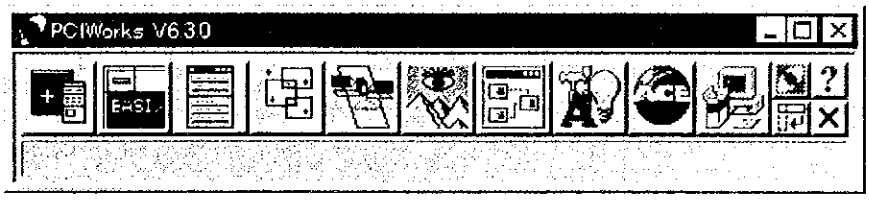
Geometric Correction of SPOT Satellite Image by PCI Software

1. Outline of PCI Software

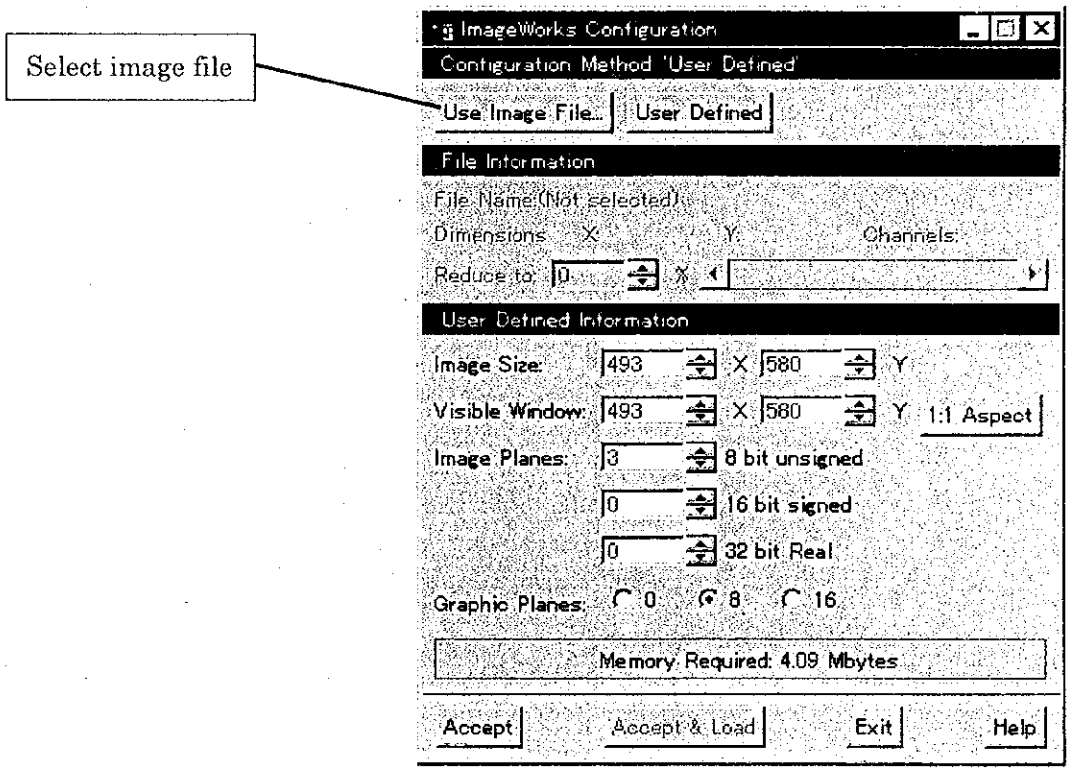
PCI Works : Launcher of PCI modules

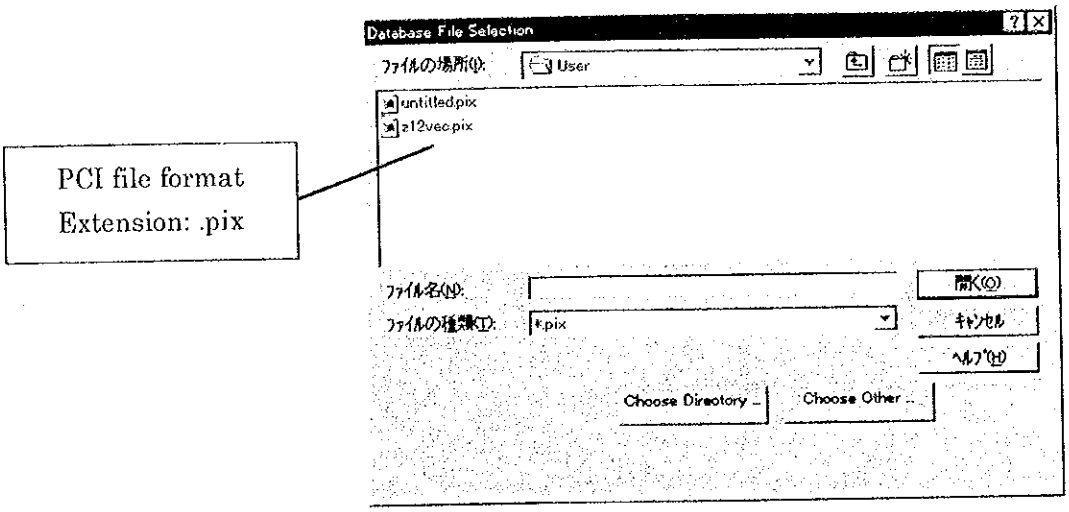


PCI software modules:

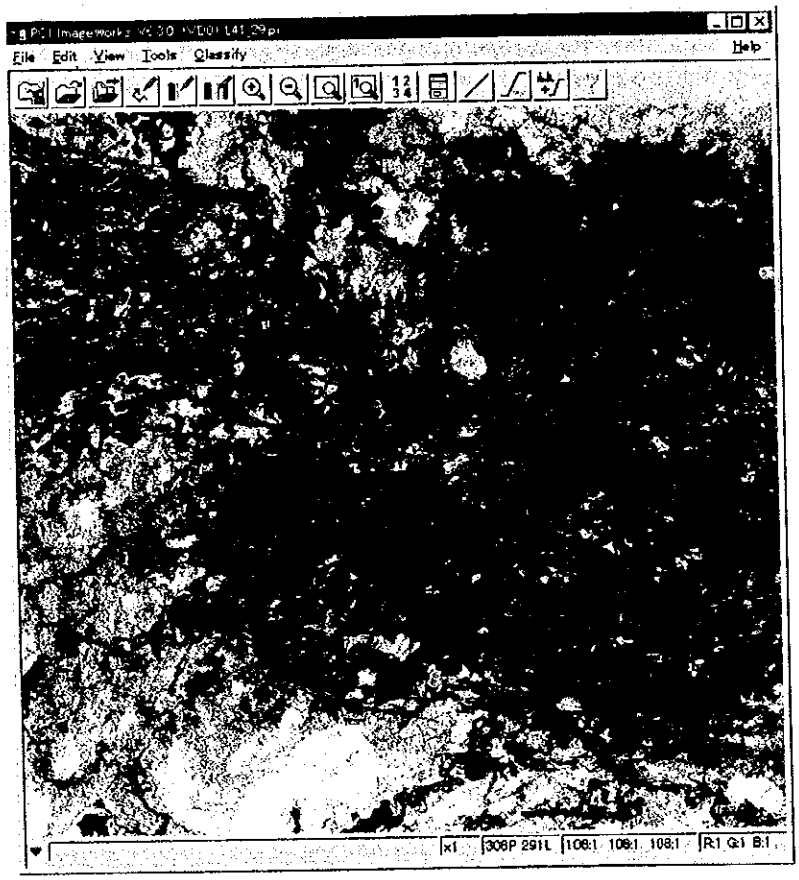
- Image Works : Image viewing and classification.
- EASI : Image processing by command interface.
- X-PACE : Image processing by graphical interface.
- GCP Works : Geometric correction and mosaicking.
- Ortho Engine SE : Ortho correction of satellite image.

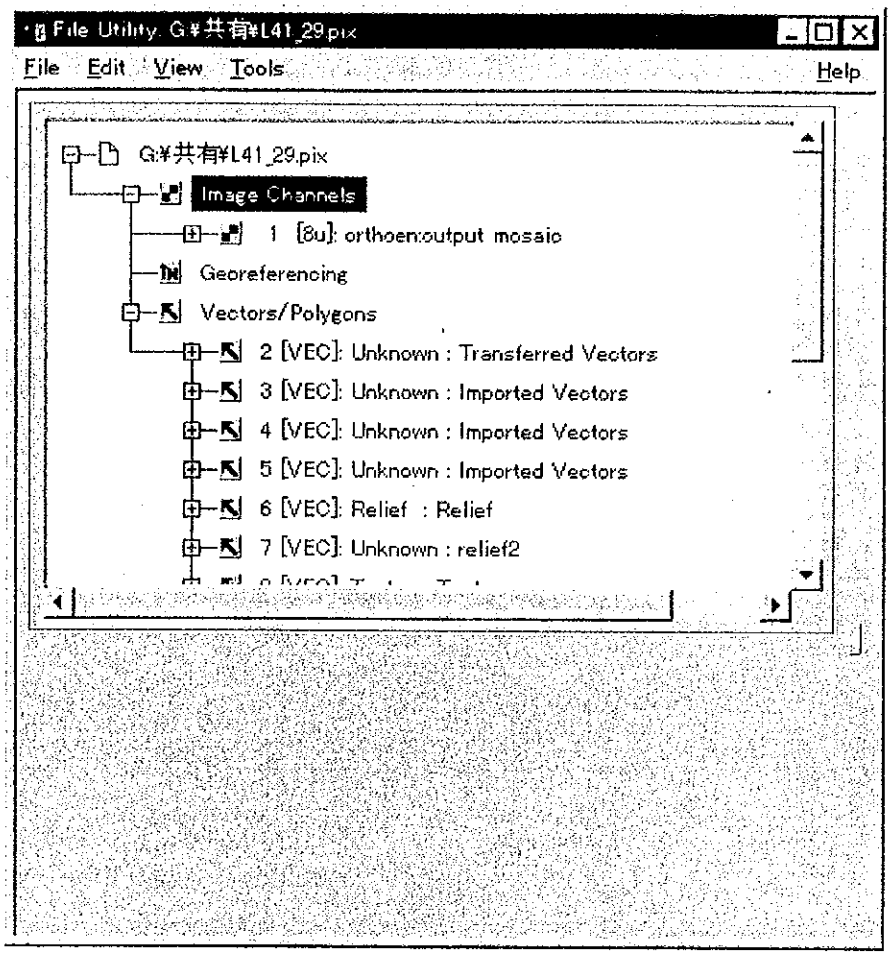
Image Works





Viewing raster image and vector overlay. This module also performs supervised and unsupervised image classification.

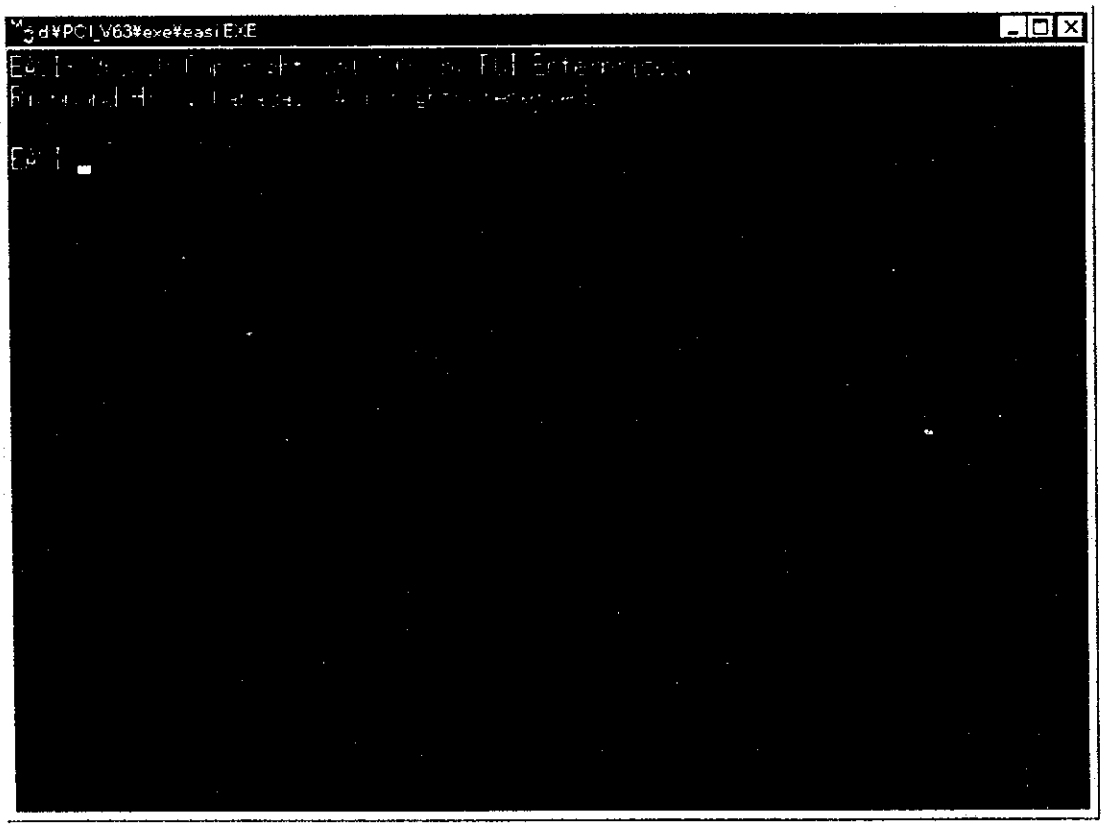




File Utility is invoked by every PCI modules. Data contents of PIX file are listed up. All data layer is managed with this module such as adding and deleting data layers.

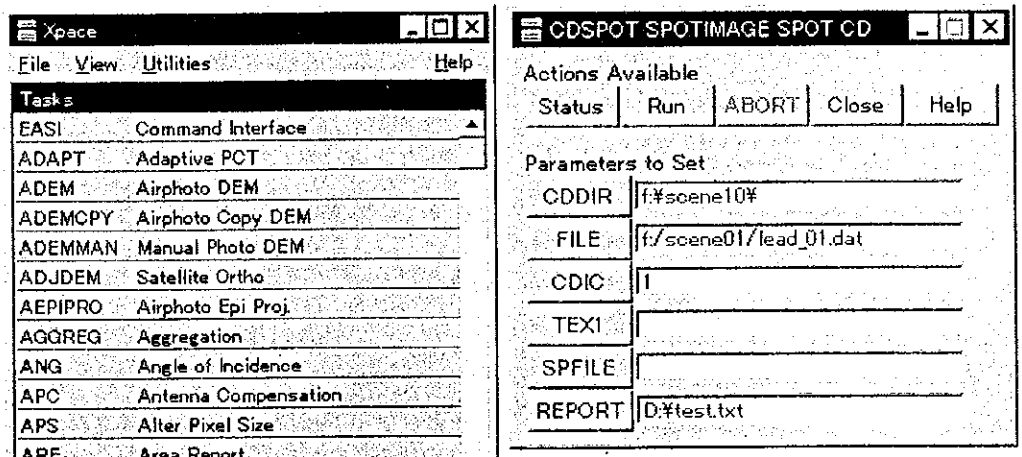
EASI

Image processing by command interface. Batch processing with scripting is available. EASI script in which a set of command s are placed enable to automate complex and time-consuming image processing. Furthermore, EASI script language includes a complete set of functions that permit the manipulation of every kind of data.



X-PACE

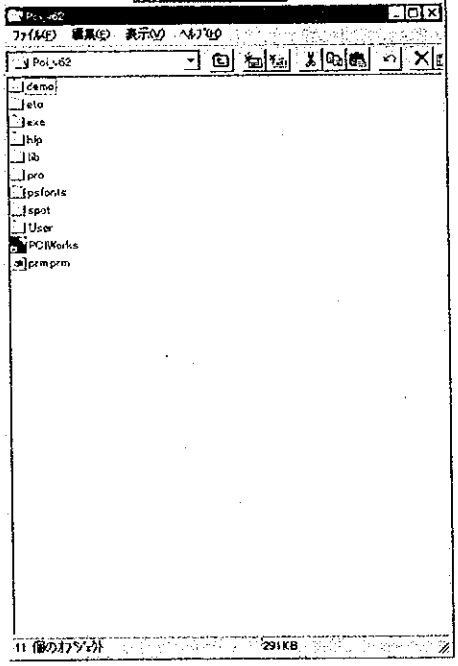
Image processing by GUI(Graphical User Interface). By clicking each button, every processing task can be executed.

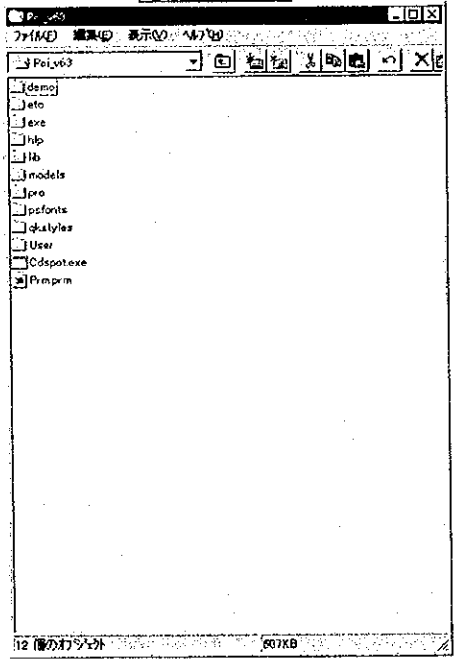


2. Modules Replacement for Making Strip Image

It is necessary to replace/add modules listed below for strip making.

