating the digital topographic maps for the whole of Montenegro will not be completed successfully unless the process is advanced significantly by creating a new division specialized in the task. DRE can not afford to be satisfied with the fact that the new technology was transferred to 2 C/Ps, and it is desirable that the level of engineers' technical capabilities is raised.

3) Creation of a new Inspection Division

It is impossible to eliminate all human errors, however accurately we understand the specifications and however correctly we plot and edit maps. If data verification is not conducted rigorously and accurately, problems will almost always occur in the downstream processes such as the construction of GIS databases and map symbolization.

In short, it is indispensable that verifications are conducted and instructions for correction be given by engineers who can correctly understand the content of the digital topographic maps, the database structure, and fundamental specifications. It is also necessary for DRE to set up a system for this purpose as soon as possible.

4) Early completion of spatial data infrastructure for the remaining 30%

Many domestic and international users hope that it will be possible to capture the entire national area as a single and seamless piece of data to be utilized in diverse development planning, environmental preservation, and management, and they hope that DRE will make efforts in this field. In order to satisfy such demands, there will be no alternative to DRE finding solutions to the above three issues as quickly as possible, and engineers in various fields need to make continuous efforts through mutual cooperation and competition.

5) Development and sale of new products exploiting output products of this study

As stated in the earlier section "5.1.3 Effective Utilization of Digital Topographic Maps," DRE will not need to create a new database of maps on scales less than 1:25,000 in the future. This means, DRE will be able to reduce the scale of data obtained through this study and to alter and edit the data to create geographic information on scales of 1:50,000, 1:100,000 and 1:200,000.

In addition, DRE will be able to offer and sell aerial photos in the form of digital data as they are or by processing them into orthophoto maps using a DEM.

(3) DRE as a whole

1) Formulation of strategies

The completion of this study will be the starting point for DRE to make new efforts and it cannot be denied that how DRE can reinforce its capabilities of "planning," "implementing," "maintaining," "managing," and "offering for sale" will affect the future development of Montenegro as a nation.

It is desirable that DRE act in the future by recognizing that the enhancement of efforts to develop the spatial data infrastructure is one of its key strategies along with other strategies such as the enhancement of cadastral surveys and real estate management formulated based on the existing medium-term plan.

2) Establishment of appropriate sale prices

As indicated in the above words of "maps are living documents," maps as part of the spatial data infrastructure will play a vital role in and offer benefits of providing fresh information to many users. At the same time, maps will lose freshness as time advances and they need to be updated.

Updating maps is naturally one of the missions DRE is given, and in order to regularly update maps it is important for DRE to set appropriate sales prices to increase sales and to cover the costs of software and hardware maintenance as well as costs of upgrading. This means, if prices are too high, there will be no large sales and if they are too low, maintenance and upgrading costs cannot be covered. For setting reasonable prices, DRE may need to seek examples in neighboring European countries. In particular, because digital data is vulnerable to unauthorized copying, it is necessary to carefully study and set prices, while establishing a legal system and penal regulations for the handling of this type of data.

DRE has made it clear it will provide free of charge or for the cost of materials to the various national and local government agencies, donor agencies and so on; however, regarding a sale price for users such as tourists, private companies, and the general public, and are currently conducting a price survey in neighboring countries and have just started deliberating an appropriate price. The following table is for reference showing the sales prices ascertained by this study team in neighboring and European countries and Japan.

Table 23: Sale Price in Neighboring Countries & Japan: from each countries map making agencies web site (Unit: Euro)

1:25,000 Topographic maps	Slovenia	Croatia	Bosnia and Herzegovina :Republica Srpska	Bosnia and Herzegovina: Bosnia/Croat Federation	Macedonia	Hungary	Italy	Japan
Printed Maps		9.96	50.00 4 colors	35.00	2.50	7.00	9.36	2.25 3 colors
Raster Data	2.59 TIFF	92.96 TIFF	100.00		10.00			
Vector Data	2.78 Each Layer				160.00 Each Layer			62.50 Each Prefecture
DEM		265.60 25mX25m			35.00			62.50 1/3 of country
Orthophoto Maps					8.50			25.00 30″x30″
Thematic Maps			25.00 Topography, Hydrology, Agriculture					

As you can see they are not uniform, each country and agency has set selling prices according to there own calculation methods and viewpoint. In order to set an appropriate price, not only will the remaining 30% need completing, but the total cost, including that of updating the entire area in future will need to be added up.

In addition, various cost calculations are necessary, such as for media like CDs or DVDs that the data is sold on, consumables like the roll paper and ink etc. used in printing, and possibly the cost of high quality printing or the like if used rather than regular printing.

There are many unclear points such as these, but the study team recommends the following price settings.

1. Printed maps (mass produced): Around 3 Euros
2. Output maps (printed on demand): Around 10 Euros
3. Rasta Data (CD / DVD): Around 5 Euros – Discounted by volume
4. Vector Data (CD / DVD): Around 50 Euros – Discounted by volume

3) Publication and dissemination via website

DRE has already disclosed information on real estate through its website. Mainly, they have made available information on real estate for which cadastral surveys were completed and cadastral maps were established. It is desirable, however, that in the future DRE disclose to the public components of the spatial data infrastructure, too, including aerial photos, orthophoto maps, digital topographic maps and GIS databases.

The spatial data infrastructure will be offered to and used freely by the government of Montenegro and concerned organizations such as donors, but the issue for DRE in the near future will be how to offer it for sale and how to collect the charges from general users. As the internet becomes increasingly popular, we now are in an era where we can place an order to purchase a wide range of products from home or from anywhere around the world through PCs and mobile phones. DRE cannot get away from these situations and, therefore, it is desirable that DRE make vigorous efforts to advertise and disseminate the spatial data infrastructure.