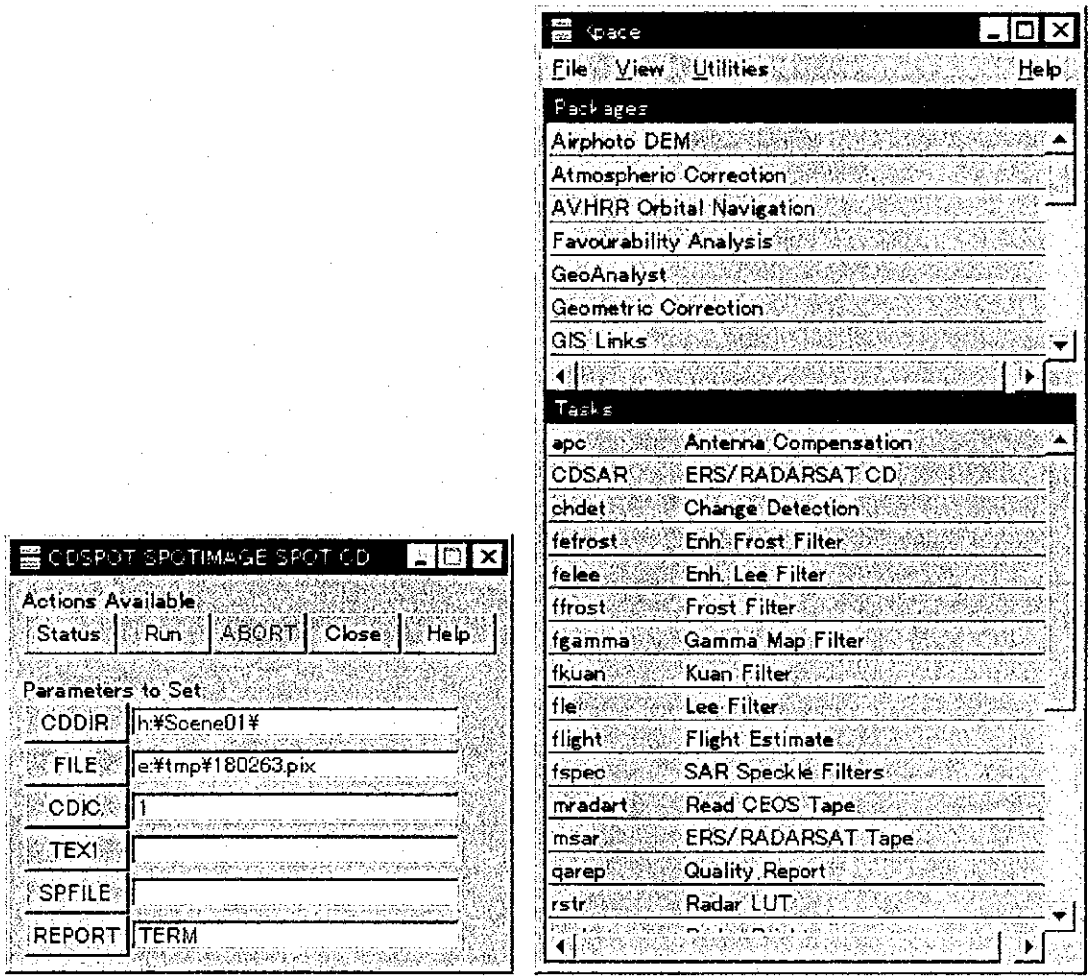
Cdspot.exe	: Import SPOT data from CD-ROM
Merspot.exe	: Merge SPOT images
Merspot.hlp	: Help file
Orthose.exe	: Ortho Engine
Prm.prm	: Parameter file of PCI software





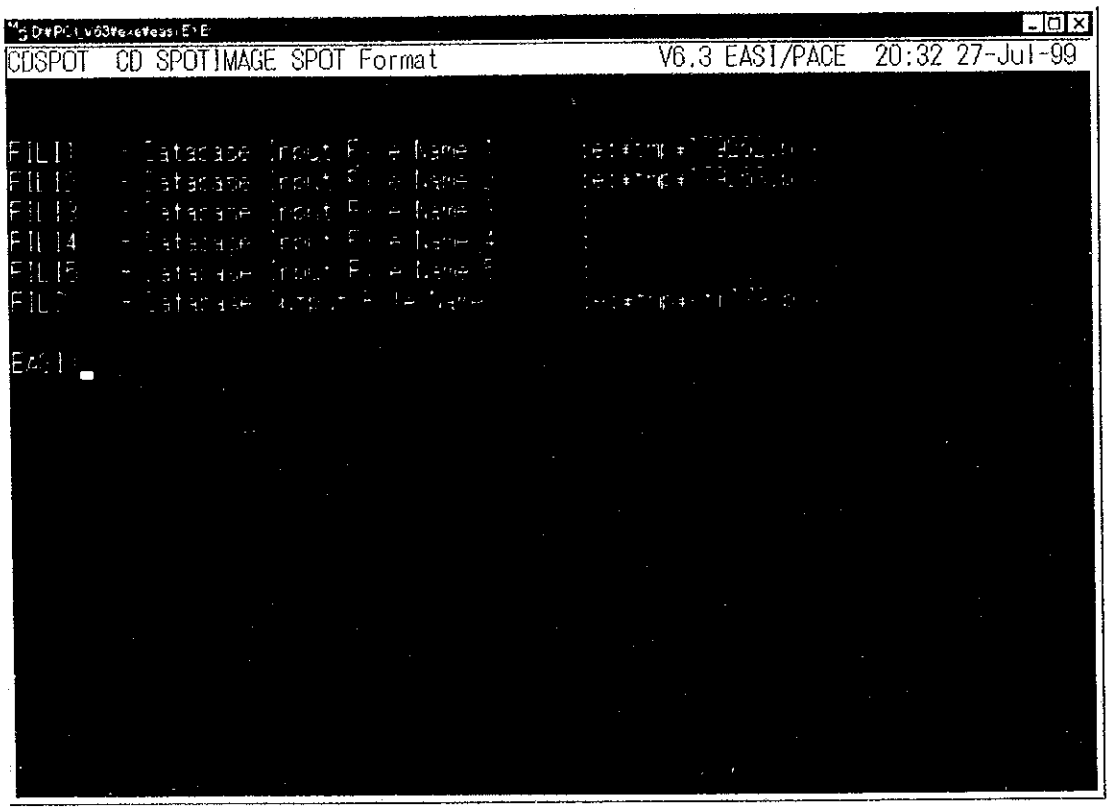
Directory to install	File name	File name
exe	Orthose.exe	Cdspot.exe Merspot.exe
help		Merspot.hlp
user		Prm.prm

3. Importing SPOT Data from SPOT CD



At the beginning, SPOT data should be converted into PCI format data (PCIDSK format) from SPOT CD-ROM by 'CDSPOT' in X-Pace. Set "CDDIR" the directory that has target data. The output data includes not only image but also satellite orbital data. This command is available through both X-Pace and EASI.

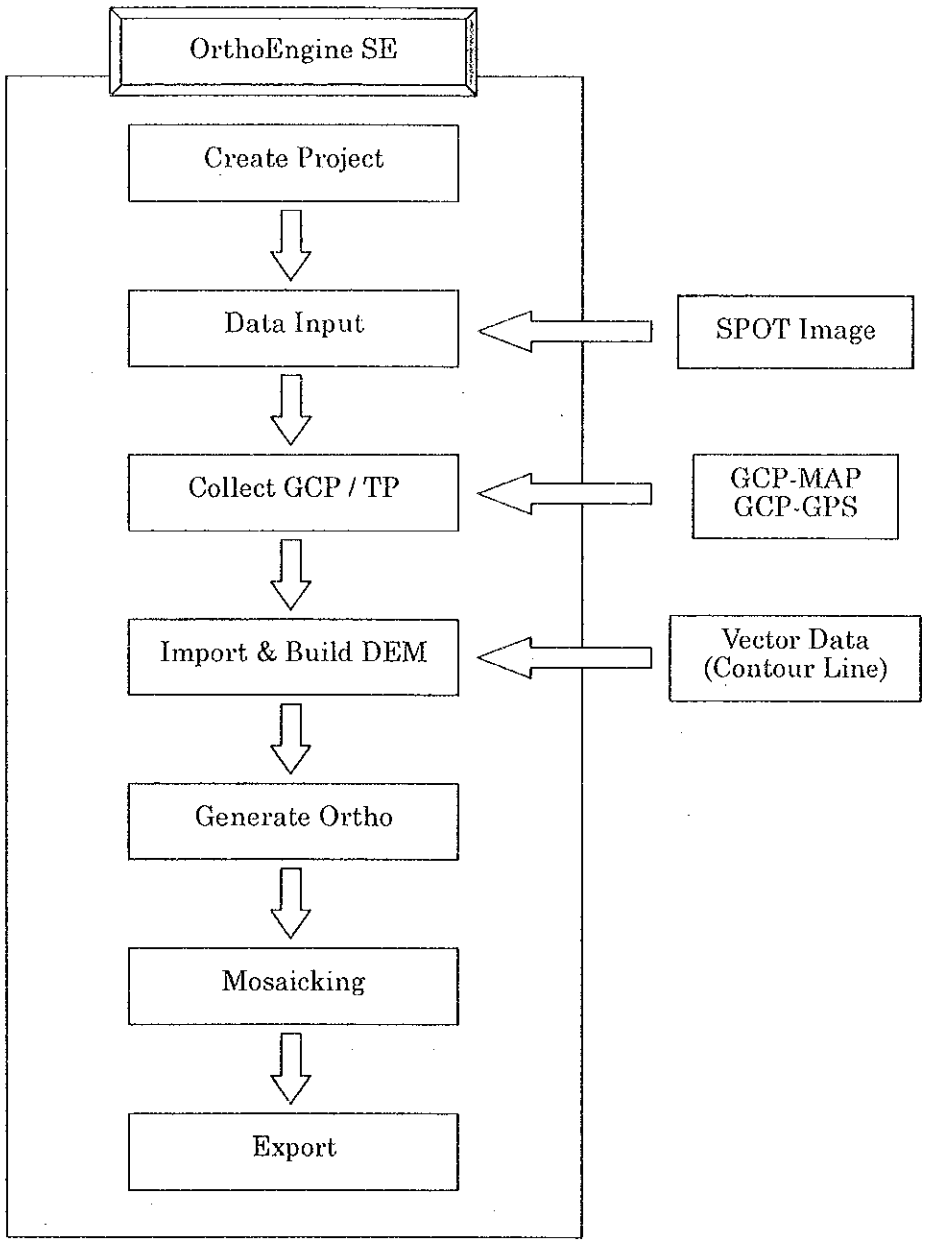
4. Merge Scene Data to Strip Image



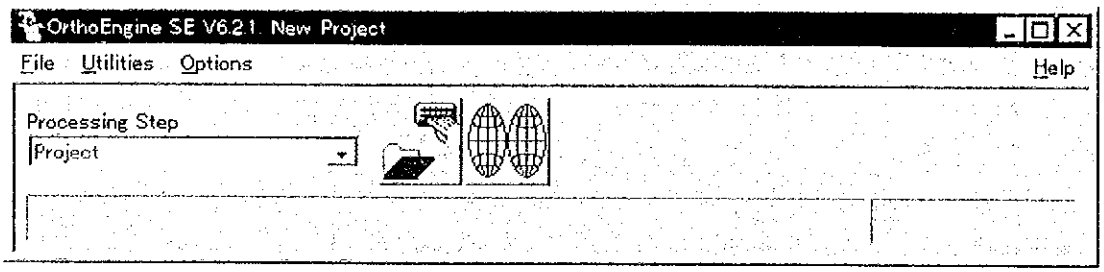
SPOT scene data (image and orbital info) taken at same date and orbit can be merged into a strip image by 'MERSPOT' in EASI. Up to 5 scenes can be combined. In case of less than 5 images, some parameter must be blank like above. This command is available in only EASI interface.

5. OrthoEngine SE (Orthorectify Satellite Image)

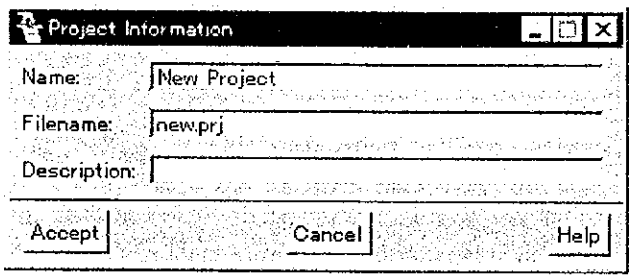
Satellite ortho images are created by OrthoEngine SE using GCP (Ground Control Point) and DEM data. The processing flow is as follows.



1) Project Setting

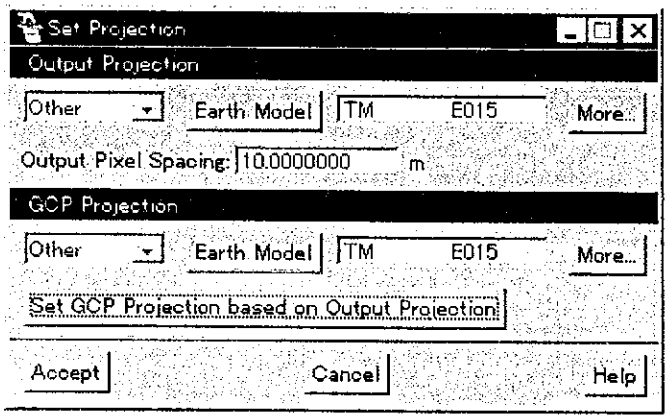


Select 'File' – 'New' on the main panel. OrthoEngine manages image processing based on the setting file called 'Project file' in which image file names are stored.



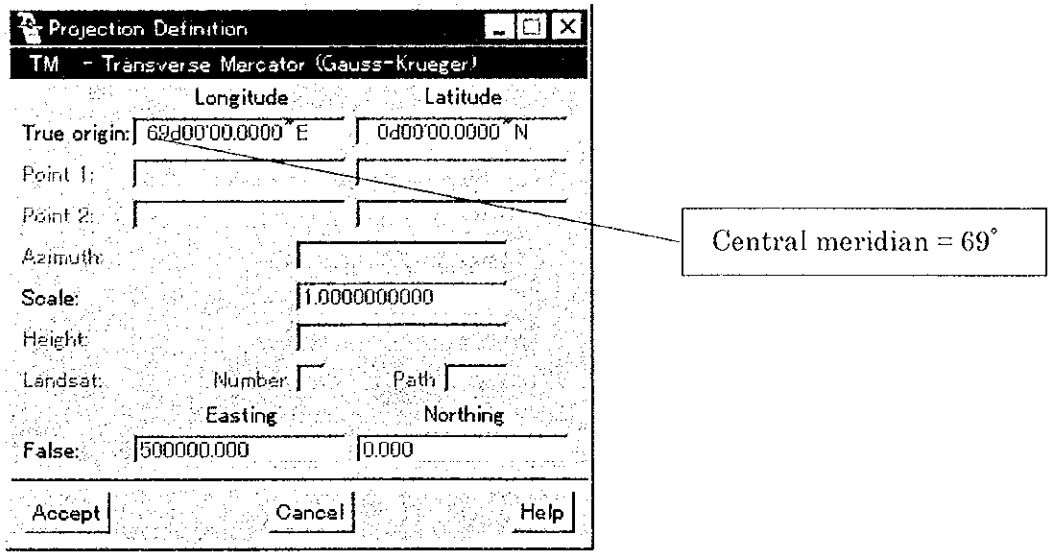
Set project name and file name, description of the project.

Set projection parameters for output and GCPs.



In this project, Transverse Mercator (Gauss Kruger) projection with the spheroid of Krassovsky is selected. 'Output Pixel Spacing' is the same as the resolution of SPOT Panchromatic image resolution. GCP projection can be set different from Output projection. Detailed parameters for the projection are set in the next dialogue box by clicking on the 'More..' button.

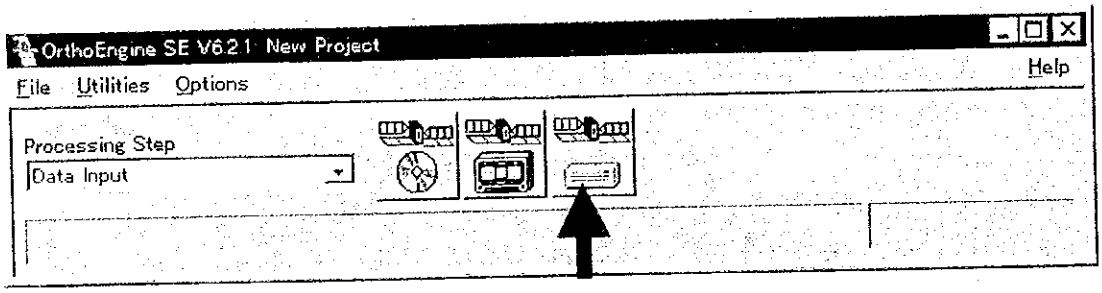
Setting example for Zone 12 in Kazakstan



Setting of parameters that defines the projection. Ortho Engine project setting should be made separately for each zone.

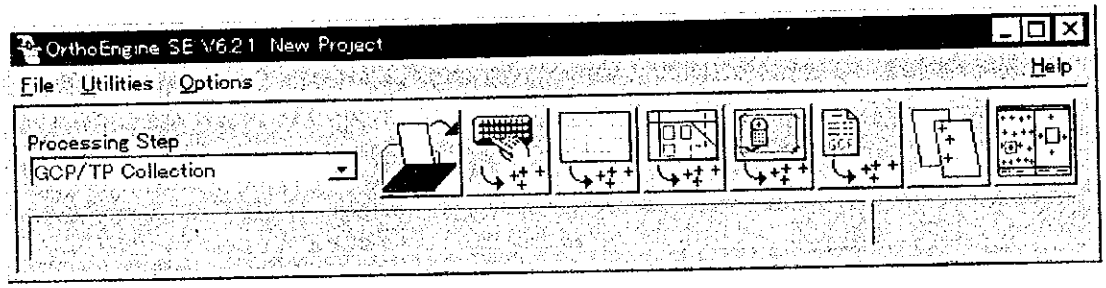
NOTE: False Easting parameter should be set without zone number because of limitation of Ortho Engine.

2) Registration Image Data to Project

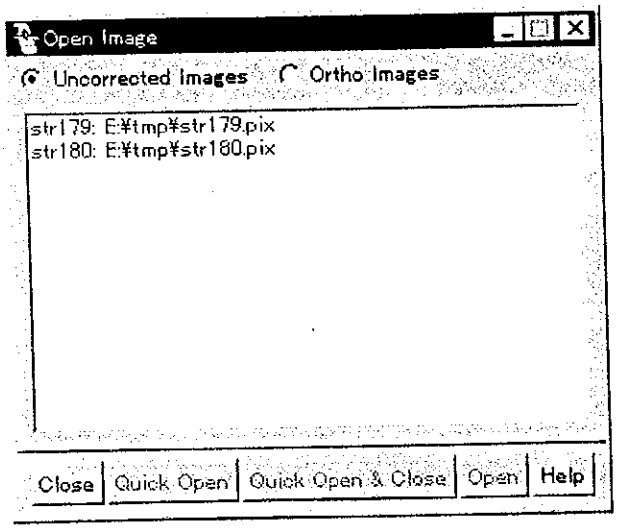


Change Processing Step to 'Data Input' on the main panel. Click on the 'Read PCIDSK file' button and add uncorrected images to the project.

3) Ground Control Point and Tie Point Collection



Change Processing Step to 'GCP/TP Collection'. In this step, collect GCP's and TP's by choosing point on the image window or by reading GCP text file. Distribution of these points can be confirmed after collecting.



Select 'Open Image' button and select image to open.

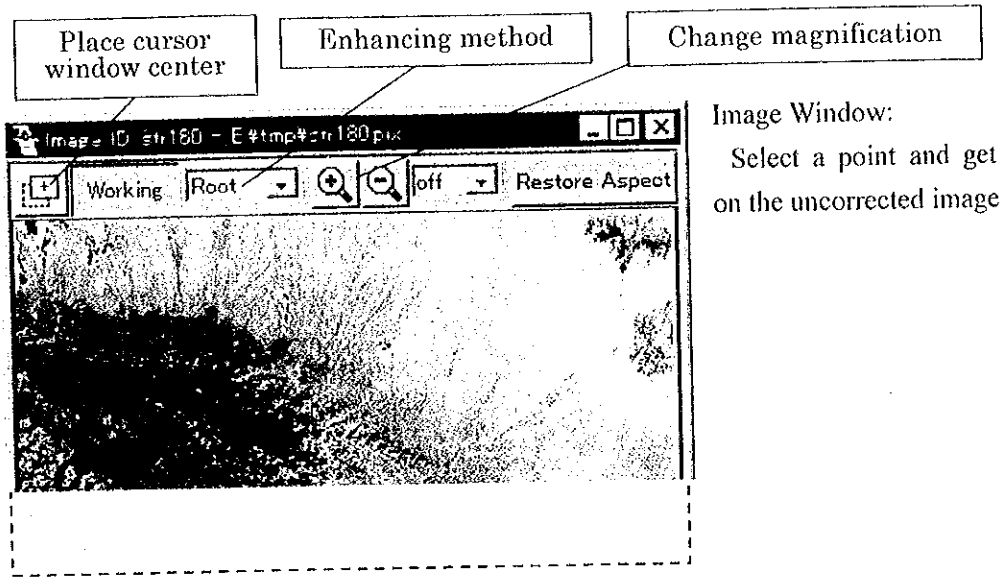
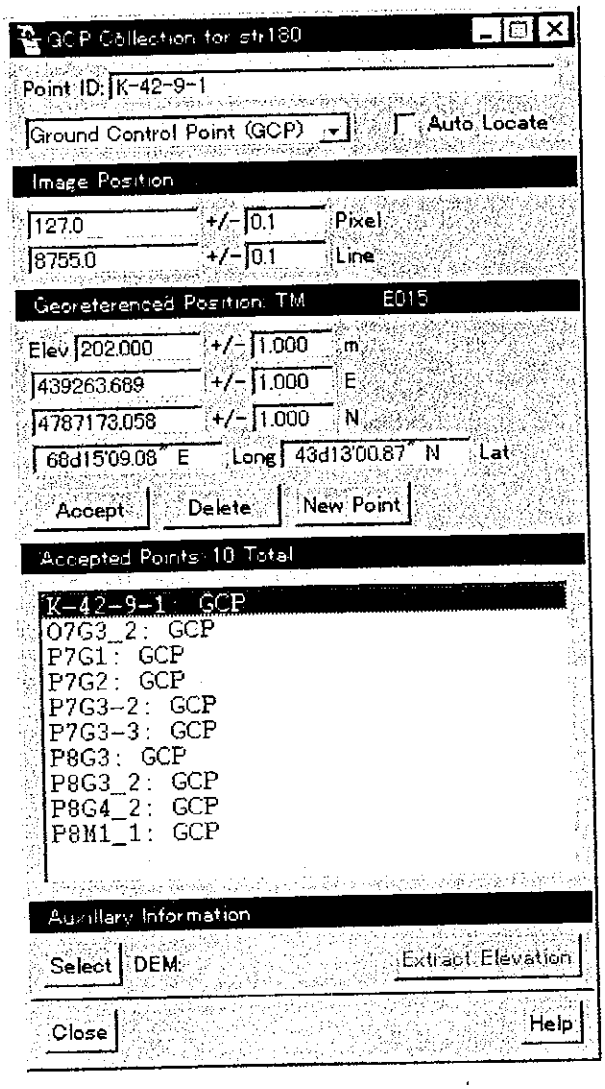


Image Window:

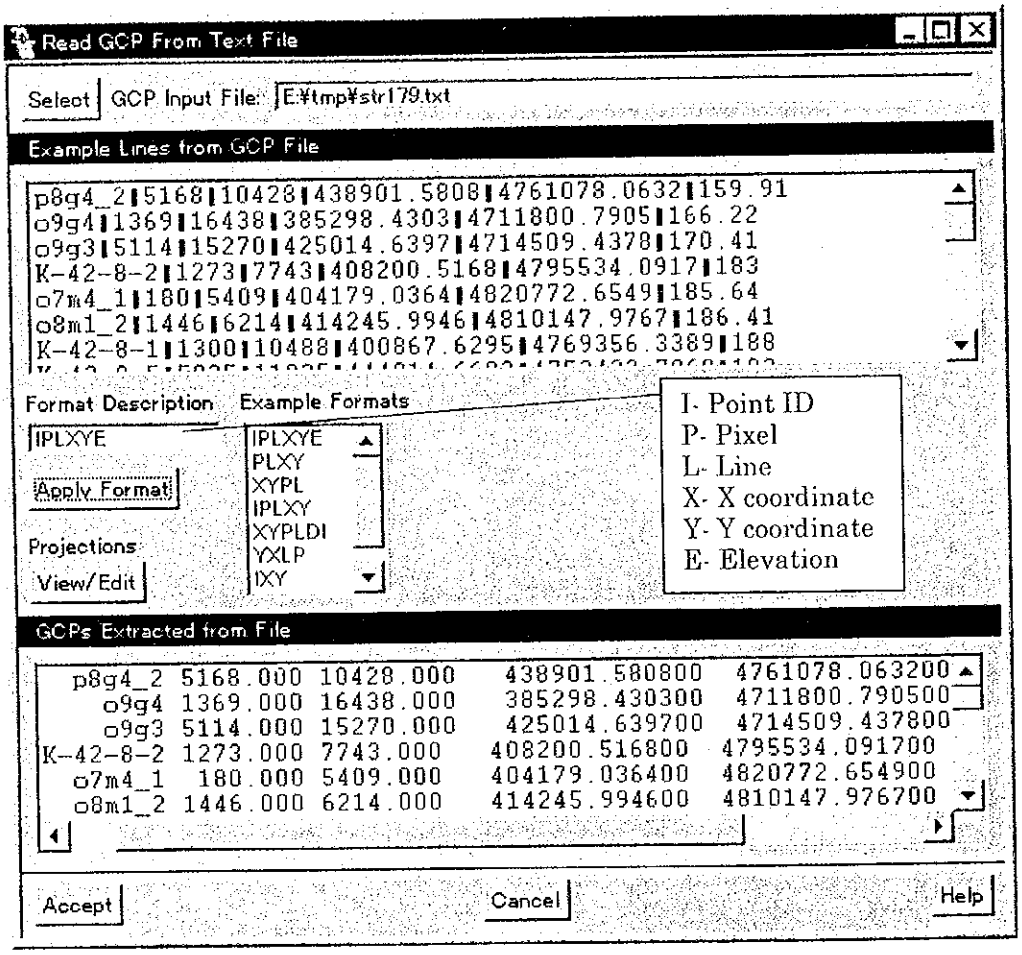
Select a point and get pixel coordinate on the uncorrected image.

GCP Collection Panel



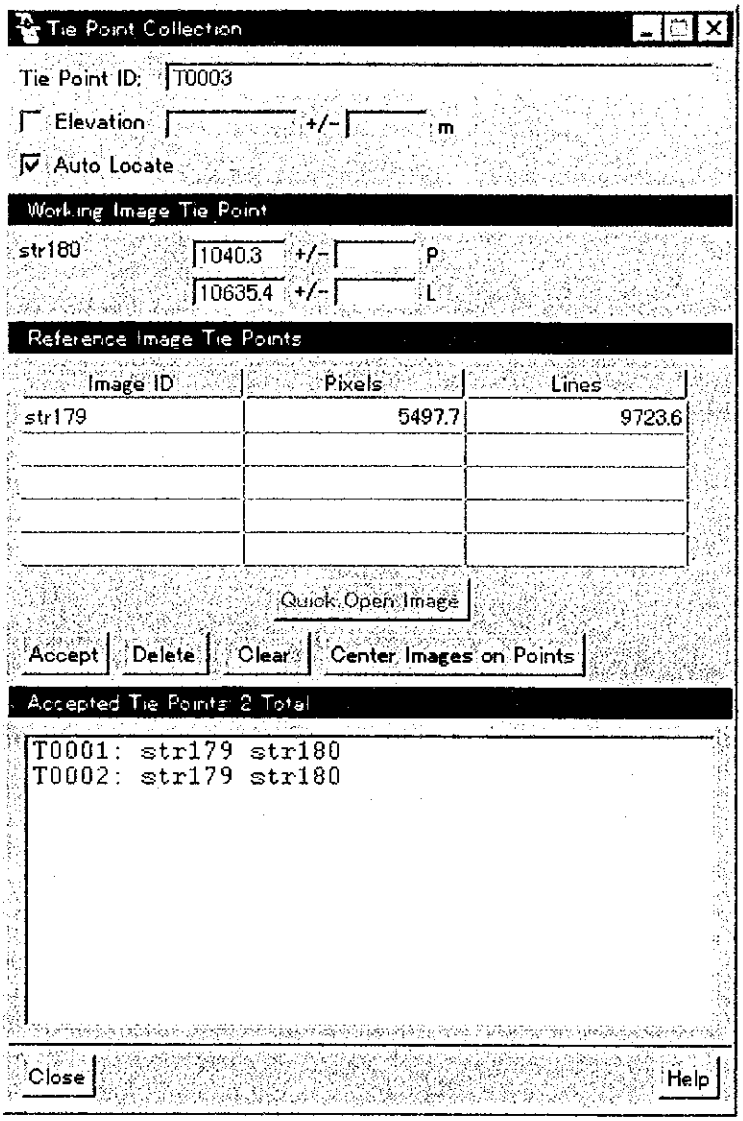
Enter geographic coordinate corresponding to the pixel coordinate on image window.

This panel is invoked by clicking on the 'Import GCP's from text file' button.

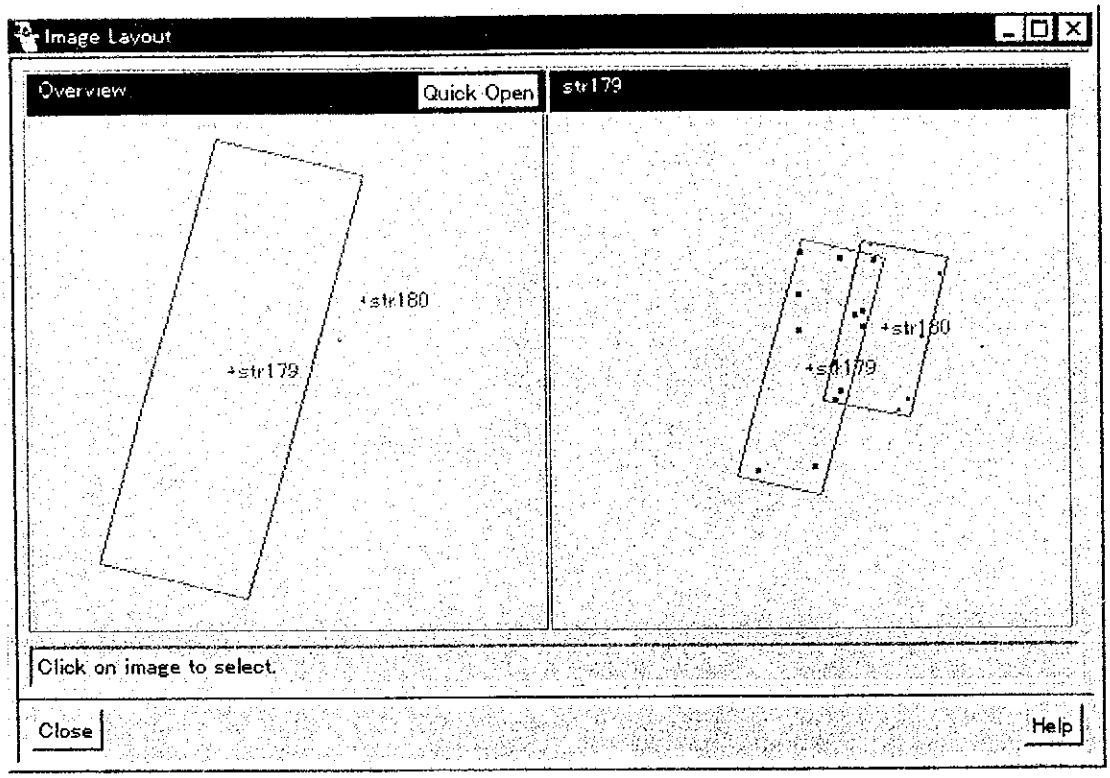


After choosing input file, specify the data format according to the data order.

Tie Point Collection panel

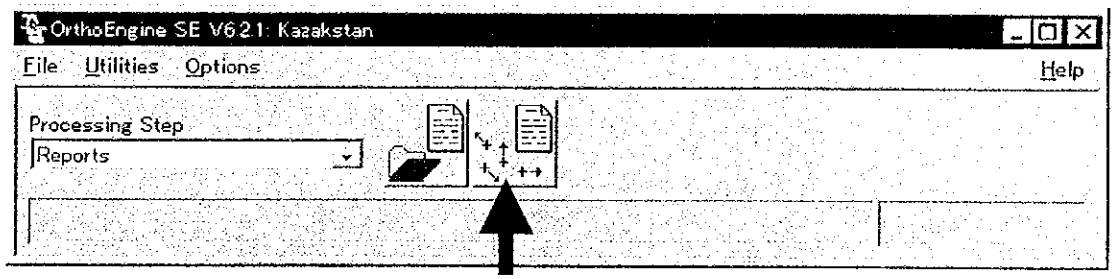


This panel is invoked by clicking on the 'Collect tie points' button. Open plural image simultaneously, and collect tie point on overlapped area with neighboring image.



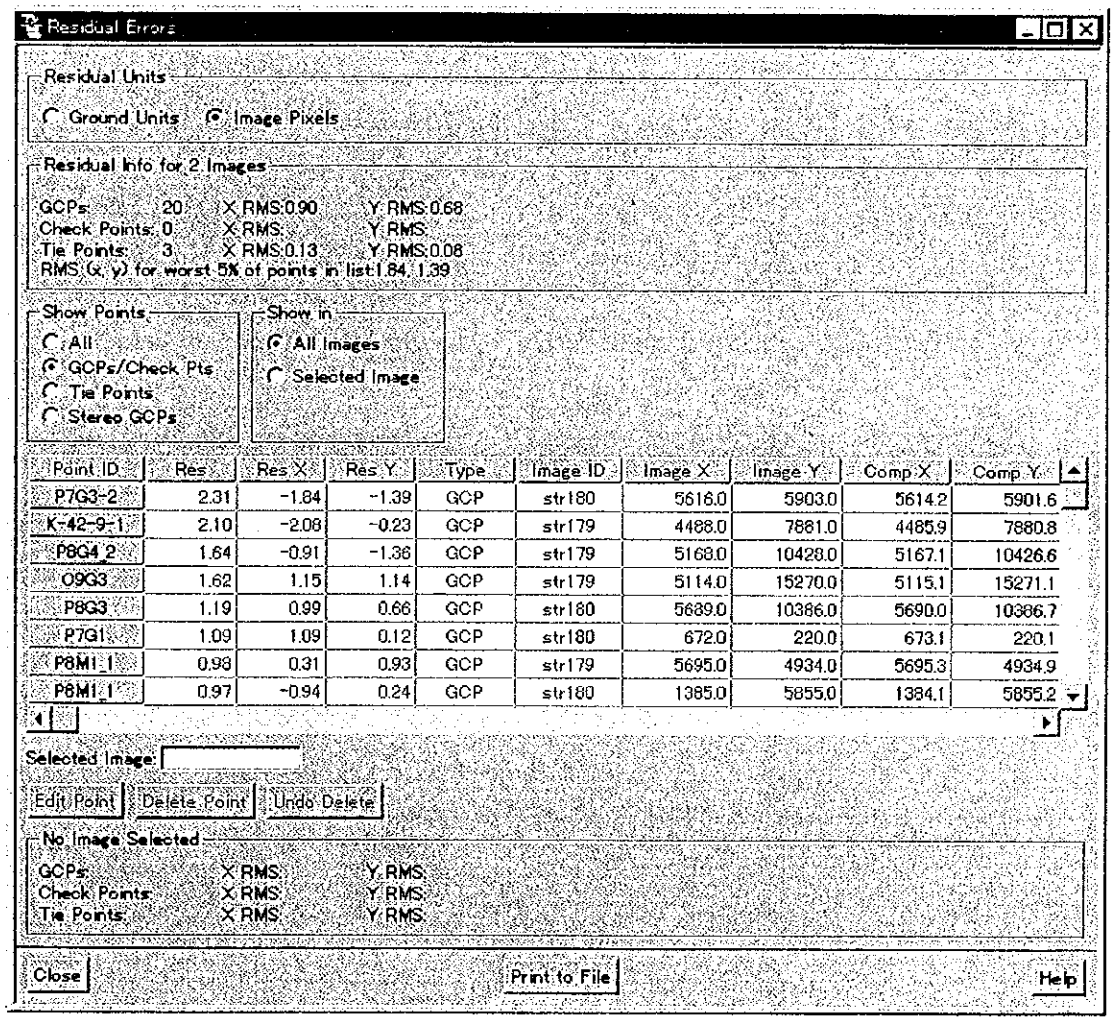
Check the distribution of GCP/TP after collecting those points. Red point and blue point correspond to GCP and TP respectively. Uniform distribution is ideal. At least 4 points are indispensable for ortho correction per image.

4) Residual Error Report



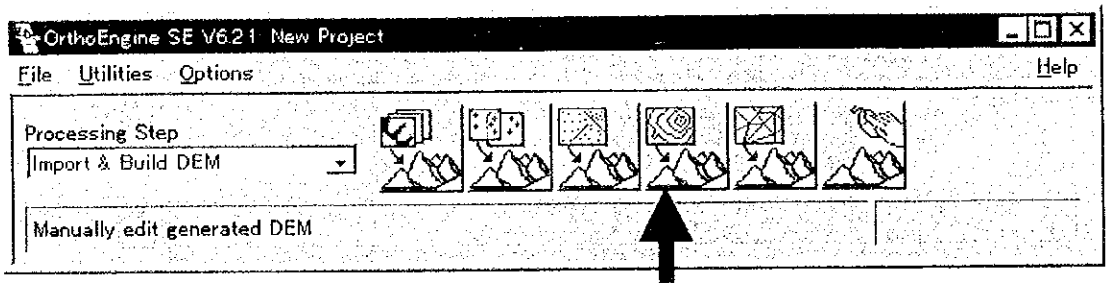
Change Processing Step to 'Reports', and click on the 'Residual report' button.

Residual error report panel



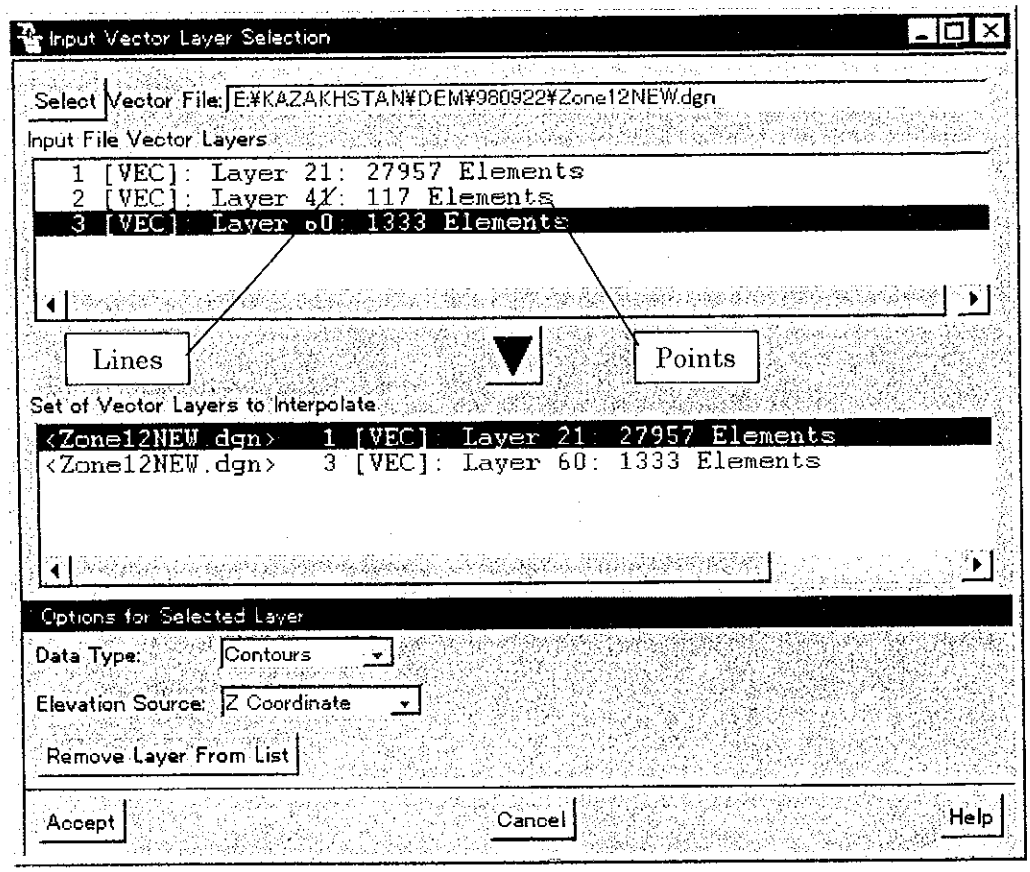
This panel shows RMS error report. Residual unit can be chosen by ground units or image pixels.

5) Building DEM from vector data

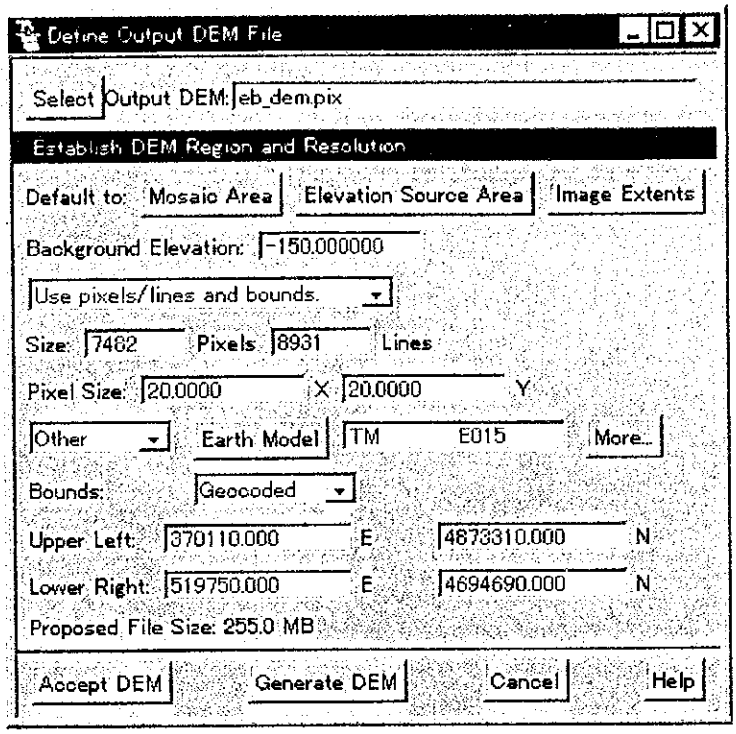


Creating DEM data from vectorized contour line of existing map.

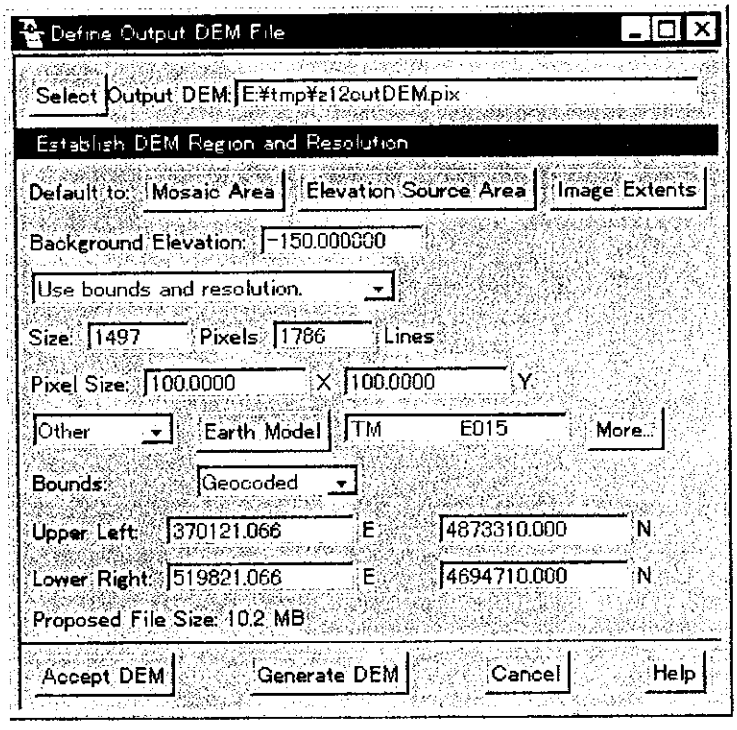
Change Processing Step to 'Import & Build DEM', and click on the 'DEM from contours' button.



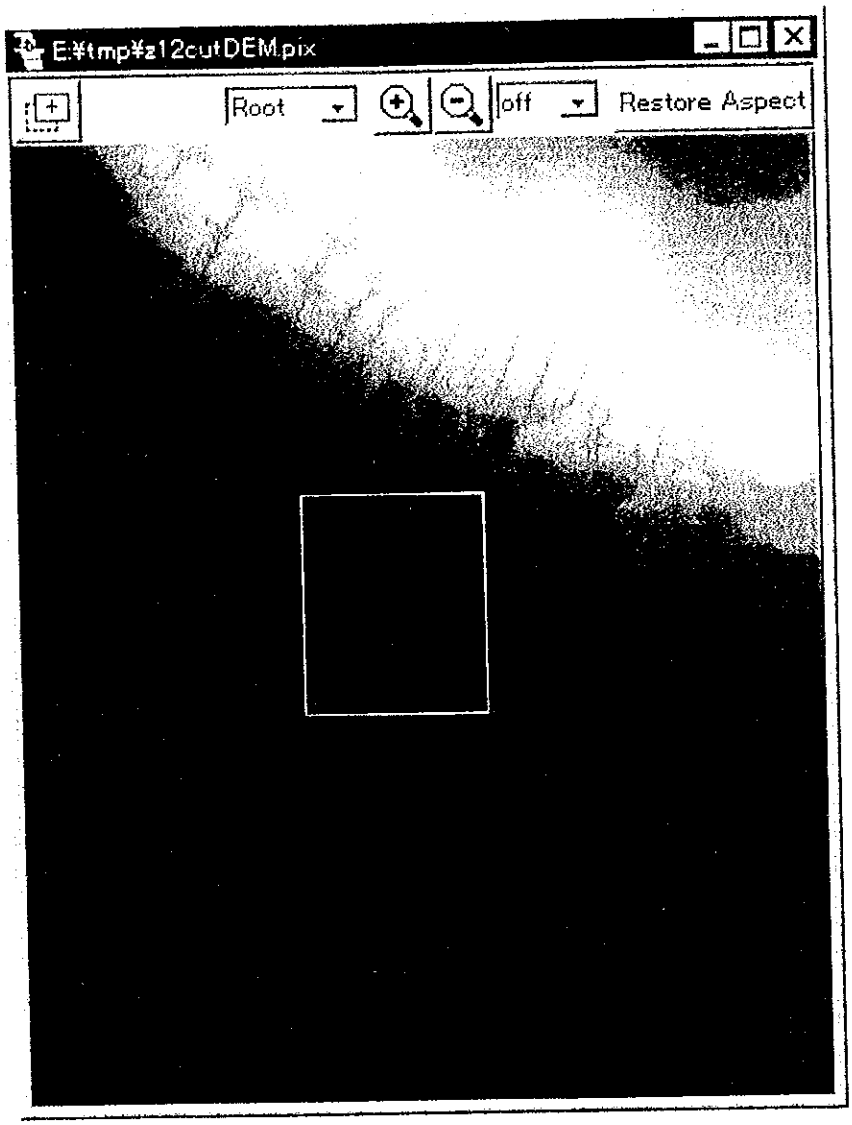
Select vector layers containing contour line. Choose 'Data Type' and 'Elevation Source' according to source data. Click on the 'Accept' button.



Definition of output DEM file. Default setting is like above, this bounds setting covers whole area of image.

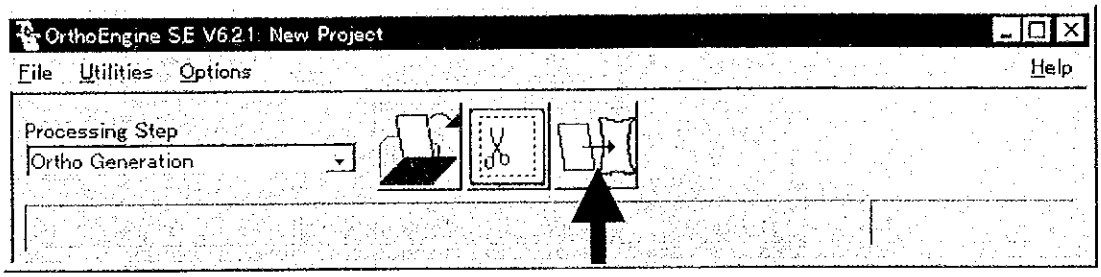


This is a setting sample for a map sheet in zone 12.

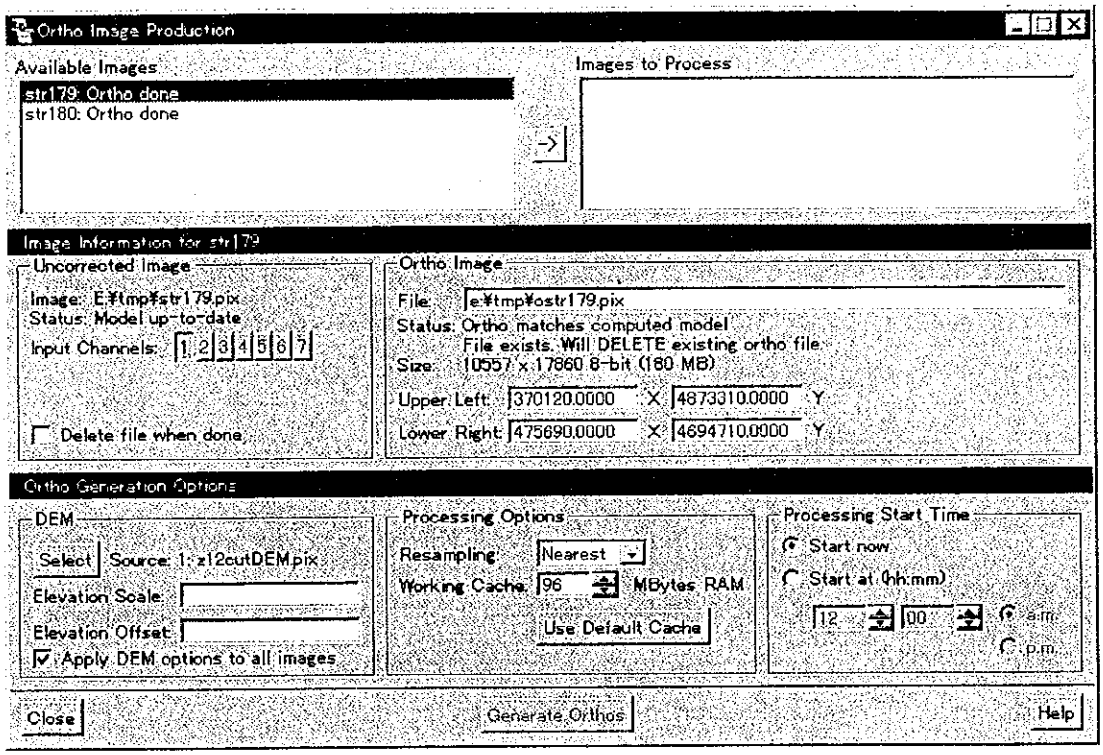


Overview of generated DEM. Pixel brightness represents elevation of the point.

6) Generate Ortho Image

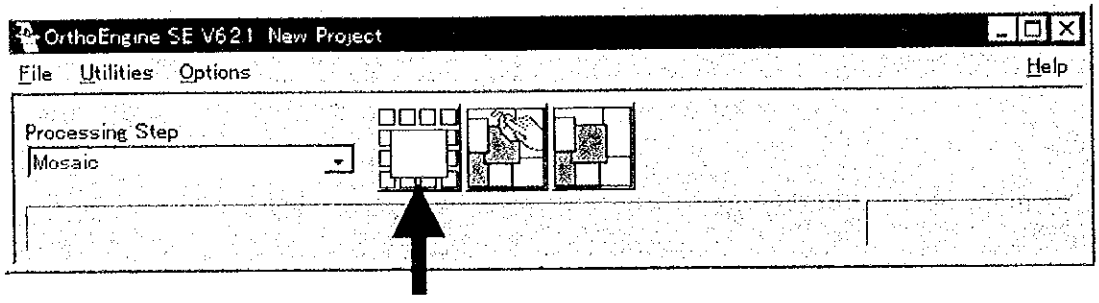


Change Processing Step to 'Ortho Generation', and click on the 'Schedule ortho generation' button.



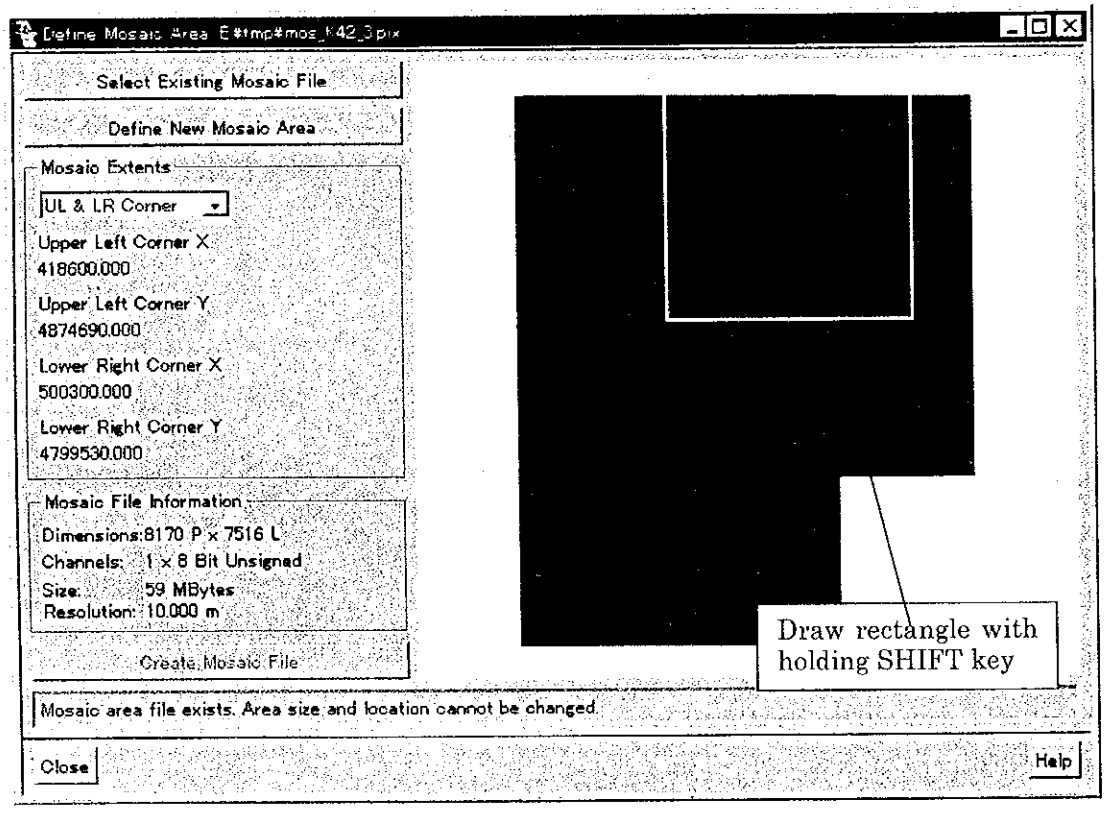
Select the image to create ortho, and set DEM parameters for ortho correction. Execute correction by clicking on the 'Generate Orthos' button.

7) Image Mosaicking



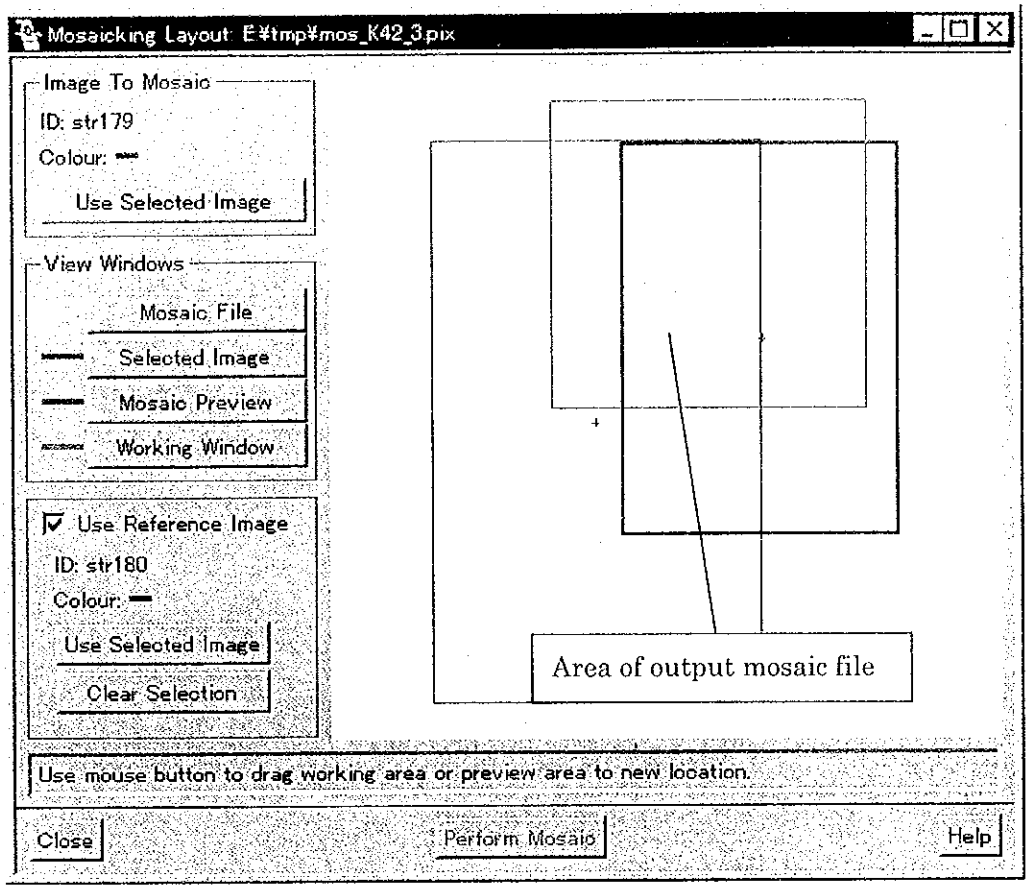
Ortho images are created one by one. Image mosaicking is necessary to fill map sheet frame with satellite ortho image.

Change Processing Step to 'Mosaic', and click on the 'Define mosaic area' button.

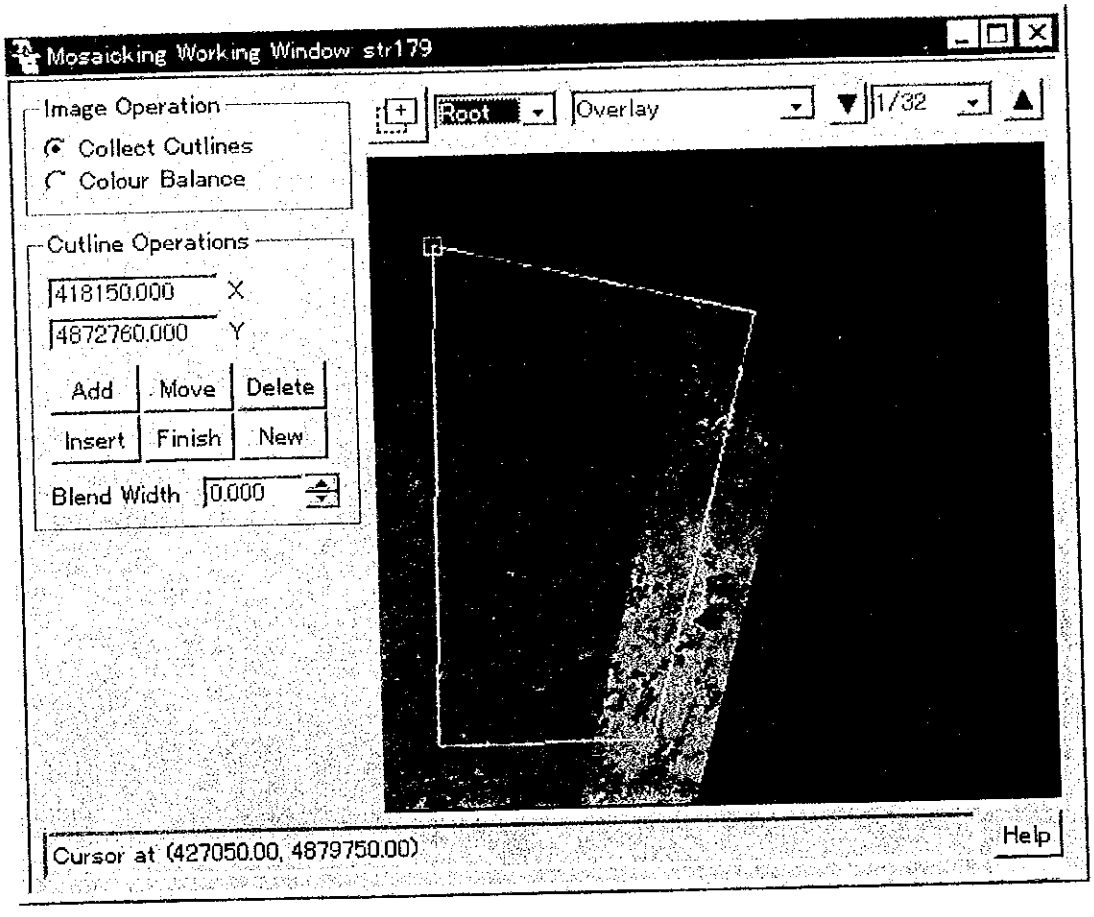


First of all, output file should be made corresponding to proper area. Existing file can be also selected for mosaic output file. Map sheet PIX file is selected as above example.

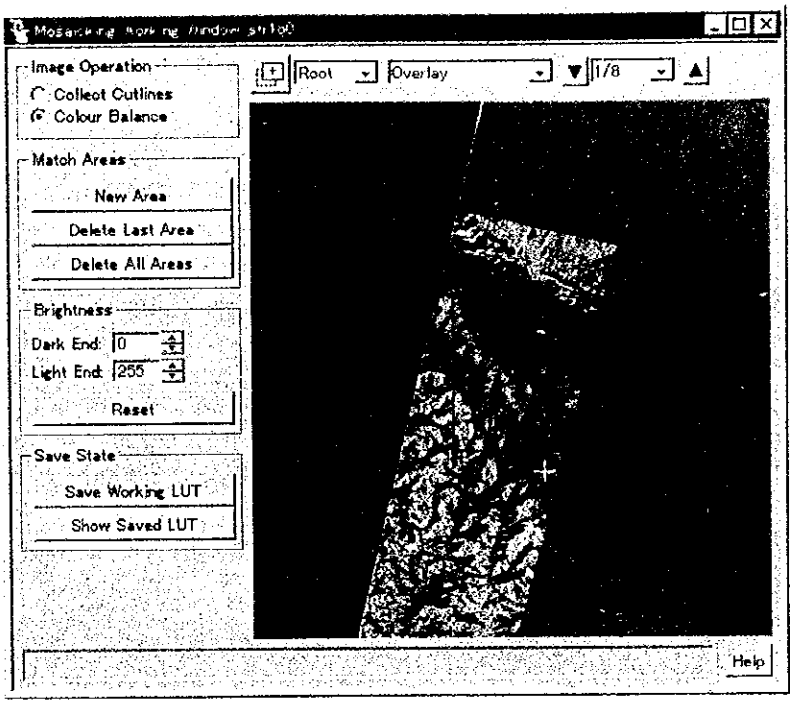
This example image boundary has margin because map frame boundary does not cross at right angles to projection coordinate.



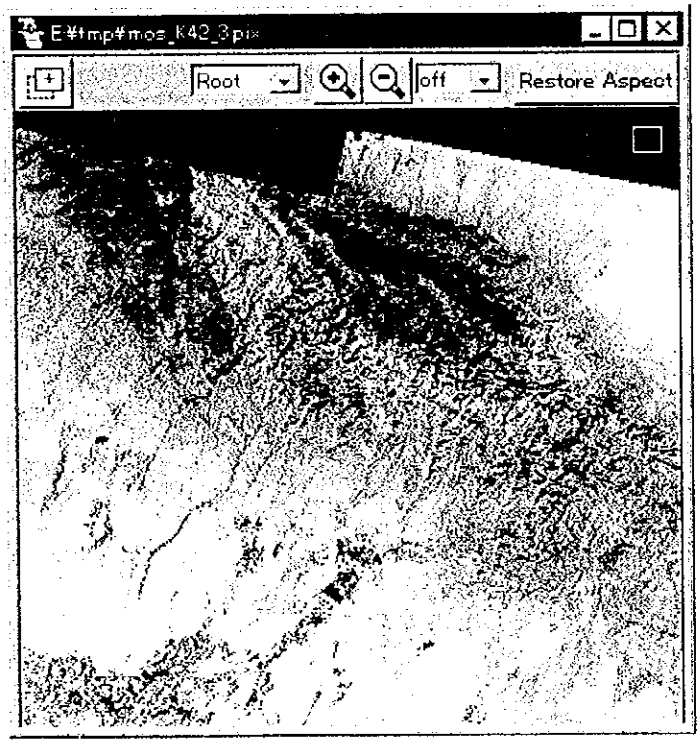
After defining output mosaic file, this panel comes up by clicking 'Manual Mosaicking' button. This shows image layout of output mosaic file and related ortho corrected image. Select image to mosaic.



Collect cutline on the image. Only enclosed image is copied to output mosaic file.



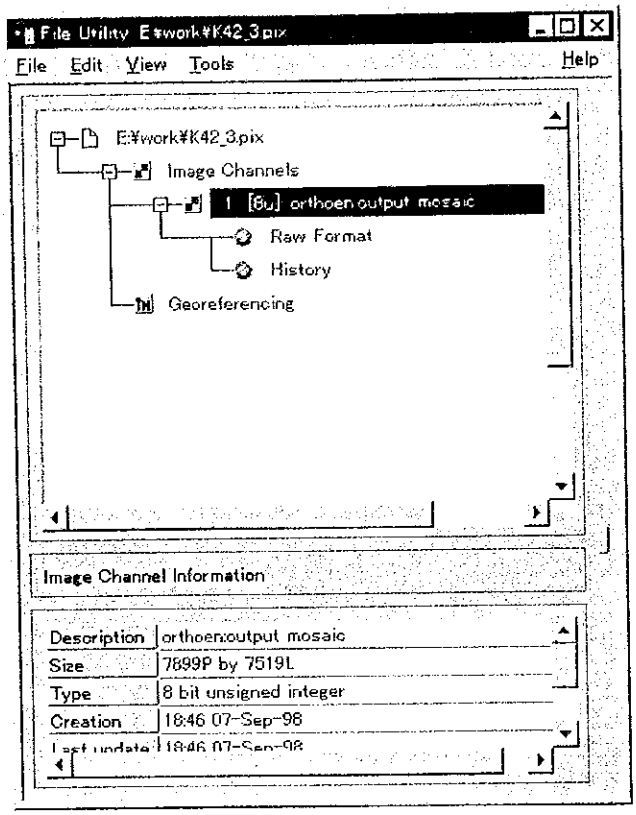
Select 'Colour Balance' in the Image Operation, then draw colour-matching area on overlap region of ortho images.



Result of mosaic. This map sheet area is covered with 2 ortho strip images.

6. GCPWorks　　Geometric Correction of Scanned Map Image

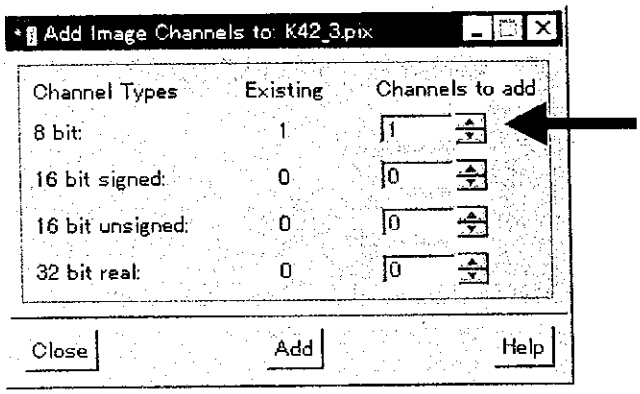
Scanned map image can be overlaid on satellite ortho image after geometric correction with the corner coordinates of the map sheet. This overlay image enables to check the result of ortho correction roughly.

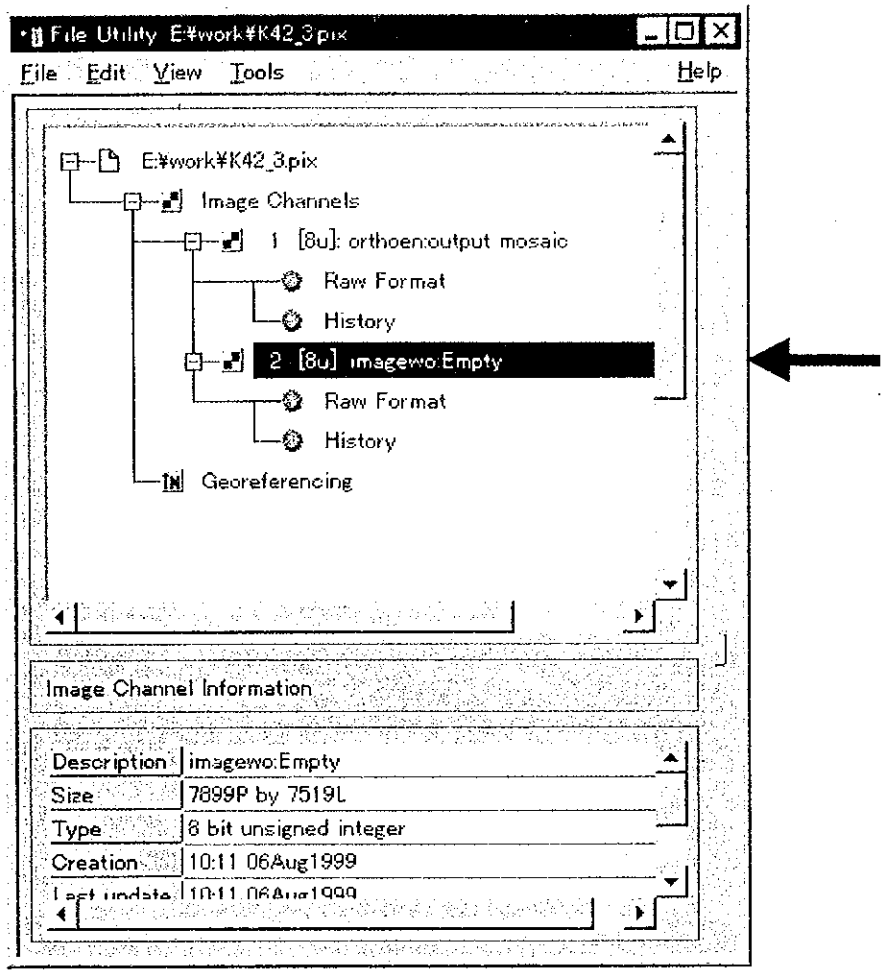


Output channel should be made to save corrected image before geometric correction.

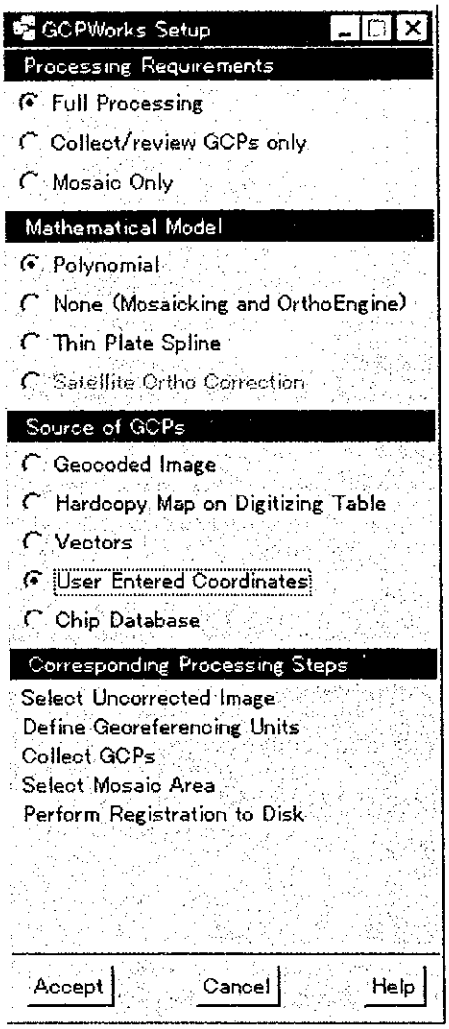
Select 'Edit'-'Add Channels...' in File Utility.

Add 8 bit one channel for saving corrected image.



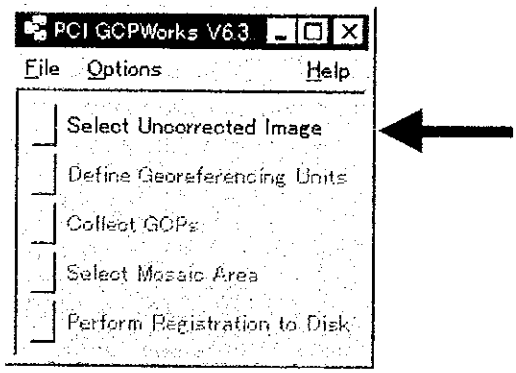


New empty channel appears in File Utility window. This channel will be selected for output of geometric correction.

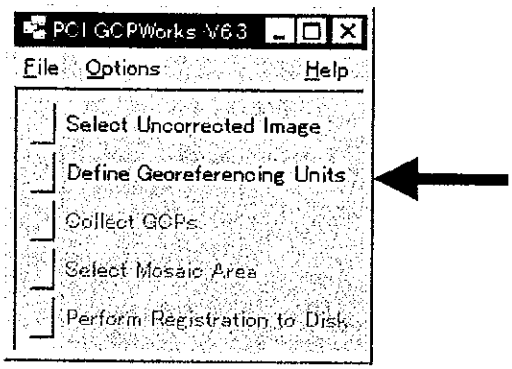


GCPWorks first setting panel

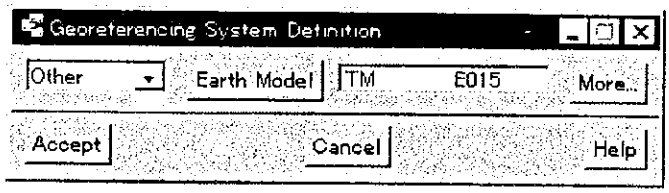
Start GCPWorks, and click on the 'Accept' button with above setting.



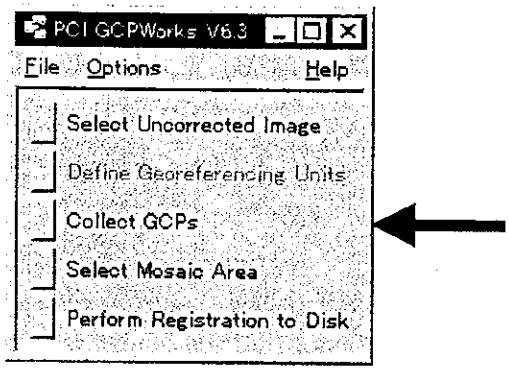
Select uncorrected image (scanned map image).



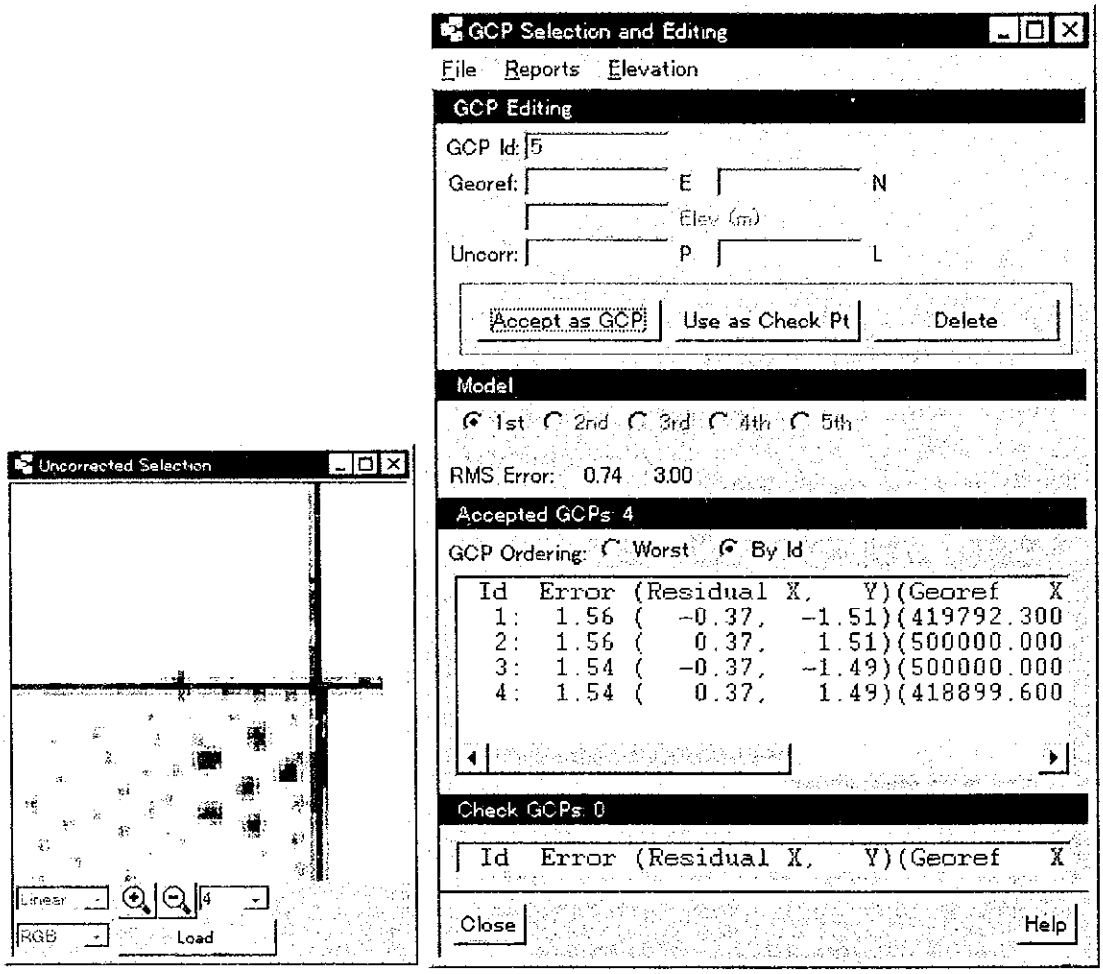
Click on the 'Define georeferencing units' button and enter parameters.



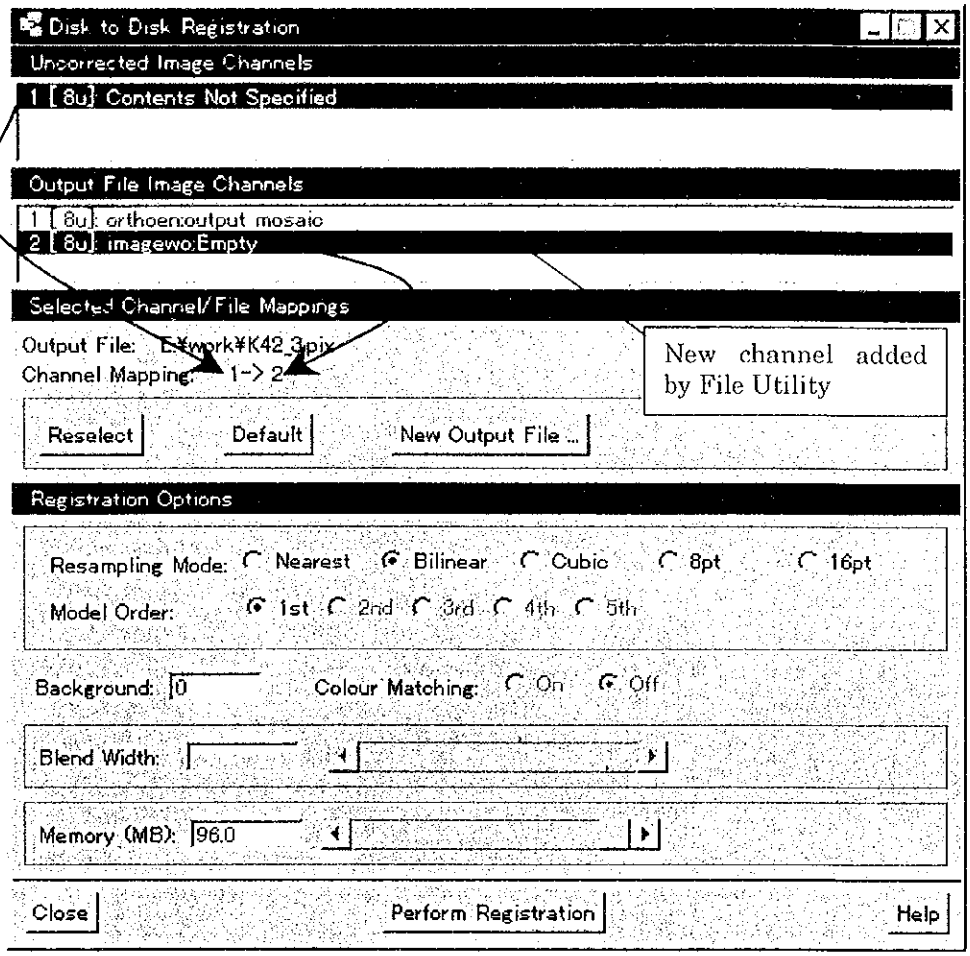
Same as map projection.



Select 'Collect GCPs'.



Enter 4 corners coordinate of map sheet corresponding to image pixel.



Select output file and channels, and perform geometric correction.

Checking overlay image with ImageWorks. In this example, ortho image and map image are assigned to R, B plane and G plane respectively.

Outline
of
Digital Mapping

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Introduction

This operational specification is prepared for the technical cooperation project "Urgent Establishment of National Basic Geographic Data in the Southern Area of Kazakstan" which has been implemented from January 1998 to March 2000 by the Japan International Cooperation Agency (JICA) for the Republic of Kazakstan. The specification is a guideline for Kazak specialists to continue their work on digital mapping after completion of the Project.

The objective of the project is to transfer the medium scale digital mapping technology from Japan to the Republic of Kazakstan.

Technology transfer includes:

① Production of 1/100,000 scale topographic digital map data

② Production of 1/200,000 scale topographic framework digital data

The specification gives detailed operational procedure. Those are not described according to map scales. For more effective use of the systems provided to Kazakstan description refers to the particular hardware and software.

Work, fulfilled by Kazakstan side is not described in detail, assuming they know technology.

1. Planning and Preparatory Work

There are two main objectives in digital map production. First – more effective production of printed maps comparing to conventional method. Second - data production for Geographic Information System (GIS).

If printed map production is the only aim, data expression forms shall be determined according to conventional map symbols (Layer Classification). In this case layers shall be selected without mistake. If a smart software (such as for illustration) is used, results may be better than analogue method. But data expressions purposed only for a map printing are hard to use for various computer applications. It is desirable to produced data both for map printing and GIS.

If the purpose is to produce data for GIS only, it should be clear which data is to be analyzed with GIS and digitize only necessary data. As map data must be updated from time to time, unused data can be required later. However necessary data must be classified strictly. Exact classification of necessary data is needed to receive correct analyzed GIS results. And as blank area is acceptable, unnecessary map items are not required for analysis, while blank area on a printed map must be filled out by some map items. Expressions, which cannot be specified, are acceptable. Displaying function of GIS application will transfer them into understandable data. Besides, some data with another accuracy, can be mixed as far as accuracy information is clear. In GIS, data is selected according to a purpose.

If the objective is both, the production of printed maps and data for GIS, it must be understood that their data quality is not equivalent even though they refer to the same map data. Expressions are important for printed map production, while layer classification and data structure are important for producing GIS data. There are no systems which can satisfy both demands. We were to choose whether to create original conversion programs by themselves or produce two types of results individually with a great burden.

In this project, the former way was selected. After production of GIS data, programs converting GIS data for printing map data were customized and included into software provided to Kazakstan.

Production of the digital map and use of GIS are just at a developing stage and not standardized yet. Therefore, at planning and preparatory stages, the objective shall be defined and then operation plan and process of operation need to be fully examined. Special attention must be paid to determination of acquisition standard and the production method of layer classification and data structure.

2. Outline of the Work

2.1. Outline of the work

The work is roughly divided into three (3) steps.

a. Digitalization of topographic features from existing maps. Acquired data is utilized not only for map data but also for converting satellite images into orthographic projection.

b. Image interpretation and digitalization of framework features with the help of aerial photographs after conversion of geometrically corrected satellite images into orthographic projection.

c. Digitalization of detailed map features from collected materials. At this project step it was digitalization of existing maps, the same as topographic features, because all collected materials included existing maps.

2.2. Work result

Results of this work are:

① Structuralized data file for GIS

② Symbolized data file for printing

③ Positive film for printing

Structuralized data file for GIS was made in MapInfo data format, MicroStation data format (only for 1/200,000 scale map) and exchangeable text data format, acceptable for the most commercially available application software.

Symbolized data file for printing was made in MapInfo data format and then converted into PostScript data format, which is the existing standard in digital printing.

Positive printing films were made by colors.

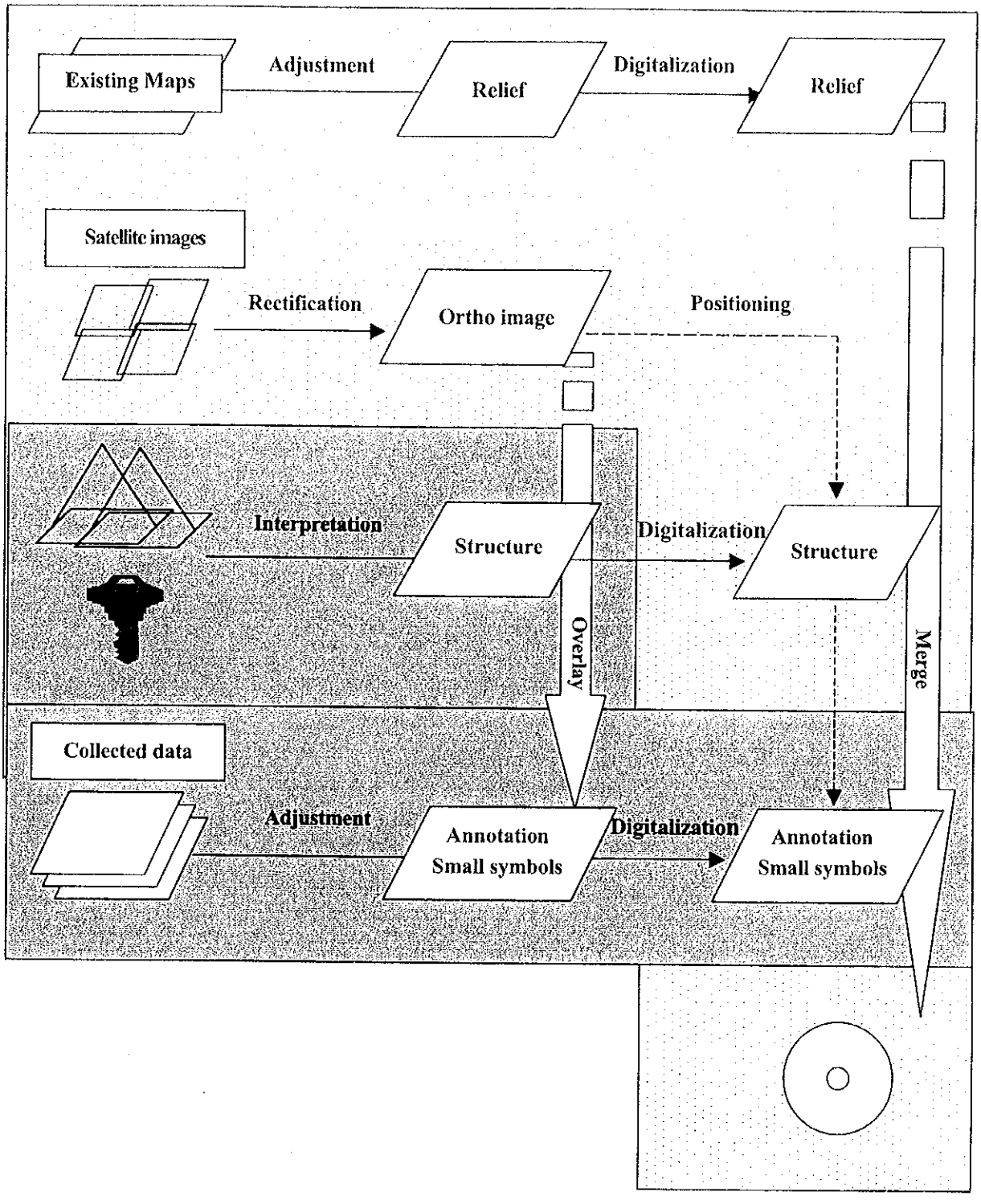

Figure 2.2-1 Work Flow

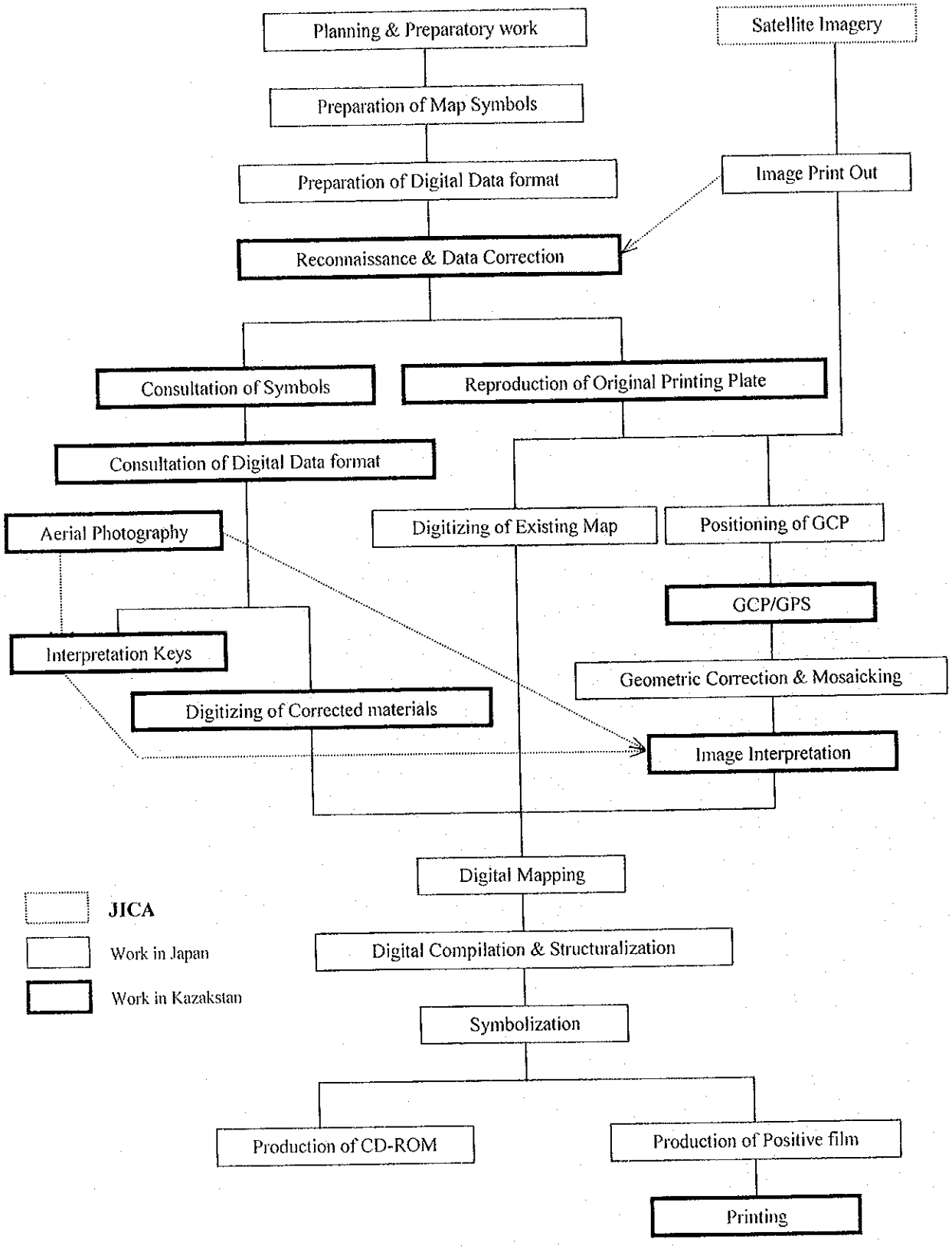

Figure 2.2-2 Work Flow

2.3.Work Flow

Figure 2 shows workflow of digital mapping.

2.3.1. 1/100,000 scale map data

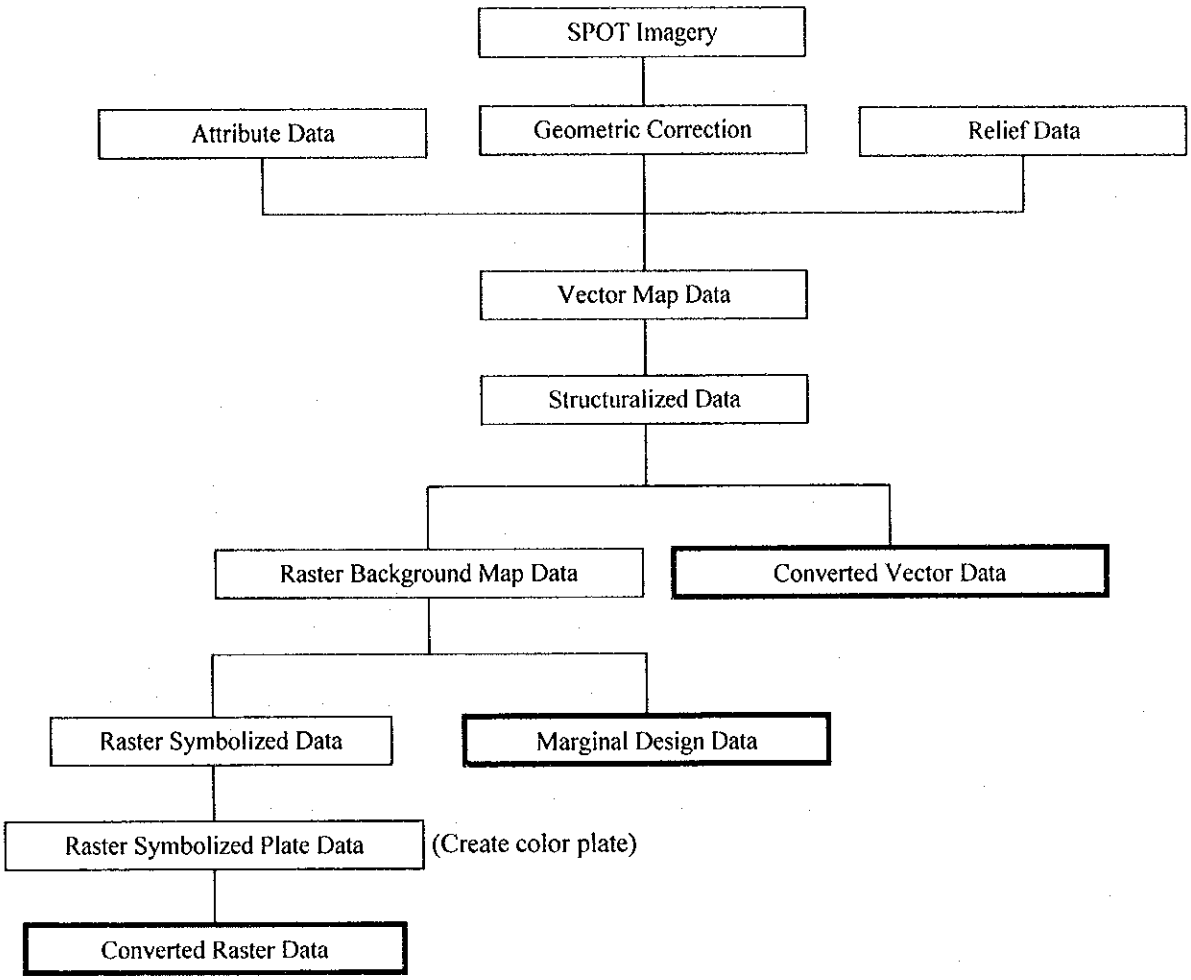

Figure 2.3-1 Map Data Processing, 1/100,000

2.3.2. 1/200,000 scale framework data

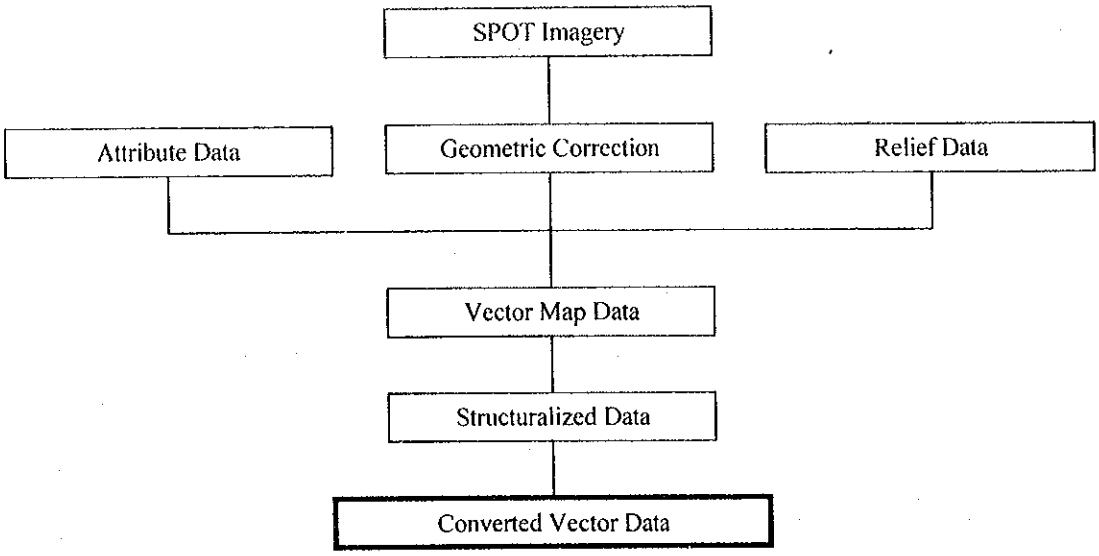

Figure 2.3-2 Framework Data Processing, 1/200,000

3. Systems

3.1. Hardware

The List of hardware is:

-Personal Computer	
-Figure Output	: Color ink jet plotter (A0 size)
-Temporary Data Saving	: Magneto-Optic disk
-Text Output	: Color printer
-Existing Map Digitalizing	: Large size scanner (A0 size)
-Data Saving	: CD-ROM writer

3.2. Software

Software and computer languages are the following:

-Image processing	: OrthoEngine (PCI)	
-Image writing	: PhotoShop (Adobe)	
-CAD	: MicroStation (Bentley)	: MDL
-GIS	: MapInfo (MapInfo)	: MapBasic

Computer language for Windows98 and WindowsNT (Microsoft):

-Microsoft	: C
-Absoft	: Fortran

4. Map Symbols

4.1. Investigation of map symbols

At the beginning of works, examination of map symbols is needed. As a rule, existing map symbols are accepted as basic symbols, but the following points are to be examined and decided:

- Classification of map details for printing according to their expression
- Selection of digitizing items for GIS
- Determination of data structure

For production of printed maps more detailed classification of existing map symbols shall be done. The classified symbols are divided into layers so that they can be expressed in a computer.
It is desirable to transform map symbol to be expressed in original functions of consisted software. However, CAD and GIS software are originally not programmed to make expressions for printed map. The following selection must be done:

- To use illustration software, which can express symbols similar to printed map
- To edit data to express printing map
- To customize the new function for expression of printed map

If printed map production is the only objective and the use for GIS is not expected, the software for illustration is preferable. But if the use for GIS is expected too, editing data to express printing map is not efficient as the data will be difficult to use for another purpose. Therefore, if both - geographic information and printing map data are expected to be used, it is desirable, after completion of layer classification, to customize the software for automatic symbolization of data according to layer and edition of data according to map expression.

Data structure shall consider not only data format where data items are acquired as points, lines, polygons or text, but also an analysis, for example a network analysis or polygon overlay analysis for GIS. If various data use are considered, strict node connection of basic items, such as roads, railways, buildings, water systems, administration boundaries and so on shall be observed for easier re-editing to layer structure or polygons. In this case the data will be more valuable.

4.2. Layer classification

For the benefit of map printing and GIS in general, the following layer classification is desirable:

- Each layer shall be classified including more details for map expression
- Each layer shall be classified by color, line weight and line style
- Each layer shall not possess attributes

The main purpose of a detailed layer classification shall be effective operation of customized software for automatic symbolization. For GIS use, the detailed layer classification introduces the proper choice of map items in accordance with the purpose. As for automatic symbolization, every kind of data items is symbolized individually.

It is convenient if MapInfo data format is divided into several files, but in principle, better not to divide into files.

In detailed layer classification, all data items are divided individually according to color, line weight and line style. It is desirable to have an individual code for each classification, but there are no any fixed code systems for digital mapping. In practice temporary codes are given in case of necessity.
On the other hand, exchangeable text data, independent on application software, shall be stored in suggested code system for this project. The code consists of 6 column numbers, and each column has the following meaning:

-Upper 2 columns	: Layer code	: Classification for data quality
-Middle 2 columns	: Item code	: Classification for data specification
-Lower 2 columns	: Distinction	: Classification for the same map symbols but different expressions

For map printing or producing map data better not to use attributes which are basic data for GIS. They are used by GIS user for registration management or layer structure maintenance.
However, information, which requires three-dimensional data, such as contour line, shall be given attributes, because MapInfo can not possess three-dimensional structure.

4.3. Interpretation Keys

Interpretation keys shall be made for each mapping object with the explanation of satellite images, aerial photographs, ground photographs and so on for general recognition of images. Preparation of interpretation keys is desirable especially with the use of not well-experienced data, such as satellite images.

5. Acquisition of Satellite Imagery

To acquire satellite images, an order to an authorized agent shall be done after confirming particular date, cloud condition, overlap of images.

Usually, panchromatic images, which have high ground resolution, are used for map production. Besides, there is pan-sharpen imagery, which have false high resolution made from low resolution multi-spectrum imagery and high-resolution panchromatic imagery.

If there is a need to plot topography, stereo images must be ordered with B/H ratio (base-height ratio) and seasonal data acquisition. B/H ratio is basically the same as aerial photography, but from a point of view of satellite photography, it is worse than aerial photography. In case of this project, digitizing contour lines from existing maps is more effective than using photogrammetric method, because there are not so many topographic changes in the area.

6. Reconnaissance and Data Collection

Field identification and verification are essential for map production. However, on this project it was difficult to reconnoiter large project area in a short period and investigate the availability of the effective materials to confirm necessary map expression (geographic names, administration boundaries, facility names and so on), then collect and adopt if they exist.

7. Reproduction of Original Printing Plate

To produce new digital map, map items having little secular changes (such as topographic information) shall be digitized from existing maps. Original printing plate from dimensionally stable material, such as polyester sheet, shall be used for reproduction.

8. Aerial photography

The quality of satellite images, in resolution and positional accuracy, is inferior to aerial photographs due to the limitation of pixel size and image density or color contrast. Therefore, it is more efficient to acquire and use aerial photographs to supplement interpretation of satellite images and substitute field reconnaissance for large area.

Aerial photography shall observe the following:

- Photographic scale shall be about two times of map scale, for medium scale (i.e. 1/100,000) mapping
- Interpretation accuracy shall be reached maximum by stereo photography
- Photographs shall be taken at luxuriant vegetation season.

9. Ground Control Point Survey

Satellite images have got geodetic coordinates from the raw data of satellite spatial orbit. They possess various distortions. Therefore, to get accurate geodetic coordinates of satellite images, geometric correction must be executed with geodetic coordinates, acquired by ground control point survey with the use of several clearly identified features on a satellite image.

To execute ground control point survey, it is necessary to select clearly identified features on a satellite image at suitable position for geometric correction.

There are several ways for measurement of ground control points of selected features, such as GPS survey and the use of existing maps or combination of both.

Results of ground control point survey shall be arranged as a "Description of GCP" and "GCP layout".

Distortions of satellite images are corrected by computation, measure or survey of coordinates of measuring point on existing maps or field. The coordinates shall be used as ground control points.

9.1. Number of ground control points

The number of ground control points on a single satellite image shall be minimum four (4) points, and preferably more in a single scene solution.

Reduction of ground control points and accuracy improvement of geometric correction can be reached by using strip images and not scene block.

9.2. Point selection

Features, shown both on satellite images and topographic map (such as road crossings, bridges, large buildings and so on), should be selected as ground control points without fieldwork. In case points can't be selected from existing maps, clearly interpretable features (such as road crossings, bridges, large buildings, changing points, topographic distinctive points and so on) shall be selected in the field and field GPS observation is to be carried out for acquiring coordinates as ground control points.

Position of ground control points is at four corners of a scene at satellite images. If it is possible to select points on overlapped area between adjusting scenes, number of points can be reduced and tying accuracy of images can be improved.

9.3. Global Positioning System survey (GCP-GPS survey)

At selection of ground control points, GPS observation is conducted for points, which coordinates are difficult to measure from existing maps. GSP observation is carried out by static survey from a base camp for each surveying area. Observation period and distance between base camp and observation point shall be considered to secure necessary accuracy.

9.4. Measurement from existing map (GCP-Map)

If existing maps with enough accuracy of ground control points are available, it is desirable to make measurements from them. Second printing plate, which is made by copying original printing plate to polyester sheet with minor expansion, shall be used as an existing map.

9.5. Description of GCP and Layout

Results of GCP survey shall be arranged as "Description of GCP" and layout for geometric correction. Name of the point, coordinates, satellite image (wide area /small area), pass/row of satellite image, existing map and sheet name of existing map shall be mentioned in "Description of GCP".

10. Digitalization of Contour Line

In case of availability of old maps, digitalization of contour lines from existing maps shall be efficient, as usually there are not so many topographic secular changes.

If old maps are not available or topographic secular changes are substantial, it is necessary to digitize from aerial photographs or stereo satellite images.

Digitalization of counter lines is performed by vectorization from rasterized contour plate, the edited copy from the existing map. The next step is processing of digitized contour data into utilizable GIS data, with some editing, such as adding attributes.

Height information of contour lines can be checked easily by transforming two-dimensional contour data to three-dimensional data.

11. Geometric Correction and Mosaicking

Satellite images shall be geometrically corrected by GCP coordinates. After that, geometrically corrected satellite images shall be converted into orthographic projection with the help of DTM, created from digitized contour data.

Orthographically projected satellite images are mosaicked with each sheet area before cutting out to individual sheets. At the same time, reseau marks for positioning shall be printed on satellite image, so that polyester sheet can be positioned accurately at image interpretation.

12. Image Interpretation

Framework features shall be interpreted from satellite images with the help of aerial stereo photographs. The results of interpretation shall be compiled on polyester sheets covered on geometrically corrected satellite image, and edited by different colors according to map items.

13. Digital Mapping

On a computer screen, background by satellite images which are geometrically corrected and orthographic projected or rasterized interpretation result, map vector data shall be acquired based on the map symbol specification and layer classification.

Using rasterized interpretation result, distortion shall be inspected before geometric correction of the data.

14. Digitization of Collected Materials

Map details such as geographic names, administration boundaries and facilities shall be digitized from collected materials according to layer classifications and map symbol specifications. At digitizing, rasterized framework data shall be displayed at background so that contradictions will not occur.

15 Digital Compilation and Structuralization

Acquired map vector data shall be structuralized for GIS application. In case various data use is considered, strict node connection of basic items, such as roads, railways, buildings, water systems, administration boundaries and so on is considered for easier re-editing to layer structure or polygons.

If map printing is considered, structuring for automatic symbolization is carried out.

16. Symbolization

Creation of symbolized data from structuralized map data by automatic processing. Symbolized data shall be output to individual layer, based on the order of output.

In case symbolization does not correspond to map symbols or annotation text after printing plate output, data is converted into figures by outline process.

It is difficult to create completely the same map automatically and conventionally. It can be looked better than conventional map at one place, but in other places it can be worse because of difficulty of delicate adjustment, which traditionally is executed by hand. The problems, which correspond to map data structure or programs, can be solved.

Editing symbolized data means revising both structuralized and symbolized data, if some mistakes are found out at map data. The same refers to map revision, and it decreases efficiency in both cases.

17. Production of Printing Film

Printing films shall be produced by piling individual layer file, which are created according to map expression priority. Printer that can print out with three primary colors or the special colors shall be selected as output equipment.

In case output equipment is controlled with Macintosh or another program, data shall be transferred after converting into print data description format such as PostScript.

18. Printing

Printing out with printing plate film.

19. Storing of Digital Data

Final data shall be stored and managed with the following information:

① Structuralized data file for GIS
② Structuralized data file for printing
③ Printing plate for printing
④ Layer classifications and specifications of map symbols
⑤ Data format
⑥ Quality evaluation report
⑦ Metafile

Digital Mapping

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I. Introduction

Digital Mapping (DM) project in the Republic of Kazakstan is divided into 1/100,000 and 1/200,000 scales. MapInfo was used for production of 1/100,000 scale topographic maps and MicroStation was used for production of 1/200,000 scale topographic framework map based on interpretation map prepared with the help of SPOT satellite images and aerial photographs in Kazakstan.

1. Outline of Work

Figure1. shows outline of digital mapping. Production of interpretation map based on SPOT satellite images and aerial photographs is carried out before scanning. Digital mapping is carried out on the basis of scanned interpretation map.

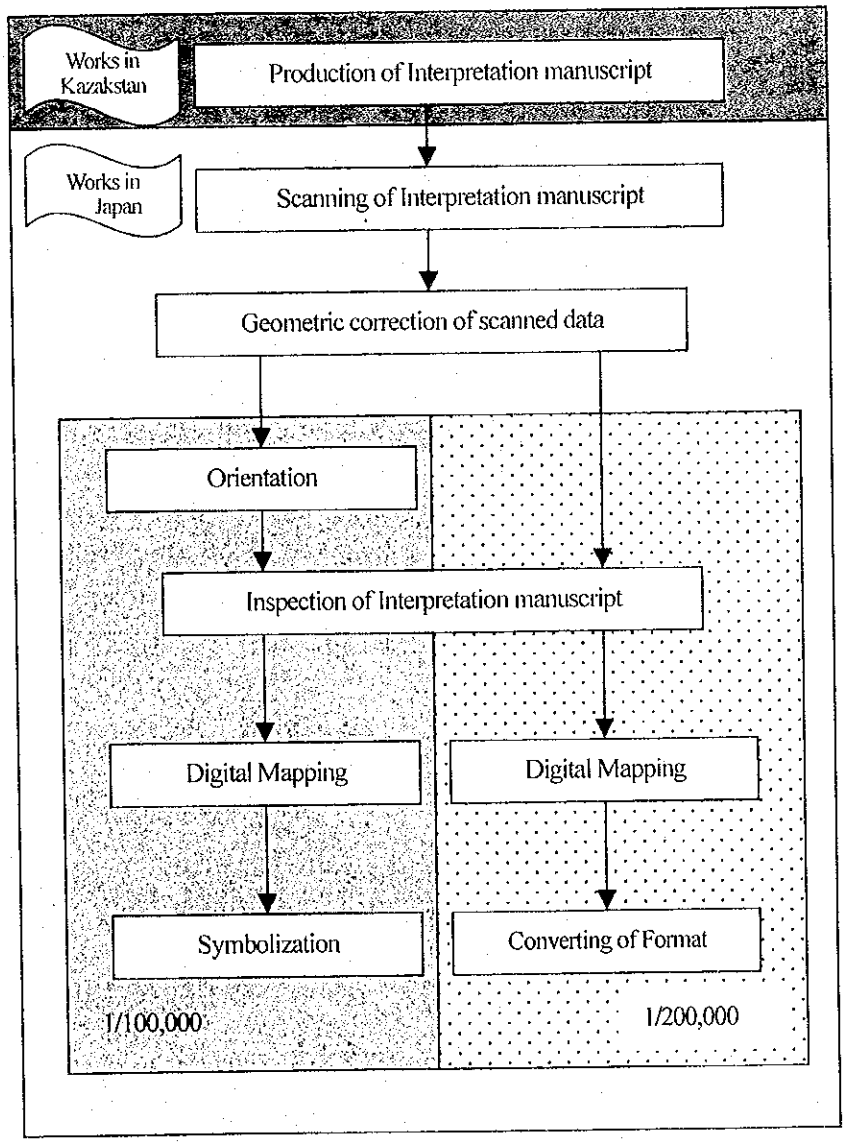
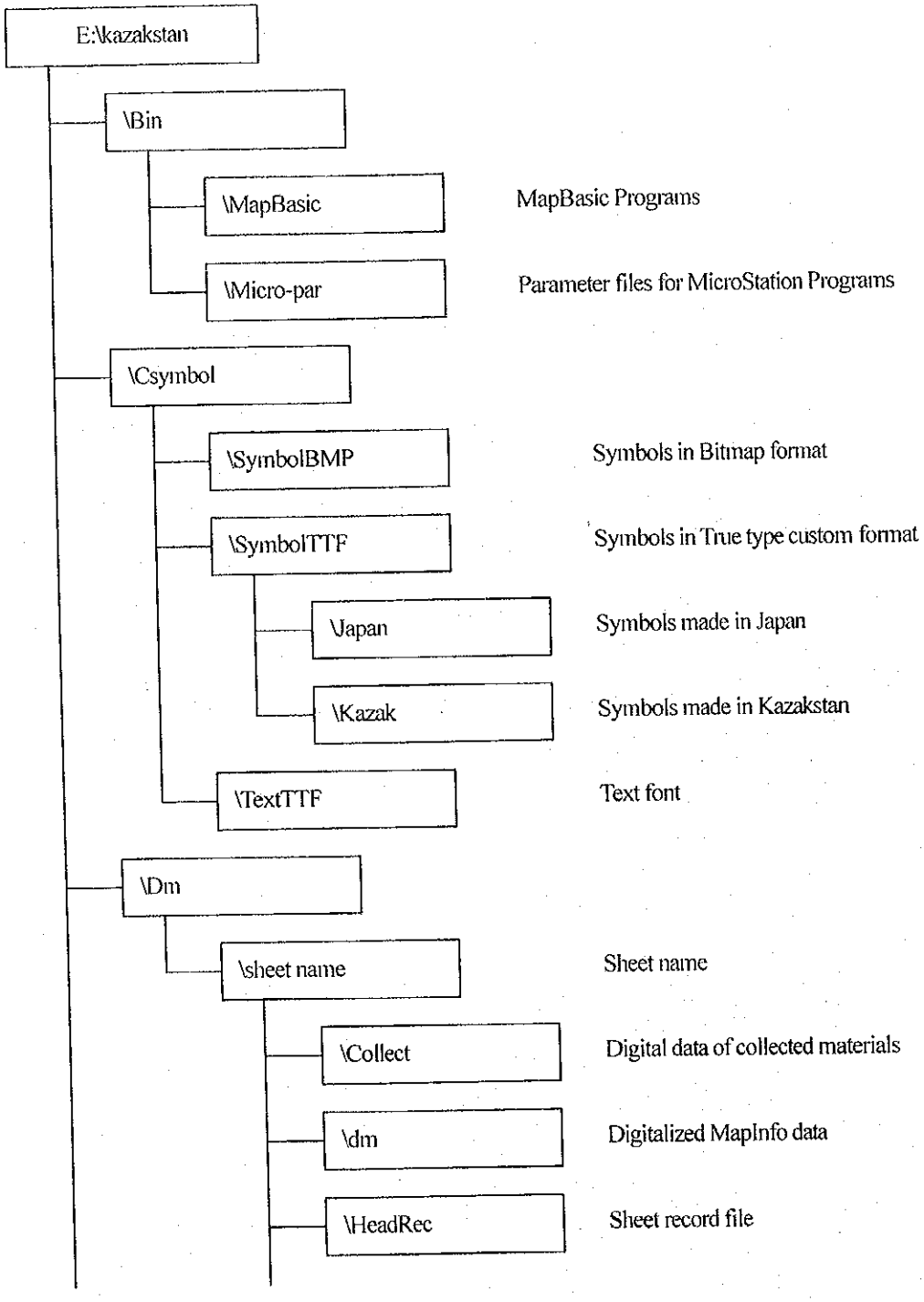


Figure 1. Outline of Work

2. Data Storing

2. 1. Method of storing

Each data is stored in the individual classified directory as shown on figure 2.



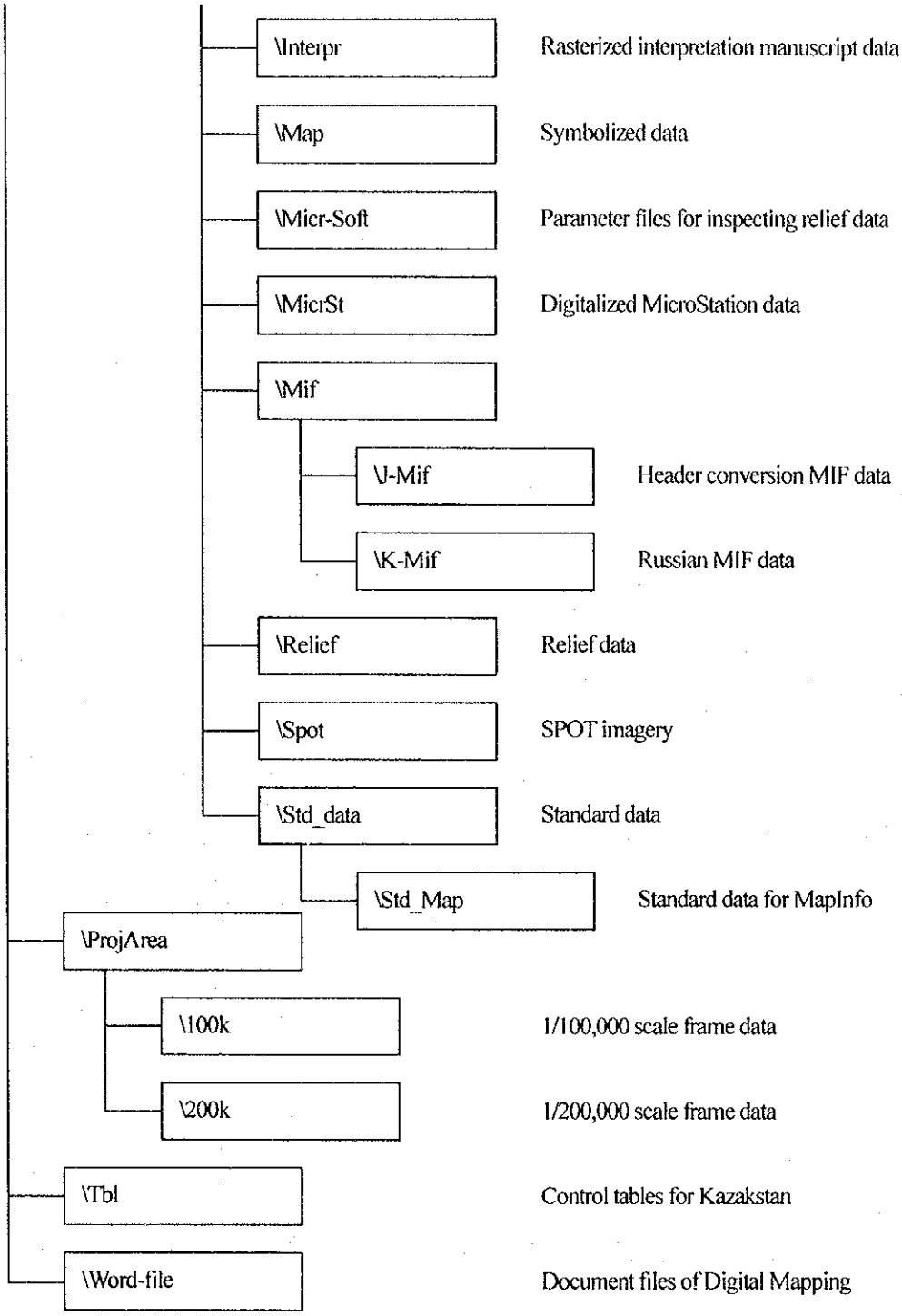


Figure 2. Directories of Data Storage

2-2. Storing of results

At the end of the project, result data and data for controlling programs are stored in a determined recording device.

3. Workflow of Digital Mapping

Figure 3. shows workflow and procedure (including software) in Japan.

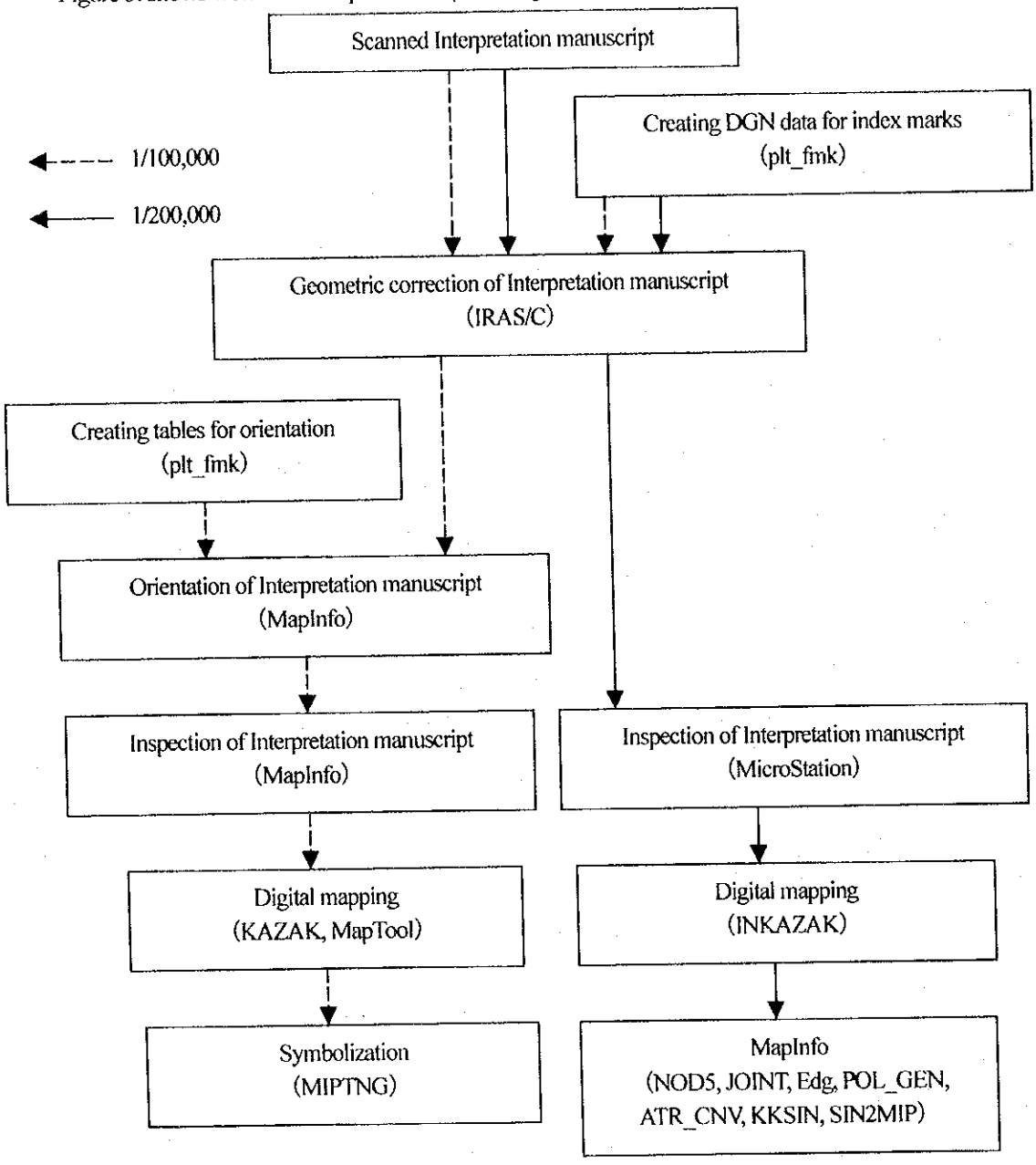


Figure 3. Workflow of Digital Mapping

4. 1/100,000 Scale Topographic Map

4-1 Image enhancement

Scanned interpretation manuscripts are enhanced into suitable images by reducing noise and adjusting color balance by Photoshop to facilitate the subsequent operations. Automatic level adjustment must be done attentively as image quality depends on it.

4-2 Creating index mark file in MicroStation DGN format

DGN data with index marks are created for each 1/4 sheet for geometric correction of interpretation manuscript by MicroStation.

Table 1. Plt_fmk (MicroStation)

Items	File name	Remark
Name of software	Plt_fmk	
Necessary files	Sheet record data	
	Parameter file	

4-3. Geometric correction of scanned interpretation manuscript

Geometric correction of scanned interpretation manuscript is carried out by IRAS/C, MicroStation, adjusting four corner coordinates of index mark file and scanned images.
Geometric correction of 1/100,000 scale topographic map is also made by MicroStation, because MapInfo has no function for resample.

4-4. Creating index mark file in MapInfo format

Index mark file in MapInfo format is created for each 1/4 sheet of 1/100,000 scale topographic map for orientation of geometrically corrected interpretation manuscript.

Table 2. Plt_fmk (MapInfo)

Items	File name	Remark
Name of software	Plt_fmk.mbx	
Necessary files	Sheet record data	
	Parameter file	
	Index mark file	

4-5. Orientation of scanned interpretation manuscript

Topographic coordinates (Orientation) for 1/100,000 scale topographic map are defined and plotted in MapInfo. Orientation is executed by standard MapInfo function.

4-6. Creating of grid line

Grid line is created by standard MapInfo function. Closing between neat lines is inspected.
Parameters for creating grid line for 1/100,000 and 1/200,000 scale maps are the following:

Space between lines	: 0.016666666666 (repeat "6" for ten times)
Latitude, altitude	: Down to ten places of decimals
Additional node	: 0

4-7. Inspection of interpretation manuscript

1/100,000 scale topographic maps are inspected by MapInfo. Some clearly interpretable features on geometrically corrected SPOT images and interpretation manuscripts are plotted to inspect discrepancy.

4-8. Digital Mapping (Plotting)

One sheet of interpretation manuscript is divided into four 1/50,000 scale sheets. Plotting of each 1/100,000 scale sheet is made by joining four sheets. Input menu and Map Tools are used for plotting. (See II Digital Mapping of 1/100,000 scale topographic map.)

Table 3. Kazak

Items	File name	Remark
Name of software	Kazak	Input Menu
Necessary files	Addition.dll	Dynamic Link Library
	Hydro.dll	Dynamic Link Library
	Institute.dll	Dynamic Link Library
	Railway.dll	Dynamic Link Library
	Relief.dll	Dynamic Link Library
	Resident.dll	Dynamic Link Library
	Road.dll	Dynamic Link Library
	Vege.dll	Dynamic Link Library

Table 4. MapTool

Items	File name	Remark
Name of software	MapTool	MapTool

4-9. Symbolization

Symbolization of plotting data format and map expression data is carried out to inspect plotting code type, way of plotting and omitted features. Inspection of map expression is done by comparing output results with interpretation manuscript.

Run MapBasic program of MapInfo and choose MIPTNG.mbx, then execute these programs after specifying necessary input directory and output directory.

Table 5. MIPTNG

Items	File name	Remark
Name of software	MIPTNG.mbx	
Necessary files	Sheet record data	
	Kazafu.tbl	Control table
	FONT.tbl	Font symbol pattern table
	PLT_LINE.tbl	Line pattern table

5. 1/200,000 Scale Topographic Framework Map

5-1. Image enhancement

See "I-4-1 Image enhancement".

5-2. Creating index mark file in MicroStation DGN format

See "I-4-2 Creating index mark file in MicroStation DGN format".

5-3. Geometric correction of scanned interpretation manuscript

See "I-4-3 Geometric correction of scanned interpretation manuscript".

Orientation is not needed for production of 1/200,000 topographic framework map, because definition of topographic coordinates is executed together with geometric correction.

5-4. Inspection of interpretation manuscript

1/200,000 scale topographic framework map is inspected by MicroStation. (See "I-4-7 Inspection of interpretation manuscript")

5-5. Digital mapping (Plotting)

One sheet of interpretation manuscript is divided into four 1/100,000 scale sheets. Plotting of each 1/200,000 scale sheet is carried out by joining four sheets. (See III. Digital Mapping of 1/200,000 scale topographic framework map.)

5-6. Data converting to MapInfo format

Figure 4. shows conversion procedure (including software) from MicroStation data format to MapInfo data format.

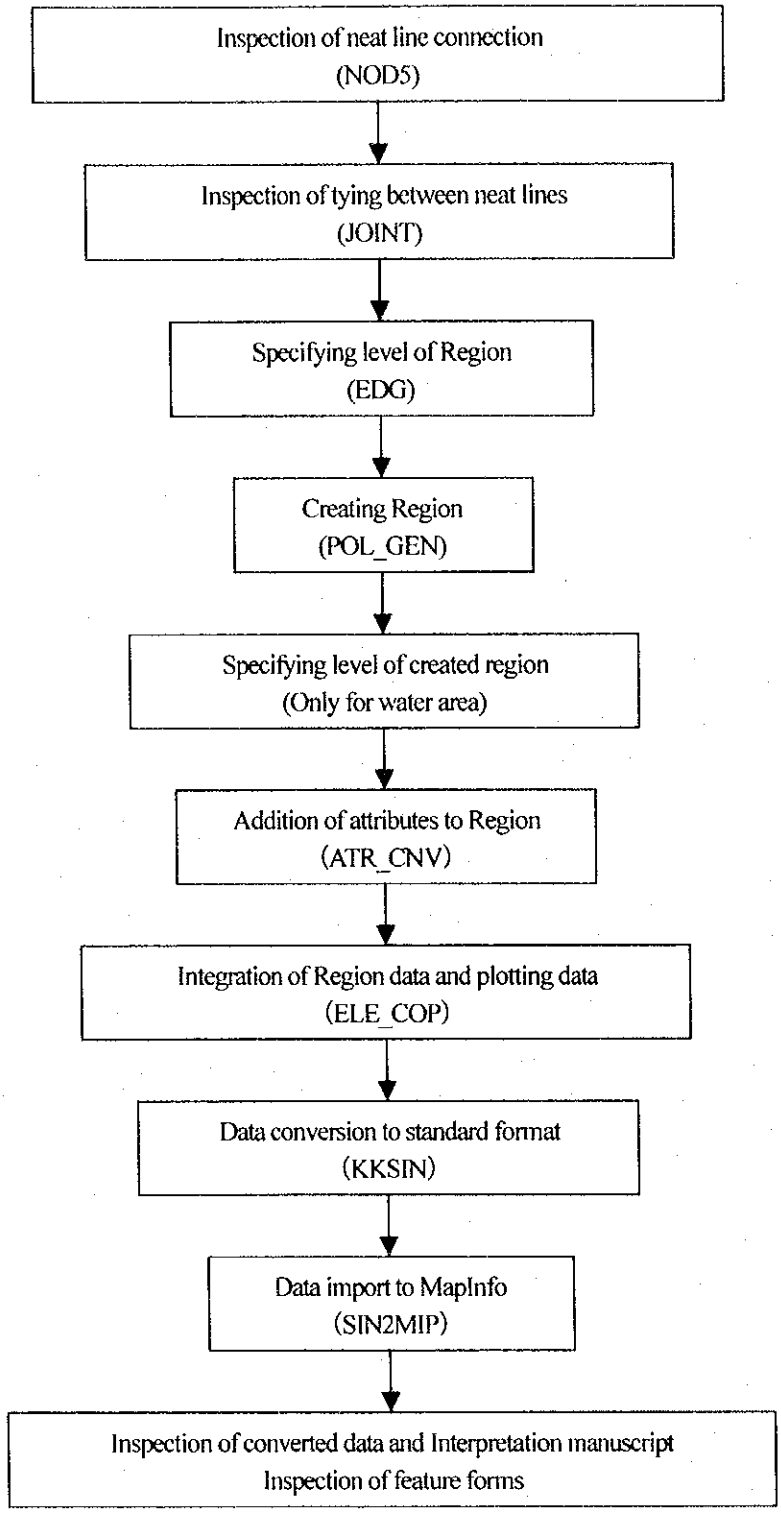


Figure 4. Data conversion method

Plotting of 1/200,000 topographic framework map is carried out by MicroStation, and all data is acquired from line objects. Before converting MicroStation data to MapInfo data, Region data is created from line data. After creating Region data, conversion of data to standard format and data import to MapInfo are executed; then MapInfo data is plotted out together with interpretation manuscript. Line weight and color of plotted manuscripts are inspected.

5-6-1. Inspection of neat line connection and tying between neat lines

Inspection of neat line connection and tying between neat lines is executed. Error circle is put on incorrect connection points. Nodes are to be inserted to those line-crossing points, which do not have them (for Regions creation nodes inputs are necessary)

Output files are prepared in executing programs. After correction of an error point based on output file, program is executed again. Steps are repeated until completion of errors. Then data will pass to the next process.

Inspection of tying between neat lines is executed by JOINT program. At executing JOINT program, lines, with the same style and their length, smaller than thresh holding value, are connected. Lines, which length is larger than thresh holding value are edited manually with the help of interpretation manuscript.

Table 6. NOD5

Items	File name	Remark
Name of software	NOD5	
Necessary files	DGN data to input	
	Parameter file (dmshiji.dat)	

Table 7. JOINT

Items	File name	Remark
Name of software	JOINT	
Necessary files	DGN data to input	
	Sheet record data	
	Adjoining sheets	

5-6-2. Specifying level of Region

All features input in MicroStation are stored in the same layer (Layer 1). It is easier to create Regions with individual attributes when levels are classified.

Levels shall be changed according to color, line weight and line styles of features. Table 9. shows feature levels after change.

Table 8. EDG

Items	File name	Remark
Name of software	EDG	Standard function of MicroStation
Necessary files	DGN data to input	

Table 9. Feature level after change

Category	Feature Number	Code	Level
Residential area	14-01	22 01 01	2
	14-02	22 01 02	3
Railway	96	42 01	4
Water part	129	51 01 00	5
	130	51 02	6
	134	52 02	7
	134	52 02 04	8
	134	52	9
	135	52 03	10
	145	53 02 00	11
	146	53 03 00	12
Auxiliary line		92 03 00	13

5-6-3. Creation of Region and classification of water area Layer

Create Region from line data. At Region creation double input lines are detected as error, except adjoining Regions. Two adjoining regions are marked by double line at a border. (See III 5-1).

Table 11. shows feature levels after Regions creation.

Table 10. POL_GEN

Items	File name	Remark
Name of software	POL_GEN	
Necessary files	DGN data to input	
	Parameter file (Fontlib.dat)	

Table 11. Each feature levels after creating Regions

Category	Feature Number	Code	Level
Residential area	14-01	22 01 01	52
	14-02	22 01 02	53
Rail way	96-01	42 01 01	54
Water part	129	51 01 00	60(55)
	130	51 02 00	60(60)
	134-03	52 02 03	60(57)
	134-04	52 02 04	60(58)
	134-05	52 02 05	60(59)
	135-03	52 03 03	56
	146	53 03 00	51

5-6-4. Addition of attributes to Region

Attributes disappear in the process of Region creation. Therefore, parameter files are used to add attributes to created Regions.

Table 12. ATR_CNV

Items	File name	Remark
Name of software	ATR_CNV	
Necessary files	DGN data to input	
	Parameter file (atr_cnt.par)	

5-6-5. Integration of Region data and plotting data

Created Region data and plotting data are integrated to DGN data for the purpose of converting to standard format data. This program is executed only for specific features in specific levels by parameter files.

Table 13. ELE_COP

Items	File name	Remark
Name of software	ELE_COP	
Necessary files	DGN data to input	
	Parameter file (ELE_COP.par)	
	DGN data to output	

5-6-6. Conversion of data to standard format

Integrated DGN data is converted to standard format data to be imported to MapInfo.

One letter from A to F is added to input DGN data as a cognitive character.

Table 14. KKSIN

Items	File name	Remark
Name of software	KKSIN	
Necessary files	DGN data to input	
	Sheet record data	
	Parameter file (KKSIN.PAR)	

5-6-7. Data import to MapInfo

Plotting data is imported from standard format to MapInfo format by executing programs.

Run MapBasic program and execute SIN2MAP program after specifying standard format data and table "KAZAF".

Table 15. SIN2MIP

Items	File name	Remark
Name of software	SIN2MIP	
Necessary files	Standard format data	
	Table "KAZAF"	

6. Inspection of Results

Numeric data (MapInfo MIF format) of corrected materials digitized in Kazakstan is imported and plotted out with symbolized data in the same scale. Expressed discrepancy of corrected materials and numeric data are inspected by visually.
All expressed discrepancy and errors are corrected.

6-1. 1/100,000 scale topographic map data

Inspection Standard	:	Collected materials	- Existing map - Map symbol specification
		Digital mapping	- Items, indicated in Kazakstan (See Second phase Progress Report) - Map symbol specification
Inspection Procedure	:	Plot out symbolized data at regular scale. Inspect visually with existing maps. Error correction files. (Error files are used at symbolization, in case of errors.)	
Correction Procedure	:	Collected materials	- Use SQL search function. (Search function of feature number in browser)
		Digital mapping	- Manual Correction

6-2. 1/200,000 scale topographic framework map data

Inspection Standard	:	Plotted manuscript	- Discrepancy more than one line thickness
		Programs	- Made thresh holding value of line adjoining 0
Inspection Procedure	:	Plot out together with raster data and inspect by eye Inspect line connection by programs	
Correction Procedure	:	Manual correction	

7. Import of Digitized Collected Data

7-1. Problems of MIF format data import

Headers of MIF import data were corrected, because of differences between operating systems used in Japan and Kazakstan. Besides, data imported to MapInfo was interrupted because there were some irregular values in Pen file of MIF data. Therefore, all ineffective numbers were inspected and corrected.

7-2 .Hydro、Industry、Border、Gridmeter

There were some objects, which didn't coincide to map symbol specification, in Hydro, Industry, Border and Gridmeter layer of 1/100,000 scale collected materials. These objects were corrected by using SQL search function.

7-3. Relief2

Some data of Relief2 overlapped digitized data. All this data is deleted, because it was based on existing maps and can be judged as secular changed.

7-4. Symbol data of Culture, Hydro and Industry layer

More than two symbols were used for one map symbols.

True Type Font symbols were created and corrected in Japan for the purpose of uniting symbols.

II. Digital Mapping of 1/100,000 Scale Topographic Map

1. Input Procedure

File → Run MapBasic program → Open both Kazak.mbx (Input menu) and MapTools.mbx (Edit menu)

1-1. Input menu

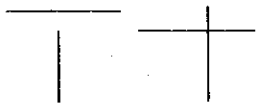
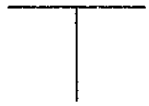
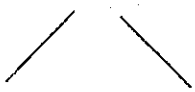
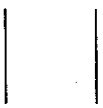
- Select number, coinciding the number on interpretation manuscript.

1-2. Edit menu

[JOIN]

- For joining lines without node, such as extending a line to a neat line. Not for joining the line absolutely. (Ex. Road)
- Click the desired joining pattern icon. Click the desired line to be extended and drag till destination line.

Table 17. Joining Pattern

Name	Before execution	After execution
"T" joining		
"A" joining		
"W" joining		
"N" joining		

[SCALE]

- Scale will change to 1/100,000 by clicking Change scale/Standard. By clicking Change scale/Zoom in and Change scale/Zoom out, scale will change to 1/1000,000, 1/500,000, 1/250,000, 1/100,000, 1/50,000, 1/25,000, 1/10,000 and 1/5,000.